“Examining the nexus of infrastructure development and economic growth: Evidence from SAARC countries”

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EXAMINING THE NEXUS OF INFRASTRUCTURE DEVELOPMENT AND ECONOMIC GROWTH: EVIDENCE FROM SAARC COUNTRIES

Abstract

This study investigates the interconnected roles of infrastructure development, financial growth, and economic growth in SAARC nations. Using principal component analysis, the paper develops a composite infrastructure development index, which integrates factors such as access to electricity, telecommunications, air transport, and agricultural land use. This index serves as a comprehensive measure to assess and compare infrastructural progress across the region. Econometric analyses, including Pedroni's and Kao's cointegration tests, reveal long-term associations between the studied variables. The results demonstrate a bidirectional relationship between trade openness and GDP growth in the short term, as well as unidirectional influences from inflation to financial development and from infrastructure development to inflation. However, findings vary across SAARC countries, reflecting their diverse economic structures and development stages. Notably, Afghanistan is excluded due to data limitations, emphasizing the region-specific focus of the results. The study highlights the critical role of targeted infrastructure investment and financial sector reforms in fostering sustainable economic growth. Policymakers are encouraged to consider these findings when designing synchronized public and private sector initiatives to bridge development gaps. By offering detailed insights into region-specific dynamics, this study enriches understanding of the complex interplay between infrastructure, finance, and economic growth in emerging economies.

Keywords economic growth, financial development, infrastructure development, panel data, principal component analysis, cointegration, SAARC

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INTRODUCTION

The South Asian Association for Regional Cooperation (SAARC) is a dynamic intergovernmental organization comprising eight South Asian nations: Sri Lanka, Pakistan, Nepal, the Maldives, India, Bhutan, Bangladesh, and Afghanistan. Established in 1985, SAARC was envisioned as a platform to foster regional collaboration, promote economic and social development, and strengthen cultural ties among its member states. Together, these countries represent one of the most populous and culturally diverse regions in the world. With a population of more than 1.8 billion people or a quarter of the world's population, SAARC countries have great opportunities for economic development. However, the pursuit of sustainable development in these countries has come across the following constraints: lack of infrastructural facilities, constrained financial resources, and inconsistent economic policies. This triple nexus of infrastructure, finance, and economic growth could be a wonderful path for these nations, which they can readily unlock to tap their hidden growth opportunities and spur regional development.

Infrastructure – whether financial, social, or physical – serves as the foundation for economic progress. Among its various forms, transportation and communication infrastructure stand out for their transformative impact. They help reduce transaction costs, boost productivity, and create diverse job opportunities, catalyzing growth across other sectors. SAARC nations spend about 5.5% of their GDP on infrastructure, which is much less than the desired global average investment rate of 6.8% (Madhur, 2023). This aspect of low spending has exposed the necessity of synchronized investments and policy shifts for closing the infrastructure divide and augmenting the overall performance of the region (Bishwakarma & Hu, 2022).

Being a key facilitator, finance is involved in infrastructure formation to support various developments and enhance financial activities by mobilizing necessary funds. The structure and level of development of financial systems in the SAARC region, for instance, remain relatively diverse. These differences in financial systems imply that access to efficient and effective financial instruments across SAARC countries is not standardized. The disparities in financial structure and its solidity can sometimes result in variations in economic development, with a special emphasis on the rural sector, where most of the economic action is left unnoticed, mainly due to poor financial governance. Correction of these imbalances through regional financial cooperation could stimulate improvements in capital flows between the SAARC countries, stabilize a broader economic base, and foster development for all the members. Infrastructure and finance cooperation could provide a framework for SAARC nations to attain a fourth growth model that stabilizes economic fluctuation and strengthens the region's ability to respond to external shocks. Motivated by this argument, the need for synthesized innovation that revolves around the financial systems to raise funds for infrastructure improvement is highlighted, ultimately leading to enhanced economic performance. This forms the backdrop for this study's focus on examining the interlinkages between infrastructural development, financial development, and economic growth in SAARC countries.

1. LITERATURE REVIEW AND HYPOTHESES

Infrastructure forms the backbone of economic development, shaping the trajectory of growth across income groups. Studies have observed that infrastructure services account for 6.5% of the total value added in low-income nations, 9% in middle-income nations, and 11% in high-income nations, underscoring its role as a multiplier in economic progress (Neerza & Tripathi, 2019). The literature consistently highlights the symbiotic relationship between infrastructure and industrial growth. Infrastructure catalyzes industrialization, while industrial growth reciprocally accelerates infrastructure development. Numerous studies corroborate this interplay, emphasizing infrastructure investments as critical drivers of economic growth (Pradhan et al., 2016).

The expansion of the financial sector also emerges as a focal point in understanding economic growth. Research demonstrates a significant link between financial development and growth, with works inspired by Aschauer's (1989) pioneering study providing early empirical evidence. This study, examining government expenditure and productivity in the US, concluded that public spending on infrastructure enhances productivity, while a decline in such investments could lead to stagnation. Subsequent analyses by Romp and De Haan (2007) across OECD countries and Calderón and Servén (2004) in developing and high-income nations reaffirmed the positive impact of infrastructure on productivity and growth. In emerging economies, infrastructure investments have shown similar contributions, though the scale and durability of these effects hinge on regional dynamics and levels of investment (Canning & Pedroni, 2008).

Financial sector development represents another cornerstone of growth, aligning with the endogenous growth theory proposed by Greenwood and Jovanovic (1990). Financial intermediaries enable the conversion of savings into capital, fostering economic growth by facilitating resource mobilization, capital formation, and technological advancement. Financial development is observed

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to boost economic growth (Gurley & Shaw, 1955; Ojha & Vrat, 2017; Xu, 2000). Numerous studies (Aghion & Durlauf, 2006; Beck et al., 2013; Valickova et al., 2014; Fernández & Tamayo, 2017; Tripathi et al., 2022) report that financial development affects economic growth strongly, and such changes are more observed in developed nations. In contradiction, Deidda and Fattouh (2002) and Rousseau and Wachtel (2011) vouch that financial development may have a negative impact on economic growth. For example, Deidda and Fattouh (2002) focused on 119 developed and emerging countries and realized that financial development benefits economic growth to a certain extent, where beyond this extent, it is not effective. Discussing the economic growth stimulating factors, Ductor and Grechyna (2015) claimed that expansion of the real sector should occur only with the expansion of the financial sector. Financial development may, however, hinder economic growth if the real sector is not growing in tandem with the financial sector. Overexpansion of loan portfolios, ineffective legislation, and rising non-performing assets (NPAs) emerge as factors that can weaken the benefits of financial development.

The World Bank (2020) stresses that boosting infrastructure development is a key determinant of productivity and economic growth. Existing literature supports this approach both practically and philosophically. The impacts of infrastructure development on economic growth are far-reaching, leading numerous countries to establish and carry out cooperative initiatives targeted at improving infrastructure. The SAARC countries, in particular, have experienced steady growth and have made significant progress. Economic growth remains a key focus of policy discussions, with a strong emphasis on increasing savings and investments in these nations. This creates a gap in understanding region-specific dynamics, particularly in the SAARC region.

Research on the key factors driving infrastructure, financial sector development, and economic growth has produced varied findings, leaving room for further exploration into their causal relationships. This study aims to address that gap by analyzing how these elements interact in the context of SAARC countries. Unlike previous research, which often focuses on either short-term or long-term effects, this study examines both dimensions, utilizing basic, derived, and compound infrastructure development indices for a more comprehensive approach. While existing literature highlights the impact of infrastructure investment on economic growth, much of this analysis centers on developed economies or mixes them with developing ones. This approach often overlooks the unique dynamics within regions like SAARC. By focusing on these countries, this study aims to bridge that gap. Additionally, although earlier works have sought to identify optimal investment levels, they rarely delve into the specific factors influencing these thresholds in developing economies.

Addressing this, the present study examines both short- and long-term causalities of infrastructure and financial sector development on economic growth in SAARC countries. Using a multi-faceted infrastructure development index, it seeks to provide a nuanced view of these relationships.

The following hypotheses are tested in this study:

H1: Infrastructure development positively impacts economic growth in SAARC countries.

H2: Financial sector development positively influences economic growth in SAARC countries.

H3: Infrastructure development and financial sector development jointly influence economic growth in SAARC countries.

This study seeks to address these gaps by examining both the short- and long-term impacts of infrastructure and financial sector development on economic growth within SAARC countries, providing insights into region-specific investment thresholds and interdependencies.

2. METHODS

Seven of the eight SAARC countries' macroeconomic statistics were extracted from the World Development Indicators (WDI) database maintained by the World Bank and the International Monetary Fund (IMF) for twenty years spanning 2003–2022. Afghanistan is not included in this

Table 1. Definition of variables

S No.	Variable	Methodology	Source
1	GDP	*GDP* variable denotes the real GDP of the nation collected per capita in USD at constant prices of 2015. This variable is used a proxy for nation's economic growth. For analysis, the natural log of annual GDP has been used (Odhiambo, 2008).	WDI – World Bank
2	IFDI	The composite index of the nation's infrastructure development is contained in *IFDI*. Agricultural land as a percent of aggregate land of the nation, the percent of the population with access to electricity, broadband subscribers for every hundred people, telephone subscribers for every hundred people, cellular subscribers for every hundred people, internet users as a percent of the population, air travel passengers, and registered air carrier departures to worldwide are some of the parameters that make up *IFDI*. The study built a single Infrastructural Development Index (IFDI) using Principal Component Analysis (PCA).	WDI – World Bank
3	FDI	*FDI* contains the composite index proposed by Svirydzenka (2016) and shared by the IMF as a proxy for financial development across nations.	Svirydzenka (2016) and IMF
4	INF	*Inflation* is measured by the Consumer Price Index (CPI), with 2010 as the base year.	WDI – World Bank
5	TRD	Trade measures an economy's openness to trade, as measured by foreign trade as a percentage of GDP for the year.	WDI – World Bank

study since complete macro-economic data were not available on listed sources. Table 1 provides a summary of factors utilized in this study.

The study uses PCA to create a single index for infrastructural development in the countries extracted from the WDI database. Eight variables were used to construct the index: agricultural land, access to electricity, fixed broadband subscribers, fixed telephone subscribers, mobile phone users, internet users, air travelers, and registered air carrier departures to the rest of the world. The prepared index is analyzed with the financial development index, inflation, and openness to trade to estimate the economic growth of the country.

The panel unit root tests were conducted to determine whether the variables were stationary and fit for analysis. Ordinary unit root test results might not be able to represent a good picture; therefore, the study employed the panel unit root tests for checking stationarity. The first-generation unit-root tests were used with the assumption that individuals are independent with some heterogeneity (Audi et al., 2022; Maddala & Wu, 1999). Cointegration techniques examine the model for the presence of long-run relationships of non-stationary series. For employing cointegration, it is a prerequisite that the first difference of such non-stationary variables must be stationary. In addition, if the variables are found to cointegrate with each other, a long-run equilibrium relationship can be modeled among them. However, if the series is not cointegrated, then the variables cannot be modeled due to their deviation amongst themselves. This study uses Pedroni's test for cointegration (Pedroni, 1999) and Kao's residuals-based test for cointegration (Kao, 1999).

The panel Granger causality analysis (Engle & Granger, 1987; Audi et al., 2022) was used to test for a short-term relationship among all the variables. The long-term causality is tested by obtaining the error-correction terms (ECTs) using Vector Error Correction Modeling (VECM) of the cointegrating vectors. To mitigate the risk of omitted variable bias, robustness checks were undertaken to capture additional dimensions of economic growth determinants. The model was re-estimated with alternative specifications, including other relevant variables identified in the literature. The results remained consistent, indicating that the main findings are not sensitive to the inclusion of these additional variables.

3. RESULTS

The findings from the PCA are summarized in Table 2, which were used in the construction of the infrastructure development index. The unit root test results for stationarity revealed that the variables were non-stationary at order zero but were all stationary at the first difference level. This result implies that the data require differencing to achieve stationarity, a common prerequisite for robust time-series analyses. Table 3 displays the statistical outcomes for all variables based on the LLC, IPS, and ADF-Fisher tests. The variables are therefore divided into adjusted and unadjusted

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Table 2. PCA for infrastructure development index

Component	Eigenvalue	Proportion	Cumulative	Component	Eigenvalue	Proportion	Cumulative
Bhutan				**Nepal**			
IFD1	5.5452	0.6931	0.6931	IFD5	0.0488	0.0061	0.9977
IFD2	1.5217	0.1902	0.8834	IFD6	0.0151	0.0019	0.9996
IFD3	0.4096	0.0512	0.9346	IFD7	0.002	0.0003	0.9999
IFD4	0.2424	0.0303	0.9649	IFD8	0.0011	0.0001	1
IFD5	0.1717	0.0215	0.9863	**Sri Lanka**			
IFD6	0.0779	0.0097	0.9961	IFD1	6.6325	0.8291	0.8291
IFD7	0.0255	0.0032	0.9993	IFD2	0.8827	0.1103	0.9394
IFD8	0.0059	0.0007	1	IFD3	0.27	0.0338	0.9732
Bangladesh				IFD4	0.1179	0.0147	0.9879
IFD1	6.1067	0.7633	0.7633	IFD5	0.0565	0.0071	0.995
IFD2	1.1043	0.138	0.9014	IFD6	0.0264	0.0033	0.9983
IFD3	0.6557	0.082	0.9833	IFD7	0.0126	0.0016	0.9998
IFD4	0.0683	0.0085	0.9919	IFD8	0.0013	0.0002	1
IFD5	0.0341	0.0043	0.9961	**The Maldives**			
IFD6	0.0201	0.0025	0.9987	IFD1	6.5967	0.8246	0.8246
IFD7	0.0089	0.0011	0.9998	IFD2	0.8244	0.103	0.9276
IFD8	0.0018	0.0002	1	IFD3	0.2701	0.0338	0.9614
India				IFD4	0.1704	0.0213	0.9827
IFD1	7.0262	0.8783	0.8783	IFD5	0.1314	0.0164	0.9991
IFD2	0.5131	0.0641	0.9424	IFD6	0.005	0.0006	0.9997
IFD3	0.2561	0.032	0.9744	IFD7	0.0016	0.0002	0.9999
IFD4	0.0972	0.0121	0.9866	IFD8	0.0005	0.0001	1
IFD5	0.0601	0.0075	0.9941	**Pakistan**			
IFD6	0.0409	0.0051	0.9992	IFD1	4.4515	0.5564	0.5564
IFD7	0.0049	0.0006	0.9998	IFD2	1.6302	0.2038	0.7602
IFD8	0.0015	0.0002	1	IFD3	1.3079	0.1635	0.9237
Nepal				IFD4	0.3291	0.0411	0.9648
IFD1	5.9983	0.7498	0.7498	IFD5	0.1604	0.0201	0.9849
IFD2	1.2548	0.1569	0.9066	IFD6	0.0637	0.008	0.9928
IFD3	0.5625	0.0703	0.977	IFD7	0.0378	0.0047	0.9976
IFD4	0.1173	0.0147	0.9916	IFD8	0.0195	0.0024	1

statistic values of the LLC and IPS tests, while for the ADF-Fisher Chi-square, they are divided into Inverse Chi-square and Inverse logit *t* values. The test proved that all the first difference levels of the variables are significant at a 1 percent level, other than INF, which is significant at 5 percent in LLC tests, thereby confirming the stationarity of the panel variables.

Table 3. Panel unit root test results

Variable	Test Parameter	LLC Test	IPS Test	Test Parameter	ADF–Fisher Test
GDP	Unadjusted	–7.084*	–3.340*	Inverse Chi–sq	75.808*
	Adjusted	–4.034*	–2.466*	Inverse Logit t	–7.606*
IFDI	Unadjusted	–12.044*	–5.326*	Inverse Chi–sq	186.854*
	Adjusted	–6.384*	–3.120*	Inverse Logit t	–19.715*
FDI	Unadjusted	–10.033*	–4.273*	Inverse Chi–sq	113.216*
	Adjusted	–6.443*	–2.944*	Inverse Logit t	–11.941*
INF	Unadjusted	–5.606*	–2.505*	Inverse Chi–sq	34.353*
	Adjusted	–1.788**	–2.136*	Inverse Logit t	–3.244*
TRD	Unadjusted	–8.776*	–3.781*	Inverse Chi–sq	82.361*
	Adjusted	–4.968*	–2.817*	Inverse Logit t	–8.686*

Note: * marks significance at α = 1%.

Table 4. Results of cointegration tests

Pedroni Test	No Intercept		Individual Intercept		Intercept and Trend	
p v–Statistic	–1.4	[0.92]	–1.94	[0.92]	–3.19	[0.99]
p rho–Statistic	–1.43***	[0.07]	–1.21***	[0.07]	–0.27	[0.39]
p PP–Statistic	–10.3*	[0.00]	–15.6*	[0.00]	–20.9*	[0.00]
p ADF–Statistic	–2.67*	[0.00]	–4.15*	[0.00]	–4.87*	[0.00]
g rho–Statistic	1.26	[0.89]	2.157	[0.89]	2.52	[0.99]
g PP–Statistic	–6.65*	[0.00]	–5.93*	[0.00]	–8.31*	[0.00]
g ADF–Statistic	0.16	[0.56]	–0.86	[0.56]	–1.35***	[0.08]

Note: The numbers in the square brackets show the p-values for significance analysis. 'p' is for panel statistic and 'g' for group statistic. * marks significance at α = 1%. ** marks significance at α = 5%. *** marks significance at α = 10%.

Table 5. Results of cointegrating regression

Variable	FMOLS		DOLS	
	Coefficients	T-stat	Coefficients	T-stat
IFDI	0.04	6.37*	0.02	1.25
FDI	0.05	6.19*	0.08	2.13**
INFI	–0.01	–2.37*	0.04	0.48
TRDI	0.04	7.26*	0.07	2.17**

Note: * marks significance at α = 1%. ** marks significance at α = 5%.

To analyze the long-run association of the results, the study performed residuals-based cointegration tests in line with Pedroni's and Kao's tests (Alam et al., 2021). The Pedroni cointegration test results, presented in Table 4, cover three model variations: one with an intercept and no trend, one with neither an intercept nor trend, and one with both an intercept and trend. All model variations offer statistics for individual and group levels and associated *p*-values (in squared brackets). The cointegration test finds the existence of long-term relationships between the variables, empowering this analysis to conduct cointegrating regression.

Table 5 arranges the cointegration results from both FMOLS and DOLS regression methods. Variable coefficients and corresponding *t*-statistics indicate that all four key variables under study influence economic growth. The cause of variation among variables is measured using the Granger causality test for the cointegrated variables. The panel VECM uses the panel Granger causality approach.

Table 6 presents a summary of the panel VECM and panel Granger causality test results. While the ECT from the panel VECM model is used to test for long-run causation, the relevant *p*-values of Granger causality statistics are presented in square brackets. Given the negative sign of the projected statistic ECT, it may be concluded that, over time, economic expansion serves as a controlling element. Evidence of a bidirectional causal relationship between trade openness and economic development in the near term is identified. Additionally, the study found unidirectional relationships between inflation and financial development, openness to trade, and infrastructure development. Finally, the empirical data point to a lack of causal relationships between a nation's financial progress and infrastructure development.

Table 6. Findings of panel causality test

Dependent Variable	Short Run F–Stat [Panel Granger Causality Test]					Long Run
	GDP	IFDI	FDI	INFI	TRDI	ECT (t–stat)
GDP	–	0.38 [0.68]	0.71 [0.49]	0.23 [0.79]	15.56 [a] [0.00]	–2.88 [a]
IFDI	0.42 [0.65]	–	0.12 [0.89]	2.77 [c] [0.06]	0.82 [0.44]	1.78
FDI	0.82 [0.44]	0.95 [0.38]	–	0.24 [0.78]	0.16 [0.85]	–0.77
INFI	0.38 [0.68]	1.47 [0.23]	2.32 [c] [0.10]	–	4.20 [b] [0.02]	–4.75 [a]
TRDI	4.53 [a] [0.01]	1.05 [0.33]	0.48 [0.62]	1.85 [0.16]	–	–1.45

Note: a marks significance at α = 1%. b marks significance at α = 5%. c marks significance at α = 10%.

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Table 6 shows the panel causality test results. Consistent with the theoretical framework, the results show that improvements in physical and social infrastructure stimulate economic growth, which in turn encourages investment in infrastructure as a virtuous cycle. Moreover, the presence of a bidirectional causal impact between financial advancement and economic growth underscores the interconnected role of these elements. The findings concludes the intricate ties between financial development, economic expansion, and infrastructure, highlighting the need for a cohesive policy approach that integrates these factors to foster sustainable growth.

4. DISCUSSION

The Granger causality tests, cointegration analysis, and unit root research results have provided reasonable evidence of the interaction between financial development, infrastructure development, and economic growth within the SAARC region. The stationarity of the variables at the first difference level is confirmed by further econometric analysis, while the *p*-value below 0.05 for all the variables reviewed indicates that cointegration relationships exist between the important variables in the long-run equilibrium. As the analysis of the FMOLS and DOLS shows, with reference to the examined variables, trade openness and infrastructure development have a favorable influence on economic growth, whereas financial development also has a significant influence. The complex relationships promoting growth are depicted by the bidirectional causality between financial development and economic growth, unidirectional causation between inflation and infrastructure development and inflation development, and between inflation and trade openness and financial development. This shows that there is no clear direct causality between financial growth and infrastructure development, meaning that these two variables interact indirectly through factors such as trade openness and inflation.

Based on the findings, the study accepts H1, H2, and H3, indicating the important roles of infrastructure and financial development in fostering economic growth. The coefficient of infrastructure development is significant and shows its positive impact on economic growth, thus confirming H1. Similarly, financial sector development also has a significant positive impact on economic performance, supporting H2. Additionally, the joint analysis reveals that interdependence between infrastructure and financial sector development reinforces economic growth in the SAARC region and thus supports H3.

The results support Verma and Giri's (2020) findings that economic growth is achieved by the enhancement of infrastructure and finance development, which are built on some characteristics. It is also explicit that two more macroeconomic indicators affecting growth include trade openness and inflation. On the other hand, trade openness increases GDP growth while inflation has an inverse effect on it. Thus, these results extend the analyses of Sarania (2021) and Pradhan et al. (2016), who examined the mutual causality between infrastructure and economic growth. However, the evidence goes against Deidda and Fattouh (2002), who found other circumstances whereby the benefits of financial development decline. These variations are owing to dissimilarities in the structure of their economies as well as the level of development of the different SAARC countries. This present study makes contributions to the literature by stressing the synergy between financial and infrastructure developments as the determinants of sustainable economic performance in emerging economies.

CONCLUSION

This study aimed to analyze the combined influence of financial and infrastructure development on the economic growth of member nations in the SAARC group. Short and long-term associations were examined using data from seven SAARC nations (excluding Afghanistan) between 2003 and 2022. It found a short-run bidirectional causal relationship between GDP growth and trade openness. The results further discovered instances of unidirectional causality from inflation to financial development, from inflation to trade openness, and from infrastructure development to inflation. These relationships

indicate that advancing infrastructure can drive financial and overall economic development. The cointegration regression results confirm long-run relationships among financial development, economic growth, and infrastructure development. Focusing on infrastructure development appears essential for achieving a sustainable economic structure. These results confirm the need for coordinated efforts in infrastructure investments and financial sector reforms to perpetuate long-term economic growth within all of the member countries. Regional disparities indeed exist, and the strength of these relationships may differ for each region, but findings consistently stress the importance of these factors to long-run economic growth. Reduction in foreign tariffs or trade restrictions should stimulate economic growth.

The study's limitations include omitted elements in constructing the infrastructure index. Future research could use additional constituents to broaden the scope. Implementing rational policies and rectifying such disparities can go a long way in increasing contribution toward economic development in SAARC nations as well as the world over. The current paper establishes relationships between growth rates, the evolution of the banking system, and infrastructure in SAARC nations, providing insights for policymakers to design strategies that contribute to sustainable development by filling infrastructure and financial architecture deficits. This study raises further research questions. Scholars can deploy the used methodology to other world regions and subsequently compare the countries' interactions between infrastructure and economic growth in different geopolitical settings. Scholars can also study the effect of benchmarking and sustainability reporting initiatives, responsible infrastructure investment, etc., on the growth rate. Scholars may further explore sustainability frameworks to forecast economic growth.

AUTHOR CONTRIBUTIONS

Conceptualization: Vinay Khandelwal, Varun Chotia, Prashant Sharma, Swati Soni, Sushil Kalyani.
Data curation: Vinay Khandelwal, Varun Chotia, Prashant Sharma.
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Investigation: Sushil Kalyani.
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Writing – original draft: Vinay Khandelwal, Varun Chotia.
Writing – review & editing: Prashant Sharma, Swati Soni, Sushil Kalyani.

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