ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26may1223

Comparative Study of COVID-19 Infection and Mortality Trends in India, the United States and Brazil Using Statistical Analysis

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Publication Date: 2026/05/30

Abstract: A deadly respiratory illness known as COVID-19, triggered by a novel betacoronavirus designated SARS-CoV-2, emerged unexpectedly in Wuhan, Hubei Province, China, towards the end of 2019. The pathogen demonstrated extraordinary transmission efficiency, crossing international borders within weeks and infecting tens of millions of individuals across every continent. Its swift propagation imposed an enormous burden on hospital networks, disrupted national economies, paralyzed education systems, and fundamentally altered everyday life worldwide. Among all affected nations, India, the United States of America, and Brazil endured particularly devastating consequences, accumulating the highest combined tallies of confirmed infections and fatality counts.

The present review undertakes a rigorous cross-national examination of pandemic trajectories in these three countries, focusing on key epidemiological metrics including the volume of laboratory-confirmed infections, case fatality proportions, patient recovery percentages, diagnostic testing throughput, and immunization rollout progress. Quantitative data were drawn exclusively from authoritative open-access repositories — encompassing official intergovernmental bodies, national health ministries, and peer-reviewed epidemiological databases — and were subsequently processed and visualized through Microsoft Excel and Power BI analytical platforms.

The investigation brings to light substantial divergences in how each nation approached pandemic containment, shaped by unique combinations of healthcare system capacity, legislative responses, demographic distribution, surveillance coverage, and civic engagement levels. Analytical findings consistently reveal that administrations which enacted prompt, coordinated countermeasures and sustained broad-based immunization efforts achieved comparatively superior outcomes in curtailing both severe disease incidence and overall mortality.

The conclusions drawn from this work underscore the critical necessity of proactive healthcare readiness, rigorous real-time epidemiological surveillance, and sustained public engagement during large-scale disease emergencies. The evidence presented here is intended to inform and assist policymakers, public health administrators, and scientific communities as they refine frameworks for pandemic prevention, response coordination, and long-term health system strengthening.

Keywords: *COVID-19, SARS-CoV-2, Comparative Analysis, Mortality Rate, Recovery Rate, Vaccination, Public Health, Epidemiology, Healthcare Infrastructure, Statistical Analysis.*

How to Cite: Gaurav Bhabhar; Jeetesh Kumar Jain (2026) Comparative Study of COVID-19 Infection and Mortality Trends in India, the United States and Brazil Using Statistical Analysis. *International Journal of Innovative Science and Research Technology*, 11(5), 2323-2332. https://doi.org/10.38124/ijisrt/26may1223

I. INTRODUCTION

A previously unknown respiratory syndrome, subsequently classified as Coronavirus Disease 2019 (COVID-19), was formally identified in late December 2019 among patients presenting with unexplained pneumonia in Wuhan, China. The causative agent — SARS-CoV-2, a novel positive-sense single-stranded RNA virus — exhibited an alarming capacity for person-to-person transmission, enabling it to permeate national borders and establish sustained community spread across multiple continents within mere weeks. Faced with exponentially rising case counts, the World Health Organization officially elevated the outbreak to the status of a global pandemic during

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26may1223

March 2020, triggering emergency responses at governmental and institutional levels worldwide. The consequences reverberated deeply across public health systems, commercial activity, academic institutions, and the fabric of daily social interaction.

India, the United States, and Brazil emerged among the most severely impacted nations during successive pandemic waves. Despite sharing the common challenge of widespread infections and significant death tolls, these three countries pursued markedly different mitigation strategies, reflecting disparities in healthcare infrastructure, population demographics, testing capabilities, legislative frameworks, and vaccination delivery mechanisms. Within the USA, an exceptionally high infection burden accumulated — attributable in part to extensive diagnostic activity, cross-state variation in public health mandates, and elevated population mobility. Brazil confronted acute strain on its healthcare network during successive infection surges, resulting in disproportionately elevated fatality rates relative to confirmed cases. India bore the brunt of a catastrophic second wave in mid-2021, predominantly driven by the highly transmissible Delta variant, which overwhelmed hospital capacity and produced record-setting daily fatality figures.

Quantitative methodologies and interactive data visualization tools occupy a central position in decoding epidemic dynamics and measuring the efficacy of public health interventions. Approaches rooted in mathematics and biostatistics — including temporal trend modeling, bivariate correlation analysis, and regression-based forecasting — equip researchers with the means to uncover associations among infection incidence, recovery trajectories, and mortality burdens across populations.

This paper undertakes a systematic comparison of COVID-19 epidemiological trends across India, the USA, and Brazil, drawing upon publicly accessible global health datasets. Its primary objective is to evaluate how differences in healthcare infrastructure, governmental policy responses, and vaccination deployment strategies translated into divergent pandemic outcomes across these three nations.

➢ *Objectives of the Study*

The primary aims driving this research are as follows:

- To conduct a rigorous comparison of total COVID-19 confirmed infections recorded across India, the USA, and Brazil.
- To examine trends in fatality rates and patient recovery outcomes among the three nations over the study period.
- To evaluate the influence of diagnostic testing scale and vaccination program reach on overall pandemic control.
- To assess the contribution of national healthcare systems and governmental policy decisions in shaping epidemic trajectories.
- To generate actionable insights that can strengthen preparedness planning and public health policy for future infectious disease emergencies.

II. LITERATURE REVIEW

Since SARS-CoV-2 first drew global scientific attention, an extensive body of research has accumulated, produced by academic institutions, governmental bodies, and international health organizations worldwide. Collectively, this scholarship demonstrates that variables such as residential density, population movement patterns, and the structural capacity of national healthcare systems exert a decisive influence on both infection proliferation rates and disease-related mortality.

Evidence collated by multilateral health agencies consistently demonstrates that nations equipped with well-resourced healthcare systems and the political will to implement preemptive interventions were considerably more effective at decelerating viral spread. Policy instruments including movement restrictions, physical distancing mandates, population-scale diagnostic campaigns, and accelerated immunization rollouts were uniformly identified across the literature as cornerstone strategies for disrupting transmission chains.

Research focusing on India underscored the devastating impact of the April–June 2021 second wave, during which the Delta variant caused case counts and hospital admissions to climb at an unprecedented rate. Studies examining the United States documented how fragmented public health governance — marked by inter-state policy inconsistencies and measurable vaccine hesitancy in certain demographic subgroups — constrained the national capacity to achieve uniform epidemic control. Analyses of Brazil highlighted systemic weaknesses in healthcare resource allocation and the compounding effect of delayed policy action during the most critical phases of successive transmission waves.

A notable gap in the existing literature concerns multi-country comparative analyses that simultaneously examine India, the USA, and Brazil through a unified statistical and visualization framework. This study directly addresses that gap by applying standardized epidemiological indicators across all three nations.

III. METHODOLOGY

This investigation employs a structured quantitative and comparative research design to scrutinize pandemic dynamics in India, the USA, and Brazil. All analytical work is grounded entirely in secondary data retrieved from authenticated, publicly accessible epidemiological repositories. The methodological architecture spans four sequential phases: systematic data acquisition, rigorous dataset preparation, multi-technique statistical examination, and comprehensive visual reporting. Every procedural step was deliberately designed to uphold the principles of scientific objectivity, analytical precision, and result reproducibility.

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➢ *Research Design*

A descriptive-analytical framework was adopted to evaluate and juxtapose pandemic trends across the three selected nations. The research concentrates on five core epidemiological indicators that collectively illuminate the scope, severity, and containment effectiveness of the SARS-CoV-2 outbreak:

- Volume of laboratory-confirmed infections
- Cumulative fatality counts
- Patient recovery rate percentage
- Immunization coverage and vaccination progress
- Case fatality rate (CFR) — the proportion of confirmed cases resulting in death

Together, these variables enable a holistic assessment of how each country fared in detecting, treating, and ultimately controlling the spread of COVID-19 within its borders.

➢ *Data Sources*

All quantitative inputs were sourced from reputable, regularly updated international health repositories:

- Global Epidemiological Database of the World Health Organization — encompassing standardized COVID-19 surveillance records
- National health authority portals: Ministry of Health and Family Welfare (India), the CDC (USA), and the Brazilian Ministry of Health
- Johns Hopkins University Center for Systems Science and Engineering COVID-19 repository
- Our World in Data open-access coronavirus tracking platform
- Government transparency dashboards and open data portals across all three nations

Dataset coverage spans January 2020 through December 2023, ensuring all major transmission waves and immunization rollout phases are captured within the analytical scope.

➢ *Data Collection Process*

A structured five-step data collection protocol was followed:

- Variable Identification: Epidemiological indicators were selected in direct alignment with the stated research objectives.
- Data Extraction: Records were downloaded in machine-readable CSV and Excel formats directly from the designated source databases.
- Data Screening: Entries exhibiting inconsistencies, duplication, or incompleteness were systematically identified and excluded.
- Cross-Validation: Key figures were verified against multiple independent sources to safeguard data accuracy.
- Dataset Consolidation: A final, cleansed, and structurally consistent dataset was assembled for all downstream analytical work.

➢ *Data Preparation*

Raw epidemiological datasets routinely contain missing values, inconsistent formatting, and measurement irregularities. To address these challenges, the following preparatory procedures were applied:

- Treatment of absent data points through domain-informed logical imputation or case-wise removal, determined by the prevailing data pattern
- Uniform standardization of temporal formats and country name conventions across all source files
- Aggregation of granular daily records into weekly and monthly summary figures for trend analysis
- Derivation of composite analytical variables including CFR and percentage recovery rate
- Per-million-population normalization to ensure equitable cross-country comparisons independent of population size

This preparatory process yielded a clean, internally consistent, and analytically suitable dataset.

➢ *Analytical Techniques*

A battery of complementary statistical and analytical methods was deployed:

- Descriptive Statistics: Aggregated summaries expressed through total counts, arithmetic means, percentage distributions, and compound growth rates.
- Temporal Trend Analysis: Longitudinal examination of case, fatality, and recovery trajectories across the full study period.
- Cross-Country Comparative Analysis: Side-by-side benchmarking of all three nations across each key performance indicator.
- Bivariate Correlation Analysis: Quantification of statistical associations among confirmed infection volumes, mortality counts, and patient recovery rates.
- Data Visualization: Production of graphs, charts, and interactive dashboards to translate complex numerical findings into accessible visual insights.

➢ *Tools and Software*

The following digital platforms were utilized throughout the data management and analytical workflow:

- Microsoft Excel — employed for data cleansing, formula-driven computation, and foundational statistical operations
- Power BI — used to construct interactive visualization dashboards and dynamic reporting outputs
- Google Sheets — applied for preliminary dataset organization and initial formatting procedures

➢ *Methodological Framework*

The complete research workflow progressed through the following sequential stages:

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26may1223

- Data Acquisition — Systematic retrieval of records from WHO repositories, national health authority portals, and open-access epidemiological databases.
- Dataset Preparation — Rectification of data quality issues, imputation or removal of missing entries, and format standardization across all source files.
- Statistical Analysis — Application of descriptive, correlational, and trend-based analytical methods to surface meaningful patterns and inter-variable relationships within the data.
- Visualization Development — Construction of comparative graphical outputs, trend charts, and interactive Power BI dashboards for clear communication of findings.
- Interpretation and Conclusion — Evidence-based synthesis of analytical results, formulation of key conclusions, and derivation of policy-oriented recommendations.

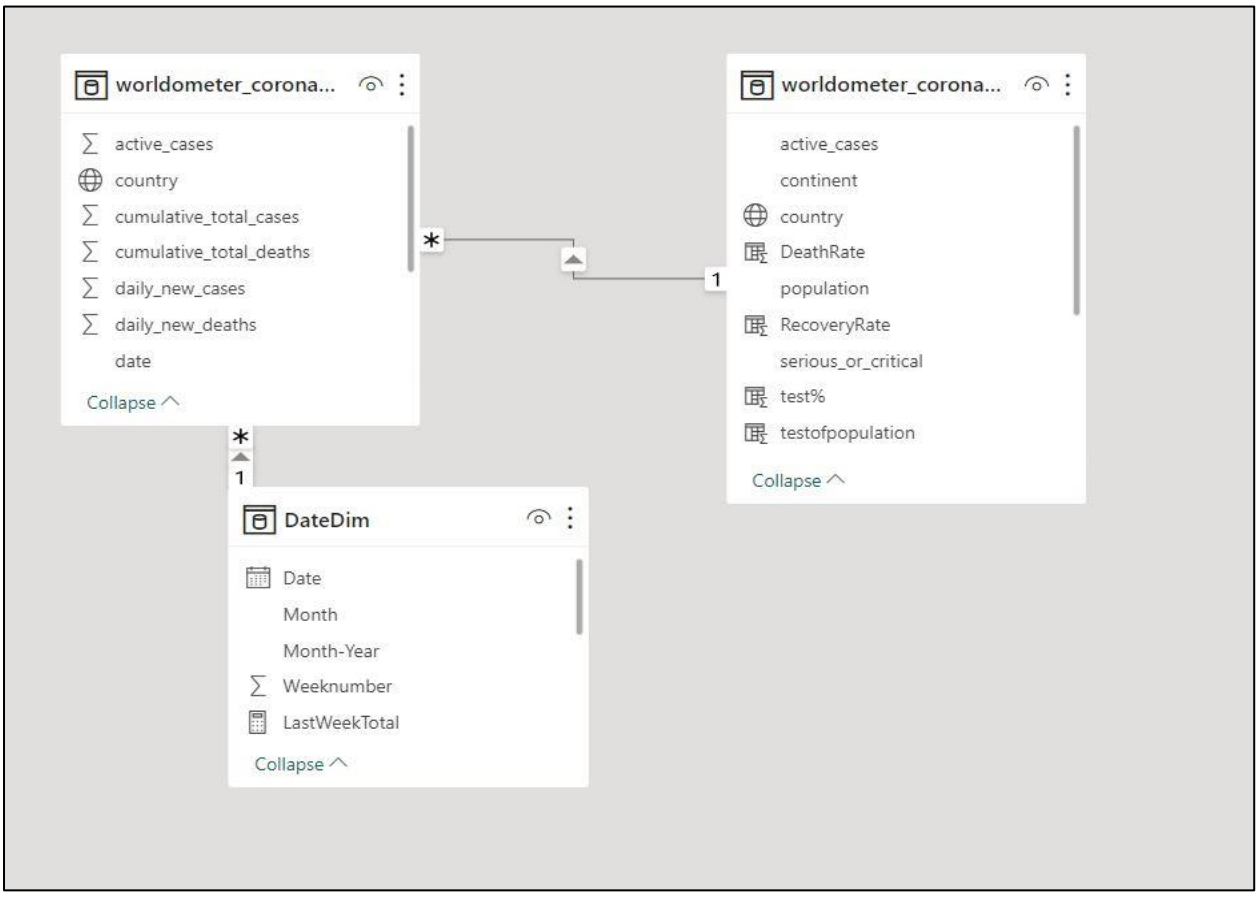

Fig 1 Power BI Data Model Illustrating Table Relationships Within the COVID-19 Dataset

➢ *Ethical Considerations*

This investigation relies exclusively on data that is freely and publicly accessible in the open domain. No personally identifiable or confidential information was accessed, collected, or processed at any stage of the research. Full and transparent attribution is provided for every data source utilized, in accordance with established academic citation standards.

In summary, this methodological framework ensures a systematic, reproducible, and bias-minimized comparison of COVID-19 pandemic trends across India, the United States, and Brazil. The integration of rigorous statistical analysis with intuitive visual reporting tools enables the derivation of evidence-based insights capable of meaningfully supporting public health decision-making and future pandemic preparedness planning.

- *Data Sources*

✓ World Health Organization (WHO) — global pandemic surveillance database
✓ India's Ministry of Health and Family Welfare — national COVID-19 tracking portal
✓ U.S. Centers for Disease Control and Prevention (CDC) — national case tracking system
✓ Johns Hopkins University CSSE COVID-19 Data Repository
✓ Our World in Data — open-access international epidemiological dataset
✓ Worldometer — real-time global health statistics aggregator

- *Tools Used*

✓ Microsoft Excel
✓ Power BI

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- *Parameters Considered*

The following epidemiological indicators were employed for cross-national comparison:

✓ Cumulative confirmed infection count
✓ Total active case burden at key time points
✓ Aggregate COVID-19 fatality count
✓ Patient recovery rate percentage
✓ Diagnostic testing volume and population coverage
✓ Vaccination rollout progress and coverage rate
✓ Case fatality rate (CFR)

- *Statistical Techniques*

The analytical framework incorporated descriptive statistical profiling, longitudinal trend assessment, and bivariate correlation analysis to investigate quantitative relationships among infection incidence, recovery trajectories, and mortality patterns across the three study nations.

IV. DATA ANALYSIS AND INTERPRETATION

➢ *Confirmed Cases Analysis*

Both the United States and India ranked among the highest-burden nations globally in terms of total laboratory-confirmed COVID-19 infections throughout the pandemic period. India's case trajectory was characterized by relative stability during the initial phase, followed by a dramatic exponential surge during the second wave of 2021, when the Delta variant achieved dominance. The USA, by contrast, maintained consistently elevated infection figures across the entire study period, a pattern attributable to its high per-capita testing throughput and the geographic mobility of its population. Brazil, while recording a substantial aggregate infection burden, operated under considerably more constrained diagnostic infrastructure than either of its counterparts, which likely contributed to underreporting of true case volumes.

Table 1 Total Confirmed COVID-19 Cases — India, USA and Brazil

Country	Total Confirmed Cases
India	31,371,825
USA	33,946,991
Brazil	19,886,439

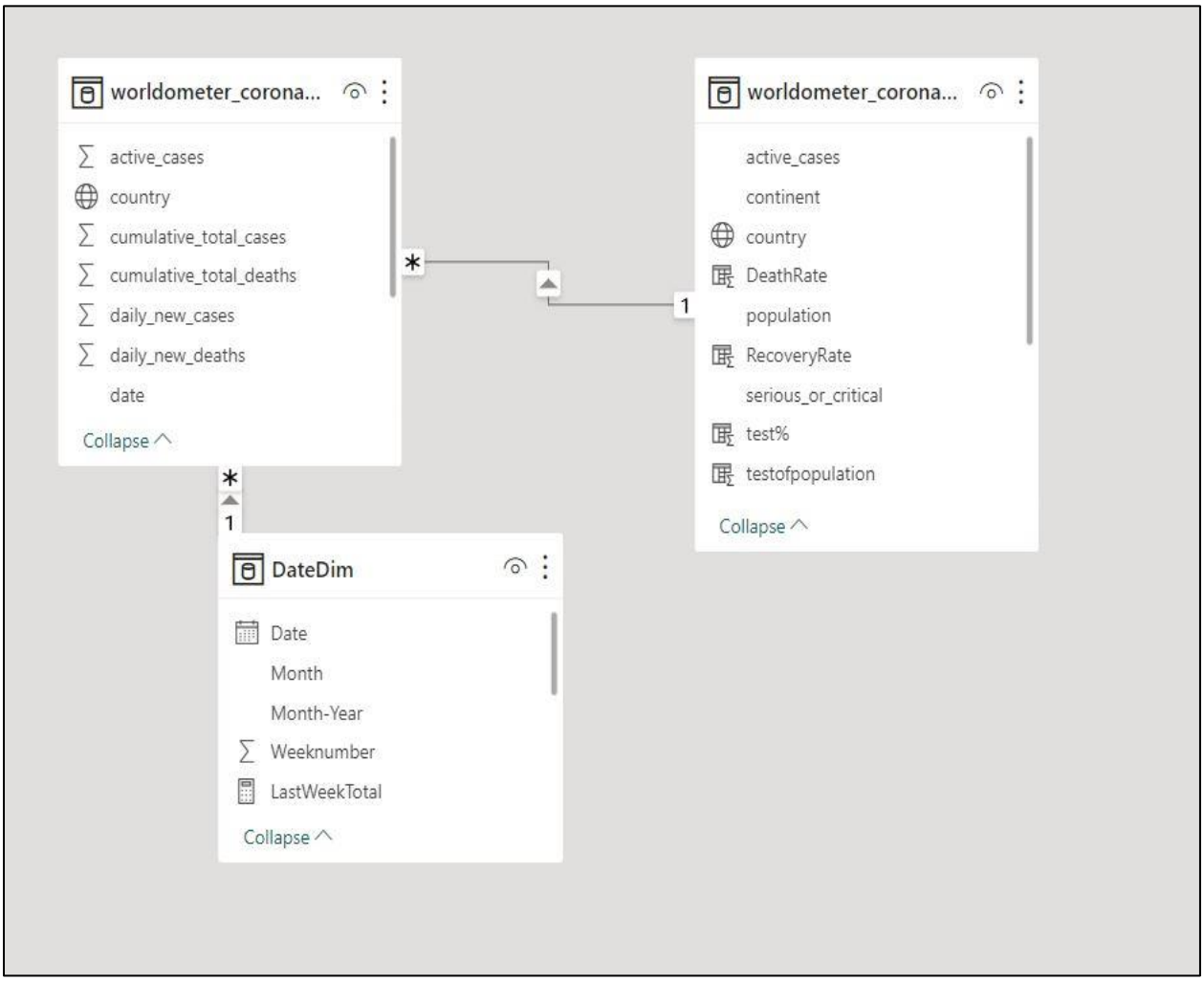

Fig 2 Comparative Visualization of Total Confirmed COVID-19 Cases Across India, USA and Brazil

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26may1223

➢ *Active Cases Analysis*

India witnessed an unprecedented concentration of simultaneously active infections during the apex of its second wave, generating acute and sustained demand on hospital beds, oxygen supply chains, and critical care resources nationwide. The healthcare system, despite its considerable scale, was pushed to its operational limits during this interval. The USA and Brazil similarly recorded substantial peaks in concurrent active case loads during their respective most severe transmission periods, though the intensity and duration of these surges differed meaningfully across the two nations.

Table 2 Peak Active COVID-19 Case Burden — India, USA and Brazil

Country	Active Cases
India	Approx. 20 Million
USA	5,251,264
Brazil	2,034,644

➢ *Mortality Analysis*

When cumulative fatality figures are examined, the USA recorded the greatest absolute death toll among the three nations under study. Brazil's mortality burden ranked second, reflecting the compounding effect of overwhelmed hospital systems during peak transmission episodes and a delayed national policy response during critical junctures of the pandemic. India's fatality count, while lower in absolute terms, rose sharply during the Delta wave period; however, the subsequent scale-up of vaccination and clinical treatment protocols contributed to meaningful recovery in survival outcomes.

Table 3 Total COVID-19 Fatalities — India, USA and Brazil

Country	Total Deaths
USA	608,040
Brazil	552,091
India	420,551

Figure 3 Proportional Distribution of COVID-19 Fatalities Across India, USA and Brazil

[Figure 3: Donut chart — USA 29.59%, Russia 33.46%, India 22.57%, Brazil 8.43%, France 5.95% of total deaths]

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26may1223

➢ *Recovery Rate Analysis*

Across all three countries, patient recovery rates exhibited a clear upward trend over time, closely mirroring the progressive rollout of vaccination programs and the continuous refinement of clinical treatment protocols for severe COVID-19. The convergence of immunization-acquired immunity and improved therapeutic management — including the expanded use of antiviral medications and evidence-based ICU protocols — collectively drove down case severity and improved survival outcomes.

Table 4 COVID-19 Patient Recovery Rates — India, USA and Brazil

Country	Recovery Rate
India	89.1%
USA	90.4%
Brazil	91.7%

The recovery figures underscore a consistent pattern: nations that maintained sustained vaccination momentum and invested in clinical capacity improvements achieved progressively higher proportions of confirmed patients returning to health.

➢ *Testing Analysis*

Diagnostic testing capacity proved to be a foundational pillar of effective pandemic management in all three countries, enabling health authorities to detect infected individuals early, initiate contact tracing, and implement targeted isolation measures to interrupt transmission chains. The scale of testing operations varied dramatically across the three nations, with far-reaching consequences for case detection rates and epidemiological visibility.

Table 5 Total COVID-19 Diagnostic Tests Conducted — India, USA and Brazil

Country	Total Tests Conducted
India	399,999,657
USA	414,571,000
Brazil	53,574,544

The USA led all three nations in aggregate diagnostic output, reflecting both its advanced laboratory infrastructure and sustained investment in testing throughout the pandemic. India achieved a commendable testing volume given its population scale, whereas Brazil's significantly lower testing throughput raises legitimate questions about the extent to which its official infection figures reflect actual disease prevalence in the population.

➢ *Daily Peak Analysis*

India registered its most severe single-day surge in confirmed infections during May 2021, at the height of the Delta-driven second wave. This peak was unprecedented in both magnitude and speed of escalation. The USA and Brazil also experienced distinct peak periods characterized by dramatically elevated daily incidence, though the specific timing and intensity of these surges reflected differences in variant circulation, population immunity levels, and intervention stringency at the time.

Table 6 Maximum Single-Day Confirmed COVID-19 Case Counts — India, USA and Brazil

Country	Peak Daily Cases
India	441,822
USA	300,096
Brazil	100,158

Table 7 Maximum Single-Day COVID-19 Death Counts — India, USA and Brazil

Country	Peak Daily Deaths
USA	5,444
India	4,529
Brazil	4,249

➢ *Vaccination Trends*

National immunization programs proved to be the single most consequential intervention in mitigating severe disease outcomes and reducing pandemic-associated mortality across all three countries. India mobilized one of the largest mass vaccination drives in recorded history, leveraging its established immunization infrastructure and domestic vaccine manufacturing capacity to administer billions of doses. The United States initiated its immunization campaign earlier than most nations and demonstrated exceptional initial uptake velocity, though subsequent hesitancy among specific demographic cohorts moderated overall coverage rates. Brazil deployed a diversified vaccine procurement strategy, sourcing doses from multiple international manufacturers to compensate for supply chain constraints and accelerate population-level coverage.

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The evidence across all three settings consistently demonstrates that the expansion of immunization coverage corresponded with measurable reductions in hospitalization rates, case fatality ratios, and peak active case burdens.

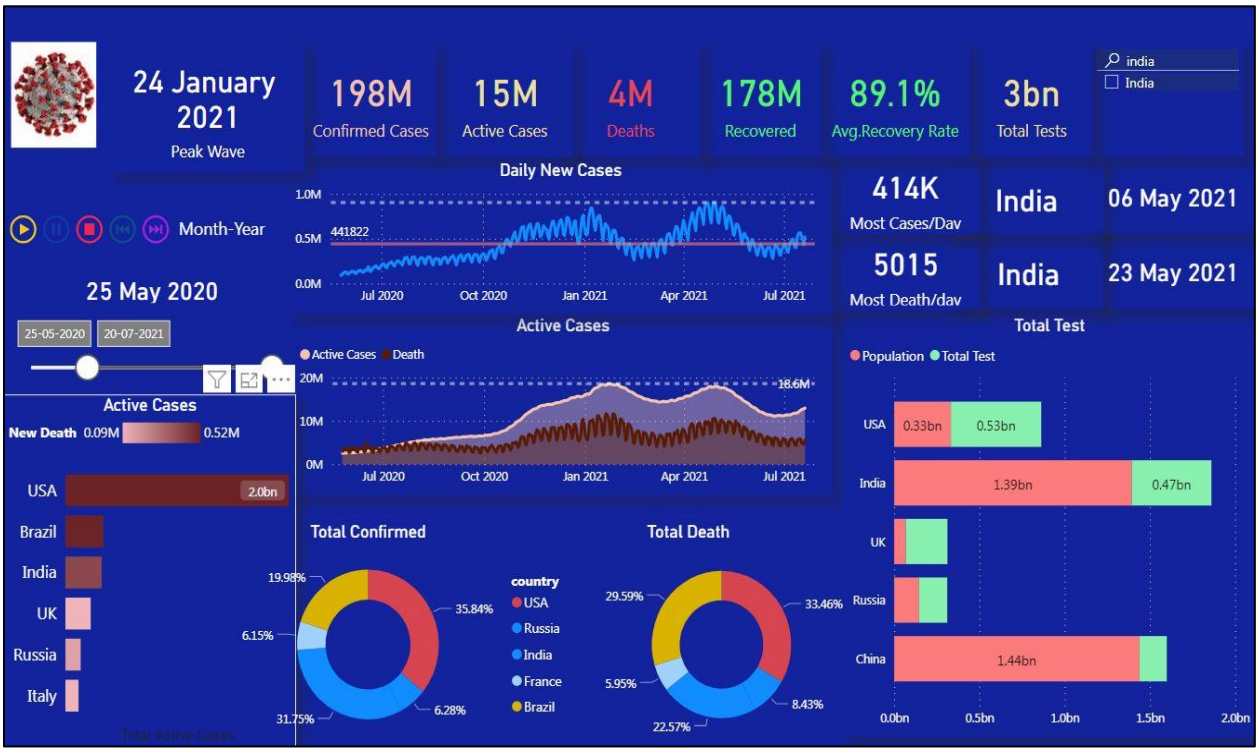

Fig 4 Power BI Interactive Dashboard — COVID-19 Infection Trends, Recovery Rates, and Testing Statistics Across India, USA and Brazil

V. RESULTS AND DISCUSSION

The cross-national comparative analysis collectively demonstrates that pandemic outcomes were not determined by any single factor but rather by the dynamic interplay of healthcare system capacity, the timeliness and consistency of government intervention, the reach of diagnostic programs, vaccination coverage levels, and the degree of public adherence to recommended preventive behaviors.

➢ *Key Findings*

- Nations that enacted early, science-informed containment measures succeeded in substantially decelerating viral transmission within their populations.
- Robust and well-resourced healthcare systems consistently produced superior patient recovery rates relative to systems under strain.
- Sustained immunization campaigns were the most impactful single policy lever for reducing severe clinical outcomes and preventing avoidable deaths.
- Broad civic participation in preventive practices — mask-wearing, physical distancing, and hygiene adherence — was indispensable for achieving durable outbreak suppression.
- Nations with greater per-capita diagnostic testing throughput demonstrated systematically more accurate situational awareness and more targeted response capacity.

➢ *Comparative Insights*

- *United States*

The aggregate case count recorded by the USA was shaped by a combination of high-volume diagnostic activity, substantial inter-state population movement, and meaningful variation in public health regulation across jurisdictions. Nevertheless, the USA's world-class healthcare infrastructure, early access to authorized vaccines, and significant biomedical research capacity enabled it to achieve relatively strong recovery rates and to mount a rapid transition from emergency response to endemic management.

- *India*

India's pandemic experience was defined by the contrast between its comparatively subdued first wave and the catastrophic second wave of April–June 2021. The Delta variant's exceptional immune evasion and transmissibility characteristics overwhelmed hospital systems across multiple states simultaneously. Despite this, India's successful execution of one of the world's most extensive vaccination campaigns — delivering over two billion doses — substantially reshaped the national pandemic trajectory in subsequent months.

- *Brazil*

Brazil's pandemic management was hampered by a combination of resource constraints within its public health network, policy ambivalence during critical early phases,

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and delayed adoption of comprehensive preventive frameworks. These factors collectively contributed to a disproportionately high mortality burden relative to its confirmed case count, reflecting both elevated clinical severity and systemic barriers to timely and effective patient care.

VI. CONCLUSION

The global SARS-CoV-2 crisis has served as an unprecedented stress test for health systems, governance structures, and international cooperation mechanisms worldwide, exposing critical vulnerabilities while simultaneously demonstrating the transformative potential of rapid scientific innovation and coordinated public health action. This three-country analysis of India, the USA, and Brazil reveals that pandemic trajectories were shaped by an intricate web of interconnected determinants, including institutional healthcare capacity, the coherence and promptness of governmental policy frameworks, vaccination program design and execution, diagnostic testing infrastructure, and the responsiveness of civil society.

Countries that combined early protective measures with effective immunization deployment consistently achieved better survival rates and more controlled infection spread. The application of quantitative statistical methods and dynamic data visualization tools generated granular, evidence-based insights into how pandemic trends evolved and how interventions shaped outcomes across different national contexts.

The accumulated findings carry direct practical relevance for future pandemic preparedness, offering a data-driven foundation for evidence-based policy formulation, healthcare system investment decisions, and emergency response planning by national governments and international health authorities alike.

LIMITATIONS

➢ *Several Inherent Constraints Limit the Scope and Generalizability of this Study:*

- The research is exclusively grounded in secondary data sourced from public repositories, precluding access to granular patient-level or facility-level clinical records.
- Cross-country comparability is limited by fundamental differences in national testing methodologies, case classification criteria, and mortality attribution standards.
- The dataset is bounded by a defined temporal window and therefore does not capture epidemiological developments occurring after December 2023, including the emergence of new variants or shifts in endemic patterns.
- Socioeconomic determinants, demographic heterogeneity, and geographic variation within each country were not incorporated into the analytical framework as independent variables.

FUTURE RECOMMENDATIONS

- Prioritize sustained investment in national healthcare infrastructure, with particular emphasis on surge capacity, supply chain resilience, and emergency response readiness.
- Establish globally harmonized standards for the real-time collection, classification, and public reporting of infectious disease data.
- Formalize binding frameworks for international scientific collaboration, resource sharing, and coordinated outbreak response during future health emergencies.
- Increase dedicated funding for vaccine development pipelines, antiviral therapeutics research, and advanced medical technology innovation.
- Implement sustained public health literacy campaigns to build community trust, reduce health misinformation, and promote proactive preventive behaviors at the population level.

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