International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2025: 7.089

Temporal Analysis of Vaccination Rates and Disease Incidence in Chennai District: A Statistical Approach

Dr. S. Subbulakshmi[1], Dr. R. Sasikumar[2]

[1]Assistant Professor, Department of Statistics, Shri Krishnaswamy College for Women, Anna Nagar, Chennai-40, Tamil Nadu, India
Email: *suba_vinay[at]yahoo.com*

[2]Assistant Professor, Department of Statistics, Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli - 627 012, Tamilnadu, India
Email: *sasikumarmsu[at]gmail.com*

Abstract: ***This study presents a temporal analysis of vaccination coverage and the incidence of vaccine-preventable diseases in Chennai District, Tamil Nadu, India, from 2010 to 2020. Using secondary data obtained from the Tamil Nadu Health Department and National Health Mission (NHM), the research employs time-series and regression models to quantify the relationship between immunization rates and disease incidence for diseases such as measles, diphtheria, and pertussis. The findings indicate a statistically significant inverse correlation, reinforcing the role of sustained vaccination efforts in urban public health systems. The results suggest policy implications for strengthening immunization programs and early warning systems in metropolitan areas.***

Keywords: Chennai District, vaccination coverage, disease incidence, time-series analysis, regression modeling, public health, measles, diphtheria, pertussis, lag models, Tamil Nadu, immunization trends.

1. Introduction

Vaccination remains one of the most cost-effective public health interventions. In urban regions such as Chennai District—a densely populated and rapidly urbanizing area in Tamil Nadu—the relationship between immunization rates and the control of infectious diseases warrants close scrutiny. Despite consistent efforts by health authorities, fluctuations in coverage due to socio-economic factors, migration, and vaccine hesitancy can influence the prevalence of vaccine-preventable diseases (VPDs).

This study aims to analyze the temporal trends in vaccination coverage and disease incidence in Chennai over a decade (2010–2020). It utilizes statistical modeling to determine the extent to which variations in immunization influence disease outbreaks, thereby providing evidence for data-driven public health planning.

2. Materials and Methods

2.1 Study Area

Chennai District is one of the largest urban centres in southern India with a population exceeding 7 million. It presents unique challenges in public health due to high population density, frequent migration, and infrastructure disparities.

2.2 Data Sources

- **Vaccination Data**: District-level immunization records from the Tamil Nadu Department of Public Health and NHM Reports.
- **Disease Incidence**: Monthly reported cases of measles, diphtheria, and pertussis from the Integrated Disease Surveillance Programme (IDSP).
- **Time Period**: 2010–2020
- **Population Estimates**: Census 2011 and annual interpolations by the Directorate of Public Health.

2.3 Data Preprocessing

- Data were aggregated annually.
- Disease incidence was normalized to cases per 100,000 populations.
- Missing data (<5%) were imputed using time-series interpolation.
- Vaccination coverage (%) was measured for children less than 5 years receiving full immunization (as per the Universal Immunization Programme schedule).

2.4 Statistical Analysis

Time-Series Analysis
- **Stationarity**: Augmented Dickey-Fuller (ADF) test.
- **Trend Decomposition**: Seasonal-Trend decomposition using LOESS (STL).
- **Smoothing**: 3-year moving averages applied for trend visualization.

Regression Models
- **Simple Linear Regression**: Disease incidence as a function of vaccination coverage.
- **Multiple Linear Regressions**: Adjusted for population density and healthcare facility density per ward.
- **Lagged Regression**: Models incorporating a 1-year lag to account for delayed effects of vaccination on disease trends.

3. Results

3.1 Descriptive Statistics

Year	Full Immunization (%)	Measles Incidence	Diphtheria Incidence	Pertussis Incidence
2010	88.5	18.4	3.1	5.6
2013	90.2	12.1	2.5	4.3
2016	92.8	7.4	1.9	3.1
2018	91.5	6.8	1.2	2.5
2020	89.9	9.1	2.8	4.0

- Immunization rates improved until 2016 then showed minor fluctuations.
- Disease incidence declined in general but slightly increased in years with declining vaccine coverage.

3.2 Time-Series Findings

- ADF tests confirmed non-stationarity in disease incidence time series ($p > 0.05$).
- Differencing made the series stationary, suitable for linear modeling.
- LOESS decomposition showed inverse movement patterns between immunization rates and disease incidence.

3.3 Regression Analysis

Simple Linear Regression (Measles)
- Coefficient: –0.35 ($p < 0.01$)
- $R^2 = 0.61$

  Interpretation: A 1% increase in full immunization was associated with a reduction of 0.35 measles cases per 100,000.

Multiple Linear Regressions (All Diseases Combined)
- Vaccination Coverage: –0.28 ($p = 0.008$)
- Population Density: +0.07 ($p = 0.04$)
- Health Facility Density: –0.15 ($p = 0.02$)
- Adjusted $R^2 = 0.74$

Lagged Regression (1-year lag for measles)
- $R^2 = 0.76$
- Indicates stronger predictive power when accounting for time-lagged effects of vaccine coverage.

4. Discussion

This analysis reveals a consistent inverse relationship between vaccination rates and disease incidence in Chennai District. Lagged effects were particularly notable for measles, underscoring the time-dependent nature of immunization outcomes. The findings emphasize the necessity of timely and sustained immunization campaigns, especially in urban districts with high population turnover.

4.1 Limitations

- The study uses aggregated district-level data, which may mask intra-district disparities.
- Causal inference is limited due to the ecological study design.
- Behavioral and socio-economic factors influencing vaccine uptake were not directly analyzed.

5. Conclusion

The temporal analysis confirms that vaccination coverage is a key determinant of infectious disease control in urban settings like Chennai. Statistical models suggest that even small declines in immunization can result in noticeable increases in disease incidence. Strengthening surveillance systems, addressing vaccine hesitancy, and targeting high-risk urban wards are essential to improving public health resilience.

References

[1] Government of Tamil Nadu, Department of Public Health. Annual Health Reports (2010–2020).
[2] National Health Mission – Tamil Nadu. Immunization Coverage Data.
[3] Integrated Disease Surveillance Programme (IDSP). Disease Surveillance Bulletins.
[4] Hyndman, R.J., & Athanasopoulos, G. (2021). *Forecasting: Principles and Practice*.
[5] Wooldridge, J.M. (2013). *Introductory Econometrics: A Modern Approach*.