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ORIGINAL ARTICLE

INSIGHT360TN: AN AI-POWERED WEB PLATFORM FOR NFHS DATA VISUALIZATION AND PUBLIC HEALTH INSIGHTS IN TAMIL NADU – A PROCESS DOCUMENTATION

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ABSTRACT

The National Family Health Survey (NFHS) is a cornerstone of India's public health system, yet its vast datasets are often locked in formats that are inaccessible for timely local-level decision-making. To address this critical gap, the Insight360TN platform was developed as a web-based tool to transform complex NFHS statistics for Tamil Nadu into interactive and actionable insights. Built entirely with client-side technologies, the platform integrates optimized NFHS-4 (2015–16) and NFHS-5 (2019–21) data to power a suite of analytical tools, including dynamic choropleth maps, district performance rankings, and correlation analyses. A key innovation is the integration of Google's Gemini 1.5 Pro AI, which generates natural language summaries to make statistical findings understandable to non-technical users. The result is a high-performance, cost-effective platform that successfully democratizes access to vital health data, demonstrating a powerful model for bridging the gap between data availability and evidence-based policymaking in Tamil Nadu.

The Challenge of Actionable Health Data in Public Health Governance

National health surveys like the National Family Health Survey (NFHS) are a cornerstone of India's public health system, providing invaluable data for planning and evaluation.[3] However, the strategic value of this data is entirely contingent on its accessibility and usability for the local-level decision-makers responsible for implementing policy. For years, a persistent challenge has been the disconnect between the availability of rich data and the capacity of administrators to apply it effectively.

The primary barrier lies in the traditional format of NFHS data. Findings are typically disseminated through lengthy technical reports, large and cumbersome spreadsheets, and complex datasets that are difficult for non-specialists to navigate.[1], [2] This format creates a significant hurdle for practical application by policymakers, district health officers, and program managers who need to make timely, evidence-based decisions. The problem is not a lack of information but a critical lack of tools that can convert abstract numbers into a clear, usable narrative of progress and disparity.

Without modern digital tools, simple yet critical analytical tasks become slow and difficult. For example, a district health officer attempting to compare immunization coverage trends between two neighboring districts or a state planner seeking to understand the relationship between rising female literacy and maternal health outcomes would face a time-consuming manual process. This inability to easily visualize trends, compare geographic performance, or explore relationships between different health indicators means that valuable insights remain buried within the data. Ultimately, the core challenge is the lack of tools to transform static data into dynamic, actionable knowledge. This disconnect impedes responsive public health management and prevents the full potential of national survey data from being realized, setting a clear stage for the need for a technological solution.

Introducing Insight360 TN: A Solution Engineered for Tamil Nadu

The Insight360TN platform was engineered as a direct and strategic response to the challenges of data inaccessibility. Its core mission is to bridge the gap between raw data and actionable intelligence by transforming complex national survey statistics into an optimized, user-friendly, and interactive tool tailored specifically for Tamil Nadu. The platform was designed to convert the static, tabular data of the NFHS into an engaging visual story of public health across the state.

To achieve this, Insight360TN was built to empower decision-makers at all levels by combining meticulously

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optimized datasets, powerful visualization tools, and AI-generated summaries. The platform's goal is to make intricate health data simple, engaging, and understandable, enabling users to explore indicators, compare district-level performance, and uncover the evidence needed to craft more effective public health policies.

The following sections detail the rigorous methodology and process undertaken to build this innovative platform, from data sourcing and optimization to the establishment of a robust statistical framework.

The Methodological Blueprint: Building an Optimized and Intelligent Platform

The development of Insight360TN was guided by a multi-faceted approach that prioritized performance, accuracy, and usability. This required a robust strategy for sourcing and validating data, a breakthrough technical optimization to ensure a responsive web experience, a novel method for handling administrative boundary changes, and a clear statistical framework to ensure that all analyses were meaningful and easy to interpret.

Data Sourcing and Architecture Strategy

The platform's foundation rests on a carefully selected set of high-quality data sources and a modern, lightweight technical architecture.

National Family Health Survey (NFHS): District-level indicators from NFHS-4 (2015–16) and NFHS-5 (2019–21) were obtained from the National Data and Analytics Platform (NDAP), a NITI Aayog initiative.[1,2]

Administrative Boundaries: Geographic boundary data for Tamil Nadu's districts was sourced from the Tamil Nadu Geographic Information System (TNGIS) to ensure spatial accuracy.[5]

Insight360TN was built entirely with client-side technologies—HTML5, CSS3, and JavaScript—which eliminates the need for external servers and reduces operational costs. Data visualization is powered by Chart.js for charts and Leaflet.js for interactive maps. This serverless architecture was a key strategic decision to ensure the platform's accessibility and sustainability.

The Data Optimization Pipeline: A Technical Breakthrough

A primary technical hurdle was the large size of the raw NFHS datasets and geographic files, which were unsuitable for efficient delivery in a web browser. To overcome this, a rigorous optimization pipeline was implemented, involving the pruning of redundant fields from the JSON data and the conversion of high-precision GeoJSON boundaries to the more compact TopoJSON format.

Table 1: Size Reduction Achieved Through Data Optimization Pipeline

Data Component	Original Size	Optimized Size	Size Reduction
NFHS JSON Data	15 MB	2.1 MB	86%
Geographic Boundaries	8 MB	1.8 MB	77.5%
Total Data Payload	**23 MB**	**3.9 MB**	**83%**

This aggressive 83% reduction in the total data payload was the critical breakthrough that made a high-performance, entirely client-side, and server-independent platform feasible.

A Novel Approach to District Reorganization

Between the NFHS-4 and NFHS-5 survey periods, Tamil Nadu underwent a significant administrative reorganization that resulted in the creation of six new districts. This posed a major challenge to data comparability, as direct trend analysis would be inconsistent.

To solve this, a novel "inheritance model" was developed. For the NFHS-4 period, new districts inherited the health indicator values from their parent districts to ensure historical continuity and enable trend analysis. For the NFHS-5 period, these new districts were represented by their own independently collected survey data, reflecting the new administrative reality.

This reorganization was not merely a cartographic exercise but a strategic public health initiative. Each new district was formed with a specific focus, such as enhancing rural healthcare coverage in Kallakurichi, improving tribal population health in Tenkasi, and managing industrial health in Ranipet. The inheritance model ensures these newly defined administrative units can be analyzed within a consistent historical context.

Establishing a Statistical Framework for Meaningful Interpretation

To ensure that data visualizations and rankings were statistically sound and easy to interpret, a clear analytical framework was established.

Indicator Classification: All NFHS indicators were classified into one of three categories: Positive (n=74, 57.8%), where

higher values are better (e.g., immunization coverage); Negative (n=47, 36.7%), where lower values are better (e.g., mortality rates); or Neutral (n=7, 5.5%), representing descriptive metrics like sex ratio. This system is essential for generating meaningful rankings and comparisons.

Normalization and Ranking: To allow for comparisons across different indicators, all values were normalized using min-max scaling. Districts were then grouped into tertiles (top, middle, and bottom performers) for clear visual classification on maps and charts.

Correlation Analysis: The platform uses Pearson correlation coefficients and plots regression lines to enable users to analyze and visualize the relationships between any two indicators, facilitating a deeper understanding of the social determinants of health.

This robust methodological blueprint culminated in a high-performance platform capable.

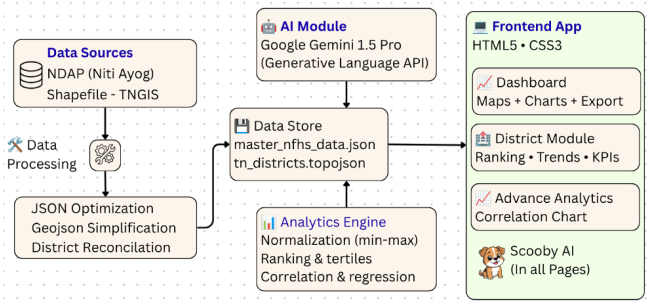

Figure 1: System Architecture of Insight360TN: Data Pipeline, Analytics Engine, and Frontend Integration

Platform Architecture and AI Integration

The strategic choice of a lightweight, client-side architecture was central to achieving the project's goals of high performance, universal accessibility, and cost-effectiveness. By design, the platform operates entirely within a user's web browser, eliminating the need for expensive server infrastructure and ensuring rapid, responsive performance.

The platform was built using a modern technical stack of HTML5, CSS3, and JavaScript, with specialized libraries for visualization. Chart.js powers the dynamic statistical charts, while Leaflet.js is used for the interactive geographic maps. This lean architecture ensures that the entire application can be delivered quickly, even on modest internet connections.

A key innovation of Insight360TN is the integration of Google's Gemini 1.5 Pro AI via a Firebase REST API. This allows the platform to translate complex statistical patterns and data visualizations into clear, concise, and understandable natural language summaries. This feature is designed to bridge the gap between data analysts and policymakers, making sophisticated findings accessible to non-technical users and directly supporting evidence-based decision-making.

This integrated architecture supports the platform's core features and analytical capabilities, transforming raw data into actionable intelligence for public health governance.

Results: Platform Performance and Analytical Capabilities

The rigorous methodology and optimized architecture resulted in a platform that successfully balances analytical depth with exceptional speed and accessibility. Insight360TN provides a suite of powerful features designed to equip users with immediate, data-driven insights.

Platform Performance and Accessibility

The platform's design choices resulted in outstanding technical performance and ease of access:

Total application size: The entire platform is only 4.5 MB, ensuring a minimal footprint.

Initial loading time: Loads in under three seconds on a standard internet connection.

Rendering speed: Interactive maps and dynamic charts render almost instantly, allowing for fluid data exploration.

Data Export: Users can export the underlying data for any visualization as a CSV file, enabling easy integration into external reports and presentations.

Core Features for Data-Driven Insights

Insight360TN provides four primary features designed to transform raw data into clear, actionable intelligence

Interactive Choropleth Maps: Users can visualize the geographic distribution of any health indicator across Tamil Nadu's districts. A simple toggle allows for a direct comparison between NFHS-4 and NFHS-5 data, making it easy to observe changes and trends over time.

District Performance Rankings: This feature automatically displays the best and worst-performing districts for any selected indicator, enabling health administrators to rapidly identify priority areas that may require targeted interventions or further investigation.

Correlation Scatter Plots: This powerful analytical tool allows users to explore the relationship between two different health indicators—for example, plotting female literacy rates against immunization coverage to visually assess their connection.

AI-Powered Summaries: Integrated directly into the user interface, this feature provides concise, narrative context for visualized data. It transforms complex statistical patterns into understandable summaries, making findings accessible to non-technical stakeholders.

Illustrative Analytical Findings

The platform's capabilities make it easy to uncover and communicate important public health relationships. Analyses conducted with the tool clearly show that districts with higher female literacy rates consistently perform better on key maternal and child health indicators. Similarly, the platform visualizes the strong correlation between high immunization coverage and lower infant mortality rates. It also highlights the link between positive nutrition outcomes and indicators of women's empowerment, underscoring the critical role of social determinants in overall public health.

These results demonstrate the platform's success in translating a complex methodological vision into a tangible, high-impact tool for public health policy and technical innovation.

Discussion: Contributions, Implications, and Limitations

Beyond its immediate utility as an analytical tool, the Insight360TN project offers significant contributions to the field of public health informatics. Its design and implementation provide a valuable blueprint for making complex national data more accessible, understandable, and actionable for a wide range of stakeholders.

Key Contributions and Public Health Implications

The platform's primary contributions lie in its technical approach and its potential to transform public health practice.

1. Technical Innovation: The project successfully demonstrates that large national datasets can be highly optimized for use in lightweight, client-side web applications. Furthermore, the "inheritance model" for handling administrative boundary changes represents a novel methodological contribution for ensuring longitudinal data integrity—a common challenge in public health informatics.

2. Data Democratization: The platform empowers a wide range of stakeholders by providing tailored benefits. For the State Health Department, it offers real-time monitoring and evidence-based planning support. District Health Officers can use it for performance analytics and priority area identification. Researchers and academics gain standardized, exportable data access, while policymakers receive visual insights and AI-powered recommendations to ground discussions in evidence.

3. Bridging the Analyst-Policymaker Gap: The integration of AI-generated summaries is a key innovation that translates statistical findings into clear, actionable language. This feature allows policy discussions to be grounded in data without requiring all participants to have advanced statistical training.

Direct Policy and Intervention Applications

Insight360TN is a practical tool designed to directly guide public health planning and interventions. By providing instant access to visualized data, the platform achieves an estimated 75% reduction in report generation time and eliminates the need for manual data compilation. This allows health officials to quickly pinpoint districts with persistently low immunization coverage and target them for special vaccination campaigns. Similarly, areas with a high prevalence of anemia can be identified for focused nutrition programs, and data from regions with weak maternal health indicators can provide clear evidence to support initiatives aimed at strengthening institutional delivery services.

Strengths and Limitations

A balanced assessment reveals the platform's significant strengths alongside areas for future development.

Table 2: Comparative Assessment of Platform Strengths and Limitations

Strengths	Limitations
High Accessibility: Runs in any standard browser with no additional infrastructure required.	Data Latency: Relies on NFHS data, which is only collected every five years.
Cost-Effective: Client-side architecture eliminates the need for external servers.	Geographic Scope: Currently covers only Tamil Nadu, though the design is scalable.
Open and Transparent: The entire source code is openly available under an MIT license.	AI Dependency: AI summaries are supportive tools and depend on the quality of underlying models.
	Functionality Gaps: The platform is not yet mobile-friendly and lacks flexibility to incorporate datasets beyond NFHS.

These strengths and limitations frame the platform's current utility and highlight a clear path for its future evolution.

Conclusion and Future Directions

Insight360TN successfully illustrates the immense potential of technology to transform dense, complex health data into actionable, user-friendly knowledge. By combining highly optimized datasets, intuitive geographic visualization, and AI-powered natural language interpretation, it effectively converts static NFHS tables into a dynamic tool for evidence-based policymaking. The platform demonstrates a replicable blueprint for data democratization efforts globally, particularly through its solutions for handling administrative reorganization and establishing a statistically robust framework for indicator classification.

In essence, the platform serves as a "system of nerves," transmitting critical signals from the data across the body of the public health system, making it more responsive and adaptive to the needs of the population. Looking ahead, future directions for the platform include expansion to other states, integration with the forthcoming NFHS-6 data, and the enhancement of its analytical capabilities with predictive analytics to forecast health trends and better inform proactive public health strategies.

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Acknowledgments

Live

Application: The application can be accessed at https://insight360tn.web.app/ and is best viewed on a laptop or desktop.

Source Code: The complete source code is available on GitHub under the MIT license at https://github.com/drsivambbs/Insight360TN.

CONFLICT OF INTEREST

None

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