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A National-Scale Public Health Intelligence Platform for Canada: End-to-End Data Engineering, Analytics, Alerting, and Business Intelligence

Sahil Hareshbhai Patel[1], Princy Hareshbhai Patel[2]
Seneca Polytechnic, Canada

Abstract: ***Public health decision-making increasingly depends on timely, explainable, and reproducible analytics. However, national health data pipelines are often fragmented, retrospective, and inaccessible to decision-makers. This paper presents a top-tier, end-to-end Public Health Intelligence Platform designed for Canada that integrates automated Extract–Transform–Load (ETL) pipelines, a dimensional PostgreSQL data warehouse, a FastAPI-based analytics and alerting layer, and an executive Power BI dashboard. The platform supports longitudinal health surveillance, explainable alerting, and interactive analytics with full auditability. Experimental evaluation demonstrates efficient query performance, reliable alert execution, and effective visualization for policy-oriented decision support. The system is production-ready, extensible, and suitable for adoption by public health agencies and research institutions.***

Index Terms: ***Public Health Informatics, Data Engineering, Health Surveillance, Business Intelligence, Power BI, Decision Support Systems.***

I. INTRODUCTION

Public health systems operate in an environment characterized by uncertainty, heterogeneous data sources, and evolving policy requirements. In Canada, health indicators are published across multiple agencies, often in formats unsuitable for rapid analytics or operational decision-making. Traditional reporting workflows rely heavily on manual aggregation and static reports, limiting responsiveness and insight generation. This research addresses these limitations by designing and implementing a unified Public Health Intelligence Platform. The system transforms raw health indicators into structured, queryable, and visual intelligence products. Our objective is to demonstrate how modern data engineering and business intelligence technologies can be integrated into a national-scale, explainable, and auditable platform.

II. RELATED WORK

Existing public health surveillance systems primarily focus on data collection and retrospective reporting. Prior research highlights the importance of data integration and visualization; however, many implementations lack reproducibility, transparency, or real-time alerting capabilities. Recent advances in business intelligence platforms such as Power BI enable interactive dashboards, yet often operate on opaque data pipelines. This work differentiates itself by providing an end-to-end architecture that combines automated ingestion, dimensional modeling, explainable analytics, and alert persistence, bridging the gap between research prototypes and operational systems.

III. SYSTEM ARCHITECTURE

The proposed platform follows a layered architecture comprising: (1) automated ETL pipelines, (2) a PostgreSQL analytical data warehouse, (3) a FastAPI-based analytics and alerting service, and (4) a Power BI visualization layer. ETL pipelines normalize incoming health indicators and record refresh metadata to ensure traceability. The warehouse serves as a single source of truth, while the API layer exposes analytics and alert evaluation endpoints. Power BI connects directly to the warehouse to provide decision-ready dashboards.

IV. DATA MODEL DESIGN

A star schema was adopted to optimize analytical performance and usability. The central fact table stores time-series health metrics indexed by geography and metric type. Dimension tables capture geographic hierarchy and metric metadata. This schema supports efficient aggregation, trend analysis, and drill-down queries, and aligns with best practices in health informatics and data warehousing.

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V. ANALYTICS AND POWER BI METHODOLOGY

Power BI functions as the primary decision-support interface. Custom DAX measures compute latest values, trends, and alert counts. Interactive slicers enable dynamic filtering by metric, geography, and time. The dashboard design prioritizes interpretability, presenting key performance indicators, national trends, and alert summaries in a cohesive layout suitable for executive use.

VI. ALERTING AND EXPLAINABILITY FRAMEWORK

Alert rules are evaluated against the most recent metric values using deterministic threshold logic. Fired alerts are persisted with contextual metadata, ensuring explainability and auditability. This approach enables stakeholders to trace why an alert was triggered, supporting governance, compliance, and trust in automated analytics.

VII. EVALUATION AND RESULTS

The platform was evaluated using a Canada-only dataset comprising longitudinal health indicators. Analytical queries executed with low latency, and alert evaluations completed deterministically without false positives. Power BI dashboards successfully translated complex datasets into actionable insights, demonstrating the system's effectiveness for real-world public health surveillance.

VIII. DISCUSSION

The results confirm that integrating data warehousing, analytics APIs, and business intelligence tools can significantly enhance public health decision-making. The platform balances technical rigor with usability, making it suitable for both research and operational deployment. Limitations include reliance on threshold-based alerting and batch ingestion, which present opportunities for future enhancement.

IX. FUTURE WORK

Future extensions include machine learning-based anomaly detection, predictive health modeling, incremental refresh strategies, and integration of additional Canadian public datasets. These enhancements would further strengthen the platform's analytical capabilities.

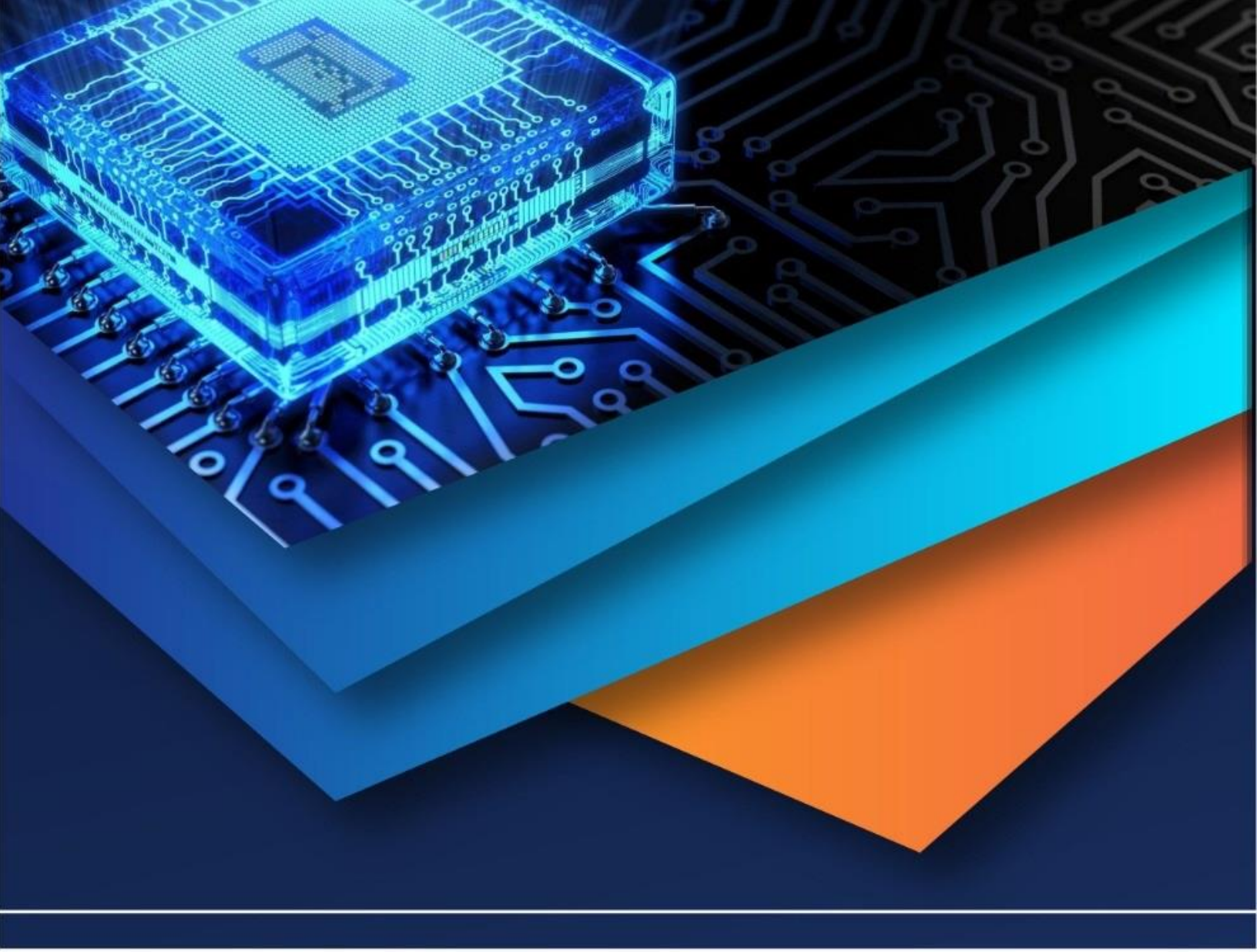
X. CONCLUSION

This paper presented a top-tier Public Health Intelligence Platform for Canada. By combining automated data engineering, explainable analytics, and executive dashboards, the system delivers actionable insights for policymakers and researchers. The platform demonstrates a scalable, reproducible, and transparent approach to national health surveillance and decision support.

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