

IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE
AND TECHNOLOGY

VOLUME : 11 ISSUE : 06 Print / Issue Publication Date: October 2026

ISSN : 2455-2143

Indexed In

Google SCHOLAR OPEN ACCESS doi Crossref

WWW.IJEAST.COM

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International Journal of Engineering Applied Sciences and Technology, 2026
Vol. 11, Issue 06, ISSN No. 2455-2143, Pages 93-102
Published Online October 2026 in IJEAST (http://www.ijeast.com)

WARD-LEVEL PUBLIC HEALTH DECISION SUPPORT USING A COMPOSITE HEALTH INDEX: SYSTEM DESIGN AND EVALUATION PROTOCOL

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Abstract—**Municipal public-health planning depends on information about disease burden, diagnostic testing, facility capacity, and prevention, but these data are often recorded through separate service workflows. This paper describes a ward-level decision-support prototype that connects five stakeholder-facing platforms: a citizen mobile application, hospital portal, diagnostic laboratory portal, pharmacy portal, and municipal dashboard. All five platform prototypes were built and demonstrated using synthetic/dummy citizen and service records. This demonstration supports claims about prototype implementation and workflow coverage, but does not establish operation with live provider feeds or improvement in health outcomes. The paper also specifies a seven-indicator Ward Health Index (WHI) covering active case burden, recent case growth, test positivity, case-fatality ratio, doctor availability, bed availability, and vaccination coverage. Indicators are normalized to a 0–100 scale, with direction aligned so higher scores are more favorable, before provisional weighted aggregation. The method draws on the direction-aware scaling and weighted-average structure of NITI Aayog's Health Index, but does not reuse state-level indicators or thresholds as ward-level standards. Candidate weights and score bands remain unvalidated. The paper documents the prototype architecture, synthetic-data demonstration scope, and an evaluation protocol; validation with real ward data, sensitivity analysis, independent alert evaluation, and performance and security testing remain necessary before operational use**

Keywords—**Composite health index, public-health surveillance, municipal decision support, healthcare interoperability, ward-level analytics, data quality.**

I. INTRODUCTION

City-level public-health decisions often rely on information collected by several stakeholders. A patient visit may lead to a laboratory test, a prescription, a resource update, and a report relevant to surveillance. When these records sit in separate systems, municipal staff must reconcile different formats, reporting periods, and levels of completeness before comparing conditions across wards. The project documentation reviewed for this study identifies coordination, resource visibility, and ward-level data consolidation as design requirements. These are requirements inferred from the project, not measured outcomes of a citywide field study.

Digital-health strategies emphasize interoperable information systems, appropriate governance, and protection of personal health information [6], [7], [10]. For local planning, the underlying indicators also need clear definitions, population denominators, reporting periods, and data-validation rules. A dashboard can make stale or incomplete records easier to see, but it cannot correct poor source data by itself. Electronic health data quality should be assessed in terms such as conformance, completeness, and plausibility, with verification distinguished from validation [12]. For that reason, this design treats provenance and data freshness as part of the decision-support process rather than as interface details.

Reliable decision support also depends on systematic assessment of the underlying health data. The World Health Organization's Data Quality Review framework provides a

basis for evaluating health-facility data quality and identifying issues that may affect the interpretation of reported indicators [15]. Accordingly, the proposed system treats data-quality checks as a prerequisite for interpreting ward-level health scores rather than assuming that all reported values are equally reliable.

The study has four objectives: (i) define a modular architecture for five stakeholder groups with role-specific access; (ii) specify a ward-level composite index using explicit normalization and aggregation rules; (iii) describe how verified reports could feed surveillance signals that are reviewed by authorized personnel; and (iv) set out tests for calculation correctness, robustness, data quality, and operational usability.

The contribution is a documented five-platform prototype and a provisional index specification informed by composite-indicator methods [1]–[4]. All five platforms were demonstrated with synthetic records, showing workflow coverage rather than live deployment or a validated WHI. The paper describes the method, architecture, candidate index, prototype demonstration, and evaluation still needed before real-world use.

II. RELATED WORK

NITI Aayog's first-round Health Index is a useful Indian methodological precedent. It scales indicators according to whether higher values represent better or worse performance, then combines the scaled values through a weighted composite score [1, pp. 10–11]. The report also describes data validation and gaps in indicator availability. Its indicator set and state-level comparison bounds should not be copied directly for wards. The present design borrows the direction-aware scaling and weighted aggregation structure, while proposing that ward-level calibration bounds be chosen locally and kept stable for longitudinal comparison.

Sharma, Prinja, and Aggarwal developed a district-level health-system performance index in Haryana and examined its robustness through sensitivity analysis [3]. Doke's Maharashtra study used multiple health indicators to compare disparities among districts [4]. Both studies show how a composite measure can support comparisons below the state level, but neither validates the seven indicators or thresholds proposed here. The choice of indicators, their definitions, and the data used to scale them remain specific to the setting.

Rothenberg et al. reviewed urban health indicators and indices and highlighted the need for methods that can support local-level health assessment rather than relying only on large-area comparisons [13]. Prasad et al. evaluated the implementation of the WHO Urban HEART tool in 15 cities across Asia and Africa, reporting the importance of stakeholder coordination, locally relevant indicators, and reliable neighbourhood-level data for prioritizing health-related action [14]. These studies support the need for localized health assessment and municipal decision support. However, they do not validate the specific seven-indicator Ward Health Index (WHI) proposed in this study, which requires separate evaluation using appropriate ward-level data.

The OECD/European Union/Joint Research Centre handbook recommends documenting the theoretical basis, normalization, weighting, aggregation, missing-data treatment, and uncertainty of a composite indicator [2]. These choices can change a score or ranking even when the underlying observations stay the same. Saisana, Saltelli, and Tarantola describe uncertainty and sensitivity analysis as tools for testing the robustness of composite indicators [9]. Such analyses are therefore part of the proposed WHI evaluation; no robustness result is claimed in this paper.

For outbreak early warning, Mwaura, Ndirangu, and Wamuyu describe a citizen-observatory approach that uses clustering and outlier detection to flag possible changes in disease activity [5]. That work supports considering trends and anomalies, but a statistical signal is not a confirmed outbreak. Any signal from this system would need verification against the source records, relevant disease context, and review by qualified personnel. WHO similarly frames surveillance as the systematic collection, analysis, interpretation, and dissemination of information for public-health action, with ethical use and public trust as important considerations [8].

India's National Digital Health Blueprint promotes interoperable, standards-based digital-health systems and emphasizes privacy and confidentiality [6]. The proposed platform is consistent with those principles at the design level. The project materials, however, do not show a completed integration with national digital-health services, nor do they establish formal certification or regulatory compliance. The paper therefore describes the architecture as interoperability-oriented, not as a certified or nationally integrated system.

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TABLE I. RELATED WORK AND DESIGN IMPLICATIONS

Reference / focus	Approach or contribution	Relevance and limitation
NITI Aayog Health Index [1]	Direction-based min–max scaling; weighted average; data validation.	Methodological basis; state-level indicators and bounds cannot be assumed valid for wards.
OECD/JRC handbook [2]	Guidance on normalization, weights, missing values, uncertainty and sensitivity.	Supports transparent index specification; decisions on weights remain context-dependent.
Sharma et al. [3]	District-level Indian health-system composite index with sensitivity analysis.	Shows subnational index design is possible; study used a different dataset and setting.
Doke [4]	Composite community-health index for Maharashtra districts.	Local precedent; a district index is not automatically suitable for dynamic municipal wards.
Mwaura et al. [5]	Citizen-observatory disease signals with clustering/outlier detection.	Supports anomaly-monitoring rationale; abnormal patterns still need human validation.
MoHFW / WHO [6]–[8]	Interoperability, routine health information and surveillance governance.	Establishes system-level design principles, not proof of this prototype's effectiveness.

Research Gap

The practical gap addressed here is the link between separate health-service workflows and the information needed for ward-level planning. The project specification brings citizen, hospital, laboratory, and pharmacy activity into a proposed municipal view, while the WHI is intended to summarize capacity, prevention, and epidemiological indicators. This paper does not claim that no comparable systems exist. Its contribution is to make the proposed data flow, index calculation, quality controls, and human-review points explicit enough to support subsequent implementation and testing.

III. STUDY METHOD

Study design and materials. This paper reports a system-design and prototype-demonstration study. The project documentation and implementation notes were reviewed to identify the five stakeholder-facing platforms, their responsibilities, shared data entities, and intended workflow transitions. All five platform prototypes were built and demonstrated with dummy/synthetic citizen and service records. Those records are used to demonstrate interface and workflow behaviour; they are not observations of actual municipal disease burden and do not represent real patient records.

Prototype walkthrough and analysis. The demonstration scope spans citizen-facing services, hospital records, laboratory test/result records, pharmacy inventory or dispensing records, and a municipal summary view. The manuscript describes this as prototype coverage based on synthetic records. No standardized latency benchmark, user study, security penetration test, clinical outcome measure, or retrospective outbreak dataset was supplied for quantitative analysis. The WHI specification was reviewed for unit consistency, indicator direction, weight allocation, and cases where rate calculations are undefined or unstable.

Evaluation boundary. The results section therefore reports implementation scope and the use of synthetic records, not statistical evidence of clinical or epidemiological effectiveness. Formal calculation tests, sensitivity analysis, retrospective alert evaluation, operational load testing, and independent privacy/security review remain part of the evaluation protocol.

IV. SYSTEM ARCHITECTURE

The implemented prototype is organized into four logical layers: (1) role-specific access channels; (2) an application/API layer; (3) shared data and domain services; and (4) municipal decision support. The five interfaces are a citizen mobile application, hospital portal, diagnostic laboratory portal, pharmacy portal, and municipal dashboard. Each supports a different workflow and should expose only the functions and records required for its role. Municipal views should use ward-level aggregates wherever identifiable clinical details are not needed for an authorized task.

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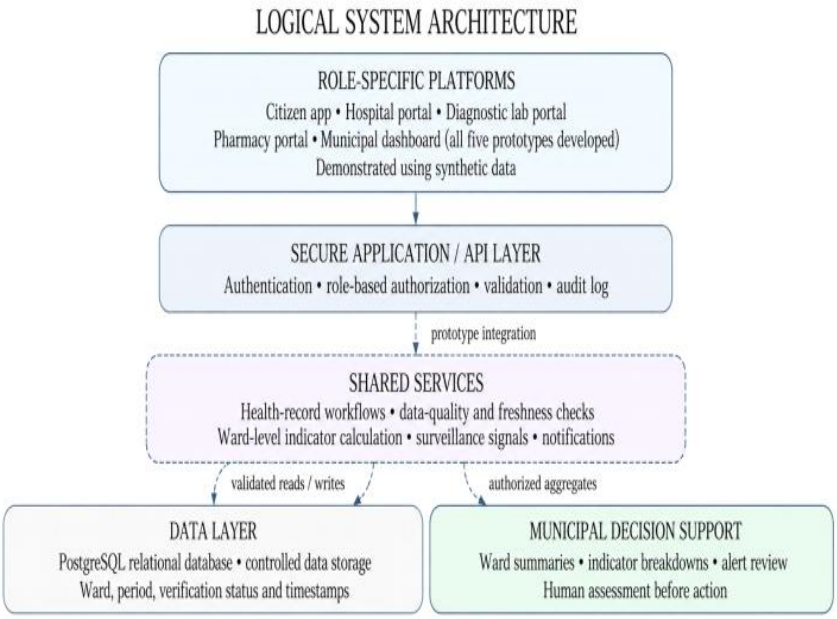


Fig. 1. Logical system architecture of the five-platform public-health decision-support prototype.

The application layer is intended to handle authentication, server-side authorization, input validation, and audit logging. The shared data layer may store structured records for wards, organizations, case reports, resources, and indicator observations, with controlled storage for diagnostic documents. Each observation should carry its source organization, event date, reporting window, verification status, and last-updated timestamp. These fields let the dashboard distinguish a recent verified report from an incomplete or stale one.

The project implementation materials identify Next.js/React and TypeScript for the web portals, Flutter/Dart for the citizen mobile application, FastAPI/Python for backend services, and PostgreSQL through Supabase for shared structured data and storage. The technical design also describes token-based authentication, role-based access control, and database-level row security. These are implementation details of the prototype; the manuscript does not claim independent penetration testing, formal security certification, or a live connection to municipal or national health systems.

TABLE II. PLATFORM RESPONSIBILITIES AND DOCUMENTED STATUS

Platform / role	Main information and functions	Status in supplied report
Municipal dashboard	Ward summaries, facility/resource views, administrative monitoring.	Implemented prototype; demonstrated with synthetic ward/service records. No live municipal feed evaluated.
Citizen application	Health-card lookup, permitted records, service discovery, appointments and alerts.	Implemented prototype; demonstrated with synthetic citizen records.
Hospital portal	Appointments, encounters, prescriptions, referrals and facility updates.	Implemented prototype; demonstrated with synthetic patient/service records.
Laboratory portal	Test-order status, verified results and controlled report upload.	Implemented prototype; demonstrated with synthetic test/result records.
Pharmacy portal	Medicine stock, expiry, availability and dispensing records.	Implemented prototype; demonstrated with synthetic stock/dispensing records.
Index / surveillance services	Index computation, trend signals, anomaly review and notifications.	Weights and bands remain provisional; no validation with real ward data or retrospective alerts.

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Security and data governance

The prototype uses role-specific interfaces, but production use requires independent verification that permissions are enforced by the API and database as well as by the interface. QR codes should identify a record or provide a lookup reference, not expose readable medical history or grant access by themselves. Least-privilege roles, encrypted transport, private document storage, access and change logs, retention and correction rules, and de-identified municipal reporting should be tested before any real records are processed. The project documents describe security mechanisms, but no independent security assessment or compliance certification was supplied.

V. PROPOSED WARD HEALTH INDEX

The Ward Health Index (WHI) is proposed as a 0–100 composite score for a ward and a defined reporting period. A higher score represents a more favorable profile across the included indicators; a lower score signals the need for closer review. It is intended to help prioritize attention, not to diagnose an individual, declare an outbreak, or replace public-health judgment.

The project specification lists seven candidate indicators and provisional weights. Its draft equation adds resource/ prevention measures to epidemiological measures even though the raw inputs use different units, such as rates per 1,000 residents, percentages, and growth rates. Adding those raw values directly would not produce a comparable 0–100 score. Each indicator is therefore normalized first, following the direction-aware structure described in NITI Aayog's Health Index [1, pp. 10–11], with all normalized scores oriented so that 100 is favorable and 0 is unfavorable. The 45:55 split between capacity/prevention and epidemiological indicators is retained as a design assumption only; it has not been validated against ward-level outcomes.

TABLE III. CANDIDATE INDICATORS AND PROVISIONAL WEIGHTS

Indicator	Direction / weight	Input definition (to be finalized)
Active disease incidence	Negative; 0.20	Confirmed cases per 1,000 ward residents in the defined period.
Recent case growth	Negative; 0.15	Change in cases across comparable weekly windows; handle low/zero baseline.
Test positivity	Negative; 0.10	Positive tests divided by all valid tests for the same disease/time window.
Case-fatality ratio	Negative; 0.10	Deaths divided by confirmed cases; small denominators and reporting lag must be flagged.
Doctor availability	Positive; 0.15	Available doctors per 1,000 residents; define whether count is headcount or FTE.
Available-bed ratio	Positive; 0.15	Available beds divided by staffed/operational beds; timestamp required.
Vaccination coverage	Positive; 0.15	Eligible residents vaccinated divided by eligible target population.

For case growth, a pre-specified definition such as $100 \times (C_t - C_{t-1}) / C_{t-1}$ may be used for comparable reporting windows. When the preceding count is zero or very small, the percentage change is undefined or unstable; the implementation must apply a documented disease-specific rule rather than substituting an arbitrary value.

A. Direction-aware normalization

Let x_{ij} be the observed value of indicator j for ward i. Let L_j and U_j be the agreed lower and upper calibration bounds for that indicator, with U_j greater than L_j. For an indicator where higher values represent better performance, the normalized score is:

$$S_{ij} = 100 \times (x_{ij} - L_j) / (U_j - L_j) \quad \text{(positive indicator)}$$

For an indicator where lower values represent better performance, the orientation is reversed:

$$S_{ij} = 100 \times (U_j - x_{ij}) / (U_j - L_j) \quad \text{(negative indicator)}$$

Scores should be clipped to [0, 100] after normalization. Bounds should be selected using policy targets, agreed epidemiological reference values, or a documented baseline period and then held stable for longitudinal comparison. If bounds are re-estimated from each month's wards, the result becomes relative to the current cross-section and may change even when a ward's own health conditions do not. If $U_j = L_j$, the calculation is undefined; the indicator must be reviewed, excluded for that period or scored using a pre-defined target rule, and the decision recorded.

B. Weighted aggregation

The proposed aggregate is a weighted arithmetic mean of the normalized, direction-aligned scores:

$$WHI_i = \Sigma_j (w_j \times S_{ij}) / \Sigma_j w_j, \quad \text{with } w_j \geq 0$$

The candidate weights in Table III sum to 1.00. The three capacity/prevention indicators account for 0.45 of the total

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weight, while the four epidemiological indicators account for 0.55. Because the negative indicators are reversed during normalization, every score has the same interpretation and the aggregate does not subtract the epidemiological terms again. The complementary zone-risk display can be written as $ZRS_i = 100 - WHI_i$; it is a visualization derived from the WHI, not an independently validated probability of risk.

C. Missingness, coverage, and provisional bands

A missing value must not be treated as zero cases or as a perfect score. The dashboard should show the number of available indicators, the reporting period, and data freshness for each ward. Scores calculated from incomplete inputs should be marked with their coverage; where missingness would make the aggregate misleading, the system should suppress it rather than display an unqualified rank. If the implementation renormalizes weights after excluding an indicator, that rule and the minimum coverage requirement must be documented in advance. Missing-data decisions can materially change composite scores [1], [2].

The project documents propose three display bands: WHI 75–100 (favorable profile), 50–74.9 (intermediate), and below 50 (priority for review). These cut-offs are provisional interface choices only. They have not been calibrated against a reference outcome or reviewed with municipal public-health experts, and they have not been tested for false reassurance or excessive alerts. Before operational use, the thresholds must be reviewed with domain experts and assessed against retrospective ward data.

TABLE IV. PROPOSED INTERPRETATION BANDS (UNVALIDATED)

WHI band	Suggested display	Required interpretation
75–100	Favorable profile / routine review	Does not imply that no local outbreak or service gap exists.
50–74.9	Intermediate / closer review	Inspect domain scores, reporting coverage and recent trends.
Below 50	Priority for review	Verify source data and context before reallocating resources or issuing public messages.

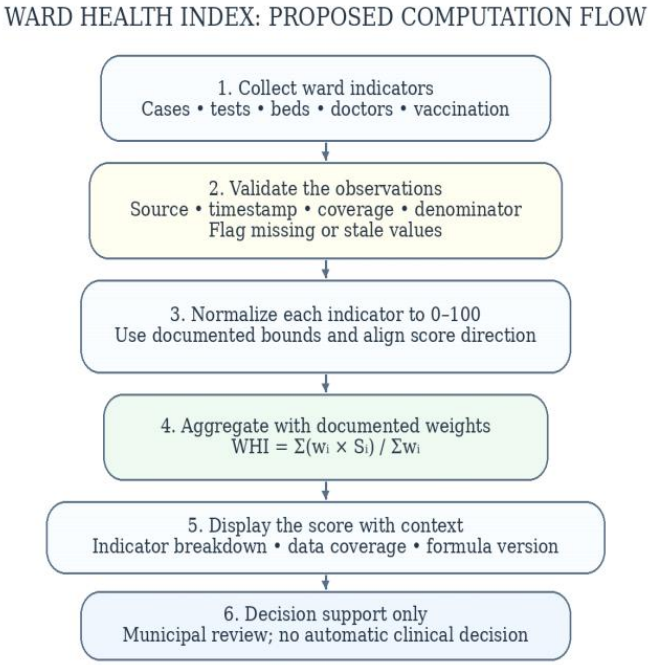


Fig. 2. Proposed WHI computation flow from source observations to context-aware display.

VI. SURVEILLANCE AND DECISION-SUPPORT WORKFLOW

The proposed surveillance logic would flag patterns that warrant inspection. A practical approach could combine disease-specific absolute thresholds, changes across comparable reporting periods, and deviations from a ward's historical baseline. Thresholds should reflect the disease and local public-health protocol; a single case-count threshold is unlikely to be suitable for every condition. The project

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design describes trend checks and outlier checks, but the evidence supplied does not include a retrospective evaluation of alert performance. Established surveillance-system evaluation guidance also emphasizes assessing system attributes and performance before operational conclusions are drawn [11]. The alert workflow in Figure 3 is therefore a design model, not proof of outbreak-detection accuracy.

Each proposed signal should identify the disease or indicator, ward, observation window, comparison baseline, data source, completeness, and freshness. Before acting, an authorized municipal officer should check whether a signal reflects delayed reporting, changed testing volume, duplicate records, or a genuine rise in burden. Follow-up actions—such as requesting confirmation, organizing a field investigation, or reviewing resource needs—should be decided by authorized personnel and recorded. Automated or generative summaries must not be treated as an epidemiological source of truth.

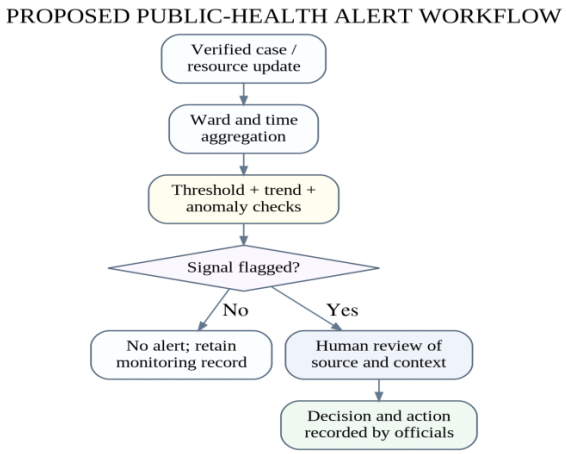


Fig. 3. Proposed surveillance workflow: an anomaly prompts verification and human review, not automatic outbreak declaration.

UML use-case model

The use-case view summarizes the five role-specific prototype interfaces. Citizens use the mobile application for permitted profile and service functions; hospital staff work with appointments, encounters, and facility records; laboratory staff manage test and result records; pharmacy staff handle stock and dispensing records; and municipal officers review aggregated ward information. These workflows were demonstrated with synthetic data. The use-case diagram does not imply that real providers are connected or that the system is operating in a live municipal environment.

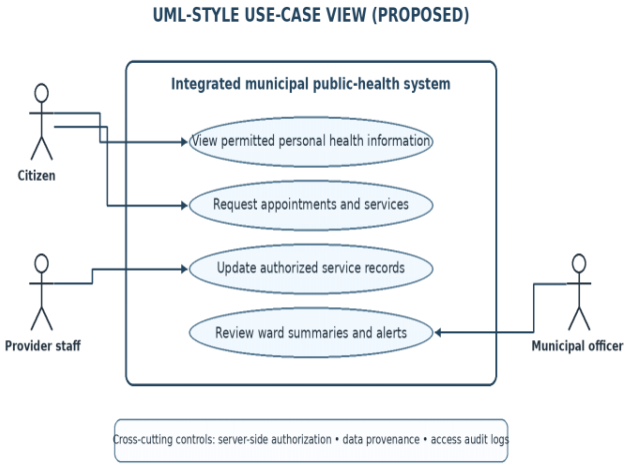


Fig. 4. UML-style use-case model of the five role-specific prototype platforms and shared access controls.

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VII. IMPLEMENTATION AND SYNTHETIC-DATA DEMONSTRATION

The prototype comprises five platform interfaces: the citizen mobile application, hospital portal, diagnostic laboratory portal, pharmacy portal, and municipal dashboard. All five were built and demonstrated using dummy/synthetic citizen and service records. The implementation uses Flutter/Dart for the mobile application; Next.js/React and TypeScript for the web-facing portals; FastAPI/Python for backend services; and PostgreSQL through Supabase for shared data and storage. Synthetic records were used to demonstrate role-specific screens and cross-platform workflow scenarios without using real patient data.

The demonstrated implementation result is functional prototype coverage across the five platforms using synthetic records. A demonstration scenario connects a dummy citizen profile with service activity in the hospital, related laboratory result records, pharmacy stock or dispensing information, and an aggregated municipal view. Because these records are synthetic, they cannot establish real ward disease burden, clinical effectiveness, the accuracy of the WHI, or outbreak-detection performance. No standardized quantitative test log, timing benchmark, independent reference classification, historical outbreak dataset, or independent security-test report was supplied; the paper therefore does not report fabricated numerical performance results.

Evaluation plan

The next evaluation should separate software correctness from public-health validity. Each test should record its data source, reporting period, index version, software version, expected behaviour, environment, and acceptance criterion. Synthetic-data tests can confirm workflow behaviour and formula implementation, but validation of ward-level conclusions requires suitable real or retrospective data under the appropriate governance approvals.

TABLE V. RECOMMENDED EVALUATION PROTOCOL

Evaluation area	Test method / measure	Evidence to report
Calculation correctness	Recalculate a stratified set of ward-period scores independently; verify normalization, weights and bounds.	Test count, mismatches, numerical tolerance, formula version.
Data quality	Audit duplicates, missing fields, denominators, stale reports and mismatched dates.	Completeness by source/ward, stale-data rate and exclusion rules.
Index robustness	Vary weights and calibration bounds; compare scores and rankings (e.g. rank correlation).	Ranking changes, indicator influence and sensitivity findings.
Alert quality	Compare candidate alerts with adjudicated retrospective signals; estimate precision/recall.	True/false alerts, missed events, lead time and disease-specific results.
Operational performance	Measure endpoint response, update latency and concurrent user behavior under defined load.	Dataset size, hardware/environment, percentiles and failures.
Access and privacy	Test role/record authorization, direct API calls, audit logging and sensitive-data exposure.	Pass/fail cases, policy findings and remediation status.

For index validation, compare ward scores with independent indicators or expert assessments not used to construct the score. If sufficient historical data become available, repeat the analysis across seasons and diseases. Sensitivity analysis should vary weights and calibration bounds and remove one indicator at a time. Sharma et al. [3], the OECD/JRC handbook [2], and Saisana et al. [9] provide methodological precedents for these checks. These remain recommended tests: no validation statistic is reported in this paper.

VIII. DISCUSSION AND LIMITATIONS

A single index can help staff scan a complex ward profile, but aggregation can hide weaknesses in individual dimensions. For example, a ward's overall score might appear moderate even if bed availability is low or cases are rising sharply, because strong vaccination coverage offsets those values in the weighted average. The interface should therefore show each indicator and domain score alongside the aggregate, provide trend views, and display the reporting period and completeness. Resource decisions should draw on several sources of evidence rather than a rank alone.

Each proposed indicator brings a different measurement issue. Case-fatality ratios are sensitive to reporting delays, case ascertainment, and small denominators. Test positivity depends on who is tested and how testing volume changes. Case growth becomes unstable when the preceding period

contains few or no cases; the formula and zero-baseline rule must therefore be specified before implementation. Bed availability can change within hours, doctor availability needs a consistent measure (headcount or full-time equivalent), and vaccination coverage depends on a reliable eligible-population denominator. These definitions should be agreed with the data providers before routine collection begins.

For municipal use in India, interoperability, privacy, consent, retention, and access controls must be reviewed against applicable requirements [6], [8]. Since the prototype demonstration used synthetic records, it did not test the handling of live identifiable health data. The documents do not establish provider deployment agreements, independent security audit results, formal certification, or connection to national health services. Any future study involving human participants or identifiable patient records should obtain the applicable institutional and ethics determinations and describe them accurately.

The design is anchored to one municipal context. Population denominators, facility catchment areas, disease thresholds, indicator bounds, and resource-planning practices may differ across cities. The architecture may be reusable, but the weights and display bands should not be transferred to another municipality without local review and validation.

IX. CONCLUSION AND FUTURE WORK

This paper describes a ward-level public-health decision-support prototype comprising five platforms: a citizen application, hospital portal, diagnostic laboratory portal, pharmacy portal, and municipal dashboard. The authors report that all five were built and demonstrated with synthetic/dummy records. The paper also defines a provisional seven-indicator Ward Health Index and specifies direction-aware normalization, weighted aggregation, and the data-quality and review requirements that should accompany the score. The method draws on the composite-indicator structure in NITI Aayog's Health Index [1] and broader composite-indicator guidance [2], while leaving the indicator choices, weights, calibration bounds, missing-data rules, and interpretation bands open to empirical validation.

The next steps are to publish reproducible functional and integration test cases for all five prototypes; define precise indicator denominators and reporting periods; implement and test missing-data and zero-baseline rules; and conduct sensitivity analysis of WHI weights and bounds. Evaluation with appropriate ward-level data is needed to test whether the index agrees with independent indicators or expert review. Retrospective assessment of alerts, load and latency testing, and an independent privacy/security review should precede any live deployment. The synthetic-data demonstration establishes prototype coverage only; it does not establish improved health outcomes or validated outbreak prediction.

Data and ethics statement—The prototype demonstration described in this paper used synthetic/dummy records, not real patient records, and did not recruit human participants. Any future evaluation using identifiable health data or human participants will require the applicable institutional and ethics review before the study is conducted.

SOURCE CODE AVAILABILITY

The source code for the proposed ward-level public health decision-support prototype is available at:

GitHub Repository:

https://github.com/codesbyuday/samved-health-project

The prototype was demonstrated using synthetic data and has not been validated using real-world municipal health data.

ACKNOWLEDGMENT

The authors thank their project guide for valuable guidance and review. Declaration on AI use: the authors used an AI assistant [ChatGPT(OpenAI)] to help improve the language, structure and formatting of this manuscript and to help read the project source code when preparing the descriptions. The authors reviewed and verified the manuscript and take full responsibility for its content, including the figures, numerical values, and references. AI Tool is not an author. The authors declare no conflict of interest and confirm that no external funding was received.

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