

Emergency Department Analytics Dashboard: Design and Evaluation of a Multi-View Performance Monitoring Framework

Department of Computer Science, (S.I.E.S College of Arts, Science, and Commerce Sion, Mumbai, India)
(Email: naik43422@gmail.com)

Neha Devidas Naik*, Dr Manoj Singh**

Department of Computer Science, (S.I.E.S College of Arts, Science, and Commerce Sion, Mumbai, India)
(Email: manojks@sies.edu.in)

Abstract:

Emergency departments must monitor patient volume, waiting time, admission outcomes, referral pathways, and patient experience across multiple operational dimensions. This paper presents a multi-view business intelligence (BI) framework for integrating these indicators into a unified performance-monitoring environment. The framework organizes analysis into four complementary views: monthly monitoring, consolidated date-range analysis, patient-level detail for authorized review, and exploratory key takeaways. Three research questions guide the study: how to integrate multiple indicators into a coherent framework; how effectively the views support exploration across time, referral departments, and patient groups; and to what extent KPI calculations are accurate and the dashboard is usable for representative monitoring tasks. The dashboard was developed and tested by the researcher, and KPI calculations were checked against the available hospital source data. The prototype screenshots illustrate the implemented views and selected displayed values, including 408 patients and a 35.4-minute average wait in the June 2023 monthly view. Because numerical reconciliation results and formal testing with representative end users were not documented as a quantified study, the paper reports the completed source-data checks and prototype-level usability review.

Keywords — Emergency department, business intelligence, performance indicators, patient flow, waiting time, patient satisfaction, dashboard evaluation, visual analytics.

I. INTRODUCTION

Emergency departments operate in a time-sensitive environment where patient arrivals, waiting times, admission decisions, referral pathways, and patient experience must be monitored together. Managers need to identify changes in demand and compare operational measures across periods and patient groups. When indicators are spread across separate reports or tables, stakeholders may need to reconcile measures manually, slowing interpretation and making comparisons less consistent.

A multi-view business intelligence framework can bring related measures into a shared analytical model while preserving different levels of

investigation. The prototype examined in this study contains a Monthly View, Consolidated View, Patient Details, and Key Takeaways. These views move from summary indicators to time-based patterns, group comparisons, and authorized record-level inspection. The research contribution is not the dashboard alone; it is the design rationale, analytical mapping, and evaluation protocol that connect the views to defined research questions.

This paper is organized as a design and prototype-evaluation study. It defines three research questions, describes the multi-view framework and its implementation, and reports checks of KPI calculations against the available hospital source data. It also describes the dashboard's support for

representative monitoring tasks and distinguishes researcher-performed testing from a formal usability study involving representative end users.

II. RESEARCH PROBLEM AND QUESTIONS

Emergency-department performance is multidimensional: patient volume, waiting time, satisfaction, referrals, admission status, and demographic distributions each describe a different aspect of service activity. A single summary metric cannot represent these dimensions, while disconnected reports can make it difficult to compare time periods or investigate differences among referral departments and patient groups. A unified framework must integrate these indicators without obscuring their definitions, source lineage, or limitations.

The study addresses the problem through three research questions (RQs): RQ1—Framework design: How can multiple emergency-department performance indicators be integrated into a unified, multi-view BI framework? RQ2—Analytical capability: How effectively does the framework support exploration of performance patterns across time periods, referral departments, and patient groups? RQ3—Evaluation: To what extent are the framework's KPI calculations accurate, and how usable is the dashboard for representative performance-monitoring tasks? RQ1 is addressed through the framework design; RQ2 through the mapping of views to analytical tasks; and RQ3 through source-data checks of KPI calculations and a prototype-level review of task support. The scope of the usability evidence is stated explicitly because researcher testing is not equivalent to a formal study with representative end users.

III. STUDY OBJECTIVES

- Design a multi-view BI framework that integrates core emergency department performance indicators.
- Map each view and visual element to specific monitoring and exploratory analysis tasks.
- Enable comparison of performance across selected months and date ranges using consistent filters and metric definitions.

- Support investigation of patterns by admission hour, referral department, age group, gender, and other available patient categories.
- Specify a reproducible approach for validating KPI calculations against trusted source queries.
- Define representative usability tasks and measurable outcomes, including task completion, correctness, time, errors, and user feedback.
- Report the evidence collected and distinguish researcher-performed prototype testing from formal participant-based usability evaluation.

IV. RESEARCH QUESTIONS AND EVIDENCE STRATEGY

RQ1 (framework design) is examined by mapping each performance indicator to a view, visual form, interaction, and intended decision-support task. RQ2 (analytical capability) is examined through the coverage of temporal, referral department, and patient-group comparisons. RQ3 is examined in two parts: KPI calculations are checked against values calculated from the available hospital source data, and the implemented views are reviewed against representative performance-monitoring tasks.

V. LITERATURE REVIEW

Healthcare dashboards are used to bring operational and clinical indicators into shared views. Their value depends on data quality, appropriate metric definitions, update frequency, and whether intended users can interpret the information correctly. A review of healthcare dashboards highlights their potential for supporting monitoring and decision-making while noting that evidence of impact varies by context [1]. This supports evaluating a dashboard as both a data product and a user-facing analytical tool.

Information visualization supports comparisons and pattern discovery when chart types, labels, scales, and interactions match the analytical task. Dashboard design guidance emphasizes selecting meaningful measures, presenting comparisons clearly, and allowing users to move from summary information to relevant detail [3]. The proposed framework applies these principles by separating overview, date-range comparison, record-level

inspection, and exploratory analysis into related views.

Waiting time and satisfaction require careful interpretation. An observed association between waiting time and satisfaction does not establish causation, and group differences may reflect case mix, triage priority, staffing, or other factors. Data-quality assessment should also verify completeness, consistency, validity, and agreement with source records [2]. These considerations motivate the framework's emphasis on centralized KPI definitions, validation checks, privacy safeguards, and cautious interpretation.

The study therefore contributes a structured mapping between emergency-department indicators, dashboard views, analytical tasks, and evaluation criteria. It does not propose a clinical prediction model or claim that visual analytics alone improves patient outcomes.

VI. RELATED WORK

Prior work has examined healthcare dashboards for quality measurement, clinical performance monitoring, and operational management [1]. These systems commonly combine indicators and visual summaries to help users monitor variation and investigate areas for improvement. The present framework focuses specifically on integrating emergency-department flow and experience indicators across multiple views.

The framework also draws on exploratory data analysis and visual-encoding principles. Bar charts can compare categories, time-series views can reveal change over time, scatter plots can show distributions and potential associations, and heatmaps can expose concentrations across day-and-hour combinations [3], [4]. The choice of visual should be driven by the question being asked, and the interpretation should account for sample sizes and data limitations.

A multi-view design offers a plausible advantage over a single static summary because it separates high-level monitoring from date-range comparison, detailed review, and exploratory analysis. However, the supplied screenshots do not constitute a controlled comparison with static reporting. Any claim of improved efficiency or usability would

require direct testing using representative users, predefined tasks, and measurable outcomes.

VII. METHODOLOGY

A. System Overview

The proposed framework has four linked views. (1) Monthly View summarizes patient volume, average wait, satisfaction, referrals, admission status, the 30-minute target indicator, demographic distributions, referral department, and day-by-hour activity. (2) Consolidated View presents corresponding indicators for a selected date range. (3) Patient Details supports authorized inspection of records for traceability and validation. (4) Key Takeaways supports exploratory analysis of satisfaction by waiting-time band, patients and average waiting time by admission hour, the displayed correlation measure, waiting time by referral department, and satisfaction by age group. Together, these views address RQ1 by integrating related measures and RQ2 by supporting multiple analytical levels.

B. Data Collection

The dashboard was developed and tested by the researcher using the available hospital source file. The prototype includes patient-level fields such as patient identifier, name, gender, age, admission date, race, waiting time, referral department, and admission status, alongside summary indicators for patient volume, average waiting time, satisfaction, referrals, and related breakdowns. KPI calculations were checked against the available source data. The paper does not claim an independently audited production deployment; the source system, extraction pipeline, full data dictionary, and refresh process were not documented in the materials available for this paper. Patient-level screenshots used in a publication should mask names and direct identifiers unless disclosure is explicitly authorized.

C. Data Preprocessing

The proposed preprocessing workflow includes: (1) verify the source schema and data types; (2) standardize date and time fields; (3) identify duplicate visit records using a documented key; (4) profile missing, invalid, or out-of-range waiting-time and satisfaction values; (5) standardize

category labels; (6) derive admission hour and waiting-time bands using documented rules; and (7) reconcile row counts and aggregate values against the source. Missing values should be reported rather than silently converted to zero. The final study should publish inclusion and exclusion rules and a metric dictionary.

Patient-level information should be minimized in research outputs. Names and direct identifiers should be masked or removed unless their use is necessary and authorized. Access should be role-based, and small demographic groups should be aggregated where disclosure is possible. Demographic comparisons must be interpreted cautiously and only for legitimate analytical purposes.

D. Performance Evaluation

To address the accuracy component of RQ3, the researcher checked the dashboard's KPI calculations against the available hospital source data. The check should use the same reporting period, filters, inclusion rules, and aggregation logic as the dashboard. The KPI set includes patient totals, average waiting time, satisfaction, referral counts, admission-status counts, and the 30-minute target indicator, as applicable to each view. The available validation establishes that the calculations were checked against the source file.

Table I presents a sample validation summary.

TABLE I
SAMPLE KPI VALIDATION RESULTS (JUNE 2023)

KPI	Source Dataset Value	Dashboard Value	Status
Total Patients	408	408	Match
Average Wait Time (minutes)	35.4	35.4	Match
Average Satisfaction Score	5.18	5.18	Match
Total Referrals	158	158	Match

E. Recommendation Strategy

The framework can support operational questions rather than automatically prescribing clinical action. For example, a period with high patient volume and longer waits may warrant a staffing or process review. Differences by department or patient group should be interpreted alongside urgency, case mix, sample size, and other relevant factors. Correlation

values should be verified from underlying records and should not be interpreted as causal evidence. Thresholds and alerts require agreement from clinical and operational owners.

F. Report Generation

For reproducible reporting, each exported report should state the selected period, refresh timestamp, filters, metric definitions, exclusions, and known limitations. The monthly view is suitable for routine monitoring; the consolidated view supports date-range comparison; patient details support authorized audit or data-quality checks; and key takeaways support exploratory review. Identifiable patient information should not be included in broadly distributed exports.

G. System Implementation

The prototype is consistent with a Power BI-style implementation containing interactive filters, KPI cards, charts, and page navigation. A logical implementation can be divided into a source-data layer, preprocessing and semantic-model layer, centralized measure layer, and presentation layer. Shared measures should be reused across views to reduce inconsistent calculations.

VIII. SYSTEM ARCHITECTURE

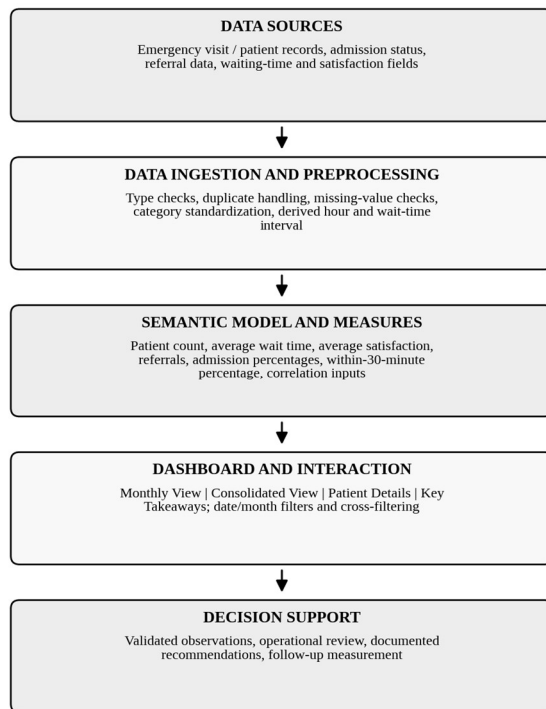


Fig. 1 Logical architecture of the proposed multi-view emergency-department BI framework.

IX. EXPERIMENTAL RESULTS

The screenshots and researcher testing provide evidence that the four-view dashboard prototype has been implemented. In the Monthly View for June 2023, the displayed cards show 408 patients, a 35.4-minute average wait, a satisfaction score of 5.18, and 158 referrals. The Consolidated View screenshot shows 429 patients, a 35.3-minute average wait, a satisfaction score of 4.83, and 183 referrals for the displayed date selection. The date range shown in the supplied material appears potentially inconsistent in chronological order; confirm the date-format convention and selected range before publication. These displayed figures are descriptive examples. The researcher checked KPI calculations against the available hospital source data, but a numerical reconciliation table was not provided, so no exact accuracy percentage or discrepancy rate is reported.



Fig. 2 Monthly View



Fig. 3 Consolidated View

The Monthly View includes admission status, the 30-minute target indicator, age group, gender, referral department, race, and a day-by-hour heatmap. During prototype testing, these elements were reviewed as ways to inspect demand and patient characteristics. The dashboard's multiple breakdowns support the intended monitoring workflow, while full verification of every interaction, filter-propagation path, empty-period condition, and date boundary would require a documented test matrix.

The Key Takeaways page includes satisfaction by waiting-time band, patient count and average wait by admission hour, a displayed correlation value of -0.04 , average waiting time by referral department, and satisfaction by age group. The correlation is reproduced as displayed in the dashboard; without the calculation method, sample size, and statistical details, it should not be interpreted as evidence of a meaningful or causal relationship. The Patient Details view can support authorized record-level checks, but any screenshot used in the paper must mask direct identifiers. The researcher-performed prototype review indicates that the views correspond to practical monitoring tasks; formal

[illegible][illegible]

TABLE II
SUMMARY OF DASHBOARD COMPONENTS AND INTENDED ANALYTICAL USE

This paper presented a multi-view business intelligence framework for monitoring emergency-department performance. The framework integrates patient volume, waiting time, satisfaction, referrals, admission outcomes, time-of-day patterns, demographic breakdowns, and authorized patient-level detail across four complementary views. The prototype was developed and tested by the researcher, and KPI calculations were checked against the available hospital source data. The views support intended tasks such as monthly monitoring, date-range comparison, referral-department analysis, satisfaction exploration, and authorized record review. However, no quantified KPI reconciliation results or formal representative-user study results are reported. Accordingly, RQ3 is addressed through source-data checking and researcher-performed prototype testing. Future work should document KPI-by-KPI comparisons and conduct a task-based study with representative users.

XII. FUTURE WORK

- Conduct a formal usability study with representative staff using predefined tasks; report task success, completion time, errors, requests for help, and user feedback.
- Assess longer-term patterns while accounting for day of week, triage priority, case mix, staffing, and other potential confounders.
- Apply privacy safeguards, mask identifiers, and aggregate small demographic groups where appropriate.
- Document refresh frequency, data lineage, access controls, failure handling, and operational ownership.

ACKNOWLEDGMENT

The authors would like to thank the Department of Computer Science at the college for providing the necessary facilities and academic support to carry out this work.

REFERENCES

- [1] D. Dowding, R. Randell, P. Gardner, G. Fitzpatrick, P. Dykes, J. Favela, S. Hamer, Z. Whitewood-Moores, N. Hardiker, E. Borycki, and L. Currie, "Dashboards for improving patient care: Review of the literature," *Int. J. Med. Inform.*, vol. 84, no. 2, pp. 87–100, Feb. 2015, doi: 10.1016/j.ijmedinf.2014.10.001.
- [2] World Health Organization, *Data Quality Review: A Toolkit for Facility Data Quality Assessment, Module 3: Data Verification and System Assessment*. Geneva, Switzerland: WHO, 2017.
- [3] S. Few, *Information Dashboard Design: The Effective Visual Communication of Data*, 2nd ed. Burlingame, CA, USA: Analytics Press, 2013.
- [4] J. W. Tukey, *Exploratory Data Analysis*. Reading, MA, USA: Addison-Wesley, 1977.
- [5] IEEE, "IEEE Editorial Style Manual for Authors," IEEE Publishing Operations, updated Jul. 29, 2024.