




Business Intelligence-Based System to Enhance National Health Insurance Claim Reporting in Hospitals: Design and Optimization Approach

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Abstract. This study aims to design a system based on Business Intelligence (BI) with an integrated Data Warehouse (DW) foundation. The system was developed to address critical operational and financial challenges in the National Health Insurance (JKN) claim process as well as improve reporting efficiency in hospitals. Additionally, it is designed to transform the claim management pattern from an administrative function into a strategic function based on data. Our methodology employs a four-phase strategy: the first phase is the design of the system architecture, the next phase is the ETL (Extract, Transform, Load) process, the third phase is the development of a data warehouse, and the last phase is the development of business intelligence. As an outcome, this research presents a claims monitoring dashboard interface, which includes analysis of rejected claims, department performance, financial trends, and claims submission monitoring. This design primarily produces a set of interactive dashboards and analytical reports to facilitate strategic decision-making. This study obtained data from the Hospital Information System (SIMRS), integrated with the INACBG (Indonesia Case Based Groups) platform and the National Health Insurance (JKN) e-claim application. Data will be extracted in accordance with standards via the ETL process for presentation in BI format. In conclusion, the developed system can help optimize the JKN claims process, assist management in decision-making, and improve hospital claims acceptance. Thus, this research has an impact on improving the financial performance and income of hospitals.

Keywords: Business Intelligence, Data Warehouse, Claim, JKN, Dashboard.

1 Introduction

In the landscape of healthcare financing in Indonesia, the primary source of hospital revenue comes from the National Health Insurance (JKN) program administered by BPJS Kesehatan [1, 2]. BPJS Kesehatan claims reporting is the process of collecting and submitting patient care costs to BPJS Kesehatan [3]. The claims submission process is supported by a workflow that utilizes three main systems: SIMRS, the INA-CBGs

grouping application, and the E-Claim platform. This flow is highly complex, ineffective, prone to data redundancy, and difficult to monitor and evaluate [4]. As a result, claim submission is suboptimal. Therefore, Business Intelligence (BI) with a Data Warehouse foundation is relevant for integrating, analyzing, reporting, and optimizing the BPJS claims process [5].

The main issue in the implementation of this reporting process is the lack of integration between these systems. Many Hospital Management Information Systems (SIMRS) in Indonesian hospitals are not yet interconnected, or even if they are, they are still unable to connect with the E-Claim application through a bridging system. This condition forces staff to repeatedly perform manual data entry, a redundant and time-consuming process that is prone to human error [4]. As a result, delays in claim payments often occur, which can significantly disrupt the hospital's financial cash flow [2, 6].

To address this challenge, an integrated system is needed that can transform raw data into strategic information for further action. Business Intelligence (BI) is a set of processes and technologies that can help organizations collect, analyze, and present data visually to support better decision-making [7]. In the healthcare service paradigm, BI can integrate data from various sources to optimize financial procedures such as the JKN claim process, provide a comprehensive view, monitor service quality, and improve efficiency [5].

Although hospitals possess large volumes of data generated from various operational systems, this data is often poor in information quality because it remains merely transactional, isolated, and cannot be analyzed holistically [8]. This issue is also encountered by the author at the research site, Dr. Hasan Sadikin General Hospital in Bandung, Indonesia. The claim process there has not yet integrated data from SIMRS with the IN-ACBG's application and the BPJS E-Claim platform, making the claim process inefficient and creating operational and financial risks. Furthermore, there is no data visualization for claim submissions, making it difficult for management to monitor the claim process. Data shows that this problem is systematic; case studies from other hospitals in Indonesia highlight that 25.2% of total inpatient claim files are returned by BPJS, with the main reasons being coding confirmation (42.4%) and incomplete medical summaries (30.3%) [2]. Another study at UNS Hospital also revealed that 11.3% of pending claims were caused by INACBG coding issues [3]. These figures underscore the urgency of an integrated and intelligent reporting system.

Previous studies have mapped out the landscape of problems and potential solutions. A study by Saputra & Prima (2022) [4] comprehensively described the technical workflow and integration challenges between SIMRS and the E-Claim system in Indonesia [4]. Meanwhile, research by Opitasari & Nurhayati (2019) [2], Bella et al. (2024) [3], Santiasih et al. (2021) [6], and quantitatively demonstrated the high rate of delayed claims and identified the root causes in coding and document completeness, which negatively impact hospital cash flow [6]. At the international level, have shown that the implementation of BI and data warehousing can effectively improve financial efficiency and patient safety, providing a proven model for success [8].

Based on the problems and studies mentioned above, the author hypothesizes that the design of a Business Intelligence system with a Data Warehouse foundation can

optimize the claim reporting process to BPJS. Business Intelligence can centrally integrate isolated data from SIMRS, the INACBG's application, and the BPJS E-Claim platform. BI dashboards and automated reporting offer benefits such as reducing claim processing time, lowering the number of pending and ineligible claims, providing strategic insights for management in decision-making, and improving hospital revenue efficiency.

2 Literature Review

Previous studies define Business Intelligence (BI) as a set of technologies and processes that can transform raw data into useful information for decision-making [9]. In the healthcare sector, previous research indicates that BI systems can assist stakeholders in making better decisions. BI can also improve service quality, reduce costs, and control risks more effectively [10]. Other studies have shown that BI can transform a static reporting culture into dynamic reporting through interactive dashboards, empowering managers and healthcare professionals to monitor Key Performance Indicators (KPIs) and detect anomalies in real time [11].

A Business Intelligence (BI) system is fundamentally based on a Data Warehouse (DW), which serves as a centralized repository that consolidates data from many sources into a structured manner for analytical objectives [12, 13]. A data warehouse encompasses multiple processes, including Extract, Transform, and Load (ETL). ETL is employed to purify data from diverse heterogeneous sources [14]. The processed data is subsequently organized into a framework referred to as Online Analytical Processing (OLAP). This paradigm allows users to conduct analysis from several perspectives—capabilities that typical transactional databases cannot easily provide [15]. In hospitals, data warehouses have been proven to support quality improvement efforts, for example, in conducting retrospective medical detection quality control [16].

In Indonesia, JKN claims submission involves several different, non-integrated systems: the Hospital Management Information System (SIMRS), the INA-CBGs grouping application, and the E-Claim platform [4]. As a result, repetitive data entry is required. Consequently, data inconsistencies often result in delays in the hospital claims submission process, and these delays are a major cause of claim rejections [17].

International studies have demonstrated success in optimizing the insurance claims process. The implementation of BI has improved the accuracy of insurance claims billing. BI can significantly improve claims collection [8]. Recent studies have shown that BI can increase claim approvals, reduce claim rejections, and optimize resource allocation [1]. This demonstrates the potential for BI to positively impact BPJS claims.

However, in reality, implementing BI technology is not as easy as it seems. Other factors influencing the sustainability of BI include top-level management, a non-technical aspect for BI users and decision-makers. Alignment of vision, mission, and work culture is also a non-technical factor. Furthermore, good governance is another factor for BI's success [18]. Furthermore, during the development process, end-users need to be involved with BI. User training is necessary after BI is implemented. This is a key factor in the success of a BI system [18].

3 Method

We initiated this research in four phases, each focused on the design and development of information technology products to address issues in JKN claims. In the first phase, the authors created the system design architecture. This architecture divides the design into three main layers: the source layer, the database layer, and the application layer. The next phase explains the process of extracting data from various existing sources. The data is transformed and cleaned according to applicable standards, then loaded into a centralized database. The third phase involves creating the data warehouse. The data warehouse that was created adopted the star schema concept. The star schema groups data into fact tables and dimension tables. The final phase is the core of this research, focusing on creating a BI-based front-end dashboard. This process makes the data warehouse easy to understand quickly through the visualization of the existing BI dashboard.

4 Results and Discussions

4.1 Multi-Layer System Architecture Design

The BI system architecture is provided in several layers, which are useful for ensuring BI is built according to plan and ensuring system scalability is maintained according to the scope of needs. The first layer is the source layer, which consists of operational systems that serve as the primary data sources, including the Hospital Information System (SIMRS), the INA-CBG application, and the E-claim application. SIMRS as the main application in hospitals is a collection of applications that are integrated with each other. These applications contain various kinds of data including: patient data, administrative data, EMR data, pharmacy data, supporting services, billing data, and employee data. When a patient visits the hospital, registration will be carried out in SIMRS [3]. During registration, SIMRS will generate a unique code as the patient's hospital identity in the form of a medical record number. However, this medical record number is not recognized in the E-claim JKN application and cannot be integrated into INA-CBG. E-claim only generates the BPJS participant number as an identity and the SEP (Eligibility Letter of Participant) number as a marker that the patient is hospitalized. With SIMRS, officers need to manually enter those numbers when patient registration is performed [17], as illustrated in Fig. 1.

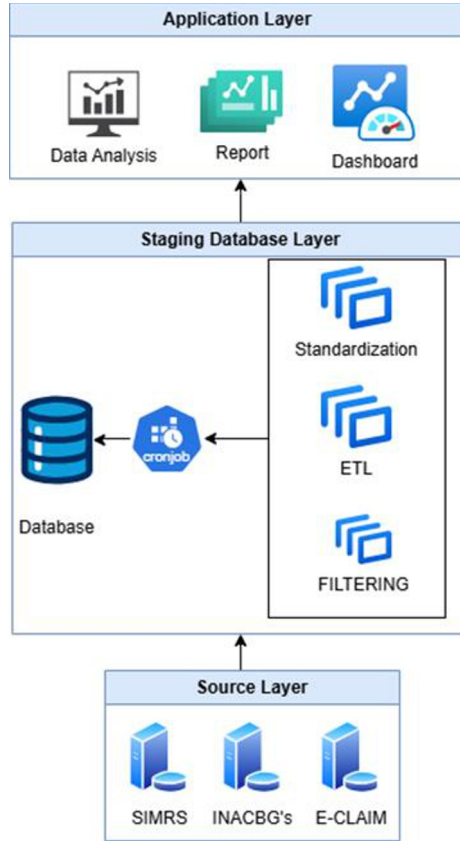


Fig. 1. Multi-layer system architecture.

The second layer is the Database Staging Layer, where raw data from the source is collected, processed, and prepared. The processes carried out include cron jobs to run scheduled tasks, standardization to generalize data type formats, ETL processes for data mapping, and filtering to segment data according to required criteria. The ETL process is used to collect data from layer 1 and process it semantically and syntactically, thereby making it valuable for users. The formatted data will be stored in a centralized database that can be accessed by BI [19].

The third layer is the application layer, which handles BI dashboard visualization, analytics, and claims reporting. The data that has been stored in the layer 2 database will be retrieved and visualized to become useful information for users. This architecture serves as a foundation to ensure that all relevant data is accessible for subsequent processing and analysis stages, as illustrated in Fig. 1.

4.2 Extract, Transform, Load (ETL) Process for Data Integration

After the architecture is defined, the next step is the ETL process. In the Extract process, data is collected from three main sources, namely SIMRS, INACBG's applications, and the E-claim platform. From SIMRS, data is obtained related to patient data, service history, medical data, pharmacy, supporting examinations, service billing, and employee data through queries to the database. From INACBG's, data is obtained such as diagnosis coding (ICD-10), procedure coding (ICD-9), INA-CBG tariff, and grouping code through the get API process. Meanwhile, from the E-claim platform, data is obtained such as SEP number, submission date, claim status (accepted, rejected, pending, or disputed) through the get API process [7, 19].

In the Transform process, cleansing is carried out on service history data, medical records, diagnoses, and procedures that are incomplete. Cleansing is also applied to duplicate patient data and inconsistent patient names. Normalization is performed on doctors' diagnoses and procedures according to ICD-10 and ICD-9 coding standards. Mapping is done between BPJS doctor codes and hospital doctor codes. Data formats are standardized, for example, the date format originally in day-month-year is converted into year-month-day. All of these data are linked to a single primary key, namely the SEP number. This process ensures that previously separate data becomes integrated and consistent [7] as shown in Fig. 2.

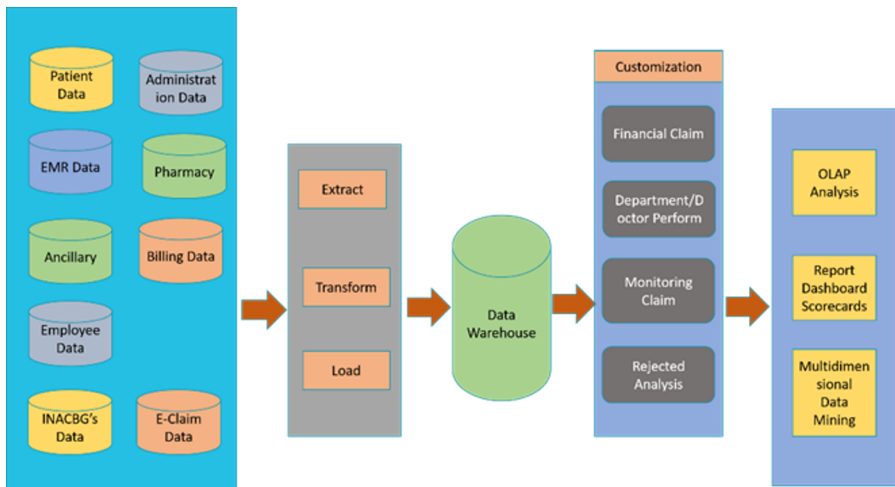


Fig. 2. . ETL process.

In the Load process, data is loaded into the Data Warehouse. After the data is normalized, cleansed, and standardized, it is first stored in the staging database before being stored in the Data Warehouse. Once the data is ready in staging, it is then structured and stored in a centralized database. This way, the data is properly categorized, making it easy and quick to access [7] as shown in Fig. 2.

4.3 Development of a Centralized Data Warehouse with a Dimensional Model

At the core of this architecture is a Data Warehouse (DW) designed using a dimensional model (star schema). This model organizes data into fact tables, which contain quantitative metrics, and dimension tables, which hold descriptive attributes, as shown in Table 1. This structure is highly optimized for fast and complex analytical queries, serving as the foundation of BI functionality (Adnane & Zerari, 2024) [20]. It is fundamentally different from the transactional databases (OLTP) used in SIMRS, which are designed for quick individual data entry and retrieval.

Table 1. Fact and Dimensional Model for BPJS Claim Analysis.

Table	Type	Column
Claim_fact	Fact Table	ID_Klaim (PK), No_medrec, Id_layanan, Id_emr, Id_penunjang, Id_billing, Nip, No_sep, Grouping_code, Tanggal_Lengkap, Bulan, Kuartal, Tahun, Jumlah_Tertagih, Jumlah_Dibayar, Jumlah_Pending, Alasan
Pasien_dim	Dimension Table	No_medrec, nama, jenis kelamin, kota
Admin-istrasi_dim	Dimension Table	Id_layanan, tanggal pelayanan, departemen, dokter
Emr_dim	Dimension Table	Id_emr, resume pasien, SBPK, diagnosis, tindakan
Farmasi_dim	Dimension Table	id_obat, nama obat
Penunjang_dim	Dimension Table	Id_penunjang, lab, radiology, nuclear, anatomical pathology, spirometry
Billing_dim	Dimension Table	id_billing, service name and service tariff
Pegawai_dim	Dimension Table	id_pegawai, employee name
INACBG's	Dimension Table	Grouping_code, diagnosis coding (ICD-10) and procedure code (ICD-9)
Eclaim	Dimension Table	No_sep, submission date, claim status, and rejection reason

4.4 Development of BI Front-End for Data Visualization

The previous layer represents a collection of processes running behind the scenes, also known as the backend. Conversely, this final layer explains the processes running on the screen, also known as the frontend. Business Intelligence is the presentation frontend of a multidimensional Data Warehouse that has been structured [15]. As needed, we built a web-based Business Intelligence dashboard using the D3JS library. D3JS is a JavaScript-based library for building dashboards on a web platform. D3JS's advantages include its flexibility and ability to handle large amounts of data, allowing dashboard visuals to be tailored to BI specifications [21]. This layer translates complex data from the Data Warehouse into visual insights that are easily understood by non-technical users through interactive dashboards and reports. For example, the claim sta-

tus percentage dashboard is taken from the DW table claim_fact, the claim trend dashboard from the claim_fact table, and the pending claims dashboard from the eclaim dimension table. The interface developed meets the specific needs of hospital management, as shown in Fig. 3.



Fig. 3. Claim Overview Dashboard.

Fig. 3 displays the real-time status of the claims process. These include displays of total claims submitted, total claims issued, the claim issued ratio, and the proportion of continued claims. This dashboard is useful for quickly monitoring the status of eligible claims. The pending dashboard and the pending reasons dashboard are used to help analyze the root causes of claim rejections. The KSM performance dashboard is used to monitor and evaluate total approvals based on the performance of claims reporting received by departments or physicians. This dashboard provides valuable insights for hospital management to inform strategic decision-making.

5 Conclusion

Business Intelligence (BI) can be used as a technology to assist the hospital claims submission process at Dr Hasan Sadikin General Hospital (RSHS). To function effectively, BI requires a Data Warehouse as its primary data source. The Data Warehouse integrates data from hospital claims tools into the BPJS claims submission process. As

a outcome, BI serves as a management assistant in future decision-making. Moreover, integration can help staff avoid re-entering data into the INACBG platform and JKN claims. In addition to these benefits, BI shows an increase in JKN revenue at RSHS from September 2024 to March 2025, proving that BI can optimize the hospital claims submission process in Indonesia.

References

1. Sambodo, N.P., Bonfrer, I., Sparrow, R., Pradhan, M., van Doorslaer, E.: Effects of performance-based capitation payment on the use of public primary health care services in Indonesia. *Social Science and Medicine* **327**, 115921 (2023)
2. Opitasari, C., Nurhayati, N.: Evaluation of claim submission and returning for BPJS inpatient services: a case study of hospital X in 2017. *Health Science Journal of Indonesia* **10**(1), 27–31 (2019).
3. Bella, C.R., Pratama, A., Abidin, A.Z.: Overview of the Causes of BPJS Health Pending Claims Due to Inaccuracy of Diagnosis Codes in Sebelas Maret University (UNS) Hospital. *Journal/Proceedings info unclear*, **6**, 75–83 (2024).
4. Saputra, W.H., Prima, A. E-Claim System For Health Insurance And Social Security (BPJS) Types In Indonesia: Innovation And Effectiveness Of Services. *Journal of Society Medicine*, **1**(1), 14-24 (2022).
5. Spil, T.A., Stegwee, R.A., Teitink, C.J.: Business intelligence in healthcare organizations. In: *Proceedings of the 35th Annual Hawaii International Conference on System Sciences*, pp. 9–pp. IEEE (2002)
6. Santiasih, W.A., Simanjourang, A., Satria, B.: Analisis penyebab pending klaim BPJS Kesehatan rawat inap di RSUD Dr. RM Djoelham Binjai. *Journal of Healthcare Technology and Medicine* **7**(2), 1381–1394 (2022)
7. Tavera Romero, C.A., Ortiz, J.H., Khalaf, O.I., Rios Prado, A. Business intelligence: business evolution after industry 4.0. *Sustainability*, **13**(18), 10026 (2021).
8. Ferranti, J.M., Langman, M.K., Tanaka, D., McCall, J., Ahmad, A.: Bridging the gap: Leveraging business intelligence tools in support of patient safety and financial effectiveness. *Journal of the American Medical Informatics Association* **17**(2), 136–143 (2010).
9. Nambiar, A., Mundra, D.: An Overview of Data Warehouse and Data Lake in Modern Enterprise Data Management. *Big Data and Cognitive Computing* **6**(4) (2022).
10. Huang, H.C., Wang, H.K., Chen, H.L., Wei, J., Yin, W.H., Lin, K.C.: Adopting business intelligence techniques in healthcare practice. In: *Informatics*, **11**(3), 65. MDPI (2024)
11. Bharadiya, J., Bharadiya, J.P.: Machine Learning and AI in Business Intelligence: Trends and Opportunities. *International Journal of Computer* **48**(1), 123–134 (2023).
12. Fan, X., Lu, J.: Enterprise Level Data Warehouse System Based on Hive in Big Data Environment. *Procedia Computer Science* **243**, 67–75 (2024).
13. Andina, M.E., Nelde, A., Nolte, C.H., Scheitz, J.F., Olma, M.C., Krämer, M., Meisel, E., Bingel, A., Meisel, A., Scheibe, F., Endres, M., Schlemm, L., Meisel, C.: Datawarehouse-enabled quality control of atrial fibrillation detection in the stroke unit setting. *Heliyon* **9**(8) (2023).
14. Antunes, A.L., Cardoso, E., Barateiro, J.: Incorporation of Ontologies in Data Warehouse/Business Intelligence Systems – A Systematic Literature Review. *International Journal of Information Management Data Insights* **2**(2) (2022).

15. Hassan, C.A.U., Hammad, M., Uddin, M., Iqbal, J., Sahi, J., Hussain, S., Ullah, S.S.: Optimizing the Performance of Data Warehouse by Query Cache Mechanism. *IEEE Access* **10**, 13472–13480 (2022).
16. Krasowski, M.D., Schriever, A., Mathur, G., Blau, J.L., Stauffer, S.L., Ford, B.A.: Use of a data warehouse at an academic medical center for clinical pathology quality improvement, education, and research. *Journal of Pathology Informatics* **6**(1), 45 (2015).
17. Oktamianiza, Rahmadhani, Y., Yulia, Y., Putri, H.M.: Literatur Riview Tentang Faktor Penyebab Klaim Tidak Layak Bayar BPJS Kesehatan Di Rumah Sakit Tahun 2020. *Jurnal Ilmiah Perekam Dan Informasi Kesehatan Imelda (JIPIKI)* **6**(1), 83–90 (2021).
18. Mauro, M., Noto, G., Prenestini, A., Sarto, F.: Digital transformation in healthcare: Assessing the role of digital technologies for managerial support processes. *Technological Forecasting and Social Change* **209**, 123781 (2024).
19. Cheng, K.Y., Pazmino, S., Schreiweis, B.: ETL Processes for Integrating Healthcare Data – Tools and Architecture Patterns. *Studies in Health Technology and Informatics* **299**, 151–156 (2022).
20. Adnane, Y.I., Zerari, M.: Optimizing business intelligence classification rule mining using quantum-inspired genetic algorithm. *IEEE Access* **12**, 137041–137053 (2024).
21. Zhao, X., Wang, X., Zou, X., Liang, H., Bai, G., Zhang, N., Huang, X., Zhou, F., Zhao, Y.: Graph visualization efficiency of popular web-based libraries. *Visual Computing for Industry, Biomedicine, and Art* **8**(1) (2025).

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