
CHAPTER 1

INTRODUCTION

1.1 Rationale

Chronic Kidney Disease (CKD) is currently one of the leading causes of death in South-east Asia and is projected to rank among the top 10 causes of years of life lost (YLL) in most Asian countries by 2040, with Indonesia estimated to contribute more than 50% of the regional burden [1, 2]. This rising trend is largely driven by the increasing prevalence of uncontrolled hypertension and diabetes, which together account for more than 60% of CKD cases.

In response, the Government of Indonesia launched the National Health Insurance (JKN) program in 2014, administered by BPJS Kesehatan, with the aim of providing equitable and comprehensive healthcare services for all citizens. As of November 2024, JKN has covered over 277 million participants. Despite the scale of this program, challenges remain in delivering timely services, especially for patients with chronic diseases who require consistent and structured outpatient care.

In the context of chronic kidney disease (CKD), Rahmani (2024) used process mining to map trajectories from diabetes to hypertension to CKD, reporting an average transition time of approximately two months between stages, with model fitness of 0.98 [3].

Zhang et.al. (2024) further propose combining cohort epidemiology with process mining to study CKD progression, enabling multi-state modeling and risk factor correlation [4]. These frameworks illustrate how event log mining can visualize and quantify delays in chronic disease pathways.

According to Indonesia's Minister of Health Decree No. HK.01.07/MENKES/1634/2023, the management of chronic kidney disease (CKD) has been standardized through a set of medical procedures to be performed periodically at primary and secondary healthcare facilities. These include diagnostic and evaluative measures such as kidney function tests, therapy assessment, and patient education, which are required to be conducted every 3 to 6 months, depending on the patient's clinical condition. This regulation serves as the baseline reference for service time in this study, enabling comparison between actual service durations from event logs and the nationally established healthcare standards.

Given these issues, it becomes essential to evaluate actual service time using data-driven methods. Process mining offers a promising approach, enabling healthcare analysts to reconstruct real process flows from event logs, identify performance bottlenecks, and measure durations of medical services. This study applies process mining techniques to outpatient data of CKD patients under JKN, aiming to assess the time dimension of care delivery across different provinces in Indonesia.

1.2 Theoretical Framework

This study is grounded in the theoretical foundation of **Process Mining**, a data-driven methodology used to analyze and optimize real-world processes by extracting knowledge from event logs recorded by information systems. In the healthcare domain, process mining has been widely applied to reveal inefficiencies, bottlenecks, and variations in service delivery, particularly regarding patient flow and service time [5, 6].

Process mining supports three core types of analysis:

- **Process Discovery:** Constructs a process model based solely on event logs without prior knowledge of the process structure.
- **Conformance Checking:** Compares the discovered model with expected or normative models to assess deviations and compliance.
- **Performance Analysis:** Measures operational performance indicators, such as throughput time, activity duration, and waiting times.

This research focuses on **performance analysis**, specifically measuring the **duration of outpatient healthcare services** for Chronic Kidney Disease (CKD) patients covered by the Indonesian National Health Insurance (JKN) program. The goal is to evaluate actual service durations and identify prolonged activities that contribute to inefficiencies in patient care.

To support this analysis, the study employs the following process mining algorithms:

- **Heuristic Miner** – suitable for discovering process models in the presence of noise or incomplete data.
- **Inductive Miner** – ensures model soundness and generates structured Petri Nets.
- **Fuzzy Miner** – useful for simplifying complex processes with many variants.

Event logs are modeled as *Petri Nets* and analyzed using tools such as **ProM**, **PM4Py**, and **Disco Miner** to visualize flow, compute throughput times, and identify bottlenecks. The central metric examined is **throughput time**, representing the total time a patient spends from registration to the completion of service.

By relying solely on process mining, this framework enables objective and systematic evaluation of service delays and regional disparities in CKD outpatient treatment under JKN, thus providing data-driven insights for healthcare quality improvement.

By analyzing actual service durations across different regions and facilities using process mining, this study aims to identify service inefficiencies, especially in outpatient care for Chronic Kidney Disease (CKD) patients. The outcome is expected to provide data-driven recommendations to improve timeliness in healthcare service delivery, in alignment with

national standards such as those stipulated in the Indonesian Ministry of Health's Minimum Hospital Service Standards (SPM) [7].

1.3 Problem Statement

Although the National Health Insurance (JKN) program has achieved near-universal healthcare coverage in Indonesia, inefficiencies in service time remain a significant issue, particularly in outpatient care for chronic conditions such as Chronic Kidney Disease (CKD). Existing monitoring systems and administrative reports often fail to capture the full sequence and duration of healthcare activities, limiting the ability to identify where time delays occur within the service process.

This lack of visibility into actual service time results in prolonged and inconsistent care delivery, negatively affecting operational efficiency and standardization of outpatient processes. A systematic, data-driven approach is needed to analyze and visualize real service durations across different regions and healthcare facilities. Without such analysis, efforts to improve service efficiency and optimize healthcare workflows remain fragmented and lack a strong empirical foundation.

1.4 Research Objectives

This research aims to:

1. Model the outpatient service process for CKD patients using process mining techniques.
2. Measure actual service durations across medical procedures, regions, and timeframes.
3. Identify service bottlenecks and activities contributing most to overall delays.
4. Provide insights for time-based process improvement within the JKN framework.

1.5 Research Contribution

This study contributes to healthcare process analysis by providing:

- Empirical evidence of time performance issues in chronic disease management.
- Region-based comparisons of service time using real-world healthcare data.
- A framework for applying process mining in evaluating service time.

1.6 Conceptual Framework/Paradigm

This study utilizes sample data from BPJS Kesehatan (Indonesia's National Health Insurance) covering the years 2015 to 2018, consisting of three types of healthcare services:

1. Primary Care Facilities (FKTP) – non-capitation
2. Advanced Referral Health Facilities (FKRTL)

However, only FKTP non-capitation and FKRTL data are used in this study because the capitation FKTP dataset does not provide detailed information about medical actions or procedures performed in each service process. Therefore, it cannot support event log construction required for process analysis.

The focus of this research is on patients diagnosed with Chronic Kidney Disease (CKD), coded as N18 according to ICD-10-CM. There are 21 CKD cases recorded in the FKTP non-capitation data and 61,803 cases in the FKRTL data. The dataset includes various attributes such as participant demographics, healthcare facility information, participant segment, diagnosis, type of service, medical procedures, and cost.

This data will be transformed into event logs, which are then analyzed using a process mining approach with three main algorithms: Heuristic Miner and Inductive Miner. The goal is to map the actual service flow received by CKD patients, analyze the service duration at each step, and identify which actions take the longest and shortest time.

This data will be transformed into event logs, which are then analyzed using a process mining approach with two main algorithms: Heuristic Miner and Inductive Miner. The objective is to reconstruct the actual service flow experienced by CKD patients, evaluate the time duration of each process step, and identify stages with the longest and shortest durations.

The discovered process models will be visualized using Petri Nets and evaluated using four key metrics: fitness, precision, generalization, and simplicity. The analysis of service time will refer to national healthcare standards established by the Indonesian Ministry of Health, particularly those related to outpatient care.

By applying process mining for service time analysis, this study aims to provide a data-driven understanding of service performance, identify bottlenecks in the CKD outpatient process, and deliver actionable recommendations for improving timeliness and efficiency in JKN healthcare delivery. The conceptual paradigm of this research is illustrated in Figure 1.1.

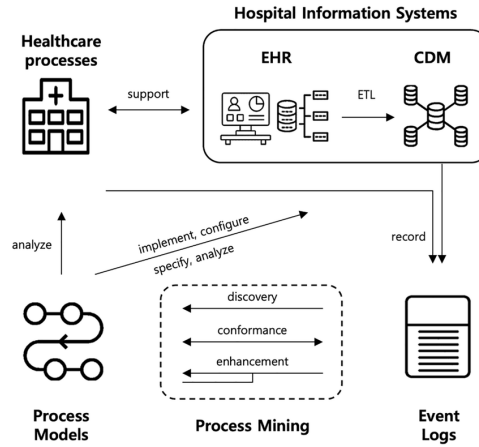


Figure 1.1: Process Mining Based Framework for Healthcare Service Time Evaluation

Source: Park et al. (2023), PLOS ONE

1.7 Statement of the Problem

The Indonesian National Health Insurance (JKN) program has successfully expanded healthcare access to millions of citizens. However, despite near-universal coverage, prolonged and inconsistent service durations particularly in outpatient services for chronic diseases such as Chronic Kidney Disease (CKD) remain a persistent issue. These delays may occur during registration, consultation, diagnostics, treatment, or pharmacy services.

Current monitoring mechanisms lack detailed, process-oriented visibility to assess how these services are actually executed. Without granular process data, it is difficult to evaluate inefficiencies or locate bottlenecks that contribute to extended waiting and treatment times. Therefore, a structured approach that leverages actual service logs is necessary to assess and improve the timeliness of patient care.

This research focuses on the following problems:

1. How can the analysis of service time in BPJS patient care processes across various healthcare facilities be performed using process mining techniques?
2. How can the application of Heuristic Miner and Inductive Miner algorithms support the identification of bottlenecks and variations in actual service duration?
3. How can process mining be applied to event log data of Chronic Kidney Disease (CKD) cases to evaluate interregional differences in service delivery time?

1.8 Objective and Hypotheses

1.8.1 Objective

To analyze service time performance in BPJS outpatient care, particularly for CKD cases, using process mining techniques to support operational improvements in healthcare delivery. The specific objectives of this research are as follows:

1. To evaluate the actual duration of outpatient services provided to BPJS patients across various cities and regencies using process mining techniques.
2. To apply and compare the performance of Heuristic Miner and Inductive Miner in modeling service flows and detecting performance issues.
3. To identify time-related bottlenecks in the healthcare process, such as delays in treatment, referral, or medication dispensing.
4. To analyze regional disparities in healthcare service duration using CKD outpatient data.
5. To propose recommendations based on empirical findings for reducing service time and improving operational efficiency.

1.8.2 Hypotheses

This study hypothesizes that the application of process mining, specifically using the Heuristic Miner algorithm, can effectively model and evaluate actual patient service flows based on healthcare event logs. By constructing Petri Net representations of service processes, it is possible to identify time-related inefficiencies, such as bottlenecks and delays, and to assess service time performance across different healthcare facilities. The Heuristic Miner algorithm supports this analysis by handling noise in real-world data and visualizing complex dependencies using logical connectors such as XOR and AND [8]. The generated Petri Net models provide insights into which activities require the most time and which process paths are most efficient, particularly in outpatient services for Chronic Kidney Disease (CKD) patients.

1.9 Assumption

The following assumptions are made to support the feasibility and validity of the process mining analysis in this study:

1. The event log data obtained from BPJS Kesehatan for the years 2015–2018 is complete, valid, and accurately reflects real healthcare service activities for CKD patients.

2. Each recorded activity contains reliable and correctly ordered timestamps, enabling accurate measurement of service durations.
3. CKD outpatient cases follow a relatively standard clinical process, allowing meaningful comparison of service durations across different healthcare facilities and regions.
4. The Petri Net process models generated by the Heuristic Miner and Inductive Miner are representative of actual service flows and are suitable for analyzing variations in time performance.
5. Process mining tools used in this study (e.g., ProM, PM4PY, Disco Miner) provide valid and interpretable output for evaluating healthcare service time performance.

1.10 Scope and Limitation

This study imposes certain boundaries to ensure a focused and feasible implementation. The scope and limitations are outlined as follows:

1.10.1 Scope

This research focuses on evaluating the duration of healthcare service delivery for patients diagnosed with Chronic Kidney Disease (CKD) under Indonesia's national health insurance program (BPJS Kesehatan). The study emphasizes the analysis of actual service times using process mining techniques to identify inefficiencies and performance issues in outpatient workflows.

The specific elements within the study scope include:

- **Methodology:** Process mining is adopted as the primary analytical approach to discover, visualize, and assess real healthcare processes based on event log data.
- **Service Type:** The analysis is limited to **outpatient services (rawat jalan)**. Other service types such as inpatient, emergency, or preventive care are excluded.
- **Focus Area:** The research focuses on patient records with a **Chronic Kidney Disease (CKD)** diagnosis, using BPJS claim data from the period of **January 1, 2015 to December 31, 2018**.
- **Geographic Scope:** The study covers **ten selected provinces** with high CKD outpatient service volume: Jakarta, West Java, Central Java, East Java, Banten, Yogyakarta, Bali, North Sumatra, South Sumatra, and South Kalimantan.
- **Process Mining Tools:** The service flows are discovered using the **Heuristic Miner** and **Inductive Miner** algorithms. Modeling is performed in **Petri net** form for further analysis.

- **Performance Evaluation:** The primary metric analyzed is **service time duration**, measured in **days**, depending on the service activity being evaluated. These durations are compared against **national service time benchmarks** outlined in **Permenkes No. HK.01.07/MENKES/1634/2023**, which specifies maximum allowable timeframes for each outpatient procedure or action.

1.10.2 Limitation

To maintain analytical clarity and validity, this study is limited in the following ways:

- Only CKD-related **outpatient** cases are analyzed; other diagnoses and service types are excluded.
- The analysis depends solely on **secondary data** derived from event logs; no surveys, interviews, or primary observational data are collected.
- The study evaluate service time
- All models are developed using a **fixed threshold value of 0.5**, which may affect the granularity or complexity of discovered process structures.
- Results may not be fully generalizable to all provinces or healthcare facilities outside the selected sample.

1.11 Significance of the Study

This study provides both theoretical and practical contributions to the field of health-care service performance analysis, particularly in the context of Indonesia’s National Health Insurance (JKN) system administered by BPJS Kesehatan. By applying process mining techniques to real-world event log data, the research presents a data-driven approach to evaluating service time, especially in outpatient care for Chronic Kidney Disease (CKD) patients.

1.11.1 Theoretical Significance

- **Application of Process Mining in Healthcare:** This study enriches academic literature by demonstrating the application of process mining—specifically, *Heuristic Miner* and *Inductive Miner*—to healthcare service data. It contributes to the growing field of digital health analytics and performance monitoring using real event logs.
- **Focus on Time-Based Performance Indicators:** Unlike traditional health service research that focuses on clinical outcomes or satisfaction surveys, this research emphasizes *service duration* as a key operational metric. It contributes to a better understanding of process efficiency in chronic disease management.

- **Insights into CKD Outpatient Workflows:** The study offers new insights into the service flow of Chronic Kidney Disease (CKD) care, providing a structured view of process patterns across multiple Indonesian provinces. This supports the broader use of event log data in evaluating chronic care delivery.
- **Comparative Modeling Techniques:** Through the comparison of Heuristic Miner and Inductive Miner outputs, the research supports future methodological advancements in selecting appropriate discovery algorithms for healthcare datasets [8].

1.11.2 Practical Significance

- **For Healthcare Providers:** This study enables hospitals and clinics to identify bottlenecks, prolonged delays, and inefficient transitions in outpatient service processes, thereby facilitating targeted process redesign to improve time efficiency.
- **For BPJS Administrators:** By revealing regional variations in service durations, the findings help BPJS prioritize healthcare facilities or provinces with significant inefficiencies for auditing and process optimization.
- **For Policymakers:** The research compares actual service durations with the latest Minimum Service Standards issued by the Ministry of Health (e.g., *Permenkes No. HK.01.07/MENKES/1634/2023*). This provides evidence to support regulatory enforcement and inform policy refinement related to outpatient care time benchmarks.
- **For Future Researchers:** This study presents a replicable framework utilizing process mining to analyze large-scale service log data. The methodology can be extended to study other diseases, time-related metrics, or healthcare domains.
- **For JKN Program Sustainability:** By highlighting inefficiencies in CKD outpatient service durations, the research contributes to improving overall healthcare service performance, supporting better resource utilization and more consistent patient care delivery within the JKN framework.