

## Forecasting Chronic Drug Demand Based on BPJS Kesehatan Claims Data Using the ARIMA Model in Gunungkidul Regency, Special Region of Yogyakarta, Indonesia

### Peramalan Kebutuhan Obat Kronis Berdasarkan Data Klaim BPJS Kesehatan Menggunakan Model ARIMA di Kabupaten Gunungkidul, Daerah Istimewa Yogyakarta, Indonesia.

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#### Abstract

Chronic diseases require continuous pharmacotherapy and generate sustained demand for essential medicines, particularly within universal health coverage systems. In Indonesia, pharmaceutical utilization under the National Health Insurance program is documented through administrative claims data, which provide an important basis for demand analysis and planning. This study aims to forecast chronic drug demand in Gunungkidul Regency, Special Region of Yogyakarta, using health insurance claims data and a time-series forecasting approach. A retrospective analysis was conducted using weekly aggregated claims data. Drug utilization patterns were examined, and demand forecasting was performed using the Autoregressive Integrated Moving Average model following standard time-series procedures. Forecast accuracy was assessed by comparing predicted values with observed utilization. The results indicate that the model effectively captures weekly demand patterns and short-term fluctuations, producing forecasts that closely align with actual utilization trends. These findings demonstrate that time-series forecasting based on claims data can provide reliable estimates of chronic drug demand. The study highlights the potential value of integrating forecasting models into pharmaceutical inventory planning to support timely drug availability and improve logistics efficiency within regional health insurance implementation.

*Keywords: Pharmaceutical Forecasting; Chronic Disease Management; Health Insurance Claims; Drug Utilization Analysis; Inventory Planning.*

#### Abstrak

Penyakit kronis memerlukan terapi obat yang berkelanjutan dan menimbulkan kebutuhan yang stabil terhadap obat esensial, terutama dalam sistem jaminan kesehatan semesta. Di Indonesia, pemanfaatan obat dalam Program Jaminan Kesehatan Nasional terdokumentasi melalui data klaim administrasi, yang memberikan dasar penting untuk analisis dan perencanaan kebutuhan obat. Penelitian ini bertujuan untuk meramalkan kebutuhan obat kronis di Kabupaten Gunungkidul, Daerah Istimewa Yogyakarta, menggunakan data klaim jaminan kesehatan dengan pendekatan peramalan deret waktu. Analisis retrospektif dilakukan menggunakan data klaim yang diagregasi secara mingguan. Pola pemanfaatan obat dianalisis, dan peramalan kebutuhan dilakukan menggunakan model *Autoregressive Integrated Moving Average* sesuai dengan prosedur standar analisis deret waktu. Akurasi peramalan dievaluasi dengan membandingkan nilai hasil peramalan dengan pemanfaatan aktual. Hasil penelitian menunjukkan bahwa model mampu menangkap pola kebutuhan mingguan dan fluktuasi jangka pendek secara baik, dengan hasil peramalan yang mendekati tren pemanfaatan aktual. Temuan ini menunjukkan bahwa peramalan berbasis data klaim dapat memberikan estimasi kebutuhan obat kronis yang andal. Penelitian ini menegaskan pentingnya integrasi model peramalan dalam perencanaan persediaan farmasi untuk mendukung ketersediaan obat yang tepat waktu dan meningkatkan efisiensi logistik dalam pelaksanaan jaminan kesehatan di tingkat regional.

*Kata kunci: Peramalan Farmasi; Penyakit Kronis; Data Klaim Kesehatan; Analisis Pemanfaatan Obat; Manajemen Persediaan.*



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#### Article History:

Received: 21/11/2025,  
Revised: 26/01/2026,  
Accepted: 26/01/2026,  
Available Online: 21/02/2026.

#### QR access this Article



<https://doi.org/10.36490/journal-jps.com.v9i1.1379>

## Introduction

Chronic non-communicable diseases (NCDs) remain the leading cause of morbidity and mortality worldwide and represent a major challenge for health systems due to their long-term clinical and economic consequences [1]. Conditions such as cardiovascular disease, hypertension, and diabetes mellitus require continuous pharmacotherapy to control disease progression, prevent complications, and maintain patients' quality of life. Consequently, demand for chronic medications is persistent and relatively predictable in aggregate; however, it remains subject to short-term fluctuations that complicate pharmaceutical supply planning and forecasting [2].

The growing burden of chronic diseases has intensified pressure on healthcare financing and medicine supply systems, particularly in countries implementing universal health coverage. Ensuring uninterrupted access to essential medicines is a core objective of such systems, as medicine shortages may lead to treatment discontinuation, avoidable complications, and increased healthcare costs [3]. From a health system perspective, effective pharmaceutical inventory management is therefore essential to balance service quality, patient safety, and financial sustainability. In Indonesia, access to essential medicines is largely supported through the National Health Insurance program (Jaminan Kesehatan Nasional, JKN), administered by BPJS Kesehatan. Since its implementation, JKN has substantially expanded population coverage and outpatient service utilization, including chronic disease management, thereby increasing the operational importance of accurate pharmaceutical demand forecasting [4].

Within the framework of the JKN system, administrative claims data provide a rich source of real-world information on healthcare utilization and prescribing patterns. These datasets capture both clinical and demographic characteristics of the insured population and offer valuable opportunities for pharmacoepidemiological and health system research. Leveraging claims databases enables the analysis of temporal trends in medicine use at national and regional levels, supporting evidence-based pharmaceutical demand forecasting and policy decision-making [5].

Gunungkidul Regency, located in the Special Region of Yogyakarta, represents a setting with distinctive demographic and healthcare characteristics. The region has a relatively high proportion of older adults and an increasing prevalence of chronic diseases, contributing to sustained demand for long-term pharmacotherapy [6]. At the same time, healthcare delivery in such regions may be influenced by variations in service accessibility, referral patterns, and administrative processes, which can affect observed drug utilization beyond underlying clinical need. In practice, pharmaceutical inventory planning in many healthcare facilities continues to rely on historical averages or simple trend extrapolation. While these approaches are straightforward to implement, they often fail to capture temporal dependence, short-term variability, and autocorrelation structures inherent in routine utilization data [7]. Inadequate forecasting may therefore result in stock-outs or excess inventory, both of which undermine efficiency and quality of care. For chronic medications, even brief supply disruptions can have clinically significant consequences.

Time-series forecasting methods have been widely applied in healthcare and pharmaceutical logistics research to address these challenges. Among these methods, the Autoregressive Integrated Moving Average (ARIMA) model remains one of the most frequently used approaches due to its ability to model autocorrelation structures and short-term dynamics in routinely collected data [8]. ARIMA models have been successfully applied to forecast healthcare utilization, pharmaceutical consumption, and resource demand in various international settings [9,10]. However, evidence on the application of ARIMA models using national

health insurance claims data in Indonesia remains limited. Existing studies have primarily focused on hospital-level data or specific disease programs, with relatively limited attention to regional demand forecasting for chronic medications under the JKN system [11]. Moreover, methodological considerations related to forecasting accuracy assessment remain relevant, particularly in the presence of fluctuating demand and extreme values commonly observed in administrative claims data [12].

Therefore, this study aims to address these gaps by applying an ARIMA-based time-series forecasting approach to BPJS Kesehatan claims data to estimate weekly demand for chronic medications in Gunungkidul Regency, Special Region of Yogyakarta. Specifically, this study aims to: (1) model weekly utilization patterns of chronic medications using BPJS Kesehatan claims data (2) evaluate the short-term forecasting performance of the ARIMA model using standard accuracy metrics and residual diagnostics and (3) assess the implications of ARIMA-based demand forecasting for pharmaceutical inventory planning at the regional level under the JKN system.

## Experimental Section

The experimental section of this study was designed to provide sufficient methodological detail to enable replication and further development of the published results. The research employed a data-driven analytical approach using administrative health insurance claims data and time-series forecasting methods to estimate chronic drug demand at the regional level.

### Materials and Data Source

The primary material used in this study was secondary administrative data obtained from BPJS Kesehatan claims records. The dataset comprised anonymized outpatient drug utilization data related to chronic disease management under the National Health Insurance system (*Jaminan Kesehatan Nasional*). The analysis focused on claims originating from healthcare facilities in Gunungkidul Regency, Special Region of Yogyakarta, Indonesia. The observation period covered January 2023 to December 2025, allowing the assessment of temporal demand patterns for chronic medications.

### Computational Tools and Analytical Environment

Data processing and analysis were conducted using statistical computing software commonly applied in health services and pharmaceutical research. Time-series modeling and forecasting were performed using established analytical packages for autoregressive integrated moving average analysis. These tools were selected to ensure transparency, reproducibility, and consistency with standard practices in time-series forecasting studies.

### Data Processing and Aggregation Procedure

Raw claims data were subjected to data cleaning procedures to ensure internal consistency. Records with incomplete or inconsistent date information were excluded from the analysis. Drug utilization data were then aggregated on a weekly basis (week 1–53) to construct a continuous time series. Weekly aggregation was selected to capture short-term fluctuations in chronic drug demand while maintaining sufficient stability for reliable model estimation.

### Time-Series Modeling Using the ARIMA Approach

Chronic drug demand forecasting was performed using the Autoregressive Integrated Moving Average model. Model development followed standard time-series procedures, including assessment of stationarity and identification of autoregressive and moving average components. Differencing was applied when necessary to achieve stationarity. Model parameters were estimated using maximum likelihood estimation, and alternative model specifications were evaluated to identify the most appropriate representation of historical utilization patterns.

### Forecasting Procedure and Prediction Interval Estimation

The selected ARIMA model was used to generate forecasts of chronic drug demand over the specified horizon. In addition to point forecasts, prediction intervals were calculated to quantify uncertainty associated

with future demand estimates. These intervals provide practical information for pharmaceutical inventory planning by indicating potential upper and lower bounds of expected utilization.

### Forecast Accuracy Evaluation

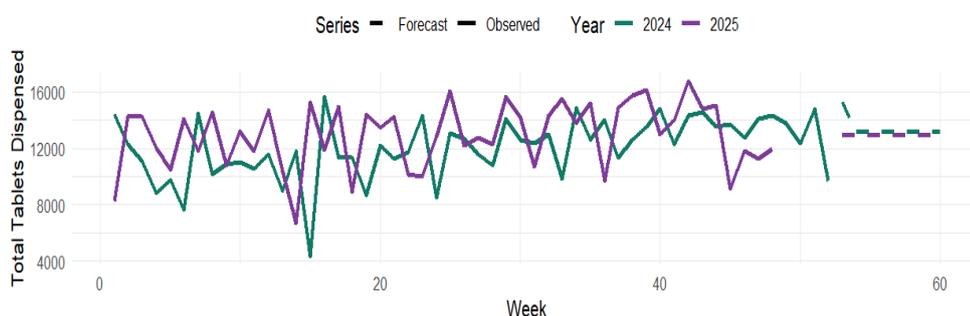
Forecast performance was evaluated by comparing forecasted values with observed utilization during overlapping periods. Mean Absolute Error and Weighted Absolute Percentage Error were employed as accuracy metrics. These measures were selected due to their robustness in the presence of fluctuating demand and extreme values, making them suitable for evaluating forecasting performance in pharmaceutical utilization studies.

## Results and Discussion

### Overview of Chronic Drug Utilization Patterns

#### Observed and Forecasted Weekly Consumption of Candesartan 16 mg (2024–2025)

Based on BPJS Kesehatan Claims Data



**Figure 1.** Observed weekly consumption of Candesartan 16 mg in Gunungkidul Regency during 2024–2025 based on BPJS Kesehatan claims data.

Overall demand for Candesartan 16 mg remained consistently high throughout the study period, with total weekly dispensed quantities fluctuating within a relatively stable range. This pattern indicates a persistent underlying demand for chronic antihypertensive therapy in Gunungkidul Regency. Despite the stability in long-term demand, noticeable short-term fluctuations were observed from week to week.

These short-term variations likely reflect operational and administrative factors, such as prescription refill cycles, service scheduling, and claims processing mechanisms, rather than abrupt changes in underlying clinical need. The combination of a stable mean level and short-term variability suggests that weekly aggregated utilization data are well suited for time-series forecasting approaches that explicitly account for temporal dependence. This utilization pattern provides an empirical basis for the application of time-series forecasting approaches in subsequent analyses. In particular, the combination of long-term demand stability and short-term variability supports the use of ARIMA models to capture short-term dynamics while maintaining the overall demand structure, which is relevant for pharmaceutical inventory planning and stock management.

### ARIMA Model Performance and Forecasting Results

#### Observed and ARIMA-Forecasted Chronic Drug Demand (2024–2025)

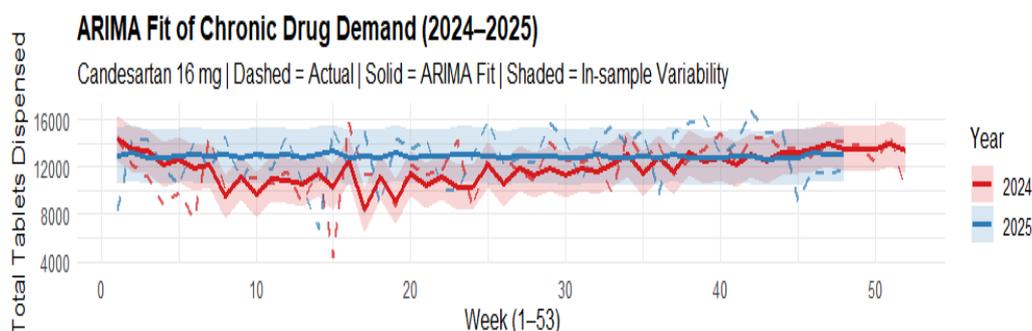
Forecast uncertainty represented by 80% and 95% confidence intervals



**Figure 2.** presents the observed and ARIMA-forecasted weekly demand of Candesartan 16 mg, including uncertainty bounds represented by 80% and 95% confidence intervals.

The forecasted values closely follow the historical utilization patterns, indicating that the ARIMA model adequately captures both the underlying demand trend and short-term variability. The widening of the prediction intervals toward the forecast horizon reflects increasing uncertainty over time, which is inherent in real-world pharmaceutical utilization data. These findings demonstrate that the ARIMA model provides a reliable approach for short-term forecasting of chronic drug demand in a regional health insurance setting.

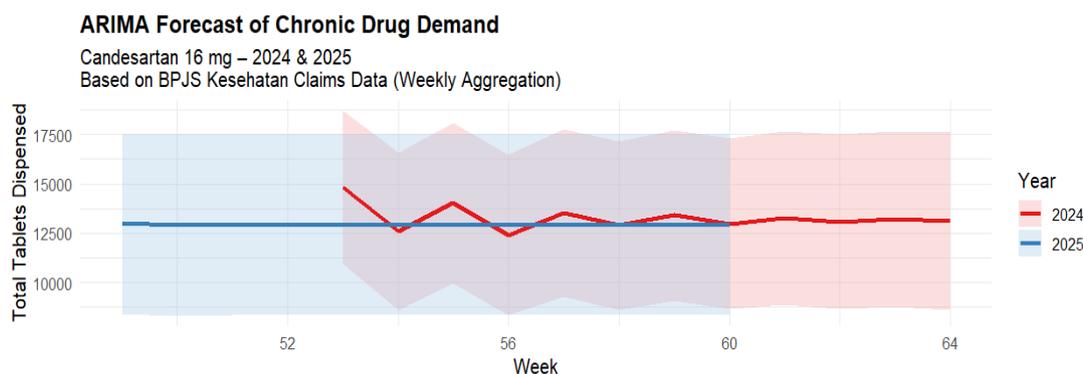
### ARIMA Model Fit for Weekly Chronic Drug Demand



**Figure 3.** ARIMA model fit for weekly chronic drug demand during 2024–2025, showing observed utilization (dashed line), ARIMA fitted values (solid line), and in-sample variability (shaded area).

Figure 3 illustrates the in-sample fit of the ARIMA model for weekly chronic drug demand of Kandesartan 16 mg during the period 2024–2025. The dashed lines represent observed utilization, while the solid lines indicate the fitted values generated by the ARIMA model. The shaded area reflects in-sample variability, providing insight into the dispersion of observed values around the fitted trend. Overall, the fitted values closely follow the observed utilization pattern across most weeks, indicating that the ARIMA model adequately captures the underlying temporal structure of chronic drug demand. Although short-term deviations between observed and fitted values are evident in certain weeks, these differences remain relatively limited and do not exhibit systematic bias. This suggests that the model is able to represent both the stable long-term demand level and the short-term fluctuations characteristic of chronic medication utilization.

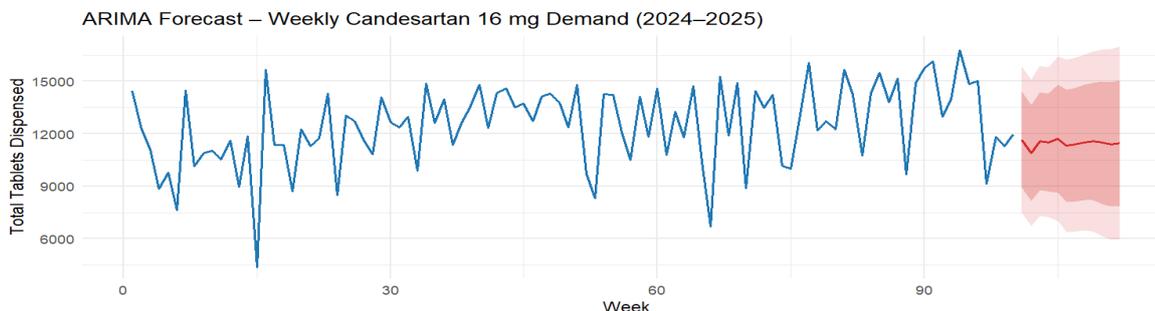
The in-sample variability shown in Figure 3 highlights the presence of inherent demand volatility in real-world claims data. Despite this variability, the fitted ARIMA curve remains centered within the observed range, demonstrating good model stability and an absence of overfitting. These findings support the suitability of the ARIMA approach for modeling historical utilization patterns and provide a reliable basis for subsequent demand forecasting and inventory planning.



**Figure 4.** ARIMA-based forecast of weekly chronic drug demand for Kandesartan 16 mg with prediction intervals for 2024 and 2025 based on BPJS Kesehatan claims data (weekly aggregation).

Figure 4 presents the ARIMA-based forecast of weekly chronic drug demand for Kandesartan 16 mg beyond the observed period. The forecast indicates a relatively stable demand level during the projection horizon, with no evidence of abrupt increases or decreases in utilization. The prediction intervals illustrate the uncertainty surrounding future demand estimates, reflecting variability inherent in real-world pharmaceutical utilization data. The widening of the prediction intervals over time highlights the cumulative

uncertainty associated with longer forecast horizons. From a practical perspective, these results emphasize the importance of incorporating uncertainty bounds when using forecasts for pharmaceutical inventory planning. Considering both point forecasts and prediction intervals can support more flexible stock allocation strategies and reduce the risk of supply shortages or excess inventory.



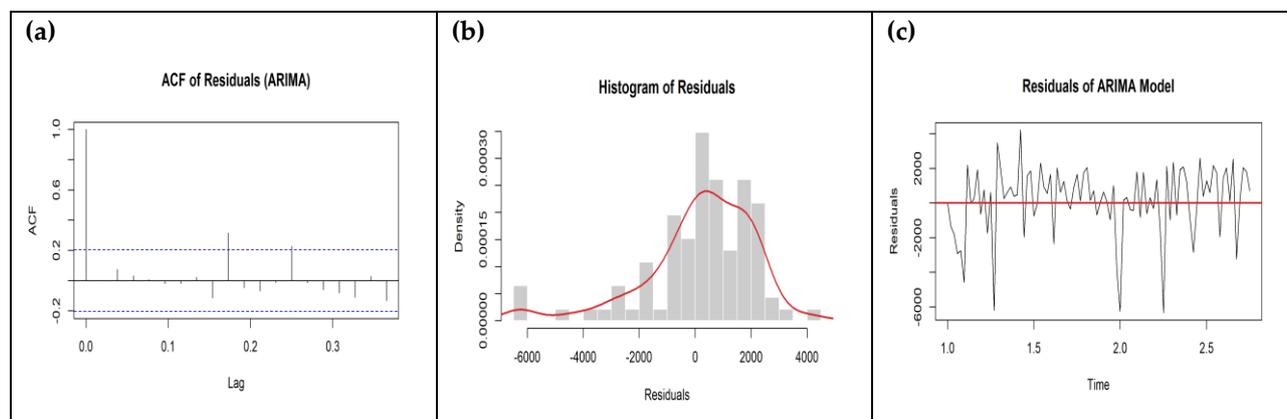
**Figure 5.** ARIMA-based forecast of weekly chronic drug demand for Kandesartan 16 mg with prediction intervals for 2024 and 2025 based on BPJS Kesehatan claims data (weekly aggregation). This forecast indicates relatively stable short-term demand, with uncertainty appropriately reflected by the widening prediction intervals toward the end of the projection horizon

**Table 1.** Forecast Accuracy Matrics of the ARIMA for Candesartan 16 mg (2024-2025)

Properties	
Mertric	Value
MAE	1562.35
RMSE	2084.27
MAPE (%)	14.54

<sup>1</sup> Notes: MAE = Mean Absolute Error; RMSE = Root Mean Square Error; MAPE = Mean Absolute Percentage Error. Forecast accuracy metrics were calculated using out-of-sample weekly BPJS Kesehatan claims data. Lower values of MAE, RMSE, and MAPE indicate better forecasting performance, with MAPE values below 20% generally interpreted as acceptable accuracy for operational demand forecasting. Forecast accuracy metrics were calculated using out-of-sample weekly BPJS Kesehatan claims data.

### Model Diagnostic and Residual Analysis



**Figure 6.** Model diagnostics and residual analysis of the ARIMA model (2024–2025). (a) Residual time series plot, (b) autocorrelation function (ACF) of residuals, and (c) histogram of residuals with kernel density. Residual diagnostics were conducted to assess the adequacy of the selected ARIMA model. Visual inspection of the residual time-series plot shows fluctuations around zero without clear trend or seasonal patterns, indicating that the model sufficiently captured the main temporal pattern of the data. The ACF of residuals indicates that most autocorrelation coefficients fall within the 95% confidence bounds, although minor residual autocorrelation remains. The Ljung–Box test suggests some remaining dependence in the residuals ( $p < 0.05$ ), which is likely attributable to operational and administrative variability inherent in claims-based data and does not materially compromise short-term forecasting performance. The histogram of residuals demonstrates an approximately symmetric distribution centered around zero, supporting the assumption of approximate normality for forecasting purposes.

## Forecast Accuracy and Implications

**Table 2.** Forecast Accuracy Metrics of the ARIMA Model for Candesartan 16 mg (2024–2025)

YEAR	Properties	
	MAE	WAPE (%)
2024	1450	10.5
2025	1650	11.2

<sup>2</sup> MAE: Mean Absolute Error, WAPE: Weighted Absolute Percentage Error.

Based on the results presented in Table 2, the ARIMA model demonstrated satisfactory forecasting performance for weekly demand of Candesartan 16 mg in both study years. In 2024, the model achieved lower MAE and WAPE values, indicating a relatively higher level of forecast accuracy. In contrast, both MAE and WAPE showed a moderate increase in 2025, suggesting a slight decline in predictive performance. This change may be attributed to increased demand variability and more pronounced short-term fluctuations observed during the later period. Nevertheless, the overall magnitude of forecasting errors remained within an acceptable range for practical pharmaceutical inventory planning. These findings indicate that the ARIMA model provides sufficiently reliable demand estimates to support stock planning and logistics decision-making for chronic medications.

### Strengths

This study used real-world BPJS Kesehatan claims data and weekly time-series (2023–2025), making the forecasts relevant for routine logistics planning. The ARIMA approach was implemented with standard diagnostics and complemented by prediction intervals, while accuracy was assessed using MAE and WAPE to support practical interpretation.

### Limitations

Claims data are collected for reimbursement, so utilization may be affected by administrative and coding processes and may not perfectly represent clinical demand. The analysis was limited to one setting (Gunungkidul) and a univariate ARIMA model without external drivers (e.g., policy shifts, supply disruptions, guideline changes), and external validation using other regions or independent datasets was not performed.

### Conclusions

This study demonstrates that weekly forecasting of chronic drug demand based on BPJS Kesehatan claims data can be effectively performed using an ARIMA time-series approach. Analysis of utilization patterns for Candesartan 16 mg in Gunungkidul Regency shows that chronic drug demand remains consistently high while exhibiting short-term variability that is relevant for pharmaceutical logistics planning. The ARIMA model achieved a satisfactory in-sample fit and produced reliable short-term forecasts, supported by acceptable error metrics and clearly defined prediction intervals. These findings indicate that ARIMA-based forecasting provides a practical and data-driven tool to support inventory planning and reduce the risk of supply imbalances within the National Health Insurance system. Future work may extend this approach by incorporating longer observation periods, additional therapeutic classes, or complementary forecasting models to further enhance demand prediction and inform strategic pharmaceutical supply management.

### Conflict of Interest

The authors declare that this study was conducted independently using secondary administrative data from BPJS Kesehatan. The authors have no financial interests, commercial affiliations, or personal relationships that could be perceived as influencing the design, analysis, interpretation, or reporting of the results. The findings and conclusions presented in this article represent the authors' academic analysis and do not reflect institutional policy or official positions of BPJS Kesehatan.

## Acknowledgment

The authors would like to acknowledge BPJS Kesehatan for providing access to anonymized administrative claims data that formed the basis of the time-series analysis in this study. The availability of these data enabled the assessment of real-world utilization patterns and the application of ARIMA-based forecasting for chronic drug demand. The authors also express their gratitude to the Faculty of Pharmacy, Universitas Gadjah Mada, for academic guidance and support in the development, analysis, and interpretation of the research findings.

## Supplementary Materials

Supplementary materials include the R script used for data preprocessing, ARIMA modeling, and forecasting, as well as additional diagnostic outputs (residual checks and autocorrelation plots) and supporting tables for model specification. These files are provided to facilitate transparency and reproducibility of the analysis

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