The Effect of Applying a Demand Forecasting Model to Assess the Accuracy of Inventory Management in a Specialty Pharmacy

Lucas Scharf, MS, PhD[1]; Tzu-Yen Hong, PhD[2]; Alex C. Lin, PhD[1]

[1]James L. Winkle College of Pharmacy, University of Cincinnati, OH, USA; [2]Department of Industrial Engineering and Management, National Taipei University of Technology, Taiwan

University of CINCINNATI

BACKGROUND

- Inventory management is a challenge which requires relevant data and advanced statistical procedures to address new growth and opportunities
- Specialty pharmacies play an important role in the care of patients with complex medical conditions by offering high-priced medications
- The current demand forecasting in the University of Cincinnati Specialty Pharmacy (UCSP) relies on the pharmacist experience with minimum data to support the decision-making process
- The need to better understand the demand information requires advanced analytical tools to create data-driven forecasts

OBJECTIVES

- Create an artificial intelligence (AI) model and commonly used statistical methods model for demand forecasting of the top-ten most-prescribed medications in the UCSP
- Determine the best-performing forecast models based on accuracy metrics
- Apply the best model in the demand forecast of the top-ten most-prescribed medications
- Assess each medication forecasting model based on its accuracy

METHODS

- Site: University of Cincinnati Specialty Pharmacy, Cincinnati, OH
- Data collection: top-ten most-prescribed medications by the UCSP (Table 2)
- Data period: 26 months from Oct 2020 to Dec 2022
- Criteria used to determine the best-performing models were:
  1) Mean Absolute Percentage Error (MAPE)
  2) Root Mean Squared Error (RMSE)

### Table 1. MAPE Values and Interpretations

Value	Interpretation
< 10%	High Accuracy
10 - 20%	Good Accuracy
20 - 50%	Reasonable Accuracy
> 50%	Not Accurate

- Both metrics assessed model error; thus, a lower value indicated a smaller error, therefore a more accurate model
- Three steps were performed to create the models
  1) Data preprocessing
  2) Long Short-term Memory (LSTM) model: Separate the data into training (first section of data ~90%) and testing (later section of data ~10%)
  3) Autoregressive Integrated Moving Average (ARIMA) model: Select the best-performing parameters based on AIC, RMSE and MAPE accuracy metrics
  4) A comparison was performed between the forecasting models to select the best-performing model (Figure 1)

Table 2. Medication, Treatment, Price in US dollars, and Manufacturer

Medication	Treatment	Treatment Price ($)	Manufacturer
Aimovig	Migraine	743	Amgen Inc.
Ajovy	Migraine	709	Teva Pharmaceuticals USA, Inc.
Emgality	Migraine	1,728	Eli Lilly and Company
Nurtec ODT	Migraine	977	Pfizer Inc.
Cellcept	Immunosuppressive	1,904	Genentech, Inc.
Prograf	Immunosuppressive	705	Astellas Pharma US, Inc.
Biktarvy	HIV	3,783	Gilead Sciences, Inc.
Enbrel	Rheumatoid Arthritis	6,896	Amgen, Inc.
Temodar	Cancer	892	Merck & Co., Inc.
Epidiolex	Seizures	982	Jazz Pharmaceuticals, Inc.

Figure 1. Study Design and Forecasting Framework with Preprocessing Steps and Rationale of the Model Selection
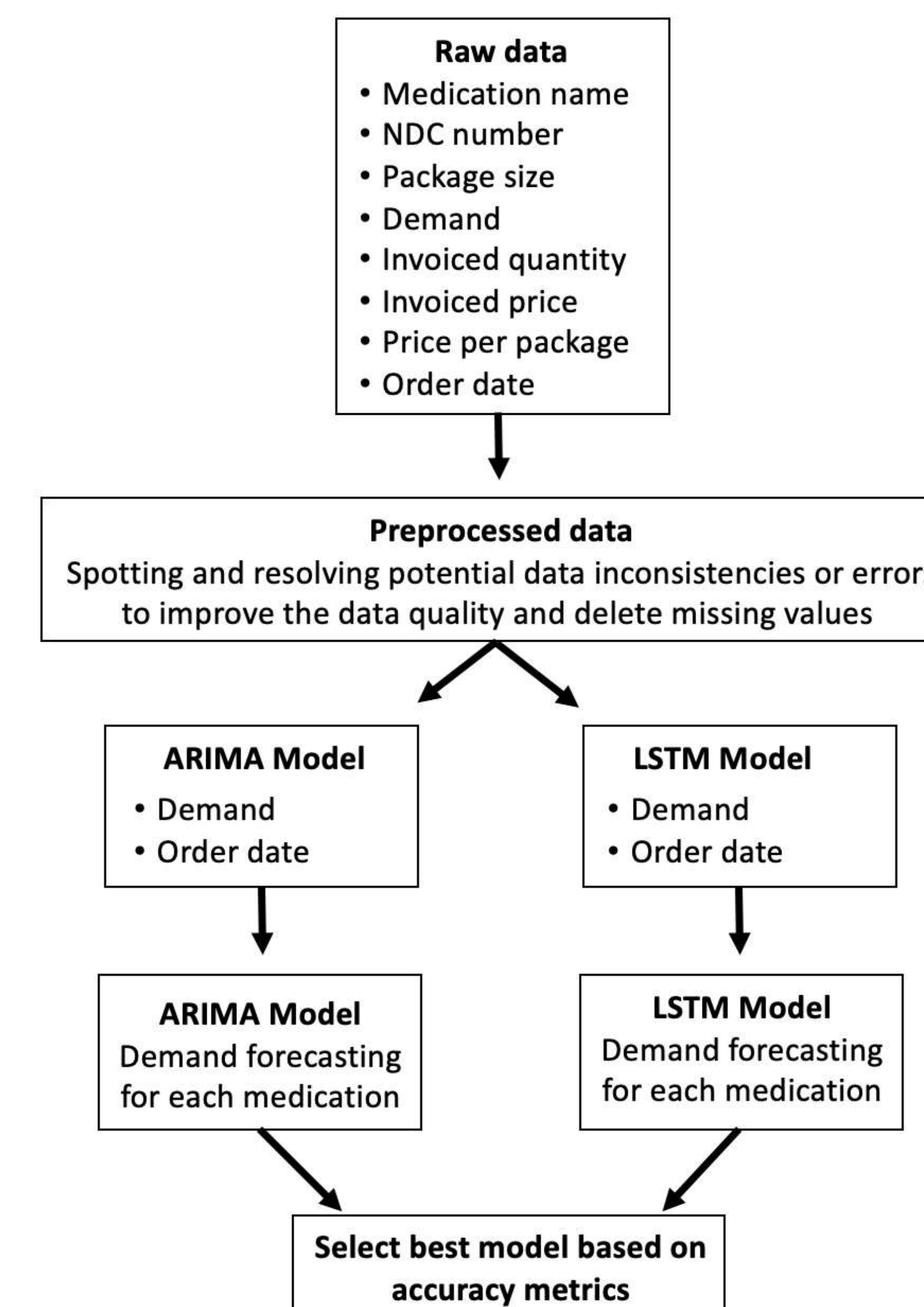
RESULTS

- Best performing model for all medication was the ARIMA model
- Two medications (Biktarvy and Temodar) models were considered highly accurate
- Seven medications (Aimovig, Ajovy, Emgality, Nurtec ODT, Enbrel, Epidiolex and Prograf) models were considered with reasonable accuracy
- One medication (Cellcept) model was considered as not accurate

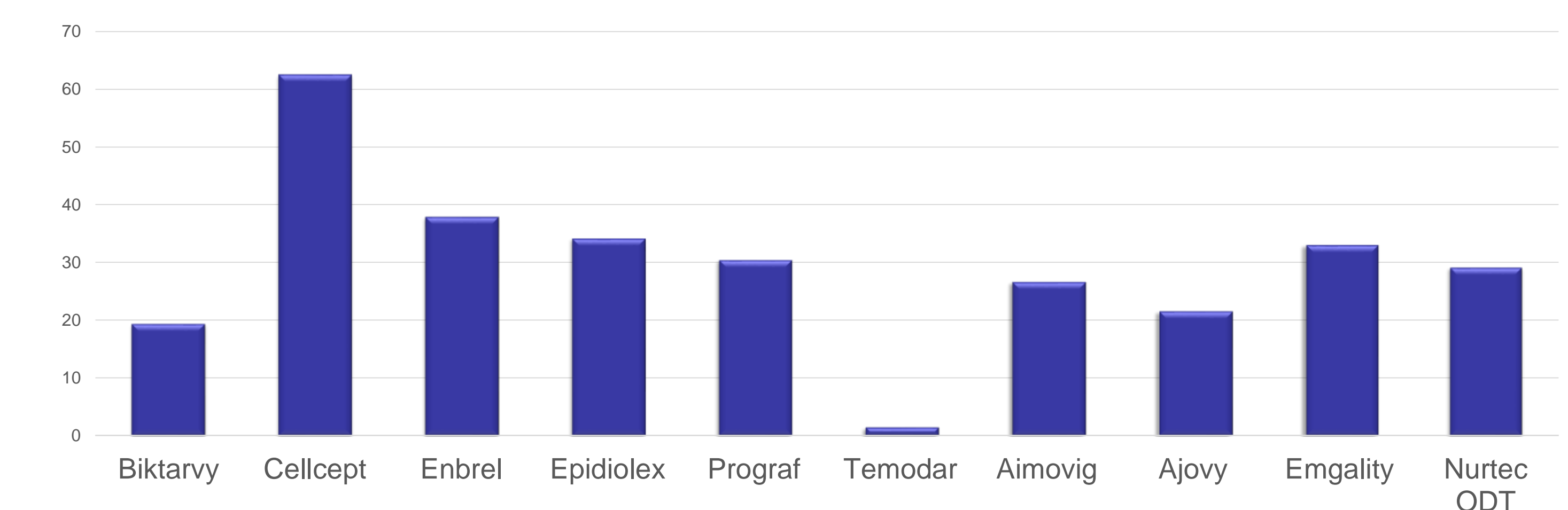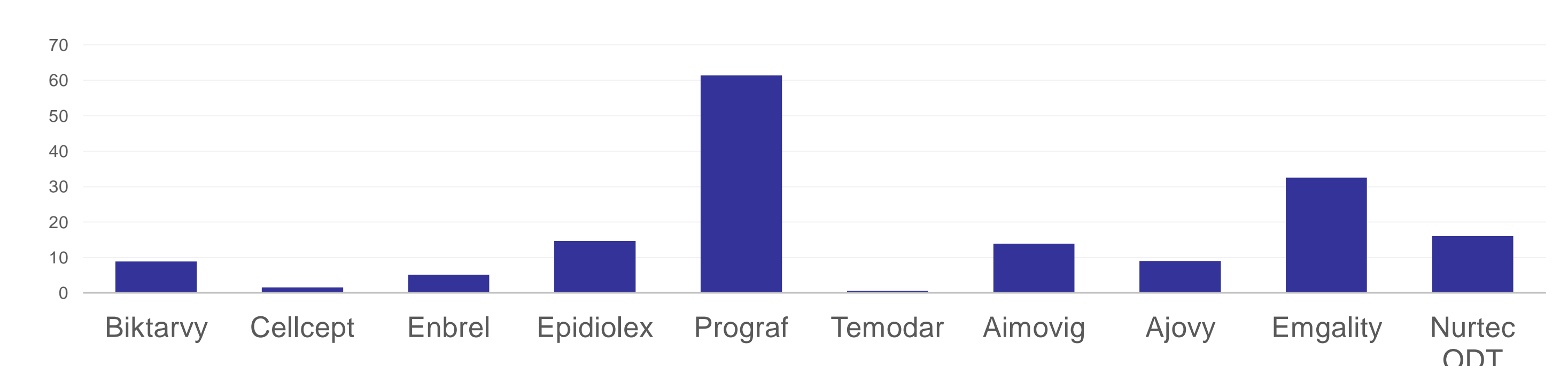Figure 2. MAPE Values for the ARIMA Models

Figure 3. RMSE Values for the ARIMA Models

DISCUSSION & CONCLUSION

- The study developed an AI model (Long Short-term Memory) and ARIMA models for demand of the top-ten most-prescribed medications in a specialty pharmacy
- The use of data-driven analytical methods may be a better approach to create demand forecasting models when compared to a traditional method that relies on the pharmacists' experience and intuition with limited data
- Nine medications' models were considered either highly accurate or with reasonable accuracy out of the top-ten most-prescribed medications in the pharmacy,

REFERENCES

1) Shamsoddin E. A COVID-19 pandemic guideline in evidence-based medicine. *Evid Based Dent;* 2020.
2) Nilsson NJ. *Principles of artificial intelligence.* Springer Science & Business Media; 1982.
3) Norvig PR, Intelligence SA. A modern approach. *Prentice Hall Upper Saddle River, NJ, USA: Rani, M., Nayak, R., & Vyas, OP;* 2015.
4) Box GE, Jenkins GM, Reinsel GC, Ljung GM. *Time series analysis: Forecasting and control.* John Wiley & Sons; 2015.