Predicting Provider Service Time in Outpatient Clinics Using Artificial Intelligence-Based Models

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Abstract : Healthcare facilities use appointment systems to schedule their appointments and to manage access to their medical services. With the growing demand for outpatient care, it is now imperative to manage physician's time effectively. However, high variation in consultation duration affects the clinical scheduler's ability to estimate the appointment duration and allocate provider time appropriately. Underestimating consultation times can lead to physician's burnout, misdiagnosis, and patient dissatisfaction. On the other hand, appointment durations that are longer than required lead to doctor idle time and fewer patient visits. Therefore, a good estimation of consultation duration has the potential to improve timely access to care, resource utilization, quality of care, and patient satisfaction. Although the literature on factors influencing consultation length abound, little work has done to predict it using based data-driven approaches. Therefore, this study aims to predict consultation duration using supervised machine learning algorithms (ML), which predicts an outcome variable (e.g., consultation) based on potential features that influence the outcome. In particular, ML algorithms learn from a historical dataset without explicitly being programmed and uncover the relationship between the features and outcome variable. A subset of the data used in this study has been obtained from the electronic medical records (EMR) of four different outpatient clinics located in central Pennsylvania, USA. Also, publicly available information on doctor's characteristics such as gender and experience has been extracted from online sources. This research develops three popular ML algorithms (deep learning, random forest, gradient boosting machine) to predict the treatment time required for a patient and conducts a comparative analysis of these algorithms with respect to predictive performance. The findings of this study indicate that ML algorithms have the potential to predict the provider service time with superior accuracy. While the current approach of experience-based appointment duration estimation adopted by the clinic resulted in a mean absolute percentage error of 25.8%, the Deep learning algorithm developed in this study yielded the best performance with a MAPE of 12.24%, followed by gradient boosting machine (13.26%) and random forests (14.71%). Besides, this research also identified the critical variables affecting consultation duration to be patient type (new vs. established), doctor's experience, zip code, appointment day, and doctor's specialty. Moreover, several practical insights are obtained based on the comparative analysis of the ML algorithms. The machine learning approach presented in this study can serve as a decision support tool and could be integrated into the appointment system for effectively managing patient scheduling.

Keywords : clinical decision support system, machine learning algorithms, patient scheduling, prediction models, provider service time

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