Real-Time Demand Forecasting in the Emergency Department

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Abstract

Shifts in the supply of and demand for emergency department (ED) services have led to ED overcrowding and make the efficient allocation of ED resources increasingly important. Reliable means of modeling and forecasting the demand for resources are critical to any ED resource planning strategy. Vector Autoregression (VAR) is a flexible multivariate time-series forecasting methodology that is well suited to modeling demand for resources in the ED.

Introduction

In their 2006 report, Hospital-Based Emergency Care: At the Breaking Point, the Institute of Medicine describes the United States’ emergency care system as being in a state of crisis. Shifts in supply and demand make the efficient allocation of emergency department resources increasingly important. Critical to any emergency department resource planning strategy are reliable means of modeling and forecasting demand for key resources. The IOM recommends that researchers develop methods to improve patient flow. Efficient patient flow can increase the capacity of the existing system, minimize patient care delays, and improve the overall quality of care.1 Although time-series analysis methods have been used to identify factors that contribute to emergency department crowding, little is reported on the development of reliable means of forecasting the surges in demand that ultimately lead to overcrowding. Hoot and Aronsky describe the development of an early warning system for ambulance diversion. This system showed good predictive ability of instances of ambulance diversion one hour in advance.2 However, their choice of ambulance diversion as their primary forecasting target is problematic. Ambulance diversion can result from many combinations of ED resource shortages. Granular forecasts of the demand for key resources such as beds, laboratory, and radiology services are likely to be more indicative of the source of crowding problems and give ED clinicians and administrators better insight into how to manage and even avert severe overcrowding.

Methods

Hourly counts of patient arrivals, laboratory orders, radiology orders, census, inpatient hospital admissions, and patient discharges were obtained from a single hospital emergency department for the period 2/15/2004-11/30/2006. No identifiable data was retrieved and the study was approved by the local institutional review board. Vector Autoregression (VAR) is a time-series method used to capture the evolution and dependencies of multiple time series based on the lags of all the variables included in the model. Data for the first 104 weeks were used to develop the VAR model. Out of sample forecasts were made for hourly census, laboratory orders, and radiology orders. Forecast accuracy in terms of the root mean squared error (RMSE) was assessed for horizons of 1 to 24 hours in advance using the 40 weeks of data not included in the training set.

Results

Forecasts generated by the VAR model provided greater forecast accuracy up to four hours in advance for hourly patient census and radiology orders, and up to two hours in advance for laboratory orders when compared to the use of forecasts based on the expected (mean) patent census for a given hour of the week.

Conclusion

VAR is a flexible multivariate time-series forecasting methodology that is capable of accurately modeling the dynamic interaction between the demand for various ED resources, and providing real-time demand forecasts for important ED resources.

References
