Forecasting Hospital Census at a Tertiary Care Children’s Hospital

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Abstract: Developing a forecasting tool for patient census allows for improved staffing, better resource utilization and mobilization, and improved timing of educational campaigns around the disease control process. Using a neural network approach we evaluated several different models and variables for predicting patient census prospectively. These initial studies enabled selection of a subset of predictor variables and show that different network models, and variables must be used based on the season.

Background: Outbreaks of respiratory viruses result in dramatic surges in emergency department visits and hospital admissions [1]. These outbreaks result in overcrowding and the associated logistical challenges for hospital administrators. Forecasting tools that can accurately predict hospital inpatient census have the potential to improve decision making around these challenges [2]. Viral Outbreaks are fueled by person-to-person spread, which is facilitated by conditions that keep humans indoors, chiefly inclement weather and/or air pollution [3]. We hypothesized that these environmental variables and several clinical variables could serve as signals for a model that could predict the daily inpatient census at a tertiary care children’s hospital. Previous work has demonstrated that forecasting tools and interventions aimed at improving patient flow/throughput can play a role in addressing the challenge that EDs face [4]. To our knowledge no research addressing the potential application of these tools to inpatient overcrowding exists in the literature.

Objectives: To develop a predictive model, using a time series artificial neural network approach, capable of predicting inpatient census.

Methodology: Using a neural network approach we evaluated several different models and variables for predicting patient census in advance. Large datasets of patient census, viral tests, and environmental factors, including weather and air quality data were gathered and analyzed for trend relating to patient census. Twenty specific candidate variables were chosen for an initial test from this large dataset, based on completeness of data and hypothesized or known relationships to disease processes that have a major effect on hospital census. These variables were tested on five years of data in multiple multilayer perceptron neural networks with varying number of layers, a range of processing elements per layer and different training methods including conjugate gradient descent, back propagation, and the quasi-newton methods. Across the different network models, the variables were tested and ranked for sensitivity in predicting hospital census. After testing several different configurations a subset of variables was selected for use in future prediction models.

Results/Discussion: Several models were tested and models with higher overall accuracy were not always as effective in predicting outbreaks or large census peaks. Viral data appeared to be a good predictor of hospital census from late fall to early spring. Pollution levels were not very predictive of hospital census overall. The top 5 variables for prediction from the analyzed set were: hospital census, minimum and maximum daily temperature, number of local births, and respiratory syncytial virus viral tests. It is apparent that different variables are important in different seasons, and that using a single set of variables and a single model to predict throughout the year diminishes the accuracy of the predictive model.

Conclusion: This initial work enabled selection of a subset of five predictor variables and show that different network models, and variables must be used based on season. Several good indicator variables have been identified that can be further studied to develop this model.