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Evaluating a Seasonal ARIMA Model for Event Detection in New York City

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Objective

To evaluate seasonal autoregressive integrated moving average (ARIMA) models for prospective analysis of New York City (NYC) emergency department (ED) syndromic data.

Introduction

ARIMA models use past values (autoregressive terms) and past forecasting errors (moving average terms) to generate future forecasts, making it a potential candidate method for modeling citywide time series of syndromic data [1]. While past research supports the use of ARIMA modeling as a detection algorithm in syndromic surveillance [2], there has been little evaluation of an ARIMA model's prospective outbreak detection capabilities. We built an ARIMA model to prospectively detect simulated outbreaks in ED syndromic data. This method is one of eight being formally evaluated as part of a grant from the Alfred P. Sloan Foundation

Methods

ED visits in NYC from 2007-2011 were classified as diarrhea, influenza-like illness (ILI), fever-flu, respiratory, or vomit syndromes, based on chief complaint text. A seasonal ARIMA model was built for each syndrome using daily ED syndrome counts from 2007 through 2009. Data between April and July 2009 were censored to avoid overestimation of future forecasts given the large increase in ED visits that occurred during the H1N1 influenza outbreak. The final seasonal ARIMA model was (1,1,1)x(0,1,1)7 with sinusoidal cross-correlation parameters to account for seasonal trends.

In order to test our final ARIMA models' ability to prospectively detect outbreaks, evaluation datasets were created by adding one simulated outbreak to a baseline of observed NYC ED data from 2010-2011. Three outbreak types were created: a single day spike, a point source outbreak based on an epi-curve of a single time-limited exposure, and a propagated outbreak based on an epi-curve due to person-to-person transmission. A total of 180 evaluation datasets were created for each of the five syndromes. Of the 900 total datasets, 20% contained a single day spike, 60% had a point source outbreak, and 20% had a propagated outbreak. Signal thresholds were set at various intervals by running the aforementioned prospective analysis on the original non-spiked data. Sensitivity and specificity were calculated for each syndrome and outbreak type. Receiver operator characteristic (ROC) curves were generated for each syndrome, stratified by outbreak type. The area under the curve (AUC) was calculated.

Results

The mean absolute percentage error (MAPE) of the original syndrome models ranged between 0.9% and 1.9%, indicating a good fit of the model to the data. Figure 1 shows the estimated ROC curves for the ILI syndrome, stratified by outbreak type. Each point is labeled with a signaling threshold which is expressed as the number of signals per number of days.

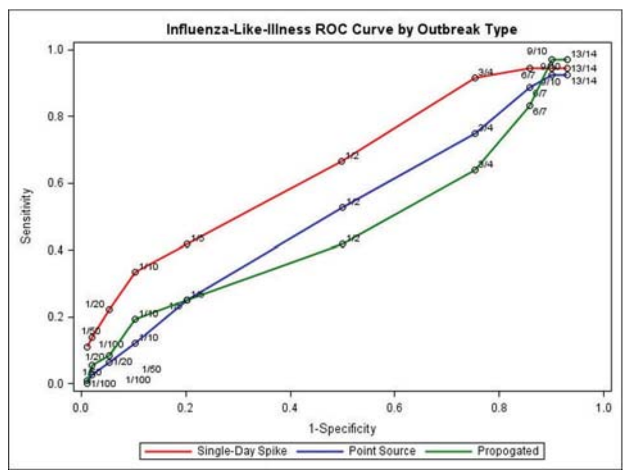
The ARIMA model for detecting outbreaks in ILI syndrome visits performed poorly for all outbreak types (single day spike: AUC=0.61; point source: AUC=0.48; and propagated: AUC=0.44). The models for other syndromes performed similarly.

Overall, 8.3% of the one-day spikes, 1.7% of the point source outbreaks, and 0.7% of the propagated outbreaks were detected at a fixed alert threshold of 1 signal per 100 days; of the simulated point source and propagated outbreaks detected at this threshold, all signals occurred at or before the peak of the outbreak.

Conclusions

An ARIMA model is not an ideal model for prospectively detecting outbreaks in syndromic data, due to frequent monitoring and adjustment of model parameters. Furthermore, by using autoregressive and moving average parameters, the model may have over-fit the data, causing outbreaks to go undetected.

ARIMA models have some limitations. Model parameters depend highly on data trends and characteristics, making geographic stratification difficult. Alternative approaches that require less frequent refitting may be easier for health departments to implement and perform better for outbreak detection.



Keywords

Seasonal ARIMA model; Outbreak detection; Evaluation

References

1. Choi, K. and S.B. Thacker, An evaluation of influenza mortality surveillance, 1962-1979. II. Percentage of pneumonia and influenza deaths as an indicator of influenza activity. Am J Epidemiol, 1981. 113(3): p. 227-35.

2. Reis, B.Y. and K.D. Mandl, Time series modeling for syndromic surveillance. BMC Med Inform Decis Mak, 2003. 3: p. 2.

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