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ISDS 2018 Conference Abstracts

ISDS INTERNATIONAL SOCIETY FOR DISEASE SURVEILLANCE

# Forecasting Emergency Department Admissions for Pneumonia in Tropical Singapore

**Cindy Lim* and Mark Chen**

Saw Swee Hock School of Public Health, National University of Singapore, Singapore, Singapore

## Objective

To develop a forecasting model for weekly emergency department admissions due to pneumonia using information from hospital-based, community-based and laboratory-based surveillance systems

## Introduction

Pneumonia, an infection of the lung due to bacterial, viral or fungal pathogens, is a significant cause of morbidity and mortality worldwide. In the past few decades, the threat of emerging pathogens presenting as pneumonia, such as Severe Acute Respiratory Syndrome, avian influenza A(H5N1) and A(H7N9), and Middle East Respiratory Syndrome coronavirus has emphasised the importance of the surveillance of pneumonia and other severe respiratory infections. An unexpected increase in the number of hospital admissions for pneumonia or severe respiratory infections could be a signal of a change in the virulence of the influenza viruses or other respiratory pathogens circulating in the community, or an alert of an emerging pathogen which warrants further public health investigation.

The purpose of this study was to develop a forecasting model to prospectively forecast the number of emergency department (ED) admissions due to pneumonia in Singapore, a tropical country. We hypothesise that there is complementary information between hospital-based and community-based surveillance systems. The clinical spectrum of many respiratory pathogens causing pneumonia ranges from asymptomatic or subclinical infection to severe or fatal pneumonia, and it is usually difficult to distinguish between the different pathogens in the absence of a laboratory test. Infected persons could present with varying degrees of severity of the infection, and seek treatment at different healthcare facilities. Hospital-based surveillance captures the more severe manifestation of the infection while community-based surveillance captures the less severe manifestation of the infection and enables earlier detection of the infection. Thus, the integration of information from the two surveillance systems should improve the prospective forecasting of ED admissions due to pneumonia. We also investigate if the inclusion of influenza data from the laboratory surveillance system would improve the forecasting model, since influenza circulates all-year round in Singapore and is a common aetiology for pneumonia.

## Methods

This was a retrospective study using aggregated national surveillance data and meteorological data during the period 3 January 2011 to 1 January 2017.

We compared the performance of autoregressive integrated moving average model (ARIMA) with multiple linear regression models with ARIMA errors, with and without the inclusion of influenza predictors at forecast horizons of 2, 4, 6 and 8 weeks in advance. Weekly data between the study period of 3 January 2011 and 1 January 2017 were split into training and validation sets, with the first three years of data used as the base training set. Time series cross validation was used to estimate the models' accuracy and out-of-sample forecast accuracy was based on the calculation of the mean absolute error (MAE) and mean absolute percent forecast error (MAPE).

## Results

The multiple linear regression model with ARIMA errors that included influenza predictors was the best performing model while the basic ARIMA model was the worst performing model for all forecast horizons. The two multiple linear regression models with ARIMA errors had a MAPE of less than 10% for all forecast horizons.

## Conclusions

Data from different multiple surveillance systems and the inclusion of influenza trends can be used to improve the forecast of ED admissions due to pneumonia in a tropical setting, despite the absence of large differences between seasons. Accurate forecasting at the national level can prepare healthcare facilities for an impending surge.

## Keywords

Pnuemonia; Emergency department; surveillance; influenza

***Cindy Lim**
E-mail: limcindy2000@yahoo.com