Winter Surge Prediction Model on Emergency Admission to Medicine Specialty

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Usually 2-3 surges in emergency medical admission every year

* The above chart only cover general acute hospitals with 24 hour A&E services.
Objective

**Predict** the surge in admission **Before** it happens

Alert

↓ Time lag to implement response plan

**Proactive Measures**
(e.g. scale down non-urgent services, add temporary beds and deploy staff)
Model Methodology
Methodology

To predict the number of emergency admissions to medical ward in 1 week ahead

Hospital Authority

Records in Clinical Management System (CMS)

Hong Kong Observatory

Temperature, relative humidity, air pressure, cold/hot weather warning, etc.

Environmental Protection Department

Air pollution index

...etc

Statistical model

(Co-integrated time-series regression model)

To establish an alert signal through empirical data analysis
Methodology

Training dataset

207 weeks’ data in 2008 to 2011

Validation dataset

104 weeks’ data in 2012 & 2013

Statistical model

(Co-integrated time-series regression model)

Model building

Model validation

Model predictive performance monitoring

2014 onwards
Model Results
The Co-integrated Time-series Regression Model

Every week predicts
Emergency admissions to medical ward, next week

Trend

Increasing trend

Emergy admissions to medical ward, this week

Possibly associated

Predictors

%Respiratory illness at GOPC, this week
%Respiratory illness at GOPC, last week
Temperature, this week

When relativity > 1, admissions ↑
When relativity < 1, admissions ↓

in quadratic relationship

holding other factors constant

\[ Y_t = C_1 \times e^{at} \times (Y_{t-1})^\beta \times \left( \frac{(X_{t-1})^\lambda_1}{(X_{t-2})^\lambda_2} \right) \times \exp \left\{ \frac{(W_{t-1} - \phi)^2}{C_2} \right\} \]
4 Predictors of Next Week’s Emergency Medical Admissions

(1) Trend

the admission number has increased by 6% per annum over the past 6 years on average.
(2) Number of emergency admissions to medical ward this week

the weekly emergency medical admissions depends on its preceding week’s value

i.e. a strong autocorrelation between week$_T$ and week$_{T+1}$ data
4 Predictors of Next Week’s Emergency Medical Admissions

(3) % Respiratory illness at General Outpatient Clinic

* Based on International Classification of Primary Care-2 (ICPC) codes: R72, R74-R78, R80, R81 and R83
4 Predictors of Next Week’s Emergency Medical Admissions

(4) Temperature

- Temperature this week
- Emergency medical admissions next week

- Average Temperature in Week $T$ (°C): 25.7°C

Graph showing the relationship between average temperature in Week $T$ and the number of emergency medical admissions in Week $T+1$. The graph indicates a negative correlation, with higher temperatures leading to an increase in emergency medical admissions.
Alert Signals

Two signals (on relative and absolute basis) will be triggered:

when the predicted number of emergency medical admissions in next week...

increases by 5% or more (vs the prior week’s)

exceeds the threshold of 6,000 admissions per week
Model Validation & Predictive Performance
Model Validation in 2012 and 2013

Predictive Performance

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
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</thead>
<tbody>
<tr>
<td>Total no. of weeks</td>
<td>52</td>
<td>52</td>
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<tr>
<td>No. of weeks with the actual value falling within 95% prediction interval</td>
<td>47 (90%)</td>
<td>49 (94%)</td>
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<tr>
<td>No. of weeks with predicted mean value being ±5% deviation from the actual value</td>
<td>37 (71%)</td>
<td>46 (88%)</td>
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Model Predictive Performance

The “relative” alert signal was first triggered as early as late November 2013.
Model Predictive Performance

The “relative” signal is sensitive to alert the surges ahead

The chart shows the weekly number of emergency admissions to the medical ward, along with the actual weekly numbers, prediction mean, 95% upper prediction limit, and 95% lower prediction limit. The graph highlights how the prediction model is able to alert before significant surges occur.
Application & Way Forward
Application

Through triggering an early alert signal, this Model can facilitate HA to implement response measures to cope with surge in service demand

What’s the next best action?

To defer elective admission in medical, surgical and other wards

To add temporary beds

etc
Way Forward

Implement and Promulgate the model & alert signals across HA through the Task Force of Winter Surge
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