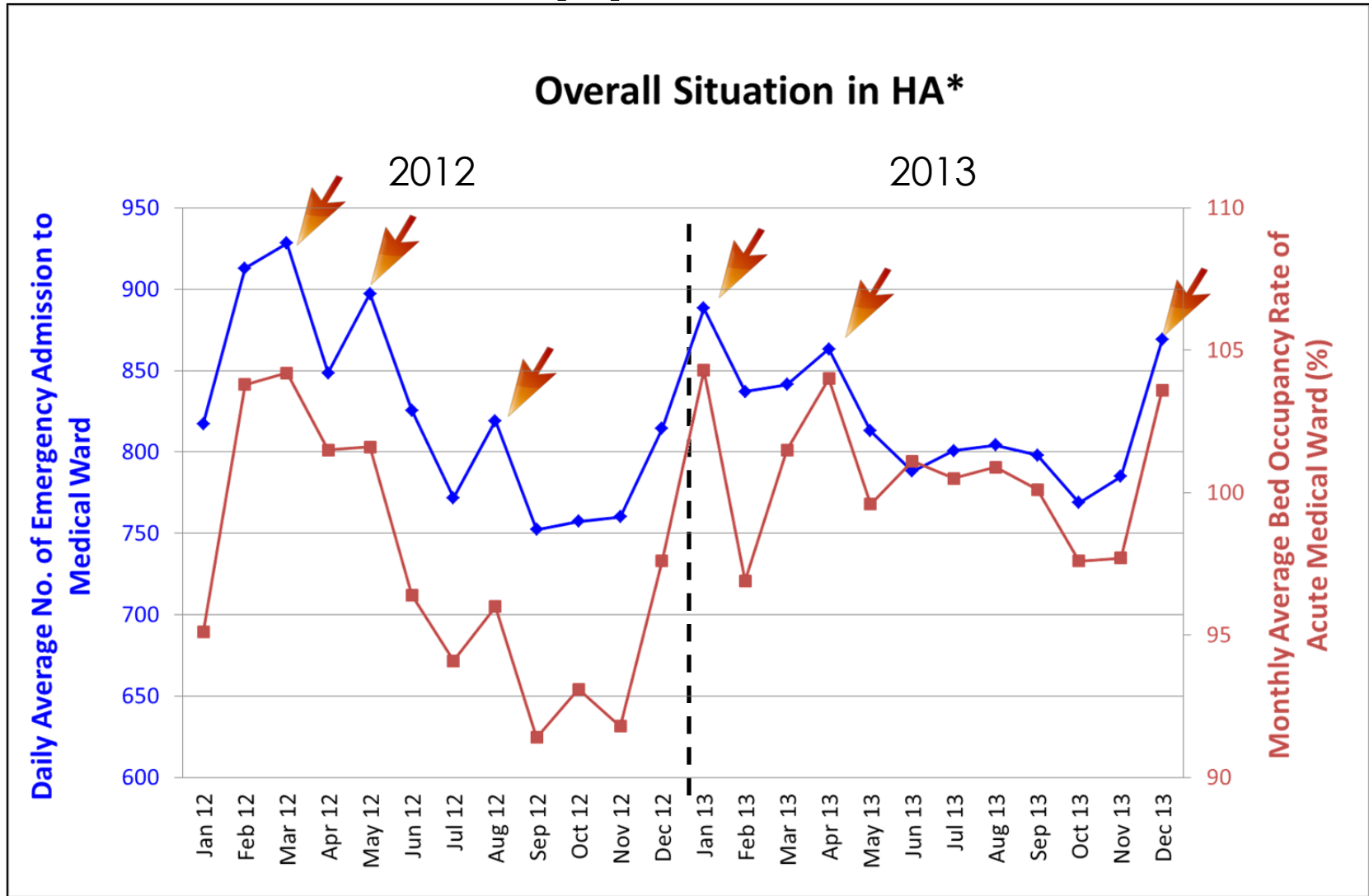# Winter Surge Prediction Model on Emergency Admission to Medicine Specialty

Cheung ATL, Au BSC, Wan CH, Zhou FF, Tsui ELH

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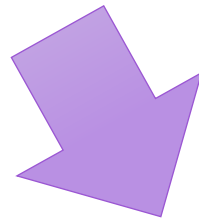# Usually 2-3 surges in emergency medical admission every year

Overall Situation in HA*

2012   2013

Daily Average No. of Emergency Admission to Medical Ward

Monthly Average Bed Occupancy Rate of Acute Medical Ward (%)

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

Objective

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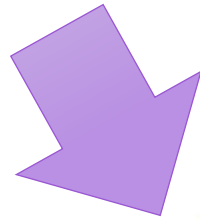
Alert 🚨

↓ **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

Hong Kong Observatory

Environmental Protection Department

…etc

Records in Clinical Management System (CMS)

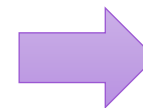*Temperature, relative humidity, air pressure, cold/hot weather warning, etc.*
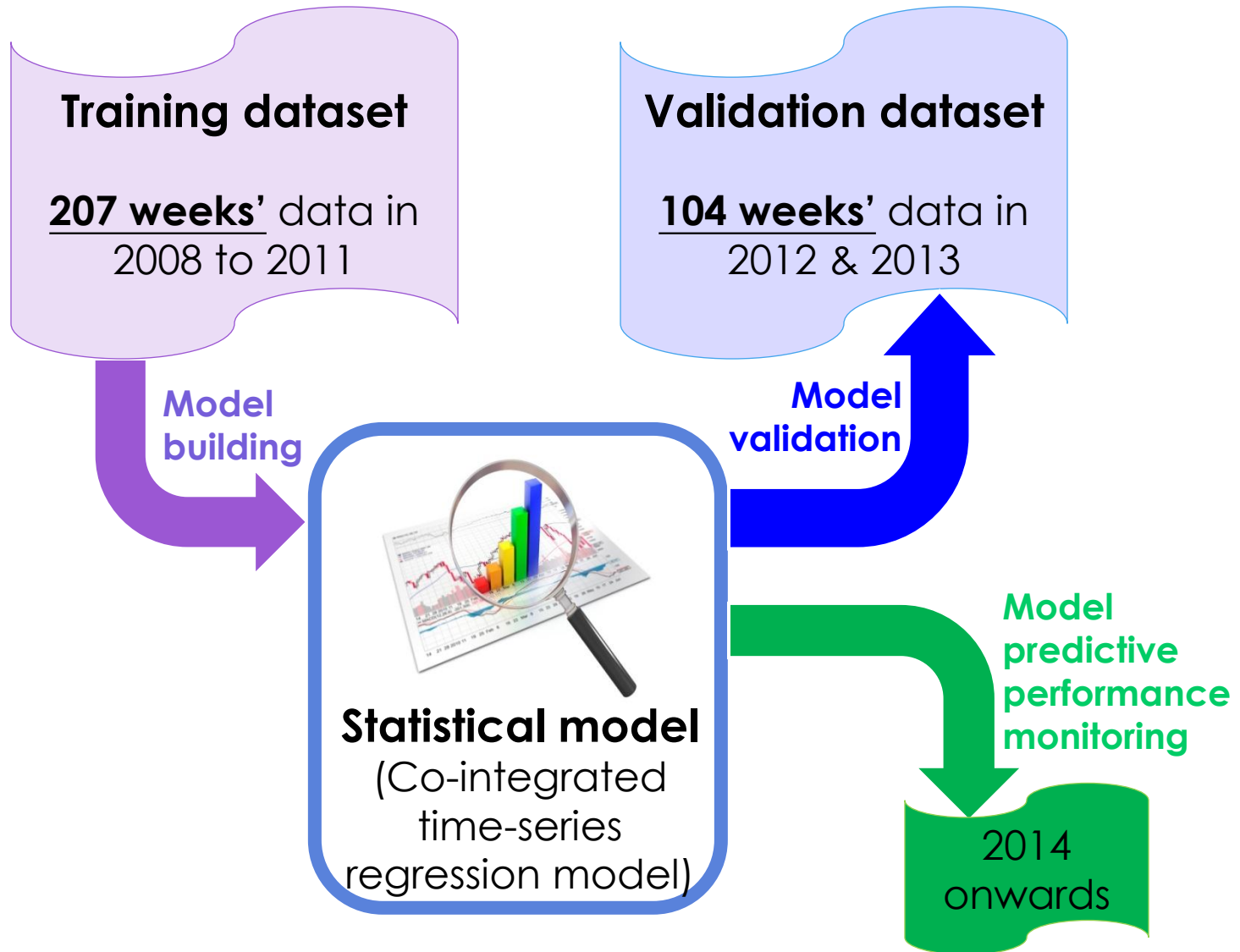
Air pollution index

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

Model building

Model validation

Statistical model
(Co-integrated time-series regression model)

Model predictive performance monitoring

2014 onwards

Model Results

The Co-integrated Time-series Regression Model

Predictors

Every week predicts

Emergency admissions to medical ward, next week

$=$

Trend

$\times$

Emergency admissions to medical ward, this week

$\times$

%Respiratory illness at GOPC, this week

%Respiratory illness at GOPC, last week

$\times$

Temperature, this week
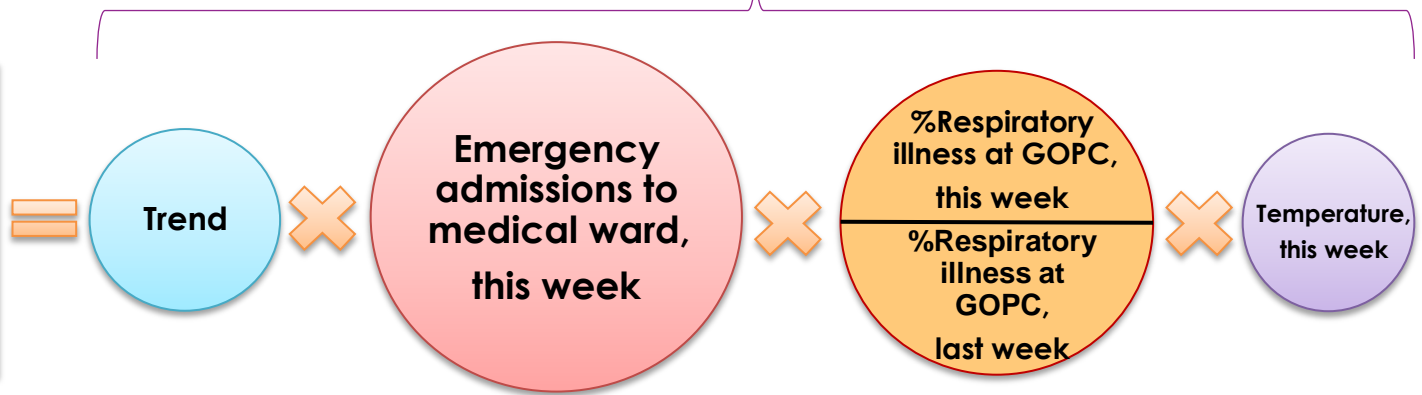
increasing trend

positively associated

When relativity > 1, admissions ↑

When relativity < 1, admissions ↓

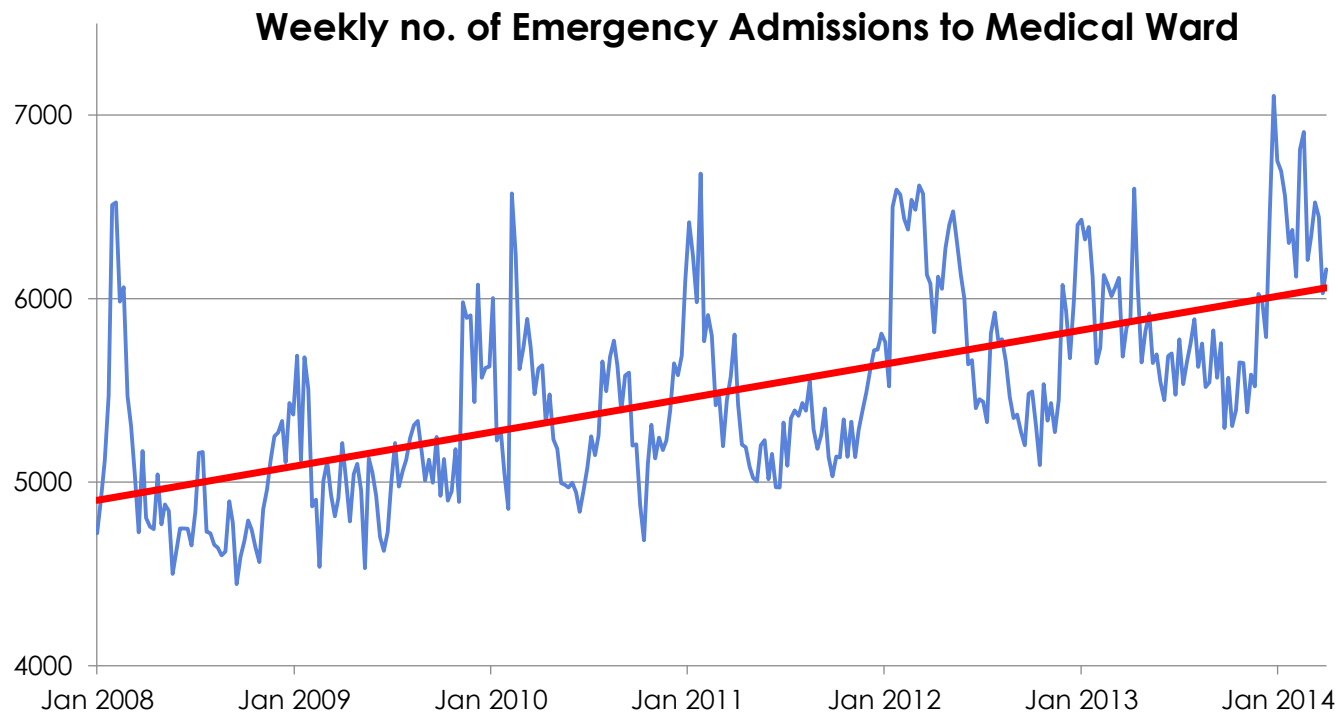**in quadratic relationship**

holding other factors constant
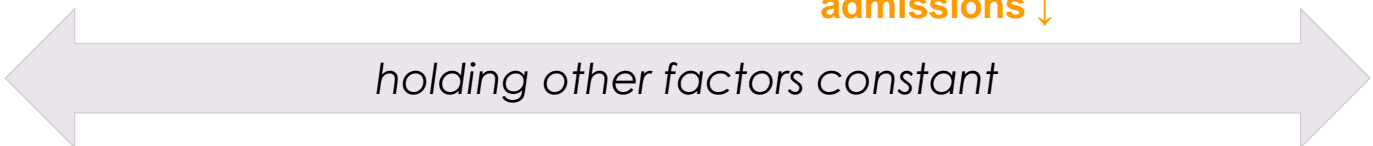
$$Y_t = C_1 \times e^{\alpha t} \times (Y_{t-1})^{\beta} \times \left\{ \frac{(X_{t-1})^{\lambda_1}}{(X_{t-2})^{\lambda_2}} \right\} \times \exp \left\{ \frac{(W_{t-1} - \phi)^2}{C_2} \right\}$$

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

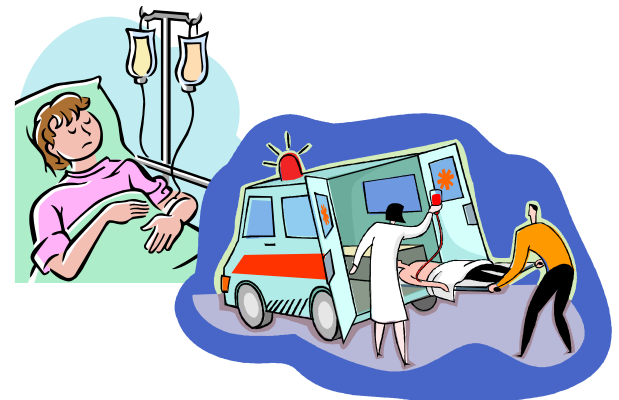**Weekly no. of Emergency Admissions to Medical Ward**

4 Predictors of Next Week's Emergency Medical Admissions

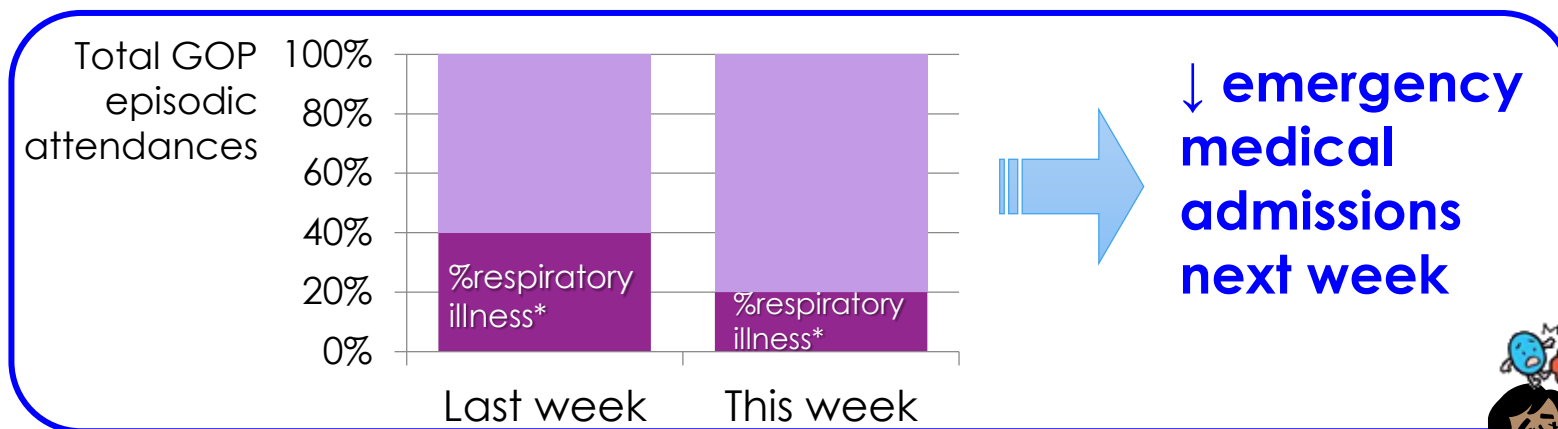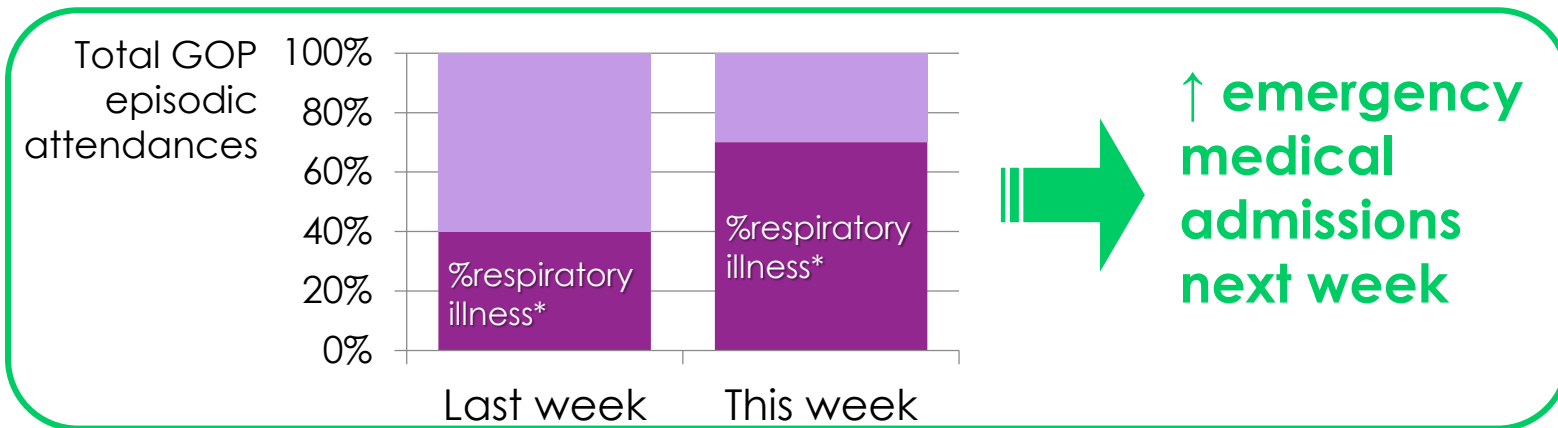(2) Number of emergency admissions to medical ward this week

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

i.e. a strong autocorrleation between week$_T$ and week$_{T+1}$ data

4 Predictors of Next Week's Emergency Medical Admissions

(3) % Respiratory illness at General Outpatient Clinic

Total GOP episodic attendances

%respiratory illness*

Last week   This week

↑ **emergency medical admissions next week**

Total GOP episodic attendances

%respiratory illness*

Last week   This week

↓ **emergency medical admissions next week**

* 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

↑ Temperature this week

↑ Emergency medical admissions next week

25.7°C

No. of Emergency Medical Admissions in Week$_{T+1}$

7000

6500

6000

5500

5000

13   17   21   25   29

Average Temperature in Week$_T$ (°C)
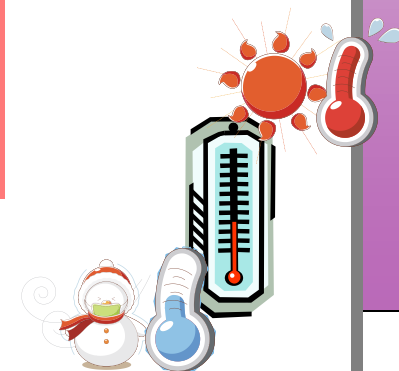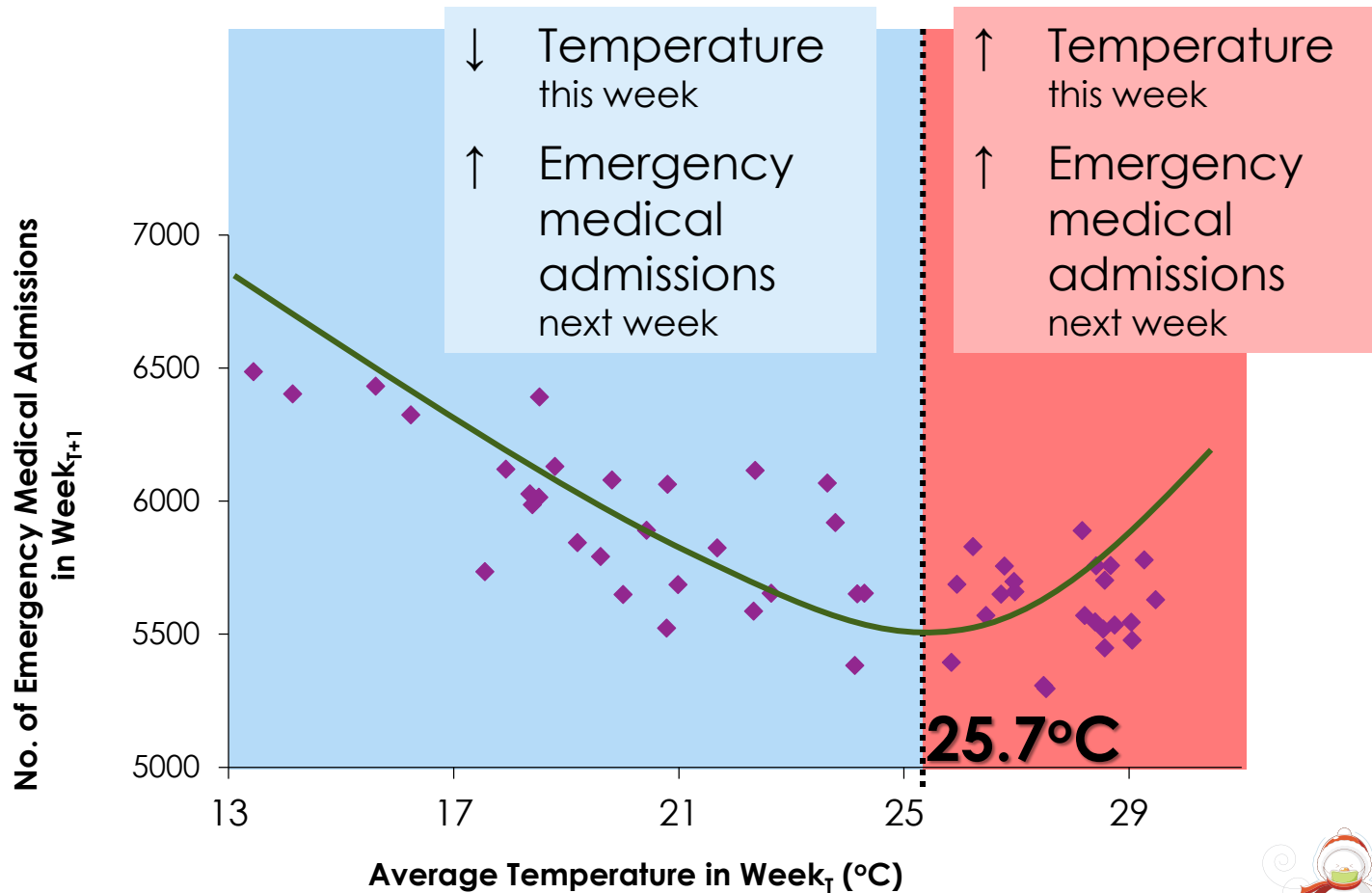
Alert Signals

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

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

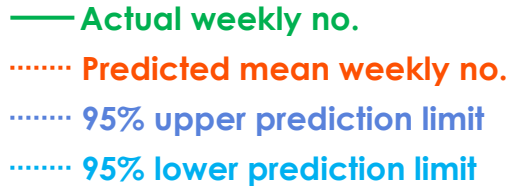**increases by 5% or more (vs the prior week's)**

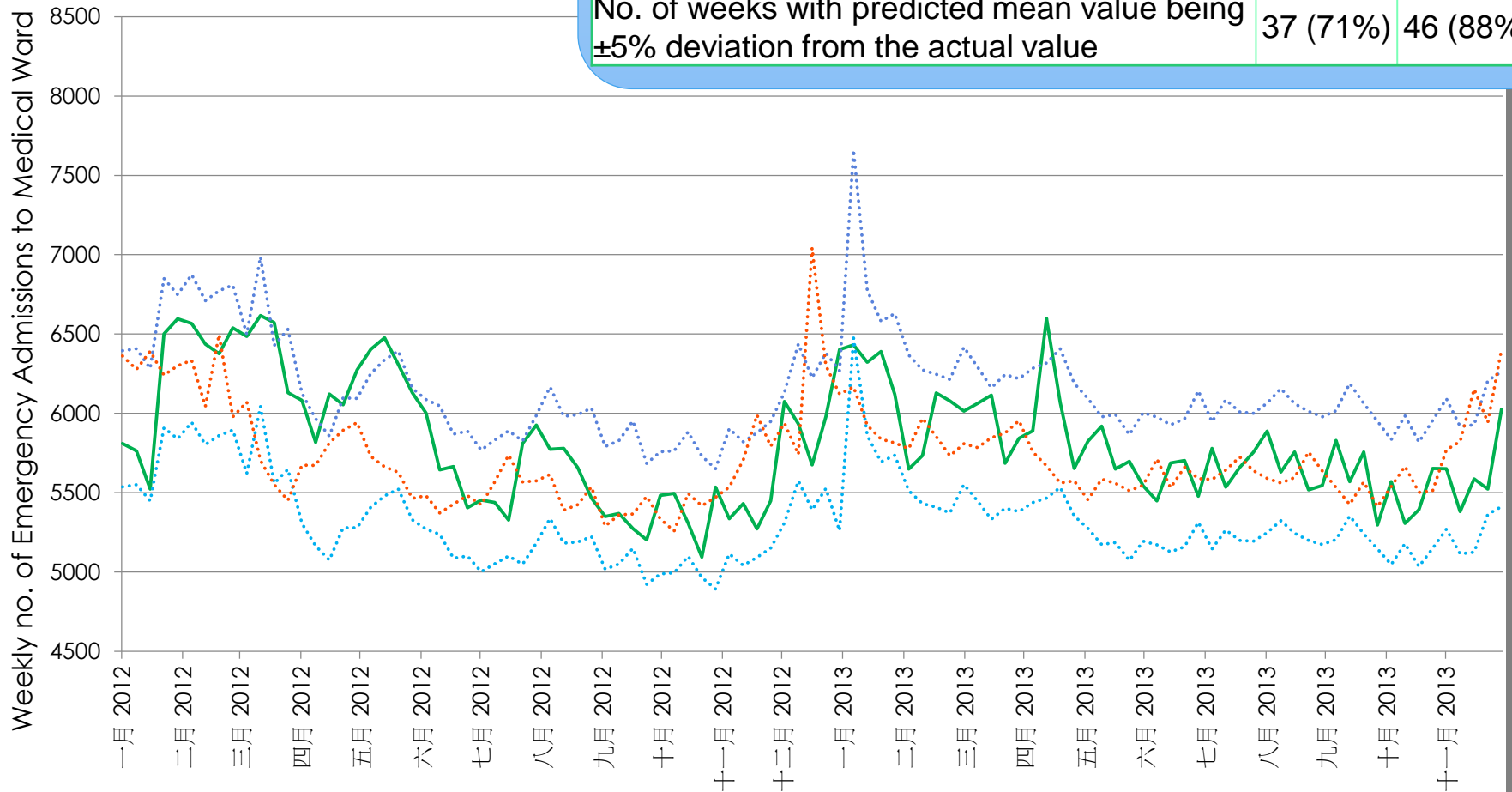**exceeds the threshold of 6,000 admissions per week**

Model Validation & Predictive Performance

Model Validation in 2012 and 2013

Predictive Performance

Year	2012	2013
Total no. of weeks	52	52
No. of weeks with the actual value falling within 95% prediction interval	47 (90%)	49 (94%)
No. of weeks with predicted mean value being ±5% deviation from the actual value	37 (71%)	46 (88%)

Legend:
- ——— Actual weekly no.
- ········ Predicted mean weekly no.
- ········ 95% upper prediction limit
- ········ 95% lower prediction limit

Y-axis: Weekly no. of Emergency Admissions to Medical Ward

X-axis: 一月 2012, 二月 2012, 三月 2012, 四月 2012, 五月 2012, 六月 2012, 七月 2012, 八月 2012, 九月 2012, 十月 2012, 十一月 2012, 十二月 2012, 一月 2013, 二月 2013, 三月 2013, 四月 2013, 五月 2013, 六月 2013, 七月 2013, 八月 2013, 九月 2013, 十月 2013, 十一月 2013
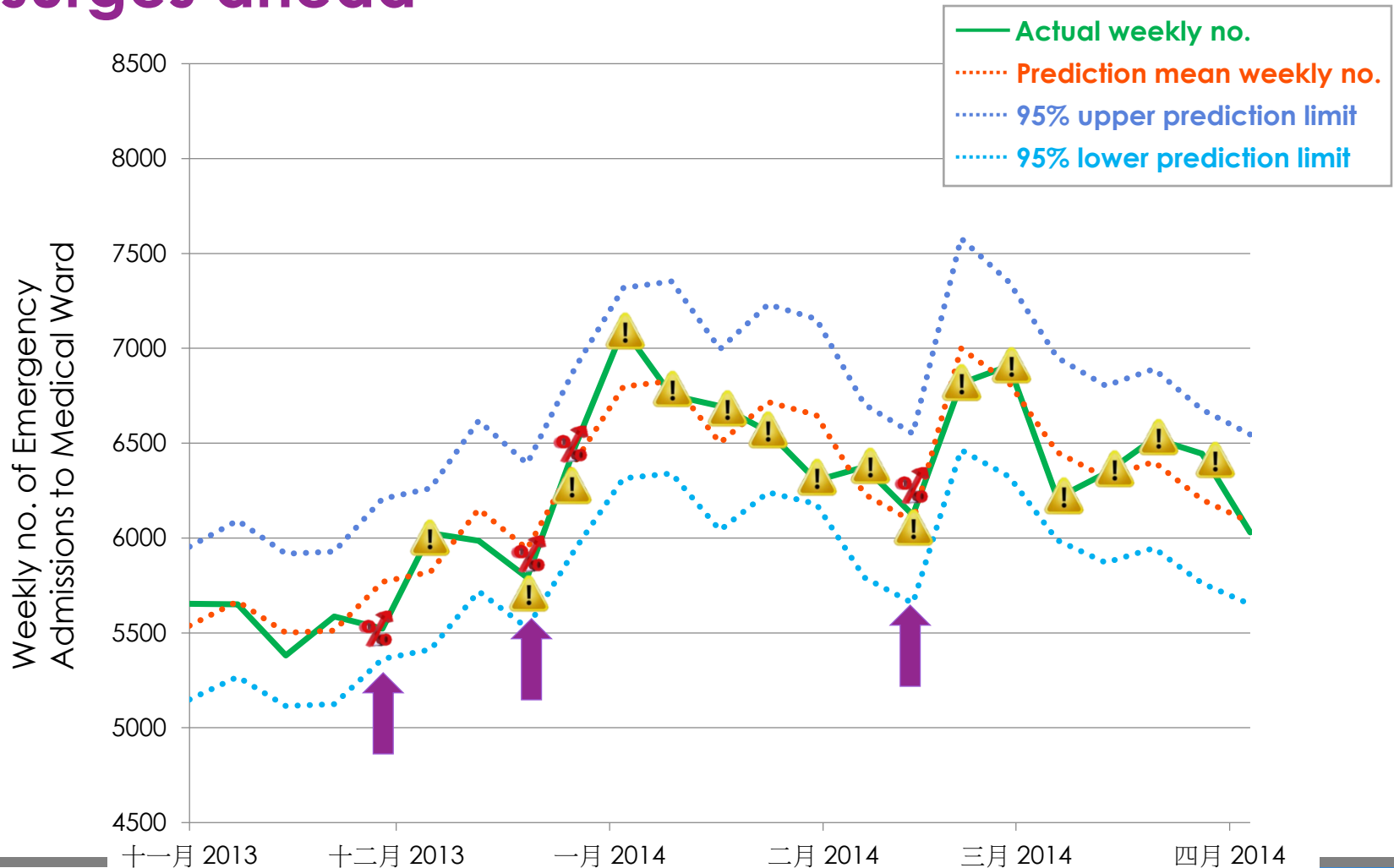
Model Predictive Performance

The "relative" alert signal was first triggered as early as late November 2013
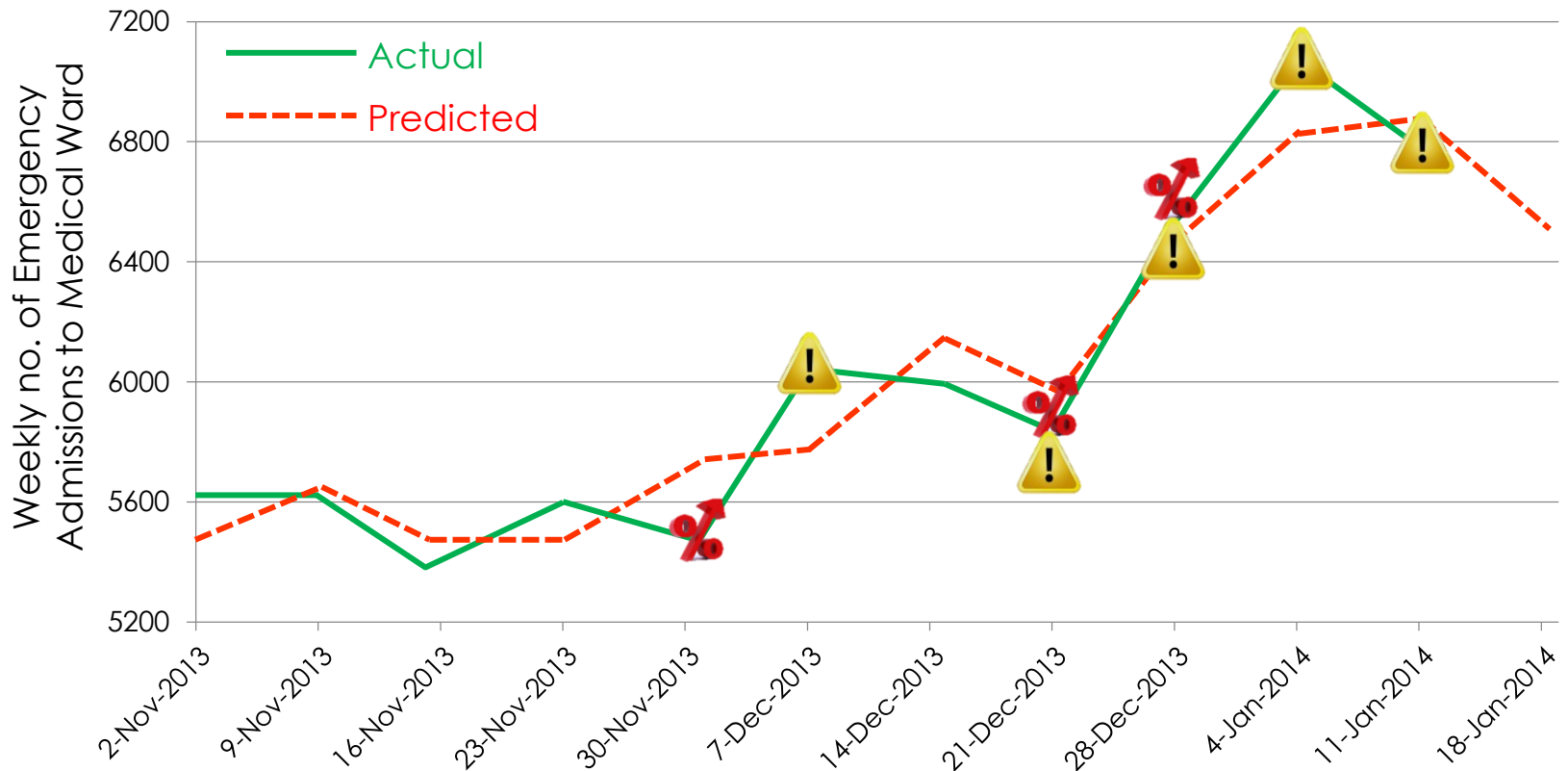
Model Predictive Performance

The "relative" signal 📈 is sensitive to alert the surges ahead

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?

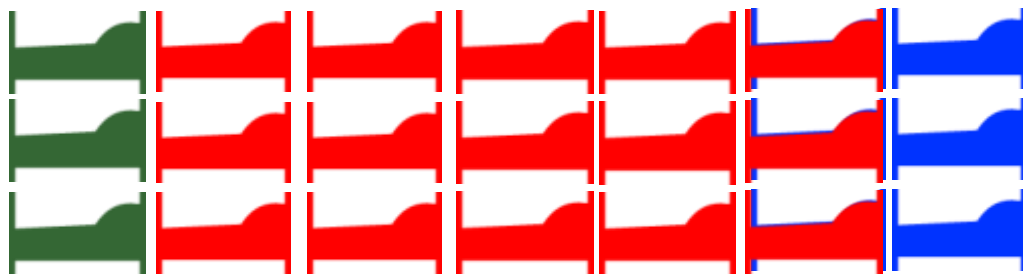To **defer elective admission** in medical, surgical and other wards

To **add temporary** beds

⋮

etc

Emergency **Elective**

Way Forward

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

Acknowledgement

- Dr S V LO   D(S&P), HAHO /
                               Dep NTWC CCE / Dep TMH HCE

- Dr David CHAO   COS(FM&PHC) UCH & TKOH, KEC

Thank You