Winter Surge Prediction Model on Emergency Admission to Medicine Specialty

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Outline of Presentation

- Background

- Model Methodology

- Model Results

- Model Validation

- Model Predictive Performance

- Applications

- Further Enhancement of the Model
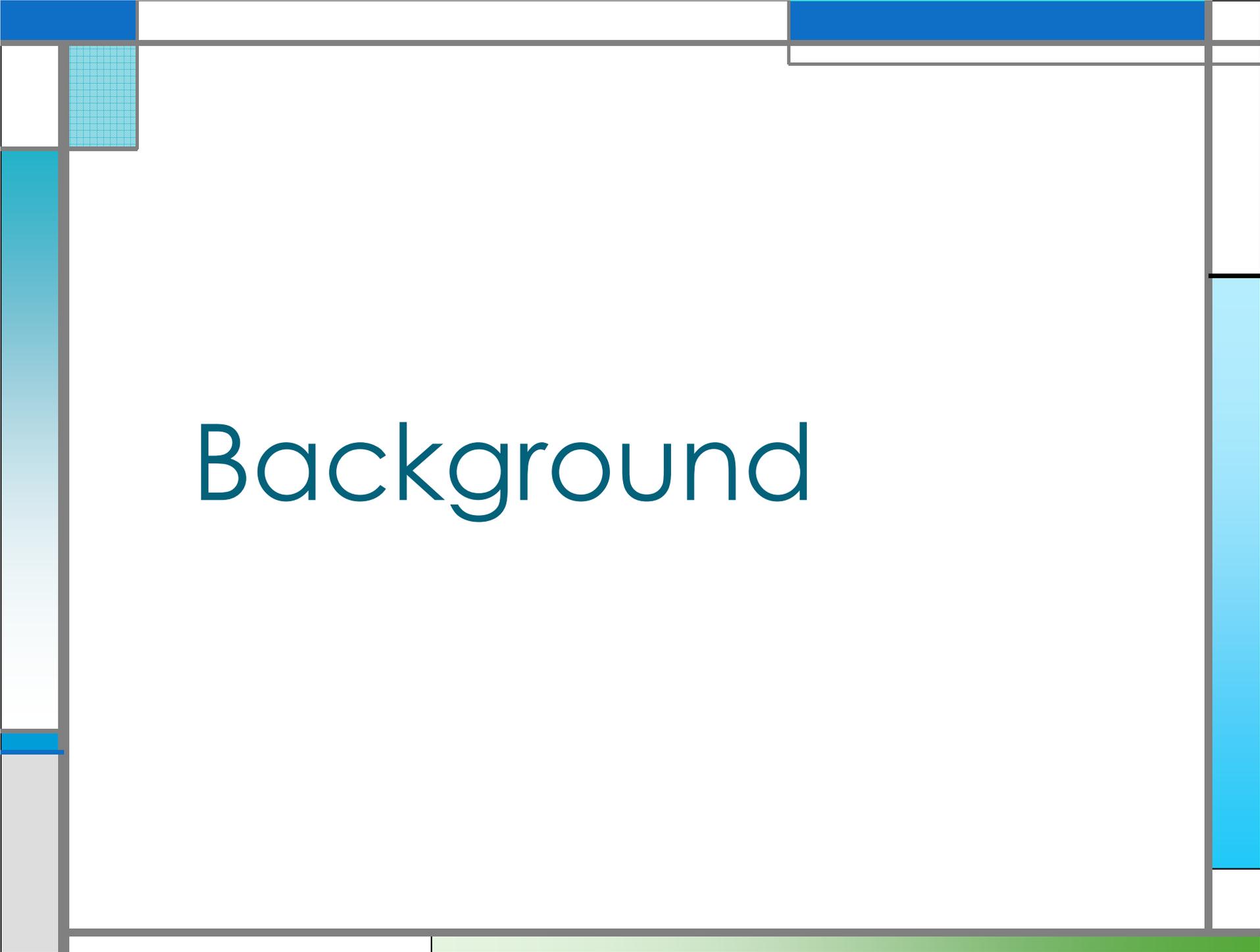
Background

Hospital Authority, Hong Kong

医院管理局
HOSPITAL AUTHORITY

Facility [as at 31 Mar 2017]	Service Throughputs in 2016/17

42 Hospitals / Institutions

28 126 hospital beds

18 Accident & Emergency (A&E) Departments

1.1M Inpatient discharges and deaths

8.6M Inpatient & day inpatient patient days

2.2M A&E attendances

No. of attendances

48 Specialist Outpatient Clinics

73 General Outpatient Clinics

Specialist outpatient (clinical):   7.6M

Allied health (outpatient):   2.7M

Primary Care: 6.4M

Manpower Total: 74 874 [as at 31 Mar 2017]

Medical	6 164	(8.2%)
Nursing	24 980	(33.4%)
Allied Health	7 572	(10.1%)
Supporting (care-related)	14 698	(19.6%)
Others	21 459	(28.7%)

Medical admissions account for almost half of total emergency admissions

No. of Emergency Admissions by Speciality in 16/17

Paediatrics and Adolescent Medicine 8%

Gynaecology 3%

Others 5%

Orthopaedics & Traumatology 10%

Medicine 46%

Emergency Medicine 12%

Surgery 16%
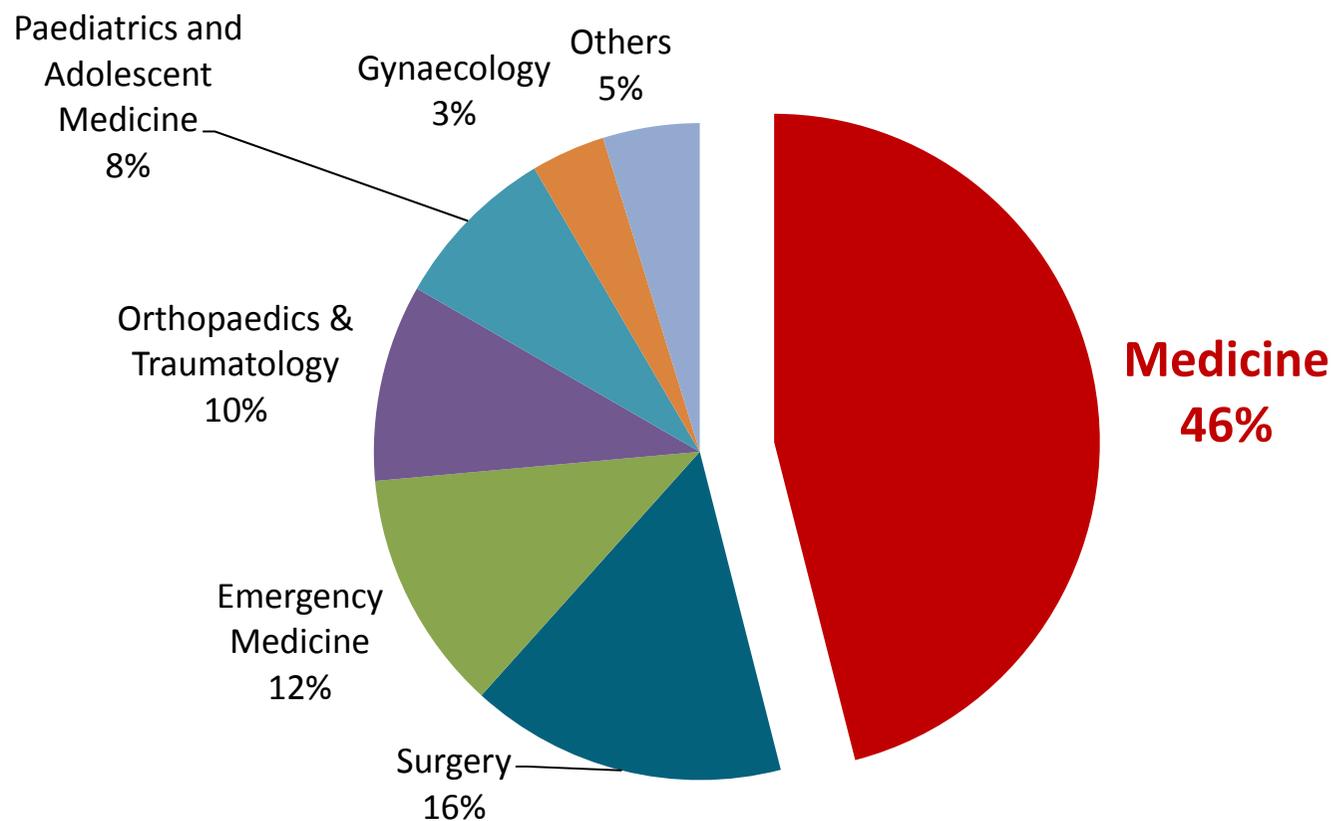
Usually 2-3 surges in emergency medical admission every year

Overall Situation for Medical Inpatient Service*
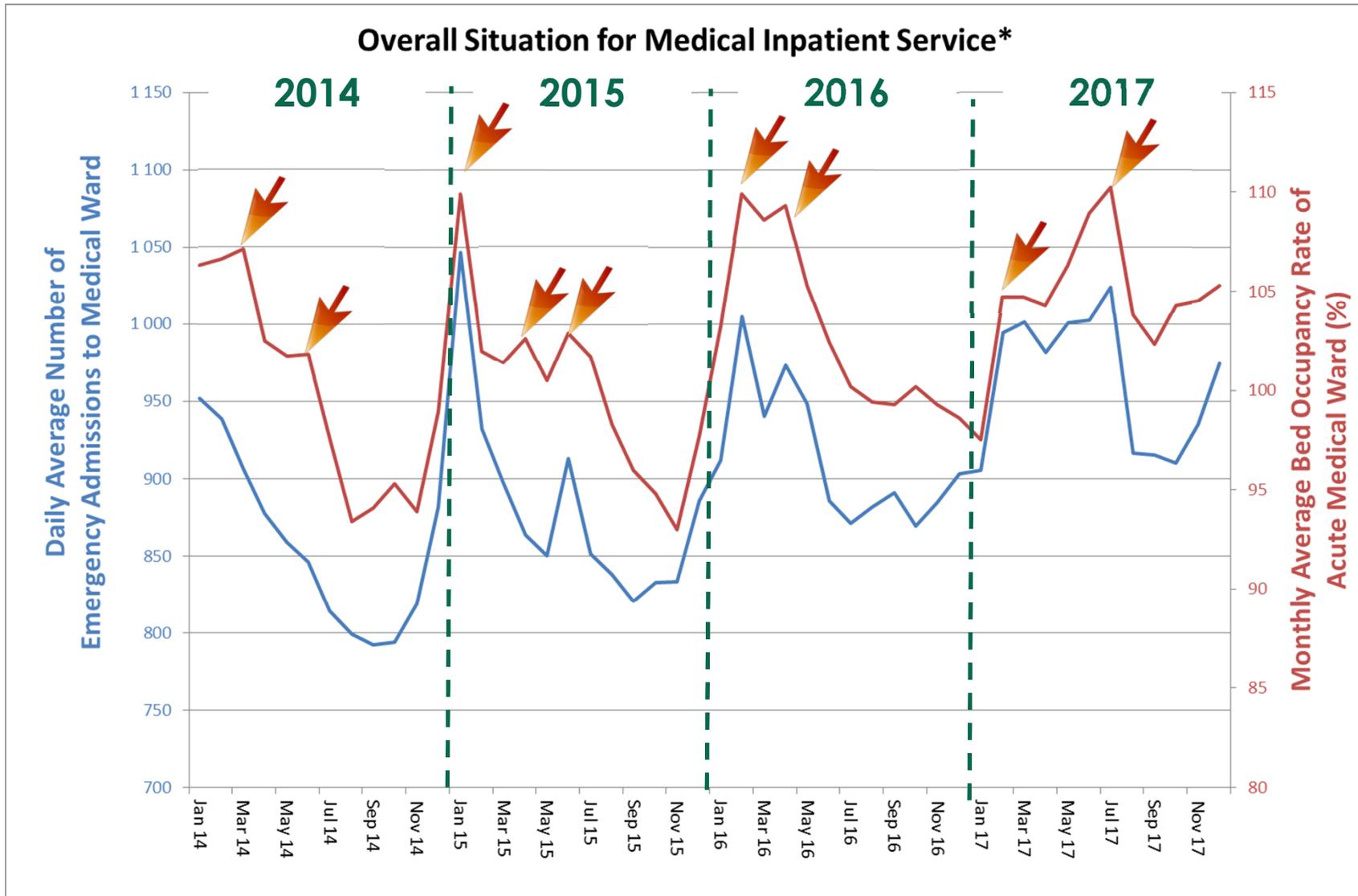
* The above chart only cover general acute hospitals with 24 hour A&E services.

How Analytics can contribute ?

Predict

To predict the surge in admission before it happens

Alert

To alert frontline / management

Proactive Measures

e.g. scale down non-urgent services; add temporary beds; deploy staff
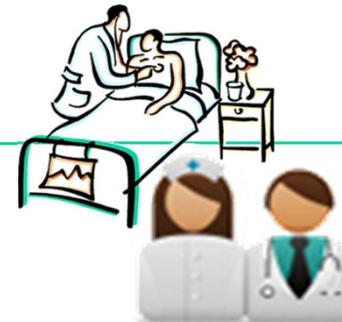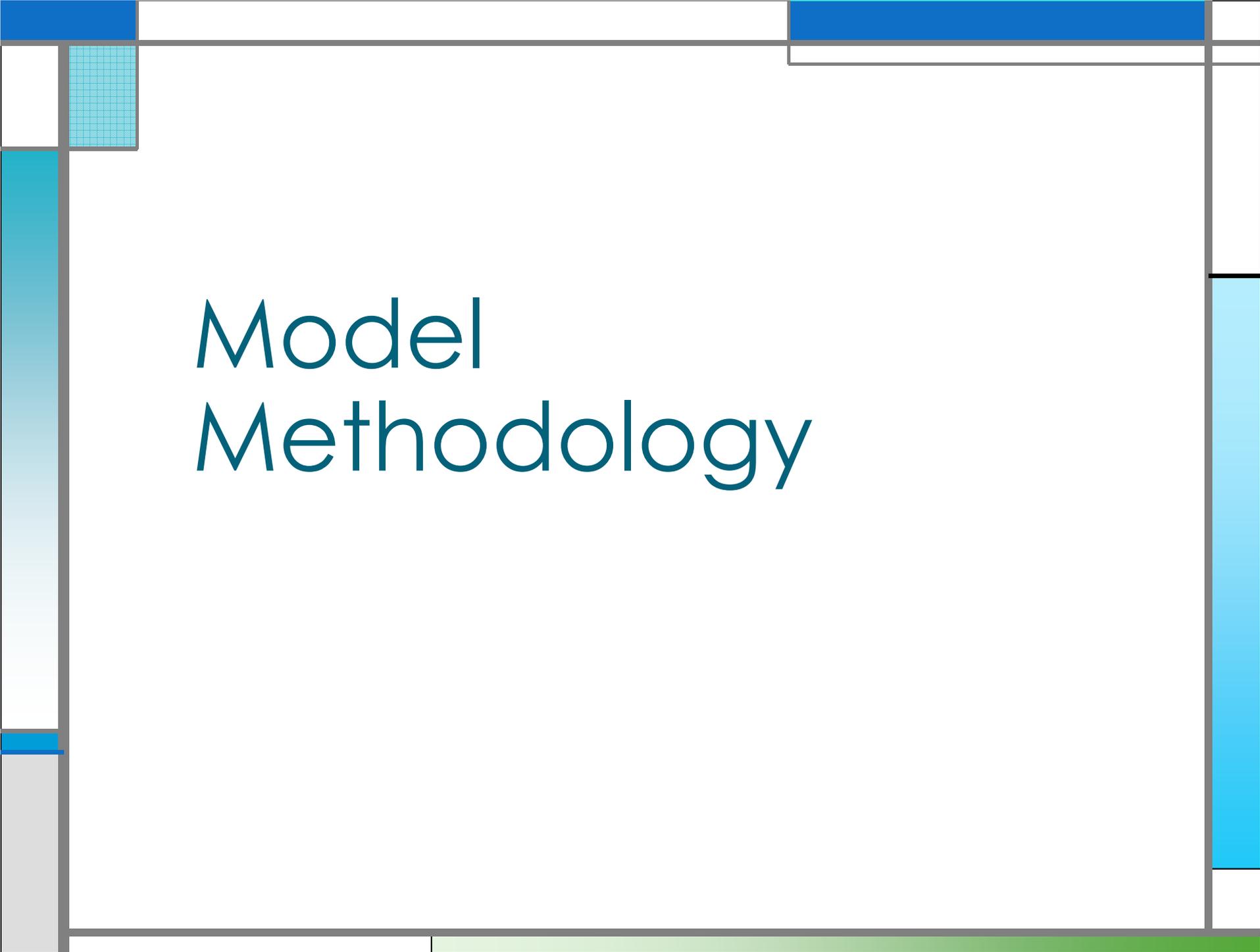
Model Methodology

Data Sources & Modelling Methodology

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)

Comparing different models by Akaike information criterion (AIC) and Bayesian Information Criterion (BIC)
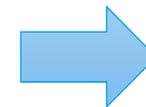
To establish an alert signal through empirical data analysis

Model Building & Validation

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
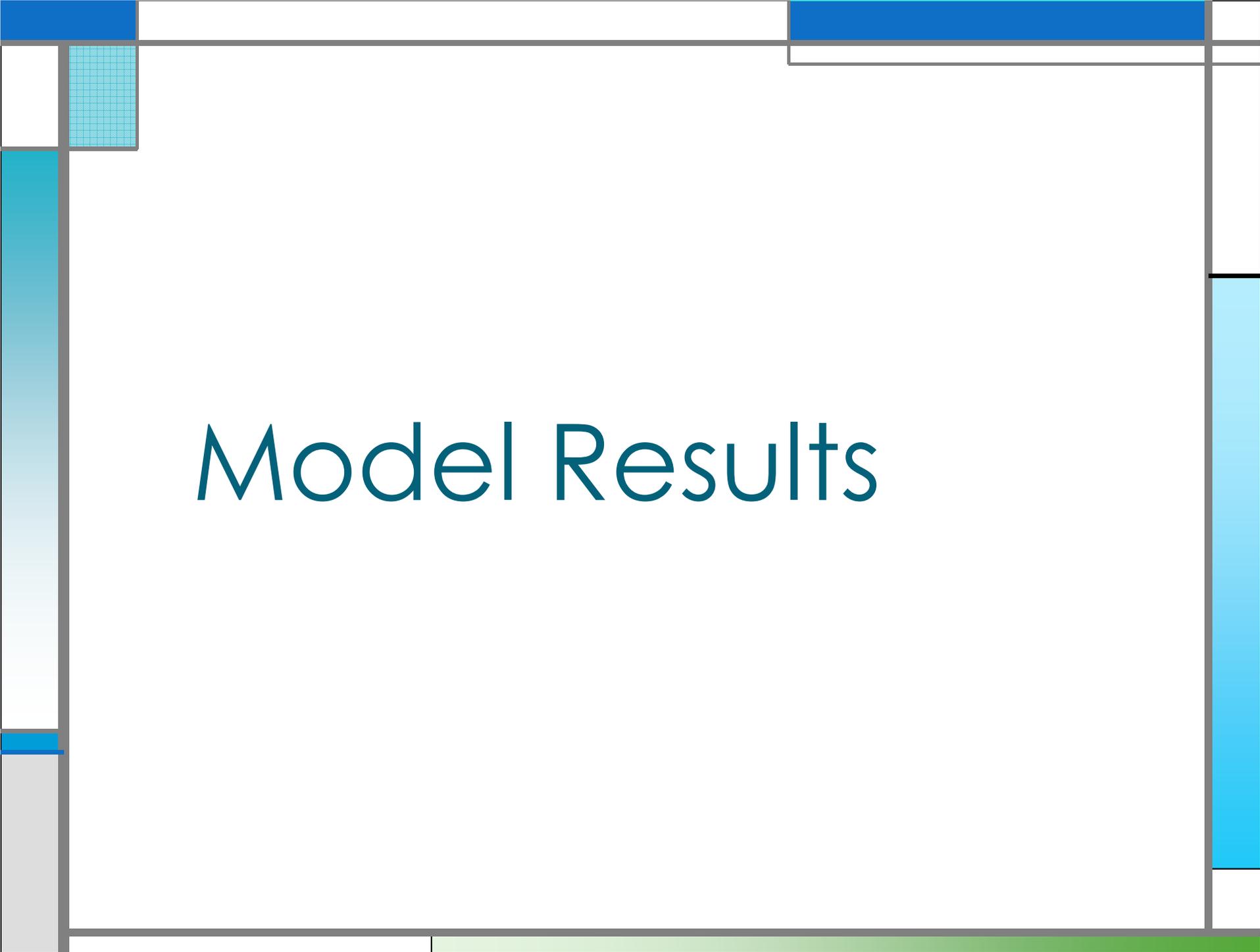
Model Results

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
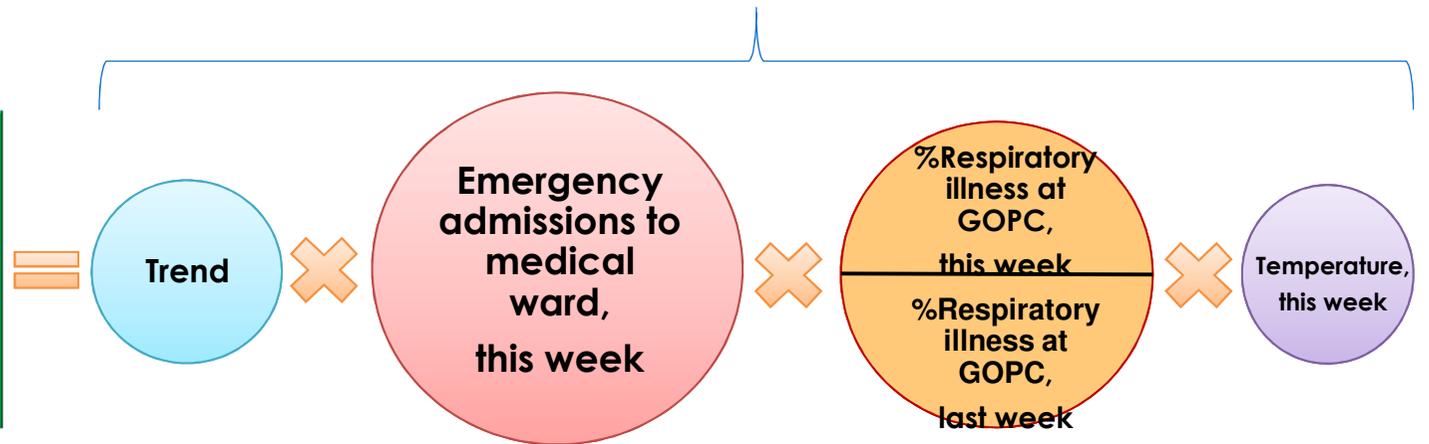
increasing trend

positively associated

When relativity > 1, admissions ↑

When relativity < 1, admissions ↓

in quadratic relationship

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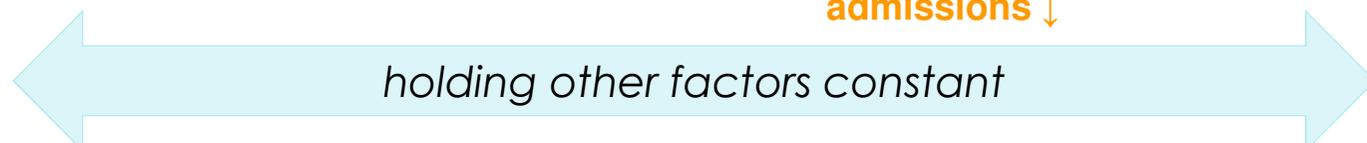
$$Y_t = C_1 \times e^{\alpha t} \times (Y_{t-1})^\beta \times \left\{ \frac{(X_{t-1})^{\lambda_1}}{(X_{t-2})^{\lambda_2}} \right\} \times \exp\left\{ \frac{(W_{t-1} - \varphi)^2}{C_2} \right\}$$

4 Predictors in the Model:
(1) Trend

On average, the admission number has increased by **3.7%** per annum over the past 6 years

Weekly no. of Emergency Admissions to Medical Ward
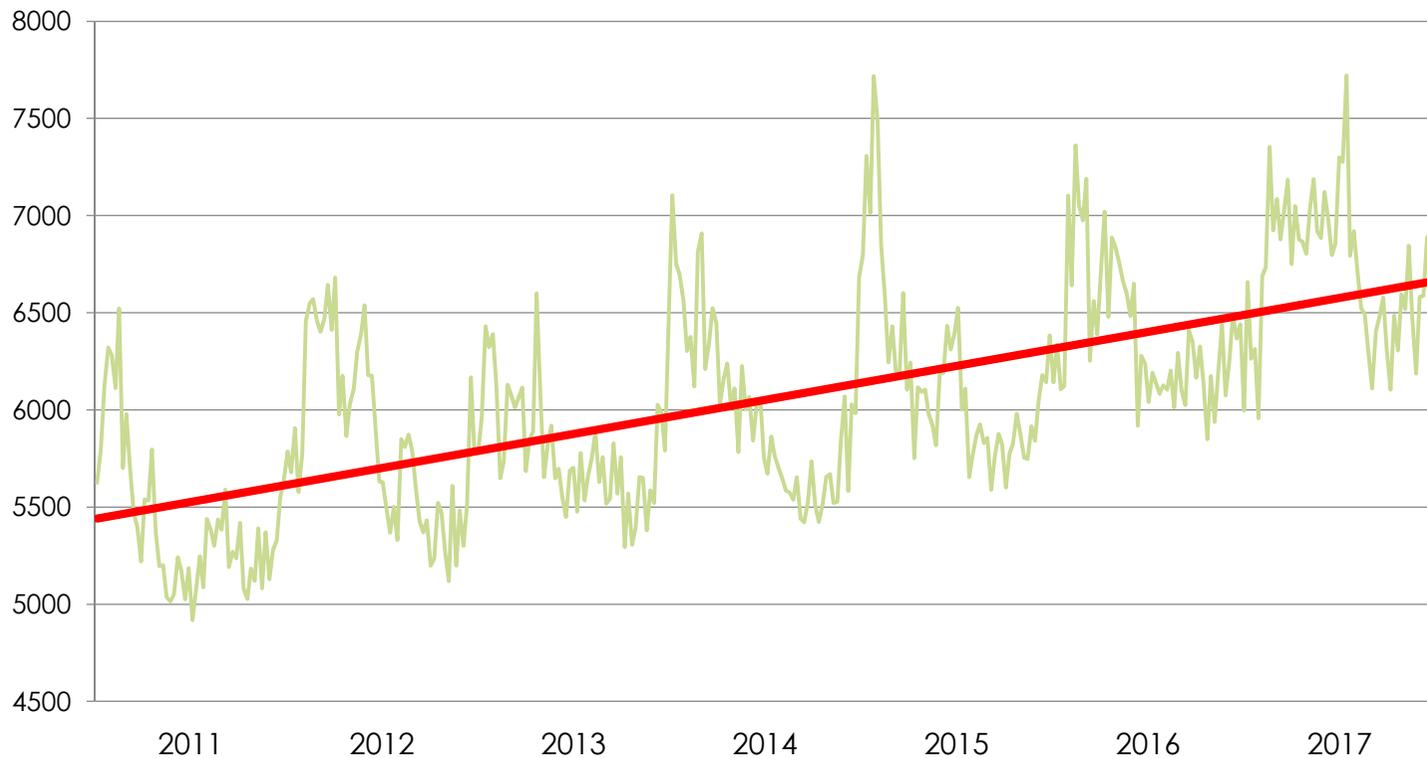
4 Predictors in the Model:
(2) Preceding Week's Figure

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

i.e. a strong autocorrelation 0.87
 between $week_{T-1}$ and $week_T$ data

4 Predictors in the Model:
(3) Respiratory Illness at General Outpatient Clinic

Total GOP episodic attendances

100%
80%
60%
40%
20%
0%

%respiratory illness*

%respiratory illness*

Last week   This week

↑ emergency medical admissions next week

Total GOP episodic attendances

100%
80%
60%
40%
20%
0%

%respiratory illness*

%respiratory illness*

Last week   This week
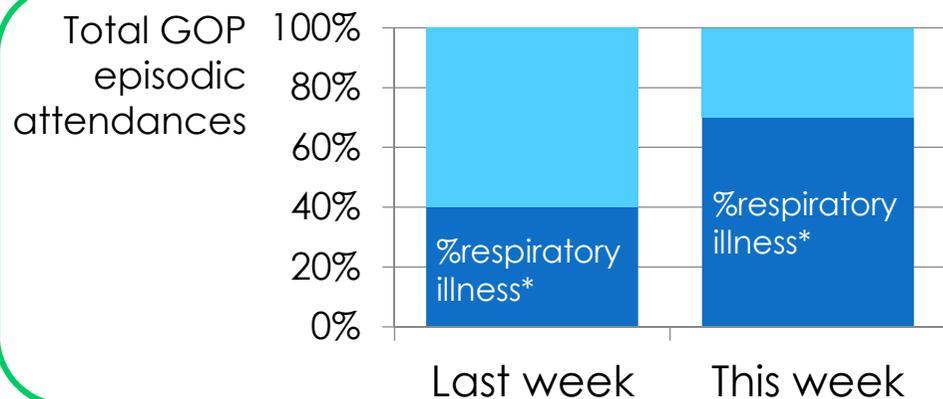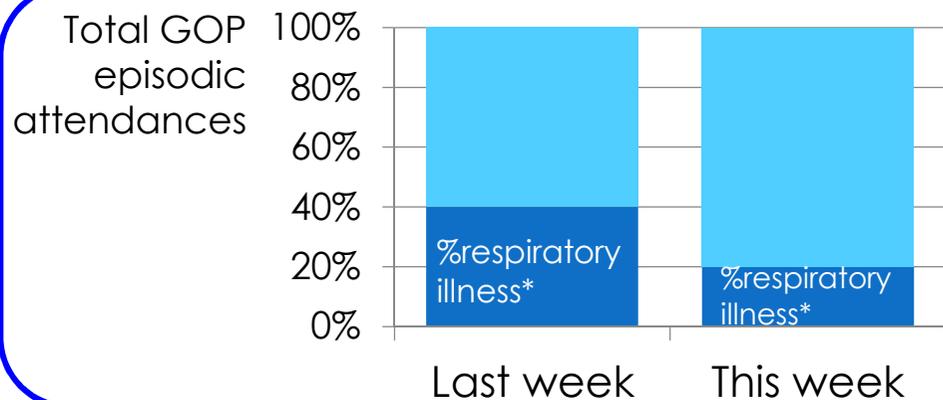
↓ emergency medical admissions next week

* Based on International Classification of Primary Care-2 (ICPC) codes:
  R72, R74-R78, R80, R81 and R83

4 Predictors in the Model: (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

Average Temperature in Week$_T$ (°C)

13   17   21   25   29
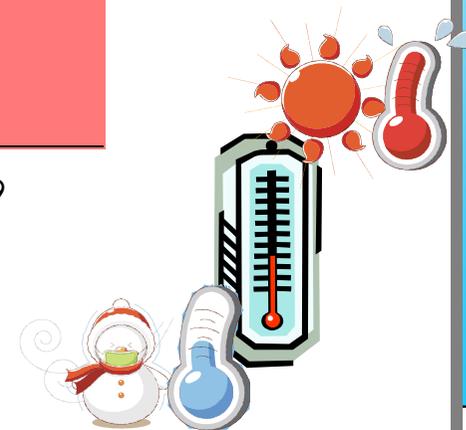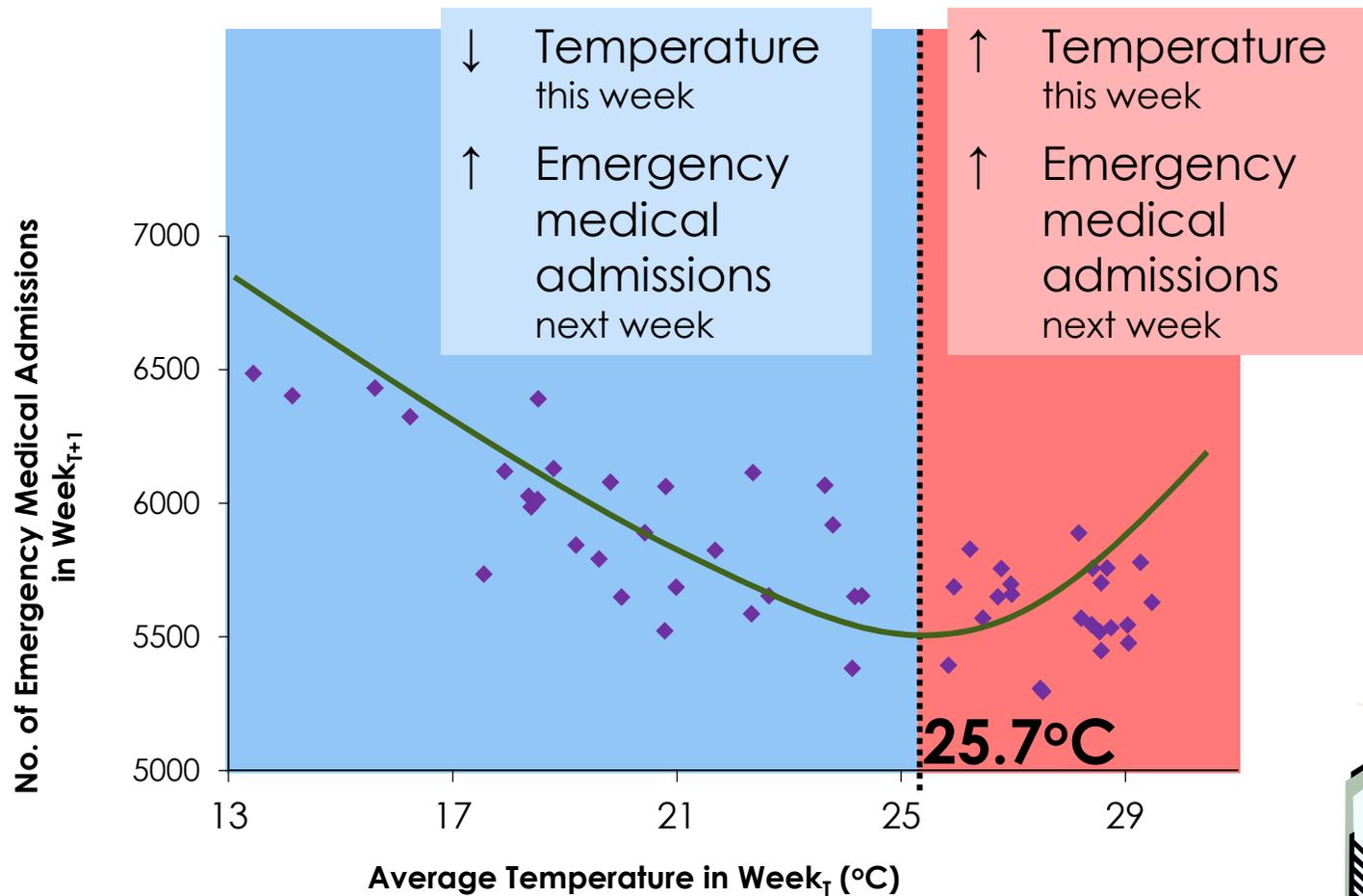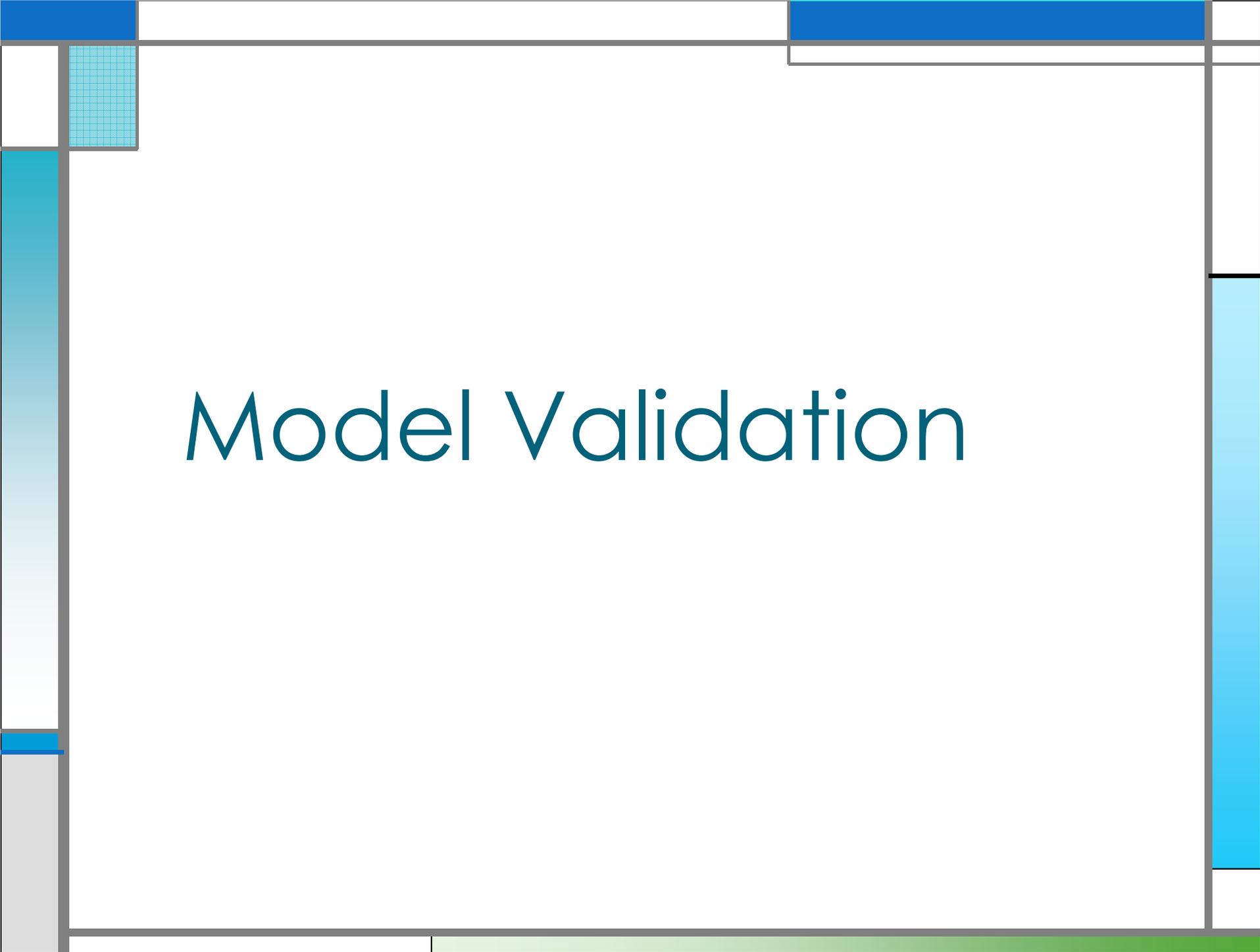
Model Validation

Model Validation in 2012 and 2013

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

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%)

Y-axis: Weekly no. of Emergency Admissions to Medical Ward (4500 to 8500)

X-axis: Jan 2012, Feb 2012, Mar 2012, Apr 2012, May 2012, Jun 2012, Jul 2012, Aug 2012, Sep 2012, Oct 2012, Nov 2012, Dec 2012, Jan 2013, Feb 2013, Mar 2013, Apr 2013, May 2013, Jun 2013, Jul 2013, Aug 2013, Sep 2013, Oct 2013, Nov 2013
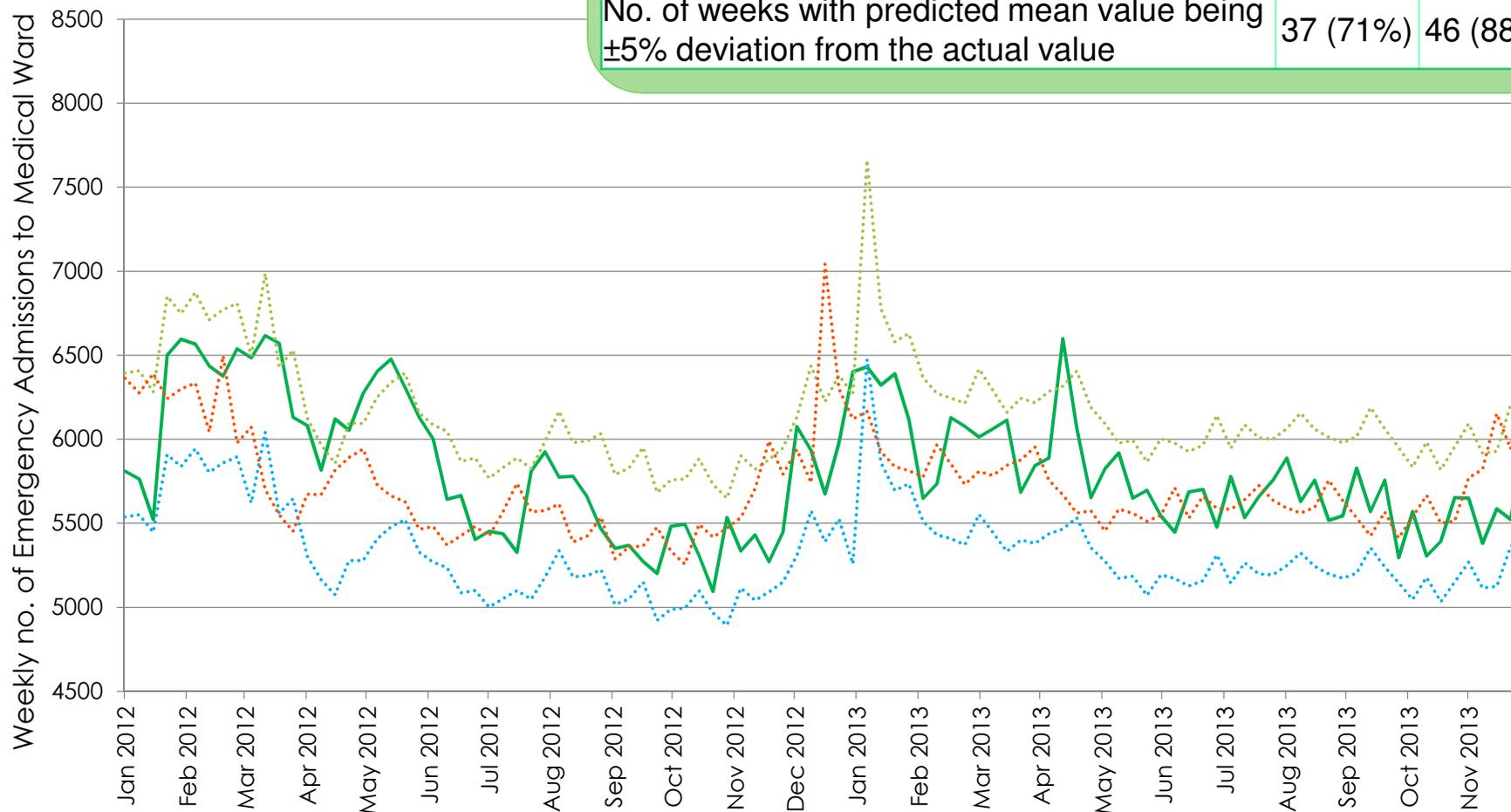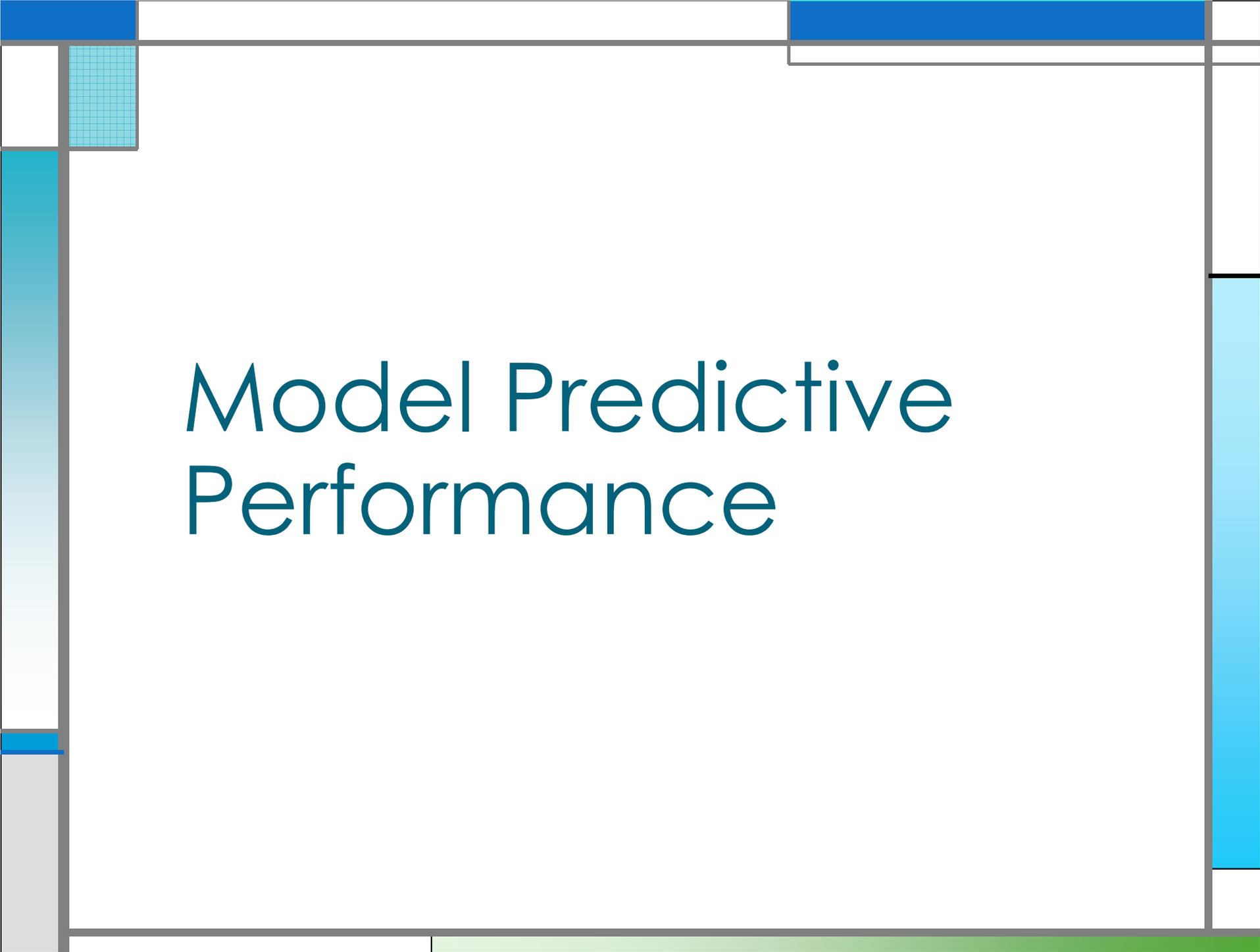
Model Predictive Performance

Set-up of Alert Signals

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

	when the predicted number for next week (T+1):
Relative Alert Signal	increases by 5% or more over this week's actual number (T)
Absolute Alert Signal	exceeds the threshold of 6,000

Model Predictive Performance in 2015/16

Alerts triggered when the predicted number for next week (T+1):
- increases by 5% or more over this week's actual number (T)
- exceeds the threshold of 6,000
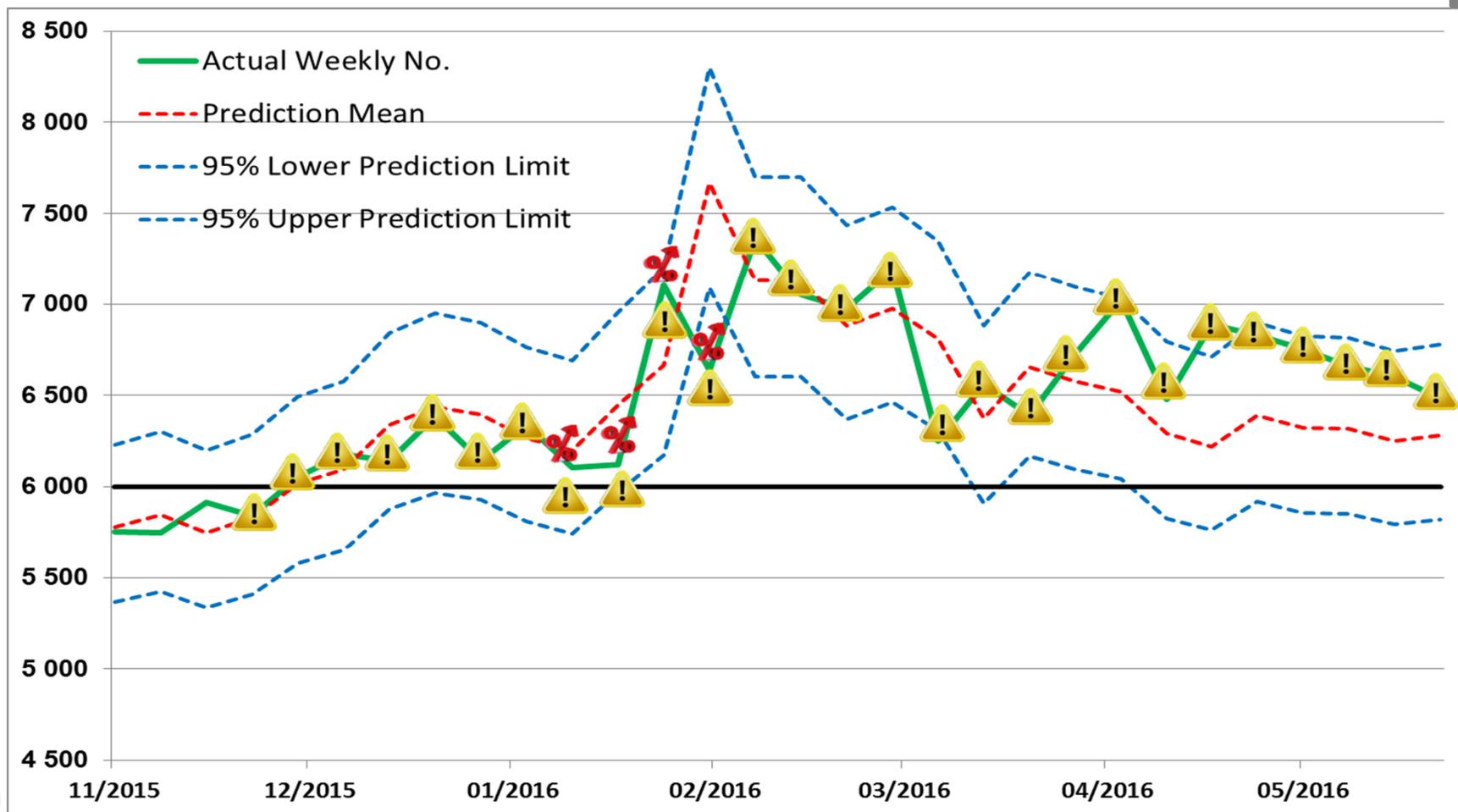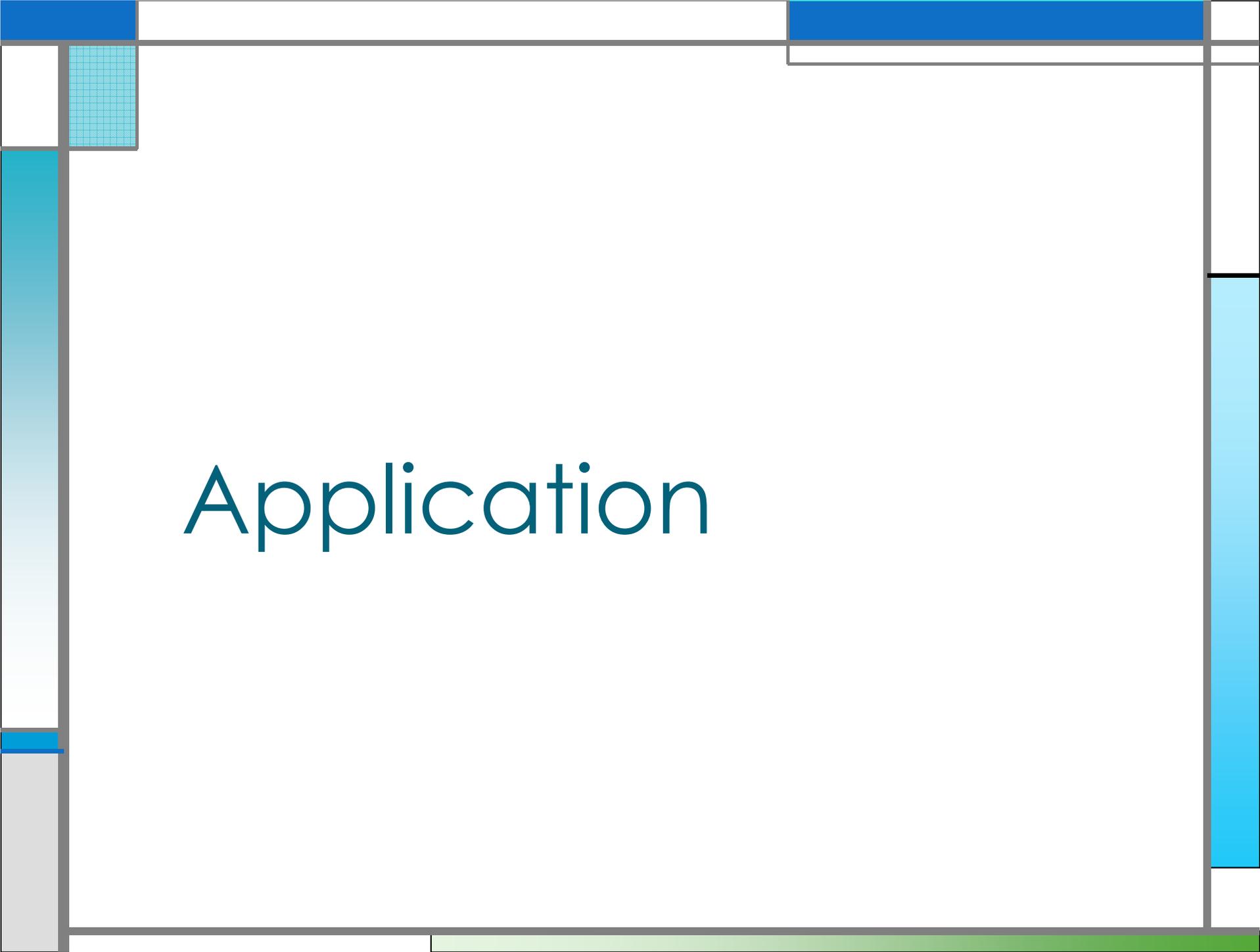
Application

Response Measures to cope with the Surge

Through triggering an early alert, this Model can facilitate HA in:

- **Optimising and augmenting buffer capacity;**
- **Reprioritising core activities**
- **…**

Emergency

Elective

Extra beds

Further Enhancement of the Model

Further Enhancement

- To extend the forecast period
  (e.g. two-week ahead forecast)

- To consider a wind speed factor for
  the Wind Chill Effect

冬季服務高峰期
WINTER SURGE

Thank You