

Value of Forecasting in Emergency Service Operational Planning

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Quarterly Forecasting Forum

21 May 2021

Outline

- How forecasts can be used to inform planning in Accident & Emergency department?
- Data & forecasting models
- Scheduling scheduling and utility measures
- Evaluate forecast accuracy
- What if we don't bother with forecasting methods?

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- How forecast can be used to inform planning in Accident & Emergency department?
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- What if we don't bother with forecasting methods?

How many nurses/doctors and When?

- Demand/capacity planning
- Staffing
- Scheduling



Forecasts can inform various planning horizons

Decision needs to be made to absorb demand uncertainty by providing effective and efficient staffing

- 6 months
- 42 days
- 48 hours

My understanding of systematic use of forecasting

Real life

Click to watch the video

Barriers in using forecasting

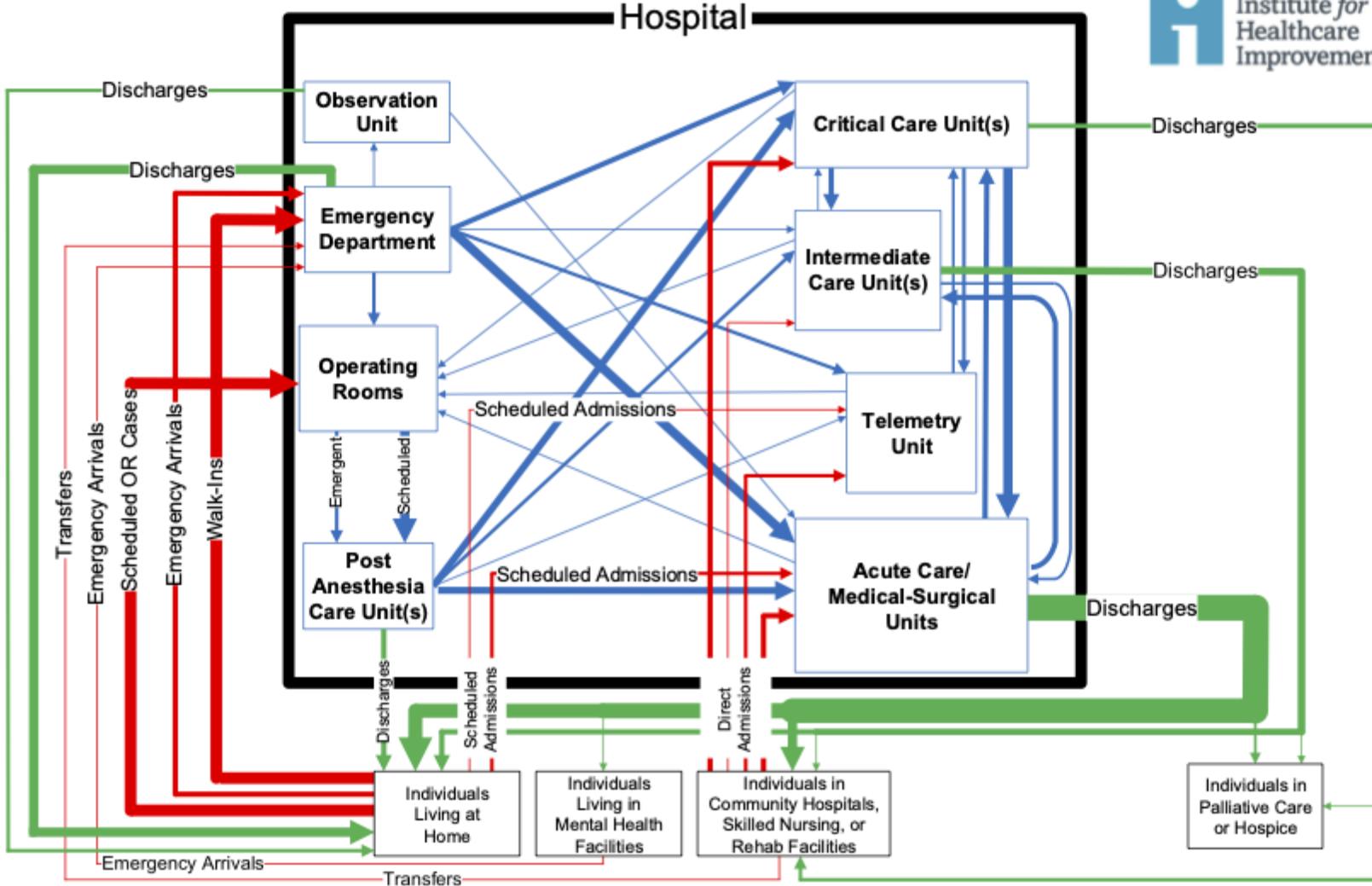
- Among other factors, **disconnection** between forecasting and decision-making plays a role
- The value/quality of a forecast should be determined by a decision it supports, something actionable
- Presenting both forecast accuracy and its impact can help to better use forecasting

Aim of this project

- Evaluate the impact of forecasting on utility measure such as cost, overtime staff, using emergency resources and waiting time
- Evaluate the use of probabilistic forecasting in planning
- What happens if you don't bother with forecasting methods

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Key: **Blue arrows:** Flow within hospital | **Red arrows:** Flow into hospital | **Green arrows:** Flow out of hospital | **Width of arrows:** Typical flow volumes

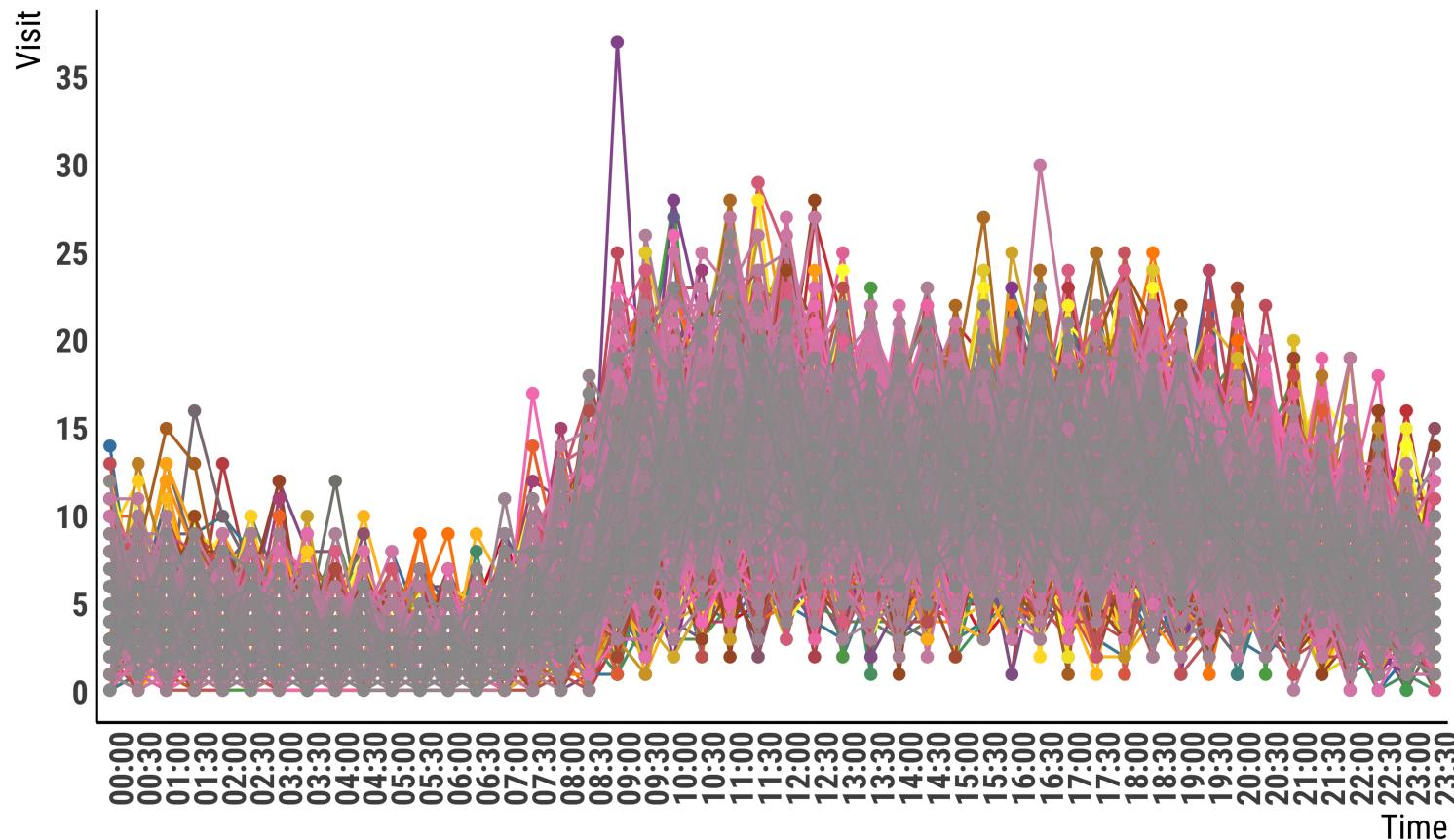
Source: Rutherford PA, Provost LP, Kotagal UR, Luther K, Anderson A. Achieving Hospital-wide Patient Flow. IHI White Paper. Cambridge, MA: Institute for Healthcare Improvement; 2017. (Available at www.ihi.org)

Data

- Data is from an Accident and Emergency department in the UK
- 5 years and 2 months of arrival time
- Public holidays, school holidays and rugby

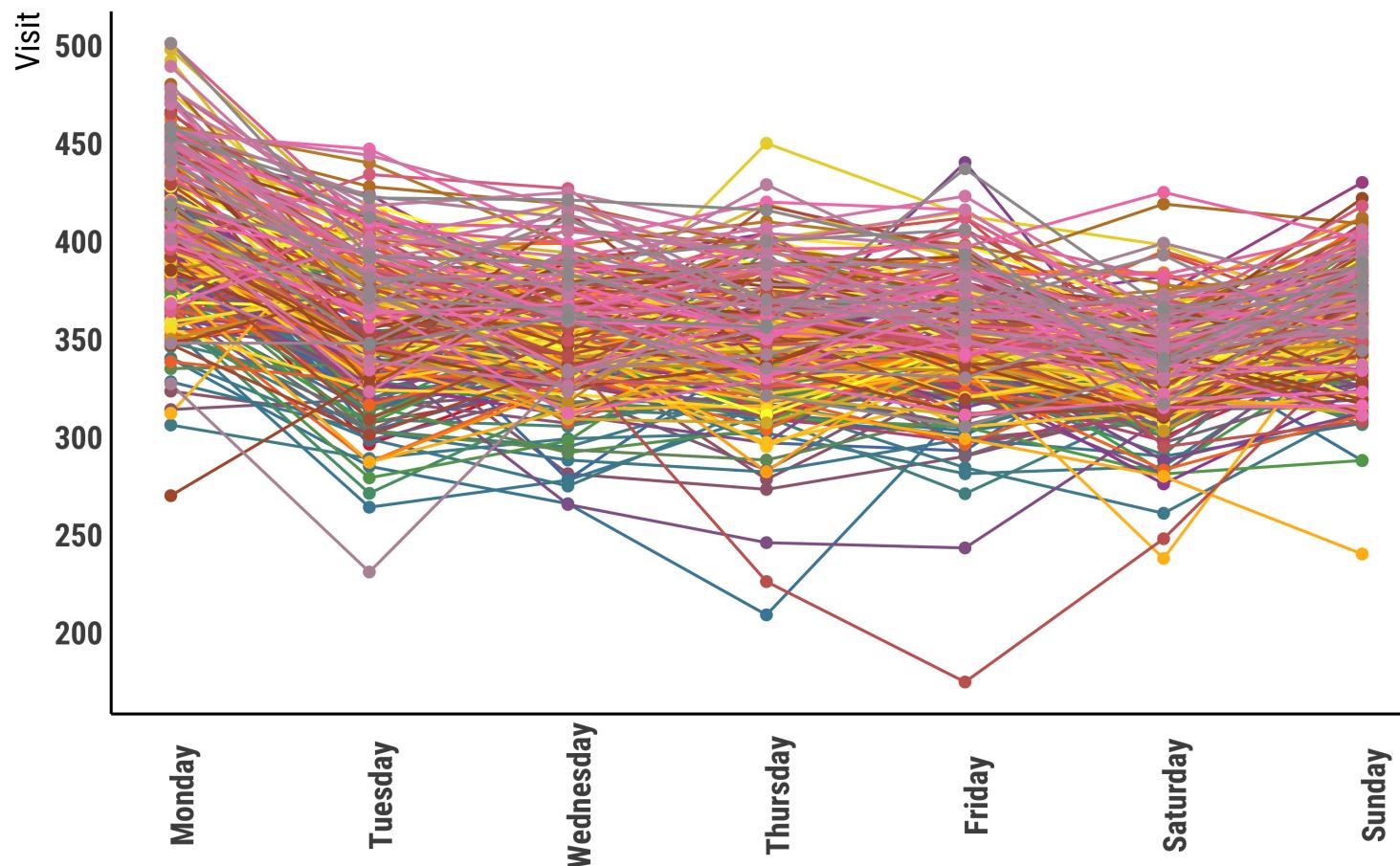
Accident & Emergency department visit

Data has a daily pattern:
Level varies depending on the day of the week



Accident & Emergency department visit

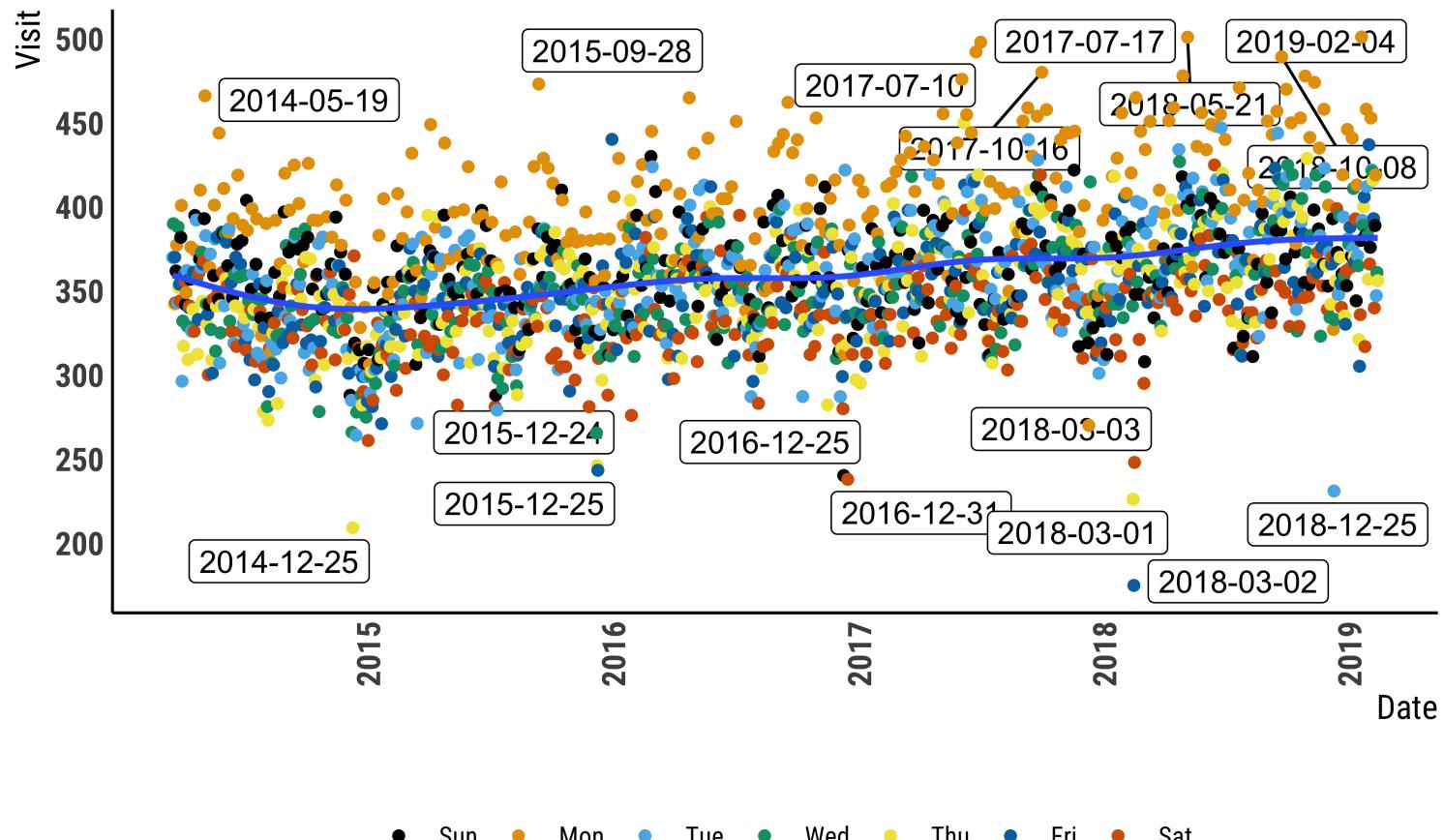
Data has weekly pattern: higher visits on Mondays, followed by Sundays
Variation in visits due to day of year effect and noise



Accident & Emergency department visit

slight long-term trend

Visits might be affected by special events: holidays, sports, etc



Forecasting methods

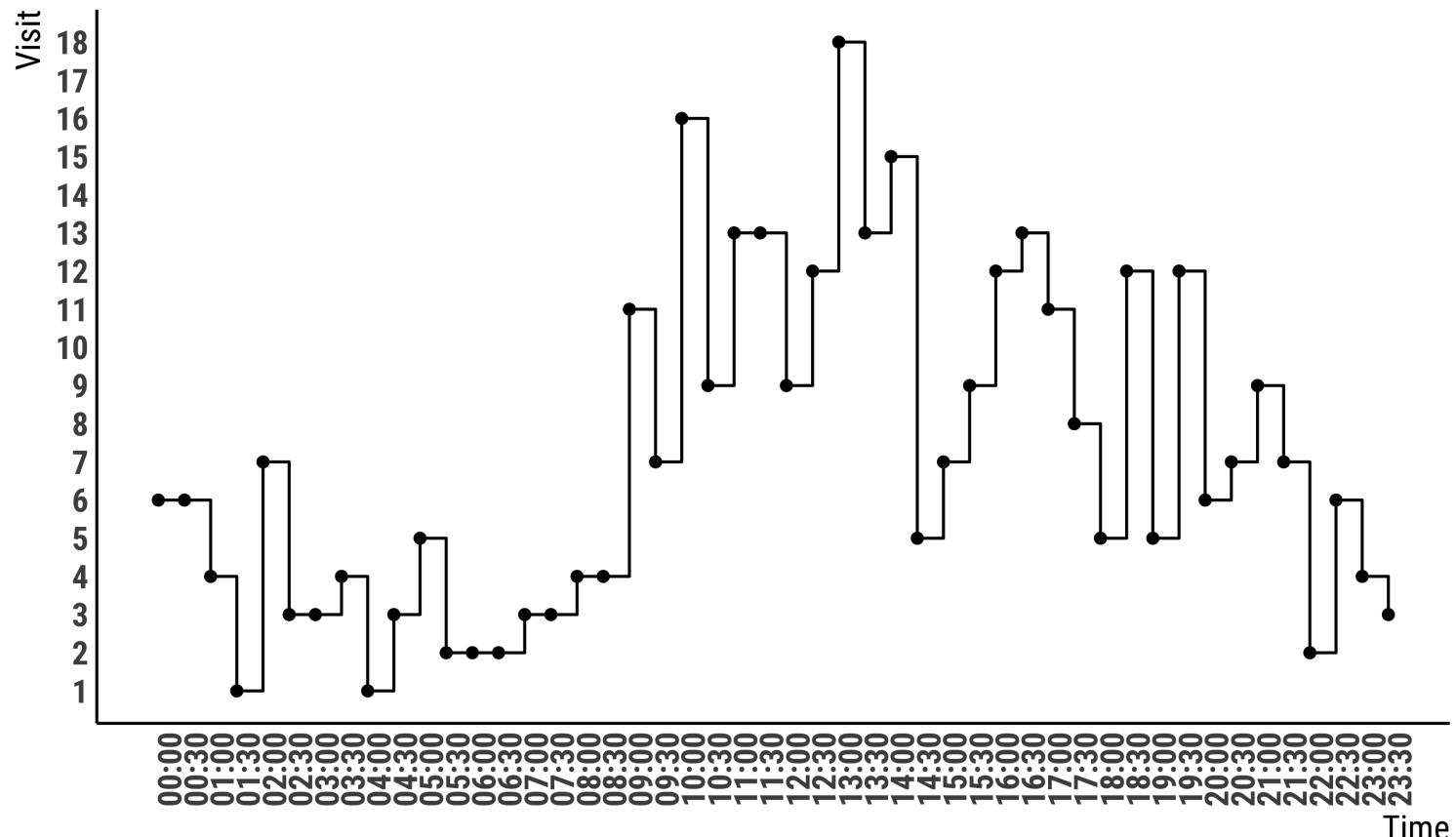
- Poisson Regression
 - Autoregressive lags, daily, weekly and yearly seasonality, Trend
- Prophet
 - daily, weekly and yearly seasonality, Trend
- ARIMA
- Exponential Smoothing
- Seasonal Naive

Outline

- How forecast can be used to inform planning in Accident & Emergency department?
- Data & forecasting models
- Shift scheduling and utility measures
- Evaluate forecast accuracy using statistical measures
- What would be the performance of planning if we plan based on forecasts?
- What if we don't bother with forecasting methods?

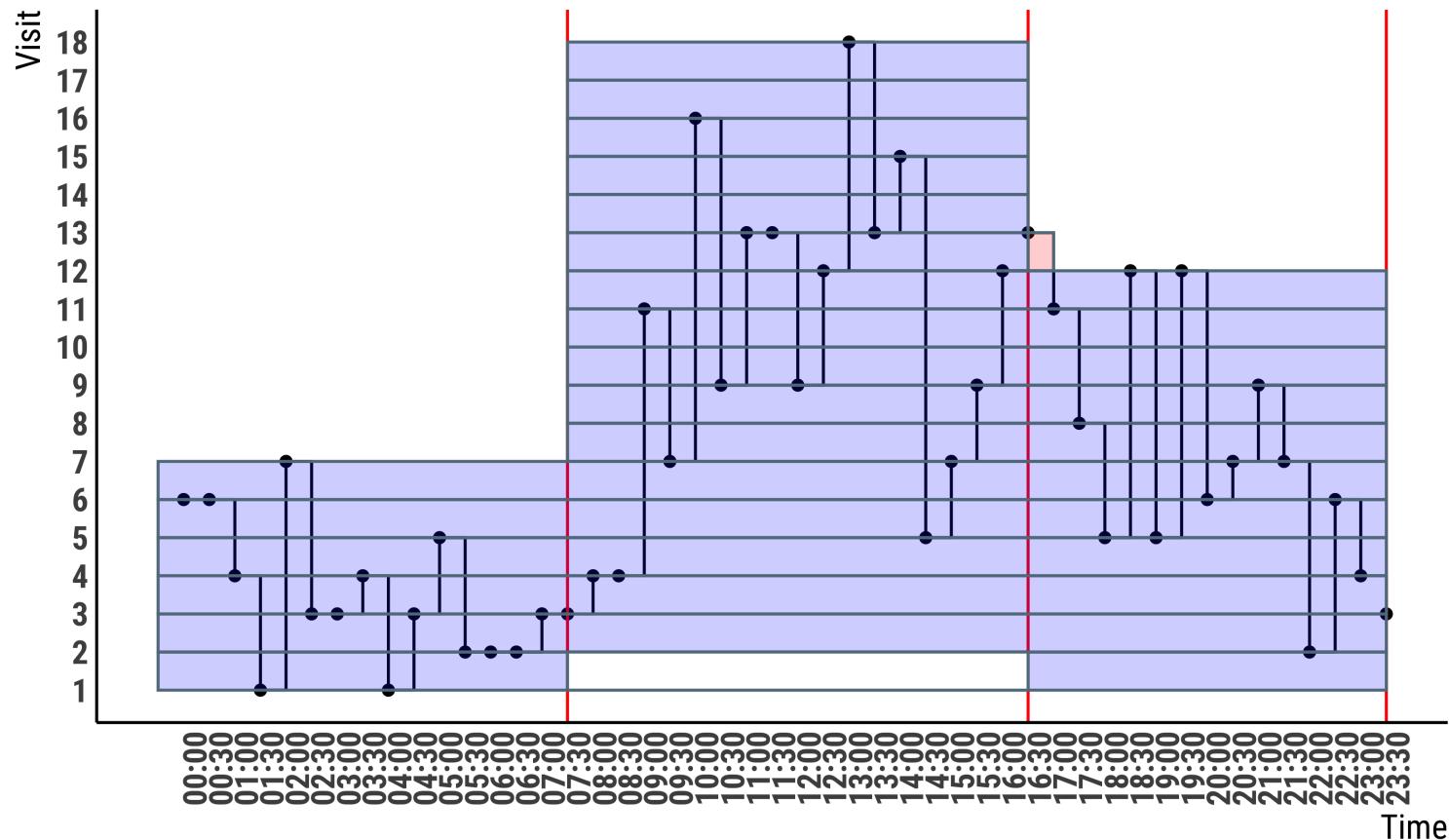
Accident & Emergency department visit

Visits in 1 day
48 periods of half-an-hour



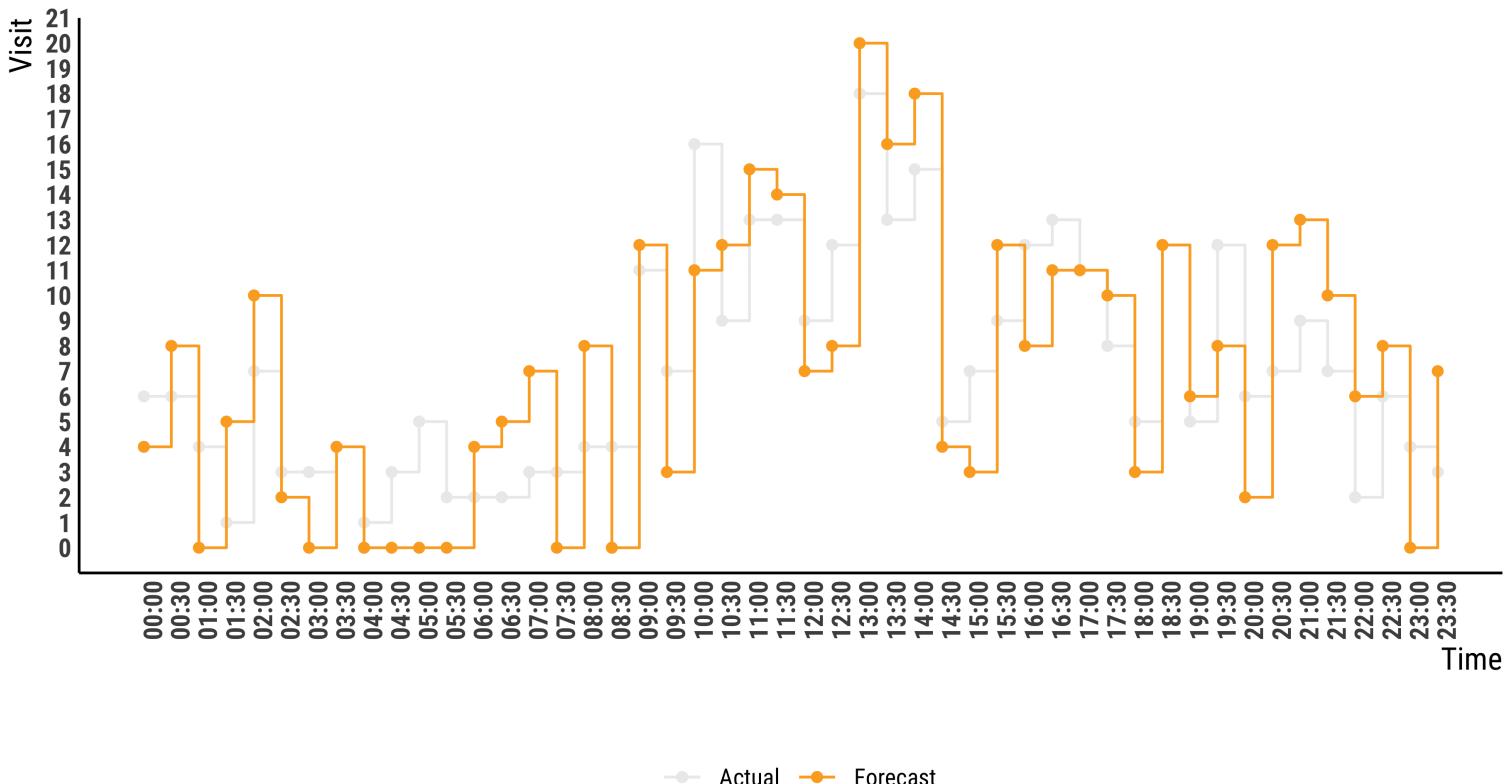
Example: shift schedule

If we had perfect information about demand (Actual) to plan
Determines Nurse value, over time, total cost



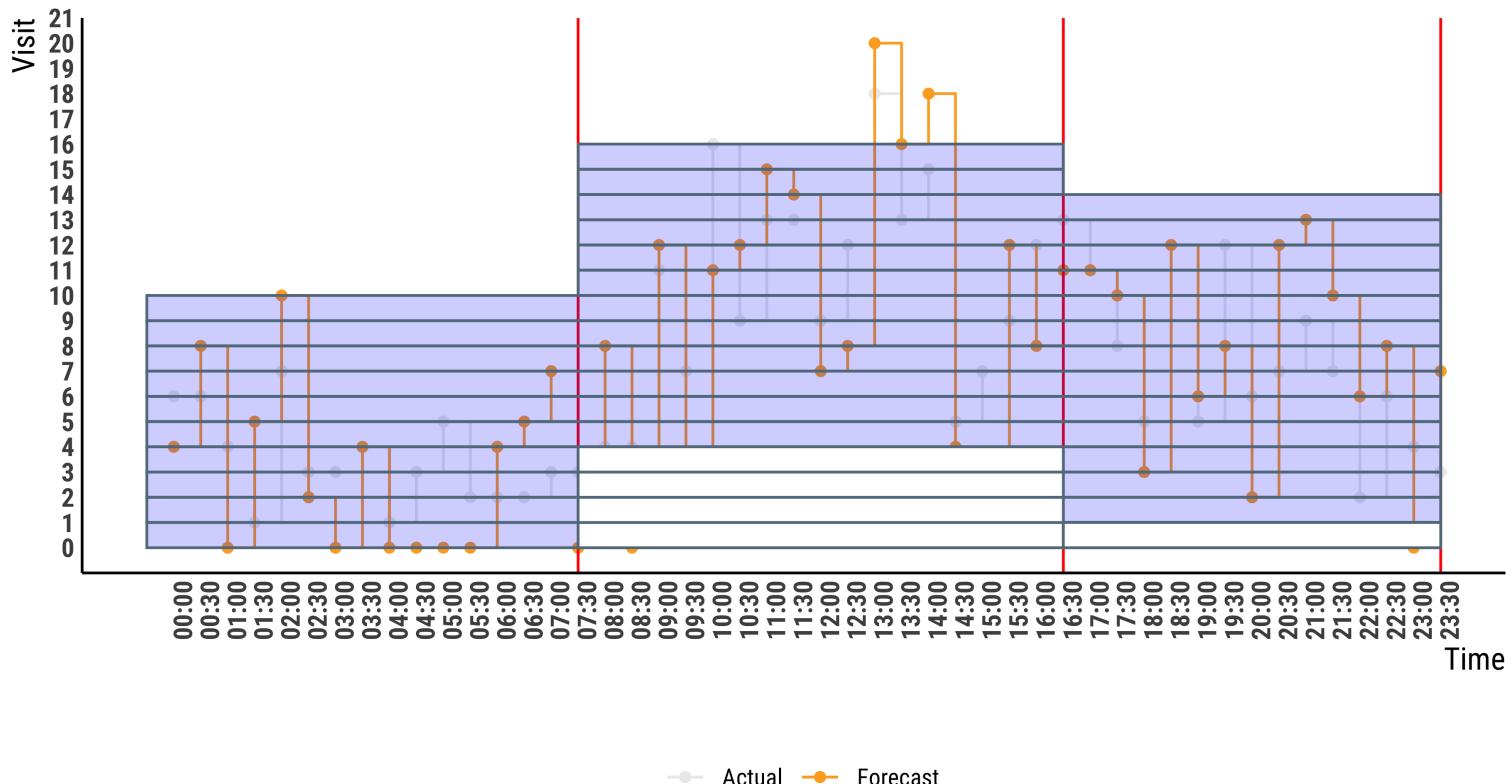
Actual vs. Forecast

We don't have actual demand, we forecast instead
Forecast is going to be different from the actual



Example: shift schedule

We don't have perfect information, we use forecast to plan
Results different Nurse value, over time, total cost compared to perfect information



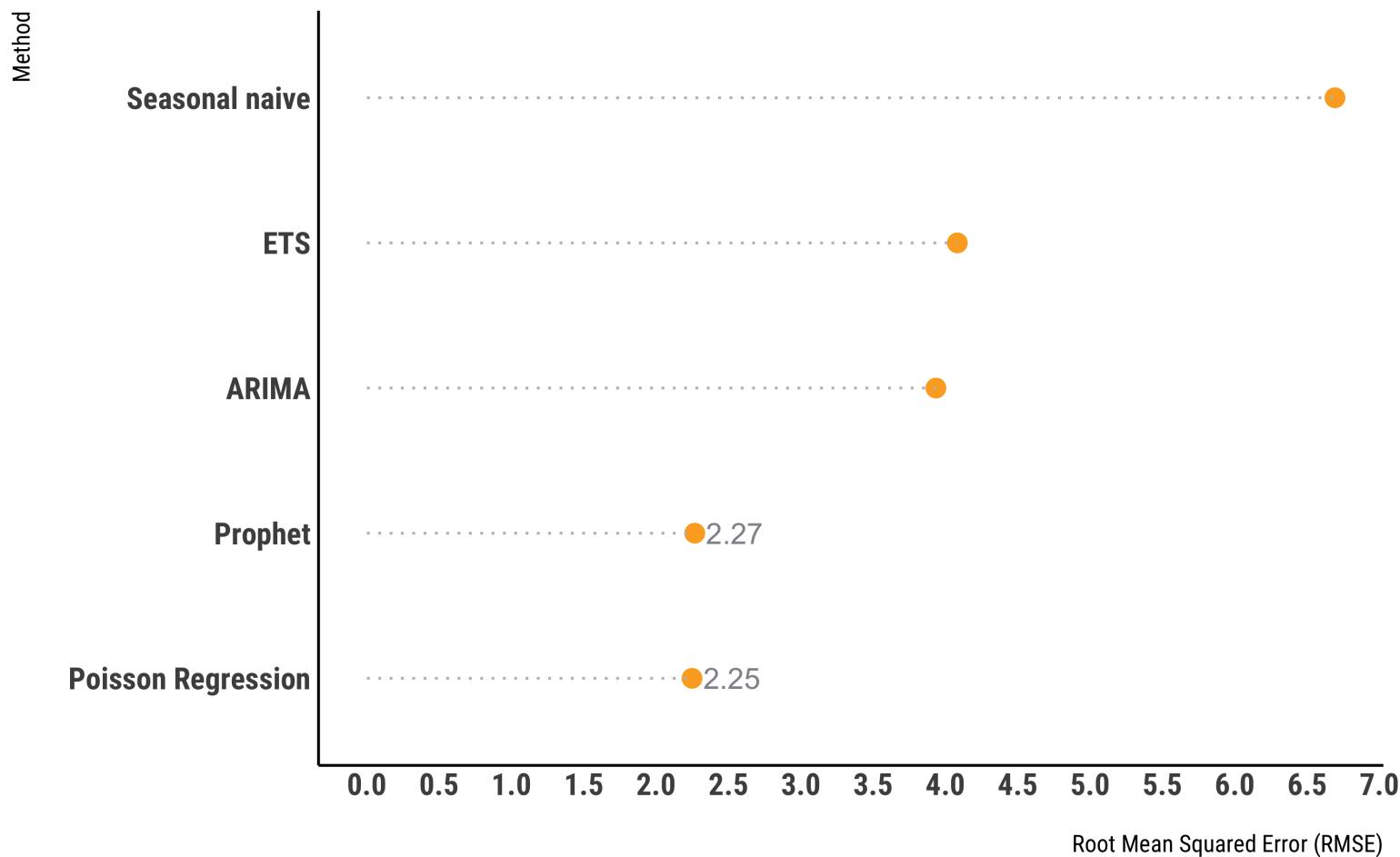
Mathematical model

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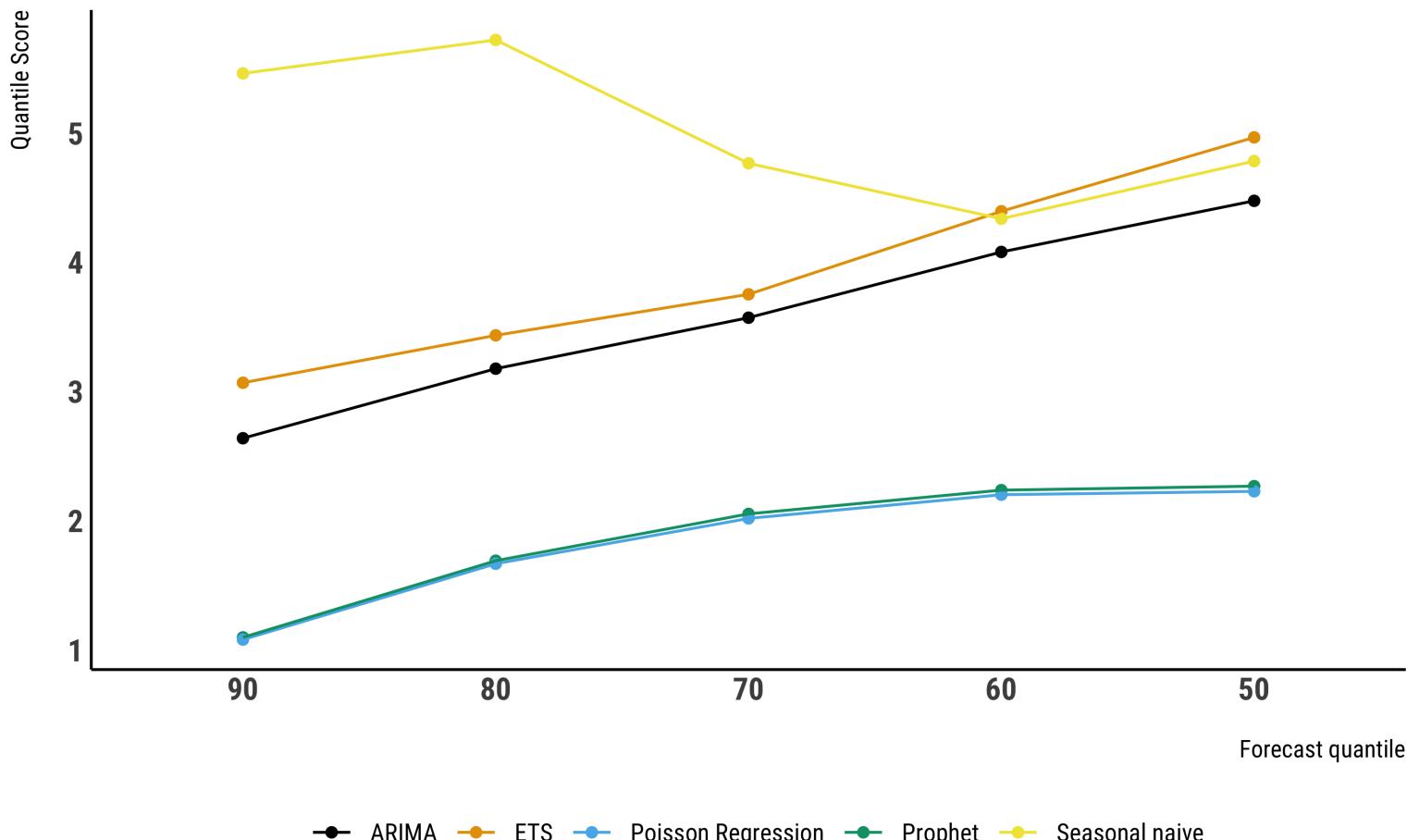
Point forecast accuracy

Poisson regression is the most accurate method, followed by Prophet



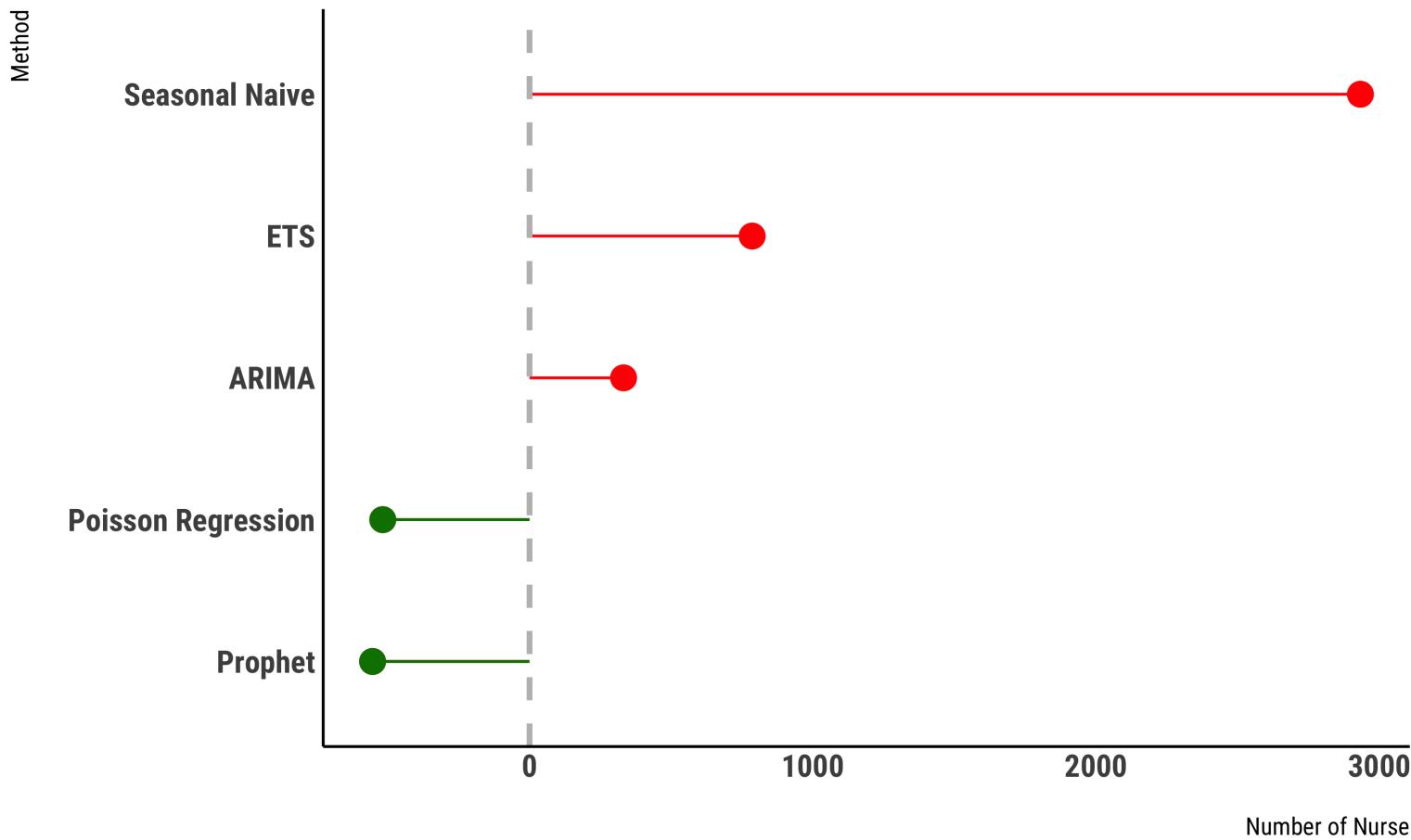
Probabilistic forecast accuracy

Poisson Regression is the most accurate



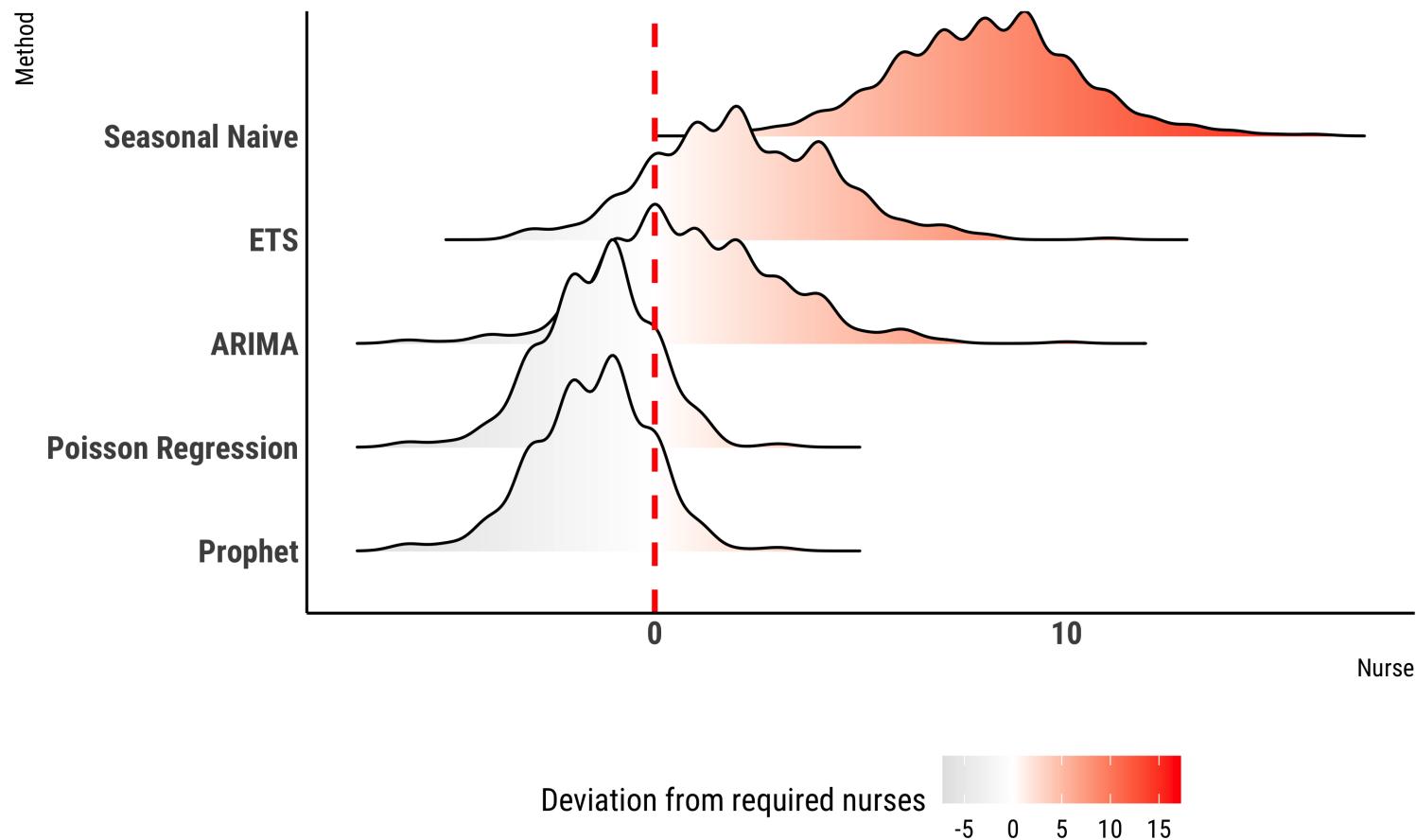
Total number of nurse/day planned compared to actual

Poisson and Prophet results in less number of nurses than required
SNaive, ETS and ARIMA generate more nurses than required



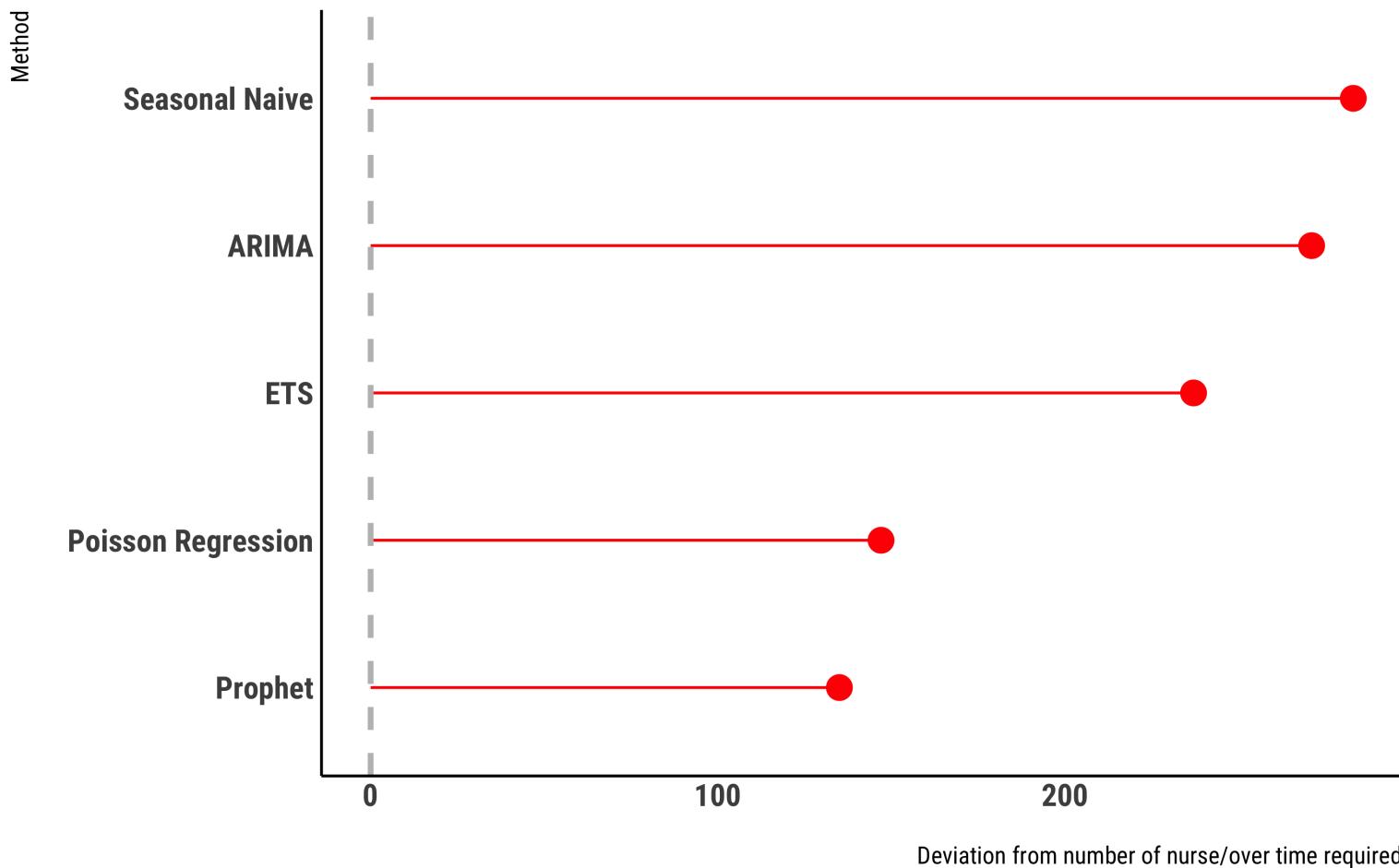
Distribution of the number of nurse

ETS and ARIMA produce over staffing and under staffing
Poisson & Prophet generates mostly less staff than required



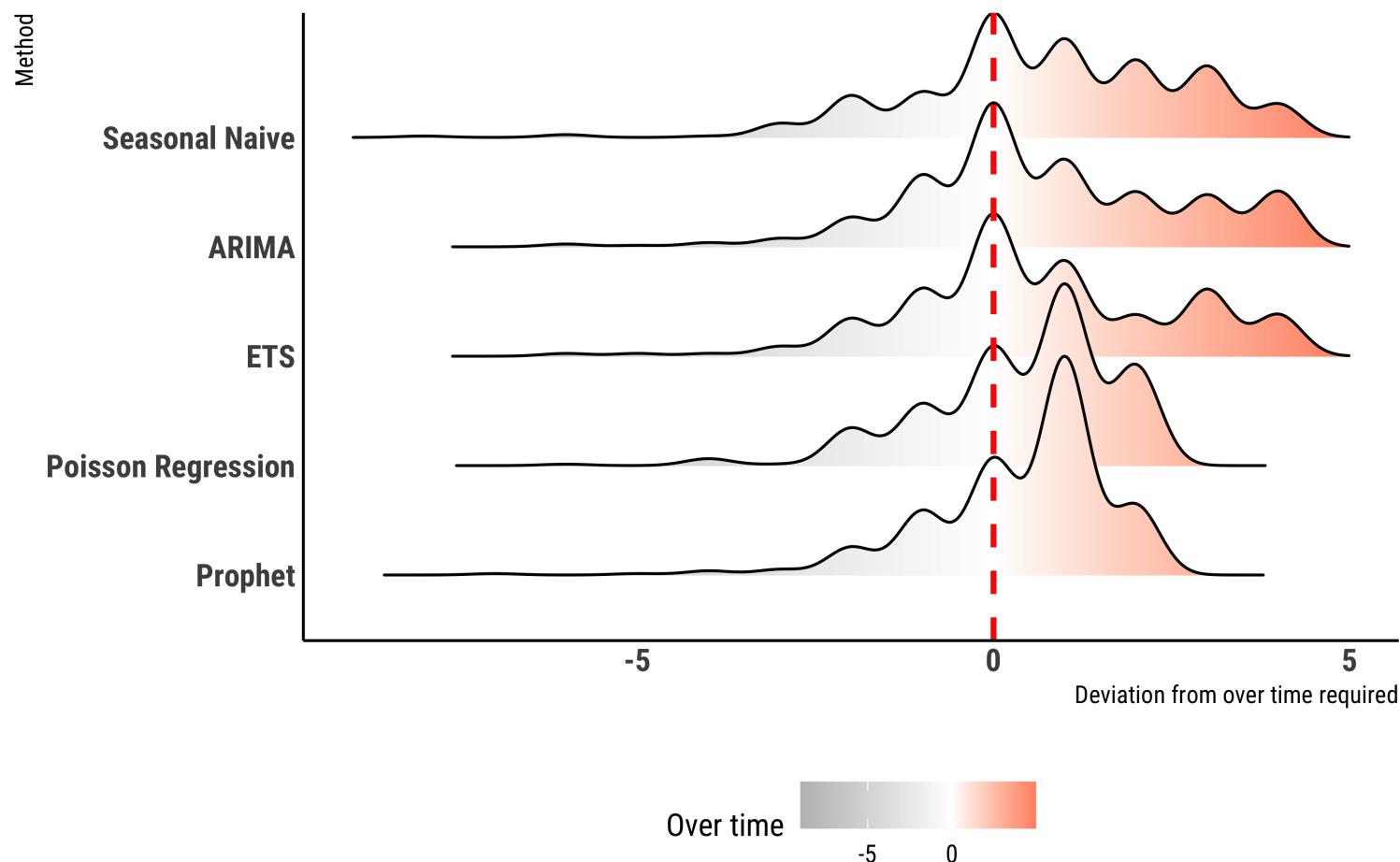
Total number of nurse/overtime compared to actual

All methods results in more over time than required



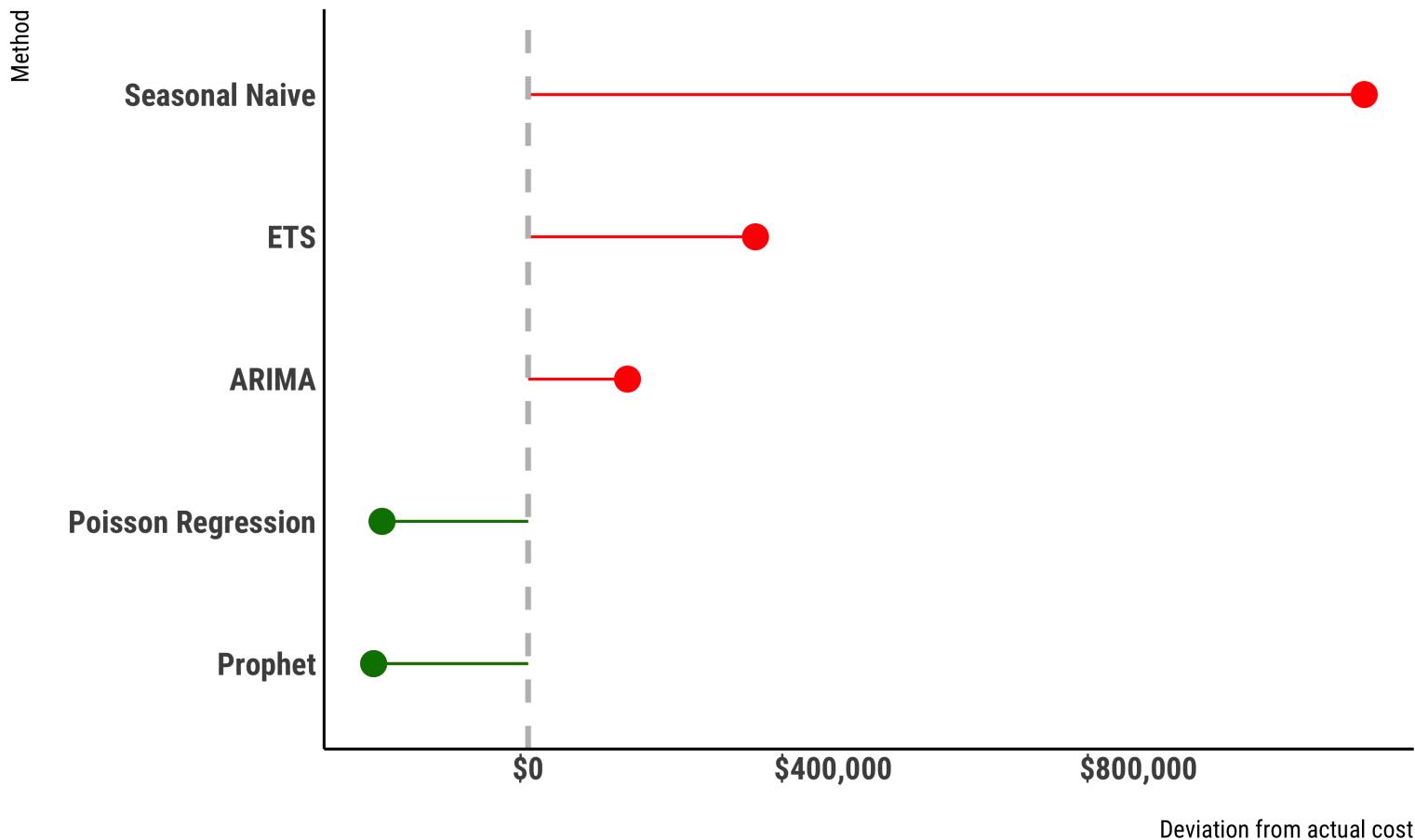
Distribution of the number of nurse/overtime

All methods generate more nurse/overtime than required



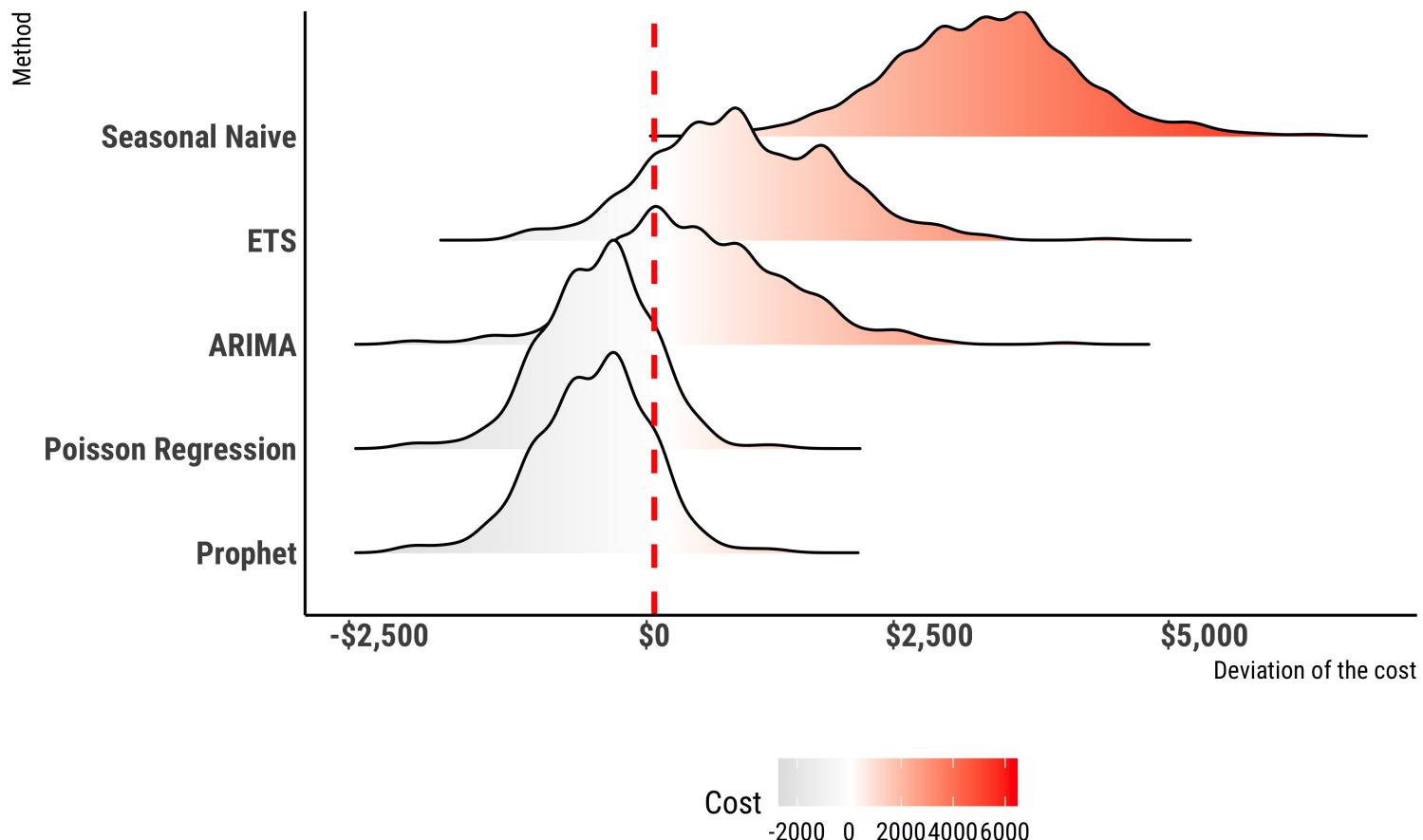
Total planning cost using forecast

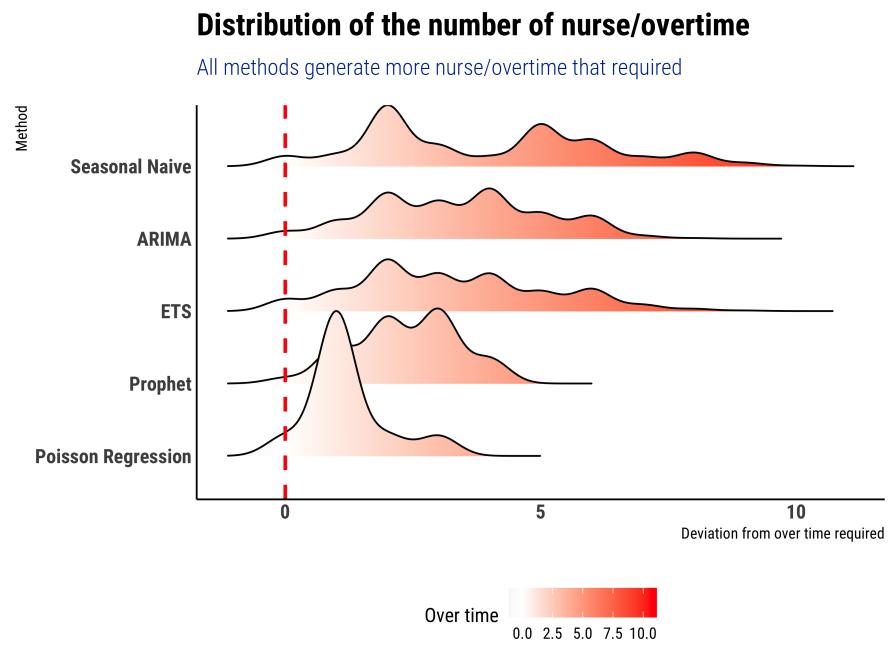
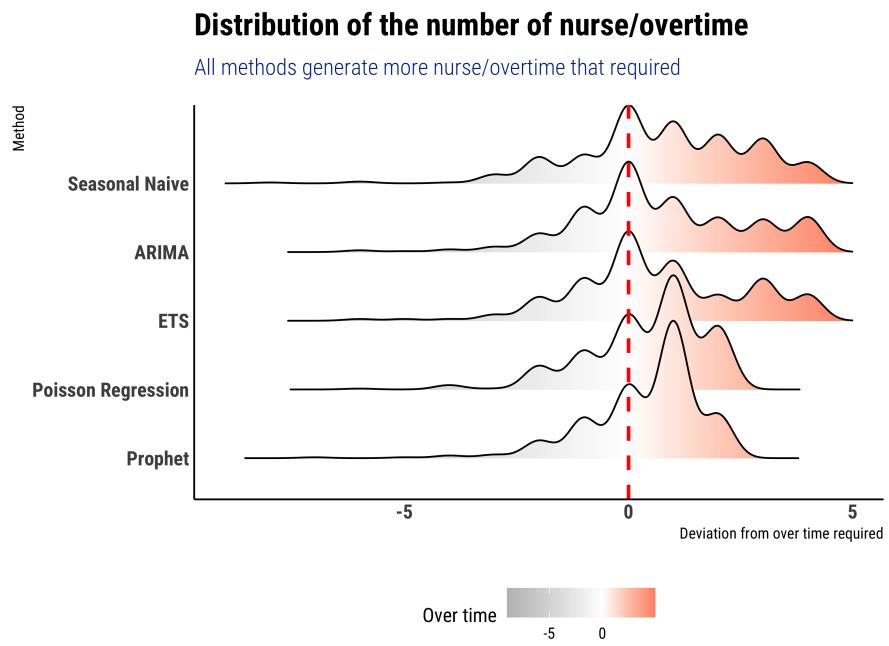
Planning based on Poisson and Prophet forecasts results in less cost
SNaive, ETS and ARIMA generate more cost



Distribution of the cost for 365 days

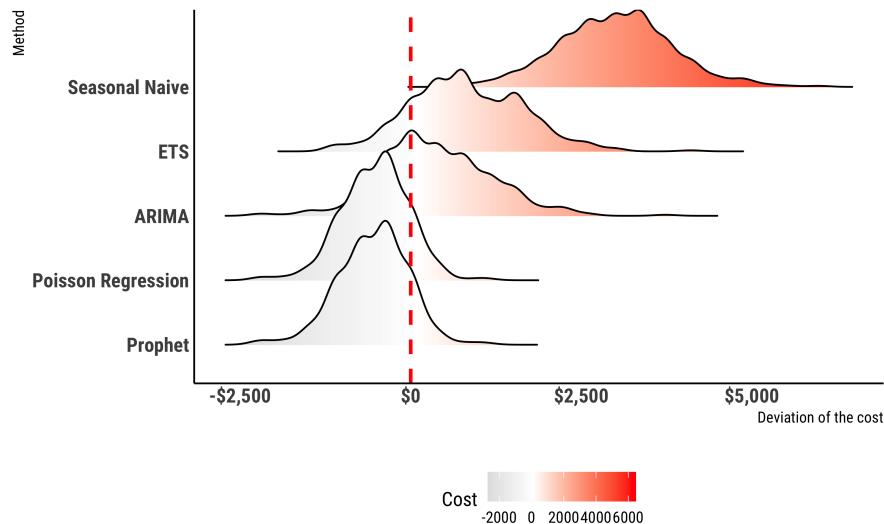
ETS and ARIMA produce over cost some days and under cost other days
Poisson & Prophet generates less cost for most days





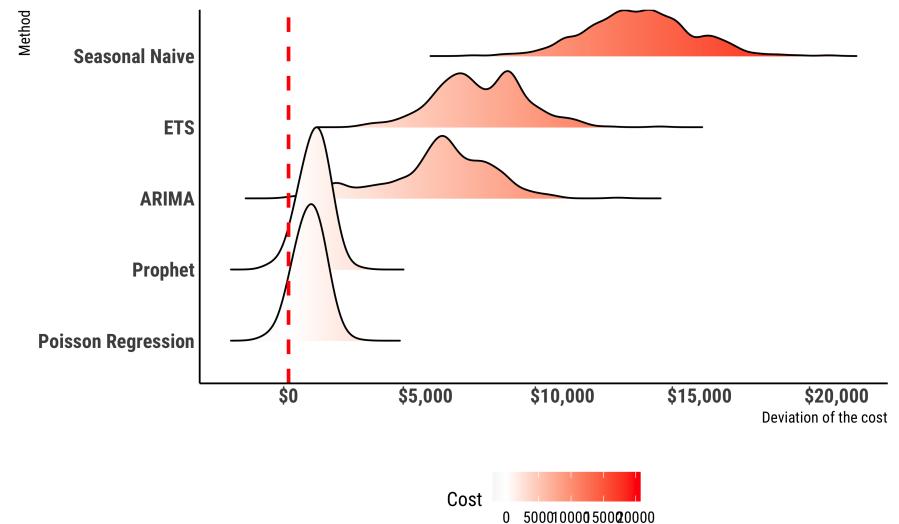
Distribution of the cost for 365 days

ETS and ARIMA produce over cost some days and under cost other days
Poisson & Prophet generates less cost for most days



Distribution of the cost for 365 days

ETS and ARIMA produce over cost some days and under cost other days
Poisson & Prophet generates less cost for most days



Next steps

- Include waiting time in the utility measure
- Evaluate the value for staffing (forecast for 42 days ahead)

Thank you

Question?

Twitter icon: Say hello: @Bahman_R_T

