

# BMJ Open Can we accurately forecast non-elective bed occupancy and admissions in the NHS? A time-series MSARIMA analysis of longitudinal data from an NHS Trust

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## ABSTRACT

**Objectives** The main objective of the study was to develop more accurate and precise short-term forecasting models for admissions and bed occupancy for an NHS Trust located in Bristol, England. Subforecasts for the medical and surgical specialties, and for different lengths of stay were realised

**Design** Autoregressive integrated moving average models were specified on a training dataset of daily count data, then tested on a 6-week forecast horizon. Explanatory variables were included in the models: day of the week, holiday days, lagged temperature and precipitation.

**Setting** A secondary care hospital in an NHS Trust in South West England.

**Participants** Hospital admissions between September 2016 and March 2020, comprising 1291 days.

**Primary and secondary outcome measures** The accuracy of the forecasts was assessed through standard measures, as well as compared with the actual data using accuracy thresholds of 10% and 20% of the mean number of admissions or occupied beds.

**Results** The overall Autoregressive Integrated Moving Average (ARIMA) admissions forecast was compared with the Trust's forecast, and found to be more accurate, namely, being closer to the actual value 95.6% of the time. Furthermore, it was more precise than the Trust's. The subforecasts, as well as those for bed occupancy, tended to be less accurate compared with the overall forecasts. All of the explanatory variables improved the forecasts.

**Conclusions** ARIMA models can forecast non-elective admissions in an NHS Trust accurately on a 6-week horizon, which is an improvement on the current predictive modelling in the Trust. These models can be readily applied to other contexts, improving patient flow.

## INTRODUCTION

Hospitals are increasingly busy, and there is more demand for resources such as hospital beds than can be easily met. Resource management is a challenge for many hospitals, and with an increase in the number of unplanned admissions, the issue of efficient resource allocation has become more urgent. The annual growth rate in England

## Strengths and limitations of this study

- The use of Autoregressive Integrated Moving Average models, which are simple to set up using *R*, and can be used to improve short term forecasts given enough input data are a strength of this study. Limitations include poorer accuracy in subforecasts, possibly due to using a simpler method.
- The coronavirus pandemic has an impact on the accuracy of forecasts, as shown by the sensitivity analysis.
- Data from only one NHS Trust were used, so the models are not validated for other contexts.

of emergency admissions is 3.2% on average over the last ten years.<sup>1</sup> Inaccurate estimates of unplanned admissions, and therefore, unpredictable emergency admissions, can lead to the cancellation of planned or routine operations.<sup>2</sup> This leads to subsequent need for more capacity to cope with routine operation backlog.<sup>3,4</sup> Granular models with daily and weekly forecasts predicted accurately can help strategically plan short-term and long-term resource management, particularly in order to cope with surges in demand.

In the past three and a half years, emergency admissions in the North Bristol NHS Trust (NBT) increased by 26% while average length of stay was reduced from 7.4 days to 6.1 days over the same period.<sup>5</sup> The North Bristol Trust is situated in Bristol and South Gloucestershire, England. The non-elective activity in NBT, particularly emergency admissions and bed occupancy, is higher than in other hospitals in the Bristol, North Somerset, South Gloucestershire Clinical Commissioning Group area. The consequences of this increase in emergency activity are a difficulty in meeting planned care, and, for the Trust, receiving less pay than expected, as unplanned procedures are paid less than