Emergency Department Pathways Modelling:
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Introduction

The Emergency Department at the Royal Lancaster Infirmary has experienced dramatically varying workloads and performance levels over the period January 2019 to December 2021. The purpose of this study is to analyse ED data from that period in order to understand the changes in performance levels and their causes, with a view to aiding RLI management to better understand and to manage ED performance in the future.

An important part of this study has been to discuss the results emerging from the analysis of the data with the domain experts in order to ensure that the results make practical sense, and to identify if any additional investigations need to be undertaken.

This report is organised in four sections. The dataset underpinning the study is described in Part A, and in Part B the data is analysed to show how the workload and the performance of the department has changed over the period January 2019 to December 2021. Part C then analyses other parts of the dataset in order to diagnose likely causes of the changes in performance levels, and if possible measures that could be taken to improve or manage performance levels in the future. Part D then presents some conclusions and ideas for further developments of the approach adopted.

Part A: The dataset underpinning this study.

The dataset provided by UHMBT contains data for all the patients that attended the Emergency Department at Royal Lancaster Infirmary from the 1st January 2019 – 30th December 2021, comprising a total of 1095 days.

The structure of the data is shown in Figure 1. Each row is a new patient number, which contains details about their arrival and departure date/time, the age group they are in, if they were admitted to the hospital, if they arrived in an ambulance, what triage group they were in, what their chief complaint and primary diagnosis was, as well as how many minutes have passed since their arrival to: being triaged, being treated by a doctor, and leaving the hospital. The data also shows how many minutes they spent waiting on a trolley, how many imaging/pathology tests they had, plus further details about when those tests were requested, when they began the tests and when they finished the tests. Minutes from arrival to being seen, and minutes from arrival to being treated are also recorded, but in the vast majority of cases these numbers were the same, so only the minutes to being seen by a doctor are used in our analyses.

patient	arrivalDT	departureDT	ageGroup	admit?	ambulance?	triage	diagnosis	mTriage	mSeen	mTrolley	mDeparture
1	01/01/2019 04:00	01/01/2019 05:38	5 to 64	Yes	Yes	2 − Urgent	Chest Pain	6	15	44	98
2	01/01/2019 06:00	01/01/2019 07:42	0 to 4	No	No	4 − Standard	Rash	5	12	0	102
...	...	...	...	...	...	...	...	...	...	...	...
164374	30/12/2021 14:00	30/12/2021 16:33	80 +	No	Yes	1 − Immediate	Falling Injury	8	12	0	153

Figure 1 – Original structure of the data.

There were some irregularities in the data. The original number of patients was 169,000 throughout the period, however, some of these were duplicated entries, which had the exact same details for every single cell, and in one case, a patient appeared thirty times. There were also some patients with nonsensical data, such as spending a negative amount of time to be triaged or seen by a doctor. After removing these, there were 164,374 total patients, indicating that there were 4626 (3%) problematic entries.

The age groups categories are 0 to 4, 5 to 64, 65 to 79 and 80+; and the triage group categories are Immediate, Very Urgent, Urgent, Standard & Non-urgent. 1.13% of patients did not have a triage category assigned and had a minutes to be triaged value of 0 minutes.

Part B: Waiting Times Experienced January 2019 to December 2021.

Figure 2 shows the average amount of time spent in the Emergency Department over the period of the dataset, i.e. from January 2019 to December 2021. Up until March 2020 it varied between 180 – 240 minutes. However when the coronavirus pandemic began there were greatly reduced arrivals (see Figure 3) and much shorter stays in the Emergency Department. This higher performance continues until around November 2020, where patients began spending longer amounts in the Emergency Department than pre-pandemic levels, before dropping to pre-pandemic levels in May 2021. From here however, the amount of time that patients spend in the hospital has steadily been increasing and has now surpassed the pre-pandemic level of time spent in the Emergency Department, with no clear signs of slowing down.
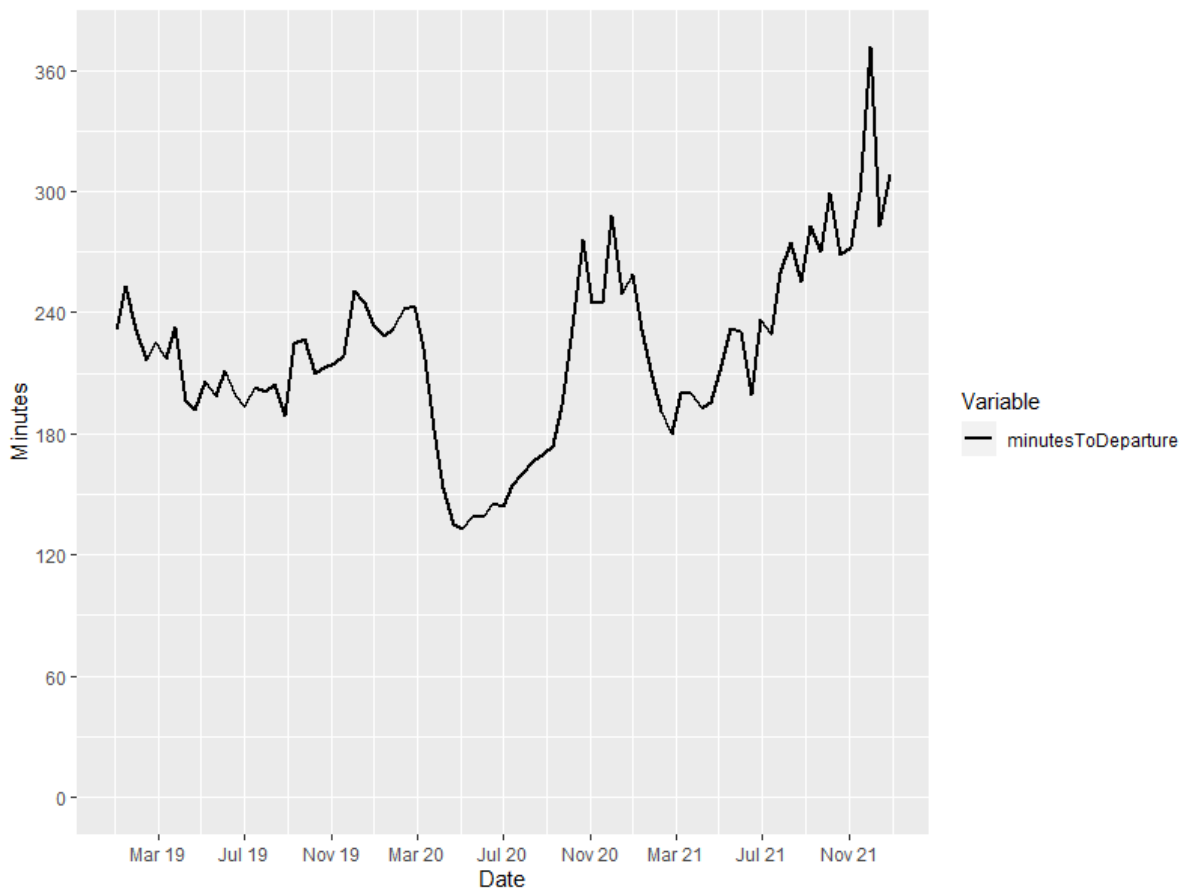

Figure 2 – Average amount of time spent in the Emergency Department, from January 2019 – December 2021

The average daily arrivals per week are shown in Figure 3. This was calculated by taking the average daily number of arrivals for each week in the dataset. There is stable behaviour in the number of arrivals from January 2019 to March 2020, with a sharp decline following the first lockdown amid the Coronavirus pandemic. After this, the arrivals begin to increase again, but they follow an erratic pattern throughout 2020, with the number of arrivals decreasing from September 2020 until March 2021. At this point, the arrivals begin to increase sharply, before settling at a new increased level (in comparison to 2019) in May 2021.
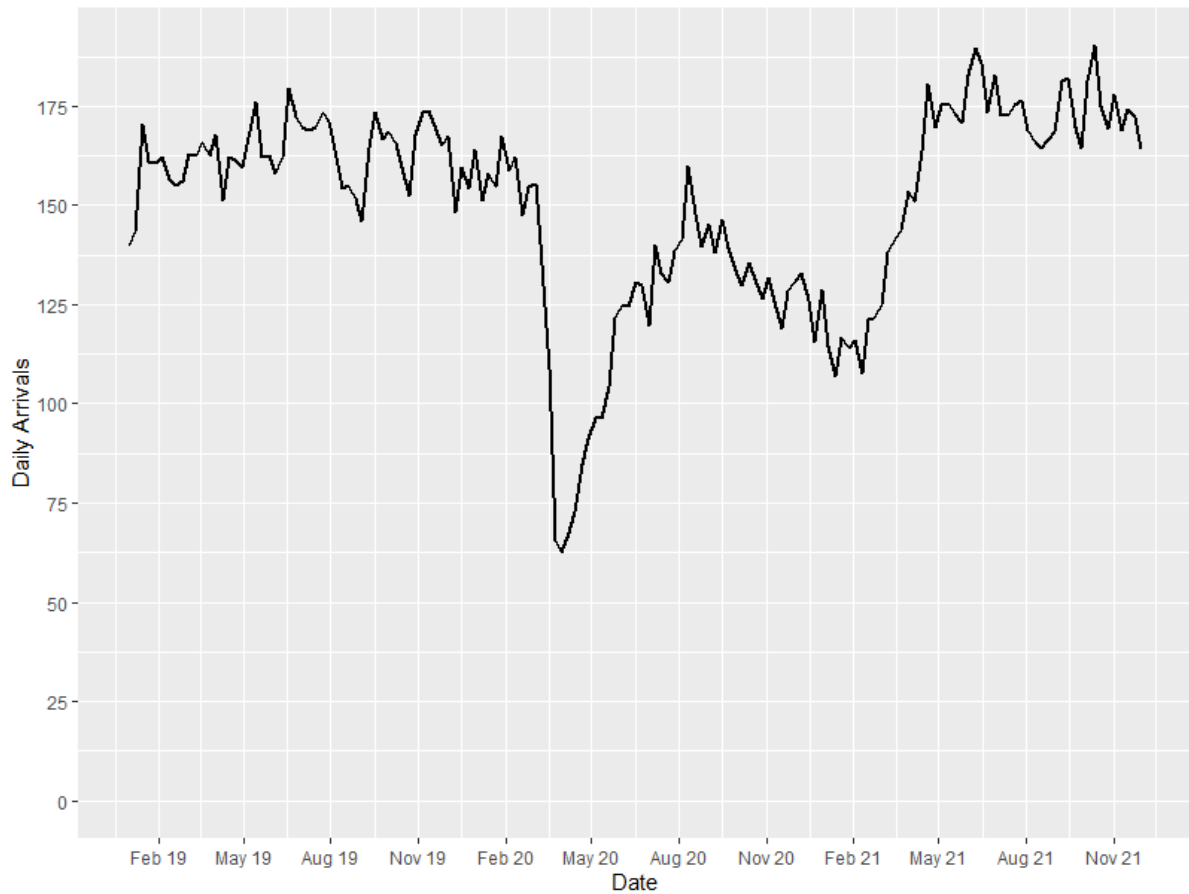

Figure 3 – Average daily arrivals to the Emergency Department from January 2019 – December 2021

The number of people who are in the Emergency Department can be calculated from the data by looking at the cumulative sum of arrivals and the cumulative sum of departures. As an example, assuming the Emergency Department is empty at 00:00 and then up until 06:00, 30 people arrived at the Emergency Department, and only 20 people had been discharged during this time, there would be 10 people in the system for this particular date & hour. The number of patients carries over from the previous day, as a continuous measurement from the beginning until the end.

The average queue size was calculated by looking at the queue size for every hour of the day, and then taking the average value of this figure, giving the average queue size for the day. Figure 4 shows this value over time. It follows a quite similar pattern to the arrivals over the period (see Figure 3), as might be expected. However, the increase in the queue size is proportionately larger than the increase in arrivals indicating additional congestion problems to those experienced previously.
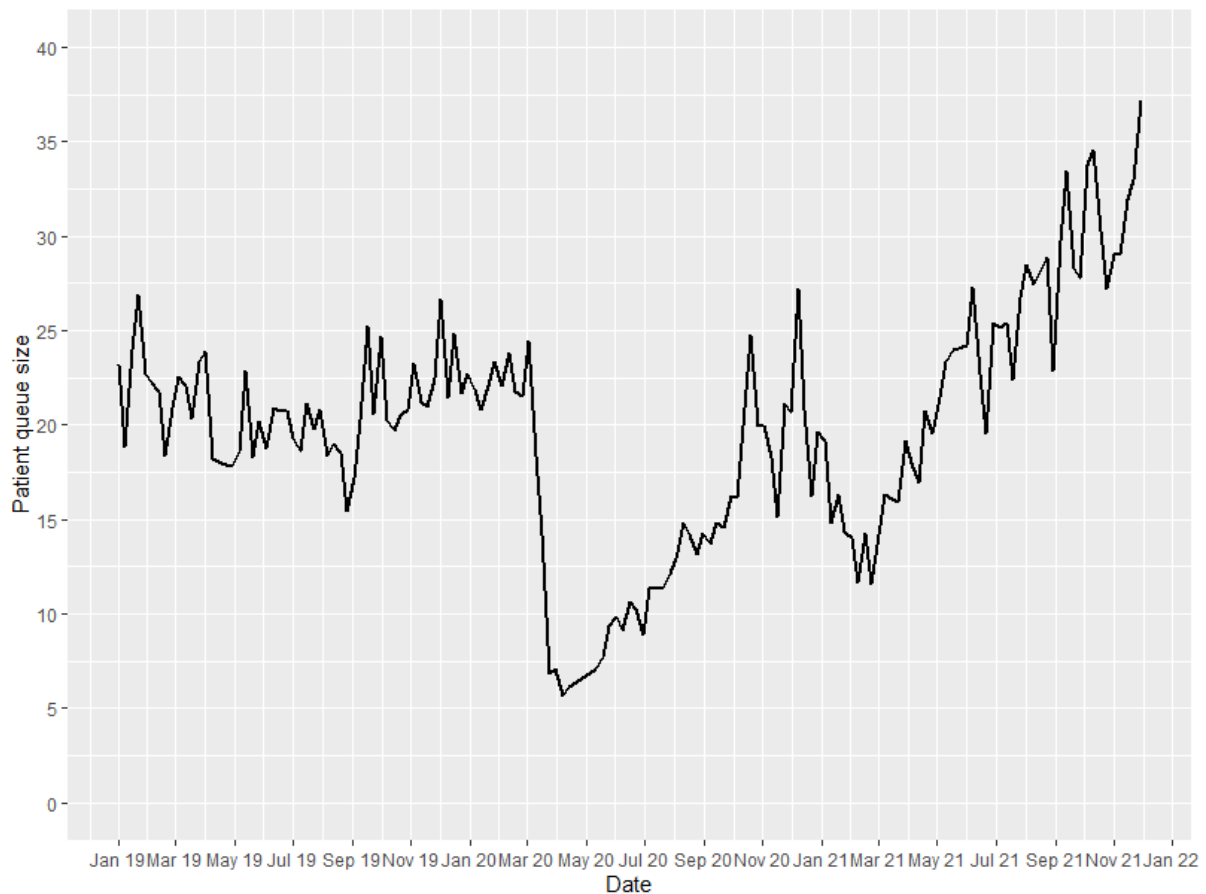

Figure 4 - Average daily patient queue sizes from 01/01/2019 - 30/12/2021

For the analyses that follow three time phases will be used. There is the pre-coronavirus phase, which is the period before mid-March 2020, the coronavirus phase, which is roughly March 2020 to March 2021, the post-coronavirus phase, which is March 2021 to the end of December 2021.

Figure 5 shows the number of patients that had a given number of minutes until departure. Behaviour in all 3 phases is very similar - there is a sharp spike at 240, which is the 4 hour target for hospitals, so a disproportionate number of patients are discharged at or shortly before this point. After this, there are still some patients that are slowly discharged. This was filtered to include only the patients that spent less than 960 minutes in the Emergency department, and there were 1763 patients that spent longer than this in the department.
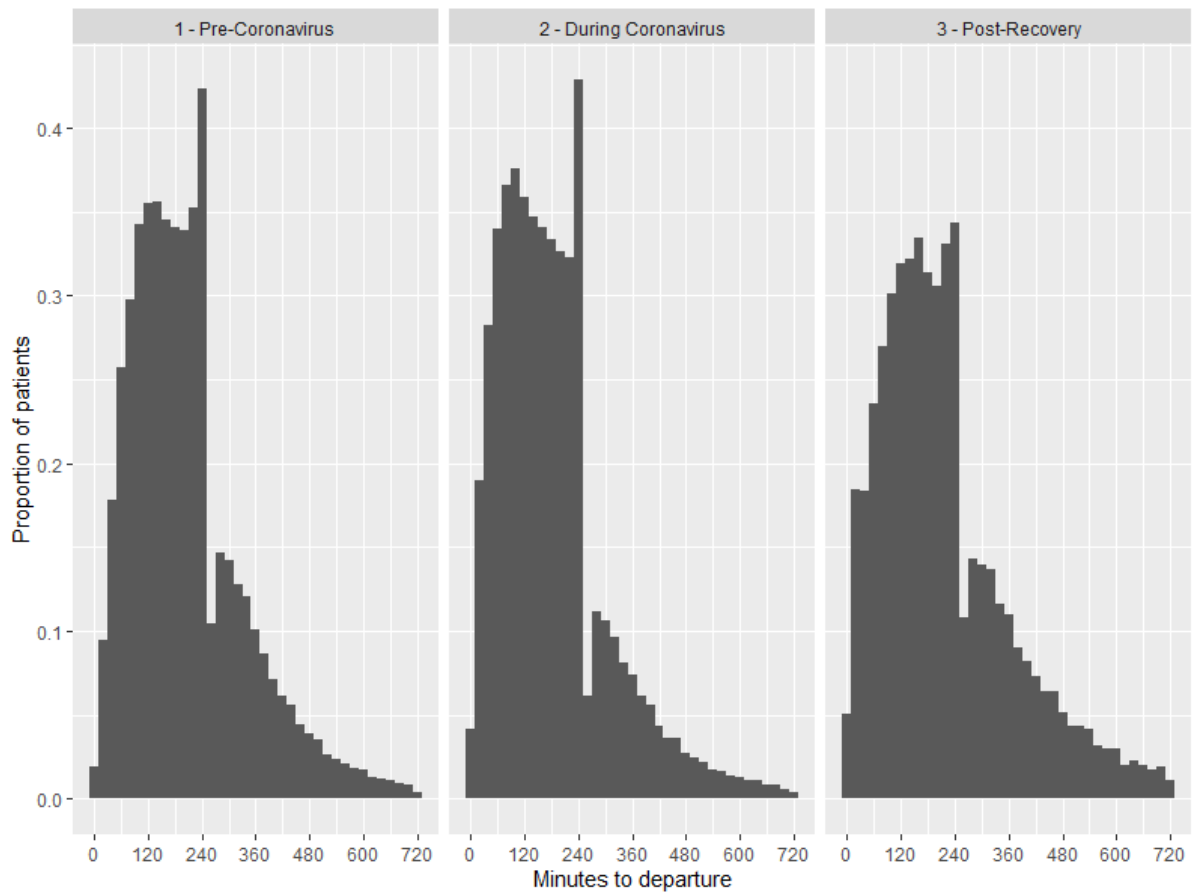

Figure 5 - Histogram showing distribution of patients by number of minutes to departure

Part C: Diagnostic Analyses.

Figure 6 shows how many minutes patients spend from their arrival the Emergency Department to being triaged, from arrival to being seen/treated by a doctor and from arrival to leaving the department. It also shows how many minutes of their stay were spent on a trolley. In comparison to phase 1, performance improved during March 2020 due to the onset of Coronavirus and the decreased number of arrivals. However during phase 3, despite the increase in arrivals back to and beyond pre-coronavirus levels the number of minutes it takes to be triaged and treated by a doctor have remained stable and have not surpassed the previous levels in 2019. However there is a very apparent increase in the amount of time that patients are spending waiting on the trolley, and in the total time they spend in the department.
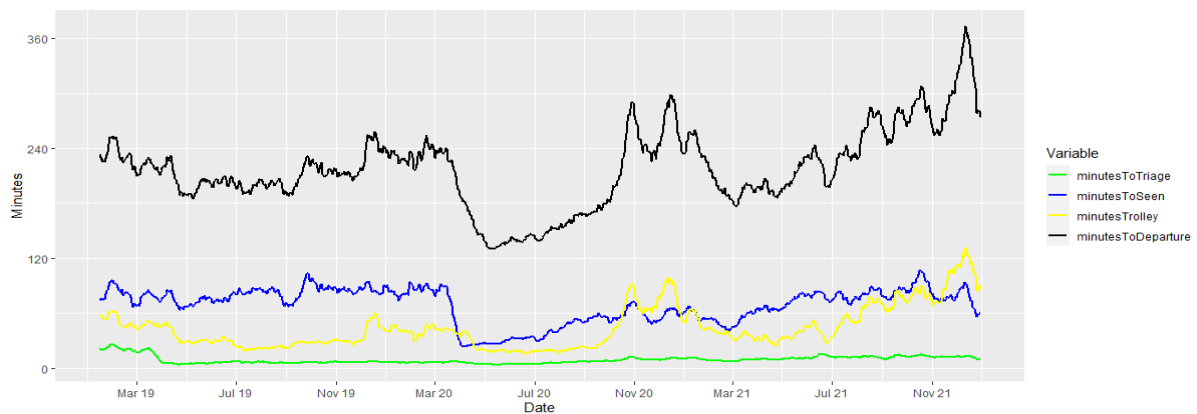

Figure 6 - Time spent on each step for all patients

Whereas previous figures have shown times from arrival to various points on the patients' journeys through the Emergency Department, Figures 7 and 8 show the times spent on various legs of those journeys, in particular: from arrival to triage, from triage to being seen/treated and from being seen/treated to leaving the department. Patients' times spent on trolleys are also included. The rationale for looking at these variables is to examine in closer detail exactly which part of the journey is causing patients to have longer overall stays. Figure 7 presents results for patients who are not admitted to hospital when they leave the Emergency department, and Figure 8 presents results for those who are admitted.
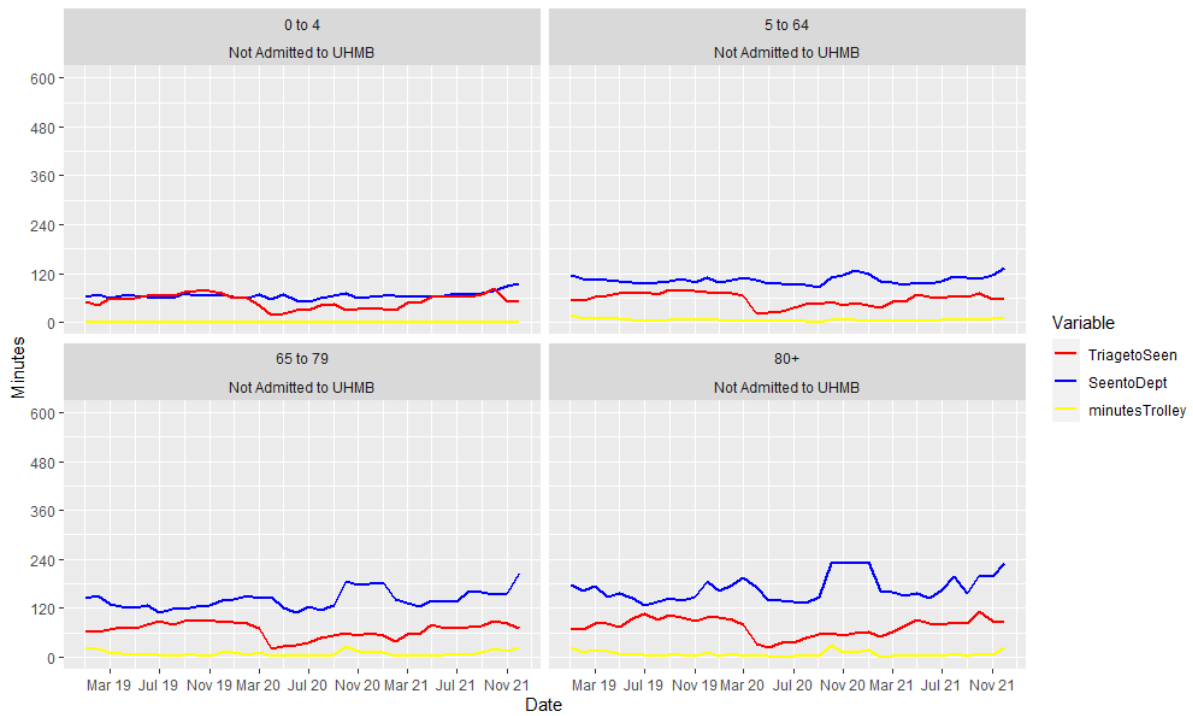

Figure 7- Time spent between phases for non-admitted patients

For patients who are not admitted, Figure 7 shows that all age groups had quite stable behaviour over phases 1 and 3 in terms of the time from triage to being seen/treated. However there is some evidence of a small increase in time from seen/treated to departure. Times on trolleys seem to be small and unaffected.

However Figure 8 shows a much more marked deterioration in performance for patients who are admitted to hospital. There is a similar story for the number of minutes it takes to be seen/treated once triaged, which has remained stable and has not surpassed pre-covid levels. However the stark difference for all age groups apart from 0 to 4 is the large increase in the time it takes to be discharged, once a doctor has seen/treated them. Because this focuses on those patients who were admitted to the hospital, this indicates that there is a severe problem in this area, whereby patients who need a bed cannot gain access to one, which leads to significantly increased waiting times, the majority of which is spent on a trolley. If the availability of beds in the hospital was sufficient, such an increase in the time to be admitted would not happen.
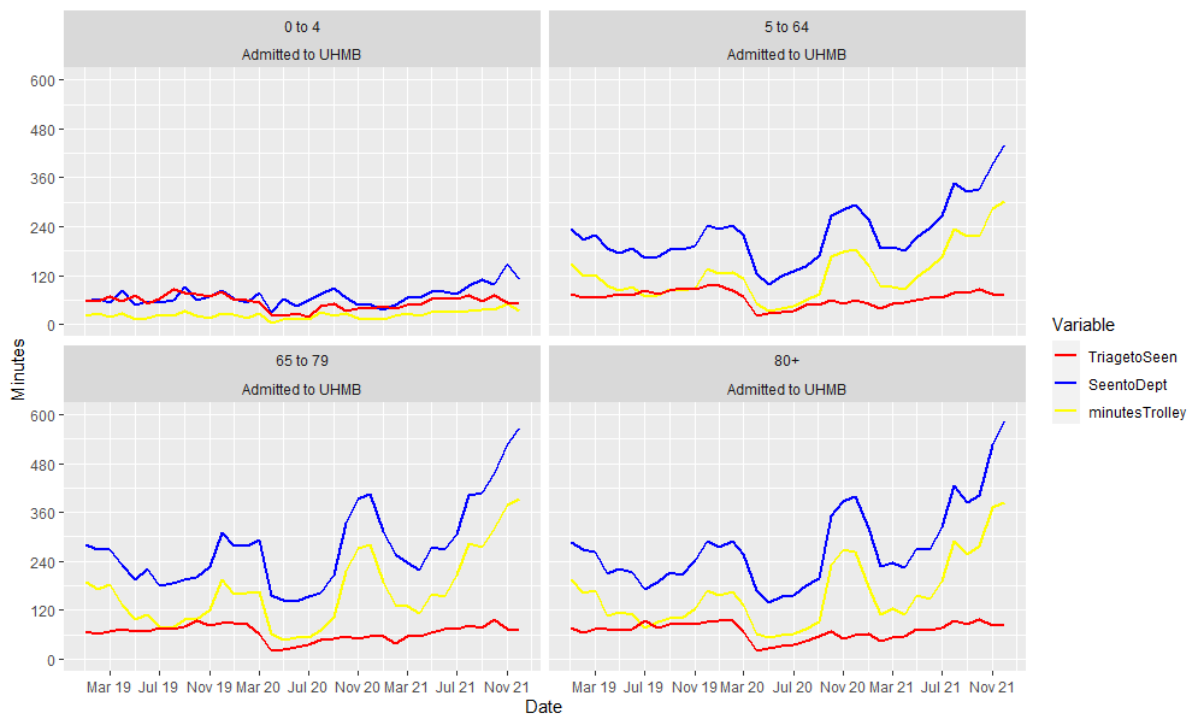

Figure 8 Time spent between phases for admitted patients

Figure 9 shows that this problem of increased waits in the Emergency Department are worst for the patients that arrive to the hospital between 5pm and 3am; and again shows the major disparity between the patients who are admitted, and those who are not admitted. It also emphasises how almost all the deterioration in performance in the post-Covid stage is concentrated on the admitted patients.
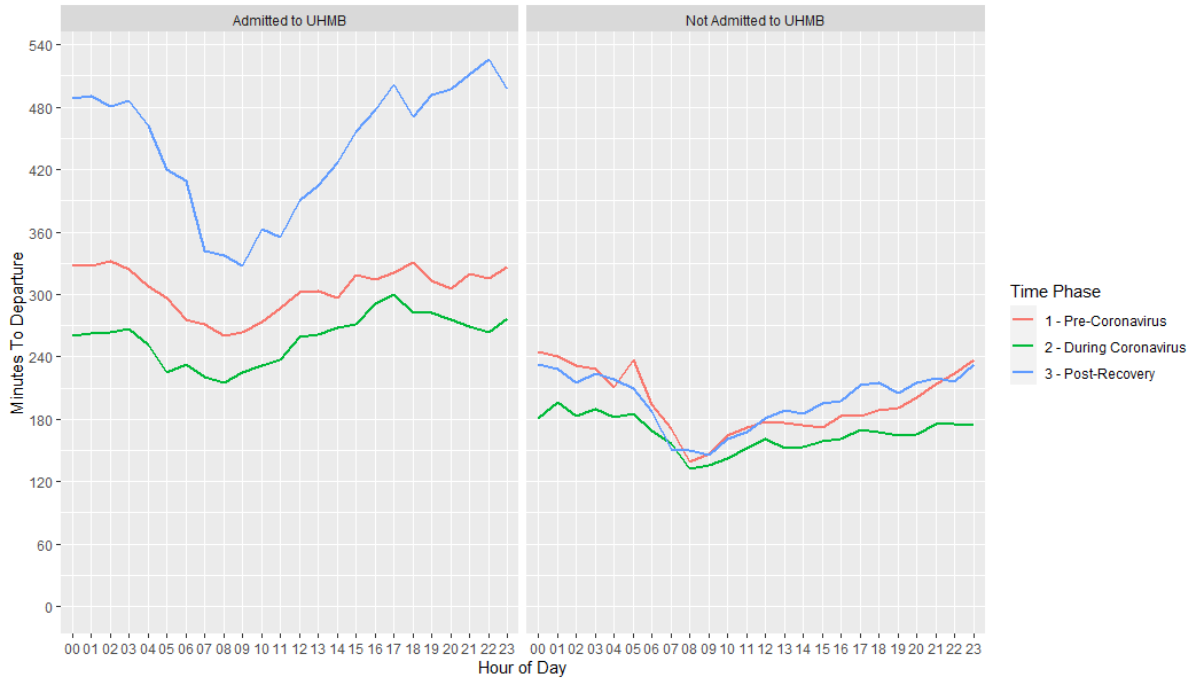

Figure 9 - Emergency Department Seasonality by time phase & admittance

Part D: Conclusions and Ideas for Further Development.

The following conclusions are presented following discussion with the domain experts in order to ensure that the results make practical sense, and to identify if any further developments that could be undertaken.

Conclusions:

i. In comparison to the pre-Covid performance levels in Phase 1 of this analysis, waiting times tended to improve during Phase 2 when Covid was at its worst, but then returned to and exceeded the pre-Covid levels during Phase 3.

ii. The worsened performance levels in Phase 3 mainly affected admitted patients, and in particular their times between being treated and their departure from A&E. The times that these patients spend on trolleys also increased substantially during Phase 3.

iii. The evidence that the waiting times of non-admitted patients are very similar in phases 3 and 1 implies that causes that would have affected these patients (as well as admitted patients), i.e. staff shortages within A&E or turn-round times for tests and imaging, are not anymore problematic in Phase 3 than they were in Phase 1. Hence the evidence in the data strongly indicates that the drop in performance between Phases 1 and 3 is mainly attributable to problems associated with finding beds for patients needing to be admitted to hospital.

Further Developments

The study reported here has concentrated on the ED performance during the period around Covid from January 2019 to December 2021. There is clearly scope for extending the approach in a number of directions.

a. Early in 2022 an SDEC was introduced at the Royal Lancaster Infirmary. Extending the study to include ED activity since that date would mean that the effects of this new facility on patients' pathways through ED could be evaluated.

b. ED performance has been a long-term area of concern in many NHS trusts (and indeed worldwide), and this level of concern has heightened in recent months. The analyses prototyped in this study could be used to provide the basis for routinely undertaking 'diagnostic analyses' of ED performance at the Royal Lancaster Infirmary that would enable causes of congestion to be quickly recognised and potential solutions to be identified.

c. A full picture of emergency care services at any NHS trust needs to combine analyses of the NHS's Emergency Care Data Set alongside the ED pathway dataset used in this study. A potential lesson from the study reported here is that there is scope for considerable insight into problems and their potential solutions if analyses extend beyond simply reporting of performance to include 'diagnostic analyses' of the available data.