Report 29: The impact of the COVID-19 epidemic on all-cause attendances to emergency departments in two large London hospitals: an observational study

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Summary

The health care system in England has been highly affected by the surge in demand due to patients afflicted by COVID-19. Yet the impact of the pandemic on the care seeking behaviour of patients and thus on Emergency department (ED) services is unknown, especially for non-COVID-19 related emergencies. In this report, we aimed to assess how the reorganisation of hospital care and admission policies to respond to the COVID-19 epidemic affected ED attendances and emergency hospital admissions.

We performed time-series analyses of present year vs historic (2015-2019) trends of ED attendances between March 12 and May 31 at two large central London hospitals part of Imperial College Healthcare NHS Trust (ICHNT) and compared these to regional and national trends. Historic attendances data to ICHNT and publicly available NHS situation reports were used to calibrate time series auto-regressive integrated moving average (ARIMA) forecasting models. We thus predicted the (conterfactual) expected number of ED attendances between March 12 (when the first public health measure leading to lock-down started in England) to May 31, 2020 (when the analysis was censored) at ICHNT, at all acute London Trusts and nationally. The forecasted trends were compared to observed data for the same periods of time. Lastly, we analysed the trends at ICHNT disaggregating by mode of arrival, distance from postcode of patient residence to hospital and primary diagnosis amongst those that were subsequently admitted to hospital and compared these data to an average for the same period of time in the years 2015 to 2019.

During the study period (January 1 to May 31, 2020) there was an overall decrease in ED attendances of 35% at ICHNT, of 50% across all London NHS Trusts and 53% nationally. For ICHNT, the decrease in attendances was mainly amongst those aged younger than 65 and those arriving by their own means (e.g. personal or public transport). Increasing distance (km) from postcode of residence to hospital was a significant predictor of reduced attendances, which could not be explained by weighted (for population numbers) mean index of multiple deprivation. Non-COVID emergency admissions to hospital after March 12 fell by 48% at ICHNT compared to previous years. This was seen across all disease areas, including acute coronary syndromes, stroke and cancer-related emergencies. The overall non-COVID-19 hospitalisation mortality risk did not differ (RR 1.13, 95%CI 0.94-1.37, p=0.19), also in comparison to previous years.

Our findings suggest emergency healthcare seeking to hospitals drastically changed amongst the population within the catchment area of ICHNT. This trend was echoed regionally and nationally, suggesting those suffering a medical emergency may not have attended other (i.e. closer-to-home) hospitals. Furthermore, our time-series analyses showed that, even after COVID-19 cases and deaths decreased (i.e. from early April), non-COVID-19 ED attendances did not increase. The impact of emergency triaging systems (e.g. 111 calls) and alternative (e.g. private hospital, chemist) health services on these trends remains unknown. However, another recent report found increased non-COVID excess deaths in the community, which may be partially explained by people experiencing an emergency and not attending health services at all. Whether those that attended ED services have done so with longer delays from the moment of emergency onset also remains unknown. National analyses into the factors causing reduced attendances to ED services and strategies to revert these negative trends are urgently needed.

1. Introduction

To tackle the COVID-19 epidemic, fundamental changes to the provision of health and social services have been instituted in England.[1,2] As a result, the NHS undertook an unprecedented re-arrangement of their resources, with specific measures including the postponing of non-urgent elective procedures and video-triaging patients for referral to hospital services.[1] Moreover, on March 12, the government implemented the first of a series of non-pharmaceutical interventions including advice for the public to self-isolate if experiencing COVID-19 symptoms, advice for social distancing, the closure of schools and universities and the ban of public events. All these measures were rapidly followed by a national lock-down on March 24,[1] with all but key workers advised to avoid interacting with others outside their households and stay at home as much as possible, unless an emergency arises.[1,3]

Perhaps largely as a result of the widespread implementation of non-pharmaceutical interventions in England (and elsewhere),[4] the country has seen a steady reduction in the daily number of COVID-19 cases and deaths.[5] However, national data show that the number of attendances to accident and emergency (ED) services (i.e. consultant-led, 24-hour services including resuscitation units) have decreased nationally by approximately 50% across all England regions (see *Figure S1,* for the authors' analysis of publicly available data).[6] Moreover, concerns have emerged that attendances to such emergency services remain low, even as the COVID-19 cases have dropped.[5]

Evidence from other countries indicates that the number of out-of-hospital cardiac arrests have increased alongside a decrease in ED attendances during the COVID-19 pandemic.[7,8] These data also suggest that the number of non-COVID-19 attendances to emergency services has not increased as expected as COVID-19 cases and deaths decrease.[7,9] To date, no published study in England has analysed the trends in non-COVID-19 attendances to ED departments during the pandemic. Such data would be crucial to understand the changes in ED attendances associated with re-directing emergency care resources in the country. Furthermore, beyond national-level situation reports,[5,6] analyses of the potential sociodemographic and epidemiological factors associated with such behind trends are urgently needed to inform strategies to understand the optimal public health approach to ensure high quality standards of care for non-COVID-19 patients.

In this report, we use administrative patient level clinical hospital records from two large London hospitals from Imperial College Healthcare NHS Trust to analyse trends in attendances to ED departments and emergency admissions pre- and post-implementation of lock-down policies in England.

2. Methods

We had access to historical (2015 to 2019) and present year (January 1 to May 31, 2020) data on ED attendances and admissions to two large London hospitals, St Mary's and Charing Cross. Together with the Hammersmith, Queen Charlotte and Western Eye Hospitals they comprise the Imperial College Healthcare NHS Trust (ICHNT), one of the largest NHS Trusts in England serving a diverse population of over 600,000 people. However, only the St Mary's and Charing Cross Hospitals provide ED services. Therefore we only focus on these two in our analysis.[10]

Historic data of ED attendances from April 2019 was used to calibrate a time series forecast model to predict the expected number of ED attendances as a counterfactual for the time period where COVID-19 impacted ED attendances (March 12 – May 31). All forecasts were obtained from Auto Regressive Integrated Moving Average (ARIMA) models, which capture the temporal structures within a time series in order to forecast future values. These simple stochastic time series models can be used to train and understand past data in order to predict future values.[11]

The ARIMA models used for our analyses have been parametrised using the most up to date data from St Mary's and Charing Cross Hospitals. Due to clerical coding changes in data recording for Charing Cross Hospital, we only relied on data from April 1, 2019 until December 31, 2019 to calibrate a time-series model for both hospitals and create a forecast of expected all-cause ED attendances and emergency admissions for the period of January 1 to May 31, 2020. We compared the forecasted trend for 2020 against patient-level administrative records from the trust. We defined two periods for the analysis, pre- and post-March 12, based on the data when the first public health measure (case-based isolation) leading to lock-down was imposed in England.[1]

Outcomes of interest were the change in crude and proportional ED attendances and emergency admissions from March 12 to May 31, 2020, compared to the predicted baseline from historic trends, overall and disaggregated by age categories, mode of attendance (e.g. ambulance or patients' own transport) and postcodes of patients' usual residence (only the first part of the postcode, consisting of two to four alphanumeric characters, is recorded in patient data). Postcodes were categorised as falling within five mutually exclusive zones based on the distance of the centre of the postcode area from the hospital of attendance – less than 1,000m (zone A), between 1,001m and 5,000m (zone B), between 5,001m and 7,500m (zone C), between 7,501m and 10,000m (zone D) and greater than 10,000m (zone Out) away from the hospital. As a proxy of attendance severity, we further quantified the proportion of attendances that subsequently required hospital admission by disease categories and mortality risks.

All statistical and geo-spatial analyses were performed in R 3.6.3, with the latter using freely available polygon files.[12] The proximity from an outer postcode to the nearest ED was calculated by measuring the centroid of an outer postcode to the location of the hospital. For all analyses the population weights of Lower Layer Super Output Area (LSOA) were used and aggregated to outer postcodes.

Study approval and role of the funding sources
To ensure compliance with General Data Protection Regulations, data was extracted from pseudonymised datasets into aggregate reports only for the outcomes of interest. Data processing was authorised by both the Imperial College Healthcare NHS Trust and School of Public Health research committees. Access to the data and authorisation for the present study was jointly granted by the Trust's Data Protection Office, Caldicott Guardian, Medical Director and the College's Big Data and Analytical Unit, under Article 6(1)(e) / 9(2)(i) of the General Data Processing Regulations (processing under public authority for purposes in the area of public health). Only anonymised data was accessed and aggregate reports and figures extracted for the present analyses.

The funders of this study had no role in the study design, data collection, analysis, interpretation, or reporting. The corresponding author had full access to all the data in the study and the final responsibility to submit for publication.

3. Results

3.1 Overall observed vs forecasted ED attendances

Between January 1 and March 11, 2020 there were 25,229 total attendances to ED services at ICHNT, which fell within the forecasted number of attendances for this period of time in this Trust (mean 26,396 with 95% confidence interval [CI] 8,571 to 44,221). After March 12, however, we observed a significant decline in the number of attendances, amounting to 18,576, a 35% (mean 28,774 with 95% confidence interval [CI] 26,625 to 30,923) decline against the forecasted attendances (**Figure 1**).

The overall decline in ED attendances to ICHNT was largely in keeping with the national trend during the current COVID-19 pandemic response (**Figure 1**), see also Supplementary material, **Figure S1**). However, for ICHNT the observed trend was mainly driven by a reduction in attendances to St Mary's Hospital, which dropped by 46% (95%CI 42% to 50%) compared to only 17% (95%CI 11% to 22%) for Charing Cross Hospital.
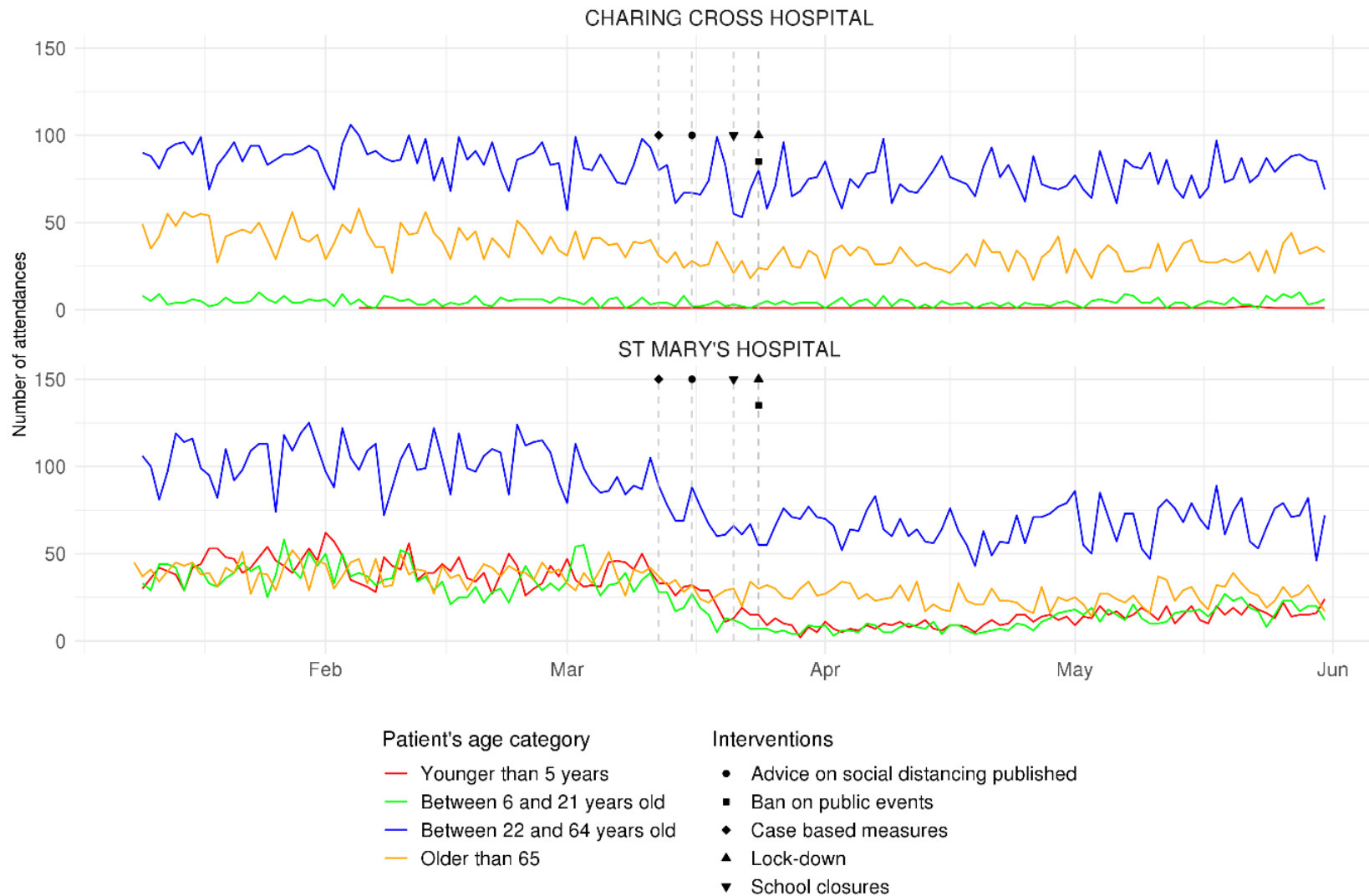
Figure 1. Time series of attendances to ED services at ICHNT (St Mary's and Charing Cross Hospitals) compared to the national decline in attendances.

3.2 Disaggregated trends in ED attendances to ICHNT

From the start of the year to March 11, both historically and in the present, the number of daily ED attendances by age to this Trust was mainly comprised of people aged 22 to 64 years, followed by those older than 65 years and paediatric attendances (***Figure 2a***). Similarly to the overall trend, the decrease in attendances by age was greater at St Mary's than at Charing Cross Hospital. However, in both hospitals, we observed a much larger decline in attendances amongst younger age groups compared to those over 65 years old (***Figure 2a***).

Regardless of age, nearly all attendances to St Mary's Hospital were by patients arriving by their own transport or emergency road ambulance services, prior to March 12. After this date, the former decreased by 13.8%, while ambulance attendances increased by 24.4% (see also ***Figure S3*** in Supplementary material). In the case of Charing Cross Hospital, the number of daily attendances by mode of transport varied very little before and after March 12. While arrivals by ambulance services dropped by 7.5%, arrivals by own means of transport increased by 4.0% (***Figures 2a and 2b***).

Further to the above, we observed significant differences in the number of attendances to each hospital by four predefined zones of patients' postcode of residence (radius of 1 km, 5 km, 7.5 km, and >10 km from the hospital). For St Mary's Hospital, 57% of attendances from March 12 to May 31 were from patients residing at a postcode within a 5 km radius (***Figure 3a***). Whilst the distribution of attendances by zone of residence remained stable after March 12, 2020 (59.6% from within 5 km), we found increasing distance between patients' postcode of residence to hospital significantly predicted decreasing ED attendances (average of -10 number of attendances per km increase, $p < 0.001$). Whilst this association disappeared when adjusting for mean number of historic attendances by postcode, the forecasted regional attendances (i.e. to all acute London NHS Trusts) revealed a drop in ED attendances by 50%, suggesting the reduction in attendances to our trust by increasing distance was not driven by people attending ED services nearer to the place of residence (***Figure 1.a***). Importantly, weighted (by population in postcode) index of multiple deprivation quintile was not a predictor of reduced ED attendances (Supplementary Table S1).
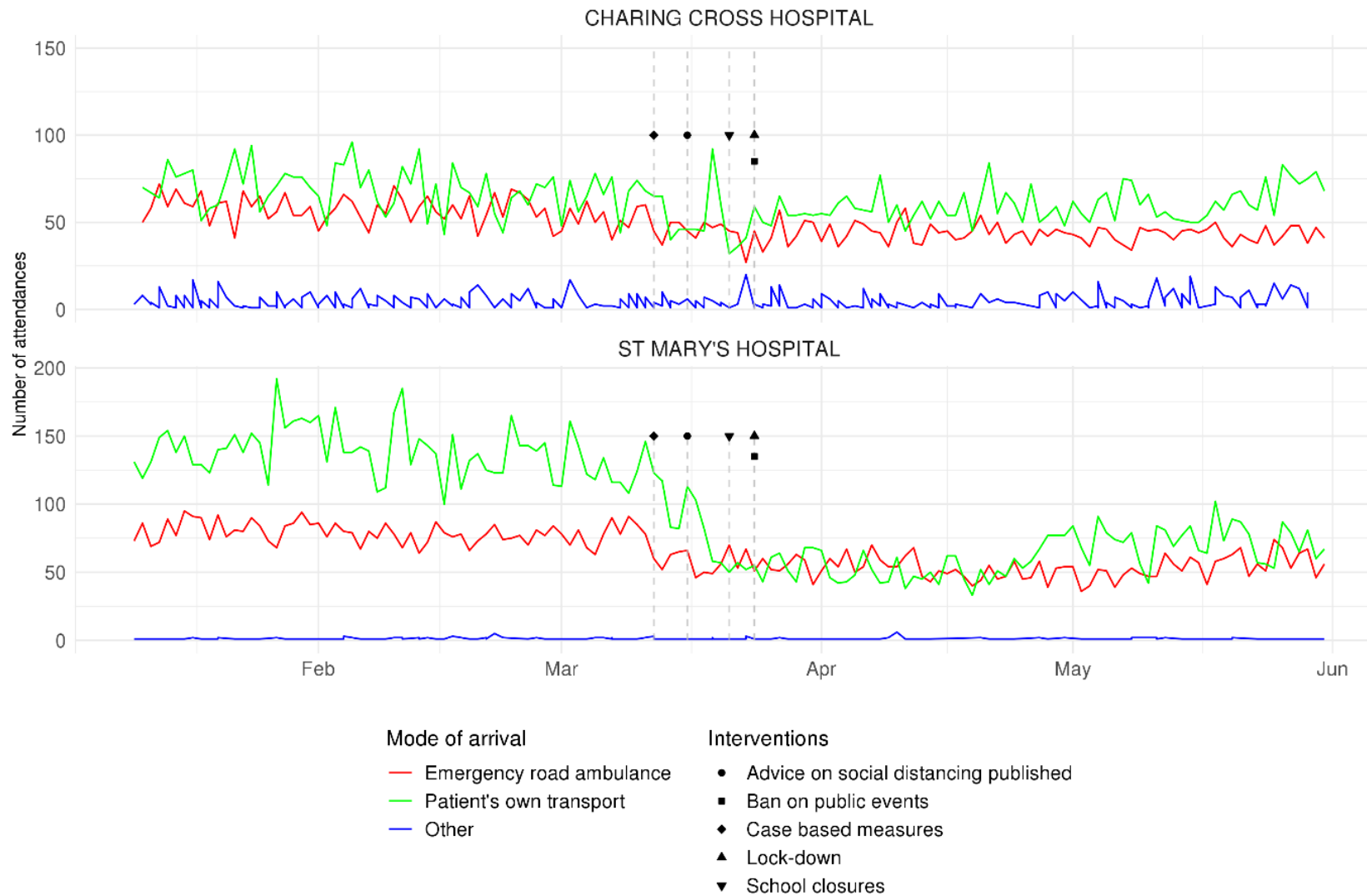
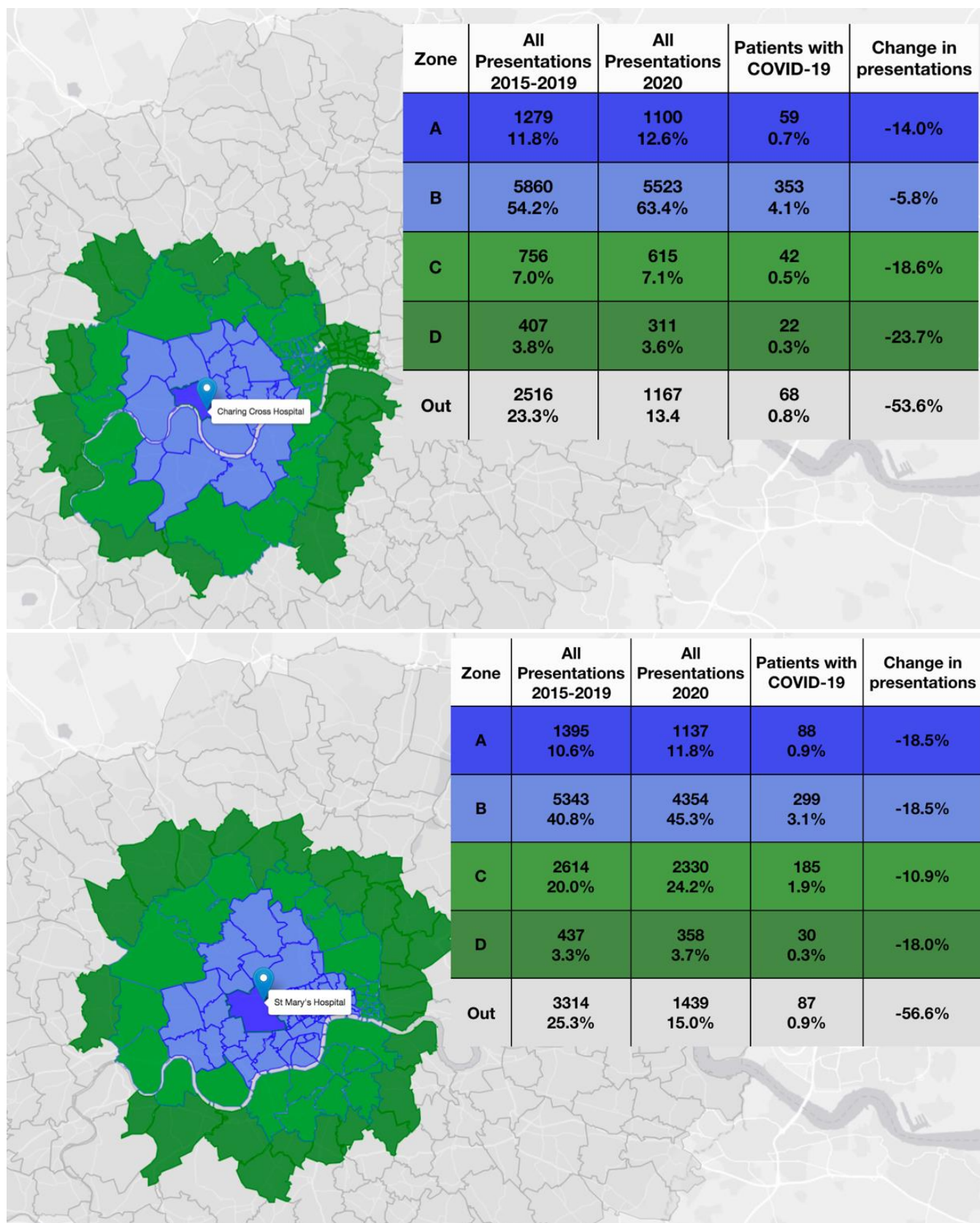**Figure 2. Daily ED attendances to ICHNT by age group (a) and mode of arrival (b).**

Zone	All Presentations 2015-2019	All Presentations 2020	Patients with COVID-19	Change in presentations
A	1279 11.8%	1100 12.6%	59 0.7%	-14.0%
B	5860 54.2%	5523 63.4%	353 4.1%	-5.8%
C	756 7.0%	615 7.1%	42 0.5%	-18.6%
D	407 3.8%	311 3.6%	22 0.3%	-23.7%
Out	2516 23.3%	1167 13.4	68 0.8%	-53.6%

Zone	All Presentations 2015-2019	All Presentations 2020	Patients with COVID-19	Change in presentations
A	1395 10.6%	1137 11.8%	88 0.9%	-18.5%
B	5343 40.8%	4354 45.3%	299 3.1%	-18.5%
C	2614 20.0%	2330 24.2%	185 1.9%	-10.9%
D	437 3.3%	358 3.7%	30 0.3%	-18.0%
Out	3314 25.3%	1439 15.0%	87 0.9%	-56.6%

Figure 3. Attendances by geographic area of patient residence to Charing Cross (*a*) *and St Mary's* hospitals.
Zone A <1,000m, zone B 1,001m-5,000m, zone C 5,001-7,500, zone D 7,501-10,000 and out ≥10,000m.

3.3 Emergency admissions and outcomes by disease area

Amongst ED attendances, we recorded a total of 16,837 admissions to hospital services at ICHNT between January 1 and May 31, 2020. This represented a 15% decline from the average number of admissions for the same period of time over the previous five calendar years. Importantly, the largest drop in admissions was seen for the period after March 12, at 39% (6,545), compared to 14% (10,292) before this date.

Out of all emergency admissions, COVID-19 was either the cause or a co-factor (i.e. documented at admission or during hospitalisation, respectively) for admission in 1,408 (8%) patients. All but three of these COVID-19 admissions occurred after March 12 (21% of admissions after this date were related to COVID-19) (*Figure 4*). As a result, the number of emergency admissions after March 12, excluding those related to COVID-19, fell by 48% (5,140) compared to the same period in previous years. Most of these non-COVID-19-related emergency admissions were for acute respiratory conditions (802, 12%), including pneumonia, asthma and chronic obstructive pulmonary disease exacerbations, amongst others; and for injuries (540, 8%); gastrointestinal & liver disorders (372, 6%); and genitourinary disorders (315, 5%).

The trend in emergency admissions to ICHNT meant an overall decrease in admissions in most disease areas (*Figure 5*); even for critical disease areas. For example, for the case of acute coronary syndromes and stroke, admissions decreased by 60% and 26%, respectively. Obstetric and perinatal emergency admissions also greatly declined, by 52% and 24%, respectively. Lastly, cancer-related emergency admissions (i.e. excluding programmed interventions and/or procedures, like chemo- and radiotherapy) and those due to injuries (for which St Mary's Hospital is a referral centre) dropped by 47% and 64%, respectively.

Importantly, whilst the crude in-hospital mortality for emergency admissions for the period between March 12 and May 31 increased from 1% historically (2015-2019) to 8% in 2020 (incidence risk ratio [IRR] 2.84, 95%CI 2.48-3.26, p<0.001), this was driven by deaths relating to COVID-19 (*Table S2*) (IRR 1.13, 95%CI 0.94-1.37,p=0.19). For most other disease areas, we saw an overall reduction in mortality risk ratio (*Table S2*), including acute respiratory conditions, acute coronary syndromes, oncological emergencies and injuries. For stroke and genitourinary emergency admissions, there was an increase in mortality risk ratio, albeit there have been historically low number of deaths, and even lower presently, driving the in-hospital mortality rates for these disease areas (*Table S2*).
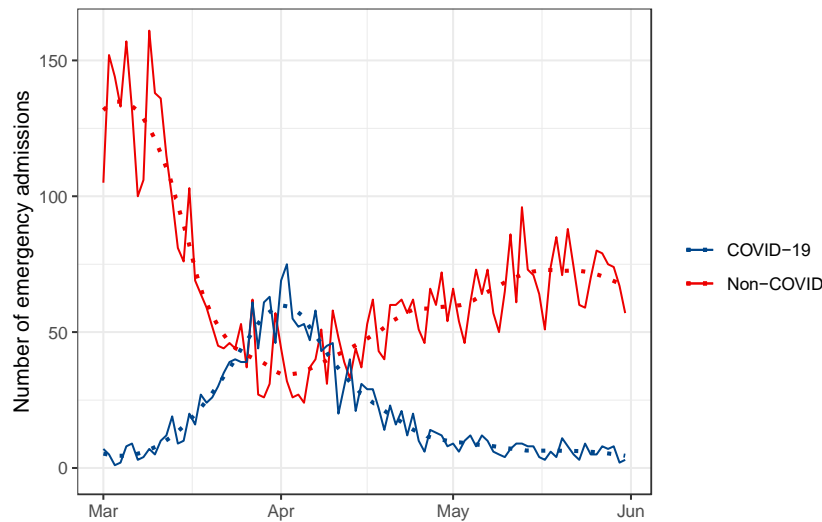
Figure 4. Overall non-COVID vs COVID-19 emergency admissions at ICHTN.
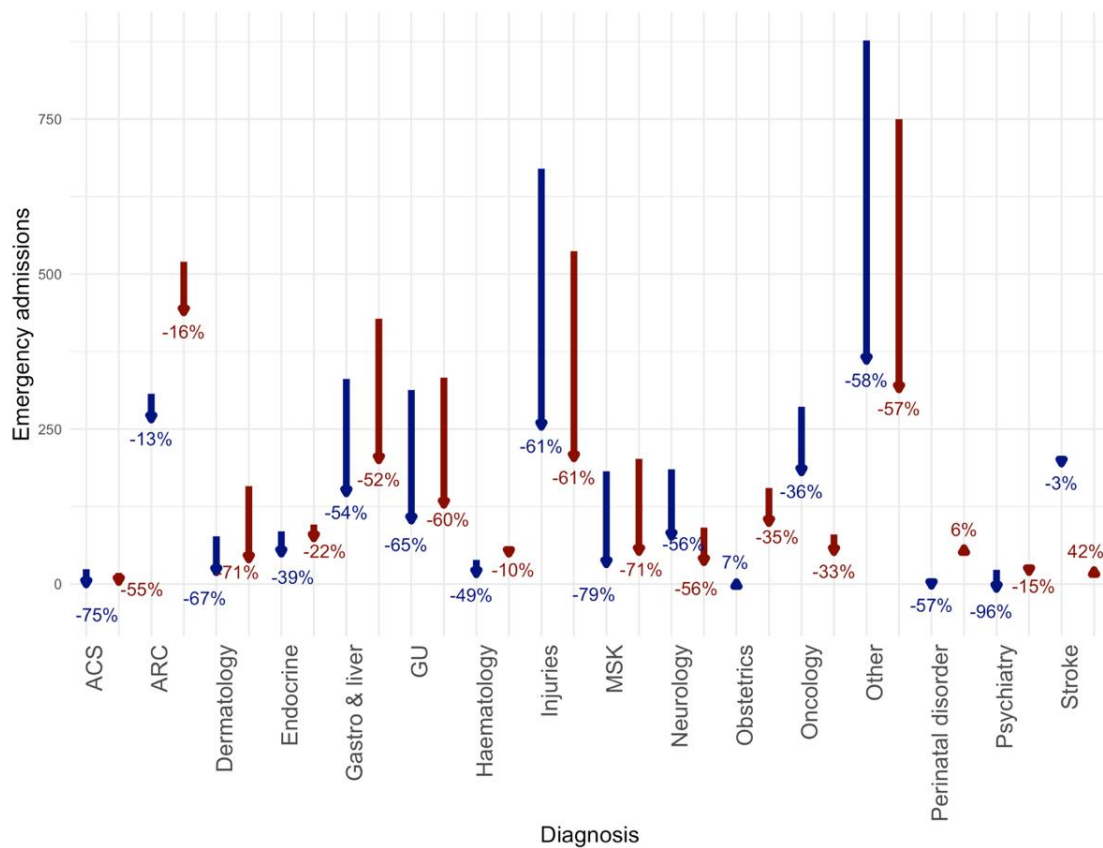

Figure 5 Change in present year vs historic (2015-2019) emergency admissions by disease area to Charing Cross (blue) and St Mary's (red) hospitals for the period of March 12 to May 31. Note that, as opposed to the analyses in Figure 1, only those ED attendances requiring hospitalisation are accounted for in this analysis. The historic data refers to the average of emergency admissions between the period from March 12 and May 31 for each year. (ACS – Acute Coronary Syndrome, ARC – Acute Respiratory Conditions, GU – Genito-Urinary conditions, MSK – musculoskeletal)

4. Discussion

The current COVID-19 epidemic has created unprecedented challenges for emergency health services in England. To our knowledge, this is the first published analysis of ED attendance in the UK, with an in-depth analysis into the disaggregated trends to a large London trust (ICHNT) as a case study. We find that overall ED attendances decreased by 35% at ICHNT, which is in line with the national trend presented. For our Trust, however, the drop in attendances was larger for St Mary's Hospital than for Charing Cross Hospital. When analysing the disaggregated trends for the Trust, we identified factors associated with decreased ED attendance, all of which may carry important public health implications and that, to a lesser or greater extent, could also explain the trend of decreased attendances at a national level.

Firstly, we identified that attendance patterns of patients aged >65 years were mostly unaffected compared to those amongst patients of younger age groups. In the present year, 44% of emergency admissions were from patients over 65 years , compared to 41% between 2015 and 2019, despite this group of patients having been the most affected by COVID-19, accounting for 54% of all COVID-19 admissions.[13] Furthermore, emerging national evidence shows that excess deaths in the community have increased, particularly amongst the elderly.[14,15]

Secondly, we find an important (64%) decrease in emergency admissions due to injuries. During the current COVID-19 public health response in England, important measures have included the closure of schools, the indication that people must work from home as much as possible and advice to avoid any unnecessary travel.[1] These measures have greatly reduced mobility across the country to a level comparable to the one reached during weekends pre-March 2020.[16,17] ICHNT is a referral trust for major trauma and injury, among many other healthcare pathways. The reduction in mobility and the increase of the public staying at home could have led to a reduction in the number of injuries occurring.

Further to the above, additional capacity of community health services created to reduce the pressure on hospital services during the pandemic, such as extended-hours practices, virtual general practice consultations, additional pathways for key disease areas and expansion telephone assessment services, could have helped to reduce ED attendances that were related to minor presentations and thus amenable to be managed in the community.[18] The absolute effect of such emergency measures warrants further investigation, so that a positive, sustainable impact on streamlined emergency care can be achieved going forward.

Thirdly, we observed indications that the severity of ED attendances may have increased during lock-down. On the one hand, whilst there was a steady decline in attendances of patients arriving by their own means (e.g. personal or public transport), the proportion of ambulance arrivals increased – a marker for illness severity. To an extent, this could be explained by the observed linear relation between increasing distance from postcode of residence to hospital and greater decrease in ED attendances. However, our finding of an overall reduction in ED attendances across London NHS Trusts (*Figure 1.a*) strongly suggests this was not equalised by healthcare seeking at ED services nearer to the patients' residence. In fact, evidence has emerged on an increase in healthcare seeking avoidance across the population during lock-down.[19] This could have translated into a proportion of those experiencing a true emergency not having attended health services at all. Our findings, paired with

national-level analyses highlighting an increase in non-COVID excess deaths in the community,[15,20] suggest emergencies in the community may have increased may have gone unattended, potentially due to healthcare-seeking delay and/or avoidance in the population. Factors behind these trends need urgent investigation.

Our study has limitations that must be acknowledged. Firstly, national-level data were monthly aggregated situation reports, which we complemented with disaggregated data from one of the largest NHS Trusts in England, serving a diverse population of over 600,000. Even between the two hospitals from our trust included in the present analyses, there were important variations in ED attendance characteristics. Further analysis and comparisons with other trusts are needed, as greater variation in trends could be underpinning different reasons from decreased ED attendances in different settings. Secondly, a change in administrative coding systems between our historic and present year datasets (i.e. between *Secondary Uses Service* and *Systematized Nomenclature of Medicine* systems, respectively) limited the ability to fully analyse the change in patients' diagnoses on presentation to ED. However, we performed an analysis of the final diagnoses at discharge or death for those that were ultimately admitted to hospital from ED in our Trust. By and large, this subgroup of patients represents those who are the sickest and thus warrant in-hospital stay and management.

In conclusion, our findings provide strong indication that emergency healthcare-seeking may have drastically changed amongst the population within the catchment area of ICHNT and nationally. This may have signified that those that attended ED services during March 12 to May 31, 2020 did so with longer delays than they used to (i.e. after emergency onset) or that they sought alternative health services. These trends were maintained even after the community-level COVID-19 case and death rates decreased and may still remain below expected levels presently. There is an urgent need to investigate reasons for reduced ED attendances. Lastly, we find it should be a public health priority to investigate optimal approaches to streamline emergency services in England so as to maintain high standard of care for both COVID-19 and non-COVID-19 patients, whilst ensuring appropriate infection prevention control measures.

5. Acknowledgements

6. Funding

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8. Appendix

8.1Attendances to ED services by region

We created timeseries models of the absolute number of attendances to ED services by region in England, using monthly NHS situation reports from June 2015 to December 2019.[6] The model was build using the *auto.arima* function from the R package *forecast*, which returns the timeseries algorithm from Hyndman and Khandakar. For the case of all ED services, we consistently observed a drop in accrued regional attendances by 50% from what would be expected for the month of April 2020 (*Figure S1*).
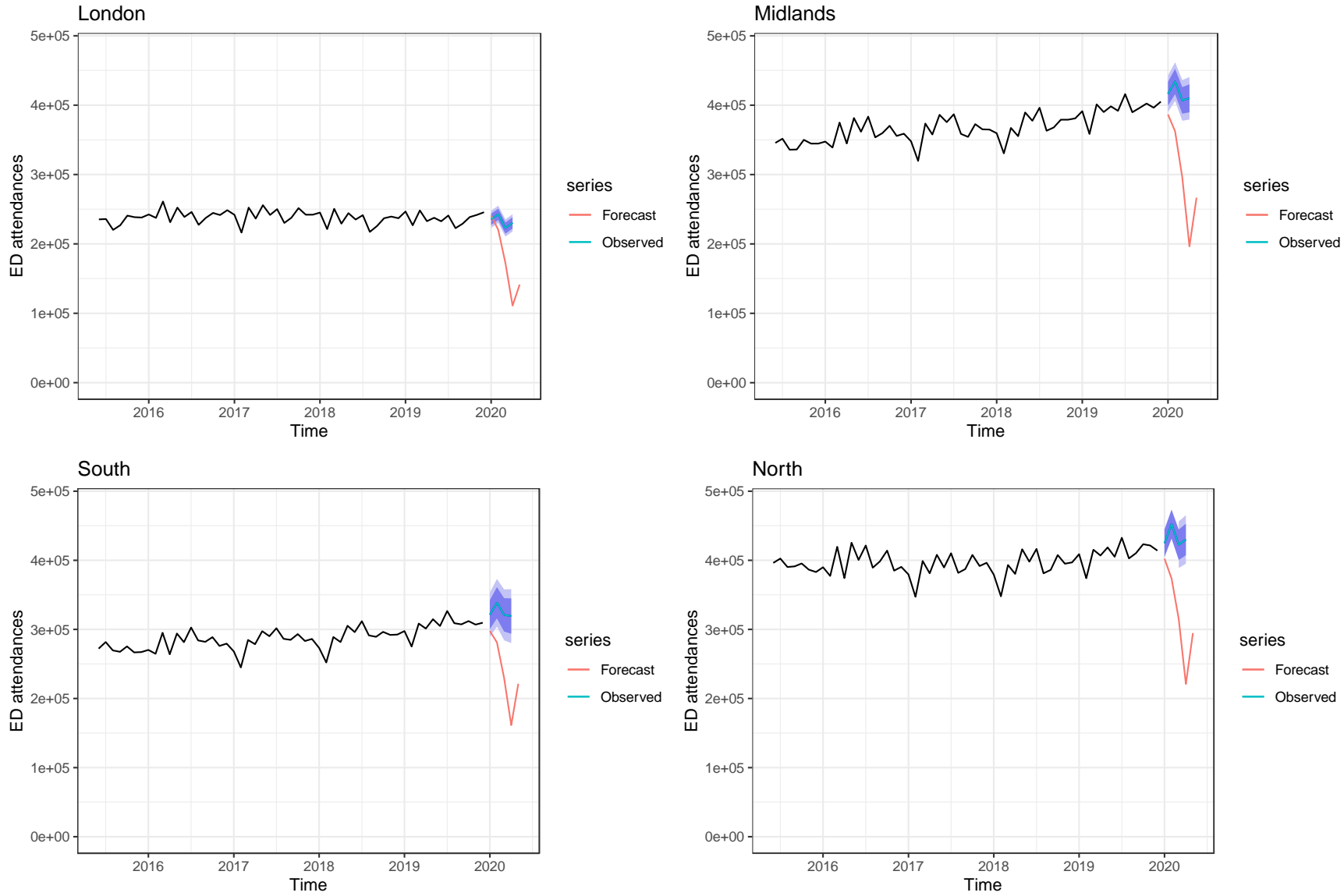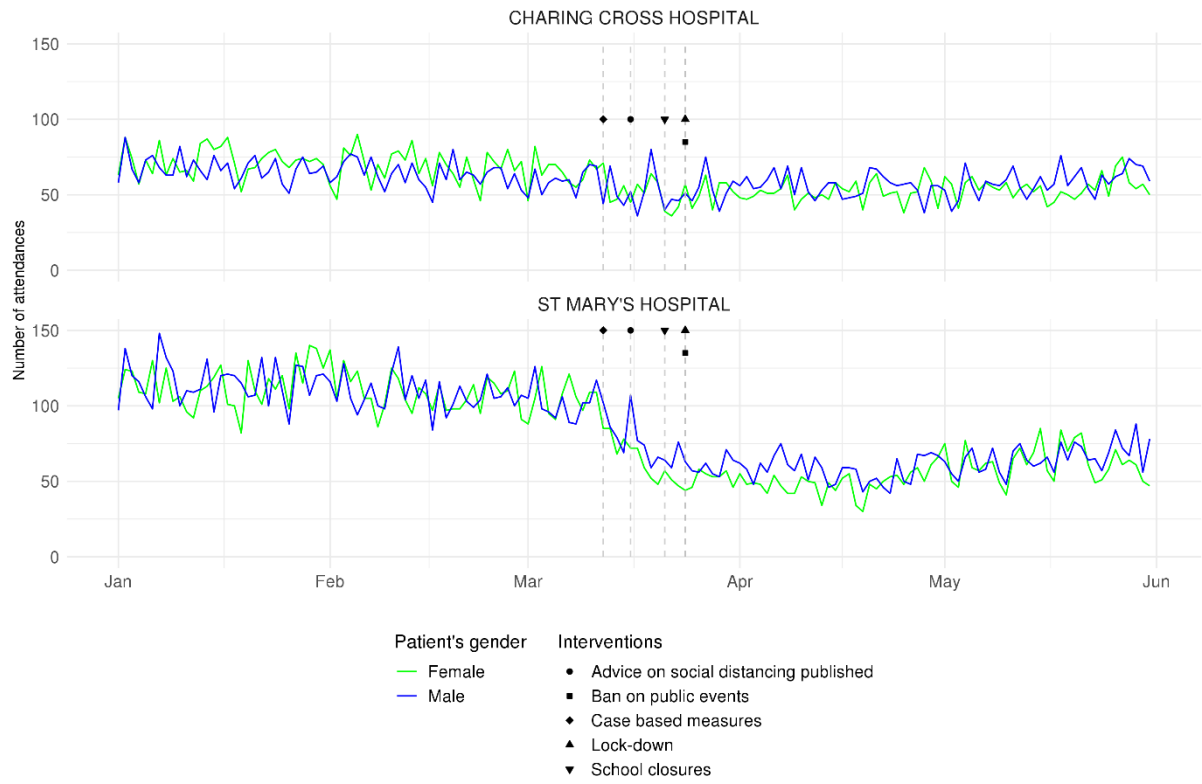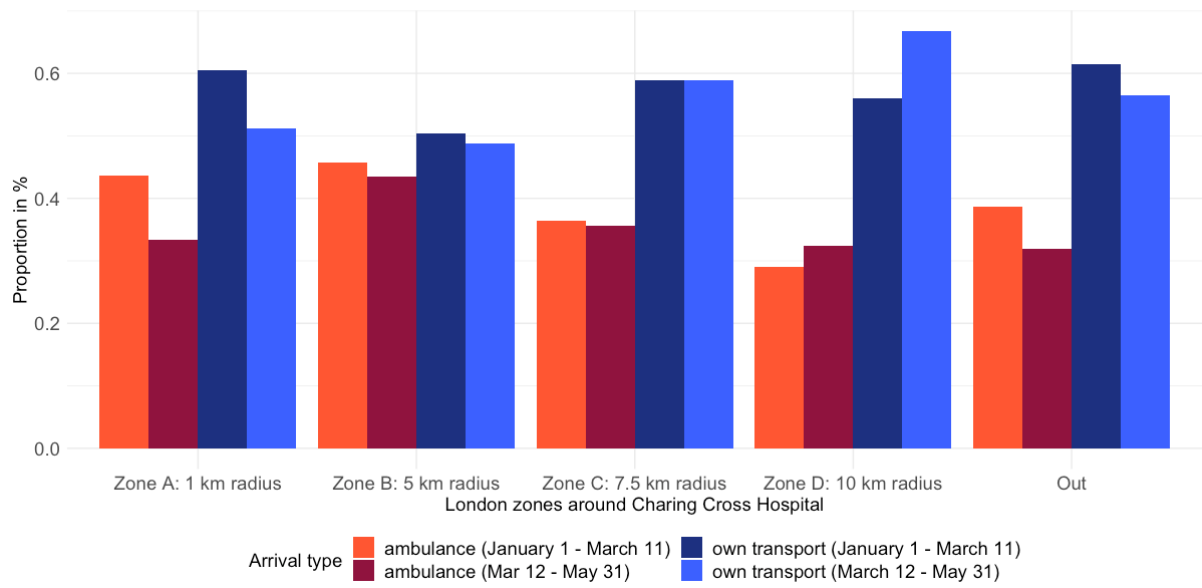
Figure S1. Monthly timeseries of attendances to ED services by region in England.

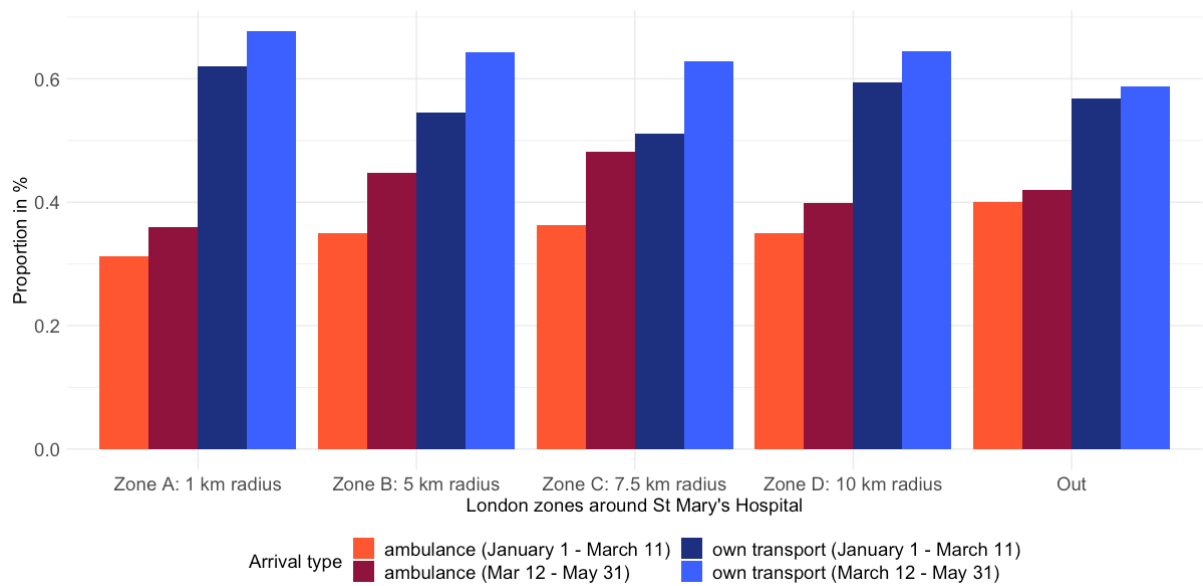**Figure S2. Daily ED attendances to ICHNT by patient's gender**

Figure S3. ED attendances to ICHNT by geographic area of patient residence and method of arrival.

Table S1. Linear regression models for reduced number of ED attendances to Imperial College Healthcare NHS Trust by postcode of patient residence.

SMH, St Mary's Hospital; CXH, Charing Cross Hospital.

Unscaled

	SMH	CXH	SMH	CXH	SMH	CXH	SMH	CXH
(Intercept)	212.64 ***	195.50 ***	-0.71	-2.36	575.50 ***	1120.00 ***	92.41	82.15
	[151.33, 273.94]	[111.99, 279.00]	[-3.24, 1.81]	[-7.42, 2.69]	[389.63, 761.37]	[837.44, 1402.56]	[-4.39, 189.20]	[-40.50, 204.80]
Distance (Km)	-0.01 ***	-0.01 ***						
	[-0.02, -0.01]	[-0.02, -0.01]						
Mean historic attendances			0.58 ***	0.76 ***				
			[0.57, 0.58]	[0.74, 0.78]				
Postcode zone B Δ					-295.83 **	-729.85 ***		
					[-493.71, -97.96]	[-1023.07, -436.62]		
Postcode zone C					-517.50 ***	-1087.78 ***		
					[-716.20, -318.80]	[-1385.62, -789.94]		
Postcode zone D					-557.15 ***	-1095.67 ***		
					[-753.65, -360.65]	[-1389.76, -801.57]		
Outermost zone					-566.27 ***	-1113.29 ***		
					[-754.34, -378.20]	[-1397.46, -829.11]		
Weighed mean IMD quintile[†]							-13.44	-7.83
							[-46.51, 19.63]	[-49.75, 34.08]
R2	0.20	0.09	0.99	0.98	0.40	0.54	0.00	0.00

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

† Weighed by total population in postcode.

Δ Intercept is postcodes within zone A (≤1,000 metres from the respective hospital).

Table S2. **Historic (2015-2019) vs present deaths amongst emergency admissions by disease area at Imperial College Healthcare NHS Trust between March 12 and May 31.**

Historic data refers to the average of emergency admissions between the period from March 12 and May 31 for each year. Specific numbers by hospital are not presented due to risk of identifiability of individuals given low number of deaths and/or admissions. Patients were categorised into disease areas by their primary diagnosis upon hospital discharge or death, based on ICD-10 codes.

*Includes codes for influenza (J09-12), pneumonia (J13-18), COPD exacerbation (J44.1, J44.1), status asthmaticus (J46) and other non-COVID related lower respiratory tract infections

**Includes all codes for disorders of the genitourinary system (N00-N99)

***Includes diagnosis codes for all other non-specified disease areas; these where group together due to potential identifiability of individuals, given very low number of admissions and/or deaths, or due to heterogeneity of primary diagnosis (ICD-10 codes for symptoms/signs [R00-R99] or for factors influencing contact with health services [Z00-Z99])

	2020		Average 2015-2019			
	Deaths	**ED admissions**	**Deaths**	**ED admissions**	**Mortality risk ratio**	**p-value**
Including COVID-19	523	6022	301	10406	2.84 (2.48, 3.26)	<0.01
Non-COVID only	164	4976	301	10406	1.13 (0.94, 1.37)	0.19
Acute respiratory conditions*	76	726	114	912	0.85 (0.65, 1.12)	0.26
Stroke	25	188	30	258	1.13 (0.68, 1.86)	0.64
Acute coronary syndromes	4	116	16	287	0.63 (0.22, 1.85)	0.39
Oncology	20	263	50	484	0.75 (0.46, 1.24)	0.26
Gastro & liver	6	366	15	829	0.91 (0.35, 2.32)	0.84
Injuries	4	536	15	1471	0.73 (0.24, 2.20)	0.58
Genitourinary**	7	308	14	834	1.35 (0.55, 3.30)	0.52
Other**	22	1474	20	3552	2.63 (1.44, 4.80)	<0.01