

The Impact of the COVID-19 Epidemic on Patterns of Attendance at Emergency Departments in Two Large London Hospitals: An Observational Study

Michaela A C Vollmer

Imperial College London

Sreejith Radhakrishnan

Imperial College London

Mara D Kont

Imperial College London

Seth Flaxman

Imperial College London

Samir J Bhatt

Imperial College London

Ceire Costelloe

Imperial College London

Kate Honeyford

Imperial College London

Paul Aylin

Imperial College London

Graham Cooke

Imperial College London

Julian Redhead

Imperial College Healthcare NHS Trust

Alison Sanders

Imperial College Healthcare NHS Trust

Helen Mangan

West London Mental Health NHS Trust Cassell Services

Peter J White

Imperial College London

Neil Ferguson

Imperial College London

Katharina Hauck

Imperial College London

Shevanthi Nayagam

Imperial College London

Pablo N Perez-Guzman (✉ p.perez-guzman@imperial.ac.uk)

Imperial College London <https://orcid.org/0000-0002-5277-5196>

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Abstract

Background

Hospitals in England have undergone considerable change to address the surge in demand imposed by the COVID-19 epidemic. The impact of this on emergency department (ED) attendances is unknown, especially for non-COVID-19 related emergencies.

Methods

We calibrated auto-regressive integrated moving average time-series models of ED attendances to Imperial College Healthcare NHS Trust (ICHNT) using historic (2015–2019) data. Forecasted trends were compared to present year ICHNT data for the period between March 12 (when England implemented the first COVID-19 public health measure) and May 31. We compared ICHNT trends with publicly available regional and national data. Lastly, we compared emergency admissions and in-hospital mortality at ICHNT during the present year to a historic 5-year average.

Results

ED attendances at ICHNT decreased by 35%, in keeping with the trend for ED attendances across all England regions, which fell by approximately 50%. For ICHNT, the decrease in attendances was mainly amongst those aged < 65 years and those arriving by their own means (e.g. personal or public transport). Increasing distance from postcode of residence to hospital was a significant predictor of reduced attendances. Non-COVID related emergency admissions to hospital after March 12 fell by 48%; there was an indication of a non-significant increase in non-COVID-19 crude mortality risk (RR 1.13, 95%CI 0.94–1.37, $p = 0.19$).

Conclusions

Our study finds strong evidence that emergency healthcare seeking has drastically changed across the population in England. At ICHNT, we find that a larger proportion arrived by ambulance and that hospitalisation outcomes of non-COVID patients did not differ from previous years. The extent to which these findings relate to ED avoidance behaviours compared to having sought alternative emergency health services outside of hospital remains unknown. National analyses and strategies to streamline emergency services in England going forward are urgently needed.

Background

The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. The views and opinions expressed in this article are solely those of the authors and do not necessarily reflect those of the institutions to which they are affiliated. The corresponding author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; and no important aspects of the study have been omitted.

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All authors have completed the ICMJE uniform disclosure form at

www.icmje.org/coi_disclosure.pdf and declare centre funding from MRC Centre for Global Infectious Disease Analysis and Abdul Latif Jameel Institute for Disease and Emergency Analytics (J-IDEA). Funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

To tackle the COVID-19 epidemic, the UK Government instituted fundamental changes to the provision of health and social services.[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 UK Government issued 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.[1] These measures were rapidly followed by a national lockdown on March 24 and legislation indicating people to stay at home and avoid social interaction with others outside their households, unless an emergency arises.[1, 3]

Perhaps largely as a result of the widespread implementation of such non-pharmaceutical interventions in England, a steady reduction in the daily number of COVID-19 cases and deaths has been observed from early April onwards.[4, 5] However, publicly available data show that the number of attendances to emergency departments (ED) (i.e. consultant-led, 24-hour services including resuscitation units) has decreased by approximately 50% across all England regions (see Figure S1, for the authors' own analysis).[6] Moreover, concerns have emerged that ED attendances remain low, despite the reduction in COVID-19 cases and deaths.[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 did not increase as expected as COVID-19 cases and deaths decrease.[7] In the United Kingdom, a recent analysis of the Scottish healthcare system has revealed similar trends, with ED attendances also decreasing during the COVID-19 response and also remaining below expected levels compared to historic trends.[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 are crucial to understand the changes in ED attendances associated with reconfiguring emergency care resources in the country. Furthermore, beyond national-level situation reports,[5, 6] analyses of potential sociodemographic and epidemiological factors associated with reduced ED attendances are urgently needed to inform a public health response to revert these trends and ensure continued high-quality standards of care for non-COVID-19 patients in England, as well as ensuring ED services do not revert to the overcrowding seen prior to the pandemic.

In this study, we use pseudonymised administrative patient-level records from Imperial College Healthcare NHS Trust (ICHNT) to: a) analyse local trends and factors associated with ED attendances and emergency admissions pre- and post-implementation of lockdown policies in March 12, 2020 in England; and b) analyse regional (all London ED services) and national situation reports to understand the magnitude and directionality of how our local trends compare against these.

Methods

We had access to historical (2015 to 2019) and present year (January 1 to May 31, 2020) pseudonymised data on: a) ED attendances to two large London hospitals, St Mary's (SMH) and Charing Cross (CXH) and b) hospital admissions to these two and other hospitals of ICHNT, one of the largest NHS Trusts in England serving a diverse population of over 600,000 people.[10]

Historic data of ED attendances from April 1 to December 31, 2019 was used to calibrate a time series forecast model and predict the expected number of ED attendances as a counterfactual for the time period from January 1 to May 31, 2020. The forecasted trend was compared against observed ED attendances in that same period. Forecasts time series were produced using Auto Regressive Integrated Moving Average (ARIMA) models. These simple stochastic time series models capture temporal structures within historic time series dataset and can thus be used forecast future values.[11] Details of the ARIMA models construction can be found in the Supplement. The validity of these models in predicting demand in ED attendances has been previously validated by authors in our group.[12]

To build a regional and national scenario against which to compare the overall trends of ED attendances and emergency admissions to ICHNT, we accessed publicly available monthly NHS England situation reports.[6] Data between June 2015 and December 2019 were used to parameterise ARIMA models by region (London, Midlands, North and South) and nationally and forecast expected ED attendances and emergency admissions from January to May 2020, which we compared to data from situation reports for the same period.

For the case of hospital admissions to ICHNT, we further analysed data on admissions that were from amongst ED attendances between January 1 and May 31. Data from this period in historic records from the past five years was used to average the number of emergency admissions and compare against observed data for the present year. We defined two periods of interest: pre- and post-March 12, 2020. This was based on the data when the first public health measure (case-based isolation) leading to lockdown was imposed in England.[1]

Our primary outcome of interest was the percent change in observed vs expected ED attendances and emergency admissions to ICHNT post-March 12, 2020. We used general linear regression to assess the effect of selected variables on the number of ED attendances. These included distance from postcode area of residence to hospital, population-weighted index of multiple deprivation (IMD) quintile and mean number of historic attendances. IMD and population (for weighting) data was obtained from publicly available resources from the Office for National Statistics and the Ministry of Housing, Communities and Local Government at the lower layer super output areas,[13, 14] which we aggregated to outer postcodes. To ensure anonymity, only the patients' postcode area (i.e. first two to four alphanumeric characters) were used and then aggregated into five mutually exclusive zones, based on the distance of the centroid of the postcode area to the hospital of attendance:

- Zone A, less than 1,000 m
- Zone B, between 1,001 m and 5,000 m
- Zone C, between 5,001 m and 7,500 m
- Zone D, between 7,501 m and 10,000 m
- Outer zone, greater than 10,000 m

Additional outcomes of interest were the change in:

- Time series of ED attendances by age, sex, mode of arrival (e.g. ambulance, own transport or other) and zone of residence
- Emergency admissions by disease categories, as per ICD-10 codes (see Supplement)
- Overall and disease area-specific mortality risk ratio amongst emergency admissions

All statistical and geo-spatial analyses were performed in R 3.6.3, with the latter using freely available polygon files.[15]

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 for the outcomes of interest. Data processing was authorised by both the ICHNT and School of Public Health research committees and 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).

The study was funded by the Abdul Lateef Jameel Institute for Disease and Emergency Analytics (J-IDEA) and the MRC Centre for Global Infectious Disease Analysis. Funders had no role in the study design, data collection, analysis, interpretation, or reporting. The corresponding authors had full access to all the data in the study and the final responsibility to submit for publication.

Results

Overall observed vs forecasted ED attendances

Between January 1 and March 11, 2020 there were 25,203 total attendances to ED services at ICHNT, which fell within the forecasted number of attendances (26,396, 95%CI 8,571 to 44,221). After March 12, however, we observed a significant decline in the number of attendances, amounting to 18,569 as of May 31, 2020. This represented a 35% decline against our forecast (28,774, 95%CI 26,625 to 30,923) (Fig. 1).

The overall decline in ED attendances to ICHNT was largely in keeping with the national trend during the current COVID-19 pandemic response (Fig. 1 and Supplementary Figure S1). However, for ICHNT the observed trend was mainly driven by a reduction in attendances to SMH, which dropped by 46% (95%CI 42–50%) compared to only 17% (95%CI 11–22%) for CXH (Fig. 1).

Disaggregated trends in ED attendances to ICHNT

From the start of the present year to March 11, the number of daily ED attendances by age to ICHNT comprised mainly of people aged 22 to 64 years, followed by those older than 65 years and paediatric attendances, in line with historic trends. Between March 12 and May 31, 2020, we observed a much larger decline in attendances amongst younger age groups, compared to those over 65 years, particularly for the case of SMH (Supplementary Figure S2a and Table S1).

Throughout the period of January 1 to May 31, 2020, the predominant mode of arrival to ICHNT for ED attendances was by patients' own transport, followed by road ambulance services. However, after March 12 there was a significant drop in the former, which was superseded by a proportional increase in ambulance arrivals (Supplementary Figure S2c and Table S3). Importantly, these changes were driven by attendances to SMH alone, as the proportional distribution of attendances at CXH by arrival mode did not vary significantly before and after March 12, 2020.

Additionally, we observed significant differences in the number of attendances to each hospital by zone of patients' postcode of residence (as defined in methods) (Fig. 2). The percent distribution of attendances by zone of residence did not differ significantly when comparing the pre- and post-March 12, 2020 periods ($p = 0.99$). However, we found that increasing distance between patients' postcode zone of residence to hospital significantly predicted decreasing ED attendances ($p < 0.001$, R^2 0.54 for CXH and 0.40 for SMH), which was not explained by population-weighted IMD quintile (Supplementary Table S4).

Emergency admissions and outcomes by disease area

We recorded a total of 16,837 emergency admissions to ICHNT between January 1 and May 31, 2020, 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. infection documented either 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) (Fig. 3a). Therefore, when excluding admissions related to COVID-19 after March 12, we saw the actual reduction in non-COVID-related emergency admissions was of 48% compared to the same period in previous years.

Most non-COVID-19-related emergency admissions were for acute respiratory conditions (802, 12%), including pneumonia, asthma and chronic obstructive pulmonary disease exacerbations, amongst others; injuries (540, 8%); gastrointestinal and liver disorders (372, 6%); and genitourinary disorders (315, 5%).

In accordance to the overall trend, for most disease areas and even for critical ones we saw a decrease in admissions (Fig. 3b). For example, acute coronary syndromes and stroke admissions decreased by 60% and 26%, respectively. Obstetric and perinatal emergency admissions also declined by 52% and 24%, respectively. Lastly, in key disease areas for which ICHNT is a referral centre, such as cancer-related emergency admissions (i.e. excluding programmed interventions and/or procedures, like chemo- and radiotherapy) and those due to injuries also dropped by 47% and 64%, respectively.

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 (Supplementary Table S5). When excluding these deaths from analyses, we saw the crude mortality risk for non-COVID-related emergency admissions was not significantly different from historic trends (IRR 1.13, 95%CI 0.94–1.37, $p = 0.19$). In fact, for most specific disease areas, we saw an overall reduction in mortality risk (Supplementary Table S5), including acute respiratory conditions, acute coronary syndromes, oncological emergencies and injuries.

Discussion

The current COVID-19 epidemic has created unprecedented challenges for emergency health services in England. To our knowledge, our study is the first to analyse detailed trends of ED attendances in England. We use ICHNT as a case study and compare it to regional and national trends. We thus find that overall ED attendances decreased by 35% at ICHNT, which is comparatively lower than the trend for all London ED services and the whole of England. Changes in transportation use and an overall hospital avoidance behaviour could be behind these differences. Moreover, when analysing disaggregated trends for ICHNT, we found evidence of additional factors associated with decreased ED attendances. Beyond providing a first look into such factors, our analyses have important and interrelated public health implications at a national level.

Firstly, we identified significant variation in the decrease of ED attendances between the trust, regional and national level. On the one hand, SMH is located in the central London borough of Westminster (next to a major railway station), which historically receives the largest inflow of daily commuters in the country, [16] and CXH is located in a residential area of the borough of Hammersmith and Fulham. Attendances to the former dropped by 46%, compared to 17% to CXH. During the present pandemic, public transportation by railway and underground tube plummeted from 96% of expected travellers in March 12 to 4% in April 10.[17] On the other hand, at a regional level, the decrease in ED attendances was more comparable, dropping to 50% for London and the South of England, 48% in the North and 52% in the Midlands by April 2020 (Supplementary Figure S1). We found distance from residence to hospital to be the main predictor of reduced ED attendances at either ICHNT hospital. This is consistent with evidence that overall mobility reduced during lockdown in England,[18] with people thus avoiding travelling into densely populated areas. Furthermore, it implies that those experiencing an emergency may have avoided seeking care in hospital ED services altogether, a hypothesis that is supported by emerging data from population behavioural data during the COVID-19 pandemic.[19]

Secondly, and added to the above, we saw that ED attendance patterns of patients aged > 65 years were not really affected. Younger age groups correspond to the main proportion of daily commuters.[16] This sector of the population is also more frequently suffering from injuries and trauma-related emergencies, which we found to have decreased by 64% despite SMH being a key trauma care pathway. Moreover, the structure of the two EDs at ICHNT is so that paediatric (< 18 years) emergencies are mostly managed at SMH, with virtually none seen at CXH. National public health advice during COVID-19 has greatly reduced mobility across the country to a level comparable to the one reached during weekends pre-March 2020.[12, 18] On the other hand, those aged over 65 represent the age group most affected by COVID-19. At ICHNT, they have accounted for 56% of all COVID-19 admissions and 78% of deaths.[20] We found that, during late March and early April, COVID-19 admissions in fact superseded all-cause non-COVID emergency admissions at our hospitals.

Thirdly, we saw a proportional increase in ED attendances arriving by ambulance services, a marker for illness severity. Public concerns have been voiced during lockdown alerting that people experiencing an emergency may have delayed or avoided attending an ED.[21] Moreover, conclusive evidence has recently indicated that non-COVID deaths in the community increased during lockdown, particularly amongst the elderly.[22–24] Whilst a recent service evaluation report found (semi-quantitative) evidence that paediatric attendances were not delayed compared to pre-COVID at seven hospitals in the UK,[25] the extent to which delayed and/or avoided ED attendance amongst older age groups is correlated to the observed increase in non-COVID deaths in the community is still unknown and warrants urgent investigation.

Lastly, after removing COVID-19 admissions and deaths, we saw a crude increase of mortality risk by 13%, which did not have statistical significance (RR 1.13, 95%CI 0.94–1.37, $p = 0.19$). In parallel to the restructuring of emergency hospital services, ambulatory healthcare was also substantially changed to tackle increased demands during lockdown. This included implementing extended-hours practices, virtual general practice consultations, additional pathways for key disease areas, such as mental health, and expansion of telephone assessment services.[26, 27] Such measures had an impact on the case mix of emergency admissions at ICHNT and may have also helped reduce pressure on ED services (i.e. by dealing with emergencies amenable to be managed in the community). Whether these or other factors meant mortality amongst emergency admissions at ICHNT was kept at its historical low levels or there was indeed an increase in mortality, which did not reach statistical significance due to sample power, is unknown. Nevertheless, the absolute positive effect of the above measures to provide out-of-hospital emergency care in England during lockdown warrants further investigation. Valuable lessons can be learnt, so that a sustainable streamlining of urgent and emergency care can be achieved going forward. Especially since rapidly scaling up capacity during the COVID-19 crisis has put already under-resourced areas of care in additional economic constraints,[28] so their capability to respond to even greater demands going forward could be compromised.

Our study has limitations that must be acknowledged. Firstly, whilst we analysed publicly available monthly (aggregated) situation reports from all ED NHS Trusts in England, we only disaggregated these trends for the case of one London Trust, ICHNT. Although this is one of the largest NHS Trusts in England, further analysis and comparisons with other acute trusts are needed. Secondly, a change in administrative coding systems between our historic and present year datasets (i.e. between Secondary Uses Services [SUS] and Systematised Nomenclature of Medicine Clinical Terms [SNOMED] systems, respectively) limited our ability to compare the change in patients' diagnoses on presentation to ED. We thus relied on aggregating hospital admissions by disease area, based on comparable ICD-10 codes between the two periods. By and large, the group of patients admitted to hospital from the ED represents those who are the sickest and thus warranted in-hospital stay and management.

Conclusions

Our findings provide strong indication that emergency healthcare-seeking may have drastically changed amongst the population within the catchment area of ICHNT and nationally. The extent to which this trend was driven by delayed and/or avoided attendances to EDs during the COVID-19 response (i.e. after emergency onset) compared to having sought alternative emergency health services outside of hospital remains unknown. Nevertheless, we find these trends have been maintained even after the community-level COVID-19 case and death rates decreased. There is an urgent need to investigate both the extent of the negative effect of decreased ED healthcare seeking at a national level, but also the potential positive externalities of having re-directed a large proportion of, in all likelihood minor, emergencies to out-of-hospital services. Foremost, going forward, it should be a public health priority to investigate optimal approaches to streamline emergency services in England, by creating safe pathways for urgent and emergency care outside of hospital settings. This will ensure high standards of care for both COVID-19 and non-COVID-19 patients can be maintained within EDs and hospitals. Avoiding overcrowded conditions in hospital

settings will facilitate maintaining social distancing and infection prevention control measures within EDs, which will in turn reduce the risk of nosocomial infections.

List Of Abbreviations

ARIMA Autoregressive integrated moving average

CXH Charing Cross Hospital

ED Emergency department

ICHNT Imperial College Healthcare NHS Trust

IMD Index of multiple deprivation

J-IDEA Abdul Lateef Jameel Institute for Disease and Emergency Analytics

RR Risk ratio

SMH St Mary's Hospital

SNOMED Systematised Nomenclature of Medicine Clinical Terms

SUS Secondary Uses Services

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for Publication

The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. The Corresponding Author has the right to grant on behalf of all authors and does grant on behalf of all authors, a worldwide licence to the Publishers and its licensees in perpetuity, in all forms, formats and media (whether known now or created in the future), to i) publish, reproduce, distribute, display and store the Contribution, ii) translate the Contribution into other languages, create adaptations, reprints, include within collections and create summaries, extracts and/or, abstracts of the Contribution, iii) create any other derivative work(s) based on the Contribution, iv) to exploit all subsidiary rights in the Contribution, v) the inclusion of electronic links from the Contribution to third party material where-ever it may be located; and, vi) licence any third party to do any or all of the above. All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Availability of data and material

Patient-level administrative data from ICHNT used for the conduction of this study are not publicly available due to Global Data Protection Regulations. Albeit these data were pseudonymized for analyses, it represents potentially identifiable and sensitive information. Publicly available data used, such as situation reports from NHS Digital, daily COVID-19 deaths in England count, shape files and the codes used for the analyses of these data can be accessed online (https://github.com/MonkeyfaceMx/aae_attendances). Reference to these data have been specified throughout the manuscript as relevant.

Funding and competing interests

We acknowledge centre funding from MRC Centre for Global Infectious Disease Analysis and Abdul Latif Jameel Institute for Disease and Emergency Analytics (J-IDEA). Funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication. We acknowledge no other competing interests.

Authors' contributions

The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care.

MV and PP conceived the study.

MV and PP wrote the first manuscript draft.

MV, SR and MDK analysed the data.

MV, SR and PP interpreted the data.

SF, SB KH and CC provided methodological advice.

PP, SN, JR, AS and HM provided clinical expertise.

JR and AS provided emergency care management expertise.

HM and AS provided perspective of out-of-hospital emergency care adaptation in the NHS.

KH, PJW and PA provided public health relevance expertise.

All authors reviewed and edited the manuscript for scientific content.

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Figures

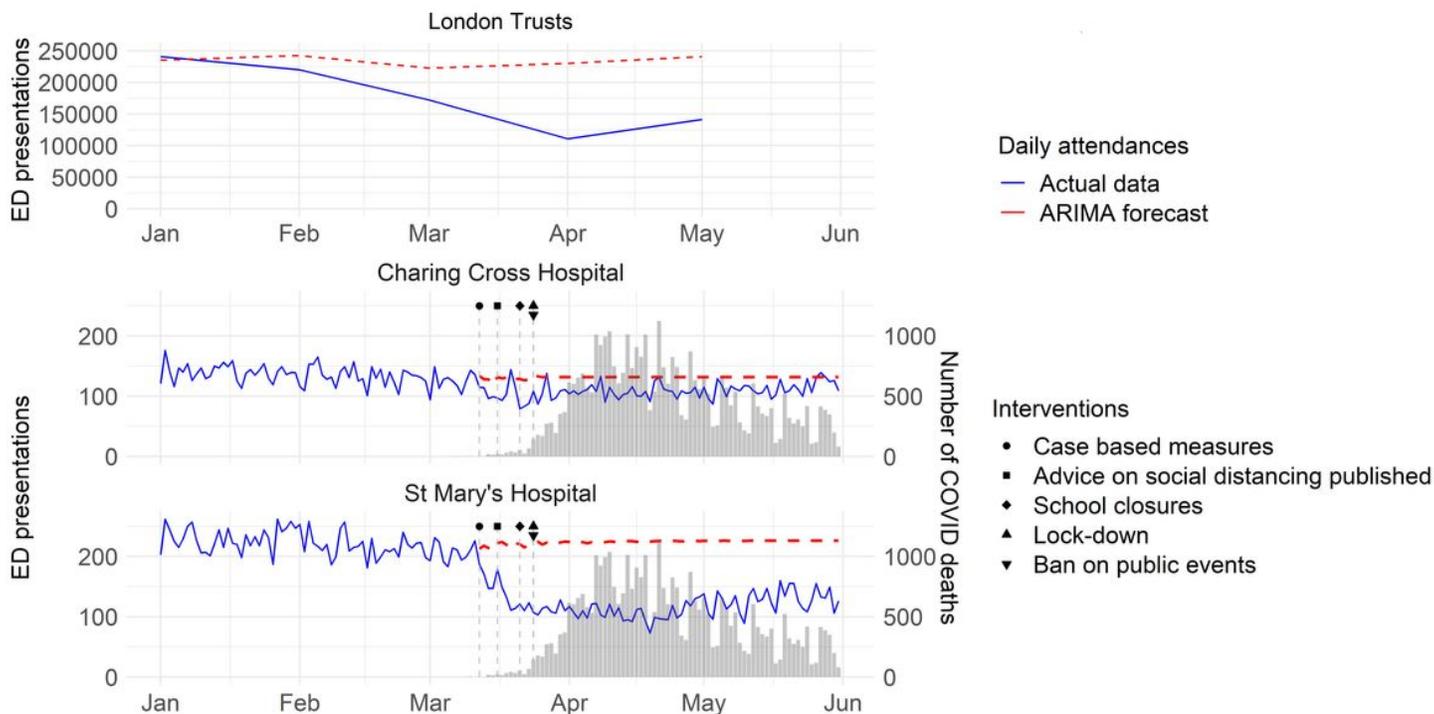


Figure 1
Time series of attendances to ED services at ICHNT (Charing Cross Hospital and St Mary's Hospital) in relation to the regional (all London EDs) decline in attendances. Data for COVID-19 deaths in background bar chart as collated from daily Public Health England reports into publicly available repository, available at: <https://raw.githubusercontent.com/tomwhite/covid-19-uk-data/master/data/covid-19-totals-england.csv>

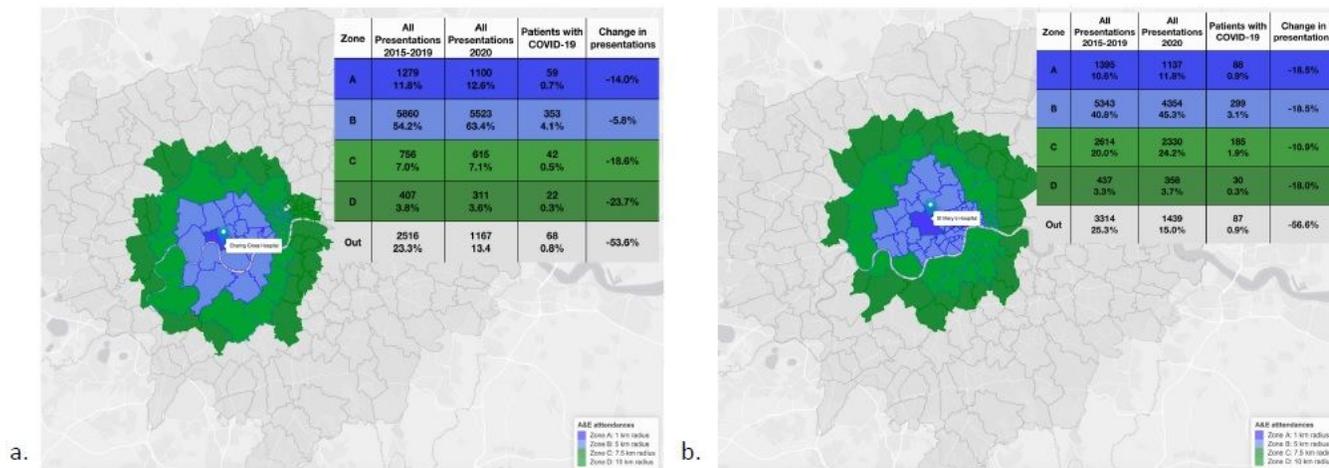


Figure 2

Attendances by geographic area of patient residence to (a) Charing Cross and (b) St Mary’s hospitals. The maps show A (<1000m), B (1001m-5000m), C (5001m-7500m), D (7501m-10,000m), and Outer (>10000m) zones defined as the distance from the centroid of the postcode to hospital. Percentages in the “All presentations” columns refer to total presentations in the respective column. Percentages in the “Patients with COVID-19” columns refer to the proportion of all attendances that became COVID-19 hospitalisations. Percentages in the “Change in presentations” columns refer to the difference in all ED attendances in 2020 compared to historic (2015-2019) data.

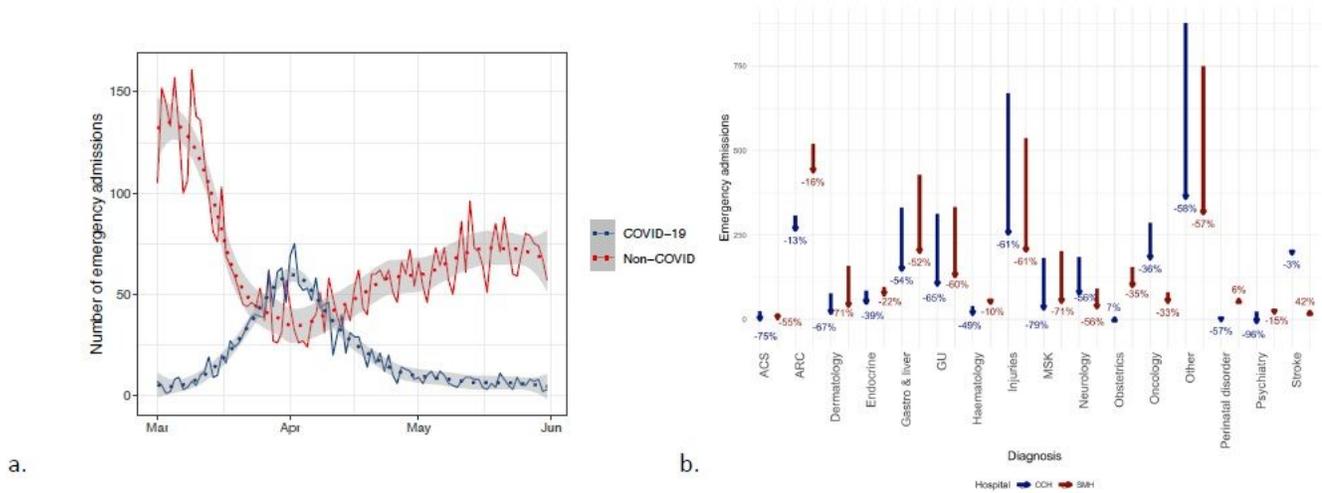


Figure 3

Daily emergency admissions at ICHNT of (a) non-COVID vs COVID-19 patients and (b) change by disease area for the period of March 12 to May 31, 2020 compared to historic (2015-2019) average. In (b), the absolute changes for Charing Cross (blue) and St Mary’s (red) hospitals are shown by arrows, with labels showing percentage changes. 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)

Supplementary Files

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