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Retrospective analysis of the national impact of industrial action by English junior doctors in 2016.

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Abstract

Objectives: To examine the impacts of the four episodes of industrial action by English junior doctors in early 2016.

Design: Descriptive retrospective study of admitted patient care, accident and emergency (A&E) and outpatient activity in English hospitals.

Setting: All hospitals across England.

Participants: All patients who attended A&E or outpatient appointments, or those who were admitted to hospital during the three week period surrounding each of the four strikes (January 12th, February 10th, March 9th-10th and April 26th-27th, excluding weekends.

Main outcome measures: Raw numbers and percentage changes of outpatient appointments and cancellations, A&E visits, admitted patients and all in-hospital mortality on strike days compared with patient activity on the same weekday in the weeks before and after the strikes.

Results: There were 3.4 million admissions, 27 million outpatient appointments and 3.4 million A&E attendances over the four 3-week periods analysed. Across the four strike days, there were 31,651 fewer admissions (-9.1%), 23,895 fewer A&E attendances (-6.8%) and 173,462 fewer outpatient appointments (-6.0%) than expected. Additionally, 101,109 more outpatient appointments were cancelled by hospitals than expected (+52%). The April 26th-27th strike, where emergency services were also affected, showed the largest impacts on regular service. Regional analysis showed that services in the Yorkshire and the Humber region were disproportionately more affected by the industrial action.

Conclusions: Industrial action by junior doctors during early 2016 caused a significant impact on the provision of healthcare provided by English hospitals. We also observed regional variations in how these strikes affected providers.

What is already known on this topic

- Doctors' strikes are a rare occurrence in the UK, with only one occurring in the 40 years before 2016 (in which only 8% of NHS doctors participated).
- Strikes cause large impacts on hospital-ordered cancelations of outpatient appointments, admitted patient care and A&E visits. Few studies have shown any significant impacts on mortality from strikes.

What this study adds

- This is the first UK study which looked at the effects of striking junior doctors, as well as the first to evaluate the impact of withheld in-hospital emergency services (the April 2016 strike was the first ever UK strike to include emergency care)
- Analysis of hospital administrative data from the 2016 strikes show a significant impact on outpatient appointments, admitted patient care and A&E visits.

Introduction

In each of the first four months of 2016, junior doctors from all specialties in England engaged in industrial action with a series of 24-48 hour strikes, culminating in a two day strike which included the withdrawal of emergency services[1]. The purpose of the action was to protest new contractual changes for all junior doctors brought by the Department of Health (DoH) regarding safe working hours and pay[2]. Doctor's strikes in the UK are very rare – before the 2016 strikes, there had been only one, much smaller strike in the previous 40 years (in 2012)[3,4].

Breaks from routine care patterns offer an important window into the effectiveness of currently established treatment services. During annual meetings of the American Heart Association and the American College of Cardiology, there are significant drops in 30-day mortality among high-risk patients admitted with heart attacks or cardiac failure[5]. Therefore, the 2016 strikes provide an ideal opportunity to evaluate the effectiveness of current systems and locate weaknesses in national responses to staffing shortages.

Metcalfe et al[6] studied strikes among doctors in Los Angeles, Jerusalem, Spain, Croatia, South Africa and the UK. Almost all of the strikes they looked at showed little to no effect on patient mortality. In fact, only one (a 20 day long strike of all doctors in a single province in South Africa in 2010) reported increased mortality rates – patients who presented in emergency departments were 67% more likely to die than during a normal period[6]. Ruiz et al[3] analysed the 24-hour strike on 21st June 2012 in England, where approximately 8% of doctors in England took part.[7] For their analysis, they used Hospital Episode Statistics (HES), the national hospital administrative database for England's NHS, and compared the week of the strike with the week immediately following and preceding it. Their analysis found an increase in outpatient appointment cancellations, but no significant differences in mortality between strike and non-strike periods.

This current work aimed to examine the impact of the junior doctors' strikes in early 2016 using, Health Episode Statistics (HES), which contains data on NHS activity. This dataset allowed us to investigate trends in the number of admissions (inpatients), outpatient appointments cancellations, Accident and Emergency (A&E) attendances and in-hospital deaths during strike periods and to compare these with the expected numbers based on an average non-strike period.

Methods

Hospital episode statistics include details of all admissions to NHS Hospitals in England and are collected by the Department of Health. HES data covering all recorded episodes of admitted patient care, outpatient appointments and A&E attendances were extracted for the week of each strike.

Strike action by English junior doctors took place on four occasions throughout early 2016 – January 12th, February 10th, March 9th-10th and April 26th-27th. For comparison with normal operations, we also extracted all data from the weeks immediately preceding and following each strike. For simplicity, weekends were excluded from our analysis.

Due to the impact upon normal hospital operations and attendance due to the bank holiday on the week of the 2nd of May, the second comparator week was replaced with the week of May 9th-13th for the April strike.

Each hospital admission is recorded as a "spell" consisting of a number of "consultant episodes," which denotes period of care under different consultants during their hospital admission[8]. If the patient admission includes transfer to other hospitals before they are discharged, the whole period of care is recorded as a "superspell." For our analysis of admitted patient care, only the first "episode" in a superspell of care was used to identify the date of initial admission, so as to avoid multiple counting.

The data from the comparator weeks were averaged into what was assumed to be a "normal" week. This allowed for comparison with the strike data to provide an indication of the impacts of individual strikes.

Daily totals for A&E attendances, outpatient appointments and hospital admissions were calculated. Admitted patients were separated into elective and emergency categories using the "admimeth" method of admission field in HES. Day surgery cases were extracted using the "CLASSPAT" field.

Outpatient appointments were analysed using the "attended" field, which includes the following categories:

0 = Not applicable - appointment occurs in the future

2 = Appointment cancelled by, or on behalf of, the patient

3 = Did not attend - no advance warning given

4 = Appointment cancelled or postponed by the health care provider

5 = Seen, having attended on time or, if late, before the relevant care professional was ready to see the patient

6 = Arrived late, after the relevant care professional was ready to see the patient, but was seen

7 = Did not attend - patient arrived late and could not be seen

9 = Not known

This analysis, as with Ruiz et al's analysis of a June 2012 strike[3], focused primarily on category 4 for cancellations, and categories 5&6 to denote actual attendance of appointments.

To obtain death counts, the discharge method field ("dismeth") was used to capture deaths in hospital. The A&E attendance disposal field ("aeattenddisp") was used to determine which patients died within the A&E department. HES Outpatient data do not have the capability to record deaths during appointments, so these data were not used for this outcome.

Finally, regional analyses were performed on all outpatient, A&E and admitted patient data using provider code data ("procode").

For our analysis, it was assumed that patient counts were described by a Poisson distribution and a Chi-squared test was used to evaluate significance for proportions. All p values < 0.05 were considered statistically significant.

Patient Involvement

No patients were involved in setting the research question or the outcome measures; nor were they involved in the design and implementation of the study. There are no plans to involve patients in the dissemination of results.

Results

In total, this study involved the extraction and analysis of 3.4 million admissions, 27 million outpatient appointments and 3.4 million A&E attendances over 12 weeks.

Table 2 shows the impacts of the industrial action of early 2016 upon admitted patient care, outpatient appointments and A&E.

Strike	Tuesday 12th January	Wednesday 10th February	Wednesday 9th-Thursday 10th March	Tuesday 26th-Wednesday April 27th	Total
Services Withheld	Routine care only	Routine care only	Routine care only	All services (including emergency care)	
Total Admissions	53,279	54,558	107,243	99,866	314,946
Change in total admissions	-4,951 (-8.5%)*	-2,633 (-4.6%)*	-5,873 (-5.2%)*	-18,194 (-15.4%)*	-31,651 (-9.1%)
Emergency admissions	20,307	21,005	40,908	40,077	122,297
Change in emergency admissions	-1,313 (-6.1%)*	-30 (-0.1%)	-99 (-0.2%)	-3,383 (-7.8%)*	-4,825 (-3.7%)
Elective admissions	32,972	33,553	66,335	59,789	192,649
Change in elective admissions	-3,638 (-9.9%)*	-2,603 (-7.2%)*	-5,775 (-8.0%)*	-14,811(-19.9%)*	-26,827 (-12.2%)

Day case admissions	23,455	23,664	47,286	42,734	137,139
Change in day case admissions	-2,367(-9.2%)*	-1,809 (-7.1%)*	-3,863 (-7.6%)*	-9,846 (-18.7%) *	-17,885 (-11.5%)
Total outpatient Appointments	470,639	439,599	871,540	881,213	2,662,991
Change in total outpatient appointments	-14,663 (-3.0%)*	-7,702 (-1.7%)*	-41,182 (-4.5%)*	-109,915 (-11.1%)*	-173,462 (-6.0%)
Outpatient Appointments completed	352,808	333,625	658,348	651,028	1,995,809
Change in outpatient appointments completed	-29,791 (-7.8%)*	-18,305 (-5.2%)*	-59,692 (-8.3%)*	-134,711 (-17.1%)*	-242,499 (-10.6%)
Outpatient appointments cancelled by provider	49,967	45,222	90,272	109,383	294,844
Change in outpatient appointments cancelled by provider	17,641 (+54.6%)*	12,739 (+39.2%)*	26,906 (+42.5%)*	43,823 (+66.8%)*	101,109 (+52.1%)
A&E total attendances	48,827	55,842	114,292	100,569	319,530
Change in A&E total attendances	-5,219 (-9.7%)*	963 (+1.8%)*	-2314 (-2.0%)*	-17,325 (-14.7%)*	-23,895 (-6.8%)
Emergency admission deaths	616	583	1011	999	3,209
Change in emergency admission deaths	16 (+2.7%)	24 (+4.3%)	40 (+4.1%)	-40 (-3.8%)	40 (+1.3%)
Elective admission deaths	21	18	30	29	98
Change in elective admission deaths	0	1 (+5.9%)	1 (+3.4%)	-2 (-6.5%)	0
A&E deaths	73	46	127	110	356
Change in A&E deaths	10 (+15.9%)	-11 (-19.2%)	21 (+19.8%)	11 (+11.1%)	31 (9.75%)
Total deaths	710	647	1,168	1,138	3,663
Change in total deaths	26 (+3.8%)	14 (+2.2%)	62 (+5.6%)	-31 (-2.7%)	71 (2.0%)

Table 1- Results of Strike Analyses. Statistical significance at the 5% level as given by the Chi-Squared test is denoted with asterisks. Percentage change vs expected non-strike volumes are shown in brackets.

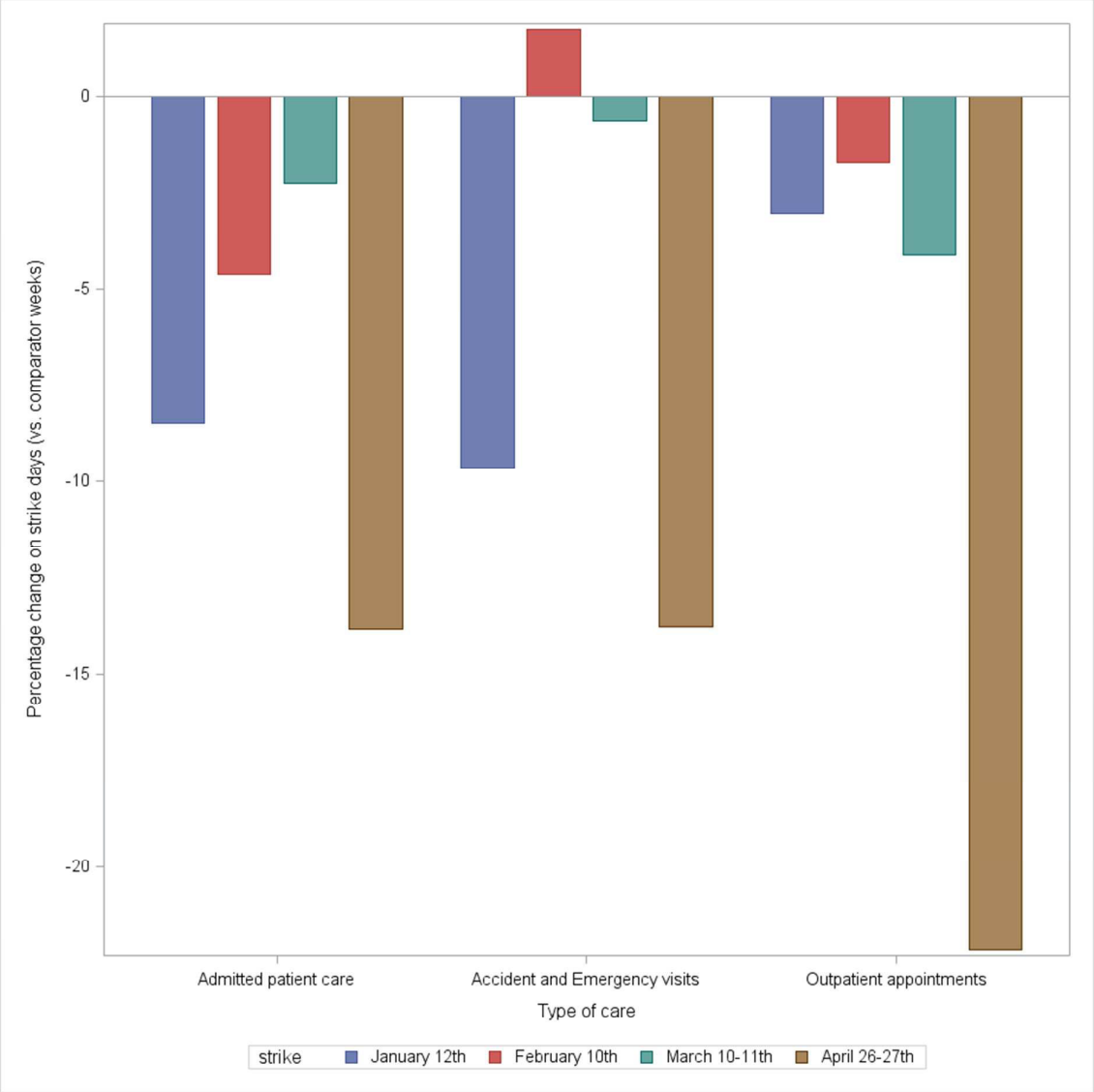

Figure 1 - Impacts of each of the four strikes on hospital activity across all strikes and types of care

Figure 1 shows the percentage change in A&E visits, admitted patients and outpatient appointments across all four strikes against the average of the chosen comparator weeks.

The largest impacts upon normal operations were seen in the April strike. This is to be expected, as it lasted 48 hours and was also the only instance where emergency care was also withheld.

During the April strike, there was a decrease in total admissions of 18,194 patients compared with the expected volume for that period, which comprised a 7.8% decrease in emergency admissions and a 19.9% decrease in elective admissions. Day cases showed a reduction of 9,846 patients, (18.7%) compared with the comparator weeks.

Furthermore, 109,915 (11.1%) fewer outpatient appointments were scheduled during the strike period than usual and 134,711 (17.1%) fewer outpatient appointments were attended during strike days. This was paired with an increase in provider cancellations of outpatient appointments of 43,823 (+66.8%). Additionally, fewer patients attended A&E during this period, with 17,325 (-14.7%) fewer attendees than expected.

The first strike which occurred (Tuesday January 12th 2016) also showed a large and significant (9.6%) decrease in A&E attendance, despite A&E services operating normally during this time. This may be due to significant media attention for this particular strike, due to its historic significance. Additionally, some providers warned patients to avoid hospitals "unless absolutely necessary"[9]. This effect diminished during the February and March strikes.

Over the course of all 6 of the strike days in 2016, 23,895 fewer A&E attendances occurred than expected. 1,995,809 outpatient appointments occurred, representing a drop of 242,499 from the expected volume during this period. Providers cancelled a total of 294,844 outpatient appointments, a 52% increase compared with the expected volume during these periods.

During all strike days, a total of 3209 patients died in hospital during emergency admissions, 98 during elective admissions and 356 died in A&E. However, numbers of recorded hospital deaths did not appear to change significantly during the strikes compared with expected numbers for either admitted patients or A&E, which is in line with what has been seen in most other studies of striking doctors globally.[6]

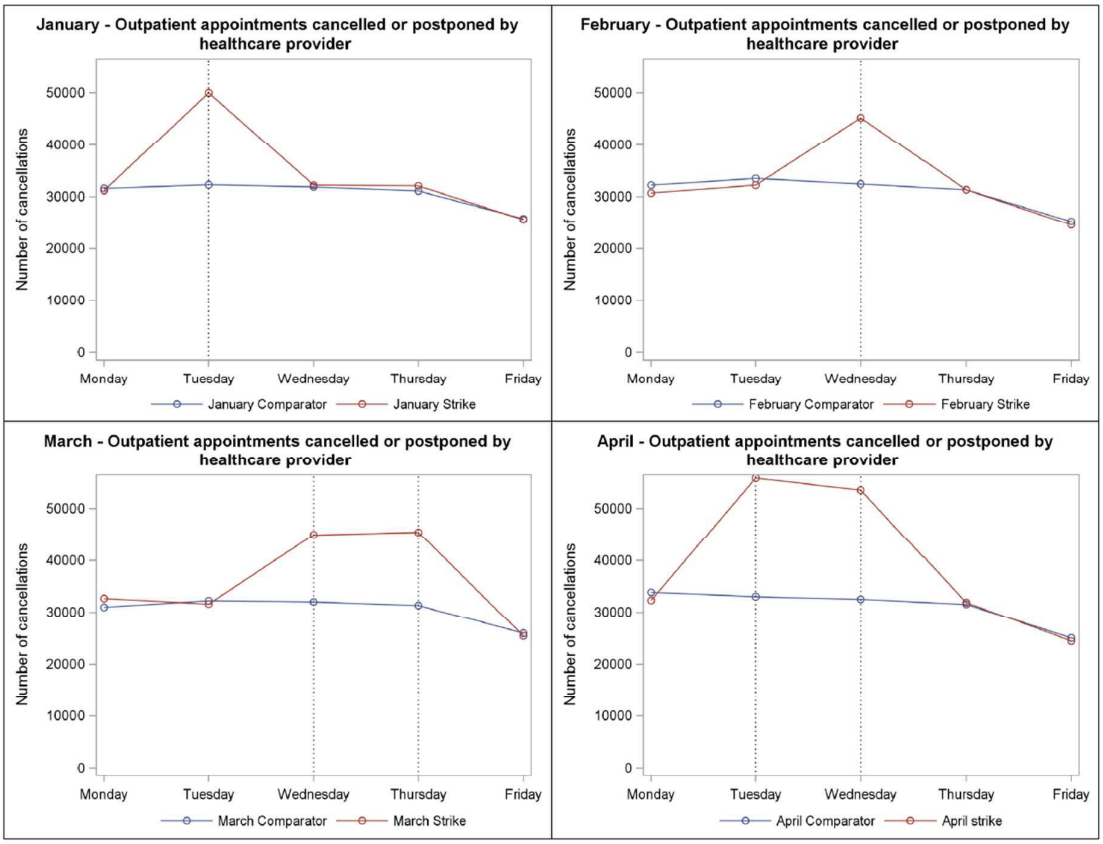

Figure 2 – Volume of provider cancellations by day during the week in which each of the four strikes occurred. Vertical grey lines on the graph represent strike days.

Cancellations

Figure 2 shows the impacts of strikes upon the numbers of appointments cancelled or postponed by health care providers. The largest impacts were seen during the January and April strikes, which showed increases of 54.5% and 66.8% compared with expected cancellations. Our analysis found that 101,109 outpatient appointments were cancelled due to strike action in 2016.

Regional analysis

Region	Change in elective admissions (%)	Change in non-elective admissions (%)	Change in outpatient appointments attended (%)	Change in outpatient cancellations (%)	Change in A&E visits (%)
North East	-9.31*	-4.69*	-6.99*	+41.89*	-7.8*
North West	-13.3*	-1.61*	-13.35*	+52.85*	-6.24*
Yorkshire/Humber	-13.59*	-4.88*	-11.86*	+65.68*	-8.05*
East Midlands	-13.6*	-2.49*	-12.62*	+44.69*	-7.55*
West Midlands	-8.37*	-5.24*	-8.39*	+45.41*	-6.53*
East of England	-9.81*	-3.76*	-9.43*	+44.89*	-5.93*
London	-17.08*	-3.61*	-13.39*	+68.2*	-6.79*
South East Coast	-14.51*	-5.21*	-10.89*	+67.1*	-6.97*
South Central	-10.15*	-2.56*	-7.31*	+22.63*	-7.74*
South West	-11.59*	-4.02*	-10.88*	+52.02*	-7.29*

Table 2 - Regional analyses of strike impacts. Statistical significance at the 5% level as given by the Chi-Squared test is denoted with asterisks

Table 2 shows the differential regional impacts of the strikes on both outpatient appointments and cancellations. This analysis shows particularly large increases in outpatient cancellations by healthcare providers in London, the south east coast and Yorkshire/the Humber. These areas also showed large decreases in the number of overall outpatient appointments attended. The East Midlands also showed a large decrease in overall appointment attendance. The south central region showed a much smaller increase in cancellations than others.

The table also shows the regional variation in admitted patient care during strike periods, separated by elective admissions (including day cases) and non-elective emergency admissions. As with outpatient appointments, the most prominently affected regions by the strikes for elective admissions were Yorkshire and the Humber, London and the East Midlands, which all showed sizable drops in recorded elective admissions. For emergency (i.e. non-elective) admissions, recorded

impacts were smaller and seemed to affect different areas, such as the South West and West Midlands.

Our analysis found an average reduction in A&E patient volume of 7.09% across all strike days. The largest regional drops in volume were found in Yorkshire and the Humber (8.05%) and the North East (7.8%). Impacts were more limited in the East of England (5.93%) and the North West (6.24%).

Discussion

We found that industrial action by junior doctors in 2016 resulted in total 31,651 fewer admissions, 173,462 fewer outpatient appointments and 23,895 fewer A&E attendances compared with expected volumes from similar weeks. Large effects were seen in the numbers of cancelled outpatient appointments by healthcare providers, with an average increase in cancellations of 52.2% during strike days. The most pronounced effects on NHS operations were seen during the first (January 12th) and last (April 26th-27th) strikes. Regional analysis showed that strikes disproportionately affected London, Yorkshire and the Humber and the East Midlands for outpatient appointments and elective admissions. Emergency admissions were most affected in the South West and West Midlands regions. A&E attendance was most affected in the North East, Yorkshire and the Humber and South Central England. The January 12th strike corresponded with a 9% drop in A&E admissions, despite industrial action not affecting emergency services. This is noteworthy as it implies many patients may have consciously avoided going to hospital during this period, perhaps due to intense media coverage of the event and explicit instructions from some providers to avoid all non-urgent hospital attendances.

Our analysis is broadly consistent with similar studies of this type. Prior work by Ruiz et al[3] has shown the effects of striking doctors on outpatient cancellations by provider. This work replicates that effect – during the strike on April 26th-27th 2016, there was an increase in cancellations of 67% when compared with average figures from the surrounding weeks. As with Ruiz et al[3] and other papers[6], this work did not find a significant effect on mortality among either admitted or A&E patients during strike days. This could be either because there is no effect, or our study did not have enough power to demonstrate an effect, due to the small study period involved in strike days. It may be the case that during periods of industrial action, staffing priority is given to critical care, resulting in small differences in mortality but a poorer patient experience in non-vital care, as discussed by Metcalfe et al[6] .

This is a large national study which was able to analyse the majority of admissions, outpatient appointments and A&E visits during the 2016 strikes. Hospital episode statistics have previously

been shown to have reasonable accuracy at both outpatient[10] and inpatient[11] levels. Furthermore, the strike on April 26th and 27th also demonstrates the first opportunity for researchers in the UK to investigate the effects of industrial action upon emergency personnel – previous strikes did not withhold emergency care. During this period, there was a drop in the number of patients attending A&E of 17,325 (almost 15%) compared with the expected volume for this time period.

The weaknesses of this work are predominantly due to what was not investigated – for example, HES data alone do not allow the investigation of the effects of strikes upon patients who did not attend A&E during this period. Furthermore, analysis focused only on the weeks where strikes occurred, which prevented the capture of lagged effects in the immediate aftermath of a strike. Outcomes (especially mortality) proved more difficult to measure. Death counts during strike days were small, and hence lacking in statistical power, and many patients stayed in hospital for more than a single day. Importantly, other outcomes such as uncaptured morbidity, as well as opportunity costs for both the NHS (through rescheduling elective operations and other procedures) and patients (taking time off work, childcare costs etc) were uncaptured. This study also includes no qualitative element, which prevents us from capturing unrecorded outcomes of strikes, such as disappointment, inconvenience, stress and worry. Finally, the occurrence of a national bank holiday on the week of the 2nd of May meant that patient profiles were likely to differ between strike and comparator weeks. As such, in our analysis the second comparator week for the April strike was replaced with data from the week of May 9th-13th instead.

Conclusions

The four junior doctor's strikes between January-April 2016 resulted in significant negative impacts upon patient care as measured by hospital activity. Significant increases in outpatient appointment cancellations by hospitals were paired with decreases in admitted patients and A&E visits. The major outcome we investigated was mortality, which is likely to be the least sensitive to quality and safety concerns. Future work in this area should focus on how the strikes affected waiting times and similar quality outcomes. Strike-related morbidity (such as disease progression in the time between rescheduled operations/appointments) would likely be a fertile avenue for investigation. Delays will also be likely to have an associated cost burden in terms of worse patient outcomes and hence costlier treatment. Finally, it should be determined whether quality of care was negatively impacted in the period immediately following the strikes.

Contributorship statement

All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript.

Study design: Paul Aylin, Daniel Furnivall

Data collection: Daniel Furnivall

Data analysis and interpretation: Daniel Furnivall, Alex Bottle, Paul Aylin

Drafting the article: Daniel Furnivall

Critical revision of the article: Paul Aylin, Alex Bottle

Final approval of version to be published: Paul Aylin, Alex Bottle, Daniel Furnivall

Guarantor: Paul Aylin

Transparency Declaration

Professor Paul Aylin affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Copyright

Competing Interests Declaration

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no other relationships or activities that could appear to have influenced the submitted work. PA is principal investigator for The Dr Foster Unit, an academic unit in the

Department of Primary Care and Public Health, within the School of Public Health, Imperial College London. The unit receives research funding from Dr Foster Intelligence, an independent health service research organisation (a wholly owned subsidiary of Telstra).

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Ethics

The principal investigator has approval from the Secretary of State and the Health Research Authority under Regulation 5 of the Health Service (Control of Patient Information) Regulations 2002 to hold confidential data and analyse them for research purposes (CAG ref 15/CAG/0005). We have approval to use them for research and measuring quality of delivery of healthcare, from the London - South East Ethics Committee (REC ref 15/LO/0824).

Data Sharing Statement

All SAS code used in the study is available upon request from the corresponding author.

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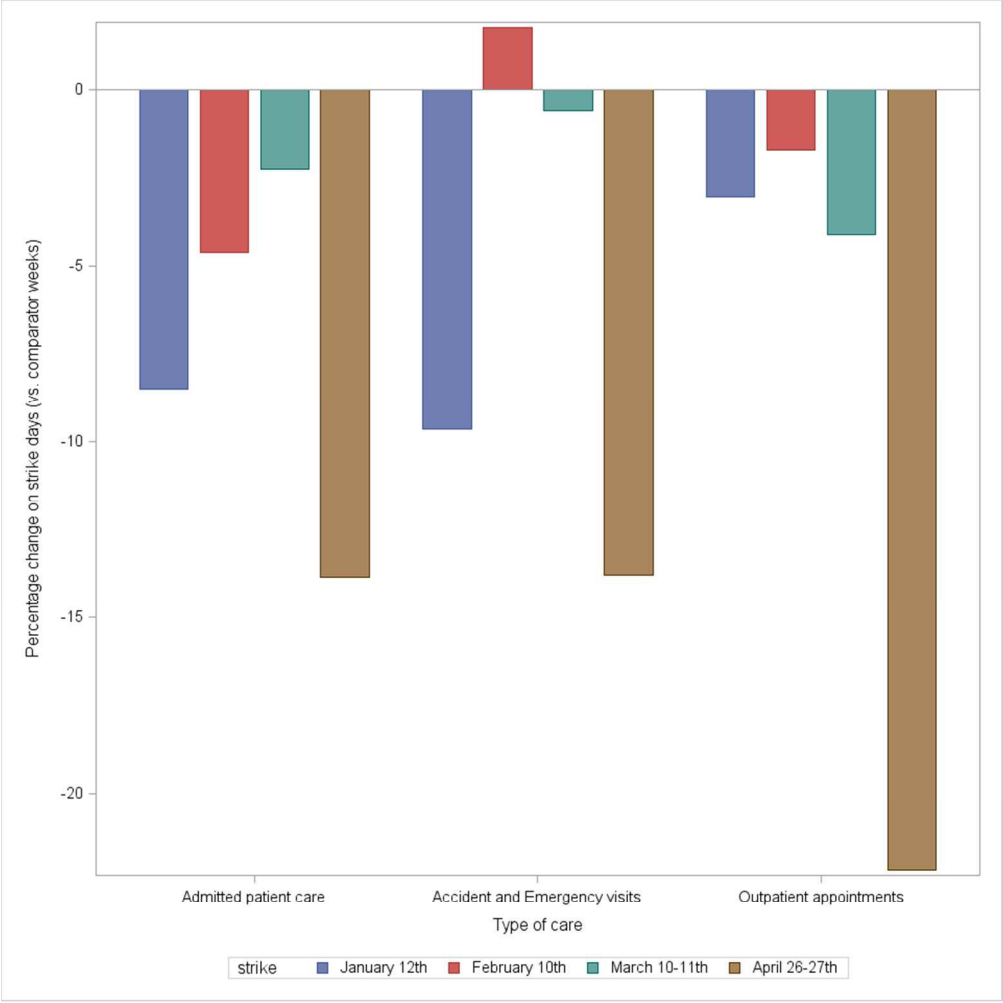

Figure 1 - Impacts of each of the four strikes on hospital activity across all strikes and types of care

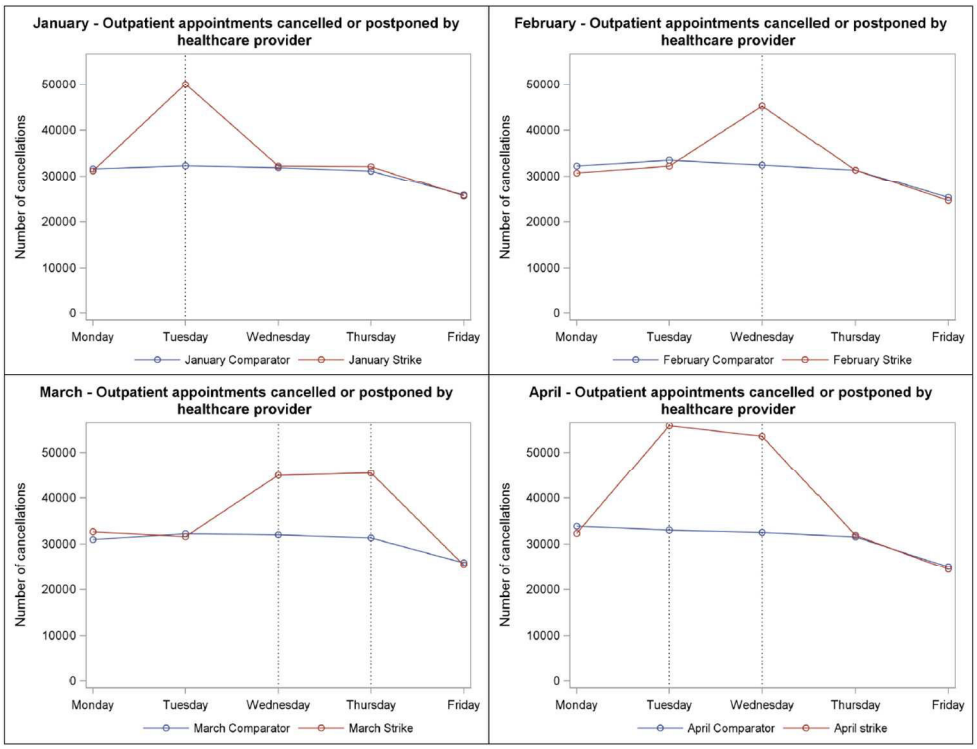

Figure 2 - Volume of provider cancellations by day during the week in which each of the four strikes occurred. Vertical grey lines on the graph represent strike days.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **(Page 1)**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **(Page 2)**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **(Pages 2&3)**
Objectives	3	State specific objectives, including any prespecified hypotheses **(Centre of page 3)**
Methods		
Study design	4	Present key elements of study design early in the paper **(Pages 3&4)**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **(Page 4)**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **(Pages 4&5)**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **(Page 5&6)**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **(Page 3)**
Bias	9	Describe any efforts to address potential sources of bias **(Top of page 4)**
Study size	10	Explain how the study size was arrived at **(N/A - entire population)**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **(N/A – counts only)**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **(page 4,5,6)**
		(*b*) Describe any methods used to examine subgroups and interactions **(Pages 5+10)**
		(*c*) Explain how missing data were addressed **(N/A)**
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy **(Pages 3&4)**
		(*e*) Describe any sensitivity analyses **(N/A)**

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (**Pages 5&6**)
		(b) Give reasons for non-participation at each stage (N/A)
		(c) Consider use of a flow diagram (N/A)
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (**N/A – entire population)**
		(b) Indicate number of participants with missing data for each variable of interest (**N/A)**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures **(Pages 5&6)**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (**Page 5,6,10)**
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses (**Page 10 – regional analysis)**
Discussion		
Key results	18	Summarise key results with reference to study objectives (**Page 11)**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias (**Page 12)**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence (**Page 12)**
Generalisability	21	Discuss the generalisability (external validity) of the study results (**Page 12)**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based (**Page 14)**

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Retrospective analysis of the national impact of industrial action by English junior doctors in 2016

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Retrospective analysis of the national impact of industrial action by English junior doctors in 2016.

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Abstract

Objectives: To examine the impacts of the four episodes of industrial action by English junior doctors in early 2016.

Design: Descriptive retrospective study of admitted patient care, accident and emergency (A&E) and outpatient activity in English hospitals.

Setting: All hospitals across England.

Participants: All patients who attended A&E or outpatient appointments, or those who were admitted to hospital during the three week period surrounding each of the four strikes (January 12th, February 10th, March 9th-10th and April 26th-27th, excluding weekends.)

Main outcome measures: Raw numbers and percentage changes of outpatient appointments and cancellations, A&E visits, admitted patients and all in-hospital mortality on strike days compared with patient activity on the same weekday in the weeks before and after the strikes.

Results: There were 3.4 million admissions, 27 million outpatient appointments and 3.4 million A&E attendances over the four 3-week periods analysed. Across the four strike days, there were 31,651 fewer admissions (-9.1%), 23,895 fewer A&E attendances (-6.8%) and 173,462 fewer outpatient appointments (-6.0%) than expected. Additionally, 101,109 more outpatient appointments were cancelled by hospitals than expected (+52%). The April 26th-27th strike, where emergency services were also affected, showed the largest impacts on regular service. Mortality did not measurably increase on strike days. Regional analysis showed that services in the Yorkshire and the Humber region were disproportionately more affected by the industrial action.

Conclusions: Industrial action by junior doctors during early 2016 caused a significant impact on the provision of healthcare provided by English hospitals. We also observed regional variations in how these strikes affected providers.

Strengths and limitations of this study

- **Strength**: This is the first UK study which looked at the effects of striking junior doctors, as well as the first to evaluate the impact of withheld in-hospital emergency services (the April 2016 strike was the first ever UK strike to include emergency care)
- **Strength**: This was a large analysis of English hospital administrative data from the 2016 strikes show a significant impact on outpatient appointments, admitted patient care and A&E visits.
- **Limitation:** This work did not include any financial modelling of the impact of industrial action on either the national or the regional level.
- **Limitation:** The study was unable to examine the health impacts on patients who could not attend hospitals due to industrial action. Additionally, qualitative outcomes such as disappointment and inconvenience were not collected.

Introduction

In each of the first four months of 2016, junior doctors from all specialties in England engaged in industrial action with a series of 24-48 hour strikes, culminating in a two day strike which included the withdrawal of emergency services[1]. The purpose of the action was to protest new contractual changes for all junior doctors brought by the Department of Health (DH) regarding safe working hours and pay[2]. Doctor's strikes in the UK are very rare – before the 2016 strikes, there had been only one, much smaller strike in the previous 40 years (in 2012)[3,4].

Breaks from routine care patterns offer an important window into the effectiveness of currently established treatment services. During annual meetings of the American Heart Association and the American College of Cardiology, there are significant drops in 30-day mortality among high-risk patients admitted with heart attacks or cardiac failure[5]. Therefore, the 2016 strikes provide an ideal opportunity to evaluate the effectiveness of current systems and locate weaknesses in national responses to staffing shortages.

Metcalfe et al[6] studied strikes among doctors in the USA, Israel, Spain, Croatia, South Africa, India and the UK. Almost all of the strikes they looked at showed little to no effect on patient mortality. In fact, only one (a 20 day long strike of all doctors in a single province in South Africa in 2010) reported increased mortality rates – patients who presented in emergency departments were 67% more likely to die than during a normal period[6]. Ruiz et al[3] analysed the 24-hour strike on 21st June 2012 in England, where approximately 8% of doctors in England took part.[7] For their analysis, they used Hospital Episode Statistics (HES), the national hospital administrative database for England's NHS, and compared the week of the strike with the week immediately following and preceding it. Their analysis found an increase in outpatient appointment cancellations, but no significant differences in mortality between strike and non-strike periods.

This current work aimed to examine the impact of the junior doctors' strikes in early 2016 using, Health Episode Statistics (HES), which contains data on NHS activity. This dataset allowed us to investigate trends in the number of admissions (inpatients), outpatient appointments cancellations, Accident and Emergency (A&E) attendances and in-hospital deaths during strike periods and to compare these with the expected numbers based on an average non-strike period.

Methods

Hospital episode statistics include details of all admissions to NHS Hospitals in England and are collected by the Department of Health. HES data covering all recorded episodes of admitted patient

care, outpatient appointments and A&E attendances were extracted for the week of each strike. Strike action by English junior doctors took place on four occasions throughout early 2016 – January 12th, February 10th, March 9th-10th and April 26th-27th. For comparison with normal operations, we also extracted all data from the weeks immediately preceding and following each strike. For simplicity, weekends were excluded from our analysis.

Due to the impact upon normal hospital operations and attendance due to the bank holiday on the week of the 2nd of May, the second comparator week was replaced with the week of May 9th-13th for the April strike.

Each hospital admission is recorded as a "spell" consisting of a number of "consultant episodes," which denotes period of care under different consultants during their hospital admission[8]. If the patient admission includes transfer to other hospitals before they are discharged, the whole period of care is recorded as a "superspell." For our analysis of admitted patient care, only the first "episode" in a superspell of care was used to identify the date of initial admission, so as to avoid multiple counting.

The data from the comparator weeks were averaged into what was assumed to be a "normal" week. This allowed for comparison with the strike data to provide an indication of the impacts of individual strikes.

Daily totals for A&E attendances, outpatient appointments and hospital admissions were calculated. Admitted patients were separated into elective and emergency categories using the "admimeth" method of admission field in HES. Day surgery cases were extracted using the "CLASSPAT" field.

Outpatient appointments were analysed using the "attended" field, which includes the following categories:

0 = Not applicable - appointment occurs in the future

2 = Appointment cancelled by, or on behalf of, the patient

3 = Did not attend - no advance warning given

4 = Appointment cancelled or postponed by the health care provider

5 = Seen, having attended on time or, if late, before the relevant care professional was ready to see the patient

6 = Arrived late, after the relevant care professional was ready to see the patient, but was seen

7 = Did not attend - patient arrived late and could not be seen

9 = Not known

This analysis, as with Ruiz et al's analysis of a June 2012 strike[3], focused primarily on category 4 for cancellations, and categories 5&6 to denote actual attendance of appointments.

To obtain death counts, the discharge method field ("dismeth") was used to capture deaths in hospital. The A&E attendance disposal field ("aeattenddisp") was used to determine which patients died within the A&E department. HES Outpatient data do not have the capability to record deaths during appointments, so these data were not used for this outcome.

Finally, regional analyses were performed on all outpatient, A&E and admitted patient data using provider code data ("procode").

For our analysis, it was assumed that patient counts were described by a Poisson distribution, as all values are discrete non-negative integers. A Chi-squared test was used to evaluate significance for proportions. All p values < 0.05 were considered statistically significant.

Patient Involvement

No patients were involved in setting the research question or the outcome measures; nor were they involved in the design and implementation of the study. There are no plans to involve patients in the dissemination of results.

Results

In total, this study involved the extraction and analysis of 3.4 million admissions, 27 million outpatient appointments and 3.4 million A&E attendances over 12 weeks.

Table 1 shows the impacts of the industrial action of early 2016 upon admitted patient care, outpatient appointments and A&E.

Strike	Tuesday 12th January	Wednesday 10th February	Wednesday 9th-Thursday 10th March	Tuesday 26th-Wednesday April 27th	Total
Services Withheld	Routine care only	Routine care only	Routine care only	All services (including emergency care)	
Total Admissions	53,279	54,558	107,243	99,866	314,946
Change in total admissions	-4,951 (-8.5%)*	-2,633 (-4.6%)*	-5,873 (-5.2%)*	-18,194 (-15.4%)*	-31,651 (-9.1%)
Emergency admissions	20,307	21,005	40,908	40,077	122,297
Change in emergency admissions	-1,313 (-6.1%)*	-30 (-0.1%)	-99 (-0.2%)	-3,383 (-7.8%)*	-4,825 (-3.7%)
Elective admissions	32,972	33,553	66,335	59,789	192,649
Change in elective admissions	-3,638 (-9.9%)*	-2,603 (-7.2%)*	-5,775 (-8.0%)*	-14,811(-19.9%)*	-26,827 (-12.2%)

Day case admissions	23,455	23,664	47,286	42,734	137,139
Change in day case admissions	-2,367(-9.2%)*	-1,809 (-7.1%)*	-3,863 (-7.6%)*	-9,846 (-18.7%) *	-17,885 (-11.5%)
Total outpatient Appointments	470,639	439,599	871,540	881,213	2,662,991
Change in total outpatient appointments	-14,663 (-3.0%)*	-7,702 (-1.7%)*	-41,182 (-4.5%)*	-109,915 (-11.1%)*	-173,462 (-6.0%)
Outpatient Appointments completed	352,808	333,625	658,348	651,028	1,995,809
Change in outpatient appointments completed	-29,791 (-7.8%)*	-18,305 (-5.2%)*	-59,692 (-8.3%)*	-134,711 (-17.1%)*	-242,499 (-10.6%)
Outpatient appointments cancelled by provider	49,967	45,222	90,272	109,383	294,844
Change in outpatient appointments cancelled by provider	17,641 (+54.6%)*	12,739 (+39.2%)*	26,906 (+42.5%)*	43,823 (+66.8%)*	101,109 (+52.1%)
A&E total attendances	48,827	55,842	114,292	100,569	319,530
Change in A&E total attendances	-5,219 (-9.7%)*	963 (+1.8%)*	-2314 (-2.0%)*	-17,325 (-14.7%)*	-23,895 (-6.8%)
Emergency admission deaths	616	583	1011	999	3,209
Change in emergency admission deaths	16 (+2.7%)	24 (+4.3%)	40 (+4.1%)	-40 (-3.8%)	40 (+1.3%)
Elective admission deaths	21	18	30	29	98
Change in elective admission deaths	0	1 (+5.9%)	1 (+3.4%)	-2 (-6.5%)	0
A&E deaths	73	46	127	110	356
Change in A&E deaths	10 (+15.9%)	-11 (-19.2%)	21 (+19.8%)	11 (+11.1%)	31 (9.75%)
Total deaths	710	647	1,168	1,138	3,663
Change in total deaths	26 (+3.8%)	14 (+2.2%)	62 (+5.6%)	-31 (-2.7%)	71 (2.0%)

Table 1- Results of Strike Analyses. Statistical significance at the 5% level as given by the Chi-Squared test is denoted with asterisks. Percentage change vs expected non-strike volumes are shown in brackets.

Figure 1 - Impacts of each of the four strikes on hospital activity across all strikes and types of care

Figure 1 shows the percentage change in A&E visits, admitted patients and outpatient appointments across all four strikes against the average of the chosen comparator weeks.

The largest impacts upon normal operations were seen in the April strike. This is to be expected, as it lasted 48 hours and was also the only instance where emergency care was also withheld.

During the April strike, there was a decrease in total admissions of 18,194 patients compared with the expected volume for that period, which comprised a 7.8% decrease in emergency admissions and a 19.9% decrease in elective admissions. Day cases showed a reduction of 9,846 patients, (18.7%) compared with the comparator weeks.

Furthermore, 109,915 (11.1%) fewer outpatient appointments were scheduled during the strike period than usual and 134,711 (17.1%) fewer outpatient appointments were attended during strike days. This was paired with an increase in provider cancellations of outpatient appointments of 43,823 (+66.8%). Additionally, fewer patients attended A&E during this period, with 17,325 (-14.7%) fewer attendees than expected.

The first strike which occurred (Tuesday January 12th 2016) also showed a large and significant (9.6%) decrease in A&E attendance, despite A&E services operating normally during this time. This may be due to significant media attention for this particular strike, due to its historic significance. Additionally, some providers warned patients to avoid hospitals "unless absolutely necessary"[9]. This effect diminished during the February and March strikes.

Figure 2 – Volume of provider cancellations by day during the week in which each of the four strikes occurred. Vertical grey lines on the graph represent strike days.

Cancellations

Figure 2 shows the impacts of strikes upon the numbers of appointments cancelled or postponed by health care providers. The largest impacts were seen during the January and April strikes, which showed increases of 54.5% and 66.8% compared with expected cancellations. Our analysis found that 101,109 outpatient appointments were cancelled due to strike action in 2016.

Regional analysis

Region	Change in elective admissions (%)	Change in non-elective admissions (%)	Change in outpatient appointments attended (%)	Change in outpatient cancellations (%)	Change in A&E visits (%)
North East	-9.31*	-4.69*	-6.99*	+41.89*	-7.8*
North West	-13.3*	-1.61*	-13.35*	+52.85*	-6.24*
Yorkshire/Humber	-13.59*	-4.88*	-11.86*	+65.68*	-8.05*
East Midlands	-13.6*	-2.49*	-12.62*	+44.69*	-7.55*

West Midlands	-8.37*	-5.24*	-8.39*	+45.41*	-6.53*
East of England	-9.81*	-3.76*	-9.43*	+44.89*	-5.93*
London	-17.08*	-3.61*	-13.39*	+68.2*	-6.79*
South East Coast	-14.51*	-5.21*	-10.89*	+67.1*	-6.97*
South Central	-10.15*	-2.56*	-7.31*	+22.63*	-7.74*
South West	-11.59*	-4.02*	-10.88*	+52.02*	-7.29*

Table 2 - Regional analyses of strike impacts. Statistical significance at the 5% level as given by the Chi-Squared test is denoted with asterisks

Table 2 shows the differential regional impacts of the strikes on both outpatient appointments and cancellations. This analysis shows particularly large increases in outpatient cancellations by healthcare providers in London, the south east coast and Yorkshire/the Humber. These areas also showed large decreases in the number of overall outpatient appointments attended. The East Midlands also showed a large decrease in overall appointment attendance. The south central region showed a much smaller increase in cancellations than others.

The table also shows the regional variation in admitted patient care during strike periods, separated by elective admissions (including day cases) and non-elective emergency admissions. As with outpatient appointments, the most prominently affected regions by the strikes for elective admissions were Yorkshire and the Humber, London and the East Midlands, which all showed sizable drops in recorded elective admissions. For emergency (i.e. non-elective) admissions, recorded impacts were smaller and seemed to affect different areas, such as the South West and West Midlands.

Our analysis found an average reduction in A&E patient volume of 7.09% across all strike days. The largest regional drops in volume were found in Yorkshire and the Humber (8.05%) and the North East (7.8%). Impacts were more limited in the East of England (5.93%) and the North West (6.24%).

Discussion

We found that industrial action by junior doctors in 2016 resulted in total 31,651 fewer admissions, 173,462 fewer outpatient appointments and 23,895 fewer A&E attendances compared with expected volumes from similar weeks. Large effects were seen in the numbers of cancelled outpatient appointments by healthcare providers - providers cancelled a total of 294,844 appointments, a 52% increase compared with the expected volume during these periods. The most pronounced effects on NHS operations were seen during the first (January 12th) and last (April 26th-27th) strikes. During all strike days, a total of 3209 patients died in hospital during emergency

admissions, 98 during elective admissions and 356 died in A&E. However, numbers of recorded hospital deaths did not appear to change significantly during the strikes compared with expected numbers for either admitted patients or A&E, which is in line with what has been seen in most other studies of striking doctors globally.[6] We found no measurable effect on mortality within the dates analysed, although deaths due to poor care are likely to have an associated delay. Regional analysis showed that strikes disproportionately affected London, Yorkshire and the Humber and the East Midlands for outpatient appointments and elective admissions. Emergency admissions were most affected in the South West and West Midlands regions. A&E attendance was most affected in the North East, Yorkshire and the Humber and South Central England. The January 12th strike corresponded with a 9% drop in A&E admissions, despite industrial action not affecting emergency services. This is noteworthy as it implies many patients may have consciously avoided going to hospital during this period, perhaps due to intense media coverage of the event and explicit instructions from some providers to avoid all non-urgent hospital attendances.

Our analysis is broadly consistent with similar studies of this type. Prior work by Ruiz et al[3] has shown the effects of striking doctors on outpatient cancellations by provider. This work replicates that effect – during the strike on April 26th-27th 2016, there was an increase in cancellations of 67% when compared with average figures from the surrounding weeks. As with Ruiz et al[3] and almost every previous study of this type both nationally and internationally[6], this work did not find a significant effect on mortality among either admitted or A&E patients during strike days. This could be either because there is no effect, or our study did not have enough power to demonstrate an effect, due to the small study period involved in strike days. It may be the case that during periods of industrial action, staffing priority is given to critical care, resulting in small differences in mortality but a poorer patient experience in non-vital care. This has previously been discussed by Metcalfe et al in their international comparison of the impacts of industrial action by doctors[6] .

This is a large national study which was able to analyse the majority of admissions, outpatient appointments and A&E visits during the 2016 strikes. Hospital episode statistics have previously been shown to have reasonable accuracy at both outpatient[10] and inpatient[11] levels. Furthermore, the strike on April 26th and 27th also demonstrates the first opportunity for researchers in the UK to investigate the effects of industrial action upon emergency personnel – previous strikes did not withhold emergency care. During this period, there was a drop in the number of patients attending A&E of 17,325 (almost 15%) compared with the expected volume for this time period. We found no evidence of increased mortality during the study period.

The weaknesses of this work are predominantly due to what was not investigated – for example, HES data alone do not allow the investigation of the effects of strikes upon patients who did not attend A&E during this period. Furthermore, analysis focused only on the weeks where strikes occurred, which prevented the capture of lagged effects in the immediate aftermath of a strike. The design of the study ensured that no outcomes were measured at weekends – this is a limitation, partly due to the lack of measured outcomes but additionally due to the context of the debate over the existence of a 'Weekend Effect' in mortality. Outcomes (especially mortality) proved difficult to measure. Death counts during strike days were small, and hence lacking in statistical power, and many patients stayed in hospital for more than a single day. Importantly, other outcomes such as morbidity, direct financial costs and opportunity costs for both the NHS (through rescheduling elective operations and other procedures) and patients (taking time off work, childcare costs etc) were uncaptured. This study also includes no qualitative element, which prevents us from capturing unrecorded outcomes of strikes, such as disappointment, inconvenience, stress and worry. Finally, the occurrence of a national bank holiday on the week of the 2nd of May meant that patient profiles were likely to differ between strike and comparator weeks. As such, in our analysis the second comparator week for the April strike was replaced with data from the week of May 9th-13th instead.

Conclusions

The four junior doctor's strikes between January-April 2016 resulted in significant negative impacts upon patient care as measured by hospital activity. Significant increases in outpatient appointment cancellations by hospitals were paired with decreases in admitted patients and A&E visits. The major outcome we investigated was mortality, which showed no measurable change. However, this is likely to be the least sensitive outcome for quality and safety concerns. These findings may also suggest that NHS Trusts responded effectively to the industrial action by cancelling outpatient appointments to protect higher-risk services. Future work in this area should focus on how the strikes affected waiting times and similar quality outcomes. Strike-related morbidity (such as disease progression in the time between rescheduled operations/appointments) would likely be a fertile avenue for investigation. Delays will also be likely to have an associated cost burden in terms of worse patient outcomes and hence costlier treatment, which should be accounted for. Finally, it should be determined whether quality of care was negatively impacted in the period immediately following the strikes.

Contributorship statement

Study design: Paul Aylin, Daniel Furnivall

Data collection: Daniel Furnivall, Paul Aylin, Alex Bottle

Data analysis and interpretation: Daniel Furnivall, Alex Bottle, Paul Aylin

Drafting the article: Daniel Furnivall

Critical revision of the article: Paul Aylin, Alex Bottle

Final approval of version to be published: Paul Aylin, Alex Bottle, Daniel Furnivall

Transparency Declaration

Professor Paul Aylin affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Competing Interests Declaration

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no other relationships or activities that could appear to have influenced the submitted work. PA is principal investigator for The Dr Foster Unit, an academic unit in the Department of Primary Care and Public Health, within the School of Public Health, Imperial College London. The unit receives research funding from Dr Foster Intelligence, an independent health service research organisation (a wholly owned subsidiary of Telstra).

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Ethics

The principal investigator has approval from the Secretary of State and the Health Research Authority under Regulation 5 of the Health Service (Control of Patient Information) Regulations 2002 to hold confidential data and analyse them for research purposes (CAG ref 15/CAG/0005). We have approval to use them for research and measuring quality of delivery of healthcare, from the London - South East Ethics Committee (REC ref 15/LO/0824).

Data Sharing Statement

All SAS code used in the study is available upon request from the corresponding author.

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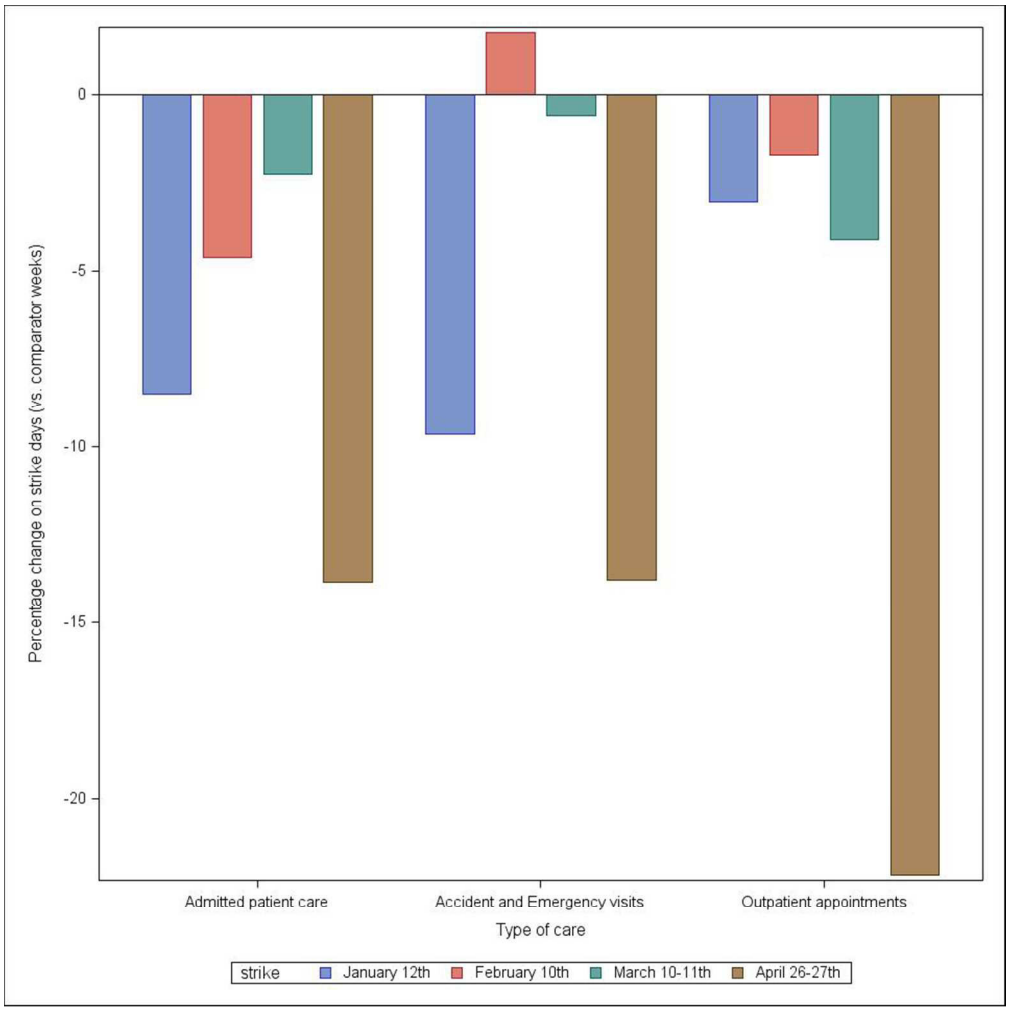

Impacts of each of the four strikes on hospital activity across all strikes and types of care

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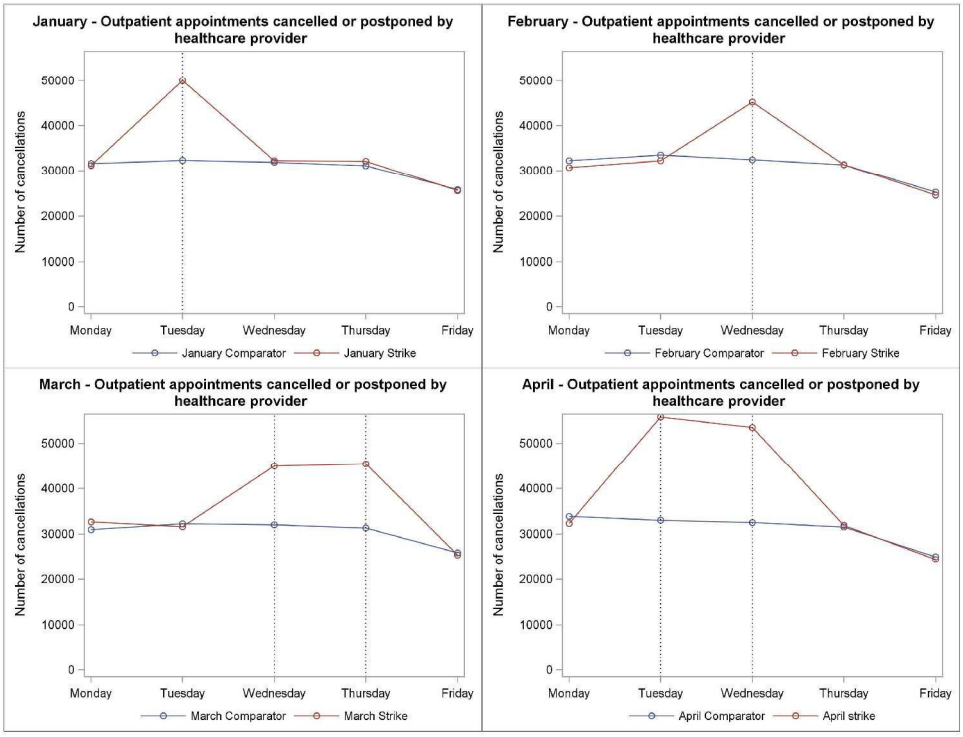

Volume of provider cancellations by day during the week in which each of the four strikes occurred. Vertical grey lines on the graph represent strike days.

279x215mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **(Page 1)**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **(Page 2)**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **(Pages 2&3)**
Objectives	3	State specific objectives, including any prespecified hypotheses **(Centre of page 3)**
Methods		
Study design	4	Present key elements of study design early in the paper **(Pages 3&4)**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **(Page 4)**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **(Pages 4&5)**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **(Page 5&6)**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **(Page 3)**
Bias	9	Describe any efforts to address potential sources of bias **(Top of page 4)**
Study size	10	Explain how the study size was arrived at **(N/A - entire population)**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **(N/A – counts only)**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **(page 4,5,6)**
		(*b*) Describe any methods used to examine subgroups and interactions **(Pages 5+10)**
		(*c*) Explain how missing data were addressed **(N/A)**
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy **(Pages 3&4)**
		(*e*) Describe any sensitivity analyses **(N/A)**

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (**Pages 5&6**)
		(b) Give reasons for non-participation at each stage (N/A)
		(c) Consider use of a flow diagram (N/A)
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (**N/A – entire population)**
		(b) Indicate number of participants with missing data for each variable of interest (**N/A)**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures **(Pages 5&6)**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (**Page 5,6,10)**
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses (**Page 10 – regional analysis)**
Discussion		
Key results	18	Summarise key results with reference to study objectives (**Page 11)**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias (**Page 12)**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence (**Page 12)**
Generalisability	21	Discuss the generalisability (external validity) of the study results (**Page 12)**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based (**Page 14)**

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Retrospective analysis of the national impact of industrial action by English junior doctors in 2016

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Retrospective analysis of the national impact of industrial action by English junior doctors in 2016.

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Abstract

Objectives: To examine the impacts of the four episodes of industrial action by English junior doctors in early 2016.

Design: Descriptive retrospective study of admitted patient care, accident and emergency (A&E) and outpatient activity in English hospitals.

Setting: All hospitals across England.

Participants: All patients who attended A&E or outpatient appointments, or those who were admitted to hospital during the three week period surrounding each of the four strikes (January 12th, February 10th, March 9th-10th and April 26th-27th, excluding weekends.)

Main outcome measures: Raw numbers and percentage changes of outpatient appointments and cancellations, A&E visits, admitted patients and all in-hospital mortality on strike days compared with patient activity on the same weekday in the weeks before and after the strikes.

Results: There were 3.4 million admissions, 27 million outpatient appointments and 3.4 million A&E attendances over the four 3-week periods analysed. Across the four strike days, there were 31,651 fewer admissions (-9.1%), 23,895 fewer A&E attendances (-6.8%) and 173,462 fewer outpatient appointments (-6.0%) than expected. Additionally, 101,109 more outpatient appointments were cancelled by hospitals than expected (+52%). The April 26th-27th strike, where emergency services were also affected, showed the largest impacts on regular service. Mortality did not measurably increase on strike days. Regional analysis showed that services in the Yorkshire and the Humber region were disproportionately more affected by the industrial action.

Conclusions: Industrial action by junior doctors during early 2016 caused a significant impact on the provision of healthcare provided by English hospitals. We also observed regional variations in how these strikes affected providers.

Strengths and limitations of this study

- **Strength**: This is the first UK study which looked at the effects of striking junior doctors, as well as the first to evaluate the impact of withheld in-hospital emergency services (the April 2016 strike was the first ever UK strike to include emergency care)
- **Strength**: This was a large analysis of English hospital administrative data from the 2016 strikes show a significant impact on outpatient appointments, admitted patient care and A&E visits.
- **Limitation:** This work did not include any financial modelling of the impact of industrial action on either the national or the regional level.
- **Limitation:** The study was unable to examine the health impacts on patients who could not attend hospitals due to industrial action. Additionally, qualitative outcomes such as disappointment and inconvenience were not collected.

Introduction

In each of the first four months of 2016, junior doctors from all specialties in England engaged in industrial action with a series of 24-48 hour strikes, culminating in a two day strike which included the withdrawal of emergency services[1]. The purpose of the action was to protest new contractual changes for all junior doctors brought by the Department of Health (DH) regarding safe working hours and pay[2]. Doctor's strikes in the UK are very rare – before the 2016 strikes, there had been only one, much smaller strike in the previous 40 years (in 2012)[3,4].

Breaks from routine care patterns offer an important window into the effectiveness of currently established treatment services. During annual meetings of the American Heart Association and the American College of Cardiology, there are significant drops in 30-day mortality among high-risk patients admitted with heart attacks or cardiac failure[5]. Therefore, the 2016 strikes provide an ideal opportunity to evaluate the effectiveness of current systems and locate weaknesses in national responses to staffing shortages.

Metcalfe et al[6] studied strikes among doctors in the USA, Israel, Spain, Croatia, South Africa, India and the UK. Almost all of the strikes they looked at showed little to no effect on patient mortality. In fact, only one (a 20 day long strike of all doctors in a single province in South Africa in 2010) reported increased mortality rates – patients who presented in emergency departments were 67% more likely to die than during a normal period[6]. Ruiz et al[3] analysed the 24-hour strike on 21st June 2012 in England, where approximately 8% of doctors in England took part.[7] For their analysis, they used Hospital Episode Statistics (HES), the national hospital administrative database for England's NHS, and compared the week of the strike with the week immediately following and preceding it. Their analysis found an increase in outpatient appointment cancellations, but no significant differences in mortality between strike and non-strike periods.

This current work aimed to examine the impact of the junior doctors' strikes in early 2016 using, Health Episode Statistics (HES), which contains data on NHS activity. This dataset allowed us to investigate trends in the number of admissions (inpatients), outpatient appointments cancellations, Accident and Emergency (A&E) attendances and in-hospital deaths during strike periods and to compare these with the expected numbers based on an average non-strike period.

Methods

Hospital episode statistics include details of all admissions to NHS Hospitals in England and are collected by the Department of Health. HES data covering all recorded episodes of admitted patient

care, outpatient appointments and A&E attendances were extracted for the week of each strike. Strike action by English junior doctors took place on four occasions throughout early 2016 – January 12th, February 10th, March 9th-10th and April 26th-27th. For comparison with normal operations, we also extracted all data from the weeks immediately preceding and following each strike. For simplicity, weekends were excluded from our analysis.

Due to the impact upon normal hospital operations and attendance due to the bank holiday on the week of the 2nd of May, the second comparator week was replaced with the week of May 9th-13th for the April strike.

Each hospital admission is recorded as a "spell" consisting of a number of "consultant episodes," which denotes period of care under different consultants during their hospital admission[8]. If the patient admission includes transfer to other hospitals before they are discharged, the whole period of care is recorded as a "superspell." For our analysis of admitted patient care, only the first "episode" in a superspell of care was used to identify the date of initial admission, so as to avoid multiple counting.

The data from the comparator weeks were averaged into what was assumed to be a "normal" week. This allowed for comparison with the strike data to provide an indication of the impacts of individual strikes.

Daily totals for A&E attendances, outpatient appointments and hospital admissions were calculated. Admitted patients were separated into elective and emergency categories using the "admimeth" method of admission field in HES. Day surgery cases were extracted using the "CLASSPAT" field.

Outpatient appointments were analysed using the "attended" field, which includes the following categories:

0 = Not applicable - appointment occurs in the future

2 = Appointment cancelled by, or on behalf of, the patient

3 = Did not attend - no advance warning given

4 = Appointment cancelled or postponed by the health care provider

5 = Seen, having attended on time or, if late, before the relevant care professional was ready to see the patient

6 = Arrived late, after the relevant care professional was ready to see the patient, but was seen

7 = Did not attend - patient arrived late and could not be seen

9 = Not known

This analysis, as with Ruiz et al's analysis of a June 2012 strike[3], focused primarily on category 4 for cancellations, and categories 5&6 to denote actual attendance of appointments.

To obtain death counts, the discharge method field ("dismeth") was used to capture deaths in hospital. The A&E attendance disposal field ("aeattenddisp") was used to determine which patients died within the A&E department. HES Outpatient data do not have the capability to record deaths during appointments, so these data were not used for this outcome.

Finally, regional analyses were performed on all outpatient, A&E and admitted patient data using provider code data ("procode").

For our analysis, it was assumed that patient counts were described by a Poisson distribution, as all values are discrete non-negative integers. A Chi-squared test was used to evaluate significance for proportions. All p values < 0.05 were considered statistically significant.

Patient Involvement

No patients were involved in setting the research question or the outcome measures; nor were they involved in the design and implementation of the study. There are no plans to involve patients in the dissemination of results.

Results

In total, this study involved the extraction and analysis of 3.4 million admissions, 27 million outpatient appointments and 3.4 million A&E attendances over 12 weeks.

Table 1 shows the impacts of the industrial action of early 2016 upon admitted patient care, outpatient appointments and A&E.

Strike	Tuesday 12th January	Wednesday 10th February	Wednesday 9th-Thursday 10th March	Tuesday 26th-Wednesday April 27th	Total
Services Withheld	Routine care only	Routine care only	Routine care only	All services (including emergency care)	
Total Admissions	53,279	54,558	107,243	99,866	314,946
Change in total admissions	-4,951 (-8.5%)*	-2,633 (-4.6%)*	-5,873 (-5.2%)*	-18,194 (-15.4%)*	-31,651 (-9.1%)
Emergency admissions	20,307	21,005	40,908	40,077	122,297
Change in emergency admissions	-1,313 (-6.1%)*	-30 (-0.1%)	-99 (-0.2%)	-3,383 (-7.8%)*	-4,825 (-3.7%)
Elective admissions	32,972	33,553	66,335	59,789	192,649
Change in elective admissions	-3,638 (-9.9%)*	-2,603 (-7.2%)*	-5,775 (-8.0%)*	-14,811(-19.9%)*	-26,827 (-12.2%)

Day case admissions	23,455	23,664	47,286	42,734	137,139
Change in day case admissions	-2,367(-9.2%)*	-1,809 (-7.1%)*	-3,863 (-7.6%)*	-9,846 (-18.7%) *	-17,885 (-11.5%)
Total outpatient Appointments	470,639	439,599	871,540	881,213	2,662,991
Change in total outpatient appointments	-14,663 (-3.0%)*	-7,702 (-1.7%)*	-41,182 (-4.5%)*	-109,915 (-11.1%)*	-173,462 (-6.0%)
Outpatient Appointments completed	352,808	333,625	658,348	651,028	1,995,809
Change in outpatient appointments completed	-29,791 (-7.8%)*	-18,305 (-5.2%)*	-59,692 (-8.3%)*	-134,711 (-17.1%)*	-242,499 (-10.6%)
Outpatient appointments cancelled by provider	49,967	45,222	90,272	109,383	294,844
Change in outpatient appointments cancelled by provider	17,641 (+54.6%)*	12,739 (+39.2%)*	26,906 (+42.5%)*	43,823 (+66.8%)*	101,109 (+52.1%)
A&E total attendances	48,827	55,842	114,292	100,569	319,530
Change in A&E total attendances	-5,219 (-9.7%)*	963 (+1.8%)*	-2314 (-2.0%)*	-17,325 (-14.7%)*	-23,895 (-6.8%)
Emergency admission deaths	616	583	1011	999	3,209
Change in emergency admission deaths	16 (+2.7%)	24 (+4.3%)	40 (+4.1%)	-40 (-3.8%)	40 (+1.3%)
Elective admission deaths	21	18	30	29	98
Change in elective admission deaths	0	1 (+5.9%)	1 (+3.4%)	-2 (-6.5%)	0
A&E deaths	73	46	127	110	356
Change in A&E deaths	10 (+15.9%)	-11 (-19.2%)	21 (+19.8%)	11 (+11.1%)	31 (9.75%)
Total deaths	710	647	1,168	1,138	3,663
Change in total deaths	26 (+3.8%)	14 (+2.2%)	62 (+5.6%)	-31 (-2.7%)	71 (2.0%)

Table 1- Results of Strike Analyses. Statistical significance at the 5% level as given by the Chi-Squared test is denoted with asterisks. Percentage change vs expected non-strike volumes are shown in brackets.

<Figure 1>

Figure 1 - Impacts of each of the four strikes on hospital activity across all strikes and types of care

Figure 1 shows the percentage change in A&E visits, admitted patients and outpatient appointments across all four strikes against the average of the chosen comparator weeks.

The largest impacts upon normal operations were seen in the April strike. This is to be expected, as it lasted 48 hours and was also the only instance where emergency care was also withheld.

During the April strike, there was a decrease in total admissions of 18,194 patients compared with the expected volume for that period, which comprised a 7.8% decrease in emergency admissions and a 19.9% decrease in elective admissions. Day cases showed a reduction of 9,846 patients, (18.7%) compared with the comparator weeks.

Furthermore, 109,915 (11.1%) fewer outpatient appointments were scheduled during the strike period than usual and 134,711 (17.1%) fewer outpatient appointments were attended during strike days. This was paired with an increase in provider cancellations of outpatient appointments of 43,823 (+66.8%). Additionally, fewer patients attended A&E during this period, with 17,325 (-14.7%) fewer attendees than expected.

The first strike which occurred (Tuesday January 12th 2016) also showed a large and significant (9.6%) decrease in A&E attendance, despite A&E services operating normally during this time. This may be due to significant media attention for this particular strike, due to its historic significance. Additionally, some providers warned patients to avoid hospitals "unless absolutely necessary"[9]. This effect diminished during the February and March strikes.

<Figure 2>

Figure 2 – Volume of provider cancellations by day during the week in which each of the four strikes occurred. Vertical grey lines on the graph represent strike days.

Cancellations

Figure 2 shows the impacts of strikes upon the numbers of appointments cancelled or postponed by health care providers. The largest impacts were seen during the January and April strikes, which showed increases of 54.5% and 66.8% compared with expected cancellations. Our analysis found that 101,109 outpatient appointments were cancelled due to strike action in 2016.

Regional analysis

Region	Change in elective admissions (%)	Change in non-elective admissions (%)	Change in outpatient appointments attended (%)	Change in outpatient cancellations (%)	Change in A&E visits (%)
North East	-9.31*	-4.69*	-6.99*	+41.89*	-7.8*
North West	-13.3*	-1.61*	-13.35*	+52.85*	-6.24*
Yorkshire/Humber	-13.59*	-4.88*	-11.86*	+65.68*	-8.05*
East Midlands	-13.6*	-2.49*	-12.62*	+44.69*	-7.55*

West Midlands	-8.37*	-5.24*	-8.39*	+45.41*	-6.53*
East of England	-9.81*	-3.76*	-9.43*	+44.89*	-5.93*
London	-17.08*	-3.61*	-13.39*	+68.2*	-6.79*
South East Coast	-14.51*	-5.21*	-10.89*	+67.1*	-6.97*
South Central	-10.15*	-2.56*	-7.31*	+22.63*	-7.74*
South West	-11.59*	-4.02*	-10.88*	+52.02*	-7.29*

Table 2 - Regional analyses of strike impacts. Statistical significance at the 5% level as given by the Chi-Squared test is denoted with asterisks

Table 2 shows the differential regional impacts of the strikes on both outpatient appointments and cancellations. This analysis shows particularly large increases in outpatient cancellations by healthcare providers in London, the south east coast and Yorkshire/the Humber. These areas also showed large decreases in the number of overall outpatient appointments attended. The East Midlands also showed a large decrease in overall appointment attendance. The south central region showed a much smaller increase in cancellations than others.

The table also shows the regional variation in admitted patient care during strike periods, separated by elective admissions (including day cases) and non-elective emergency admissions. As with outpatient appointments, the most prominently affected regions by the strikes for elective admissions were Yorkshire and the Humber, London and the East Midlands, which all showed sizable drops in recorded elective admissions. For emergency (i.e. non-elective) admissions, recorded impacts were smaller and seemed to affect different areas, such as the South West and West Midlands.

Our analysis found an average reduction in A&E patient volume of 7.09% across all strike days. The largest regional drops in volume were found in Yorkshire and the Humber (8.05%) and the North East (7.8%). Impacts were more limited in the East of England (5.93%) and the North West (6.24%).

Discussion

We found that industrial action by junior doctors in 2016 resulted in total 31,651 fewer admissions, 173,462 fewer outpatient appointments and 23,895 fewer A&E attendances compared with expected volumes from similar weeks. Large effects were seen in the numbers of cancelled outpatient appointments by healthcare providers - providers cancelled a total of 294,844 appointments, a 52% increase compared with the expected volume during these periods. The most pronounced effects on NHS operations were seen during the first (January 12th) and last (April 26th-27th) strikes. During all strike days, a total of 3209 patients died in hospital during emergency

admissions, 98 during elective admissions and 356 died in A&E. However, numbers of recorded hospital deaths did not appear to change significantly during the strikes compared with expected numbers for either admitted patients or A&E, which is in line with what has been seen in most other studies of striking doctors globally.[6] We found no measurable effect on mortality within the dates analysed, although deaths due to poor care are likely to have an associated delay. Regional analysis showed that strikes disproportionately affected London, Yorkshire and the Humber and the East Midlands for outpatient appointments and elective admissions. Emergency admissions were most affected in the South West and West Midlands regions. A&E attendance was most affected in the North East, Yorkshire and the Humber and South Central England. The January 12th strike corresponded with a 9% drop in A&E admissions, despite industrial action not affecting emergency services. This is noteworthy as it implies many patients may have consciously avoided going to hospital during this period, perhaps due to intense media coverage of the event and explicit instructions from some providers to avoid all non-urgent hospital attendances.

Our analysis is broadly consistent with similar studies of this type. Prior work by Ruiz et al[3] has shown the effects of striking doctors on outpatient cancellations by provider. This work replicates that effect – during the strike on April 26th-27th 2016, there was an increase in cancellations of 67% when compared with average figures from the surrounding weeks. As with Ruiz et al[3] and almost every previous study of this type both nationally and internationally[6], this work did not find a significant effect on mortality among either admitted or A&E patients during strike days. This could be either because there is no effect, or our study did not have enough power to demonstrate an effect, due to the small study period involved in strike days. It may be the case that during periods of industrial action, staffing priority is given to critical care, resulting in small differences in mortality but a poorer patient experience in non-vital care. This has previously been discussed by Metcalfe et al in their international comparison of the impacts of industrial action by doctors[6] .

This is a large national study which was able to analyse the majority of admissions, outpatient appointments and A&E visits during the 2016 strikes. Hospital episode statistics have previously been shown to have reasonable accuracy at both outpatient[10] and inpatient[11] levels. Furthermore, the strike on April 26th and 27th also demonstrates the first opportunity for researchers in the UK to investigate the effects of industrial action upon emergency personnel – previous strikes did not withhold emergency care. During this period, there was a drop in the number of patients attending A&E of 17,325 (almost 15%) compared with the expected volume for this time period. We found no evidence of increased mortality during the study period.

The weaknesses of this work are predominantly due to what was not investigated – for example, HES data alone do not allow the investigation of the effects of strikes upon patients who did not attend A&E during this period. Furthermore, analysis focused only on the weeks where strikes occurred, which prevented the capture of lagged effects in the immediate aftermath of a strike. The design of the study ensured that no outcomes were measured at weekends – this is a limitation, partly due to the lack of measured outcomes but additionally due to the context of the debate over the existence of a 'Weekend Effect' in mortality. Outcomes (especially mortality) proved difficult to measure. Death counts during strike days were small, and hence lacking in statistical power, and many patients stayed in hospital for more than a single day. Importantly, other outcomes such as morbidity, direct financial costs and opportunity costs for both the NHS (through rescheduling elective operations and other procedures) and patients (taking time off work, childcare costs etc) were uncaptured. This study also includes no qualitative element, which prevents us from capturing unrecorded outcomes of strikes, such as disappointment, inconvenience, stress and worry. Finally, the occurrence of a national bank holiday on the week of the 2nd of May meant that patient profiles were likely to differ between strike and comparator weeks. As such, in our analysis the second comparator week for the April strike was replaced with data from the week of May 9th-13th instead.

Conclusions

The four junior doctor's strikes between January-April 2016 resulted in significant negative impacts upon patient care as measured by hospital activity. Significant increases in outpatient appointment cancellations by hospitals were paired with decreases in admitted patients and A&E visits. The major outcome we investigated was mortality, which showed no measurable change. However, this is likely to be the least sensitive outcome for quality and safety concerns. These findings may also suggest that NHS Trusts responded effectively to the industrial action by cancelling outpatient appointments to protect higher-risk services. Future work in this area should focus on how the strikes affected waiting times and similar quality outcomes. Strike-related morbidity (such as disease progression in the time between rescheduled operations/appointments) would likely be a fertile avenue for investigation. Delays will also be likely to have an associated cost burden in terms of worse patient outcomes and hence costlier treatment, which should be accounted for. Finally, it should be determined whether quality of care was negatively impacted in the period immediately following the strikes.

Contributorship statement

Study design: Paul Aylin, Daniel Furnivall

Data collection: Daniel Furnivall, Paul Aylin, Alex Bottle

Data analysis and interpretation: Daniel Furnivall, Alex Bottle, Paul Aylin

Drafting the article: Daniel Furnivall

Critical revision of the article: Paul Aylin, Alex Bottle

Final approval of version to be published: Paul Aylin, Alex Bottle, Daniel Furnivall

Transparency Declaration

Professor Paul Aylin affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Competing Interests Declaration

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no other relationships or activities that could appear to have influenced the submitted work. PA is principal investigator for The Dr Foster Unit, an academic unit in the Department of Primary Care and Public Health, within the School of Public Health, Imperial College London. The unit receives research funding from Dr Foster Intelligence, an independent health service research organisation (a wholly owned subsidiary of Telstra).

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research organisation (a wholly owned subsidiary of Telstra). The Dr Foster Unit at Imperial is affiliated with the National Institute of Health Research (NIHR) Imperial Patient Safety Translational Research Centre. The NIHR Imperial Patient Safety Translational Centre is a partnership between the Imperial College Healthcare NHS Trust and Imperial College London. The Department of Primary Care & Public Health at Imperial College London is grateful for support from the NW London NIHR Collaboration for Leadership in Applied Health Research & Care (CLAHRC) and the Imperial NIHR Biomedical Research Centre.

Ethics

The principal investigator has approval from the Secretary of State and the Health Research Authority under Regulation 5 of the Health Service (Control of Patient Information) Regulations 2002 to hold confidential data and analyse them for research purposes (CAG ref 15/CAG/0005). We have approval to use them for research and measuring quality of delivery of healthcare, from the London - South East Ethics Committee (REC ref 15/LO/0824).

Data Sharing Statement

All SAS code used in the study is available upon request from the corresponding author.

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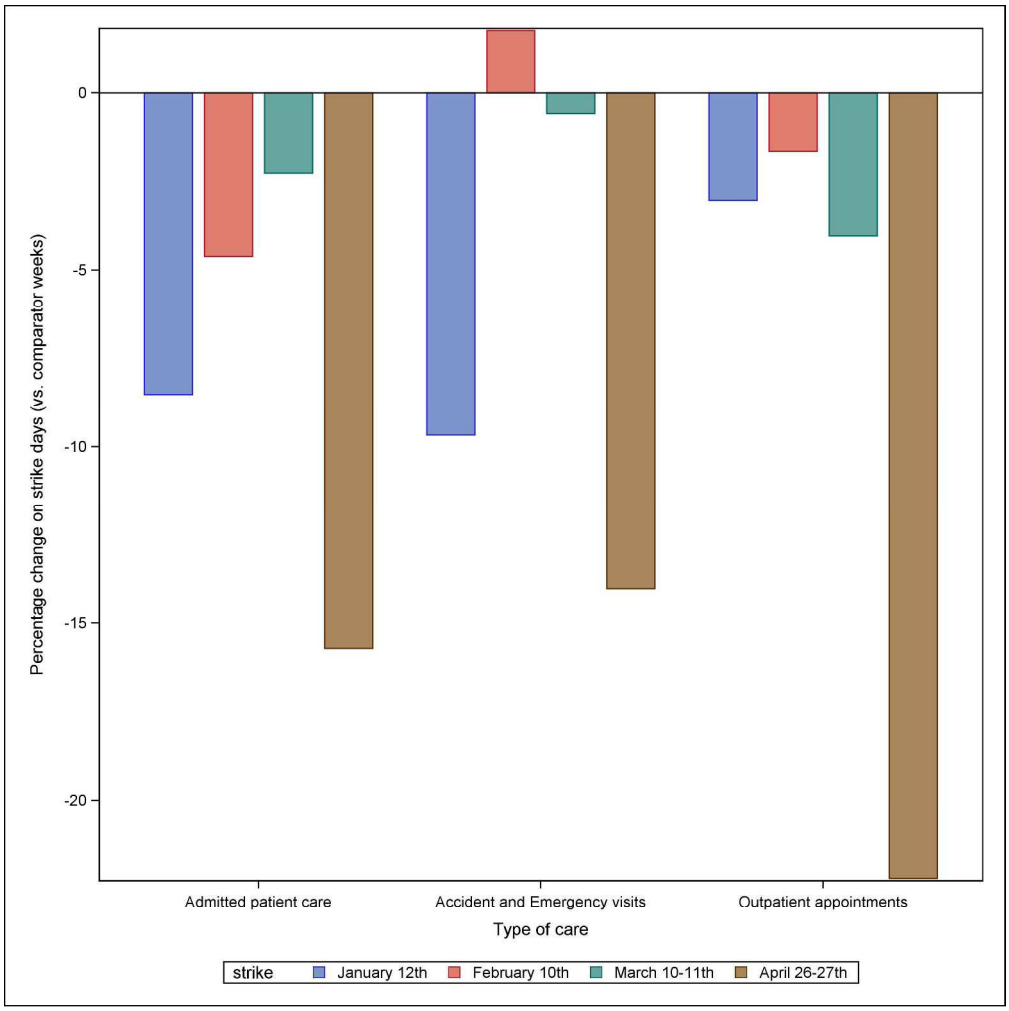
Figure Legend

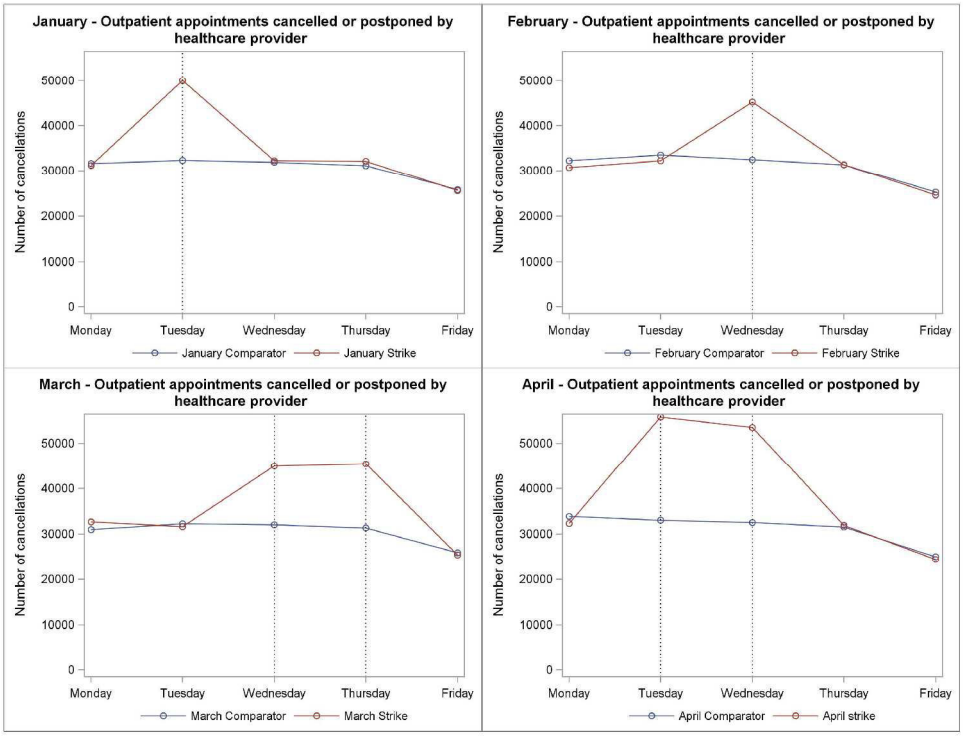
Figure 1: Impacts of each of the four strikes on hospital activity across all strikes and types of care

Figure 2: Volume of provider cancellations by day during the week in which each of the four strikes occurred. Vertical grey lines on the graph represent strike days.



Impacts of each of the four strikes on hospital activity across all strikes and types of care

254x254mm (300 x 300 DPI)



Volume of provider cancellations by day during the week in which each of the four strikes occurred. Vertical grey lines on the graph represent strike days.

279x215mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **(Page 1)**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **(Page 2)**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **(Pages 2&3)**
Objectives	3	State specific objectives, including any prespecified hypotheses **(Centre of page 3)**
Methods		
Study design	4	Present key elements of study design early in the paper **(Pages 3&4)**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **(Page 4)**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **(Pages 4&5)**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **(Page 5&6)**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **(Page 3)**
Bias	9	Describe any efforts to address potential sources of bias **(Top of page 4)**
Study size	10	Explain how the study size was arrived at **(N/A - entire population)**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **(N/A – counts only)**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **(page 4,5,6)**
		(*b*) Describe any methods used to examine subgroups and interactions **(Pages 5+10)**
		(*c*) Explain how missing data were addressed **(N/A)**
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy **(Pages 3&4)**
		(*e*) Describe any sensitivity analyses **(N/A)**

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Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (**Pages 5&6**)
		(b) Give reasons for non-participation at each stage (N/A)
		(c) Consider use of a flow diagram (N/A)
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (**N/A – entire population)**
		(b) Indicate number of participants with missing data for each variable of interest (**N/A)**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures **(Pages 5&6)**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (**Page 5,6,10)**
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses (**Page 10 – regional analysis)**
Discussion		
Key results	18	Summarise key results with reference to study objectives (**Page 11)**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias (**Page 12)**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence (**Page 12)**
Generalisability	21	Discuss the generalisability (external validity) of the study results (**Page 12)**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based (**Page 14)**

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.