

How is deprivation in different regions of England related to Accident and Emergency admissions in August 2019?

Maria-Helena Stewart, 2nd Year Medical Student, Lancaster University

INTRODUCTION

The NHS and A&E

Founded in 1948, the NHS is a free-of-charge healthcare service in the United Kingdom (UK). Within the various departments of the NHS, one of the most important is A&E (accident and emergency services).^{1,2} A&E cares for individuals who have life-threatening illnesses or accidents but is open to other urgent aspects such as emergency prescriptions. Non-urgent care can be handled by 111 services, walk-in and minor injury units, or GP appointments. Since 2011, A&E services have been under increasing strain in the majority of England's regions, which is further perpetuated by the small number of beds to offer these new patients;³ this prompts issues such as long waiting times. To ensure the quality of the services provided, the NHS uses a 10-step action plan, which includes certain criteria such as supporting 999 calls and urgent treatment centres.⁴

A&E is open around the clock every day of the year. After arrival and registration, a triage takes place which is a questionnaire to find out the reason and seriousness of the nature of the visit.⁵ A&E admissions can be sorted into different patterns, especially in terms of the patient (age, gender, socioeconomic status) and differences within the year, month, and weekday. As aforementioned, the increasing pressure on A&E services makes it ever more important to examine these patterns so that ideas on how to decrease A&E admissions can be investigated. It had been revealed that, while the number of A&E admissions has risen on average by 3.2% year on year this past decade, the number of beds has only increased by 0.3% on average during the same period.⁶

Deprivation

Townsend (1987) defines deprivation as: "a state of observable and demonstrable disadvantage relative to the local community or the wider society or nation to which an individual, family or group belongs".⁷ It is important to look at deprivation in England as it has been linked to larger A&E admissions.⁸ One of the primary reasons is that being deprived is associated with poorer living conditions.⁹ This is seen with the increased consumption of cheap 'junk food', which predisposes individuals to more comorbidities (e.g, type 2 diabetes, hypertension and coronary heart disease).¹⁰ Higher deprivation is also linked to short-termism, where individuals favour short-term fixes, such as smoking and drinking which are detrimental to health, in order to stop thinking about long terms issues such as financial instability.¹¹ Individuals in more deprived areas are also seen to have worse working conditions which may cause poorer health.¹²

Furthermore, individuals that live in more deprived areas are more likely to access A&E services due to the connotations that hospitals are less expensive than GPs.¹³ Hospitals are also perceived as more accessible and have a higher quality of care due to extra social or emotional support. In GPs, the tight management of time may subtract from the total amount of

emotional care that some individuals in more deprived areas may need.¹³

Alternative explanations relate deprivation and admissions to the number of GPs. The inverse care law states that health care is market driven and follows more affluent areas, suggesting that more deprived areas have access to fewer GPs. This further implies that deprived individuals choose not to go to the GP and wait until symptoms worsen to visit hospitals, resulting in more pressure on A&Es.¹⁴

A measure of deprivation is the Index of Multiple Deprivation (IMD) which encompasses seven domains with different weightings as suggested by the Ministry of Housing, Communities & Local Government.

Domain	Weighting
Income	22.5%
Employment	22.5%
Health Deprivation and Disability	13.5%
Education, Skills Training	13.5%
Crime	9.3%
Barriers to Housing and Services	9.3%
Living Environment	9.3%

Data is gathered from English residents into postcodes (also called a Lower-layer Super Output Area (LSOA)), which are then ranked from 1 (the most deprived) to 32,844 (least deprived). Deprivation of different neighbourhoods is only comparative as it's a relative measure.¹⁵

Aim

This paper aims to look at what impact deprivation has on A&E admissions in England and how the number of GPs may aid in the understanding of this relationship. This forms the three questions:

1. What is the relationship between the IMD index and monthly A&E admissions in 2019?
2. What is the relationship between the IMD index and A&E admissions within the different regions in England?
3. What is the relationship between the number of GPs in each region with both the IMD index and monthly A&E admissions?

Data from NHS England and Gov.UK will be analysed in the form of regressions and mixed-effect regression models which will then be compared to literature reviews and studies.

Method

To gather data NHS England^{16, 17} and Gov.UK¹⁸ databases were used (see Appendix A). After choosing the databases a time-period was defined. 2019 was chosen due to being the last pre-Covid year, which is useful as patterns between

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deprivation and A&E admissions may not be as apparent within the time Covid-19 was present. R-Software was used throughout the method.

The results are structured as such:

Descriptive statistics

1-What is the relationship between IMD index and A&E admissions in 2019?

- A regression was formed between the IMD index (independent variable) and A&E admissions (dependent). Forming the hypothesis that higher A&E admissions in each region are associated with a lower IMD index. The corresponding null hypothesis:

$$H_0: \beta_1 = 0 \text{ vs. } H_1: \beta_1 \neq 0$$

- Data for the IMD index had to be edited such that the same number of data values exist for each hospital. For each hospital, its district was found, and the corresponding postcodes were averaged
- A&E admissions were an average of five months (April to August) as this was the only data available. A&E admissions were standardised against the population of its associated region for fairer comparison.¹⁹ The value acts as a fraction of the overall population and was multiplied by 1000 to make it easier to interpret
- Residuals are the difference between the observed value and the predicted value from the model.²⁰ An equal distribution of both positive (data points above the regression line) and negative residuals means the data satisfies the assumption of the model (as the sum of the positive and negative would be close to 0)
- P-values measure the probability of the data occurring under the null hypothesis. A p-value less than 0.05 (corresponding to a confidence interval of 95%) would indicate a statistically significant relationship between the two variables
- The coefficient of determination R^2 reveals the variation in the dependent variable explained by the model. Values range from 0 to 1

2-What is the relationship between IMD index and A&E admissions within the different regions?

- A mixed-effect regression model with each region was made
- The ANOVA (Analysis of variance) was used to find the difference between the two models. The ANOVA is helpful in testing multiple variables whereas other statistical tests do not do this^{21,22}
- The Akaike information criterion (AIC) was found to find out if the general model or the mixed models of the independent regions were better at estimating future values. The model with the lowest AIC is the most appropriate model

3-What is the relationship between the number of GPs in each region with both the IMD index and monthly A&E admissions?

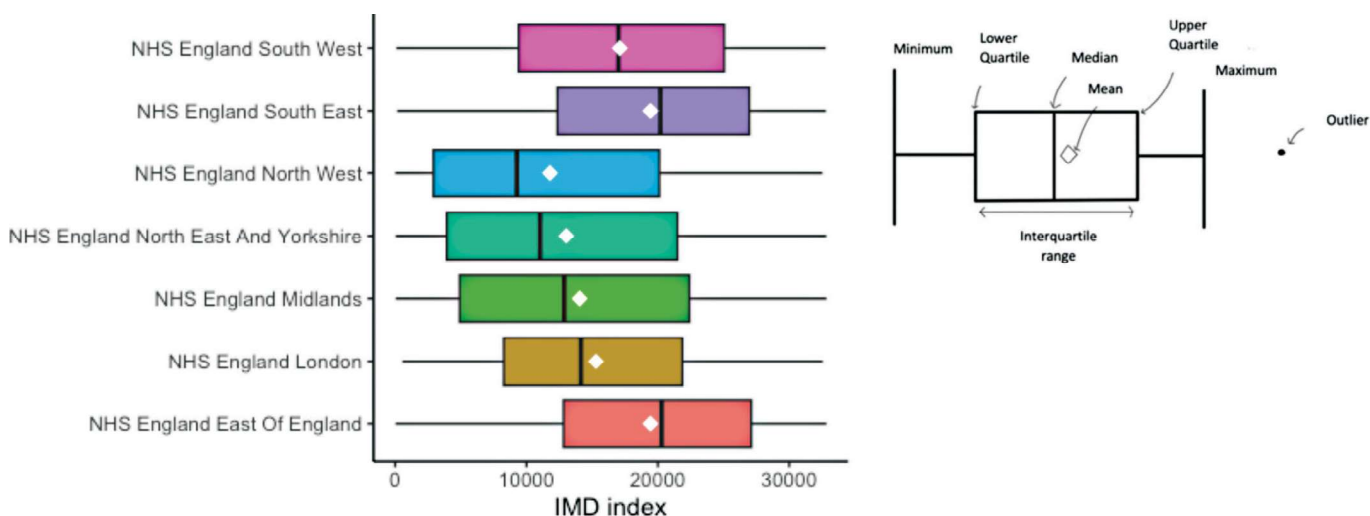
- A scatterplot was created with averages of each region for both variables for easy comparison.

RESULTS

Descriptive statistics

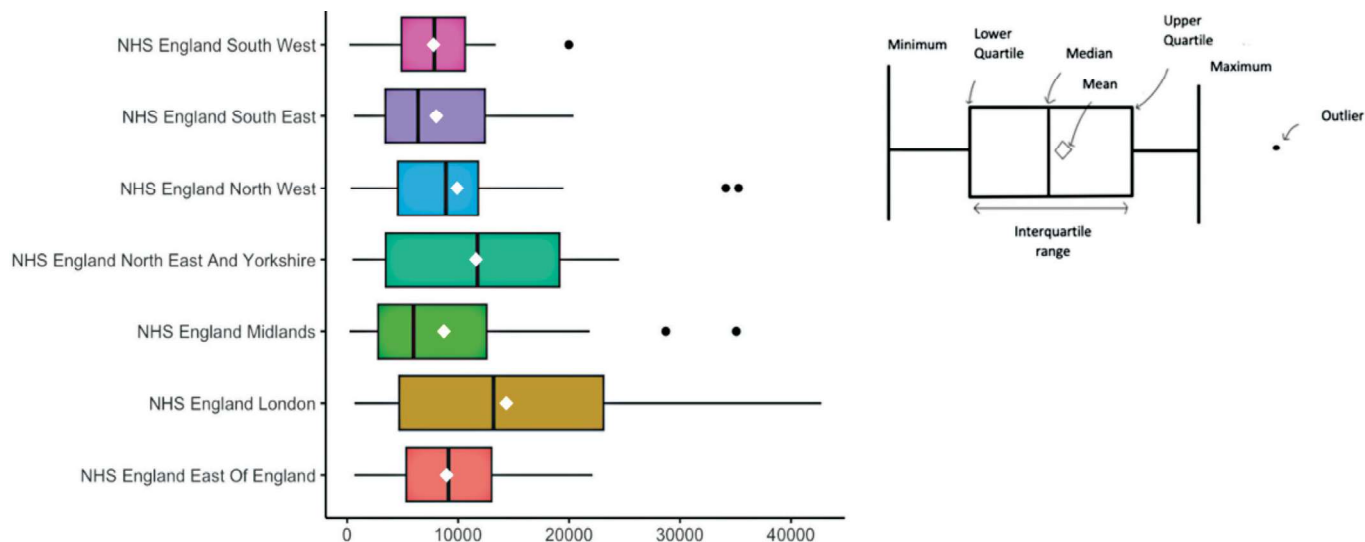
In Graph 1, South East had the highest mean IMD index which indicates it to be the least deprived on average. The North West had the lowest and thus the most deprived. In addition, many boxes had a larger distance between their mean and upper quartile range showing many regions had more less deprived areas in comparison to their average.

In Graph 2 London had the highest mean A&E admissions, whereas other regions had similar but lower mean A&E admissions. London had the largest range of A&E admissions (signifying a larger standard deviation) and South West the smallest. The mean of all A&E admissions was seen to be larger than the median showing a positive skew of the data with exception of North East and Yorkshire and East which had a similar value for both. The large standard deviation in Table 1 reveals that few values are close to the mean.



Graph 1: Box and whisker diagram for IMD index in each Region of England in 2019.

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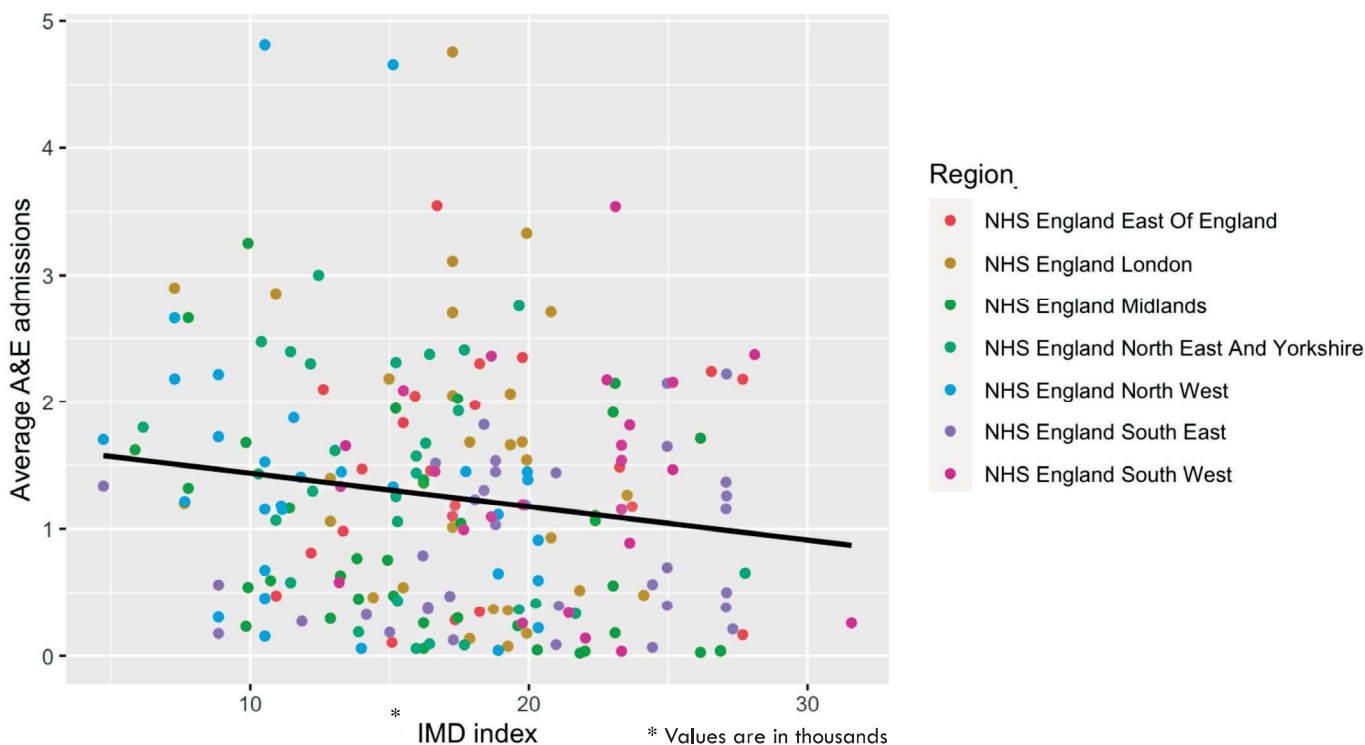
Graph 2: Monthly A&E admissions per month in each Region of England in 2019.

Term	Mean	Median	Std. dev.
Averages A&E Admissions	9727	8557	7776

Table 1: Overall descriptive statistics for the dependent variable.

Coefficient	Estimate	(P)	Std.Error	R ² =
Y-intercept	1.70	<0.001	0.2147	0.02347
IMD index	-0.0262	0.0275	0.0118	

Table 2: Model statistics.



Graph 3: Regression model showing IMD index against monthly A&E admissions within 2019 per region in England.

Investigation- 1

Graph 3 reveals a linear regression with a model of $1.70 - 0.0262x$. This reveals that an increase of one thousand IMD indexes causes a decrease in 0.0262 admissions. The p-value for the gradient is less than 0.05 and thus A&E admissions for each IMD index are statistically significantly different from zero, rejecting the null hypothesis. This p-value means that we can be 97.25% (100- (2.75 from Table 2)) sure that the true value for the gradient, if this investigation was replicated multiple times, would lie in the confidence interval between -0.038 and -0.014 as the standard error is 0.0118. The y-intercept implies that there is an initial A&E admission of 1.70 for an IMD index of 0, the p-value also reveals the intercept is statistically different from zero. Combining all this information, it is seen the model is statistically significant showing that this trend happening randomly would be negligible. The R^2 reveals that 2.3% of the variability of admissions is explained by the model.

The similar distribution of residuals that are positive and negative provides a total sum close to 0. This gives evidence that the data satisfies the assumption of the model.

Investigation- 2

The mixed regression model was used to view the variation between each region. Many have a negative trend showing that lower IMD indexes in each region are related to high A&E admissions. Only three are seen to have a positive trend.

The ANOVA of the two models was found below.

Model-1: A&E admissions~IMD index (general relationship between deprivation and A&E admissions)

Model-2: A&E admissions~IMD index + Region (general relationship including the difference in independent regions)

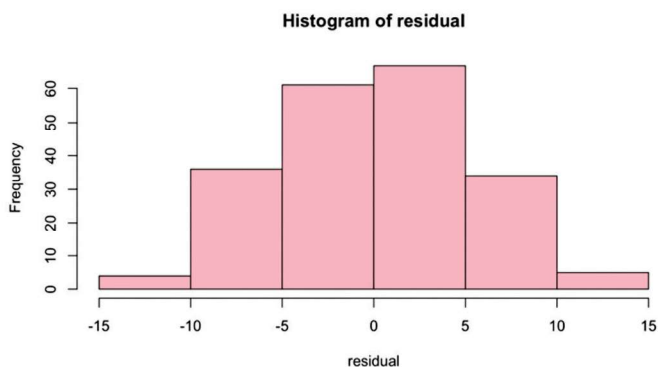
This formed a P-value of 0.01602 which is statistically significant, and therefore means there's a difference between models.

The AIC for *Model-2* is 562 and for *Model-1* is 564. *Model-2* which has the lowest value is the more appropriate model.

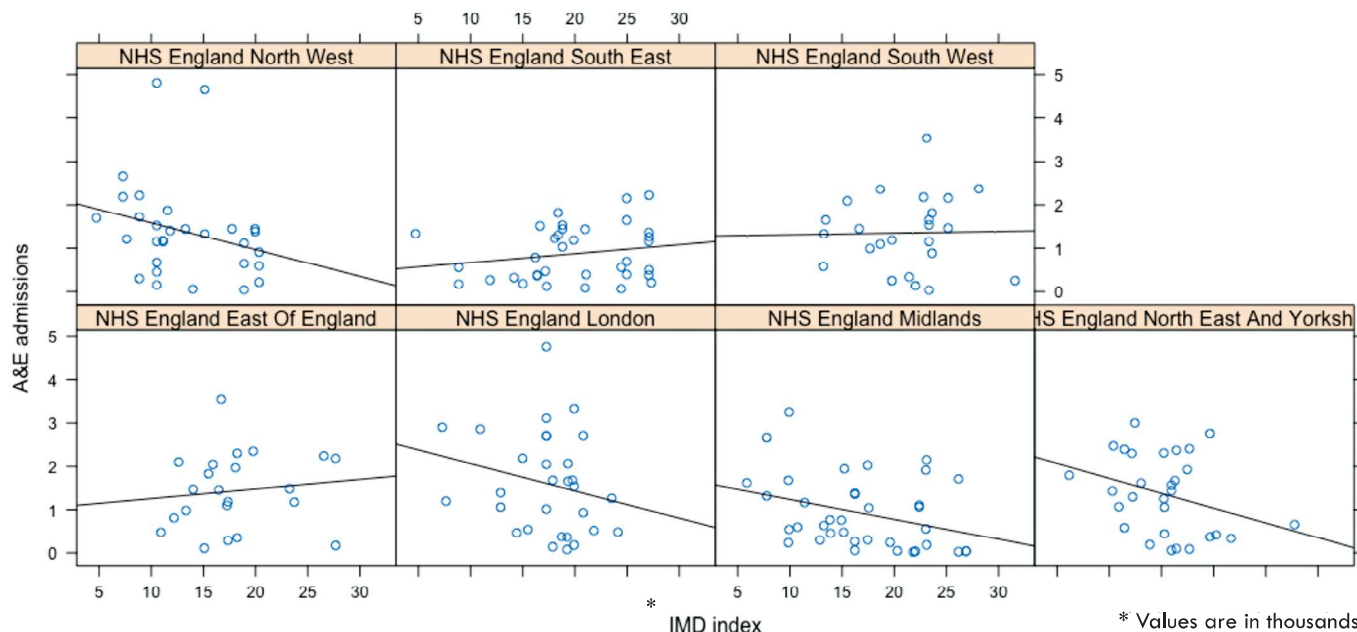
Investigation- 3

This investigation is important to add as the type of association found may explain why A&E admissions may be high in certain regions.

The scatterplot reveals the number of GP staff from 2022 which was the previous period this data was collected (previously 2013). GPs were used due to being a stronger indicator of available appointments than the number of GP practices. It is shown that the larger the A&E admissions the smaller the number of GPs and the larger the IMD index, with

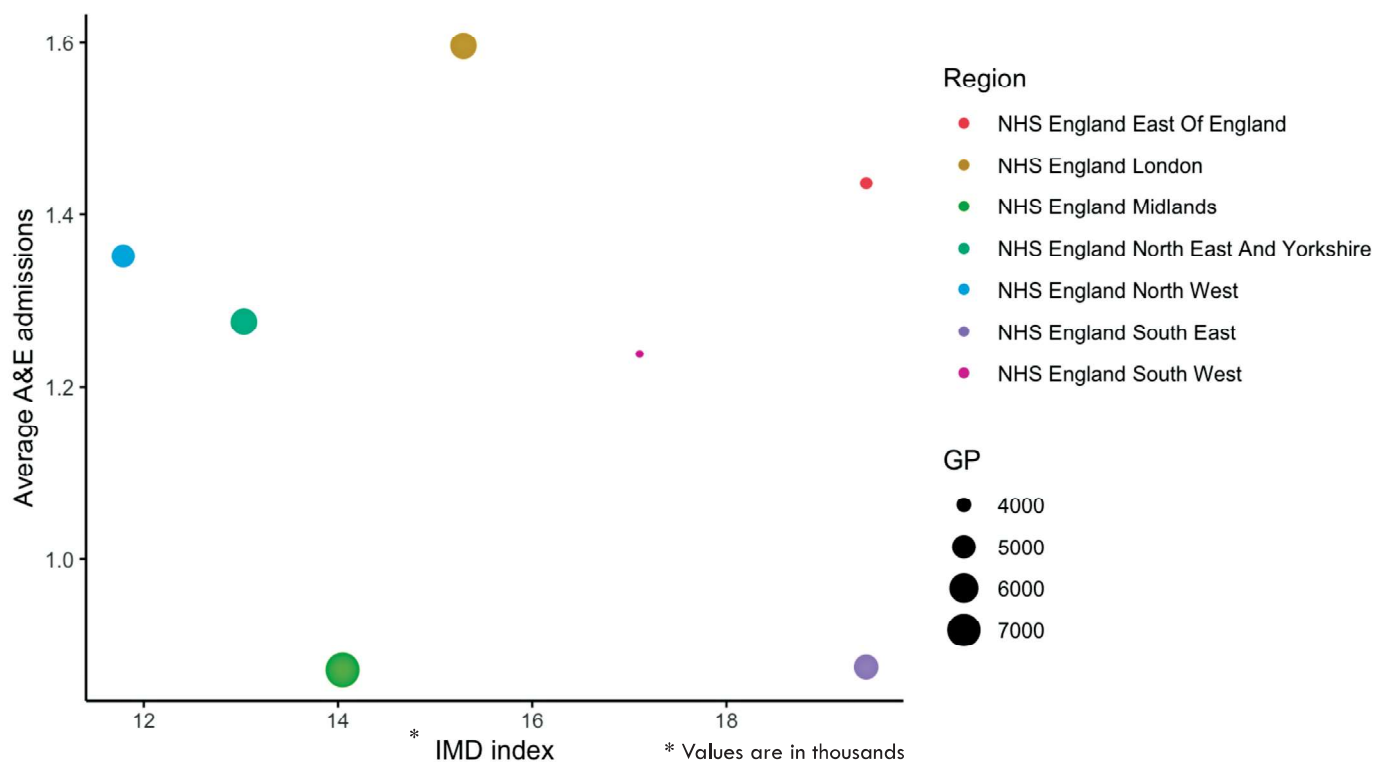


Graph 4: Histogram showing the residuals for the model in Graph 3.



Graph 5: Regressions for regions in England with IMD index against A&E admissions in 2019.

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Graph 6: Scatterplot for IMD index and monthly A&E admissions in 2019 including the number of GP staff in each region.

the exception of London which had a larger number of GP staff but high A&E admissions. Other major differences are seen between the South East and London. Although having a similar number of GPs they had opposing numbers of A&E admissions with London having the most and South East with one of the least. In addition, higher IMD indexes were associated with a smaller number of GP staff.

DISCUSSION

This paper aimed to seek if there was a relationship between deprivation and A&E admissions in England. By combining the three investigations, a negative correlation between deprivation and A&E admissions was found showing that the more deprived areas of England had higher numbers of A&E admissions. This may be due to poor health-related lifestyle choices and living conditions as a result of the lower income and education seen in deprived areas.⁹ Furthermore, larger A&E admissions were associated with a smaller number of GPs revealing that more GP access can help individuals sooner with less urgent symptoms, which would have developed into the need for hospital attention if previously unseen.¹³

Throughout the results, a few exceptions can be seen. For example, although London has large A&E admissions and a relatively low IMD value, there is a larger number of GPs. This reveals that more GPs are not always associated with fewer A&E admissions. This can be explained by London's large diversity of ethnicities.²³ The larger the number of cultures the less likely there are set terms on how to use A&E services which may explain larger A&E admissions. In addition, the Midlands had a small number of A&E admissions for how low their IMD index was (although having more GP staff) this can be attributed to having the largest number of hospitals in the

region compared to others, reducing pressure on A&E services. In general, the descriptive statistics revealed that the southern and eastern regions of England were less deprived than the northern and central regions, but many regions were seen to exhibit a negative trend showing their most deprived postcodes had higher A&E admissions. The exceptions were the South East, South West, and East which also had a low number of GPs. Their positive trends can be attributed to an older demographic of 72-year-olds or older, which may access A&E services more frequently due to having a greater number of comorbidities.²⁴ The low number of GPs in these regions (although being less deprived) opposes the inverse care law.

An advantage of this investigation is the standardisation of demographics such as population and the use of IMD index which uses multiple domains to determine deprivation. As seen in the cross-sectional study "Social predictors of accident and emergency attendance in disadvantaged neighbourhoods in 2019",²⁵ their biggest limitation is not being able to account for many domains such as income. Although the IMD index in this investigation used seven different domains, mental health such as loneliness was not included. This is identified as an important marker of deprivation as it may lead to poor lifestyle choices such as excessive drinking and drug use. Other studies, such as "Socio-economic determinants of casualty and NHS Direct use"²⁶ found that unemployment and poor housing were the main domains for increased A&E attendance. Other cross-sectional studies which looked specifically at London in 2000²⁷ found that benefits and support given by the government was an important domain. My association was consistent with a previous research study²⁵ stating that lower socioeconomic status increased risk of A&E attendance by 38% and having less access to a GP increased the likelihood of attending A&E

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by 46%. Contrary to this study, the studies used questionnaires and audits to determine deprivation which had a smaller data set than mine. One study²⁵ further investigated the IMD index where they found no statistically significant relationship between the value and A&E attendance and additionally no relationship with the researcher's own parameters of deprivation. This may additionally explain the low R^2 value in this investigation. If this paper were replicated, a different measure of deprivation could be used, especially finding primary data. A disadvantage of this investigation was manually inputting data from the IMD index and the use of only five months to represent a whole year. In the future, other years may be investigated to compare it to 2019.

2019 was an important year for pattern analysis as it was not only the last pre-Covid year but was the year the NHS tried to reduce pressure on A&E. A clear example is seen with the recruitment of up to a thousand GPs across England, this meant an additional half a million hours were used for seeing patients. Relating to 2022, which will be the first year post-Covid, it is expected to have a similar but enhanced relationship as the one in this investigation, especially as some services may have reopened, or expanded.

Although many papers have investigated a similar topic, none have delved into the regional difference in England making it ever more important. Especially as it can decrease staff stress and wait times, which are linked to lower clinical results when they are longer.²⁸ Knowing the relationship between deprivation and A&E admissions in each region (especially as the mixed regressions model in this investigation consisted of a better fit) means specific regional measures can be put in place.

CONCLUSION

This paper revealed a negative correlation between both deprivation and monthly A&E admissions, displaying that higher admissions were seen in the most deprived areas. In addition, higher A&E admissions were associated with fewer GPs in some regions than others which may be used as an explanation for the high A&E admissions in England. Although the first part of the investigation rejected the null hypothesis, there were seen to be a few differences in trends within the different regions which could be explained by other demographics other than deprivation. Therefore, an extension of this investigation would be to look at alternative demographics or different parameters of deprivation such as loneliness.

APPENDIX

Methods

NHS England sources its data from emergency care data set (from digital.NHS) and monthly reports from English NHS hospitals whereas Gov.UK is a government-run website that releases national statistics through censuses and questionnaires.

R-software incorporate both R and Rstudio which is a program used to analyse masses of data. Packages such as "lmer4" and "ggplot2" were used throughout.

To gather data on different literature analyses for the discussion, the databases PubMed and Cochrane were used. To get specific data and to make sure only specific literature reviews would show, the advanced tool search was used,

I filtered for only systemic reviews and used certain tool searches. An example of the tool search is as seen below:

"A&E" OR "Emergency services" AND "NHS" OR "Hospital admissions" OR "Emergency".

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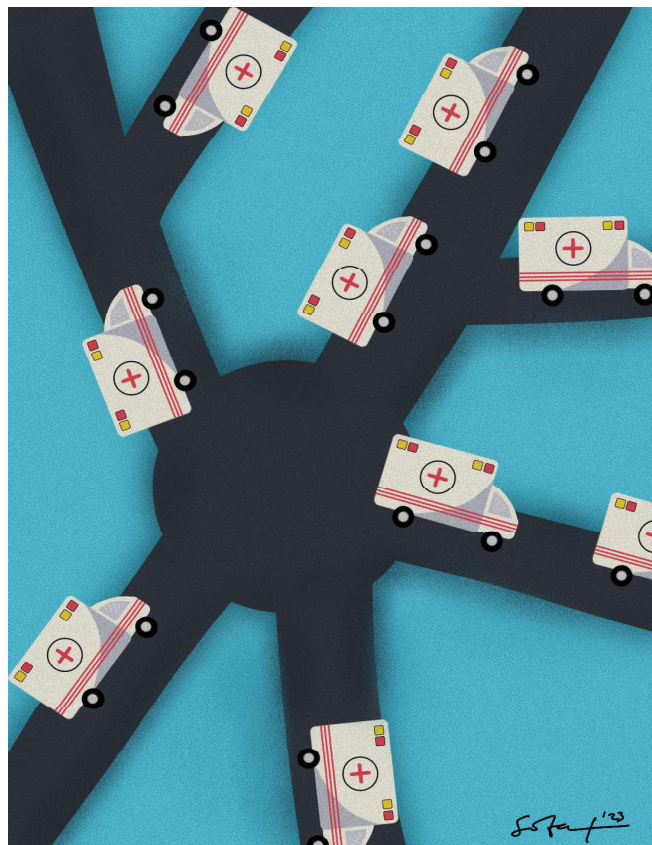
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Correspondence to:
m.h.stewart@lancaster.ac.uk

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(a full list available on request)



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