Does access to Walk-in Centres affect attendance at accident and emergency departments?

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Abstract

Walk-in Centres (WICs) provide primary care services for non-urgent cases without the need for patients to make appointments or to register. One of the policy aims was to reduce utilisation of Accident and Emergency Departments (AEDs) for non-urgent care. We examine whether areas with better access (shorter distance) to WICs have lower rates of attendance at AEDs for non-urgent cases. We use data on 2009/10 AED attendances from 2699 Lower Super Output Areas in the East Midlands and control for their demographic and socio-economic characteristics and distance to AEDs and general practices. The effects of distance to the nearest general practice were small, statistically insignificant and changed sign between linear and log models. Distance to the nearest AED reduced attendance rates for both non-serious conditions (elasticity: –0.05, p=0.029 linear model; –0.08, p=0.016 log model) and serious conditions (elasticity: –0.11, p <0.0001, linear model; –0.08, p <0.0001, log model). Greater distance to the nearest WIC increased AED attendance for non-serious cases (elasticity: 0.31, p < 0.0001, linear model; 0.50, p <0.0001, log model).

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1 Introduction

1.1 Background

A new type of National Health Service (NHS) primary care service, the walk-in centre (WIC) (Department of Health, 1999) was introduced in 2000. WICs provide predominantly nurse-led information and treatment for minor illnesses and injuries without an appointment. WICs were placed in convenient locations, had longer opening hours than general practices (NHS Choice, 2012) and are equipped with software for clinical assessment to guide the nurses through the patient consultation. The first of the WICs opened in January 2000 and by 2009/10 there were 92 WICs dealing with around 3 million patients a year (NHS Choice, 2012).

WICs were intended to improve access to the NHS and to provide a more appropriate match of services to patients. In particular there was concern about the use of Accident and Emergency Departments (AEDs) for minor ailments which could have dealt with in primary care. In this paper we examine whether access to a WIC does reduce attendances at hospital AEDs by patients with non-urgent conditions.

1.2 Literature

There is international concern about inappropriate use of AEDs (Carret et al, 2009; de la Fuente et al, 2007) and WICs or similar services operate in several other countries, such as Australia, Canada, South Africa and the USA (Salisbury and Munro, 2003). There is little international evidence on their effect on the use of other health care services. de la Fuente et al (2007) used time series analysis on monthly data over 7 years on the use of primary care and AEDs in a Spanish region and concluded that there was no evidence that primary care emergency consultations were a substitute for AED consultations.

In England, Martin et al (2007) compared 452 patients in two general practices who had “inappropriate” attendances at an AED in 1997 with matched case controls and found that they were also heavy users of their general practice. Patients in the practice with better out of hours provision had higher rates of inappropriate AED attendance nearest to the AED, although this may have been because it was also the practice closest to the AED.

In England, Salisbury et al. (2002) looked at the early stages of WIC development. WIC patients were similar to the AED users. The majority of WIC users were aged 16-44, visiting the centres between 10am and 4pm with little variation between weekdays and weekends. The waiting time for a consultation was on average 10 minutes and consultation length averaged 14 minutes. 78% of patients did not need a referral after their visit. Maheswaran et al (2009) studied repeat attenders at WICs. By using data from 4 WICs (two in London) they found that 39% of attendance were repeat attenders and that patients living within 3 kilometres of the WICs were the more likely to be repeat attendees. WIC users were 53.4% female, 51.7% aged 15-44 age group, and 76.2% of users attended on weekdays. Chalder et al. (2007) looked at patient choice, preference and satisfaction from 16 sites (8 sites with co-located AED and WIC and 8 AED sites without a WIC) They found that 79% of the survey respondents had gone to the AED first and had then been redirected to the WIC. There was no evidence of any difference in the satisfaction level for handling the main problem or the overall experience between co-located and single located AEDs. There were however, problems with the visibility of WICs since 55% of patients being treated in a WIC reporting that they had been treated in an AED.

Salisbury et al. (2007) looked at the effect of co-located AEDs and WICs at 8 sites compared to 8 AED sites without WICs before and after the introduction of the WICs. Overall the difference between AED attendance with and without WICs was very small and insignificant for patient attendance rates, waiting times, costs and outcomes. Hsu et al. (2003) undertook a controlled before and after observational study on the effect of introducing a WIC into one town in Leicestershire. They compared the effects on local practices, AEDs, minor injuries units, and out of hours services, in two towns Loughborough (where the WIC was placed) and Market Harborough (the control town) for the periods January to June 2000 and January to June 2001 (6 months after the WIC was opened). They concluded that the WIC did not affect practices' waiting times or emergency consultations, or out of hours service attendances. AED attendances fell less in Loughborough and attendance at the minor injuries unit increased, possibly because the WIC was located in the same building.

Chalder et al. (2003) compared the change in workload of local AEDs, general practices and out of hours services in 10 locations close to WICs before and after the opening of the WICs, with those of AEDs, practices, and out of hours services with no nearby WIC. They found that AEDs and practices near to WICs had lower attendances and consultations but the difference was statistically insignificant, as was the effect on out of hour's services. They suggest that the lack of effect might be due to the small sample size, the wide variation between sites and the WICs not having had enough time to adjust into the community. Maheswaran et al. (2007) found no effect of distance from practice to WICs on waiting times for GP appointments, suggesting that access to WICs did not reduce demand for GP consultations.

A systematic review of initiatives to reduce waits and attendances at AEDs concluded that the walk-in centres had not been shown to have any effect on AED attendances (Cooke et al, 2004, 63).

1.3 Objective

Our main objective is to determine whether greater accessibility to a WIC reduces the use of AEDs. Rather than using the presence or absence of WICs as in previous studies we use patient distance from the nearest WIC as a measure of the availability of WICs. If WICs are a substitute for AED attendance then areas with shorter distances to their nearest WIC should have lower attendance rates at AEDs, after controlling for other factors.

Section 2 describes the data, setting, variables, study design and potential bias connected to this analysis. Section 3 reports the results of the analysis and the conclusions, limitations and further research proposal are in section 4.

2 Methods

2.1 Data

The main source of data is the Accident and Emergency department (AED) data within Hospital Episodes Statistics (HES) (Hospital Episode Statistics, 2012), an administrative dataset containing data on all attendances at English AEDs for the financial year 2009/10 (1 April 2009- 31 March 2010). The data for each patient attendance includes diagnosis, investigation and treatment, waiting time, attendance time and date, and the patient's age, gender and Lower Super Output Area (LSOA) of residence.

There were 15M attendances at English AEDs in 2009/10. We construct a more manageable data set by restricting attention to the 1.13M attendances by patients resident in the East

Midlands Strategic Health Authority (SHA).[1] The SHA population of 4.5M is 8.6% of the English population and is reasonably representative of it. The SHA does not have a boundary with Wales or Scotland and so the SHA population is unlikely to use AEDs outside England which would not be recorded in Hospital Episode Statistics.

We attribute socio-economic characteristics from Neighbourhood Statistics (Office for National Statistics, 2010) to the 2699 LSOAs in the East Midlands. We use measures of LSOA urbanisation, income deprivation, education, and morbidity. The urbanisation categories are "urban > 10k", "town & fringe" and "village, hamlet & isolated dwellings". We measure income deprivation as proportion of population living in low income families. We use four measures of morbidity: the percentages of the LSOA reporting limiting long-term illness, claiming incapacity benefit, claiming disability living allowance, and reporting themselves as not in good health.

The NHS Choices website provided the postcodes of AEDs and WICs (accessed February 2012) and general practices (May 2011). Using the post code, we calculated the straight line distances from each LSOA centroid to the nearest AED (of which there were 26), WIC (15) and general practice branch (728), irrespective of whether they were located in the East Midland SHA or not. During the study period the Peterborough WIC moved 2.6 kilometres to its current position in May 2009 (NHS Peterborough, 2009)[2]. Our analysis was based on the current location of the walk-in centre. This creates an error in measuring distance to this WIC but we think this is unlikely to have a major impact on the results since it only affects data for the 1 month of the study year and for 1 of the 15 WICs which were the nearest for East Midlands patients.

2.2 AED attendance subgroups

To ensure that WICs were a potential substitute for AEDs we restrict the analysis to AED attendances between 8am to 8pm when all WICs nearest to East Midlands LSOAs were open.

We classified AED attendances into two groups: those by patients who could have been treated at a WIC (*minor* conditions) and a control group of attendances by patients for whom a WIC would not have been able to provide satisfactory treatment (*serious* conditions). The *minor* and *serious* conditions attendances were defined by clinical diagnosis, the form of arrival, the form of disposal, the accident/incident type and the form of referral to the AED. The details of the definition of *minor* condition attendances are in Table 1. Multiple attendances by the same patient within a 24 hour period were counted as one attendance.[3]

Thirty four (1.26%) of the 2669 LSOAs did not have any *minor* condition patients attending an AED. The majority of these LSOAs are located close to or in Leicester where an Urgent Care Centre is located in the same building as the AED. The urgent care centre opened in May 2008 before the start of our study period. It is intended to be used by patients who urgently require to see a general practitioner. We assume that *minor* condition patients arriving at that AED are diverted to the UCU on the same site and we define the urgent care centre as a WIC for the purpose of calculating distance the nearest WIC. We checked the

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[1] We used the East Midlands Strategic Health Authority area as defined in the UK Borders shapefile (http://edina.ac.uk/ukborders/)

[2] NHS Peterborough (2009). http://www.peterborough.nhs.uk/default.asp?id=912. Last accessed 21/09/12.

[3] Some patients attended more than once within 24 hours after discharging themselves. We count these as a single attendance.

robustness of results by also estimating models after dropping LSOAs which had the Leicester urgent care centre as their nearest "WIC".

We defined attendances for *serious* conditions as those where the patient had a diagnosis other than one of those used to define *minor* conditions and the patient died or was admitted to hospital after attending the AED. The AED attendances that were not define as *minor* or *serious* (76.1% of attendances) were not included in this analysis.

We excluded 33 *minor* observations and 113 *serious* observations with missing information on age or gender. Our final sample had 133,515 *minor* attendances. 85.67% of patients with a *minor* attendance only had one AED attendance in the year, 11.06% attended twice and 3.27% attended three or more times in a year. We classified 137,421 attendances as *serious* patients. 74.78% of patients in this group attended once only in the year, 16.11% went twice and 9.11 went three times or more. Nine (0.33%) of the LSOAs did not have any *serious* attendances.

2.3 Study design

The dependent variables in all the analyses are the number of attendances at any AED for *minor* or *serious* conditions by LSOA residents in 2009/10 per 100 population.

We estimate OLS cross sectional models to test the effect of distance to the nearest WIC on *minor* and *serious* AED LSOA attendance rates:

$$y_{ka} = \boldsymbol{\beta}_k \mathbf{x}'_a + \delta_{kW} d_a^W + \delta_{kAE} d_a^{AE} + \delta_{kGP} d_a^{GP} + \varepsilon_{ka}\,, \;\; k = m,s \qquad (1)$$

y_{ka} is the *minor* ($k = m$) and *serious* ($k = s$) AED attendance rate of the population of LSOA a. $\mathbf{x}_a$ is a vector of LSOA demographic (age/gender proportions) and socio-economic characteristics and includes a constant term. d_a^W, d_a^{AE}, and d_a^{GP} are distances in kilometres to the nearest WIC, AED and GP from LSOA a. The reference categories for the age and gender and rurality dummy variables are men aged 25-49 and urban. We also estimated OLS models with the log of attendance as the dependent variable, both with distance in km and the log of distance.

If WICs are a substitute for AEDs for *minor* attendances then we expect that LSOAs with greater distances to the nearest WIC will have a higher AED *minor* attendance rate: $\delta_{mW} > 0$. We also expect that LSOAs will have lower *minor* attendance rates if they are further from AEDs ($\delta_{mAE} < 0$) and higher *minor* attendance rates if they are further from the nearest general practice ($\delta_{mGP} > 0$). Since WICs have longer opening hours that general practices we also expect that, if general practices and WICs are close substitutes, the distance to WICs will have a larger positive effect on AED *minor* attendances than distance to general practices: $\delta_{mW} > \delta_{mGP}$.

WICs or general practices are not good substitutes for AEDs for patients with *serious* conditions, so we expect that the effect of distance to WICs or to general practices on *serious* LSOA AED attendance rates will be smaller than their effect on *minor* attendances, and possibly zero: $\delta_{mW} > \delta_{sW} \geq 0$; $\delta_{mGP} > \delta_{sGP} \geq 0$.

In order to test more precisely whether distance effects differ for *minor* and *serious* AED attendance rates we also estimate a pooled OLS regression with a full set of attendance type indicator interactions:

$$y_{ka} = \boldsymbol{\beta}_m \mathbf{x}'_a + \boldsymbol{\beta}_s \mathbf{x}'_a D_{ka} + \delta_{mW} d_a^W + \theta_{sW} d_a^W D_{ka} + \delta_{mAE} d_a^{AE} + \theta_{sAE} d_a^{AE} D_{ka} + \delta_{mGP} d_a^{GP} + \theta_{sGP} d_a^{GP} D_{ka} + \varepsilon_{ka} \qquad (2)$$

where $D_{ka} = 1$ if $k = s$, and $D_{ka} = 0$ if $k = m$. We expect that $\theta_{sW} < 0$, $\theta_{sGP} < 0$, and $\delta_{mW} + \theta_{sW} = 0$, $\delta_{mGP} + \theta_{sGP} = 0$.

It is also possible that by estimating the difference in the effects of the explanatories we resolve the problem of unobserved LSOA heterogeneity. Cross section regressions are vulnerable to unobserved LSOA factors which are correlated with both distance to WICs and AED attendance. It is possible, for example, that WICs were located in areas where patients had a greater propensity to use AEDs for minor ailments. If the unobserved factors affecting *minor* and *serious* attendance rates are perfectly correlated and have the same effect on these rates, then the estimated difference between coefficients on distance to the nearest WIC will be an unbiased estimate of the true difference. If we also assume that distance to the nearest WIC has no effect on *serious* attendances ($\delta_{sW} = 0$) then the estimated difference $E\left(\hat{\delta}_{mW} - \hat{\delta}_{sW}\right) = \delta_{mW}$ is an unbiased estimate of the effect of distance on *minor* conditions AED attendances.

We undertake a number of checks on the robustness of the specification. First, to allow for the possibility that the effects of distance vary by the age of the population we estimate separate models for 10 age/gender groups. Second, we allow for the co-location of the AED and an urgent care unit in Leicester by re-estimating the model after dropping 635 LSOAs which have the Leicester urgent care unit as their nearest “WIC”. Finally, we estimate an OLS model with the log of the attendance rate as the dependent variable and with distance measured in log kilometre.

3 Results

3.1 Descriptive statistics

Table 2 shows that the average straight line distance to the nearest GP is 1.2 kilometres, 9.2 kilometres to the nearest AED and 18.3 kilometres to the nearest WIC. Within a 5 and 10 kilometre radius there are on average 0.20 and 0.37 WICs, 0.33 and 0.63 AEDs and 31 and 71 general practices.

The East Midlands is somewhat less income deprived than England (0.13 vs 0.15) but more education deprived (24.97 vs 21.69). SAH is slightly worse than England as whole.

Of a population of nearly 4.5M East Midlands inhabitants 25.2% attended an AED at least once during 2009-10 (for all types of attendance – minor, serious, and unclassified). 52.6% of attenders were male, and the average age was 38.24 years. AED users visited an AED 1.03 times on average each with a maximum of 140 visits from the same patient during one year (54 of those were extra visits on the same days).

Table 2 shows that the mean number of *minor* and *serious* attendances per LSOA are nearly equal (49.29 and 50.77 respectively) as are the rates per 100 persons.

Table 3 gives the AED attendance rates for the East Midlands by age and gender for the two types of attenders. Overall, males have higher *minor* and *serious* conditions attendance rates than females (3.72 vs 2.83 and 3.61 vs 3.19). Attendance rates for *minor* conditions aer lowest for children and young adults and decline with from age 25. The oldest age groups have the highest *serious* condition attendance rates. The age pattern is U shaped for males, but not for females where women age 16-24 have the second highest rate.

Figure 2 maps the *minor* and *serious* attendance rates (darker shading indicates higher rates). The distribution of the *serious* group attendances is less concentrated than the *minor* distribution. However, areas located relatively close to an AED tend to have a larger proportion of *serious* attendances. The effect of the Leicester urgent care centre co-located with the AED (mentioned in section 3.3) can clearly be seen on Figure 2a where there are LSOAs with very low proportion of *minor* AED attendances around Leicester. For the purpose of calculating distances from LSOAs to the nearest WIC, the Leicester UCU is assumed to be a WIC in most of the analysis

3.2 Regression results

Table 4 reports results from the separate models (1) for the two types of attendance. In the final two columns we report *t* statistics from a model where the dependent variable is the difference between *minor* and *serious* attendance rates and from the pooled model (2). Unsurprisingly, many of the effects of the explanatories on *minor* and *serious* attendance rates are significantly different.

Compared to urban LSOAs, village LSOAs have smaller *minor* condition attendance rates. The rurality measures have no significant effect on attendance rates of either type, suggesting that the simple distance measures are adequately capturing the effect of distance for these areas despite their remoteness.

Income deprivation reduces *minor* attendances, perhaps because it reflects reduced availability of cars in the household. It increases the *serious* attendance rate (where we would expect car availability to be less important), suggesting that the morbidity measures may not fully capture morbidity. Education deprivation increases the *minor* attendance rate but has no effect on *serious* attendance.

Conflicting signs of the coefficients on the morbidity measures suggest that the four measures may be collinear. Only one of the age and gender groups (males aged 65 and over) has a *minor* condition attendance rate which differs significantly from the reference group of males aged 25-49. There is more variation in the age and gender effect for the *serious* attendance rate, with four groups having smaller rates and one (females aged 60 and over) a significantly larger rate than males aged 25-49..

Distance to the nearest AED reduces both the *minor* and *serious* attendance rates, with the effect on *serious* attendance being twice as large and with a much larger *t* statistic.

Distance to the nearest WIC has a highly positive significant effect on the *minor* attendance rate and, surprisingly, a negative effect on the *serious* attendance rate. However, the absolute effect on *serious* attendance is an order of magnitude smaller and has a much smaller *t* statistic. If we assume that unobserved LSOA factors affecting minor and serious attendances are perfectly correlated, have the same effect on them, and that distance to the WIC has no effect on serious attendances, then the difference between the coefficients is an unbiased estimate of the effect of distance to the WIC on minor attendances.

Distance to the nearest general practice has a negative but insignificant effect on *minor* condition AED attendance.

Table 5 reports results for separate *minor* condition attendance rate models for each age and gender group. The results are similar to those for the model pooled over the age and gender groups. Distance to the nearest AED has no effect on attendance rates for males and females aged 15-24 and 25-49. The youngest and oldest age groups are deterred by greater distances to the AED. The coefficients on distance to the nearest WIC are positive and highly significant for all age and gender groups. All age groups' *minor* attendance rates are also negatively affected by distance to the nearest general practice, though the effect is significant only for four of the 10 groups, and then only at 5%.

Table 6 has the results for separate age and gender group models for *serious* condition AED attendance rates. Apart from males aged 15-24 distance to the nearest AED reduces the *serious* condition attendance rate. The anomalous negative coefficient on distance to the nearest WIC which we noted in Table 4, appears to be driven by the youngest age group under 15 where the coefficient is negative and highly significant. In the other age groups the coefficient is positive in four cases and negative in five, with only that for females aged 60 and over being significant (at 1%) and negative.

Dropping the 653 LSOAs for which the UCU located at Leicester's hospital is the nearest "WIC", produces broadly similar results (Table 7) to those in Table 4. Greater distance to the nearest WIC increases the *minor* AED attendance rate, though the magnitude of the effect is much reduced. The negative effect of nearest WIC distance on *serious* condition attendance rates is no longer significant. Greater distance to the nearest AED now reduces attendance for both *minor* and *serious* conditions.

In Table 8 we see that the models with log attendance as the dependent variable and the logs of distances have very similar patterns of signs and significance to the linear models.

4 Conclusion

4.1 Summary

One of the aims of creating walk-in centres was to reduce the demand on local accident and emergency departments by patients who did not require the full range of AED services and could have been dealt with in primary care. In this study we have attempted to test whether WICs are indeed a substitute for AEDs by examining if populations with easier access to WICs, in the form of shorter distances to the nearest WIC, have lower rates of AED attendances for minor conditions.

Table 9 summarises the results by reporting the elasticities of attendance rates with respect to the distances to AEDs, WICs, and general practices. The elasticities from the linear model (Table 4) are calculated as the mean of the elasticities for the LSOAs. We see that distance to the AED reduces AED attendance for both *minor* and *serious* conditions, though the elasticities are quite small. Distance to the nearest WIC has a marked impact on AED attendances for *minor* conditions, with an elasticity of 0.31 or 0.50 depending on the model specification.

Distance to the nearest WIC reduces the *serious* condition AED attendance rate. The effect is an order of magnitude smaller in absolute terms than the effect of distance to the nearest WIC on the minor condition attendance rate but it as anomaly. Other things equal one might expect distance to WICs to have a positive effect on AED attendance for patients diagnosed with serious conditions because some of them may have thought they had a minor ailment that could have been treated at a WIC but were deterred by the distance to the WIC. As we saw in Table 6 the anomaly appears to arise only for attenders under 15 and, to a lesser extent, for women over 60.

Finally, we see that the distance to the nearest general practice has essentially no effect on AED attendance for minor or serious conditions: the elasticities are small in magnitude and statistically insignificant. General practices would appear to be substitutes for both AEDs and WICs for patients with minor conditions. The lack of any evidence of effect of distance to the nearest practice on AED attendances may be because the dependent variable is attendances between 8am and 8pm including weekends and will include attendances outside the normal office hours of general practices.

Previous studies from the period shortly after WICs were introduced found little evidence of an effect of the opening of WICs on AED attendances. The contrast with our results may be because these studies looked at the opening of WICs or by comparing areas with and without WICs. Our design may be more sensitive in that it allows for the effect of a WIC to depend on its distance from patients. We have also looked at the effect on a narrowly defined set of attendances, accounting for just under 12% of total AED attendances, which are likely to be more responsive to WIC accessibility.

Much more information is required to for a cost benefit analysis of WICs but estimates of the effect of walk-in centres on accident and emergency department use for minor ailments are an essential building block in such analysis.

4.2 Discussion: limitations and further work

Our definition of *minor* conditions which are most likely to be treatable at WICs as well as AEDs is based on diagnoses made by AED staff after the patient attended. However, the decision to attend an AED rather than a WIC is made by the patient and so affected by their perception of the seriousness of their condition. Thus we may classify as *minor* some attendances where the patient would not have considered a WIC as a substitute for the AED. Conversely, we may have classified as *serious* some attendances where the patient thought their condition was minor and did consider a WIC as a potential substitute. The effect of these misclassifications would be to reduce the estimated effect of distance to the nearest WIC on the *minor* condition attendances as classified by the AED system and to increase it for those classified as *serious* using AED data.

We have used straight line distance measures rather than road distance or travel times. Comparison of these alternatives in other studies of health service utilisation suggest that our results are unlikely to be very sensitive to the choice of access measure, especially as the East Midlands has no major rivers or mountains which make straight measures misleading.

We have assumed that for patients with minor conditions distance is the key factor in affecting their choice of place of treatment. However, patients may also be concerned with other characteristics of WICs, AEDs and general practices. Practice quality also affects emergency admission rates for ambulatory care sensitive conditions (Dusheiko et al, 2011) and so may affect *serious* attendances. There is evidence that patients care about the type of GP and the quality of the practice when choosing a general practice (Santos et al, 2012) which suggests they may bear these in mind when choosing between AEDs, WICs and their general practice for a minor condition. We will therefore experiment with including measures of local practice quality, practice opening hours, and waiting times at AEDs.

We have assumed in most of the models that distance has an additive linear effect on AED attendance. It is plausible that the effect of distance to WICs depends on distance to the AED: patients will be more affected by a 1 km increase in the distance to the nearest WIC the closer is the nearest AED and the closer is the nearest WIC. We will therefore experiment with other distance specifications, especially interactions.

The OLS models will yield unbiased estimates of the effects of distance to WICs on LSOA AED attendance rates only if there are no omitted variables correlated both with distance and with attendance rates. We have included socio-economic and demographic LSOA characteristics in the regression models but the risk of bias estimates remains.

One obvious extension to deal with bias from unobserved heterogeneity is to use a panel of data on AED attendances in an attempt to remove unobservable time invariant unobservables. However, AED data is only available from 2007/8 onwards and most WICs were established by then, so that there would be little variation in the key explanatory variable (distance to WICs) in the data. It may be possible to exploit changes in the location of WICs, such as the one in Peterborough which affected one month of our study period.

There is another type of variation in WIC accessibility which we can exploit. We have so far restricted attention to AED attendances between 8am and 8pm to ensure that all 40 WICs in our analysis were open. We can also use data on attendance rates outside these hours to estimate models with LSOA fixed effects:

$$\begin{aligned} y_{kta} = {} & \beta_{k0} + \beta_{ka} + \beta_{kday} D_{day} + \beta_{kmonth} D_{month} + \delta_{kW} d_a^W + \delta_{kAE} d_a^{AE} + \delta_{kGP} d_a^{GP} \\ & + \gamma_k D_{ct} + \gamma_{kW} D_{ct} d_a^W + \gamma_{kAE} D_{ct} d_a^{AE} + \gamma_{kGP} D_{ct} d_a^{GP} + \varepsilon_{kta} \qquad (3) \end{aligned}$$

for each type of attendance (*minor* and *serious*) separately. y_{kta} is the rate of type k attendance ($k = m, s$) from LSOA a during period t. Period t is either during the hours when we assume all WICs are open ($D_{ct} = 0$) or during the hours when we assume that all WICs are closed ($D_{ct} = 1$). Notice that this dummy variable takes on the same value for all LSOAs since we ignore, for the moment, the fact that not all WICS open and close at the same time. Since we include an LSOA fixed effect β_{ka} in each type k attendance and the LSOA level explanatories will not vary between the hours when WICs are assumed open and closed we do not include LSOA socio-economic or demographic variables.

We allow for attendance to vary by day of the week (day of the week dummies D_{day} may be for 7 categories (with say Sunday as the baseline) or only 2 categories (with say Saturday and Sunday as the baseline). We also allow for attendance to vary by month in the year.

We expect that when WICs are closed distance to the nearest WIC will not affect AED attendance for *minor* conditions. Hence in the regression for *minor* condition attendance rates we expect $\gamma_{mW} < 0$ and, more precisely, that $\delta_{mW} + \gamma_{mW} = 0$. The expected sign of the coefficient γ_m on D_{ct} is ambiguous: when WICs are closed we expect a higher proportion of minor cases to attend A&E. But WICs are closed during hours of the day (night time) when we would expect fewer non-serious A&E cases in any case.

Estimation of (3) is straightforward but suffers from the disadvantage that some WICs were open after 8pm and some opened before 8am. This will mean that if we define $D_{ct} = 1$ for hours between 8pm and 8am the variable is measured with error and this could bias our estimates of γ_{mW} to zero. We could avoid this problem with a more restrictive set of hours for defining $D_{ct} = 1$ (say 10pm to 6pm).

We could also make a virtue of the differences in WIC opening hours to undertake a form of difference in difference analysis to identify the effects of WICs. With data on the time of A&E attendance during say 15 minute intervals we can estimate

$$y_{kta} = \beta_{k0} + \beta_{ka} + \beta_{kday} D_{day} + \beta_{kmonth} D_{month} + \delta_{kW} d_a^W + \delta_{kAE} d_a^{AE} + \delta_{kGP} d_a^{GP}$$
$$+\gamma_{kt} D_t + \gamma_k D_t^{ca} + \gamma_{kW} D_t^{ca} d_a^W + \gamma_{kAE} D_t^{ca} d_a^{AE} + \gamma_{kGP} D_t^{ca} d_a^{GP} + \varepsilon_{kta} \qquad (4)$$

This is very similar to (3) but has many more observations since we now have 96 periods (quarters of hours) instead of 2. D_t is a dummy for the period so that γ_{kt} captures the effect of time of day. The dummy D_t^{ca} takes on the value 1 when the nearest WIC to LSOA a is closed in period t.[4] In model (3) the dummy D_c took on the value 1 during the period when all WICs were assumed to be closed. We estimate the effect of the nearest WIC being closed as $\gamma_{ka} + \gamma_{kW} d_a^W$ where we expect that $\gamma_{ka} > 0$ and $\gamma_{kW} > 0$.

If there was no variation in WIC opening and closing hours across WICs then we could not separately estimate the effect of the nearest WIC being closed γ_k and the period γ_{kt}. We would get an estimate of γ_{kW} but could not tell if this was an effect of the time of day or of the WICs being closed.

With 96 quarter hour periods OLS may not be an appropriate estimation method for (4) because of the small number of attendances per quarter hour per year: there will be about one attendance per two quarter hour periods. A count data model with the LSOA total population as the exposure term may be a more sensible estimation procedure.

Another possibility is regression discontinuity but this may be complicated to apply in our case because we have two "treatments" which affect the accessibility of WICs: their opening hours and their distance from the LSOA.

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[4] In calculating D_t^{ca} for an LSOA we must allow for travel times. For example if the nearest WIC closes at 20.30 and is 25 minutes away from the LSOA and the nearest AED is 40 minutes away, then patients from the LSOA who arrive at the AED after 20.30 plus 40 minutes minus 25 minutes ie after 20.45 did not have the nearest WIC open when they were deciding at or after 20.05 to attend the AED. Thus attendances from the LSOA after this time are made when the WIC should be treated as closed.

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Figure 1. WICs, practices, AEDs around East Midlands SHA

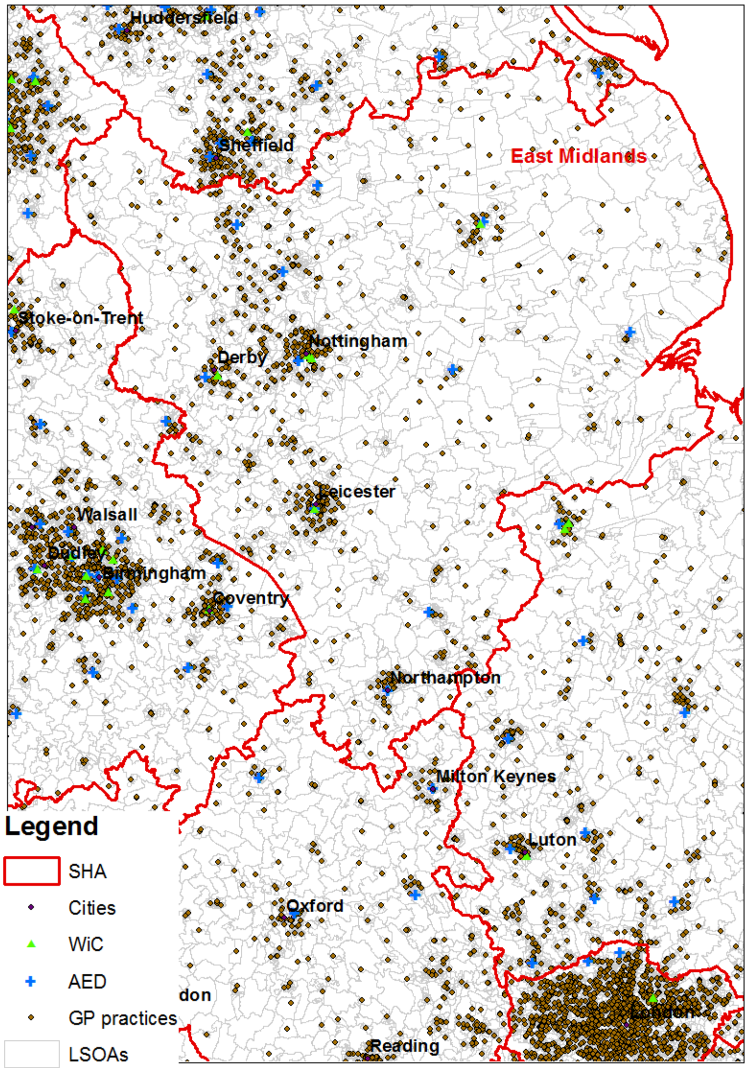
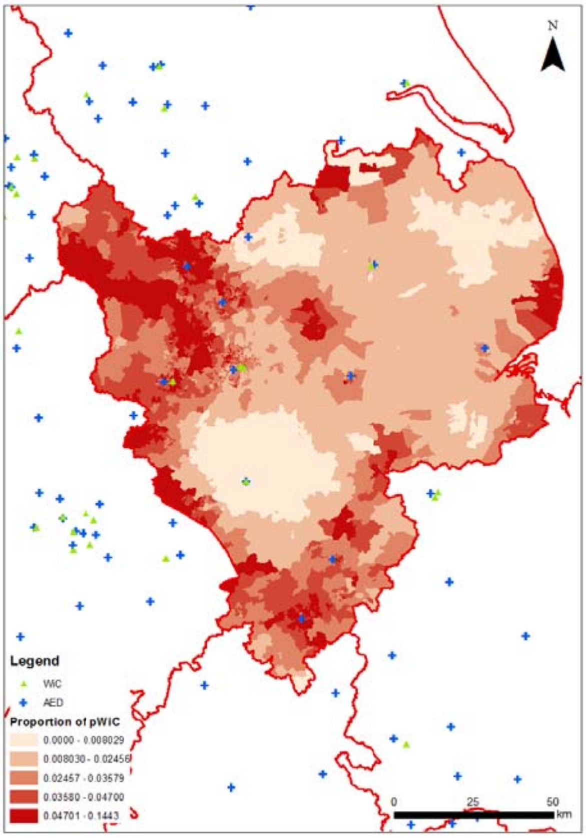
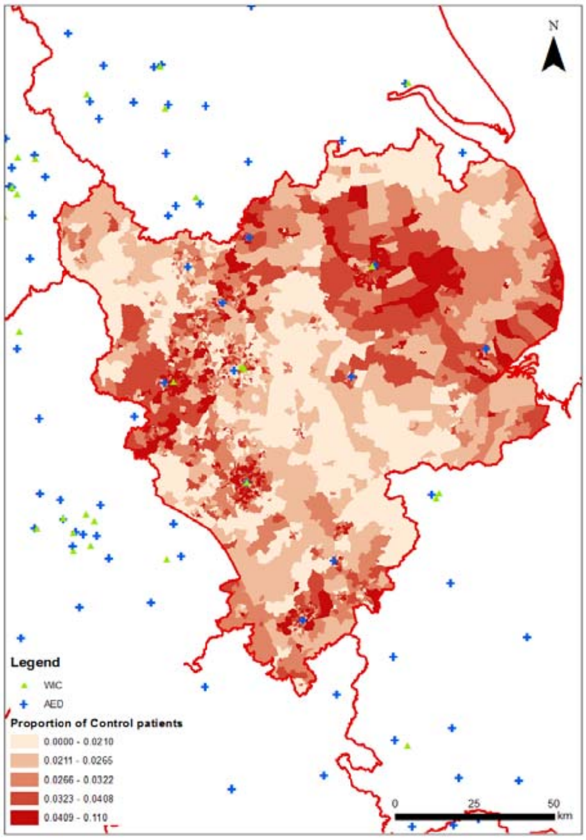


Figure 2. AED Attendance rates East Midlands SHA



(a) Attendance rates *minor* conditions



(b) Attendance rates *serious* conditions

Table 1. Definition of *minor* condition

HES A&E field	Description	Requirement for *minor* condition classification
Diag_1	Clinical diagnosis	Laceration, contusion, abrasion, soft tissue inflammation, concussion, sprain/ligament injury, bites/stings, infectious disease – non-notifiable, local infection, gastronintestinal conditions – other, dermatological conditions, allergy (incl. Anaphylaxis), ENT conditions, social problems (incl. chronic alcoholism and homelessness), diagnosis not classifiable, nothing abnormal detected, DID code
Arrivaltime	Arrival time at AED	Arrived between 8am to 8pm
Aearrivalmode	Arrival mode	Arrival model "other"
Aerefsource	Source of referral	Self referral
Aepatgroup	Incident/accident type	"other accident" or "other than above"
Aeattenddisp	Attendance disposal mode	"discharged – follow-up treatment to be provided by GP" or "discharged – did not require follow-up treatment" or "left department before being treated"

Table 2. LSOA summary statistics

Variable	**mean**[1]	**median**	**sd**	**min**	**max**
minor attendances per LSOA	49.29	48.00	35.95	0.00	355.00
serious attendances per LSOA	50.77	47.00	22.51	0.00	187.00
minor attendances per 100	3.05	3.04	2.17	0.00	14.43
serious attendances rate per 100	3.13	2.92	1.28	0.00	11.03
Distance to nearest GP, km	1.21	0.84	1.17	0.02	9.81
Distance to nearest WIC, km	18.30	16.84	13.68	0.06	59.64
Distance to nearest AED, km	9.16	7.48	6.47	0.06	37.10
Income deprivation score	0.14	0.10	0.10	0.01	0.75
Education deprivation score	24.97	19.70	19.74	0.27	99.34
% Limiting Long-term Illness	17.64	17.25	5.53	1.41	43.36
% Incapacity Benefit claimants	3.43	2.91	2.12	0.28	18.94
% Disability Living Allowance claimants	5.35	4.83	2.67	0.87	23.26
% Not good SAH	8.76	8.40	3.19	0.71	23.20
Urban	0.72				
Village	0.16				
Rural	0.12				

[1] Unweighted LSOA means except for numbers of attendances

Table 3. Population and AED attendance rates per year

	Proportion of LSOA population	*minor* conditions attendance rate	*serious* conditions attendance rate
male ≤15	9.31	4.70	2.02
male 16-24	6.15	4.60	1.39
male 25-49	16.50	3.46	1.94
male 50-64	9.47	2.27	3.12
male ≥65	7.89	1.85	8.56
all male	*49.31*	*3.72*	*3.61*
female ≤16	8.84	4.01	1.68
female 16-24	5.84	4.24	2.39
female 25-49	16.68	2.81	2.08
female 50-59	6.33	2.34	2.26
female ≥60	12.99	1.84	6.79
all female	*50.69*	*2.83*	*3.19*

LSOA attendance rates per year per 100 people

Table 4. Determinants of AED attendance for *minor* and *serious* conditions

	minor conditions[1]		*serious* conditions[1]		Difference in attendance rates		
	Coef	t-stat	Coef	t-stat	Diff	t stat[2]	t-stat[3]
Nearest AED km	-0.016	(-2.22)	-0.034	(-9.58)	0.018	(2.18)	(-2.30)
Nearest WIC km	0.054	(17.43)	-0.004	(-2.62)	0.058	(15.97)	(-16.76)
Nearest GP km	-0.081	(-1.76)	0.021	(0.93)	-0.10	(-1.90)	(1.99)
Village	-0.63	(-5.59)	-0.008	(-0.14)	-0.62	(-4.71)	(4.94)
Rural	-0.26	(-1.56)	-0.079	(-0.95)	-0.18	(-0.92)	(0.97)
Income deprivation	-5.07	(-5.00)	5.20	(10.24)	-10.27	(-0.103)	(9.05)
Education deprivation	0.014	(3.22)	-0.002	(-1.04)	0.016	(3.19)	(-3.34)
Not good SAH	0.080	(1.76)	-0.069	(-3.01)	0.15	(2.78)	(-2.92)
DLA claimants	0.11	(2.49)	-0.018	(-0.83)	0.12	(2.48)	(-2.60)
Incapacity claimants	-0.014	(-0.26)	0.109	(4.11)	-0.12	(-1.93)	(2.03)
LLI rate	0.040	(1.42)	0.058	(4.01)	-0.018	(-0.54)	(0.57)
Males under 15	-2.02	(-0.58)	-0.34	(-0.20)	-1.67	(-0.41)	(0.43)
Males 15-24	-2.40	(-0.86)	-4.31	(-3.07)	1.90	(0.58)	(-0.61)
Males 50-64	7.06	(1.70)	-5.36	(-2.58)	12.42	(2.55)	(-2.67)
Males 65 plus	-10.18	(-2.65)	-3.04	(-1.58)	-7.14	(-1.58)	(1.66)
Females under 15	-1.77	(-0.49)	-3.33	(-1.84)	1.56	(0.37)	(-0.38)
Females 15-24	-2.78	(-1.09)	-2.33	(-1.84)	-0.44	(-0.15)	(0.16)
Females 25-49	5.03	(1.41)	-4.00	(-2.23)	9.03	(2.15)	(-2.26)
Females 50-59	-5.69	(-1.17)	-11.08	(-4.57)	5.39	(0.95)	(-1.00)
Females 60 plus	-4.63	(-1.59)	6.70	(4.61)	-11.33	(-3.32)	(3.49)
Constant	1.76	(1.11)	4.12	(5.20	-2.36		(1.33)
Observations	2699		2699			2699	5398
R^2	0.212		0.433				0.269

[1] Dependent variables: LSOA AED attendance rates per year per 100 population.
[2] *t* statistic from regression of difference in *minor* and *serious* attendance rates per year per 100 population.
[3] *t* statistic from pooled regression with a dummy for *serious* and a full set of interactions of the *serious* dummy with the explanatories.

Table 5. Age and gender stratified cross section models for AED *minor* condition attendance rate

Explanatory variables	**Males u15**	**Males 15-24**	**Males 25-49**	**Males 50-64**	**Males 65 plus**	**Females u15**	**Females 15-24**	**Females 25-49**	**Females 50-59**	**Females 60 plus**
Nearest AED km	-0.077	0.003	-0.012	-0.025	-0.031	-0.068	0.020	-0.001	-0.029	-0.030
	(-5.58)	(0.19)	(-1.39)	(-3.41)	(-4.23)	(-5.79)	(1.54)	(-0.18)	(-3.54)	(-4.98)
Nearest WIC km	0.053	0.059	0.057	0.048	0.063	0.047	0.066	0.051	0.053	0.059
	(8.68)	(9.58)	(14.80)	(14.90)	(19.42)	(9.03)	(11.17)	(15.56)	(14.67)	(21.96)
Nearest GP km	-0.235	-0.053	-0.025	-0.097	-0.107	-0.206	-0.055	-0.074	-0.044	-0.020
	(-2.60)	(-0.58)	(-0.45)	(-2.02)	(-2.23)	(-2.65)	(-0.63)	(-1.53)	(-0.82)	(-0.51)
Village	-1.087	-0.593	-0.658	-0.580	-0.594	-0.719	-0.904	-0.648	-0.636	-0.564
	(-4.90)	(-2.63)	(-4.72)	(-4.92)	(-5.03)	(-3.78)	(-4.23)	(-5.48)	(-4.83)	(-5.77)
Rural	-0.137	0.087	-0.470	-0.121	-0.265	-0.227	-0.156	-0.426	-0.338	-0.388
	(-0.42)	(0.26)	(-2.30)	(-0.70)	(-1.53)	(-0.81)	(-0.50)	(-2.45)	(-1.75)	(-2.70)
Income deprivation	-8.457	-10.003	-7.539	-3.945	-1.862	-9.099	-6.578	-4.889	-3.003	-2.327
	(-4.69)	(-5.46)	(-6.64)	(-4.11)	(-1.94)	(-5.88)	(-3.79)	(-5.08)	(-2.81)	(-2.93)
Education deprivation	0.001	0.024	0.030	0.011	0.000	0.014	0.008	0.017	0.009	0.006
	(0.17)	(2.97)	(5.86)	(2.63)	(0.09)	(2.01)	(0.97)	(3.85)	(1.83)	(1.79)
Not good SAH	0.368	0.236	0.127	0.114	0.107	0.286	0.267	0.145	0.064	0.084
	(4.17)	(2.64)	(2.29)	(2.44)	(2.27)	(3.78)	(3.15)	(3.08)	(1.23)	(2.16)
DLA claimants	0.322	0.131	0.067	-0.039	-0.045	0.264	0.101	0.108	0.026	-0.029
	(3.89)	(1.56)	(1.29)	(-0.89)	(-1.01)	(3.71)	(1.26)	(2.44)	(0.54)	(-0.79)
Incapacity claimants	-0.037	0.165	0.145	0.147	0.072	0.037	0.116	0.107	0.099	0.046
	(-0.39)	(1.69)	(2.40)	(2.89)	(1.42)	(0.45)	(1.26)	(2.09)	(1.74)	(1.08)
LLI rate	-0.135	-0.045	-0.004	-0.044	-0.049	-0.114	-0.059	-0.062	-0.032	-0.040
	(-3.00)	(-0.98)	(-0.14)	(-1.84)	(-2.04)	(-2.95)	(-1.37)	(-2.57)	(-1.20)	(-2.00)
Constant	3.576	1.841	1.108	1.573	1.401	3.006	1.550	1.260	1.543	1.313
	(11.81)	(5.99)	(5.82)	(9.78)	(8.68)	(11.58)	(5.32)	(7.80)	(8.59)	(9.84)
Observations	2699	2699	2699	2699	2699	2699	2699	2699	2699	2699
R^2	0.099	0.094	0.184	0.109	0.137	0.109	0.097	0.172	0.103	0.173

Dependent variables: LSOA *minor* condition AED attendances per year per 100.

Table 6. Age and gender stratified cross section models for AED *serious* condition attendance rate

Explanatory variables	**Males u15**	**Males 15-24**	**Males 25-49**	**Males 50-64**	**Males 65 plus**	**Females u15**	**Females 15-24**	**Females 25-49**	**Females 50-59**	**Females 60 plus**
Nearest AED km	-0.018	-0.009	-0.027	-0.055	-0.110	-0.015	-0.029	-0.032	-0.034	-0.079
	(-3.16)	(-1.75)	(-6.04)	(-6.96)	(-6.73)	(-2.99)	(-3.58)	(-7.05)	(-4.70)	(-6.25)
Nearest WIC km	-0.029	-0.002	-0.001	-0.000	0.012	-0.025	0.003	0.002	0.001	-0.013
	(-11.91)	(-1.04)	(-0.71)	(-0.13)	(1.62)	(-10.77)	(0.98)	(1.04)	(0.18)	(-2.40)
Nearest GP km	-0.010	-0.007	0.034	-0.073	-0.234	0.008	0.059	0.070	-0.057	-0.137
	(-0.28)	(-0.19)	(1.14)	(-1.39)	(-2.18)	(0.23)	(1.13)	(2.34)	(-1.21)	(-1.65)
Village	0.161	0.055	0.122	-0.041	-0.389	0.091	0.250	0.021	-0.060	-0.371
	(1.80)	(0.64)	(1.68)	(-0.32)	(-1.47)	(1.10)	(1.94)	(0.28)	(-0.52)	(-1.82)
Rural	0.147	0.033	0.025	0.125	-0.449	0.001	0.096	-0.111	0.101	-0.608
	(1.12)	(0.26)	(0.24)	(0.66)	(-1.16)	(0.01)	(0.51)	(-1.03)	(0.60)	(-2.04)
Income deprivation	2.686	2.609	5.539	7.103	20.767	1.095	4.899	4.315	5.770	17.355
	(3.69)	(3.71)	(9.40)	(6.83)	(9.69)	(1.62)	(4.67)	(7.22)	(6.17)	(10.49)
Education deprivation	0.003	-0.002	0.001	-0.004	-0.015	0.007	0.015	0.008	-0.001	-0.031
	(1.02)	(-0.52)	(0.40)	(-0.89)	(-1.56)	(2.24)	(3.24)	(2.87)	(-0.16)	(-4.17)
Not good SAH	-0.022	-0.100	-0.115	0.053	0.103	-0.065	-0.136	-0.099	-0.049	0.022
	(-0.61)	(-2.90)	(-4.00)	(1.03)	(0.98)	(-1.96)	(-2.65)	(-3.38)	(-1.07)	(0.27)
DLA claimants	0.062	0.013	-0.044	-0.086	-0.310	0.061	-0.083	0.021	-0.012	-0.255
	(1.87)	(0.40)	(-1.64)	(-1.80)	(-3.15)	(1.97)	(-1.73)	(0.78)	(-0.29)	(-3.35)
Incapacity claimants	-0.001	0.076	0.196	0.350	0.257	0.021	0.099	0.108	0.219	0.215
	(-0.02)	(2.05)	(6.26)	(6.34)	(2.26)	(0.59)	(1.77)	(3.39)	(4.41)	(2.45)
LLI rate	-0.007	0.028	0.038	-0.077	0.018	0.017	0.062	0.017	-0.031	0.106
	(-0.38)	(1.59)	(2.57)	(-2.95)	(0.34)	(0.99)	(2.37)	(1.16)	(-1.32)	(2.58)
Constant	2.224	1.250	1.285	3.009	6.871	1.801	1.626	1.559	2.148	5.035
	(18.20)	(10.60)	(12.99)	(17.23)	(19.10)	(15.88)	(9.24)	(15.55)	(13.70)	(18.13)
Observations	2699	2699	2699	2699	2699	2699	2699	2699	2699	2699
R^2	0.131	0.041	0.263	0.220	0.211	0.107	0.087	0.234	0.158	0.226

Dependent variables: LSOA *minor* condition AED attendances per year per 100.

Table 7. AED attendance rates without LSOAs near Leicester

	Minor conditions		*Serious* conditions	
	Coef	t stat	Coef	t-stat
Nearest AED km	0.016	(2.22)	-0.026	(-6.30)
Nearest WIC km	0.017	(5.08)	-0.0031	(-1.63)
Nearest GP km	-0.16	(-3.46)	0.029	(1.13)
Village	2.94	(0.82)	-1.36	(-0.67)
Rural	2.27	(0.68)	-3.02	(-1.61)
Income deprivation	0.42	(0.36)	5.16	(7.86)
Education deprivation	0.015	(3.17)	-0.0050	(-1.93)
Not good SAH	0.22	(4.69)	-0.092	(-3.55)
DLA claimants	-0.079	(-1.89)	0.017	(0.74)
Incapacity claimants	-0.045	(-0.79)	0.069	(4.67)
LLI rate	-0.037	(-1.30)	0.075	(2.13)
Males under 15	20.7	(4.70)	-6.96	(-2.80)
Males 15-24	-8.04	(-2.07)	-2.22	(-1.01)
Males 50-64	3.66	(0.98)	-1.79	(-0.86)
Males 65 plus	-1.69	(-0.63)	-4.02	(-2.67)
Females under 15	5.78	(1.57)	-3.82	(-1.85)
Females 15-24	-6.88	(-1.36)	-9.87	(-3.47)
Females 25-49	-2.07	(-0.69)	5.12	(3.05)
Females 50-59	-1.00	(-8.87)	0.0479	(0.76)
Females 60 plus	-0.716	(-4.41)	-0.0513	(-0.56)
Constant	0.267	(0.16)	4.00	(4.30)
Observations	2046		2046	
R^2	0.202		0.392	

Dependent variable: LSOA AED attendance rates per year per 100 population

Table 8 Alternative functional forms

	minor conditions		*serious* conditions	
	Coef	t-stat	Coef	t-stat
Nearest AED ln km	-0.0845*	(-2.41)	-0.0767***	(-6.78)
Nearest WIC ln km	0.503***	(16.64)	-0.0650***	(-6.68)
Nearest GP ln km	0.0540	(1.55)	-0.00734	(-0.65)
Village	-0.0676	(-0.95)	-0.0187	(-0.82)
Rural	0.0341	(0.36)	-0.0138	(-0.45)
Income deprivation	-3.205***	(-4.80)	0.990***	(4.60)
Education deprivation	0.000261	(0.10)	0.00241**	(2.74)
Not good SAH	-0.00781	(-0.27)	-0.0212*	(-2.28)
DLA claimants	0.127***	(4.75)	-0.000294	(-0.03)
Incapacity claimants	-0.0225	(-0.65)	0.0222*	(2.01)
LLI rate	0.0390*	(2.17)	0.0201***	(3.48)
Males under 15	-6.024**	(-2.74)	-0.331	(-0.47)
Males 15-24	-5.746**	(-3.24)	-1.429*	(-2.50)
Males 50-64	-3.669	(-1.39)	-0.865	(-1.02)
Males 65 plus	-5.132*	(-2.11)	-1.416	(-1.81)
Females under 15	-4.630*	(-2.02)	0.0517	(0.07)
Females 15-24	-0.774	(-0.48)	-1.176*	(-2.28)
Females 25-49	1.138	(0.51)	-0.838	(-1.16)
Females 50-59	-7.941**	(-2.60)	-3.576***	(-3.63)
Females 60 plus	-5.366**	(-2.91)	2.468***	(4.16)
Constant	-2.753**	(-2.77)	-3.255***	(-10.15)
Observations	2699		2699	
R^2	0.188		0.327	

Dependent variables: log of LSOA *minor* condition AED attendances per year per 100
p-values: * = p < 0.05, **= p < 0.01, *** = p < 0.001.

Table 9. Elasticities of AED attendance with respect to distance

	Linear model		Log model	
	Minor	*Serious*	*Minor*	*Serious*
Distance to nearest AED	-0.0540*	-0.114***	-0.0845*	-0.0767***
	(-2.19)	(-9.10)	(-2.41)	(-6.78)
Distance to nearest WIC	0.314***	-0.0265**	0.503***	-0.0650***
	(16.69)	(-2.59)	(16.64)	(-6.68)
Distance to nearest GP	-0.0383	0.00958	0.0540	-0.00734
	(-1.72)	(0.93)	(1.55)	(-0.65)

For the linear models the elasticities are the average elasticities, not the elasticities at the average. *t* stats in brackets. * p <0.05, ** p < 0.01, *** p < 0.001.