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Factors Influencing A & E Attendance, Admissions and Waiting Times at Two London Hospitals

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Authors' contributions

This work was carried out in collaboration between both authors. Author NB designed the study. Author RPJ performed the analysis and wrote the first draft of the manuscript. Author RPJ managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: To inform wider debate regard attendance at the Accident & Emergency department via analysis of the complex factors regulating attendances at two London hospitals.
Study Design: Analysis of 508,569 A&E attendances from a large hospital data base.
Place and Duration of Study: Attendances between 2013/14 and 2015/16 at Kings College hospital (Denmark Hill, inner London) and between 2014/15 and 2015/16 at Princess Royal hospital (Orpington, outer London).
Methodology: Analysis of attendances and time spent in A&E based on age, gender, presenting condition, frequency of re-attendance, distance from hospital, time of day, day-of-week, month of year and deprivation score.
Results: Only 59% of attendances were from persons whose home address was closest to either KCH or PRH, indicating immediate location rather than home address plays a huge role in access to an A&E (especially for London hospitals). Unwell adult was the most common presenting condition. Some 84% of persons presenting with stroke were admitted, and 56% of persons presenting with cardiac arrest died in A&E. Children in the first year of life had the highest number of attendances, but the proportion admitted increases with age. Attendances declined in an

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exponential manner with distance, although the decay rate varied between the two sites. Attendance rates increased with Index of Multiple Deprivation (IMD) score, and were 50% higher in the most deprived areas compared to the very least deprived. Number of attendances peak on Monday and Friday, but admission rate is lowest on the weekend. Persons commuting to London for work have higher weekday attendances, while tourists and visitors have higher weekend attendances. Attendances reach a minimum, while the proportion who die reaches a maximum, in the interval between 6 am to 7am, while the proportion admitted peaks between 5 am and 6 am. Some 49% of persons (average age of 36 years) did not re-attend, while the 0.41% who re-attended after 10 days had an average age of 45.5 years.

Conclusions: A&E attendance at any hospital is a complex expression of a whole system, of which access to primary care by local residents is only a part of the bigger picture.

Keywords: Accident and emergency; age; distance; deprivation; admission rates; circadian and weekly patterns; gender; re-attendance; admitted.

ABBREVIATIONS

A&E : Accident and Emergency (equivalent to Emergency Department);
CCG : Clinical Commissioning Group;
CCU : Critical Care Unit;
IMD : Index of Multiple Deprivation;
KCH : Kings College Hospital;
OA : Output Area (contains roughly 300 persons);
OAC : Output Area Classification (derived from variables collected during the Census);
PRH : Princess Royal Hospital;
LSOA : Lower Super Output Area (contains roughly 1,500 persons);
LOAC : London Output Area Classification;

1. INTRODUCTION

In the UK, the National Health Service (NHS) provides taxation-funded and free-of-charge (mental health, primary, secondary and tertiary) medical care to all residents. Dental services are excluded and patients pay a fixed charge for drugs (waived for those with long term conditions and over the age of 60). Visitors to the UK also receive free-of-charge care for attendances to the Accident and Emergency (A&E) department. Hence there is no distortion in attendances due to insurance issues, as is observed in the US.

In England, there is an artificial split between providers and commissioners of health care. Commissioners are charged for A&E attendances at a price set by the National Tariff (based on cost data collected two years previously). In 2015/16 the tariff for an A&E attendance ranged from £57 for an attendance with no investigation and no significant treatment, dental care or attendance at a walk-in centre (a non-acute alternative to A&E), through to £246 for the most serious (category 5) treatment. While a relatively minor attendance only costs £57, this is far more expensive that a visit to a General Practitioner (also free-of-charge), where GPs are paid less than £200 per person per annum to care for all of their registered patients or roughly £45 per visit or £13 per visit to a practice nurse.

For the 12 months ending February 2016 there were some 20.3 million Accident and Emergency (A&E) attendances in England, and since 2009 A&E attendances have grown by 30.5%, or roughly 5% per annum [1]. Higher than expected growth in A&E attendances is not a new phenomenon, nor is it confined to England. Higher growth along with increasing complexity and proportion admitted has been observed in Australia, Canada, New Zealand, Northern Ireland, Spain, Switzerland, and the US [2-9].

In the interval 1974 to 1985 the increase in attendance in England was observed to show highest growth in those areas with highest (raw) rates of attendance per head of population [10]. Growth has also seemingly increased over time [5-6]. For example, in the decade 1979 to 1989 growth in new attendances in England only averaged 2% per annum [11]. However, between 1990 and 1994 the Leeds General Infirmary A&E department noted a 7% and 32% increase in total attendances and ambulance arrivals respectively [12]. The percentage admitted increased with increasing age [6,12], suggesting that the cause(s) may be more complex than realised [13-15]. One study in Oxfordshire demonstrated that only 36% of the increase could be explained by changes in population age structure [16], and this was similar to that observed in Australia [6]. In the USA, A&E attendances also showed a marked increase from around 1993 [17].

In an era of close to zero incremental growth in real terms NHS funding this growth represents a substantial cost pressure to Clinical Commissioning Groups (CCGs), and places considerable operational pressure on A&E departments to achieve waiting time targets. In this context, ways need to be found to flexibly deploy A&E staff to match demand with resources, and to segment the population into identifiable groups who may benefit from targeted attempts to reduce A&E attendance.

The King's College hospital (KCH) is a large specialist teaching hospital situated in the Denmark Hill area of London with around 10,600 A&E attendances per month, while the Princess Royal hospital (PRH) with around 4,920 attendances per month is located some 12 km away in Orpington on the outskirts of London. Attendances to the A&E departments at both hospitals are included in this study.

In the UK, all census data is aggregated at the primary level of an Output Area (OA). In London each OA contains an average of 336 persons (interquartile range 276 to 385), and is chosen based on similarity of the social and demographic characteristics of the residents. These area groupings, called the Output Area Classification (OAC) are constructed in a similar manner to that used by commercial marketing companies [18]. Due to its unique social and ethnic composition London has its own London Output Area Classification (LOAC) [19] which is used in this study. The LOAC divides London into 48 sub-groups each with similar age structure, ethnic composition, occupation, housing, education, etc. Each output area is then aggregated to a Lower Super Output Area (LSOA) containing around 1,500 persons, and then to higher geographies including electoral wards and local authorities.

Each LSOA has a measure of deprivation called the Index of Multiple Deprivation (IMD), which as the name suggests measures 'deprivation' across multiple domains such as income, crime, and access to services, health status, etc [20]. The IMD is known to correlate well with all manner of health behaviours (smoking, obesity, etc), and consequent poor health outcomes such as emergency admissions, mental health and chronic poor health [21-24]. This paper will also utilize the output of a simple method for allocating IMD values to the smaller OA groups using the LOAC, and relative population sizes. Patient A&E attendances are then allocated to an OA with its associated LOAC or IMD to determine the factors indicating high A&E utilisation. Population weighted OA geographic centroids (Easting, Northing) were used to plot the location of admissions using simple Excel charts. In this context the OA code has the huge advantage of removing patient identifiable features such as postcode from any associated analysis.

Most studies tend to focus on a single aspect of A&E and hence there is a dearth of basic comparative data regarding A&E attendances against which other hospitals can make comparison. To meet this need considerable information has been placed in the Appendix.

Lastly the paper attempts to view attendances as the output of a complex whole system, with suggested approaches to resolving some of the issues.

2. MATERIALS AND METHODS

2.1 Data Sources

The raw data in this study comprises A&E department attendances at the KCH situated in the Denmark Hill area of London between April 2013 to March 2016 (average 10,493 attendances per month), and at the PRH situated in Orpington (outer London) between January 2015 to March 2016 (average 4,920 attendances per month). These two sites are around 12 km (straight line distance) apart.

Single year of age populations in 2015 for London and elsewhere were obtained from the Office for National Statistics. Postcode to output area code is as per the lookup Table Supplied by NHS England and was performed separate to this analysis. Output area (OA) population centroids (Easting, Northing), OA to lower super output area (LSOA) lookup tables, and LSOA values for the Index of Multiple Deprivation (IMD) were all from the Office for National Statistics. The London Output Area Classification (LOAC) was obtained from the London Data Store. All data, other than that for A&E attendances, is publicly available. The data file for attendances is available on request.

2.2 Estimating IMD for Each OA

As mentioned in the Introduction, the IMD is measured at LSOA level. In London, each LSOA comprises a median number of 5 OA (range 2 to 12). Given that the wealthy and poor can live within close proximity the LSOA-based IMD is insufficiently accurate for precise identification of deprivation in small social groups seen at OA level.

The IMD for each OA in London was estimated from published LSOA-based IMD data in the following way. First, the LSOA IMD was averaged across all LOAC sub-groups. This enables all LOAC sub-groups to be ranked by relative IMD. For example, all B2b sub-groups have an average IMD of 43 (being the most deprived sub-group), while all H1c sub-groups have an average IMD of 7 (least deprived).

However, not all similar sub-groups experience the same level of deprivation across the whole of London. Adjusted values of IMD for each OA were then further refined as follows. All OA were grouped according to their respective LSOA. The LSOA value of IMD was then utilized as the population weighted average across all OA's within each LSOA using the LOAC sub-group IMD averages calculated above. For example, say a LSOA has an IMD value of 10, but has two LOAC subgroups with averaged IMD scores of 9 (population 1,200) and 15 (population 900). Hence the adjusted IMD scores will be for LOA1 = [(10 x 1,200 + 10 x 900)/(9 x 1,200 + 15 x 900)] x 9, and for LOA2 = [10 x (1,200 + 900)/(9 x 1,200 + 15 x 900)] x 15. This process adjusts the LOAC sub-groups to their respective local IMD value. For example, the range in IMD across all B2b sub-groups is 23 to 71, while the range across all H1c sub-groups is 1 to 15.

2.3 Effective Travel Distance

Approximate travel distances between OAs and the location of various critical care units was calculated as follows. Population weighted centroids give the distance north (northings) and east (eastings) from the UK focal point in meters. The easting and northing for every London critical care unit was obtained from the postcode of the hospital (as given on the respective website for each hospital), with postcode converted to easting and northing using the online tool, nearby.org.uk. Since ambulances, cars or busses cannot travel in a direct straight line (Euclidean metric), the effective travel distance was estimated as the sum of the two sides of the triangle (Manhattan metric – based on the grid-like geography of the Manhattan district of New York) rather than the hypotenuse (the straight line distance), i.e. approximate travel distance = absolute value of (Easting 1 – Easting 2) + absolute value of (Northing 1 – Northing 2). Value in meters divided by 1,000 to give kilometers (km). Each OA was then assigned to its nearest hospital using the effective travel distance. OA populations can then be summed to give the core population surrounding each hospital.

2.4 Estimating Admission Rate

The issue of small numbers has been addressed by using attendance data over a three-year period between April 2013 and March 2016. All admission rates are for this time period except for data covering the PRH site which covers a 17-month period ending March 2016.

Due to the role of distance in attendance rate (see below) all attendance rates have been adjusted for the relationship between equivalent travel distance and attendance rate. This adjustment has been performed for each OA followed by aggregation of OA into IMD groups where the distance-adjusted count of attendances has been summed for each group and then divided by the sum of population across the OAs in that group.

2.5 Mathematical Manipulation

All mathematical manipulation was performed using Microsoft Excel (v2010). Tabulated data was extracted using the Pivot Table function in Excel. All Charts were constructed using the graphical tools available in Excel.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Data accuracy and home place for attendees

Data used in this study comprises three financial years (2013/14 to 2015/16) and covers some 508,569 A&E attendances. Patients attended from all of the 120 UK postcode districts (see Table A1 in the Appendix), along with 6,160 persons from overseas (1.2% of the total). Overseas visitors are entitled to free A&E treatment during their stay in the UK.

In the UK, postcodes come in two halves with the first half containing three or four digits and the last half containing three. A degree of postcode cleansing was required to rectify common errors such as a missing space between the two halves of the post code, '0' substituted for 'O' or 'I' for '1' and vice versa, and other minor errors. After cleansing, some 95.2% of all attendances were allocated to an output area (OA) – see Table A1 in the Appendix. Most parts of London had in excess of 99% of attendances allocated to an OA. This is lower in some postcode areas, especially in those postcode areas which straddle the outer border of London. Lowest conversion rate (5.3%) to an OA occurred in postcodes lying in East London postcode district. This is not a serious limitation since East London only represents 0.6% of total attendances. Poor conversion appears to be due to higher recourse to truncated postcodes, i.e. E1 as opposed to the full five-digit code.

The preliminary analysis involving month, week, day and hour does not involve the OA code (reliant on an accurate post code). Date and time for each attendance are highly accurate as are additional details such as died in department and admitted to a hospital bed. Most presenting conditions are relatively self-explanatory but could be subject to a small level of ambiguity where a primary and secondary condition may be involved. Only 12 in 508,000 attendances (0.002%) have a blank presenting condition, while only 541 of attendances (0.1%) have a missing age. Areas closest to either hospital have the highest postcode and hence OA accuracy, hence all aspects of the data have a high level of reliability.

Fig. 1 shows the geographic distribution of attendances at KCH/PRH, where it can be seen that the bulk of attendances come from the typical London commuter belt, with expected large flows from Kent due to high speed rail links to London. An additional high inflow also occurs along the M4 motorway corridor and its associated rail links. The outer London PHRU catchment area is to the right of the larger inner London cluster of attendances.

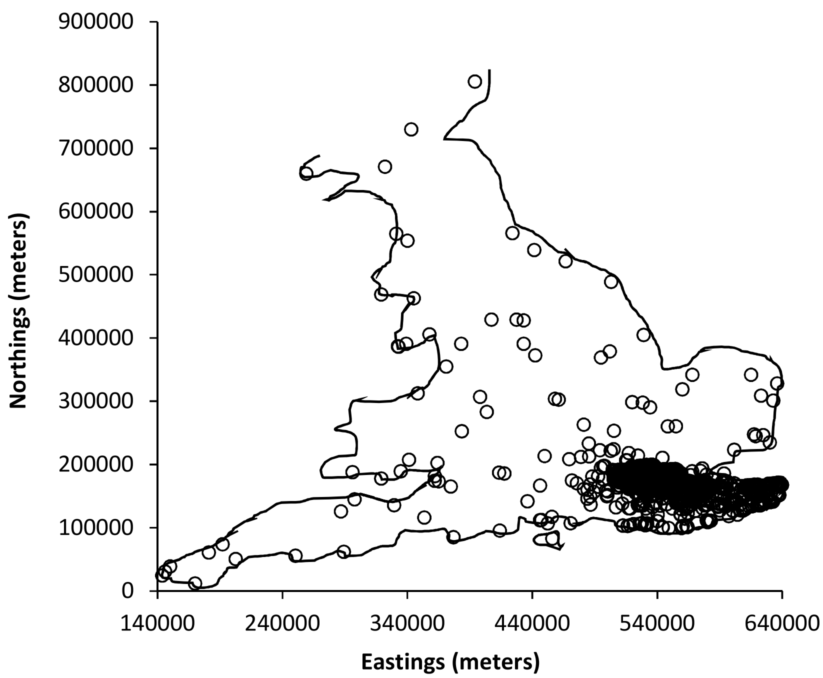

Fig. 1. Location (Easting, Northing) of patient's home for those attending the two London A&E departments

Not all locations outside of London have been included

Given the highly mobile nature of the population both within and around London Table A2 shows the proportion of attendances split by nearest hospital to the person's home address. As can be seen 40.8% of all attendances are from locations where either KCH or PRH are not the closest hospital to the person's home address. Hence the decision is not regarding 'how can I access my GP?' but rather 'how can I obtain medical assistance given my current location, and the time of day?' Hence the arguments around GP availability, may to some degree be a red herring.

3.1.2 Presenting condition

At initial triage (before a definitive diagnosis is determined) all attendances are assigned to one of a number of presenting condition/complaint groups. Details of the relative number of attendances for each presenting condition, along with average age, and the percent who died in the department, were admitted as an inpatient or who left before being seen are given in Table 1. As can be seen unwell adults comprise the highest number of attendances of which 33% proceed to an inpatient admission and 0.1% die in the A&E department. At the extremes some 56% of persons with cardiac arrest die in A&E, while 84% of persons with a presenting condition of 'stroke' are admitted. Persons who leave without being seen are predominantly those from the mental health, alcohol, overdose, self-harm or dental problems categories. No one with a haematological condition left before being seen.

Table 1. Frequency of attendance, average age, proportion who died or were admitted by presenting condition (2013/14 to 2015/16)

Condition	Attend-ances (n)	Attend-ances (%)	Average age	Admitted	Died	Left w/o being seen
Unwell adult	108,231	21.30%	50	33%	0.1%	3.6%
Limb problems	74,980	14.70%	36	7%	0.0%	2.8%
Unwell child	42,309	8.30%	4	11%	0.0%	1.2%
Abdominal pain/Adult	34,635	6.80%	41	32%	0.0%	2.8%
Chest pain	26,696	5.20%	47	26%	0.0%	3.5%
Falls	17,643	3.50%	52	36%	0.0%	2.2%
Shortness of breath/Adult	14,301	2.80%	59	54%	0.2%	2.2%
Head injury	13,735	2.70%	28	9%	0.0%	4.0%
Wounds	12,689	2.50%	31	5%	0.0%	3.6%
Eye problems	12,498	2.50%	37	2%	0.0%	3.0%
Back pain	11,568	2.30%	44	17%	0.0%	3.0%
Mental illness	8,735	1.70%	38	6%	0.0%	10.0%
Headache	7,789	1.50%	39	21%	0.0%	3.8%
Vomiting	7,530	1.50%	25	26%	0.0%	2.3%
Urinary problems	7,476	1.50%	59	33%	0.0%	1.6%
Collapsed adult	6,581	1.30%	59	43%	0.3%	3.7%
Major trauma	6,047	1.20%	37	71%	0.8%	0.1%
Rashes	5,629	1.10%	16	4%	0.0%	2.3%
Stroke	5,472	1.10%	69	84%	0.2%	0.3%
Infections/Abscess	5,431	1.10%	36	20%	0.0%	2.3%
PV bleeding	5,069	1.00%	33	12%	0.0%	2.9%
Fits	4,890	1.00%	34	37%	0.1%	3.5%
Pregnancy	4,712	0.90%	29	15%	0.0%	3.6%
Overdose/Poisoning	4,502	0.90%	31	30%	0.1%	6.2%
Ear problems	4,165	0.80%	26	1%	0.0%	2.7%
Shortness of breath/Child	4,042	0.80%	3	26%	0.0%	0.8%
Assault	4,012	0.80%	32	9%	0.0%	7.3%
Streaming nurse re-directed	3,631	0.70%	38	0%	0.0%	n/a
Asthma	3,439	0.70%	26	27%	0.0%	2.2%
Dental problems	3,237	0.60%	33	10%	0.0%	7.7%
Foreign body	3,124	0.60%	24	4%	0.0%	3.2%
Abdominal pain/Child	3,067	0.60%	9	12%	0.0%	1.1%
Neck pain	2,776	0.50%	35	5%	0.0%	3.0%
Sore throat	2,675	0.50%	30	8%	0.0%	2.7%
Apparently drunk	2,339	0.50%	40	13%	0.0%	19.1%
Bites & Stings	2,048	0.40%	34	6%	0.0%	3.5%
Burns & Scalds	1,955	0.40%	26	2%	0.1%	2.9%

Condition	Attend-ances (n)	Attend-ances (%)	Average age	Admitted	Died	Left w/o being seen
Nasal problems	1,861	0.40%	41	13%	0.0%	4.2%
Diarrhea & vomiting	1,691	0.30%	23	18%	0.0%	2.1%
Limping child	1,684	0.30%	10	2%	0.0%	0.7%
Diarrhea	1,605	0.30%	37	29%	0.1%	1.9%
Pyrexia	1,566	0.30%	7	14%	0.0%	1.1%
Gastrointestinal bleeding	1,505	0.30%	55	47%	0.0%	2.2%
Testicular pain	1,463	0.30%	31	25%	0.0%	1.9%
Diabetes	1,459	0.30%	50	53%	0.0%	3.5%
Hematological diseases	1,255	0.20%	41	60%	0.0%	0.0%
Worried parent	818	0.20%	3	7%	0.0%	1.3%
Needle stick fracture	768	0.20%	34	0%	0.0%	1.6%
Requests medication	767	0.20%	38	1%	0.0%	9.5%
Cardiac arrest	511	0.10%	63	41%	56.0%	0.2%
Deliberate self harm	426	0.10%	30	15%	0.0%	8.9%
Truncal injury	417	0.10%	41	7%	0.0%	4.8%
Behave strangely	312	0.10%	41	24%	0.0%	5.1%
Crying baby	229	0.00%	0	6%	0.0%	0.9%
Exposure to chemical	156	0.00%	20	6%	0.0%	3.8%
Febrile convulsions	143	0.00%	3	13%	0.0%	0.7%
Hemorrhage	123	0.00%	56	37%	0.0%	3.3%
Splash injury	86	0.00%	33	1%	0.0%	3.5%
Sexual infection	31	0.00%	33	3%	0.0%	3.2%
Irritable child	23	0.00%	10	26%	0.0%	0.0%

As an indication of potential inappropriate use of A&E some 30.3% of the unwell adult group were discharged without need for further follow-up, while 31.9% were referred to follow-up by a GP, outpatient clinic or another healthcare professional.

Further analysis of the 'unwell adult' and 'unwell child' group are presented in Table A3 (Appendix) using the 'diagnosis' assigned to the attendance at the conclusion of the visit. Unfortunately, around 20% to 30% of visits do not contain a correctly recorded diagnosis, however, for those that do receive a diagnosis the majority of these attendances are to do with infections. Around 1% of adult and child attendances in this group are fevers of unknown origin.

3.1.3 Monthly, weekly, hourly patterns

Seasonal factors and holidays can influence A&E attendances and Table 2 examines some of the features relating to attendances by month of the year. Note that the proportion of attendances in each month has been adjusted to give a 31-day equivalent month. The adjusted proportion of annual attendances reaches a maximum in March (8.6% of annual total) and a minimum in August (7.8% of annual). The August dip is almost certainly due to the summer school holidays when many leave London to holiday in other locations. As can be seen, average time in A&E is roughly the inverse of attendances and reaches a maximum in February and a minimum in August. Length of time in the department is condition specific with unwell adults having a longer than average stay, while those who are admitted experience the longest average wait, presumably due to delay to find an available bed.

Average age is highest in January/December (40 for all attendances, 52 for unwell adult and 57 for those admitted – the latter average including children). Average reaches a minimum around September/October for unwell adult (49 years), or admitted (53 years) and for all attendances reaches a minimum in May (37 years).

The unavailability of GPs during the weekend is sometimes considered a reason for inappropriate use of A&E. Fig. 2 explores this issue by looking at the relative number of attendances by day of week and the proportion of patients who are admitted. Attendances for both all-conditions and unwell adults are included. As can be seen attendances peak on a Monday and Friday, while the proportion admitted rises from Monday to Friday, but with a distinct weekend minimum.

Fig. 3 explores the role of hour of the day where it can be seen that attendances reach a minimum at 6 am (6:00 to 6:59) and peak at 12 am (12:00 to 12:59). The proportion who are admitted is roughly the inverse and reaches a maximum at 5 am (5:00 to 5:59) and a minimum at 9 am (9:00

to 9:59). The proportion of attendances who die reaches a maximum of 0.41% at 6 am (6:00 to 6:59) and a minimum of 0.07% at 12 am (12:00 to 12:59). Average time spent in the department (Table A4) reaches a minimum of 3.67 hr at 9:00 am for all attendances and 5.24 hr for persons admitted, while the maximum of a 5.34 hr stay is reached for all attendances at just after midnight while a maximum of 6.29 hours occurs for admitted patients in the hour before midnight. These patterns suggest changing patterns in case-mix and severity throughout the day, plus an accumulation of patients which is not cleared until 8 to 9 am of the following day when a new influx repeats the cycle in waiting time.

Those who commute into London for work are highly likely to have lower rates of weekend attendance at the two London sites. A weekend to week day ratio can be calculated with a value of 40% roughly indicating equal weekend and week day attendance. Fig. 4 clearly demonstrates that the London commuter belt areas in Kent (the Dover, Medway and Tonbridge postcode sectors) and elsewhere have a higher ratio of week day attendances.

Table 2. Monthly attendances, average age, and average time in A&E

Month	Average time in A&E (hr)			Average age (years)				Proportion		
	All	Unwell adult	Admitted	All	Unwell adult	Admitted	Annual attendances†	Unwell adult	Admitted	Died
January	4.6	5.1	6.4	39.6	51.2	56.5	8.1%	21.9%	24.2%	0.13%
February	4.7	5.2	6.6	38.9	51.3	56.3	8.4%	22.2%	24.3%	0.11%
March	4.6	4.9	6.2	37.8	50.5	55.9	8.6%	21.6%	22.8%	0.11%
April	4.3	4.6	6.0	37.3	48.9	54.5	8.3%	21.5%	20.7%	0.09%
May	4.2	4.4	5.7	37.1	48.8	54.0	8.4%	20.6%	20.8%	0.08%
June	4.2	4.4	5.3	36.9	48.4	54.2	8.6%	20.2%	20.9%	0.10%
July	4.3	4.5	5.4	37.5	48.8	54.3	8.5%	21.3%	21.1%	0.09%
August	4.0	4.4	5.2	38.8	49.2	54.5	7.8%	21.6%	21.9%	0.08%
September	4.1	4.5	5.4	37.5	48.5	53.1	8.3%	20.7%	22.0%	0.10%
October	4.1	4.4	5.7	37.3	48.5	53.2	8.2%	21.0%	21.5%	0.08%
November	4.4	4.7	5.6	37.3	50.5	54.8	8.5%	20.3%	23.8%	0.10%
December	4.7	5.3	6.3	38.6	52.0	56.9	8.2%	22.3%	23.8%	0.12%

Footnote: † Monthly attendances all adjusted to a 31-day month

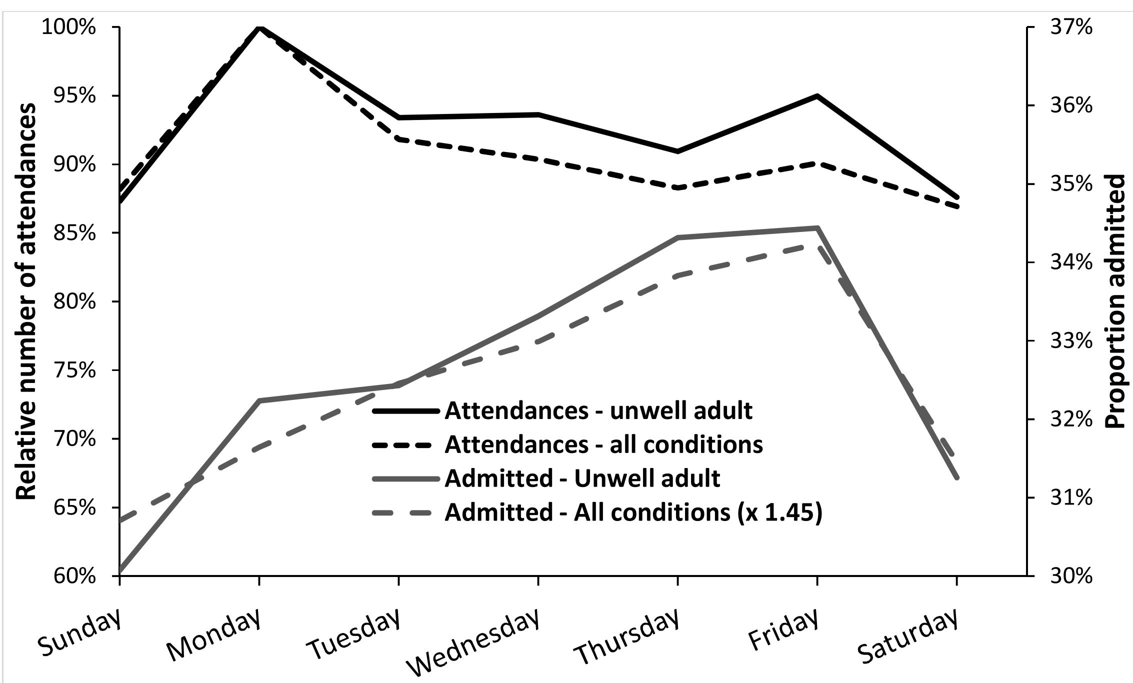

Fig. 2. Relative attendances by day of week and proportion admitted

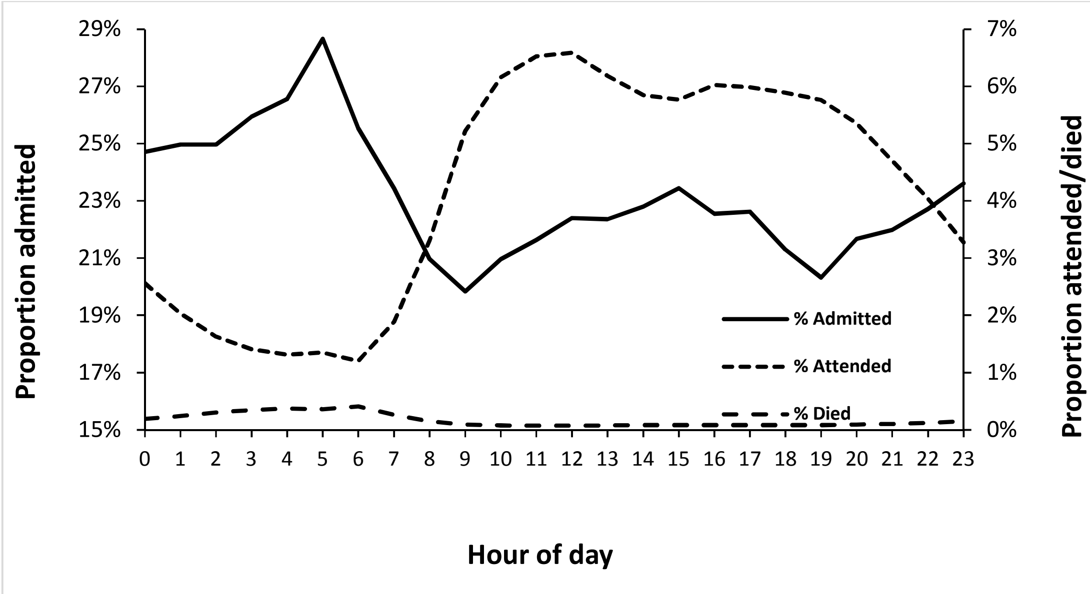

Fig. 3. Time of day and proportion attended, admitted or died

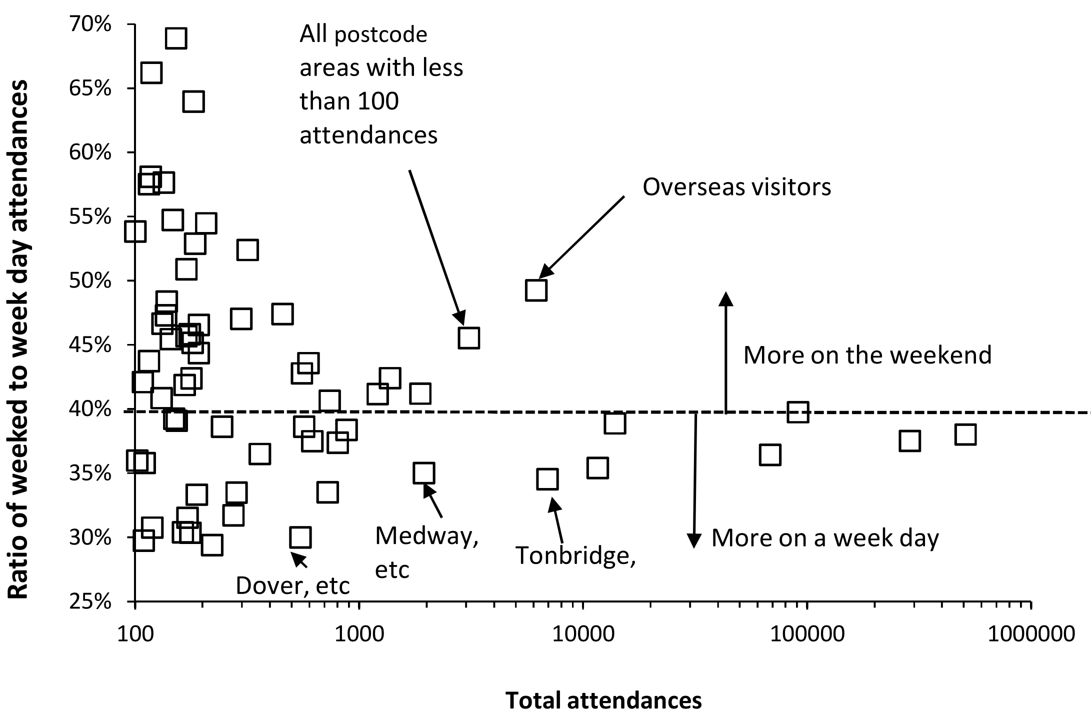

Fig. 4. Weekend to week day ratio of attendances by postcode district

Overseas visitors and other tourist visits seem to have a weekend preference to attend A&E. Fig. 4 has a logarithmic scale for number of attendances to give a typical fan-shaped response due to the increasing involvement of Poison randomness with decreasing size. As expected the weekend to week day ratio is sensitive to distance reaching an overall minimum of 35.9% for UK residents in any location with greater than a 15 km effective travel distance (data not shown) – on this occasion the ratio is driven by the far higher volume of week day work commuters rather than weekend tourist/social visits by UK residents.

However, the patterns of weekend and week day attendance are far more complex that just the movement of persons for work and recreation and Fig. A1 demonstrates clear age-dependant behaviour with a weekend maximum for young children, but a pronounced weekend minimum between the ages of 8 and 16 years. There is a second weekend minimum between the ages of 60 to 80, then rising to higher weekend attendances beyond age 80. This complexity continues with hour of the day (Fig. A2) which shows a clear weekend preference between the hours of midnight and 7 am. Beyond this there are two weekend minima at 9 am and 6 pm, and two smaller peaks in weekend attendance at 2 to 3 pm and 11 pm. Some of these trends support the notion regarding access to a GP while other peaks and troughs do not.

Lastly, Table A5 summarises the weekend to week day ratio by social group (LOAC) for London residents. Lowest weekend attendances are from the London fringes comprising typically older residents and more affluent week day commuters. Groups with higher weekend ratios tend to be University age students and typically younger inner city enclaves who are more likely to be socially active on the weekends and therefore away from home.

3.1.4 Age

The aim of this analysis is to identify those factors behind high A&E attendance in the two London hospitals, and as such no age standardization is required. Fig. 5 therefore presents the age profile (by gender) of attendances who are and are-not admitted. In those who are not admitted there is a large maximum for infants in their first year of life (especially in males) which declines to a minimum around age 13 in females and age 17 in males. Attendances then rise sharply to reach a second maxima at age 25 followed by a decline and broad shoulder between age 40 to 50 followed by further decline with increasing age. The equivalent to age-adjusted attendance profiles for England, and extremes of age structure are given In Fig. A3, where typical University cities have a pronounced peak at age 21 while more aged rural populations would show very high attendances from age 65 to 90.

For those who are admitted (Fig. 5) there is a distinct maximum during the first year of life followed by a minimum around age 10 to 14, number of admissions then continue to rise with age.

Given the different profiles between those who are and are not admitted Fig. 6 then investigates the proportion of attendances which are admitted by age and gender. Except for a slight increase for those in the first year of life the proportion admitted is somewhere around 10% through to age 35, and thereafter increases with age to around 75% to 80% admitted above age 90.

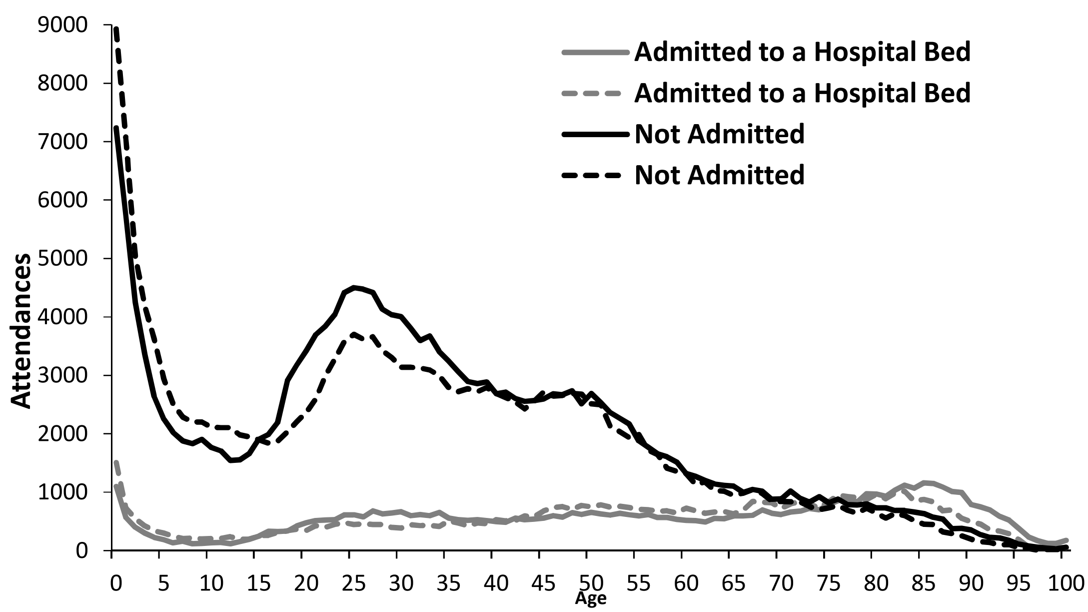

Fig. 5. Attendances by age and gender for persons who are, or are not admitted

3.1.5 Time spent in A&E

Given the 4-hour target for time spent in A&E within England this issue requires exploration. Table 2 has already presented information suggesting that average time in A&E reaches a minimum in August which is the month with lowest number of attendances. Longest waits are in the busiest months December to February. Table A4 gave additional information regarding hour of the day where attendances peak at 12 am (12:00 to 12:59), however time in the department peaks at midnight. Fig. A4 provides additional insight into the average stay for those who are admitted and those who are not, with those progressing to admission waiting one to two hours longer. Clearly those who are admitted face a second hurdle as they que for admission into an inpatient bed, and their waiting time profile shows a sharp minimum around 8 am climbing to a plateau between the hours of 4 pm and 5 am. Maximum delay occurs between 10 pm and 2 am.

Staffing appears to play a role since both admitted and not admitted show a sharp deterioration in waiting time between 10 pm and 2 am. Both also show a deterioration in waiting time between 8 am and 1 pm during the time in which attendances rise from their minimum to maximum values.

3.1.6 Distance

There is a well-known decline in the proportion who access health services as distance increases. However, London is somewhat of a unique situation. Some 50%, 75% and 95% of Londoners live within a 3.6 km, 5.6 km and 10 km respective effective travel distance to a hospital-based A&E, i.e. the sum of the two sides of the triangle rather than the direct line (Euclidian) distance. On this occasion the effective travel distance attempts to approximate travel in a densely packed urban area where straight line travel is usually not an option. The KCH site is itself surrounded by six sites all within 8 km effective travel distance (4.2 km Guy's, 5.2 km St Thomas, 6.1 km Bart's, 6.7 km Lewisham, 7.8 km Chelsea & Westminster, 7.9 km Royal London). In addition, Londoners are highly mobile with access to travel by rail, boat, bus and car for the purpose of work, family, recreation and holiday activities. At the point of needing A&E they can therefore be many miles from home as Fig. 1 has elegantly demonstrated.

Fig. 7 therefore displays the effect of distance on the attendance rate at KCH (over 3 financial years) and to either KCH or PRH (over a 15-month period). As can be seen attendance rate declines in an exponential manner up to around 11 to 12 km effective travel distance. In the KCH-only analysis attendance rate has declined to 50%, 25% and 10% of maximum at 1.8 km, 2.6 km and 5.8 km respectively, while in the KCH/PRH analysis these points of decline are reached at 3.5 km, 5.2 km and 8.4 km respectively.

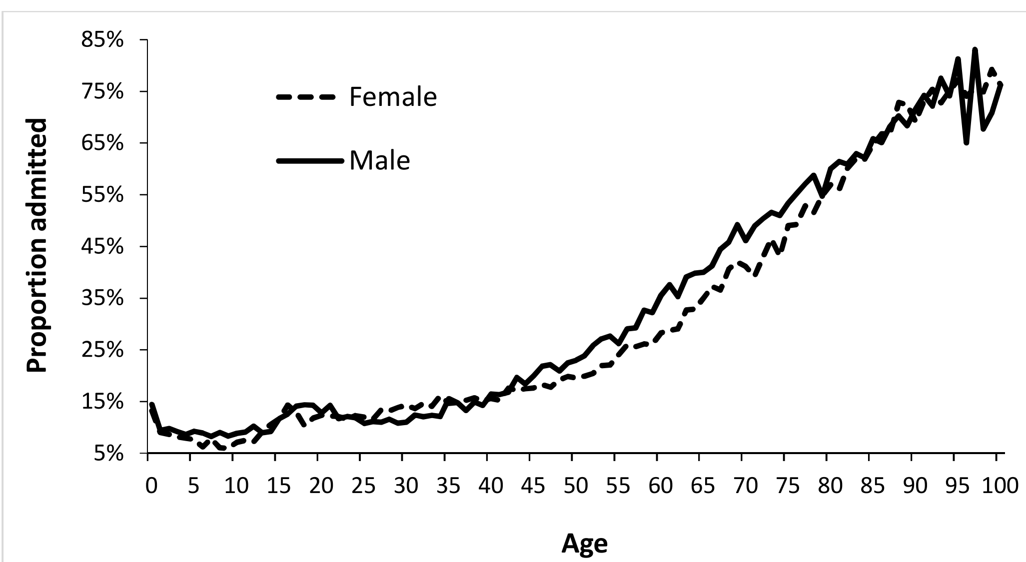

Fig. 6. Proportion of persons who are admitted by age and gender

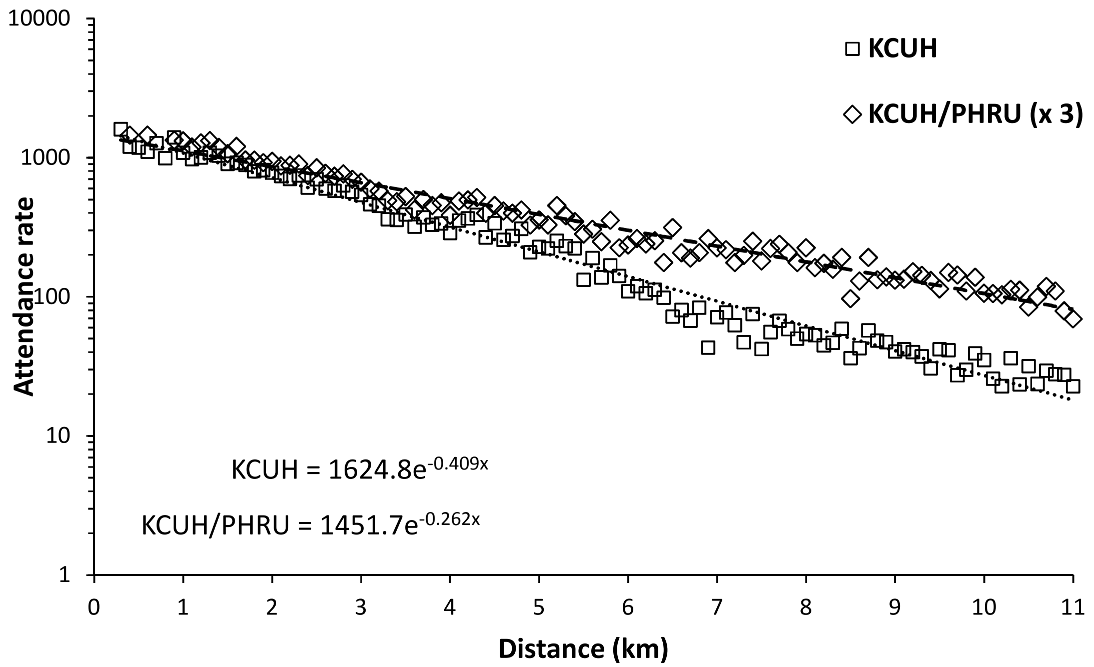

Fig. 7. Effect of distance from home address for attendance at KCH (London), 2013/14-2015/16 and KCUH/PRUH, 2015/16

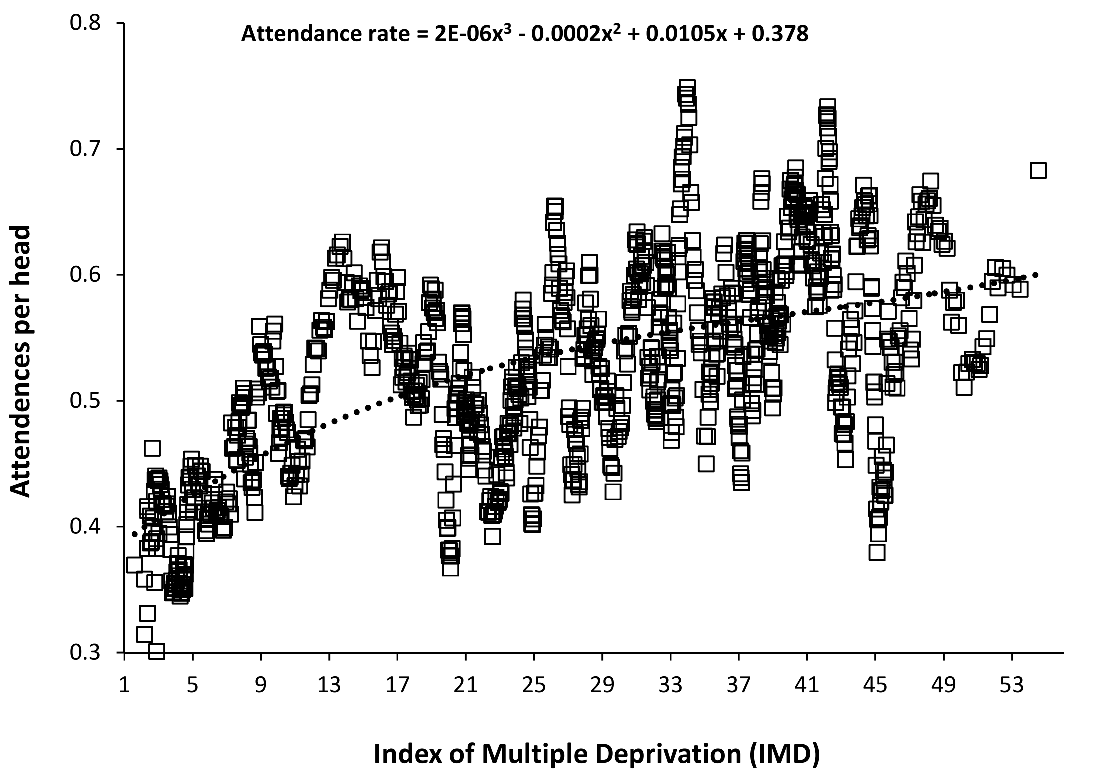

Fig. 8. Role of deprivation on attendance rate (distance adjusted) for OA within 4 km of the KCUH site or KCUH/PRUH sites combined

Each data point is an average of 20 OA ranked by order of increasing IMD

3.1.7 Deprivation

It is generally accepted that higher rates of A&E attendance are experienced for those with the highest level of deprivation. Fig. 8 shows the effect of deprivation on the distance-adjusted attendance rate. Each data point represents the average of 20 OA ranked in order of increasing IMD. Only OA within 4 km (effective travel distance) of either site was included, and OA with a distance adjusted rate of less than 10% of the maximum value were excluded as outliers (see discussion regarding distance). As can be seen the attendance rate increases with IMD with a higher slope at lower IMD values and reaching a potential asymptote at higher IMD values. Within the range of IMD encountered in this study the highest deprivation areas had a 50% higher attendance rate compared to that for the lowest IMD of around 1.

The possibility that the least deprived and the most deprived use A&E in different ways is explored in Table 3.

As can be seen the most deprived patients are 50% less likely to be admitted and 1.6-times more likely to be discharged without any follow-up. They are slightly more likely to be referred to their GP for follow-up and have twice the rate of referral to the fracture clinic. In terms of impatience they are 3-times more likely to leave without being seen and to refuse treatment.

3.1.8 Persons re-attending A&E

Repeat attenders is regarded as another cause of A&E congestion. In this three-year study some 294,545 individuals accounted for the 508,569 total attendances. Of these, 198,568 individuals (67.4%) had only 1 attendance. Fig. 9 explores the issue of the time to next attendance (days) and the average age at re-attendance. The average age has been calculated for each day up to 365 days after the previous attendance, with the flat line beyond 365 days representing the average of all days after 365 days. As can be seen 49.3% of persons with an average age of 36 years had no previous attendance while 0.9% re-attend the same day (average age 37.6 years) and 2.1% re-attend the next day (average age 36.6 years). Maximum average age of around 46 years occurs for persons re-attending after 12 to 15 days, after which the average age declines to around 37.1 years for persons re-attending after around 1 year. As can be seen in Fig. A5 (Appendix) the proportion admitted peaks at 37% on day 17.

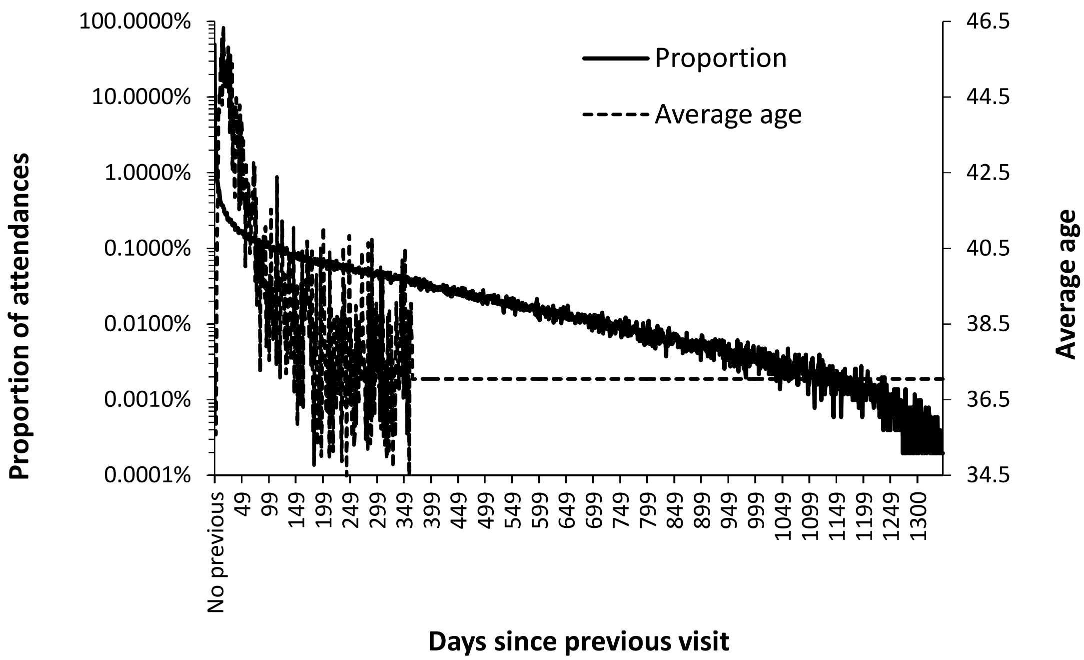

Fig. 9. Days until next attendance and average age at re-attendance

Table 3. Differences in outcome of the A&E attendance in the least and most deprived output areas

Outcome of visit	Least deprived	Most deprived	Comment
Admitted	40%	20%	Plateau >20 IMD
Discharged without follow-up	25%	40%	Plateau >20 IMD
Follow-up by GP	20%	25%	Non-linear
Refer to fracture clinic	2%	4%	Plateau >20 IMD
Refused treatment	0.5%	1.5%	Plateau > 40 IMD
Left without being seen	1.5%	4.5%	Increases with IMD

Least deprived IMD=2, most deprived IMD>60

Serial attenders are also considered a problem and Table A6 gives aggregate details of the top 100 persons for A&E attendances. This top 100 represent only 0.03% of all persons who attended during the study period. Among the top 100, attendances ranged from 34 to 147 (average 56, median 46). As can be seen in Table A6 the top 100 were far more likely to leave before being seen or to refuse treatment, or to be referred to another healthcare professional (usually mental health). At the other extreme none of them died in the department, and they were far less likely to have suffered a fracture. These 100 individuals accounted for 1% of all admissions via the A&E department, which suggests a mix of long term conditions plus probable outcomes from poor lifestyle (alcohol, drugs, poor nutrition, and self-harm in its wider manifestations).

3.2 Discussion

3.2.1 Presenting condition

Due to the pressure on A&E departments there is much media and other attention relating to 'inappropriate' use of A&E, and the effect of factors such as alcohol consumption. These are hardly a new problem, and have been documented over many years [25,26]. The general consensus is that alcohol related disease and injuries are probably 3-times higher than reported [25], and that 24% of US attendances in those aged over 65 could be associated with long-term alcohol abuse [26]. Alcohol related A&E attendances showed a small increase between the hours of 3 am and 6 am after the liberalisation of opening hours in the UK in 2005 [27]. However, it is debatable whether these issues have gotten worse over time to such a degree as to be the cause of current A&E pressures, which are probably partly to do with poor government funding to train new A&E consultants and other staffs, more so than single issues.

However, a perusal of typical presenting conditions in Table 1 seems to give a picture of a degree of appropriateness within the context of wider primary care provision and working hours. 'Apparently drunk' attendances are well down the list at 0.5% of attendances. Alcohol may be involved in some instances of head injury (2.7%), wounds (2.5%) and assault (0.8%), but while undoubtedly a problem, cannot be blamed for all manner of seemingly 'reasonable' attendances. Likewise overdose/poisoning represents only 0.9% of attendances, while deliberate self-harm represents only 0.1% of all attendances. Attendances by children may well be higher than necessary (Figs. 5 and A1), although parents presumably come to A&E in the context of a wider issue relating to access to trusted alternatives, and parental awareness relating to childhood conditions. The peak in weekend attendances for children aged 0-7 suggests that access to a GP may be a factor but out-of-hours services are readily available on weekends.

3.2.2 Age

The profile of attendances by age is very similar to that seen in Australia [6], and as demonstrated in Fig. A3 can be modified by extreme age profiles in the population surrounding the A&E. The curious pattern of weekend to week day attendances shown with age in Fig. A1 seems to reflect that older children (age 8-16), still under parental care, are not considered serious enough to warrant a visit to A&E on the weekend – is this the age group where guardians and the children themselves are least worried about minor ailments?

Higher weekend attendances among late teens and those in their 20s is not unexpected. Mental acuity in college students appears to be lowest at weekends and also after 5 pm [28], and there is also a day-of-week cycle in smoking frequency which is much higher at the weekend [29]. It is possible that 'risky' behaviours among this age group at weekends may be part of much wider day-of-week cycles.

3.2.3 Monthly, weekly and circadian patterns

While monthly patterns do exist (Table 2) they are not strong enough to justify differential staffing by month of the year. Speedier access to a bed is probably a more pressing need than more A&E staff. The slight dip in August attendance is almost certainly due to the school summer holiday. Discussion with managers from other hospitals indicate that those in typical holiday locations experience an August surge in attendances.

The proportion of unwell adults admitted to a hospital bed shows a typical summer/winter patterns seen in hospital bed occupancy, deaths and incidence of certain medical conditions [30-32] which is reflected in the accompanying patterns of average age.

Seasonal patterns in health are well documented and affect a wide range of conditions [29-31]. In particular, trauma shows a strong relationship with the weather and metrological variables [32-34]. Likewise, day of week and hour of day patterns are observed in cardio-vascular and other conditions [30-32,35-36].

The weekly pattern of attendance (Fig. 2) is more interesting. If access to Primary Care is the real issue, then attendances on the weekend should reach a maximum rather than the minimum observed. The curious pattern in proportion admitted likewise does not fit with current popular notions regarding supposed cause and effect.

To understand the day-of week patterns in A&E attendance it would appear that far too little attention has been paid to the day-of-week cycles in human health, and changes in biochemical parameters. Acute cardiovascular disease has a distinct Monday peak for both admissions and in/out-of-hospital deaths, and also has seasonal and circadian patterns [30-31]. Age-specific effects have also been reported, and cardiovascular mortality in men aged <65 years is highest on Mondays and Saturdays [37]. Death from suicide shows day-of-week patterns [38]. In England and Wales from 1969 to 1972 deaths from myocardial infarction, cerebrovascular disease, other cardiac diseases and to a lesser extent, bronchitis and pneumonia, all showed a Monday peak, while influenza and pneumonia showed a Saturday peak [39]. The occurrence of stroke is day-of-week specific, however this depends on the type of stroke; where cerebral infarction is more prevalent on a Monday and less so on Thursday/ Friday, while cerebral haemorrhage or subarachnoid haemorrhage show no day of week variation [36].

Other factors can affect day of death, and patients on different dialysis schedules experience different weekday patterns of cardiovascular and non-cardiovascular death [40]. A Canadian study of deaths from 1974 to 1994 noted day-of-week effects upon all-cause mortality, with highest average deaths on a Saturday and lowest on Thursday. This profile was more exaggerated for motor vehicle deaths with a minimum between Monday to Wednesday, and a distinct day-of-week cycle on the other days peaking at Saturday (40% higher than Wednesday). Suicides showed a less pronounced cycle with a minimum on Thursday, which was 8% less than the maximum on Sunday [35].

Further day-of-week effects have been observed in the stock market volatility and returns [41], which presumably reflect day-of-week cycles in psychological parameters. Worker productivity appears to show day-of-week effects [42], as does job satisfaction and feelings of personal well-being [43-44]. Mood, vitality and sickness symptoms also show day-of-week effects [45]. College students show a weekend peak in smoking frequency [29]. The ability to assimilate and retain new information in college students peaks on Wednesday [28]. One study conducted in 1935 demonstrated that the levels of blood constituents varied considerably from day to day, and that the degree of variability appeared to correlate with the personality trait of emotional stability [46]. An as yet unpublished study conducted in the UK using the 12 most common biochemistry tests conducted in the UK combined into a composite score (as per the study of Cohen et al. [47]) showed a clear day of week cycle with highest score (sickest patients) occurring on the weekend.

Hence a fundamental day-of-week cycle in human health and wellbeing appears to exist which will be overlaid on the other factors determining day of week and week day versus weekend attendance. These fundamental cycles may not be amenable to modification by expanded contact with primary care, but will influence attendances based on an individual's immediate location and time of day.

3.2.4 Distance

A study conducted in 1992 comparing London and out-of-London A&E attendance demonstrated that people attending the inner London department were more likely to be tourists or long-distance commuters, single or living alone, to have recently moved, or to be homeless [48]. The proportion admitted for similar social groups were identical. The international evidence suggests that A&E utilization decreases with increasing distance [49]. Both of these studies appear to be supported by the results observed in this study. A population-based study in the West Midlands area of England for patients accessing multiple A&E departments demonstrated that child and adult attendances reduced by 2.2% and 1.5% per kilometre respectively [50]. The Midlands study also observed that the decline in attendances with distance was higher in the more deprived populations, and which was more marked for children than adults. The decline per kilometre in the Midlands study is far less than that observed here because this study is site- rather than population-based.

In addition, the distance used in this study is an 'effective' travel distance approximated by the sum of the two sides of a triangle rather than the hypotenuse (straight line distance). This is a reasonable approximation for tightly packed urban areas but will begin to break down toward the outer suburbs.

The limitations of estimating travel time aside, exponential decay in attendance rate observed in this study does appear to be site specific and several factors are probably involved. Firstly, this is a hospital-based rather than a population-based study and, as demonstrated in Fig. 1 and Table A2, persons are in the vicinity of any hospital for a variety of reasons. A distance squared type relationship would be assumed to lie behind the probability of being in the vicinity of a particular site were a random walk phenomenon to be involved (as partly reflected in the exponential decay in Fig. 7). Also seen in Fig. 1 is a propensity for long-distance commute from Kent due to access to a high-speed rail network in this part of the country.

While Fig. 7 shows averages by 0.1 km increment the suspicion is that the distance landscape shows variable rates of attendance depending on the relative position of other A&E sites, hence attendance along the 6 km line (for example) will undulate depending on the relative proximity of other hospitals and the proximity to rail stations. This effect became apparent when attempting to assess the role of deprivation in this study. The first attempt to assess deprivation used at OA within 12 km effective travel distance of each site, however this appeared to suffer from the fact that the least deprived tend to live in the outer fringes of London and the process of distance adjustment then gave the false appearance of high attendance rates for the very least deprived. Hence the effect of deprivation was then restricted to an area in which each site was the closest A&E for local residents.

3.2.5 Deprivation

Unlike the USA where health insurance issues cloud the role of deprivation in A&E attendance, this English study does not suffer from these issues, except to the degree that GP provision per (need weighted) head of population may vary between different parts of London.

An early study conducted in the 1970s and 80s in England using aggregated data at health district level showed lowest attendance rates in the most advantaged health districts [10]. Emergency and mental health admissions are known to be associated with highest deprivation and/or social group, however, elective admissions are inversely associated [51]. A recent study investigating the role of GP practice characteristics and A&E attendance showed that deprivation (IMD) was the single largest contributor to attendance rates followed by population morbidity [52], i.e. the issues do not primarily seem to be related to access to a GP *per se*.

Most studies addressing this topic have used deprivation quintiles or GP practice deprivation scores, both of which will blur the effect of deprivation due to averaging. This study has detected a 50% difference in attendance rate between the least deprived (average IMD 2.0) and the most deprived (average IMD 55.0) – although the relationship is highly non-linear. A more recent study conducted in the West Midlands are of England using LSOA - rather than OA-based deprivation reported showed an incidence rate ratio of 2.2 for children and 2.26 for adults in the most deprived compared to the least deprived areas [50]. It was also noted that attendance reduced at a greater rate with distance for the more deprived areas [50]. Similar relationships between deprivation and distance have been observed in telephone calls to access out-of-hours care centres, with lowest access rates of 100 (reference point) occurring in the most deprived rural areas compared to 200 in the most deprived urban areas [53]. Hence call rates *decreased* with deprivation in rural areas while they *increase* with deprivation in urban areas [53].

All the above suggesting that the more deprived utilise A&E as a convenience choice (where proximity is close) but avoid A&E if it is inconvenient (travel distance is large). As reported elsewhere the overall relationship between attendances and deprivation is not linear but appears to approach an asymptote somewhere above an IMD of 55 [54], hence the effect of deprivation (as measured by IMD) is steepest at lower values of IMD (as per Fig. 8). In this respect, a 25% increase in attendance rate is reached at an IMD around 18 (an increment of 16 in IMD) while it takes an increment of 37 units of IMD to reach the highest rate.

The issues regarding deprivation are certainly not restricted to A&E and also extend to emergency admissions and mental health contacts [54]. High deprivation is also associated with high 'Did not attend' (DNA) rates at outpatient clinics, and it was suggested that a less structured lifestyle led to a unique set of health behaviours [55]. Higher utilization by children living in more deprived areas has been demonstrated elsewhere [56], and suggests that the problem may lie more with the parents than the children *per se.* Indeed, as demonstrated in Table 3 (and strongly implied in Table 1) there is evidence that the more deprived are far more likely to leave A&E before being seen, and to refuse treatment.

While health education targeted at higher deprivation locations is one option, the other approach may be to provide GP care located at a single central location, namely A&E – the point at which the most deprived seem motivated to attend with instant access preferred above the prospect of a longer waiting time.

3.2.6 Overutilization of A&E and admission avoidance

As presented in Table A6 just 100 individuals (0.03% of individuals attending A&E) accounted for 1.11% of all attendances and 0.98% of all admissions via the A&E department. The top attending individual (147 attendances) managed to attend nearly once per week over the three-year period.

On the other hand, Fig. 9 demonstrated that 26% of re-attendances occurred within 3 weeks of the previous attendance, and that the average age in this cohort (average around 45 years) was much higher than those with no previous attendance (average around 36 years), or those with a sporadic re-attendance after one year (average age around 37 years). It is highly likely that this cohort represents those near the end of life or whose condition is showing a period of deterioration. Analysis of the vital signs and biochemical test results of this cohort may yield valuable predictive or early warning information which could be used to pre-empt further attendances or hospital admissions.

Overutilization may be wider than just due to serial attenders, and an Australian study demonstrated that low acuity attendances (not transported by ambulance, triage category 4 or 5, and discharged back to usual residence) comprised 45% of attendances [57]. However, the issue of 'low acuity' attendances is not new and was observed in the 1960's [58]. Another study in Oxfordshire of (mainly elderly) patients transported to A&E by ambulance concluded that while many of these attendances were for medical assessment, they were entirely appropriate relative to the available alternatives currently offered by primary care [59]. The term 'overutilization' is therefore often relative to a hypothetical 'ideal case' were a range of alternatives to be offered.

3.2.7 Implications to primary care

It was noted that only 59% of patients in this study actually attended the A&E department nearest to their home address (Table A2). This proportion is probably a unique feature of London, however, it does suggest that patients are not deliberately by-passing primary care but are simply accessing the closest point of available care, relative to their current location and time of day.

This brings a degree of sanity into the debate regarding the role of primary care in diverting A&E attendances to a more 'appropriate' setting. The UK has one of the lowest ratios of GPs per head of population in the developed world [60], and hence the obvious solution is to provide 24/7 access to a GP at all A&E departments rather than vain attempts to extend opening hours at individual GP surgeries. This solution gains the benefit of economy of scale, and places GPs in close proximity to rapid diagnostic services.

It is of interest to note that changes in the provision of out-of-hours primary care in 2004 was observed to lead to an increase in A&E attendance for non-trauma patients during the out-of-hours part of the day [61]. However, a recent study offering 7-day access to a GP for local residents in the Hyde park area of London (nearby to University College London, Chelsea and Westminster, and Royal Free hospitals) resulted in a 9.9% overall reduction in A&E attendance and a 17.9% reduction over the weekend [62]. Most importantly there was also a 9.9% reduction in weekend admissions via the A&E. In the latter respect, the pilot practices in the study had a higher proportion of patients' aged 65+, i.e.11.2% versus 9.4% in the control group, and the effect of age on admission rate seen in this study suggests that weekend opening probably attracted proportionally more elderly patients to the GP surgery.

Clearly solutions need to be targeted to different groups, hence weekend opening of GP practices targeted at local residents, and A&E located GPs to address the more deprived younger patients (and their parents), along with persons in London for work and recreation.

3.2.8 Implications to A&E staffing

A&E attendance, waiting time and case mix is clearly the outcome of a complex system. The most obvious implication lies in the relationship between hour of the day and attendances, and the knock-on effects to queue length, and hence average waiting time. It would seem that resources are overwhelmed during the early morning rush and never fully recover until the next day. This may have implications to the start of the morning shift or the temporary availability of additional resources in the interval from 8 am to 12 am. This conclusion is supported by a simulation study which showed that commencing the SHO shift three hours earlier led to a significant improvement in waiting times [63]. Given the known effects of bed availability on A&E waiting time, especially for those waiting to be admitted [64], It remains to be seen how inpatient bed availability interacts with this 24-hour cycle. In this respect bed occupancy typically peaks around 2 pm, although this depends on the exact balance between arrivals and departures in each hospital, especially in the medical wards.

3.2.9 Implications to growth in A&E attendances

The factors influencing A&E utilization revealed in this study do not necessarily explain the national and international observed higher growth in A&E attendances. From Fig. 5 it is clear that changes in the number of 0-5 and 20-35 year olds plays a far greater role in A&E attendance than the elderly, however, from Fig. 7 it is clear that the growth in the number of elderly persons will have a direct impact in the growth in inpatient admissions via A&E. In recent times, the ageing population seems to have been blamed for everything without discrimination regarding the subtler sub-components [13,15].

Recall that the Oxfordshire study demonstrated that only 36% of growth in A&E attendances was due to demographic change [16], while an Australian study demonstrated 3.6% per annum growth over-and-above that explained by demography [6], with similar in the USA [8], an observation which has been replicated for emergency admissions in general [8,15]. Regarding the issue of growth, the earlier observation that growth was highest in areas with highest utilization [8], i.e. in younger and/or more deprived populations, suggests that whatever measures are taken to reduce growth *per se* need to target these groups and understand the 'need' driving the demand.

Interestingly, an Australian study demonstrated no discernible growth in low acuity attendances between 2010 and 2014 [57], suggesting that growth was mainly in the high acuity group of patients. This concurs with other studies [6,12,65], and suggests that the fundamental issues behind growth are mainly restricted to the high acuity group of non-trauma patients, i.e. those most susceptible to medical admission.

4. CONCLUSIONS

Attendance at the A&E department of a single hospital is the outcome of complex spatial patterns of population movement plus seasonal, day of week and circadian cycles in the typical conditions comprising A&E workload. Waiting time roughly approximates to arrival rate, however with seeming lagged 24 hour patterns as queue length increases and then is finally cleared by around 8 am of the following morning. This pattern is seemingly amenable to altered staffing schedules.

This study has found little overt evidence for grossly inappropriate utilization given the context of how primary care is currently organised in London, and London's role as a place of work, tourism and leisure. As reported elsewhere the most deprived areas show the highest utilization, seemingly reflecting a preference for instant access over longer waiting times. If inappropriate utilization exists it would seem more pragmatic to make GP's (or GP equivalents [66]) available at the A&E department (24/7) rather than vainly attempting to re-direct patients to GP surgeries. However, evidence suggests that elderly patients will benefit from weekend opening. Both approaches imply access to the patient record held by their local GP. However, a recent review has suggested that this option may not yield the anticipated cost savings since ease of access (especially among the more deprived) may increase attendances [67].

Finally, this study does not argue against the implementation of all manner of demand reducing schemes, it merely suggests that they be tailored to the pragmatic reality of each hospitals location and those who use its services, and the fact that primary care in England is already in short supply.

It is hoped that this study will assist both policy makers, hospital managers and academics to appreciate the multidimensional characteristics of A&E attendance, and the need to avoid simplistic 'solutions'.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable. No patient identifiable data was used in this study. The conversion of postcode to OA code was conducted separate to this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Table A1. Post code districts for A&E attenders, and proportion coded to an output area for London residents

Postal area	Attendances	Percentage	% OA coded
All	508,569	100.00%	95.2%
SE (South East London)	286,833	56.40%	99.8%
SW (South West London)	90,921	17.90%	99.6%
BR (Bromley)	68,280	13.40%	99.1%
CR (Croydon)	13,853	2.70%	97.9%
DA (Dartford)	11,598	2.30%	87.6%
TN (Tonbridge)	6,911	1.40%	46.7%
ZZ (Overseas Visitor)	6,160	1.20%	-
E (East London)	3,249	0.60%	.
N (North London)	2,288	0.40%	99.7%
ME (Rochester)	1,943	0.40%	-
NW (North West London)	1,207	0.20%	97.9%
W (West London)	1,194	0.20%	99.0%
CT (Canterbury)	876	0.20%	-
SM (Sutton)	801	0.20%	93.3%
KT (Kingston upon Thames)	738	0.10%	47.7%
RM (Romford)	721	0.10%	73.2%
TW (Twickenham)	616	0.10%	84.7%
HA (Harrow)	567	0.10%	99.3%
RH (Redhill)	554	0.10%	6.5%
IG (Ilford)	546	0.10%	93.2%
BN (Brighton)	454	0.10%	-
UB (Southall)	359	0.10%	98.9%
GU (Guildford)	321	0.10%	-
B (Birmingham)	313	0.10%	-
EN (Enfield)	297	0.10%	76.4%
SS (Southend-on-Sea)	283	0.10%	-
UN (Unknown)	274	0.10%	-
CM (Chelmsford)	245	0.00%	-
PO (Portsmouth)	207	0.00%	-
RG (Reading)	196	0.00%	-
M (Manchester)	182	0.00%	-
HP (Hemel Hempstead)	182	0.00%	-
MK (Milton Keynes)	178	0.00%	-
WD (Watford)	169	0.00%	-
LU (Luton)	166	0.00%	-
SL (Slough)	153	0.00%	-
BS (Bristol)	152	0.00%	-
SO (Southampton)	149	0.00%	-
OX (Oxford)	147	0.00%	-
PE (Peterborough)	144	0.00%	-
NG (Nottingham)	138	0.00%	-
CB (Cambridge)	137	0.00%	-
EC (East Central London)	136	0.00%	97.8%
WC (Western Central London)	132	0.00%	98.5%
CO (Colchester)	125	0.00%	-
S (Sheffield)	117	0.00%	-
NR (Norwich)	115	0.00%	-
AL (St Albans)	115	0.00%	-
IP (Ipswich)	113	0.00%	-
BT (Northern Ireland)	110	0.00%	-
CV (Coventry)	109	0.00%	-
BH (Bournemouth)	102	0.00%	-
SG (Stevenage)	100	0.00%	-
LE (Leicester)	100	0.00%	-
L.T. 100 attendances, 67 other post code districts	2,396	0.50%	-

Table A2. Attendances split by nearest hospital to the patient's home address for London residents

Nearest A&E	Total	Proportion
King's	242,855	47.8%
Princess Royal	57,989	11.4%
Lewisham	55,026	10.8%
Croydon	43,828	8.6%
Non-Londoner	25,744	5.1%
St George's	18,618	3.7%
QE Greenwich	18,022	3.5%
Guy's	15,897	3.1%
St Thomas	9,719	1.9%
Royal London	7,000	1.4%
Newham	1,875	0.4%
Royal Brompton	1,322	0.3%
Whipp's Cross	1,176	0.2%
Homerton	1,168	0.2%
Whittington	1,001	0.2%
St Hillier	986	0.2%
Charing Cross	664	0.1%
Ealing	598	0.1%
Northwick Park	571	0.1%
Kingston	546	0.1%
Chelsea & Westminster	501	0.1%
Royal Free	488	0.1%
Hammersmith	472	0.1%
Chase Farm	434	0.1%
Central Middlesex	410	0.1%
St Mary's	376	0.1%
St Bart's	344	0.1%
UCL	494	0.1%
Hillingdon	175	0.0%
Barnet	167	0.0%
Epsom	103	0.0%

Table A3. Recorded diagnosis at the conclusion of the patient visit for the 'unwell adult' and 'unwell child' presenting condition

Unwell adult	
Diagnosis	**Proportion**
No diagnosis recorded	27.3%
Other specified in comment	8.6%
Direct Referral to Specialty	6.0%
Bacteriuria / Urinary tract infection / Urinary Sepsis	1.9%
Infection, lower respiratory tract / chest, acute	1.6%
Chest pain, NEC	1.4%
Patient admitted, discharge notification to follow	1.3%
Abdominal / Flank pain/cramps / Intestinal Colic	1.3%
Viral infection	1.2%
Dizziness / Vertigo	0.9%
Collapse/Faint/Vasovagal attack/Micturition syncope. Excl. Syncope caused by heat	0.9%
No disease found / Illness NOS / Other symptoms / Unwell generally	0.9%
Upper respiratory tract infection, unspecified	0.9%
Fever / Pyrexia of unknown origin (P.U.O)	0.8%
Backache, unspecified	0.8%
Anxiety	0.8%
Headache / Facial pain	0.7%
Cough	0.5%
Unwell child	
Diagnosis	**Proportion**
No diagnosis recorded	22.4%
Upper respiratory tract infection, unspecified	8.0%
Viral infection	8.0%
Other specified in comment	6.3%
Patient admitted, discharge notification to follow	4.9%
Tonsillitis, acute	2.8%
Otitis media / Ear infection	2.2%
Infection, lower respiratory tract / chest, acute	2.2%
Bronchiolitis, acute	1.7%
Wheezing	1.6%
ENT, Tonsillitis	1.5%
Diarrhoea NOS/Gastro/Enteritis, presumed infectious. Excl Non-infectious enteritis	1.5%
Constipation	1.5%
Jaundice in newborn	1.4%
Cough	1.4%
Minor Head Injury	1.3%
Gastrointestinal, Nausea and vomiting	1.2%
No disease found / Illness NOS / Other symptoms / Unwell generally	1.1%

Table A4. Attendances, proportion admitted and died, plus average time spent in the A&E department

Hour	Attended		% Attended			Outcome		Average hours in A&E		
	All	Admitted	All	Admitted	Not-admitted	% Admitted	% Died	All	Admitted	Not-admitted
0	13,021	3,217	2.6%	2.8%	2.5%	24.7%	0.19%	5.3	6.2	5.1
1	10,352	2,585	2.0%	2.3%	2.0%	25.0%	0.24%	5.1	6.1	4.8
2	8,279	2,067	1.6%	1.8%	1.6%	25.0%	0.30%	5.0	5.9	4.7
3	7,168	1,860	1.4%	1.6%	1.3%	25.9%	0.35%	4.9	5.9	4.5
4	6,693	1,777	1.3%	1.6%	1.2%	26.6%	0.37%	4.9	6.0	4.5
5	6,857	1,965	1.3%	1.7%	1.2%	28.7%	0.36%	4.8	5.8	4.4
6	6,122	1,563	1.2%	1.4%	1.2%	25.5%	0.41%	4.4	5.7	3.9
7	9,588	2,247	1.9%	2.0%	1.9%	23.4%	0.26%	4.0	5.4	3.6
8	16,804	3,522	3.3%	3.1%	3.4%	21.0%	0.15%	3.7	5.2	3.3
9	26,552	5,266	5.2%	4.6%	5.4%	19.8%	0.09%	3.7	5.3	3.3
10	31,303	6,560	6.2%	5.8%	6.3%	21.0%	0.08%	3.9	5.4	3.5
11	33,174	7,177	6.5%	6.3%	6.6%	21.6%	0.08%	4.0	5.6	3.6
12	33,490	7,502	6.6%	6.6%	6.6%	22.4%	0.07%	4.2	5.8	3.8
13	31,435	7,029	6.2%	6.2%	6.2%	22.4%	0.08%	4.3	5.8	3.8
14	29,737	6,780	5.8%	6.0%	5.8%	22.8%	0.08%	4.3	5.9	3.8
15	29,341	6,877	5.8%	6.0%	5.7%	23.4%	0.09%	4.3	6.0	3.7
16	30,644	6,909	6.0%	6.1%	6.0%	22.5%	0.08%	4.3	6.0	3.9
17	30,432	6,883	6.0%	6.0%	6.0%	22.6%	0.08%	4.4	5.9	3.9
18	29,947	6,378	5.9%	5.6%	6.0%	21.3%	0.08%	4.4	6.1	3.9
19	29,307	5,955	5.8%	5.2%	5.9%	20.3%	0.09%	4.3	6.0	3.9
20	27,224	5,902	5.4%	5.2%	5.4%	21.7%	0.09%	4.5	6.1	4.0
21	23,896	5,252	4.7%	4.6%	4.7%	22.0%	0.10%	4.5	6.0	4.1
22	20,539	4,665	4.0%	4.1%	4.0%	22.7%	0.12%	4.9	6.1	4.5
23	16,664	3,934	3.3%	3.5%	3.2%	23.6%	0.15%	5.2	6.3	4.9

Table A5. Ratio of weekend to week day attendances by social group

LOAC	Super group name	Group name	Attendances	Weekend to weekday ratio
A2c	Intermediate lifestyles	Suburban localities	10,497	35%
H2a	Ageing city fringe	Not quite home counties	10,000	36%
H2b	Ageing city fringe	Not quite home counties	18,394	36%
H1c	Ageing city fringe	Detached retirement	10,462	37%
A1a	Intermediate lifestyles	Struggling suburbs	10,864	37%
E1a	City vibe	City & student fringe	87,237	37%
E2a	City vibe	Graduation occupation	34,034	37%
G2b	Multi-ethnic suburbs	Public sector & service	21,214	38%
A1b	Intermediate lifestyles	Struggling suburbs	20,603	38%
F2a	London life-cycle	Affluent suburbs	12,474	38%
B3a	High density & high rise	Students & minority mix	22,452	38%
B1b	High density & high rise	Disadvantaged diaspora	43,087	39%
E2b	City vibe	Graduation occupation	16,942	39%
B1c	High density & high rise	Disadvantaged diaspora	49,597	39%
F1a	London life-cycle	City enclaves	10,757	39%
E1b	City vibe	City & student fringe	22,545	39%
B3b	High density & high rise	Students & minority mix	10,064	39%
Non	Non-London	Non-London	25,503	42%

Table A6. Top 100 serial attenders and outcome of their visits (2013/14 to 2015/16)

Outcome	Count all	Count top 100	Proportion of total
Left having refused treatment	2,988	155	5.19%
Left before being seen	19,316	787	4.07%
Other	5,500	160	2.91%
Referred to other health care professional	5,244	130	2.48%
Discharged - no follow-up	193,095	2,105	1.09%
Admitted to a Hospital Bed	113,872	1,121	0.98%
Discharged - follow up by GP	115,883	1,003	0.87%
Transferred to other Health Care Provider	5,640	46	0.82%
Referred to other Out-Patient Clinic	27,029	121	0.45%
Referred to Fracture Clinic	16,307	24	0.15%
Referred to A&E Clinic	3,187	2	0.06%
Died in A&E	508	0	0.00%
Grand Total	508,569	5,654	1.11%
Individuals	**294,538**	**100**	**0.03%**
Average per individual	1.7	56.5	

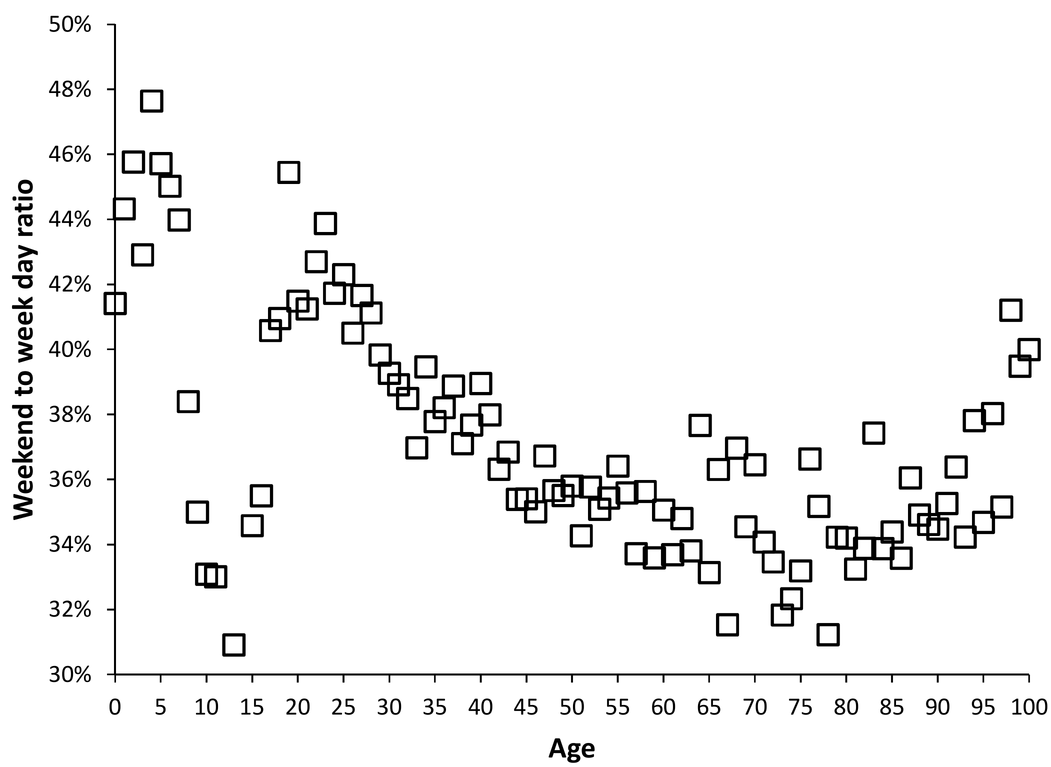

Fig. A1. Weekend to week day ratio of attendances by age

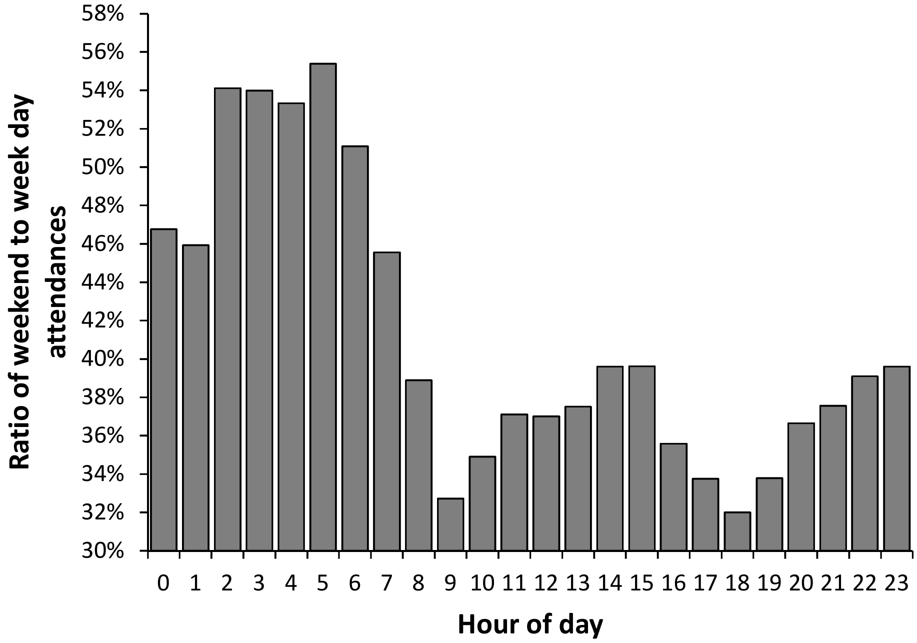

Fig. A2. Ratio of weekend to week day attendances by hour of the day at arrival

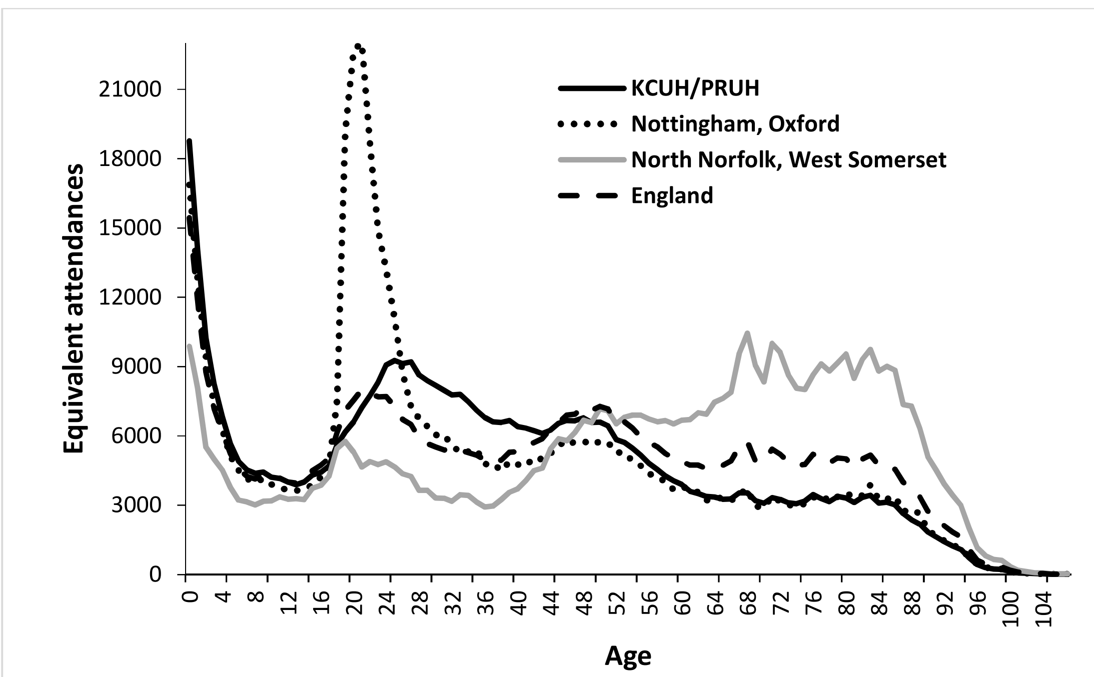

Fig. A3. Equivalent attendances by age for England and extremes of population age structure in England

Single year of age data for 2015 by local authority is from the Office for National Statistics (MYE2: Population Estimates by single year of age and sex for local authorities in the UK, mid-2015). KCUH/PRUH attendances were matched with population data for London and the resulting age-standardised rate adjusted to other population age structures

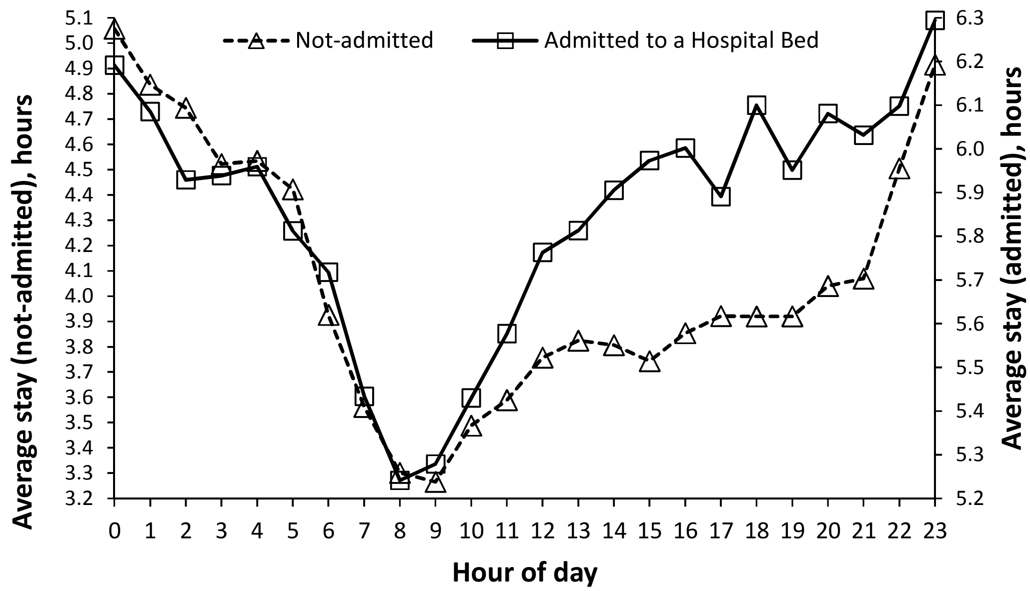

Fig. A4. Average time spent in the department for those who are admitted and those who are not, by hour of the day at arrival

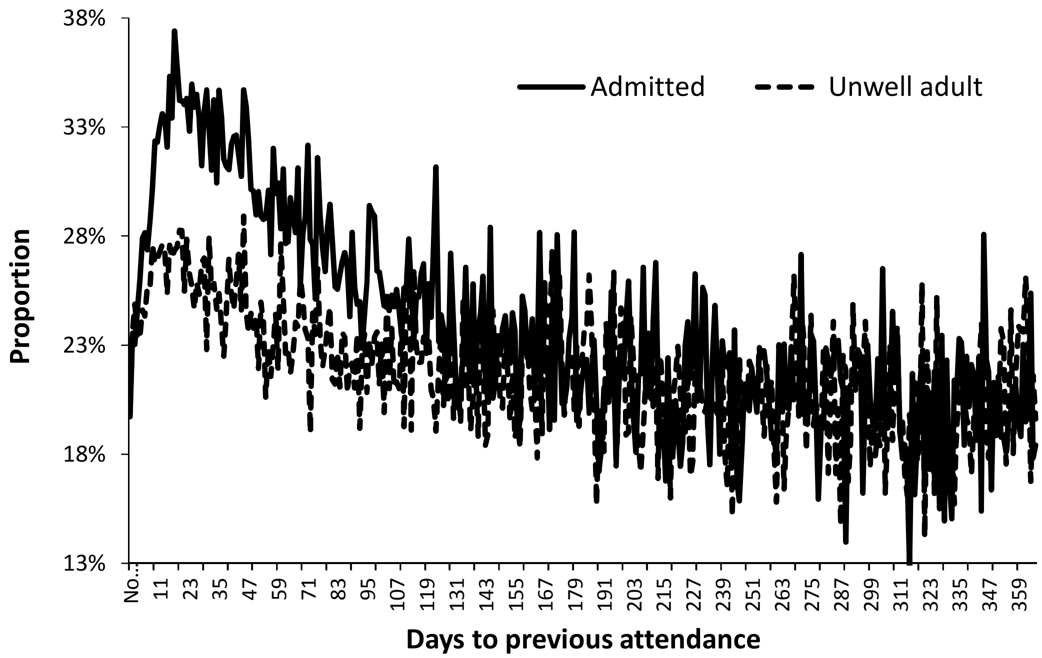

Fig. A5. Days to previous attendance and proportion admitted or unwell adult

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