The Strategy Unit.

Changes in the Acuity of Patients Presenting at Emergency Departments and the Propensity of Emergency Departments to Admit Patients
in England (2010 to 2016)

28 July 2017

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Foreword

Why has performance against the 4-hour target in major accident and emergency departments fallen so rapidly in recent years, reaching an all-time low in the last quarter of 2016/17? The number of people using major A&Es has increased only modestly, just over 1% a year since 2004/5, and the proportion of A&E patients that are admitted to hospital hasn't changed much at all. This all suggests that demand for major A&Es is relatively stable. So why are major A&Es struggling to hit the waiting times target when it was routinely achieved in the past? Our research, published in the Emergency Medical Journal, sheds some light on this paradox. First, we found that patients attending major A&Es are more unwell or more severely injured than those that attended in the past, leading us to conclude that patients with less acute conditions are being managed in other settings. Second, we found that doctors working in A&E had increased the threshold above which patients are admitted to a hospital bed, dealing with increasingly complex patients solely within the A&E department without the need for admission. In contrast to the stable picture that emerges at first glance, these findings suggest big changes in the demands on major A&Es and the ways in which A&E clinicians manage their patients' care. They also go some way to explain why those working in A&E are feeling under so much pressure.

So what does this mean for those working in or managing urgent care services, for policy makers and for those conducting research?

Implications for Clinicians and Managers working in A&E and Other Urgent Care Services

Firstly, those working in and managing A&E departments are to be congratulated; their efforts have avoided many admissions to hospital. A&E departments were able to maintain the number of people being admitted from A&E to hospital beds by managing increasingly complex cases within the A&E environment. This means more investigations and treatments in A&E departments and therefore patients are staying longer in A&E.

There is no indication in our analysis that these trends have bottomed out. Major A&Es should plan on the basis that the rise in complexity and acuity of patients will continue, with implications for work-flow, workforce, skills and infrastructure.

Whilst avoiding an unnecessary emergency hospital admission is a good outcome, there are certainly risks associated with increasing admission thresholds. Managers should be looking for any unintended consequences such as increases in the number of patients re-presenting at A&E and those that experience an unexpected deterioration after discharge from A&E.

Our findings also suggest that work to divert demand from A&E to other parts of the healthcare system may be paying off. These arrangements may need to be extended as demand continues to grow.

Implications for Policy Makers

It's important that patients don't spend any longer than necessary in A&E but this objective should not out-rank other considerations. The system appears to have concluded that spending more time with patients in A&E, missing the 4-hour target, is a price worth paying to avoid unnecessary admissions. Policy-makers will need to decide whether to back clinicians when making these hard choices or to criticise them for missing the 4-hour target. Our research suggests that it might be time to review the level at which this target is set.

In the last few years there has been considerable debate over the presence of a 'weekend effect'. Some studies find increased mortality in English hospitals on weekends whilst others claim that the weekend effect is a 'statistical artefact'. The authors argue that 'those who are admitted at the weekend are on average sicker than during the week and more likely to die, regardless of the quality of care they receive'. Our findings confirm that admission thresholds are indeed higher at the weekend.

The changes we observed could only be detected after casemix-adjustment and the patients presenting diagnosis was the most influential casemix adjustment variable. But the recording of diagnosis in A&E is not uniformly good. Our study was restricted to 47 hospital trusts that record patients presenting conditions well. Policy makers should find ways to encourage all trusts to improve the quality and completeness of diagnosis recording in A&E to allow casemix changes to be tracked in all trusts.

Implications for Researchers

Whilst our study shows that admissions thresholds have changed and that patients with urgent but less complex conditions are increasingly being managed outside of A&E, we need to better understand the implications of these changes for patient outcomes. A well-designed study could address this issue and could also inform the current debate around 7-day working and assess the impact of system shocks such as the junior doctors strike.

Including a qualitative component to examine clinical behaviours would inform recommendations for standardised safe care when increasing admission thresholds. The study could seek to understand how individual clinicians and their organisations/departments permitted higher thresholds for admission and what tensions needed to be managed. For example, does close working between an A&E and an acute-medicine service result in the spread of the acute medicine 'mindset' of admission avoidance or discharge? Also, for individual clinicians how does knowledge of the patient journey time or levels of bed-occupancy affect doctor decision making for admission. More critically, in the context of equitable care delivery why does the gender or ethnicity of the patient affect their odds of being admitted?

We note that changes in admission thresholds coincide with improvements across the emergency hospital setting such as the development of ambulatory emergency care, the wider use of fast-track clinics, increases in the number of emergency medicine consultants and the development of the acute medicine specialty. Similarly, we note that reductions in low-acuity presentations at A&E coincide with increases in ambulance 'hear and treat' and 'see and treat' strategies, with GP practice extended opening hours and with increased demand at walk-in centres. However, a direct assessment of the contribution of these strategies is required to corroborate or challenge our findings and to identify those strategies that have had the greatest effect.

This report updates, enhances and extends the analysis described in EMJ. We hope it contributes to the debate about how best to manage our urgent care system. If you found this work useful or have any additional insights or perspectives then we'd love to hear from you.

We would like to thank our co-authors, Mohammed Mohammed, Professor of Healthcare Quality and Effectiveness, University of Bradford and Deputy Director of Bradford Institute of Health Research and Professor Matthew Cooke, Regional Clinical Director, Emergency Care Improvement Programme, NHS Improvement.

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1. Introduction

1.1. This analysis builds on a paper, *Changes in Admission Thresholds in English Emergency Departments*, which explores changes in the casemix of patients attending emergency departments (EDs) and the propensity of EDs to admit patients.[1] This report builds on the journal article, incorporating additional analysis commissioned by NHS England. It provides a level of detail that could not be accommodated within the journal, extends the scope of the analysis and refines the methodology. In particular, this report;

- extends the time period of the earlier work by 12 months, up to 31st March 2016
- enhances the casemix adjustment methods by including information on patient travel times
- adjusts the formulation of a number of the casemix-adjustment variables
- includes a preliminary assessment of whether the models developed to assess changes in admission thresholds over time can also be used to compare admission thresholds between hospitals.

1.2. The analysis uses the Hospital Episode Statistics for Accident and Emergency Departments for the six-year period from 1st April 2010 to 31st March 2016. Pseudonymised extracts of these datasets were supplied by NHS Digital under a suitable Data Sharing Agreement. The analysis has been conducted using Microsoft SQL Server 2012 and R v3.3.2. Car travel times from LSOA centroids to EDs for patient attendances were supplied by NHS England.

1.3. Further information about this project can be obtained from Steven Wyatt, Head of Strategic Analytics, the Strategy Unit (email : swyatt@nhs.net).

[1] Changes in admissions thresholds in English emergency departments, Wyatt S, Child K, Hood A, Cooke M, Mohammed MA, Emergency Medical Journal 2017 (doi: 10.1136/emermed-2016-206213)

2. Key Findings

2.1. Attendances at consultant-led emergency departments rose by 1.9% per annum from 13.0 million attendances in 2010/11 to 14.3 million attendances in 2015/16. The number of admissions via ED increased at a marginally faster rate from 3.3 million to 3.9 million.

2.2. Over this period, children (0-17 years) made up 23.6% and older adults (75+ years) 14.2% of attendances. 48.6% of attendances did not contain a valid diagnosis, but of those that did the most common presenting diagnoses were for dislocation/fracture/joint injury/amputation, gastrointestinal conditions, sprain/ligament injury, respiratory conditions, laceration and soft tissue inflammation.

2.3. For patients attending emergency departments, the risk of admission varies systematically with reference to the patient's age, gender, ethnicity, deprivation and presenting diagnosis. Other factors such as the season, day of week and hour of day of attendance, arrival mode, journey time, ED provider and the patient's previous ED attendances and admissions also play a part. Diagnosis, age and arrival mode have the biggest impact on whether a patient is admitted.

2.4. Having accounted for all these factors;

- the odds of admission decrease with age in children but increase with age in adults
- men are marginally more likely to be admitted than women
- children in affluent areas are slightly more likely than children from deprived areas to be admitted. No such gradient exists for adults.
- white people are more likely to be admitted than those from other ethnic groups
- the odds of admission vary greatly by diagnosis, with septicaemia presenting the greatest risk of admission.
- patients attending during the night, on weekends and in the winter are less likely to be admitted than patients attending at other times.
- patients that have previously attended and been admitted are more likely to be admitted if re-presenting at ED within one month and to a lesser extent within one year.
- the longer the journey that patients take to get to ED, the more likely they are to be admitted.

2.5. Having accounting for changes in casemix, the odds of admission reduced by 22% for ambulance-conveyed children, 35% for child walk-ins, 33% for ambulance conveyed adults and by 30% for adult walk-ins between 2010/11 and 2015/16.

2.6. Although these inferences are based on a subset of providers that record patient diagnoses at consistently high rates, it would not be unreasonable to conclude that these findings extend to all English emergency departments since the subset of providers are similar in profile to all providers in terms of size, location, rurality etc.

2.7. Many of the attendance characteristics that have grown at the fastest rate between 2010/11 and 2015/16 are also those that have the greatest odds of admission. In particular there has been faster growth in those aged under 5 and over 75 years, in those travelling more than 20 minutes to ED, in those with septicaemia, visceral injuries, CNS and respiratory conditions and those that had previously been admitted via ED; characteristics that carry higher odds of admission. At the same time, there have been reductions in the frequency of attendances for lacerations, contusions/abrasions, sprains/ligament injuries, burns/scalds and bites/stings which carry lower odds of admission.

2.8. This weak positive relationship between growth and odds of admission signals a slow upward drift in the average acuity of patients attending ED.

2.9. A preliminary assessment indicates evidence of non-constant risks between providers. This suggests that the models used to assess trends in admission thresholds and patient acuity over time should not be used to compare the admission thresholds between providers.

3. Describing Emergency Department Attendances

3.1. Circa 82 million ED attendances constitute the study population for this analysis. This represents all attendances between 1st April 2010 and 31st March 2016 at English Emergency Departments meeting the following design and data quality criteria.

design criteria

- attendance at consultant-led ED
- not brought in dead & did not die in the department
- did not leave before being seen or having refused treatment
- not a follow-up attendance

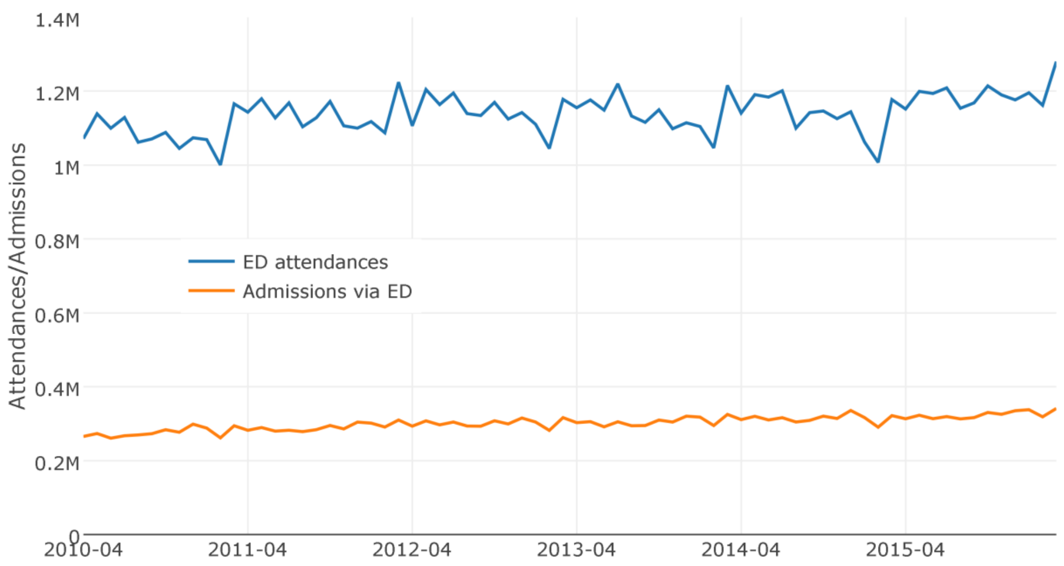
data quality criteria

- valid disposal code
- valid arrival mode code
- valid gender
- valid age
- valid Lower Super Output Area

Note that the data quality criteria exclude only 2.2% of attendances meeting the design criteria.

3.2. Figure 1 shows the trend in ED attendances and admissions via ED over this period. On average attendances at consultant-led emergency departments rose by 1.9% per annum from 13.0 million attendances in 2010/11 to 14.3 million attendances in 2015/16. The number of admissions via ED increased at a marginally faster rate from 3.3 million to 3.9 million.

Figure 1 : Trends in ED Attendances and Admissions via ED (Apr 2010 – Mar 2016)



3.3. Tables 1 and 2, set out the patient characteristics and their presenting diagnoses. Over the period between April 2010 and March 2016, children (0-17 years) made up 23.6% and older adults (75+ years) 14.2% of attendances. 48.6% of attendances did not contain a valid diagnosis, but of those that did the most common presenting diagnoses were for dislocation/fracture/joint injury/amputation, gastrointestinal conditions, sprain/ligament injury, respiratory conditions, laceration and soft tissue inflammation.

Table 1 : Patient Characteristics of ED Attendances (Apr 2010 – Mar 2016)

Characteristic	Subgroup	Frequency	Percent
Age Group	0	2,360,060	2.9%
	1-4	6,070,440	7.4%
	5-12	6,332,084	7.7%
	13-17	4,563,756	5.6%
	18-34	20,078,640	24.5%
	35-54	17,662,795	21.5%
	55-74	13,314,446	16.2%
	75+	11,602,532	14.2%
Gender	Male	41,042,728	50.1%
	Female	40,942,025	49.9%

Table 2 Presenting Diagnoses of ED Attendances (Apr 2010 – Mar 2016)

Diagnosis	Frequency	Percent
Laceration	2,770,263	3.4%
Contusion/abrasion	2,277,479	2.8%
Soft tissue inflammation	2,608,443	3.2%
Head injury	2,048,863	2.5%
Dislocation/fracture/joint injury/amputation	3,928,157	4.8%
Sprain/ligament injury	3,094,506	3.8%
Muscle/tendon injury	1,133,443	1.4%
Nerve injury	107,479	0.1%
Vascular injury	45,615	0.1%
Burns and scalds	359,766	0.4%
Electric shock	45,608	0.1%
Foreign body	585,160	0.7%
Bites/stings	279,511	0.3%
Poisoning (inc overdose)	812,959	1.0%
Near drowning	6,827	0.0%
Visceral injury	22,968	0.0%
Infectious disease	811,240	1.0%
Local infection	1,086,665	1.3%
Septicaemia	194,492	0.2%
Cardiac conditions	2,288,498	2.8%
Cerebro-vascular conditions	562,945	0.7%
Other vascular conditions	319,351	0.4%
Haematological conditions	200,283	0.2%
Central nervous system conditions	1,333,219	1.6%
Respiratory conditions	2,870,809	3.5%
Gastrointestinal conditions	3,556,842	4.3%
Urological conditions (inc cystitis)	1,491,440	1.8%
Obstetric conditions	237,908	0.3%
Gynaecological conditions	737,865	0.9%
Diabetes/endocrinological conditions	279,201	0.3%
Dermatological conditions	380,907	0.5%
Allergy (inc anaphylaxis)	320,715	0.4%
Facio-maxillary conditions	238,562	0.3%
ENT conditions	1,069,271	1.3%
Psychiatric conditions	663,467	0.8%
Ophthalmological conditions	1,666,458	2.0%
Social problems	189,169	0.2%
Nothing abnormal detected	1,512,190	1.8%
Not classifiable/classified	39,846,209	48.6%

4. The Factors Influencing Whether a Patient is Admitted

4.1. We estimate a patient's odds of admission having presented at ED using mixed effects logistic regression. This method calculates the odds of admission having taken account of a range of variables associated with the attendance. These variables can be classified as patient characteristics, diagnoses, attendance characteristics and prior hospital activity. Patient characteristics include; age, gender, deprivation, ethnicity. Diagnoses are those medical conditions with which the patient presents. Attendance characteristics include temporal factors (year, season, day of the week, time of day), arrival mode, travel time or distance and the hospital provider. Prior hospital activity takes account of whether patients' had attended ED and/or been admitted via ED in the previous month or year.

4.2. Preliminary analysis provided three important insights. Firstly that all of the above variables warranted inclusion in a multivariate model to estimate the odds of admission. Secondly that the odds of admission varied greatly between adults and children and between ambulance conveyed and other (walk-in) attendances. And finally that presenting diagnosis is the single most important predictor of admission such that models that did not include the patient's presenting diagnosis had limited predictive capability.

4.3. As a result, stratified models were developed for four attendance cohorts; children (aged 0-17 years) conveyed to ED via ambulance, children arriving at hospital by other means (child walk-in), adults conveyed by ambulance and adults arriving at hospital by other means (adult walk-in). Given that many ED providers record patient diagnosis poorly, models were developed based on a subset of providers that record the diagnosis of at least 70% of patients attending ED in each of the six years of the study. 46 providers met this criterion (see appendix A). Table 3 sets out the variables used to construct each of the four models.

4.4. The use of a subset of providers to identify the characteristics associated with increased risks of admission, introduces the potential for bias. Although not conclusive, table 4 below provides some reassurance that the subset of providers that record presenting diagnosis above the agreed threshold are broadly similar to all other hospitals in terms of size, geographic distribution, rurality, trauma centre status and change in bed numbers.

4.5. The model covariates and coefficients are shown in figure 2 below and in appendix B. Having accounted for differences in casemix, these results indicate that;

- the odds of admission decrease with age in children but increase with age in adults
- men are marginally more likely to be admitted than women
- children in affluent areas are slightly more likely than children from deprived areas to be admitted. No such gradient exists for adults.
- white people are more likely to be admitted than those from other ethnic groups
- the odds of admission vary greatly by diagnosis, with septicaemia presenting the greatest risk of admission.
- patients attending during the night, on weekends and in the winter are less likely to be admitted than patients attending at other times.

- patients that have previously attended and been admitted are more likely to be admitted if re-presenting at ED within one month and to a lesser extent within one year.
- the longer the journey that patients take to get to ED, the more likely they are to be admitted.

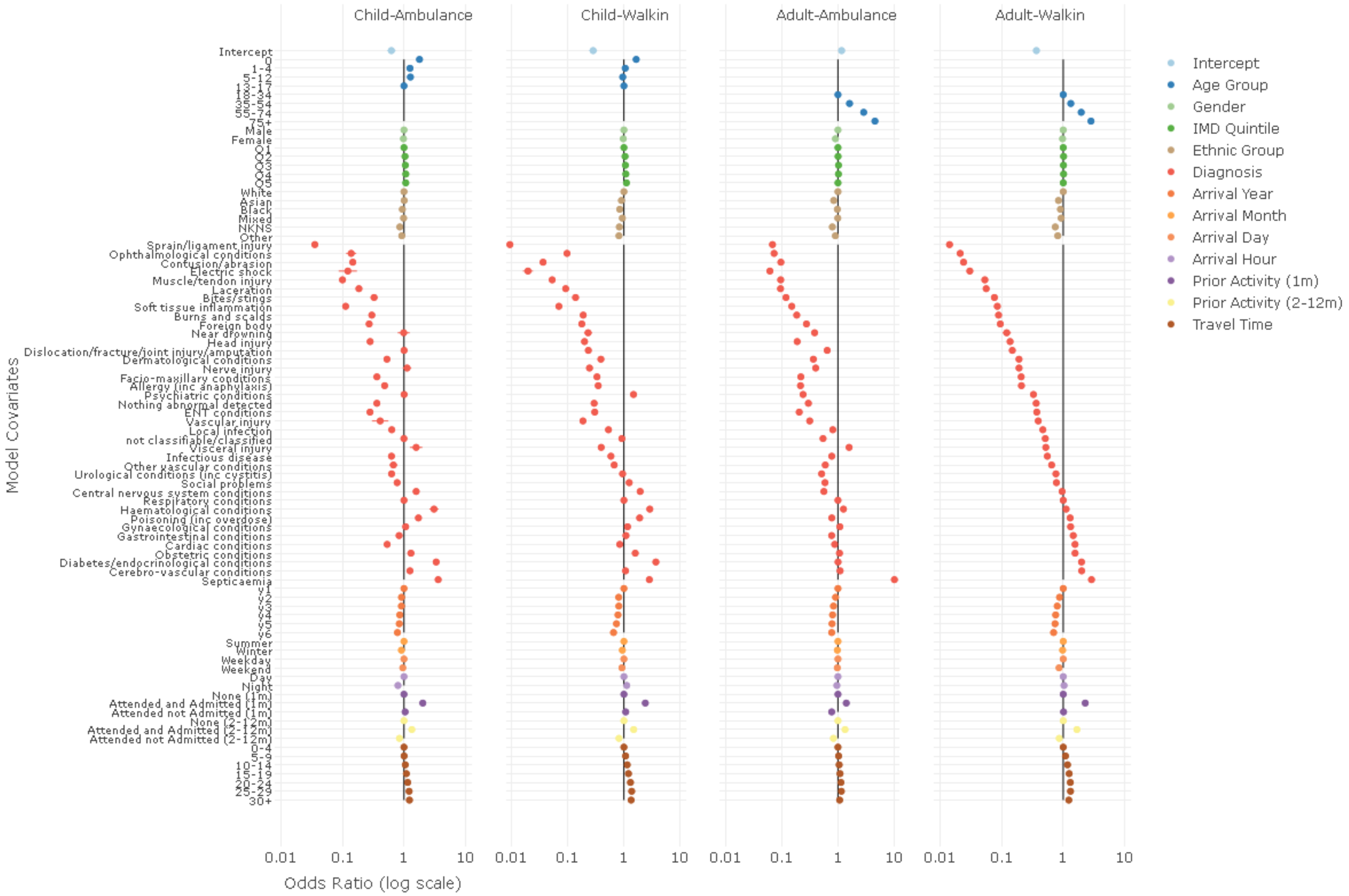
Table 3 : Model Variables and Levels

Variable	Levels (design variables)	Variable type
Age Group	0, 1-4, 5-12, 13-17, 18-34, 35-54, 55-74, 75+	Fixed effect
Gender	male, female	Fixed effect
Index of Multiple Deprivation (2004)	Quintile 1 (most deprived), Quintile 2, Quintile 3, Quintile 4, Quintile 5	Fixed effect
Ethnic group	White, Asian, Black, Mixed Heritage, other ethnic group, not known/not stated	Fixed effect
Diagnoses	laceration, contusion/abrasion, soft tissue inflammation, head injury, dislocation/fracture/joint injury/amputation, sprain/ligament injury, muscle/tendon injury, nerve injury, vascular injury, burns and scalds, electric shock, foreign body, bites/stings, poisoning (inc overdose), near drowning, visceral injury, infectious disease, local infection, septicaemia, cardiac conditions, cerebro-vascular conditions, other vascular conditions, haematological conditions, central nervous system conditions, respiratory conditions, gastrointestinal conditions, urological conditions (inc cystitis), obstetric conditions, gynaecological conditions, diabetes/endocrinological conditions, dermatological conditions, allergy (inc anaphylaxis), facio-maxillary conditions, ENT conditions, psychiatric conditions, ophthalmological conditions, social problems, nothing abnormal detected, not classifiable/classified	Fixed effect
Arrival Month	Winter (Nov-Feb), Summer	Fixed effect
Arrival day	weekday, weekend	Fixed effect
Arrival hour	day (8am-10pm), night (10pm-8am)	Fixed effect
Travel time (minutes)	0-4, 5-9, 10-14, 15-20, 25-29, 30+	Fixed effect
Prior Activity (28 days)	attended ED and admitted, attended not admitted, none	Fixed effect
Prior Activity (29-365 days)	attended ED and admitted, attended not admitted, none	Fixed effect
Provider	46 providers. See appendix A for full list	Random effect

Table 4 : Provider Characteristics

	Selected Trusts (n=44)		All Trusts with Type 1, 2 EDs (n=145)	
Region				
Eastern	7	(16%)	17	(12%)
London	2	(4%)	21	(14%)
North West	10	(22%)	23	(16%)
Northern and Yorkshire	7	(16%)	17	(12%)
South East	7	(16%)	22	(15%)
South West	4	(9%)	17	(12%)
Trent	4	(9%)	12	(8%)
West Midlands	4	(9%)	16	(11%)
Number of attendances 2014/15				
0-49,999	6	(13%)	10	(7%)
50-99,999	20	(44%)	65	(45%)
100-149,999	17	(38%)	53	(37%)
150-199,999	1	(2%)	9	(6%)
200-249,999	1	(2%)	6	(4%)
250,000+	0	(0%)	2	(1%)
% Patients from urban areas				
>= 0% and <25%	0	(0%)	0	(0%)
>= 25% and <50%	3	(7%)	6	(4%)
>=5 0% and <75%	11	(24%)	34	(23%)
>= 75% and <=100%	31	(69%)	105	(72%)
Major Trauma Centre				
Yes	7	(16%)	28	(19%)
No	38	(84%)	117	(81%)
General & Acute Beds Available				
Q4 2010-11	29,145		100,346	
Q4 2014-15	29,232		100,977	
% change	0.3%		0.6%	
General & Acute Beds Occupied				
Q4 2010-11	25,623		88,823	
Q4 2014-15	26,348		91,755	
% change	2.8%		3.3%	

Figure 2 : Model Covariates and Odds Ratios



5. Changes in Admission Thresholds

5.1. Table 4 and figure 3 show the trends in adjusted and unadjusted odds of admission between year 1 (1st April 2010 – 31st March 2011) and year 6 (1st April 2015 – 31st March 2016). Whilst the unadjusted odds of admission have changed little over the 6 year period, the adjusted odds of admission have reduced in all four cohorts. Between 2010/11 and 2015/16, the casemix-adjusted odds of admission reduced by 22% for ambulance-conveyed children, 35% for child walk-ins, 33% for ambulance conveyed adults conveyed and by 30% for adult walk-ins.

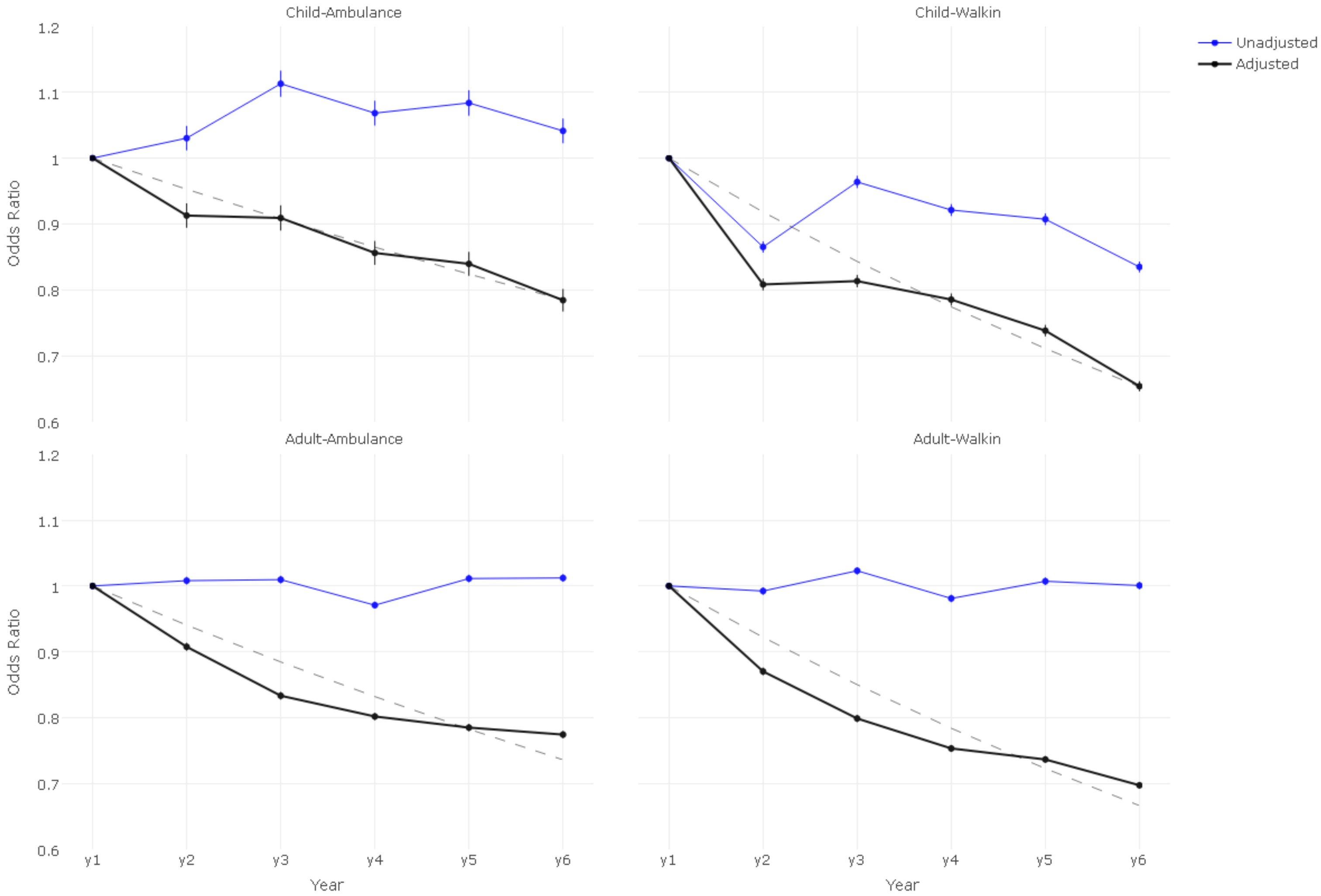
Table 4 : Adjusted and Unadjusted Odds of Admission by Year

Cohort	Year	Unadjusted OR (95% CI)		Adjusted OR (95% CI)	
Child Ambulance	2010/11 (ref)	1.00	-	1.00	-
	2011/12	1.03	(1.01,1.05)	0.91	(0.89,0.93)
	2012/13	1.11	(1.09,1.13)	0.91	(0.89,0.93)
	2013/14	1.07	(1.05,1.09)	0.86	(0.84,0.87)
	2014/15	1.08	(1.06,1.10)	0.84	(0.82,0.86)
	2015/16	1.04	(1.02,1.06)	0.78	(0.77,0.80)
Child Walk-in	2010/11 (ref)	1.00	-	1.00	-
	2011/12	0.87	(0.86,0.87)	0.81	(0.80,0.82)
	2012/13	0.96	(0.95,0.97)	0.81	(0.80,0.82)
	2013/14	0.92	(0.91,0.93)	0.79	(0.78,0.79)
	2014/15	0.91	(0.90,0.92)	0.74	(0.73,0.75)
	2015/16	0.83	(0.83,0.84)	0.65	(0.65,0.66)
Adult Ambulance	2010/11 (ref)	1.00	-	1.00	-
	2011/12	1.01	(1.00,1.01)	0.91	(0.90,0.91)
	2012/13	1.01	(1.00,1.02)	0.83	(0.83,0.84)
	2013/14	0.97	(0.97,0.98)	0.80	(0.80,0.81)
	2014/15	1.01	(1.01,1.02)	0.78	(0.78,0.79)
	2015/16	1.01	(1.01,1.02)	0.77	(0.77,0.78)
Adult Walk-in	2010/11 (ref)	1.00	-	1.00	-
	2011/12	0.99	(0.99,1.00)	0.87	(0.86,0.88)
	2012/13	1.02	(1.02,1.03)	0.80	(0.79,0.80)
	2013/14	0.98	(0.98,0.99)	0.75	(0.75,0.76)
	2014/15	1.01	(1.00,1.01)	0.74	(0.73,0.74)
	2015/16	1.00	(1.00,1.01)	0.70	(0.69,0.70)

5.2. For adults, the greatest reductions in casemix-adjusted odds of admission were seen in the first half of the study period, with reductions slowing in later years. In contrast, the odds of admissions for children saw the great reductions in the first and last years of the study period.

5.3. C-statistics, ROC curves and calibration plots for each of the 4 models are provided in appendix C.

Figure 3 : Adusted and Unadjusted Odds of Admission by Year (Apr 2010 – Mar 2011 to Apr 2015 – Mar 2016)



6. Changes in Patient and Attendance Characteristics

6.1. Table 5 below shows the frequency of patient characteristics for ED attendances between April 2010 and March 2016 and the rate at which attendances with those characteristics have changed over the six-year period. Figures are supplied for all providers and for the subgroup of providers[2] with consistently high levels of diagnosis recording that was used to construct the models.

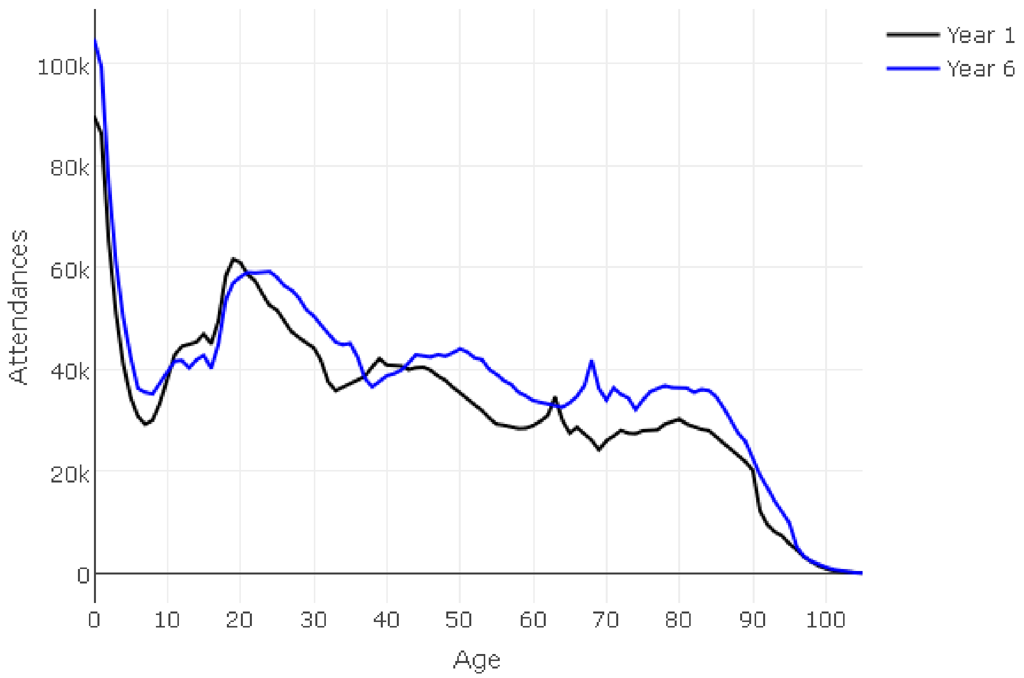
Table 5 : Frequency and Growth of Patient Characteristics (Apr 2010 – Mar 2016)

		all providers		provider subgroup[2]	
Characteristic	**Subgroup**	**Frequency**	**Growth p.a.**	**Frequency**	**Growth p.a.**
Age Group	0	2,360,060	1.2%	575,994	2.6%
	1-4	6,070,440	1.4%	1,582,220	2.9%
	5-9	6,332,084	0.9%	1,747,592	1.5%
	13-17	4,563,756	-2.7%	1,313,474	-2.1%
	18-34	20,078,640	0.2%	5,293,807	1.6%
	35-54	17,662,795	0.6%	4,767,450	1.5%
	55-74	13,314,446	3.1%	3,805,714	4.1%
	75+	11,602,532	4.2%	3,351,512	4.8%
Gender	Male	41,042,728	0.7%	11,256,481	1.6%
	Female	40,942,025	1.9%	11,181,282	3.1%
IMD Quintile	Q1	23,201,534	0.7%	6,113,778	2.1%
	Q2	18,238,315	1.0%	4,573,907	2.5%
	Q3	15,100,881	1.5%	4,285,887	2.7%
	Q4	13,367,671	1.9%	4,037,551	2.3%
	Q5	12,076,352	2.2%	3,426,640	2.1%
Ethnic Group	White	50,379,563	22.5%	15,136,209	20.9%
	Asian	4,514,965	18.9%	728,478	37.0%
	Black	2,735,444	18.4%	258,270	34.8%
	Mixed	984,220	24.6%	180,709	28.6%
	Other	2,051,401	26.3%	331,527	27.5%
	Not known/stated	21,319,160	-30.4%	5,802,570	-30.3%

6.2. The greatest increases are seen in attendances of those aged under 5 years, those aged over 55 years and in women. Attendances of older children and young adults have reduced. Improvements in ethnicity recording are also evident.

[2] See appendix A.

Figure 4 : Age Profile of ED Attenders Apr 2010-Mar 2011 and Apr 2015-Mar 2016



6.3. Table 6 provides information about the frequency and growth of presenting diagnoses. For the subset of providers with consistently high levels of diagnosis recording, the diagnoses seeing the greatest level of growth in absolute terms were ophthalmological, gastro-intestinal, cardiac, respiratory and urological conditions. The diagnoses with the greatest reductions were sprains/ligament injuries, head injuries, lacerations, contusions/abrasions and local infections.

6.4. Table 6 also indicates rapid growth in diagnoses of septicaemia/sepsis during the study period reflecting efforts to improve the identification of this condition in ED. This introduces the possibility that the average acuity of sepsis cases has fallen during the study period. Although a diagnosis of sepsis remains relatively uncommon, representing only 0.2% of all attendances between April 2010 and March 2016, the odds ratios of admission for this diagnosis are particularly high, increasing the leverage of this subset of attendances on the model results as a whole. A sensitivity analysis was conducted, estimating the parameters in the adult walk-in model having excluded the sepsis cases.[3] This demonstrated that the increased identification of sepsis cases did not materially alter the

[3] For convenience, this sensitivity analysis was based on the models fixed effects only.

headline conclusion from chapter 4; that having adjusted for casemix, patients were considerably less likely to be admitted in 2015/16 than in 20110/11.

6.5. Table 7 provides information about the frequency and growth in attendance characteristics. Ambulance conveyed attendances have grown at a slightly faster rate than walk-in attendances. Winter, weekend and night time attendances grew at a faster rate than attendances at other times. Attendances requiring travel times in excess of 20 minutes grew at a faster rate than attendances requiring shorter journeys.

6.6. Table 8 provides information about the frequency and growth of ED attendances and admissions via ED one month and 12 months prior to the index ED attendance. Attendances that were preceded by attendances that had not resulted in admission grew at the fastest rate

Table 6 : *Frequency and Growth of Patient Diagnoses (Apr 2010 – Mar 2016)*

	all providers		provider subgroup	
Diagnosis	**Frequency**	**Growth p.a.**	**Frequency**	**Growth p.a.**
Laceration	2,770,263	-2.7%	1,304,860	-2.7%
Contusion/abrasion	2,277,479	-1.7%	1,093,725	-2.6%
Soft tissue inflammation	2,608,443	-0.7%	931,333	0.6%
Head injury	2,048,863	0.2%	972,850	-4.6%
Dislocation/fracture/joint injury/amputation	3,928,157	0.3%	1,812,212	-0.4%
Sprain/ligament injury	3,094,506	-1.6%	1,501,928	-4.2%
Muscle/tendon injury	1,133,443	0.3%	637,039	3.3%
Nerve injury	107,479	5.0%	66,017	12.7%
Vascular injury	45,615	1.1%	26,530	-2.4%
Burns and scalds	359,766	-0.3%	143,852	-1.7%
Electric shock	45,608	10.9%	30,282	29.2%
Foreign body	585,160	1.1%	292,522	2.1%
Bites/stings	279,511	-3.9%	132,788	-5.6%
Poisoning (inc overdose)	812,959	5.0%	374,367	3.3%
Near drowning	6,827	-1.7%	5,117	15.2%
Visceral injury	22,968	12.8%	12,020	15.9%
Infectious disease	811,240	18.5%	311,505	17.8%
Local infection	1,086,665	-0.4%	536,201	-3.3%
Septicaemia	194,492	39.6%	105,167	35.1%
Cardiac conditions	2,288,498	6.2%	1,018,586	5.8%
Cerebro-vascular conditions	562,945	0.0%	260,631	-0.4%
Other vascular conditions	319,351	3.3%	137,338	-0.5%
Haematological conditions	200,283	5.7%	81,016	12.9%
Central nervous system conditions	1,333,219	5.5%	561,205	4.8%
Respiratory conditions	2,870,809	4.9%	1,266,217	4.6%
Gastrointestinal conditions	3,556,842	5.7%	1,582,522	4.2%
Urological conditions (inc cystitis)	1,491,440	8.7%	664,339	8.5%
Obstetric conditions	237,908	-5.7%	96,710	1.1%
Gynaecological conditions	737,865	7.2%	325,594	2.7%
Diabetes/endocrine conditions	279,201	8.1%	137,172	5.0%
Dermatological conditions	380,907	6.1%	167,734	8.2%
Allergy (inc anaphylaxis)	320,715	2.7%	140,118	3.6%
Facio-maxillary conditions	238,562	7.1%	101,657	3.7%
ENT conditions	1,069,271	7.6%	416,688	6.8%
Psychiatric conditions	663,467	10.6%	273,565	9.5%
Ophthalmological conditions	1,666,458	7.4%	790,772	18.5%
Social problems	189,169	7.0%	74,310	4.5%
Nothing abnormal detected	1,512,190	2.4%	753,439	4.4%
not classifiable/classified	39,846,209	-0.2%	3,297,835	2.0%

Table 7 : Frequency and Growth of Attendance Characteristics (Apr 2010 – Mar 2016)

		all providers		provider subgroup	
Characteristic	**Subgroup**	**Frequency**	**Growth p.a.**	**Frequency**	**Growth p.a.**
Arrival Mode	Ambulance	24,016,938	2.0%	6,639,897	2.7%
	Walk-in	57,967,815	1.0%	15,797,866	2.2%
Arrival Month	Summer	55,534,106	1.2%	15,227,829	2.3%
	Winter	26,450,647	1.6%	7,209,934	2.5%
Arrival Day	Weekday	58,795,743	1.3%	16,025,432	2.3%
	Weekend	23,189,010	1.3%	6,412,331	2.5%
Arrival Hour	Day	66,254,281	1.2%	18,235,378	2.2%
	Night	15,730,472	1.7%	4,202,385	3.2%
Travel Time (mins)	0-4	7,911,206	-0.8%	1,997,063	0.4%
	5-9	22,023,377	-0.4%	5,492,136	1.1%
	10-14	19,631,124	0.5%	4,787,210	1.7%
	15-19	12,277,907	2.4%	3,453,148	2.2%
	20-24	6,885,846	3.6%	2,157,668	4.1%
	25-29	4,157,438	5.0%	1,328,702	3.5%
	30+	9,097,855	4.2%	3,221,836	5.2%

Figure 5 : Travel Time Profile of ED Attendances Apr 2010-Mar 2011 and Apr 2015-Mar 2016

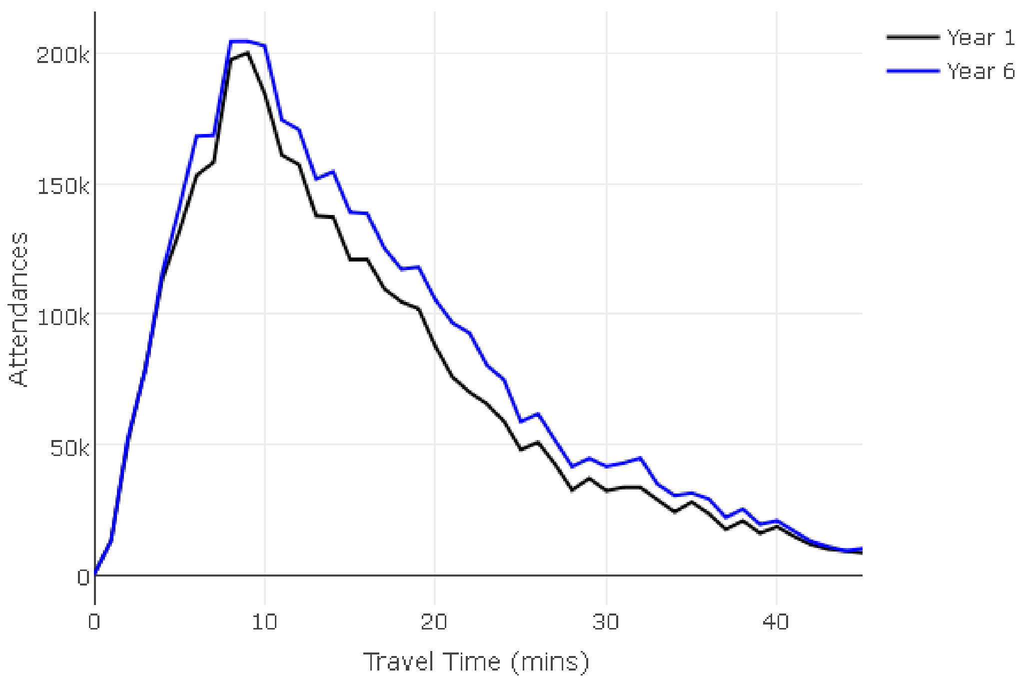


Table 8 : Frequency and Growth of Prior Utilisation Characteristics (Apr 2010 – Mar 2016)

		all providers		provider subgroup	
Characteristic	**Subgroup**	**Frequency**	**Growth p.a.**	**Frequency**	**Growth p.a.**
Prior Activity (1 month)	Attended and admitted	72,317,398	1.1%	19,959,448	2.1%
	Attended not admitted	3,575,912	4.9%	922,151	4.6%
	None	6,091,443	1.8%	1,556,164	3.8%
Prior Activity (2- 12 months)	Attended and admitted	50,136,905	0.4%	13,846,380	1.3%
	Attended not admitted	13,659,786	4.8%	3,671,287	5.1%
	None	18,188,062	1.2%	4,920,096	3.4%

7. Changes in the Acuity Profile of ED Attendances

7.1. Section 4 sets out the factors that influence the odds of admission. We use this now as a proxy for clinical acuity, i.e. those attendances with high odds of admission are taken to be those with the greatest clinical acuity[4]. By viewing this information along with the differing rates of growth of patient, diagnosis, attendance and prior utilisation characteristics (section 5) we can gain insight into the changing acuity profile of ED attendances.

7.2. We start with the 'diagnoses' characteristic given that this factor has the greatest influence on a patient's odds of admission within each of the 4 cohorts. Figure 6 below represents each of the 39 diagnoses for children conveyed by ambulance. Each diagnosis is represented by a circle in the chart. The number of attendances with the diagnosis is indicated by the circle area. The odds of admission[5], as a proxy for acuity, are represented on the vertical axis and the growth in attendances with this diagnosis is represented on the horizontal axis. Points in the top right quadrant such as septicaemia (19), visceral injuries (16), nerve injuries (8), CNS conditions (24) and respiratory conditions (25) are therefore higher acuity diagnoses that are growing in frequency. Points in the bottom left quadrant such as sprain/ligament injuries (6), soft tissue inflammation (3) and lacerations (1) are in contrast lower acuity diagnoses that are reducing in frequency. These effects are offset by growth in some lower acuity diagnoses; ENT (34) and electric shocks (11) and reductions in some higher acuity conditions; cerebro-vascular and gynaecological conditions. Nonetheless there remains a weak but significant association between growth and acuity ($r=0.356$, $p=0.026$), indicating casemix drift towards higher acuity attendances.

7.3. Figure 7 extends this approach to all casemix-adjustment variables. Similar, although less striking patterns are seen in the age group and travel time covariates, with higher acuity attendances (the very young and very old and those with long travel times) increasing whilst other lower acuity attendances are reducing or increasing at a slower rate. The relationship between acuity and growth are less clear cut in the other covariates.

7.4. Tables 9 - 12 classify each covariate for each of the 4 cohorts into the four quadrants. Characteristics in the '*higher acuity* ↑' (dark red) or '*lower acuity* ↓' (light red) quadrants indicate increased casemix acuity, whereas those labelled '*higher acuity* ↓' (dark blue) or '*lower acuity* ↑' (light blue) indicate reduced casemix acuity.

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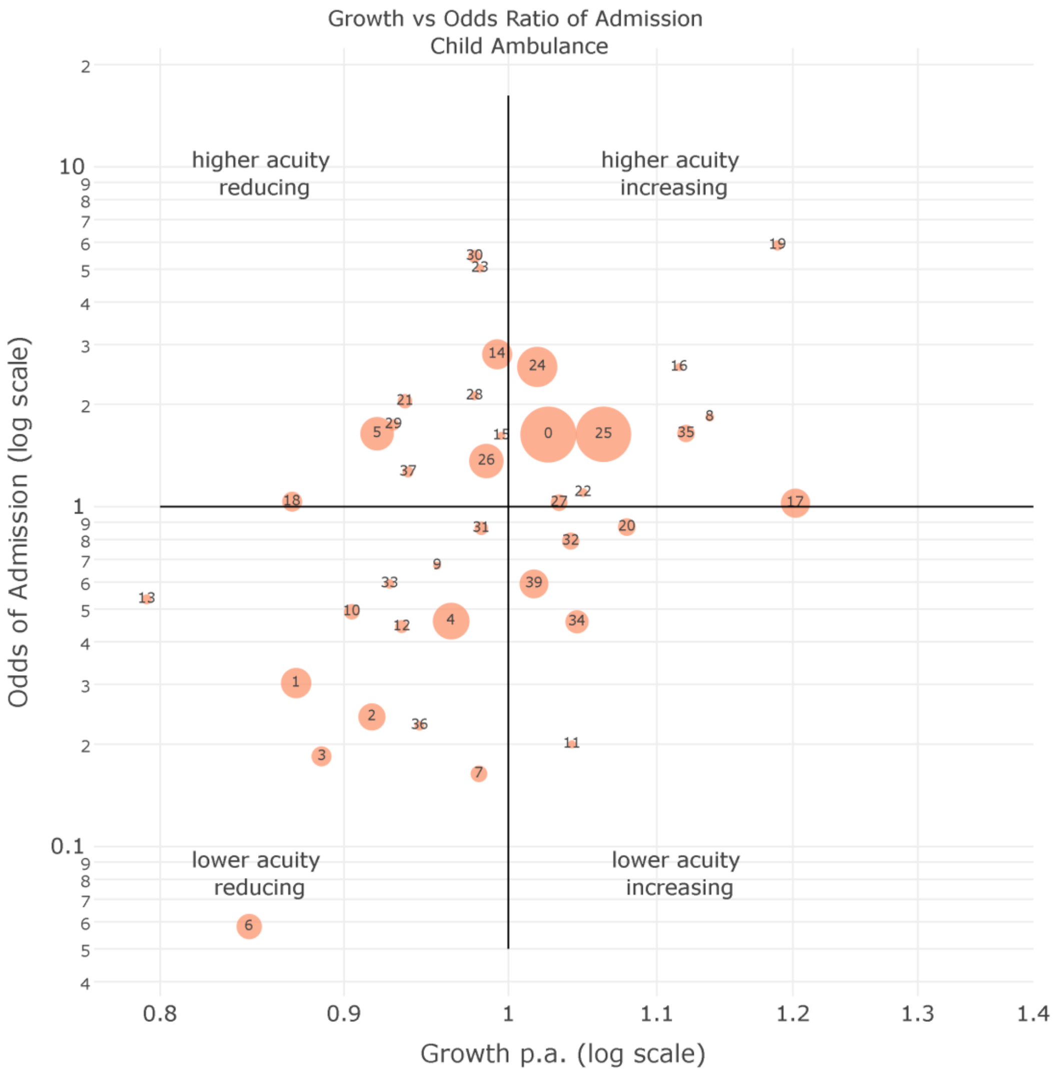
[4] We acknowledge that odds of admission is not a perfect proxy for acuity.

[5] To allow comparisons across all variables and levels (rather than to an arbitrary reference level), odds ratios have been centred on 1 using the number of attendances with a given characteristic as a weighting variable.

Figure 6 : Growth vs Odds of Admission : Presenting Diagnoses (Child Ambulance)



1	Laceration	14	Poisoning (inc overdose)	27	Urological conditions
2	Contusion/abrasion	15	Near drowning	28	Obstetric conditions
3	Soft tissue inflammation	16	Visceral injury	29	Gynaecological conditions
4	Head injury	17	Infectious disease	30	Diabetes/endocrine conditions
5	Dislocation/fracture/joint injury/amputation	18	Local infection	31	Dermatological conditions
6	Sprain/ligament injury	19	Septicaemia	32	Allergy (inc anaphylaxis)
7	Muscle/tendon injury	20	Cardiac conditions	33	Facio-maxillary conditions
8	Nerve injury	21	Cerebro-vascular conditions	34	ENT conditions
9	Vascular injury	22	Other vascular conditions	35	Psychiatric conditions
10	Burns and scalds	23	Haematological conditions	36	Ophthalmological conditions
11	Electric shock	24	CNS conditions	37	Social problems
12	Foreign body	25	Respiratory conditions	39	Nothing abnormal detected
13	Bites/stings	26	Gastrointestinal conditions	0	not classifiable/classified

Figure 7 : Growth vs Odds of Admission : All Covariates (Child Ambulance)

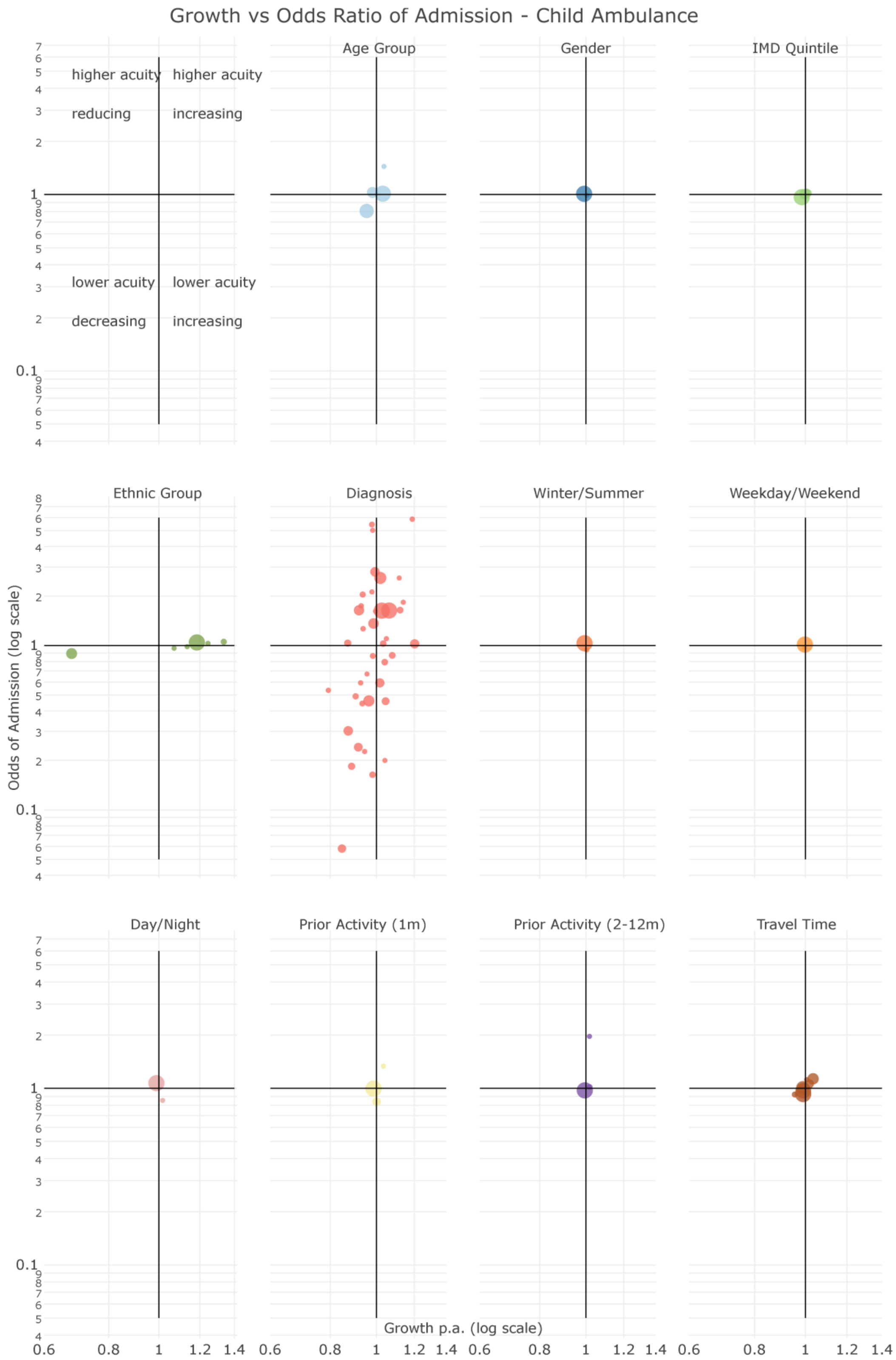


Table 9 : Acuity and Growth of Patient Characteristics

Characteristic	Subgroup	Child Ambulance	Child Walk-in	Adult Ambulance	Adult Walk-in
Age Group	0	higher acuity ↑	higher acuity ↑	*NA*	*NA*
	1-4	higher acuity ↑	higher acuity ↑	*NA*	*NA*
	5-12	higher acuity ↓	lower acuity ↑	*NA*	*NA*
	13-17	lower acuity ↓	lower acuity ↓	*NA*	*NA*
	18-34	*NA*	*NA*	lower acuity ↑	lower acuity ↑
	35-54	*NA*	*NA*	lower acuity ↑	lower acuity ↑
	55-74	*NA*	*NA*	higher acuity ↑	higher acuity ↑
	75+	*NA*	*NA*	higher acuity ↑	higher acuity ↑
Gender	Male	higher acuity ↓	higher acuity ↑	higher acuity ↑	higher acuity ↑
	Female	lower acuity ↑	lower acuity ↑	lower acuity ↑	lower acuity ↑
IMD Quintile	Q1	lower acuity ↓	lower acuity ↑	lower acuity ↑	lower acuity ↑
	Q2	higher acuity ↓	lower acuity ↑	lower acuity ↑	higher acuity ↑
	Q3	higher acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑
	Q4	higher acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑
	Q5	higher acuity ↑	higher acuity ↑	lower acuity ↑	lower acuity ↑
Ethnic Group	White	higher acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑
	Asian	higher acuity ↑	lower acuity ↑	lower acuity ↑	lower acuity ↑
	Black	lower acuity ↑	lower acuity ↑	higher acuity ↑	lower acuity ↑
	Mixed	higher acuity ↑	lower acuity ↑	higher acuity ↑	higher acuity ↑
	Other	lower acuity ↑	lower acuity ↑	lower acuity ↑	lower acuity ↑
	Not known/stated	lower acuity ↓	lower acuity ↓	lower acuity ↓	lower acuity ↓

Table 10 : Acuity and Growth of Attendance Characteristics

Characteristic	Subgroup	Child Ambulance	Child Walk-in	Adult Ambulance	Adult Walk-in
Arrival Month	Summer	higher acuity ↓	higher acuity ↑	higher acuity ↑	higher acuity ↑
	Winter	lower acuity ↑	lower acuity ↑	lower acuity ↑	lower acuity ↑
Arrival Day	Weekday	higher acuity ↓	higher acuity ↑	higher acuity ↑	higher acuity ↑
	Weekend	lower acuity ↓	lower acuity ↑	lower acuity ↑	lower acuity ↑
Arrival Hour	Day	higher acuity ↓	lower acuity ↑	higher acuity ↑	lower acuity ↑
	Night	lower acuity ↑	higher acuity ↑	lower acuity ↑	higher acuity ↑
Travel Time (mins)	0-4	lower acuity ↓	lower acuity ↓	lower acuity ↑	lower acuity ↑
	5-9	lower acuity ↓	lower acuity ↑	lower acuity ↑	lower acuity ↑
	10-14	lower acuity ↓	lower acuity ↑	lower acuity ↑	higher acuity ↑
	15-19	higher acuity ↓	higher acuity ↑	higher acuity ↑	higher acuity ↑
	20-24	higher acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑
	25-29	higher acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑
	30+	higher acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑

Table 11 : Acuity and Growth of Prior Utilisation Characteristics

Character-istic	Subgroup	Child Ambulance	Child Walk-in	Adult Ambulance	Adult Walk-in
Prior Activity (1 month)	Attended and admitted	higher acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑
	Attended not admitted	higher acuity ↑	higher acuity ↑	lower acuity ↑	lower acuity ↑
	None	lower acuity ↓	lower acuity ↑	lower acuity ↑	lower acuity ↑
Prior Activity (2- 12 months)	Attended and admitted	higher acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑
	Attended not admitted	lower acuity ↑	lower acuity ↑	lower acuity ↑	lower acuity ↑
	None	lower acuity ↓	higher acuity ↑	lower acuity ↑	lower acuity ↑

Table 12 : Acuity and Growth of Presenting Diagnoses

Subgroup	**Child Ambulance**	**Child Walk-in**	**Adult Ambulance**	**Adult Walk-in**
Laceration	lower acuity ↓	lower acuity ↓	lower acuity ↓	lower acuity ↓
Contusion/abrasion	lower acuity ↓	lower acuity ↓	lower acuity ↓	lower acuity ↓
Soft tissue inflammation	lower acuity ↓	lower acuity ↓	lower acuity ↑	lower acuity ↑
Head injury	lower acuity ↓	lower acuity ↑	lower acuity ↑	lower acuity ↓
Dislocation/fracture/joint injury/amputation	higher acuity ↓	higher acuity ↓	higher acuity ↓	lower acuity ↓
Sprain/ligament injury	lower acuity ↓	lower acuity ↓	lower acuity ↓	lower acuity ↓
Muscle/tendon injury	lower acuity ↓	lower acuity ↑	lower acuity ↑	lower acuity ↑
Nerve injury	higher acuity ↑	higher acuity ↑	lower acuity ↑	higher acuity ↑
Vascular injury	lower acuity ↓	lower acuity ↑	lower acuity ↓	higher acuity ↓
Burns and scalds	lower acuity ↓	lower acuity ↓	lower acuity ↓	lower acuity ↓
Electric shock	lower acuity ↑	lower acuity ↑	lower acuity ↑	lower acuity ↑
Foreign body	lower acuity ↓	lower acuity ↑	lower acuity ↑	lower acuity ↑
Bites/stings	lower acuity ↓	lower acuity ↓	lower acuity ↓	lower acuity ↓
Poisoning (inc overdose)	higher acuity ↓	higher acuity ↑	higher acuity ↑	higher acuity ↑
Near drowning	higher acuity ↓	higher acuity ↑	lower acuity ↓	lower acuity ↑
Visceral injury	higher acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑
Infectious disease	higher acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑
Local infection	higher acuity ↓	higher acuity ↓	higher acuity ↓	higher acuity ↓
Septicaemia	higher acuity↑	higher acuity ↑	higher acuity ↑	higher acuity ↑
Cardiac conditions	lower acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑
Cerebro-vascular conditions	higher acuity ↓	higher acuity ↓	higher acuity ↓	higher acuity ↑
Other vascular conditions	higher acuity ↑	higher acuity ↑	higher acuity ↓	higher acuity ↓
Haematological conditions	higher acuity ↓	higher acuity ↑	higher acuity ↑	higher acuity ↑
Central nervous system conditions	higher acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑
Respiratory conditions	higher acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑
Gastrointestinal conditions	higher acuity ↓	higher acuity ↑	higher acuity ↑	higher acuity ↑
Urological conditions (inc cystitis)	higher acuity ↑	higher acuity ↑	lower acuity ↑	higher acuity ↑
Obstetric conditions	higher acuity ↓	higher acuity ↓	higher acuity ↑	higher acuity ↑
Gynaecological conditions	higher acuity ↓	higher acuity ↓	higher acuity ↑	higher acuity ↑
Diabetes/endocrine conditions	higher acuity ↓	higher acuity ↑	higher acuity ↑	higher acuity ↑
Dermatological conditions	lower acuity ↓	higher acuity ↑	lower acuity ↑	higher acuity ↑
Allergy (inc anaphylaxis)	lower acuity ↑	higher acuity ↑	lower acuity ↑	higher acuity ↑
Facio-maxillary conditions	lower acuity ↓	higher acuity ↑	lower acuity ↓	higher acuity ↑
ENT conditions	lower acuity ↑	higher acuity ↑	lower acuity ↑	higher acuity ↑
Psychiatric conditions	higher acuity ↑	higher acuity ↑	lower acuity ↑	higher acuity ↑
Ophthalmological conditions	lower acuity ↓	lower acuity ↑	lower acuity ↓	lower acuity ↑
Social problems	higher acuity ↓	higher acuity ↑	higher acuity ↑	higher acuity ↑
Nothing abnormal detected	lower acuity ↑	higher acuity ↑	lower acuity ↑	higher acuity ↑
not classifiable/classified	higher acuity ↑	higher acuity ↑	higher acuity ↑	higher acuity ↑

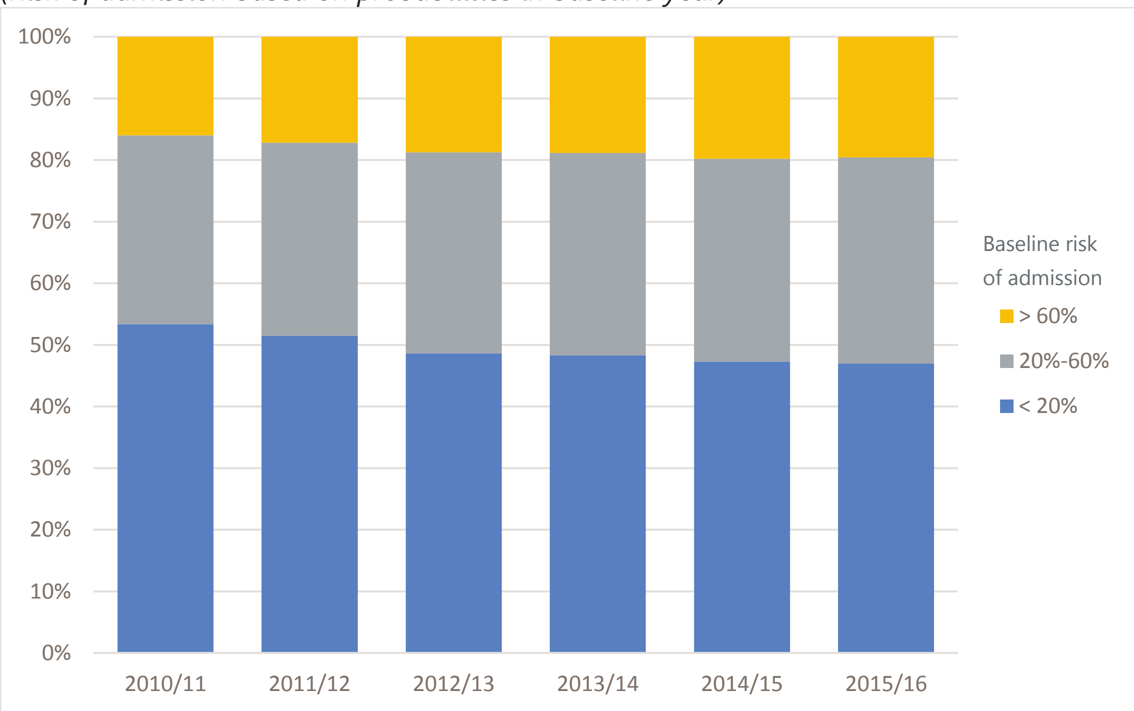
7.5. Similar results are found in child walk-in attendances, adults conveyed by ambulance and adult walk-in attendances (see appendix D), although the association between growth and acuity of diagnoses is notably stronger for adults conveyed by ambulance ($r=0.656$, $p=0.000$).

7.6. In conclusion, many of those characteristics that have grown at the fastest rate between 2010/11 and 2015/16 are also those that have the greatest odds of admission. In particular there has been faster growth in those aged under 5 and over 75 years, in those travelling more than 20 minutes to ED, in those with septicaemia, visceral injuries, CNS and respiratory conditions and those that had previously been admitted via ED; and these characteristics carry higher odds of admission. At the same time, there have been reductions in the frequency of attendances for lacerations, contusions/abrasions, sprains/ligament injuries, burns/scalds and bites/stings which carry lower odds of admission.

7.7. Using the models developed in section 4, we can explore how these changing characterises have influenced the profile of attendance acuity over time. Applying the casemix-adjusted odds of admission in 2010/11, we estimate a baseline probability of admission for each attendance. We group attendances into three acuity groups; those with less than 20% probability of admission, those with a probability between 20% and 60% and those with more than 60% probability of admission. Figure 8 shows the changing profile of attendance acuity over the study period.

7.8. Corroborating earlier analysis, this chart demonstrates that higher acuity attendances represent a greater proportion of admissions in 2015/16 than in 2010/11.

Figure 8 : % of Attendances by Modelled Risk of Admission (Risk of admission based on probabilities in baseline year)



8. The Impact on Hospital Activity and Costs

8.1. The analysis in chapters 5 and 7 imply that some low-acuity attendances have been diverted from ED to other settings and that some emergency admissions have been avoided as a result of increases in casemix-adjusted admission thresholds. Here we estimate the number of ED attendances and emergency admissions that have been avoided in 2015/16 as a result of these changes.

8.2. Chapter 7 defines low-acuity ED attendances as those with less than 20% chance of admission based on the casemix-adjusted admission thresholds that applied in 2010/11. These attendances grew by only 0.1% between 2010/11 and 2015/16, whereas other (higher) acuity attendances grew by 29.5%. If we assume that the demand pressures for low and high acuity attendances are equal, then the difference in these growth rates can be used to estimate the number of attendances that have been diverted away from EDs. We estimate this number at 549 thousand attendances in 2015/16, or 33 attendances per hospital trust per day. If we assume that these attendances would have been charged at the lowest tariff, the commissioner savings amounts to £30.7m across the 46 Trusts in 2015/16.

8.3. Chapter 5 describes the changes in the casemix-adjusted odds of admissions between 2010/11 and 2015/15. Applying the 2010/11 odds of admission to the attendances in 2015/16, we can estimate the difference between the actual number of admissions and the number that would have occurred if admission thresholds had not changed. We estimate this at 168 thousand emergency admissions in 2015/16, or 10 admissions per hospital trust per day. Estimating the commissioner cost consequence of these avoided admissions is not straightforward because the tariffs that apply are highly variable. But if we assume that all avoided attendances would have attracted the lower decile tariff for emergency admissions, then we conservatively estimate the commissioner cost saving at £77.5m in 2015/16.

8.4. The combined commissioner saving in 2015/16, from diverted low acuity ED attendances and avoided emergency admissions in the 46 study hospitals is therefore £108.3m. If these saving were replicated at all Trusts then, taking account of the size of each Trust, we estimate that this saving represents approximately 0.6% of the total CCG programme allocation.

9. Variation in Admission Thresholds between Providers

9.1. Having established the factors that influence admission via ED and assessed whether these are changing over time, a logical next question is whether some hospitals admit patients at materially different rates than others having adjusted for the casemix of patients that present. This question is non-trivial and mirrors much of the debate about methodological bias in hospital standardised mortality rates. Mohammed[6] sets out an approach to assess the validity of inter-hospital comparisons based on logistic regression models. We present here some preliminary work to assess whether the models described in section 4 above could be legitimately used compare casemix-adjusted provider admission thresholds via ED.

9.2. The approach set out by Mohammed involves evaluating whether the relationship between each casemix-adjustment variable and the outcome variable (in this case admitted y/n) is constant across all providers. In practice, this means assessing the strength of the interaction between the model covariate representing the provider and each of the other model covariates. Multiple instances of strong[7] and statistically significant interaction terms indicate non-constant risks and questions the validity of inter-provider comparisons.

9.3. For practical purposes, we limit our assessment here to adult walk-in attendances (the largest of the 4 cohorts) in 2015/16 and to the interactions between provider and diagnosis, the strongest predictor of admission. We suggest that if risks are not constant across providers, then it would be particularly evident in this cohort and with this covariate.

9.4. The models described in section 4 treat provider as a random effect and diagnosis is a fixed effect. Fitting models which include interactions terms between fixed and random effects requires considerable processing power and time. For the purposes of this assessment therefore, we treat provider as a fixed effect.

9.5. Table 13 below shows the proportion of providers with large and significant interactions with each of the diagnoses. This clearly demonstrates widespread instances of non-constant risks and therefore rules out the potential to use the models described in section 4 to legitimately assess differences between providers in casemix-adjusted admission rates via ED.

9.6. Non-constant risks can be caused by either differential measurement error[8] or inconsistent proxy measures of risk[9]. It is unclear which of these mechanisms are at play here.

[6] Mohammed MA, Deeks DJ, Girling A, Rudge G, Carmalt M, Stevens AJ, Lilford RL, Evidence of methodological bias in hospital standardised mortality ratios: retrospective database study of English hospitals, BMJ 2009;338:b780

[7] odds ratios greater than 2 or less than 0.5

[8] E.g. what one provider labels 'visceral injury' another labels 'laceration'.

[9] E.g. some areas divert simple lacerations and contusions to an MIU, leaving only complex lacerations and contusions to be treated at the emergency department.

Table 13 : % of Providers with Large Significant Interactions with Diagnoses

Diagnosis	% of Providers
Laceration	29%
Contusion/abrasion	33%
Soft tissue inflammation	50%
Head injury	41%
Dislocation/fracture/joint injury/amputation	18%
Sprain/ligament injury	63%
Muscle/tendon injury	36%
Nerve injury	16%
Vascular injury	32%
Burns and scalds	20%
Electric shock	3%
Foreign body	31%
Bites/stings	32%
Poisoning (inc overdose)	25%
Near drowning	0%
Visceral injury	23%
Infectious disease	60%
Local infection	22%
Septicaemia	0%
Cardiac conditions	22%
Cerebro-vascular conditions	69%
Other vascular conditions	91%
Haematological conditions	87%
Central nervous system conditions	10%
Gastrointestinal conditions	10%
Urological conditions (inc cystitis)	27%
Obstetric conditions	37%
Gynaecological conditions	32%
Diabetes/endocrinological conditions	18%
Dermatological conditions	65%
Allergy (inc anaphylaxis)	21%
Facio-maxillary conditions	41%
ENT conditions	80%
Psychiatric conditions	56%
Ophthalmological conditions	38%
Social problems	33%
Nothing abnormal detected	58%
not classifiable/classified	47%

10. Possible Further Work

10.1. This analysis indicates that lower acuity attendances have reduced in frequency or grown at a slower rate than higher acuity attendances, driving up the average acuity level of attendances. This trend is in line with national policy to divert lower acuity attendances to lower cost settings (e.g. walk-in centres, ambulance treat at scene, GP practices), for management via NHS Direct / NHS111 and with self-care advice. To corroborate this finding, might entail seeking direct evidence of increases in activity at these lower cost settings of the types that appear to have been diverted from EDs.

10.2. Cowling[10] found that GP practices providing more timely access to primary care, generated fewer low acuity (self-referred discharged) ED attendances per registered patient having controlled for a range of other variables. Cowling's analysis was based on HES AE data, GP Patient Survey data and socio-demographic data from 2010/11. There may be value in recreating the Cowling model using 2015/16 data to provide insight into whether the characteristics of practices that influence the rate of low acuity ED attendances are more or less common in 2015/16 than in 2010/11 and whether the influence these factors have over the number of attendances has increased or diminished since 2010.

10.3. The HES A&E datasets used in this paper do not appear to be capable of supporting robust comparisons across providers of case-mix adjusted admission thresholds, even within the subset of providers that record diagnoses at consistently high rates. There may be value in exploring the issues that give rise to this limitation and identify opportunities to eliminate or minimise these issues as part of the roll-out of the new Emergency Care Dataset[11].

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[10] Cowling TE, Cicil EV, Soljak MA, Lee JT, Millet C, Majeed A, Watcher RM, HHarris MJ, Access to Primary Care and Visits to Emergency Departments in England: A Cross-Sectional, Population-Based Study, PLoS One June 2013

[11] https://www.england.nhs.uk/ourwork/tsd/ec-data-set/

Appendices

A Provider Trusts included in Models
B Model Covariates and Coefficients
C Model C Statistics, ROC curves and Calibration plots
D Growth vs Odds of Admission

Appendix A- Provider Trusts included in Casemix Models

Torbay and South Devon NHS Foundation Trust
Southend University Hospital NHS Foundation Trust
Dorset County Hospital NHS Foundation Trust
St Helens and Knowsley Hospital Services NHS Trust
Alder Hey Children's NHS Foundation Trust
Mid Cheshire Hospitals NHS Foundation Trust
Luton and Dunstable University Hospital NHS Foundation Trust
York Hospitals NHS Trust
Airedale NHS Trust
The Queen Elizabeth Hospital, King's Lynn, NHS Foundation Trust
Colchester Hospital University NHS Foundation Trust
Liverpool Women's NHS Foundation Trust
Peterborough and Stamford Hospitals NHS Foundation Trust
West Suffolk NHS Foundation Trust
University Hospital Southampton NHS Foundation Trust
Sheffield Teaching Hospitals NHS Foundation Trust
Portsmouth Hospitals NHS Trust
Burton Hospitals NHS Foundation Trust
Northern Lincolnshire and Goole NHS Foundation Trust
East Cheshire NHS Trust
Countess of Chester Hospital NHS Foundation Trust
George Eliot Hospital NHS Trust
Bolton NHS Foundation Trust
Kettering General Hospital NHS Foundation Trust
Salisbury Health Care NHS Trust
Doncaster and Bassetlaw Teaching Hospitals NHS Foundation Trust
Moorfields Eye Hospital NHS Foundation Trust
Birmingham Women's and Children's NHS Foundation Trust
Hinchingbrooke Health Care NHS Trust
Gateshead Health NHS Foundation Trust
University College London Hospitals NHS Foundation Trust
Gloucestershire Hospitals NHS Foundation Trust
Northumbria Healthcare NHS Foundation Trust
Ashford and St Peter's Hospitals NHS Foundation Trust
South Tees Hospitals NHS Foundation Trust
University Hospitals of Morecambe Bay NHS Foundation Trust
North Tees and Hartlepool NHS Foundation Trust
Maidstone and Tunbridge Wells NHS Trust
Nottingham University Hospitals NHS Trust
East Sussex Healthcare NHS Trust
Mid Yorkshire Hospitals NHS Trust
Lancashire Teaching Hospitals NHS Foundation Trust
East Lancashire Hospitals NHS Trust
Western Sussex Hospitals NHS Foundation Trust

Appendix B - Model Covariates and Coefficients

		Child Ambulance	Child Walk-in	Adult Ambulance	Adult Walk-in
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
	(Intercept)	0.62 (0.54-0.73)	0.28 (0.24-0.33)	1.16 (1.05-1.28)	0.37 (0.34-0.40)
Age	0	1.79 (1.75-1.82)	1.65 (1.64-1.67)	-	-
	1-4	1.25 (1.23-1.27)	1.06 (1.05-1.07)	-	-
	5-12	1.27 (1.25-1.30)	0.95 (0.94-0.96)	-	-
	13-17	ref	ref		
	18-34	-	-	ref	ref
	35-54	-	-	1.61 (1.60-1.62)	1.33 (1.32-1.33)
	55-74	-	-	2.87 (2.85-2.89)	1.96 (1.95-1.97)
	75+	-	-	4.55 (4.53-4.58)	2.83 (2.81-2.84)
Gender	Male	ref	ref	ref	ref
	Female	0.98 (0.97-0.99)	0.98 (0.97-0.98)	0.90 (0.90-0.91)	0.98 (0.97-0.98)
IMD	Quintile 1	ref	ref	ref	ref
	Quintile 2	1.04 (1.02-1.06)	1.05 (1.04-1.06)	1.00 (1.00-1.01)	1.01 (1.01-1.02)
	Quintile 3	1.05 (1.04-1.07)	1.06 (1.05-1.07)	1.02 (1.02-1.03)	1.01 (1.00-1.02)
	Quintile 4	1.07 (1.05-1.09)	1.08 (1.07-1.09)	1.02 (1.01-1.03)	1.01 (1.01-1.02)
	Quintile 5	1.07 (1.05-1.09)	1.11 (1.10-1.12)	1.00 (0.99-1.01)	1.00 (0.99-1.01)
Ethnicity	White	ref	ref	ref	ref
	Asian	1.01 (0.98-1.04)	0.90 (0.89-0.92)	0.84 (0.83-0.85)	0.84 (0.83-0.85)
	Black	0.94 (0.90-0.98)	0.84 (0.83-0.86)	0.98 (0.95-1.00)	0.90 (0.88-0.92)
	Mixed	0.99 (0.95-1.02)	0.94 (0.92-0.96)	0.99 (0.96-1.03)	0.93 (0.90-0.95)
	Other	0.92 (0.88-0.96)	0.82 (0.80-0.83)	0.90 (0.88-0.92)	0.81 (0.80-0.83)
	NKNS	0.86 (0.84-0.87)	0.83 (0.82-0.84)	0.79 (0.79-0.80)	0.74 (0.74-0.75)
Arrival Year	2010/11	ref	ref	ref	ref
	2011/12	0.91 (0.89-0.93)	0.81 (0.80-0.82)	0.91 (0.90-0.91)	0.87 (0.86-0.88)
	2012/13	0.91 (0.89-0.93)	0.81 (0.80-0.82)	0.83 (0.83-0.84)	0.80 (0.79-0.80)
	2013/14	0.86 (0.84-0.87)	0.79 (0.78-0.79)	0.80 (0.80-0.81)	0.75 (0.75-0.76)
	2014/15	0.84 (0.82-0.86)	0.74 (0.73-0.75)	0.78 (0.78-0.79)	0.74 (0.73-0.74)
	2015/16	0.78 (0.77-0.80)	0.65 (0.65-0.66)	0.77 (0.77-0.78)	0.70 (0.69-0.70)
Arrival Month	Mar-Oct	ref	ref	ref	ref
	Nov-Feb	0.91 (0.90-0.92)	0.94 (0.93-0.94)	0.98 (0.97-0.98)	0.98 (0.97-0.98)
Arrival Day	Weekday	1.00 (0.00-0.00)	1.00 (0.00-0.00)	1.00 (0.00-0.00)	1.00 (0.00-0.00)
	Weekend	0.96 (0.95-0.97)	0.92 (0.92-0.93)	0.97 (0.97-0.98)	0.85 (0.85-0.86)
Arrival Hour	8am – 10pm	ref	ref	ref	ref
	10pm – 8am	0.80 (0.79-0.81)	1.12 (1.11-1.13)	0.96 (0.95-0.96)	1.03 (1.03-1.04)
Prior Activity (1m)	None	ref	ref	ref	ref
	Attended and admitted	2.02 (1.96-2.08)	2.41 (2.37-2.45)	1.41 (1.40-1.42)	2.28 (2.26-2.30)
	Attended not admitted	1.04 (1.02-1.07)	1.08 (1.06-1.09)	0.77 (0.77-0.78)	1.01 (1.01-1.02)
	None	ref	ref	ref	ref

		Child Ambulance	Child Walk-in	Adult Ambulance	Adult Walk-in
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Prior Activity (2-12m)	Attended and admitted	1.34 (1.32-1.36)	1.49 (1.48-1.51)	1.34 (1.33-1.34)	1.67 (1.66-1.68)
	Attended not admitted	0.84 (0.83-0.86)	0.82 (0.81-0.82)	0.83 (0.83-0.84)	0.86 (0.86-0.87)
Travel Time (mins)	0-4	ref	ref	ref	ref
	5-9	1.01 (0.98-1.03)	1.07 (1.06-1.08)	1.03 (1.02-1.04)	1.09 (1.08-1.10)
	10-14	1.05 (1.02-1.08)	1.14 (1.13-1.16)	1.05 (1.04-1.06)	1.17 (1.16-1.18)
	15-19	1.09 (1.06-1.12)	1.21 (1.19-1.22)	1.09 (1.08-1.10)	1.25 (1.24-1.26)
	20-24	1.15 (1.12-1.18)	1.31 (1.29-1.33)	1.13 (1.12-1.14)	1.30 (1.29-1.31)
	25-29	1.21 (1.17-1.25)	1.38 (1.35-1.40)	1.15 (1.14-1.16)	1.31 (1.30-1.33)
	30+	1.23 (1.19-1.26)	1.34 (1.32-1.36)	1.07 (1.06-1.08)	1.23 (1.22-1.24)
Diagnosis	Respiratory conditions	ref	ref	ref	ref
	not classifiable/classified	1.00 (0.98-1.02)	0.92 (0.91-0.93)	0.54 (0.54-0.55)	0.51 (0.51-0.52)
	Laceration	0.19 (0.18-0.19)	0.09 (0.09-0.09)	0.10 (0.09-0.10)	0.06 (0.06-0.06)
	Contusion/abrasion	0.15 (0.14-0.15)	0.04 (0.04-0.04)	0.10 (0.09-0.10)	0.02 (0.02-0.02)
	Soft tissue inflammation	0.11 (0.11-0.12)	0.07 (0.07-0.07)	0.15 (0.15-0.15)	0.08 (0.08-0.09)
	Head injury	0.28 (0.27-0.29)	0.20 (0.20-0.20)	0.19 (0.19-0.19)	0.14 (0.13-0.14)
	Dislocation/fracture/joint inj / amputation	1.00 (0.98-1.03)	0.23 (0.23-0.24)	0.64 (0.64-0.65)	0.15 (0.15-0.15)
	Sprain/ligament injury	0.04 (0.03-0.04)	0.01 (0.01-0.01)	0.07 (0.07-0.07)	0.01 (0.01-0.01)
	Muscle/tendon injury	0.10 (0.09-0.11)	0.05 (0.05-0.06)	0.10 (0.09-0.10)	0.05 (0.05-0.05)
	Nerve injury	1.12 (0.96-1.31)	0.24 (0.23-0.26)	0.40 (0.39-0.42)	0.19 (0.18-0.20)
	Vascular injury	0.41 (0.30-0.56)	0.19 (0.16-0.21)	0.31 (0.30-0.33)	0.39 (0.38-0.41)
	Burns and scalds	0.30 (0.28-0.32)	0.19 (0.18-0.20)	0.18 (0.18-0.19)	0.09 (0.09-0.09)
	Electric shock	0.12 (0.09-0.17)	0.02 (0.02-0.02)	0.06 (0.06-0.07)	0.03 (0.03-0.03)
	Foreign body	0.27 (0.25-0.30)	0.18 (0.17-0.18)	0.27 (0.26-0.29)	0.09 (0.09-0.10)
	Bites/stings	0.33 (0.29-0.37)	0.14 (0.13-0.15)	0.12 (0.11-0.13)	0.08 (0.07-0.08)
	Poisoning (inc overdose)	1.72 (1.67-1.77)	1.91 (1.87-1.95)	0.78 (0.77-0.79)	1.29 (1.27-1.32)
	Near drowning	0.99 (0.79-1.24)	0.23 (0.20-0.27)	0.38 (0.34-0.44)	0.12 (0.10-0.14)
	Visceral injury	1.58 (1.25-1.99)	0.39 (0.35-0.44)	1.58 (1.46-1.71)	0.52 (0.49-0.55)
	Infectious disease	0.63 (0.61-0.65)	0.59 (0.58-0.60)	0.78 (0.76-0.79)	0.55 (0.54-0.56)
	Local infection	0.63 (0.61-0.66)	0.53 (0.52-0.54)	0.81 (0.80-0.82)	0.47 (0.46-0.47)
	Septicaemia	3.60 (3.24-4.00)	2.84 (2.70-2.99)	10.11 (9.68-10.56)	2.88 (2.80-2.96)
	Cardiac conditions	0.53 (0.51-0.56)	0.84 (0.81-0.88)	0.88 (0.87-0.88)	1.56 (1.54-1.57)
	Cerebro-vascular conditions	1.25 (1.18-1.33)	1.07 (1.01-1.13)	1.09 (1.08-1.11)	1.99 (1.96-2.03)
	Other vascular conditions	0.67 (0.58-0.79)	0.67 (0.62-0.73)	0.60 (0.58-0.61)	0.65 (0.64-0.66)
	Haematological conditions	3.08 (2.59-3.65)	2.89 (2.74-3.05)	1.25 (1.22-1.29)	1.11 (1.09-1.14)
	CNS conditions	1.58 (1.54-1.61)	1.95 (1.90-2.00)	0.56 (0.56-0.57)	0.96 (0.95-0.97)
	Gastrointestinal conditions	0.83 (0.81-0.86)	1.09 (1.07-1.10)	0.77 (0.77-0.78)	1.46 (1.44-1.47)
	Urological conditions	0.63 (0.60-0.66)	0.95 (0.93-0.97)	0.51 (0.51-0.52)	0.76 (0.75-0.77)
	Obstetric conditions	1.30 (1.13-1.49)	1.59 (1.49-1.70)	1.06 (1.03-1.10)	1.56 (1.53-1.58)
	Gynaecological conditions	1.07 (0.98-1.16)	1.16 (1.11-1.21)	1.08 (1.06-1.10)	1.32 (1.30-1.33)
	Diabetes/endocrine conditions	3.34 (3.10-3.59)	3.71 (3.53-3.89)	1.00 (0.99-1.02)	1.98 (1.94-2.02)

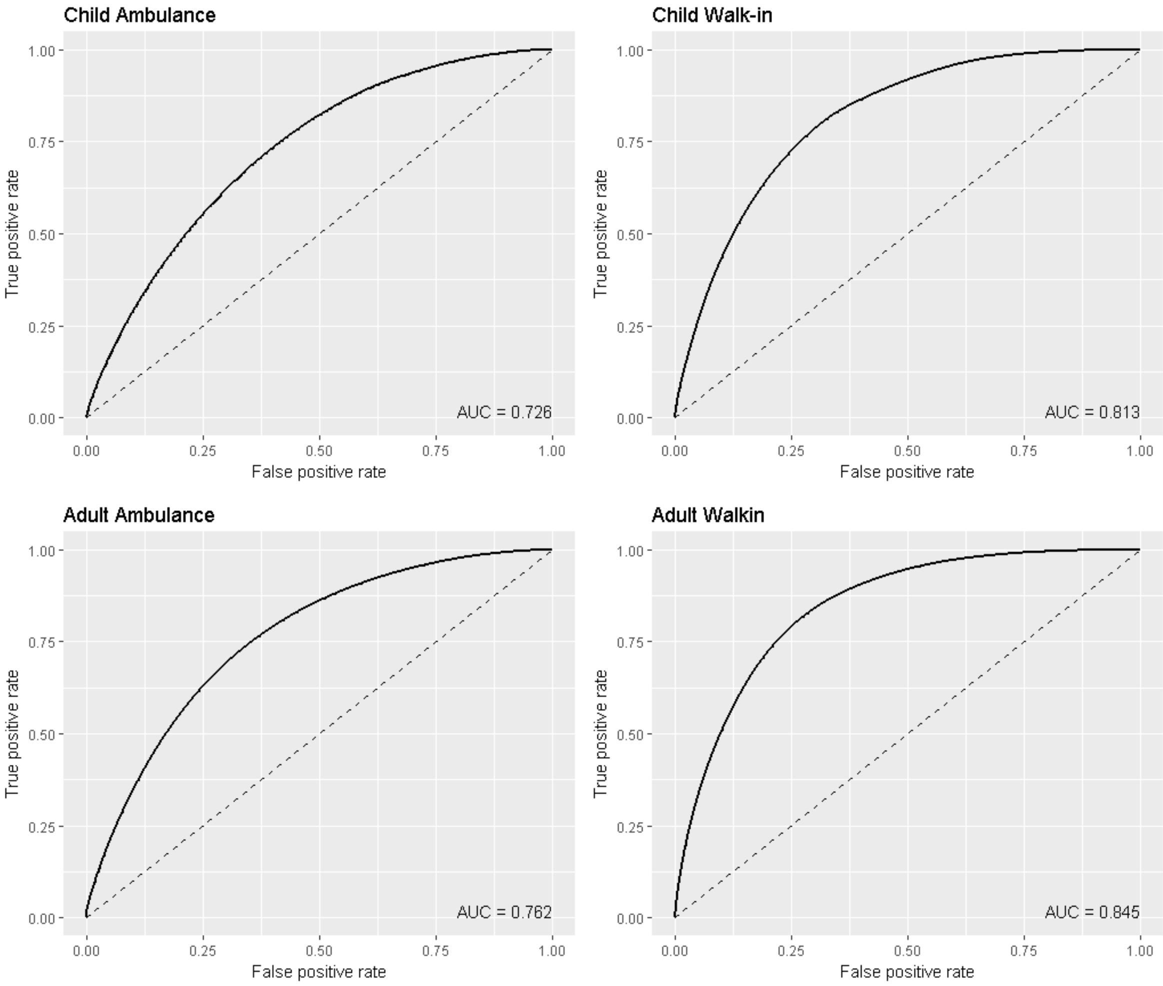
		Child Ambulance	Child Walk-in	Adult Ambulance	Adult Walk-in
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
	Dermatological conditions	0.53 (0.49-0.57)	0.39 (0.38-0.40)	0.37 (0.35-0.38)	0.19 (0.19-0.20)
	Allergy (inc anaphylaxis)	0.49 (0.46-0.51)	0.35 (0.34-0.36)	0.22 (0.21-0.22)	0.21 (0.20-0.21)
	Facio-maxillary conditions	0.36 (0.32-0.42)	0.33 (0.32-0.35)	0.22 (0.21-0.23)	0.21 (0.20-0.21)
	ENT conditions	0.28 (0.27-0.29)	0.30 (0.30-0.31)	0.20 (0.20-0.21)	0.37 (0.37-0.38)
	Psychiatric conditions	1.01 (0.96-1.05)	1.48 (1.44-1.53)	0.24 (0.24-0.24)	0.33 (0.32-0.33)
	Ophthalmological conditions	0.14 (0.11-0.17)	0.10 (0.09-0.10)	0.07 (0.07-0.08)	0.02 (0.02-0.02)
	Social problems	0.77 (0.71-0.85)	1.24 (1.15-1.35)	0.59 (0.58-0.60)	0.78 (0.75-0.80)
	Nothing abnormal detected	0.36 (0.35-0.38)	0.30 (0.29-0.30)	0.30 (0.29-0.30)	0.36 (0.36-0.37)

Appendix C - Model C Statistics, ROC Curves and Calibration Plots

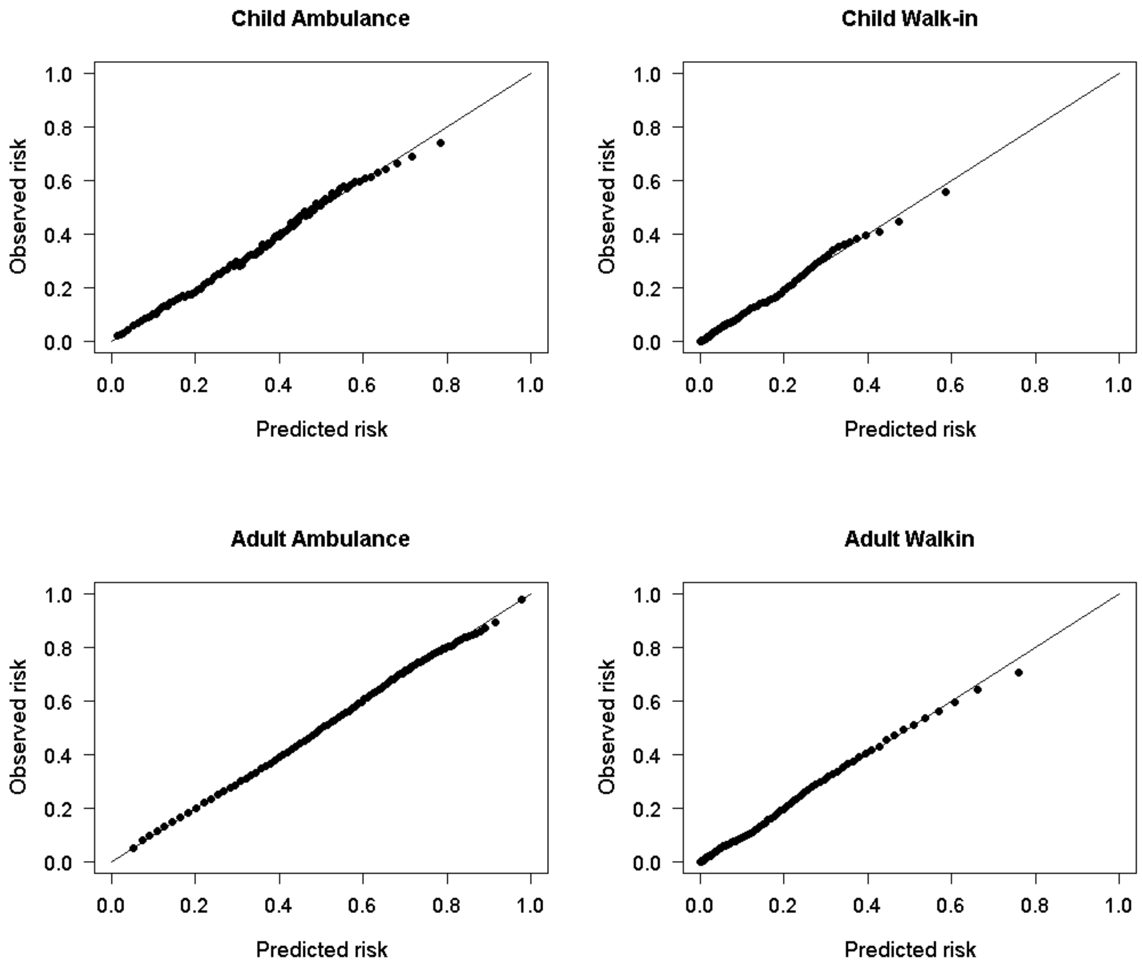
Model	C-statistic*
Child Ambulance	0.726
Child Walk-in	0.813
Adult Ambulance	0.762
Adult Walk-in	0.845

*Area under Receiver-Operating Characteristic (ROC) Curve

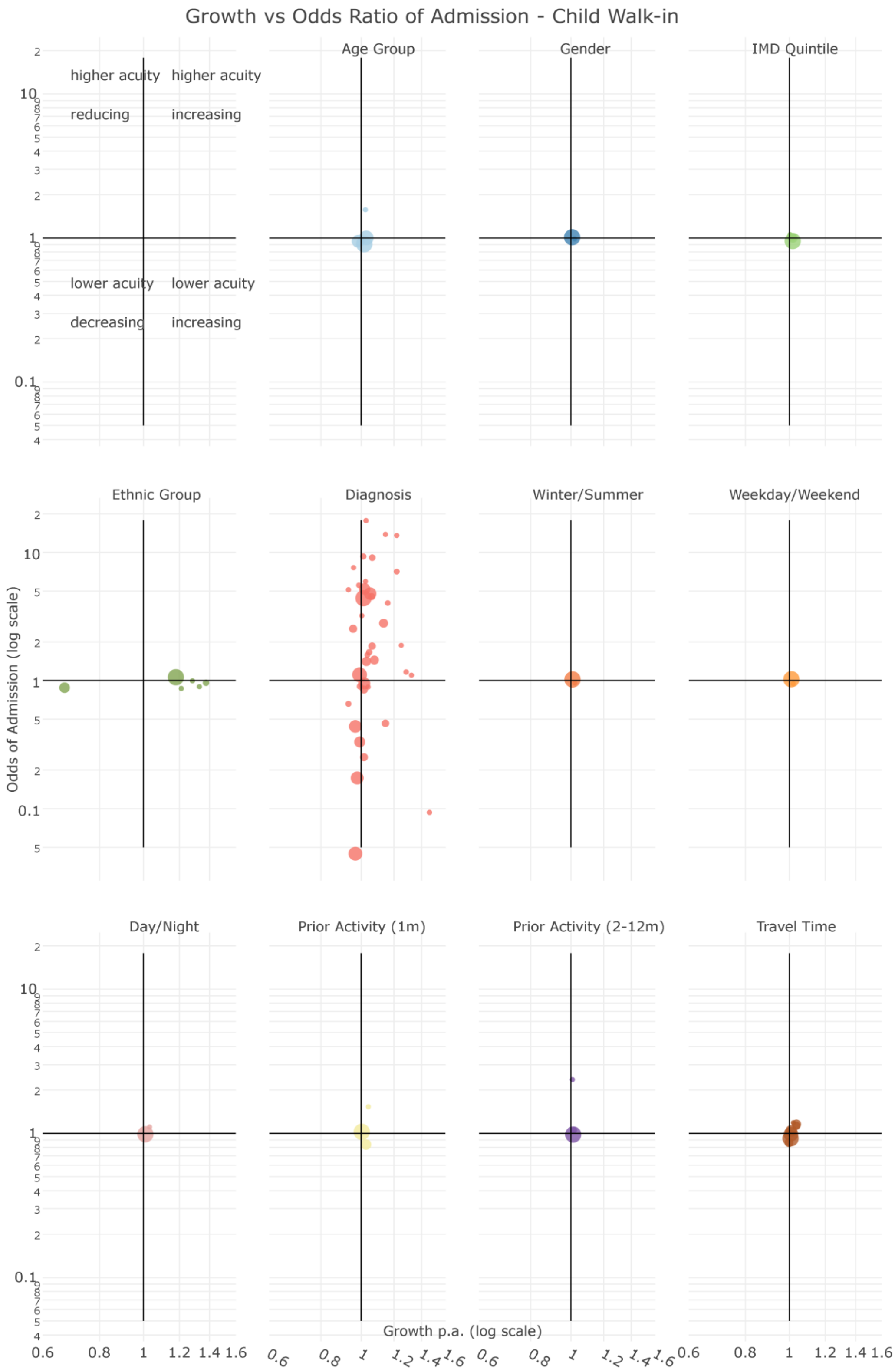
Receiver Operating Characteristic Curves

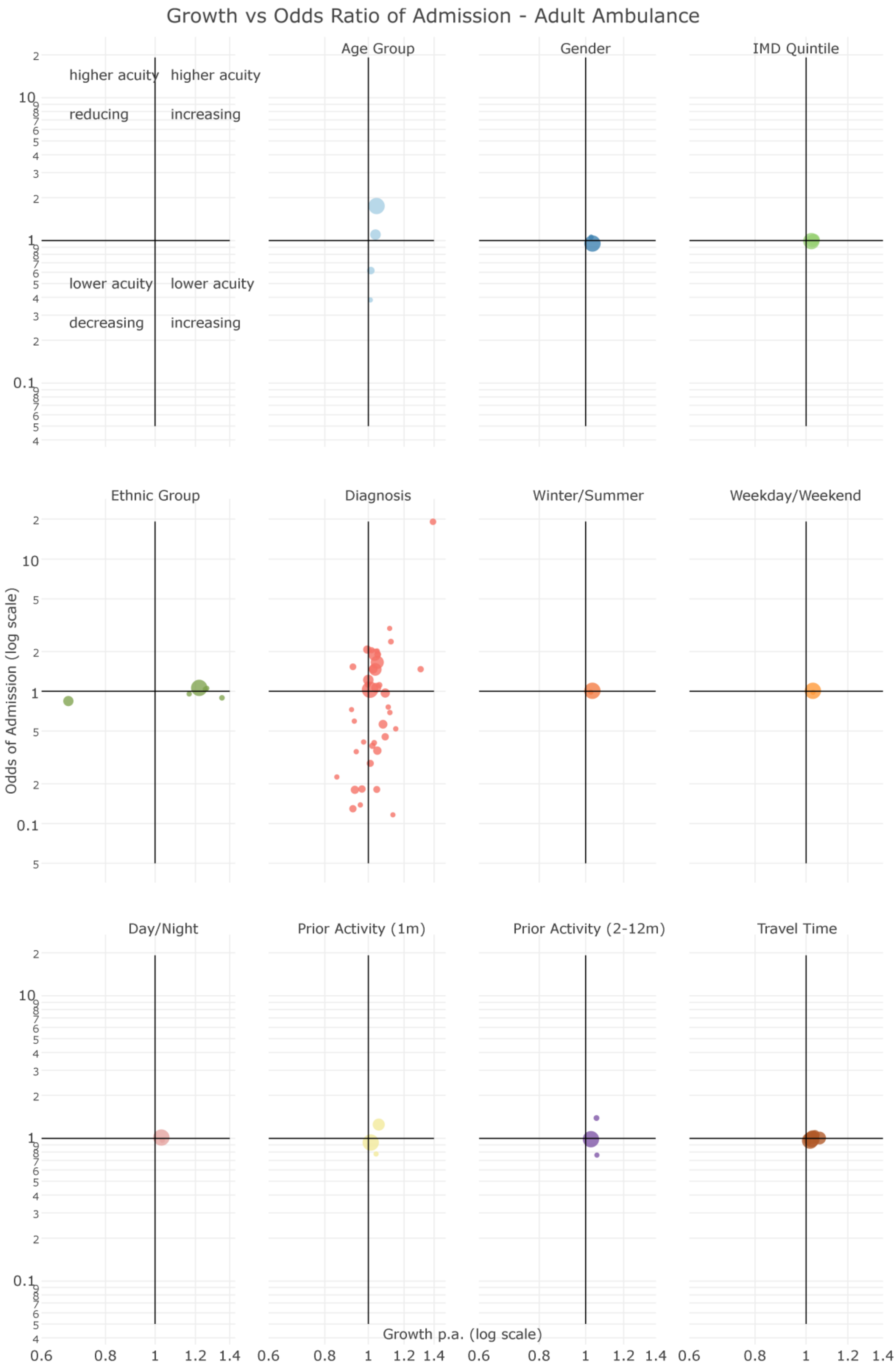


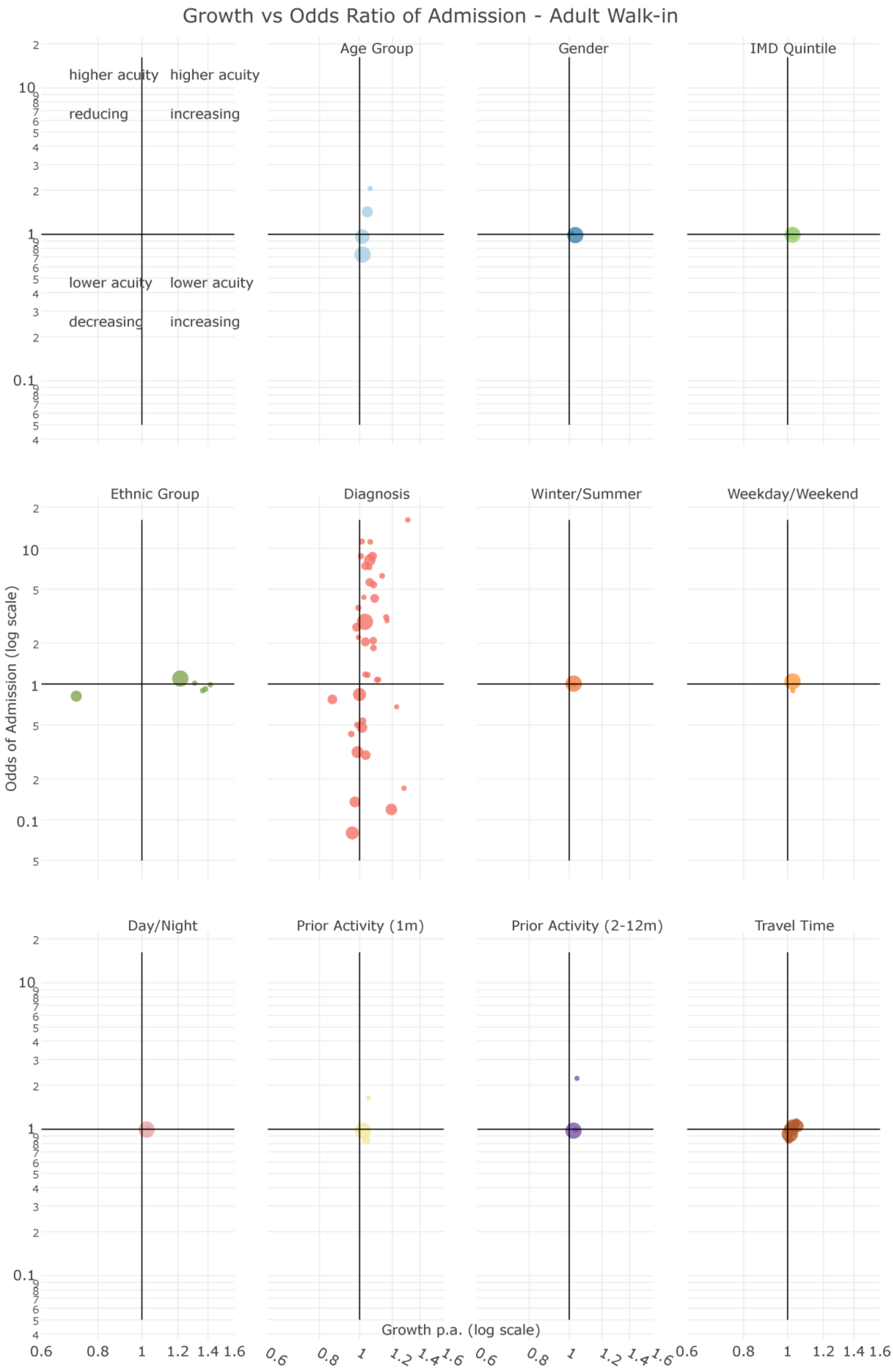
Hosmer-Lemeshow Calibration Plots



Appendix D - Growth vs Odds of Admission




Growth vs Odds Ratio of Admission - Adult Ambulance
higher acuity reducing
higher acuity increasing
lower acuity decreasing
lower acuity increasing
Age Group
Gender
IMD Quintile
Ethnic Group
Diagnosis
Winter/Summer
Weekday/Weekend
Day/Night
Prior Activity (1m)
Prior Activity (2-12m)
Travel Time
Odds of Admission (log scale)
Growth p.a. (log scale)


Growth vs Odds Ratio of Admission - Adult Walk-in
higher acuity reducing
higher acuity increasing
lower acuity decreasing
lower acuity increasing
Age Group
Gender
IMD Quintile
Ethnic Group
Diagnosis
Winter/Summer
Weekday/Weekend
Day/Night
Prior Activity (1m)
Prior Activity (2-12m)
Travel Time
Odds of Admission (log scale)
Growth p.a. (log scale)

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>
> Professor Sir Bruce Keogh, National Medical Director, NHS England

If you think we might be able to help you, please get in touch.

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The Strategy Unit.

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