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Using geographic variation in unplanned ambulatory care sensitive conditions admission rates to identify commissioning priorities; an analysis of routine data from England

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1 Abstract

Objectives: To use geographic variation in unplanned ambulatory care sensitive condition (ACSC) admission rates to identify the clinical areas and patient subgroups where there is greatest potential to prevent admissions and improve the quality and efficiency of care.

Methods: We used English Hospital Episode Statistics data from 2011/12 to describe the characteristics of patients admitted for ACSC care and estimate geographic variation in unplanned admission rates. We contrasted geographic variation across admissions with different length of stay which we used a proxy for clinical severity. We estimated the number of bed days that could be saved under several scenarios.

Results: There were 1.8 million ACSC admissions during 2011/12. Substantial geographic variation in ACSC admission rates was commonplace but mental health care and short-stay (<2 days) admissions were particularly variable. Reducing rates in the highest use areas could lead to savings of between 0.4 and 2.8 million bed days annually.

Conclusions: Widespread geographic variations in admission rates for conditions where admission is potentially avoidable should concern commissioners and could be symptomatic of inefficient care. Further work to explore the causes of these differences is required and should focus on mental health and short-stay admissions.

Keywords: Geographical distribution; Ambulatory care; Patient Admission/sn [Statistics & Numerical Data]

2 Introduction

Within the UK, reducing the number of unplanned admissions has been identified as a key priority.(1) Unplanned admissions place a tremendous strain on UK healthcare resources, accounting for 67% of hospital bed days, costing £12.5bn annually(2) and causing severe disruption for patients awaiting elective care.(3) Unplanned admission rates have risen by 47% over the last 15 years in England(2), with particularly steep increases of 124% for short-stay admissions (<2 days). Some argue that their continued rise could bankrupt the National Health Service (NHS).(4)

While many unplanned admissions may be necessary to improve patient health, a proportion are thought to be unnecessary or preventable through improved primary care. Prevention of these could lead to substantial efficiency gains. Efforts to achieve this led to the identification of a group of ambulatory care sensitive conditions (ACSCs). Lists of ACSCs have been primarily developed through consensus building among clinical experts (e.g. GPs and hospital consultants) to identify chronic and acute conditions where timely and effective primary or ambulatory care could prevent a substantial proportion (>70% in one study) of admissions.(5) Several studies have demonstrated an association between ACSC admission rates and primary care characteristics (e.g. continuity, access) suggesting that admissions might be reduced through improved GP care.(6) ACSCs account for one in five unplanned admissions.(7) In England, clinical commissioning groups (CCGs) have recently been financially incentivised to reduce the number of unplanned ACSCs(1) however it remains unclear which ACSC admissions are most preventable or which patient sub-groups should be targeted for improvement.

Investigation of geographic variation could help identify opportunities to improve the efficiency of care. This task is not straightforward as geographic variation is driven by several factors including those beyond the control of commissioners (e.g. age, deprivation) and those that are artefactual or uninformative (e.g. statistical chance, coding inconsistencies). Previous research has demonstrated wide variation in ACSC admission rates, but has focused on a small number of ACSCs.(8) A broader study,

which applies standardised methodology to a wide range ACSCs, is required to identify the clinical areas where unexplained variation is largest.

Our objective is to use geographic variation in care to identify the ACSCs where there is greatest potential to prevent admissions. We contrast geographic variation across admissions with different lengths of stay (LOS), which we use as a proxy of severity, to identify which pathways differ most. We estimate the number of bed days that could be saved under several scenarios.

3 Methods

3.1. Data source and preparation

We used the Hospital Episode Statistics (HES) admitted patient care dataset to identify admissions between 1/04/2011 and 31/03/2012.⁽⁹⁾ HES includes demographic, clinical and geographical information. Our study included all admissions for a list of 28 common (i.e. >3,000 admissions annually) ACSCs which we defined using ICD-10 diagnosis codes from previous work (Appendix 1).⁽⁵⁾ We investigated differences between 151 primary care trusts (PCTs) in England. Since April 2013, PCTs have been replaced by 212 CCGs. PCTs were responsible for around 80% of the NHS budget and commissioned primary, community and secondary health services for their populations.

We converted episodes into continuous inpatient spells (CIPS) meaning that care spanning multiple hospitals was counted only once. We included CIPS when the primary diagnoses code from the admission episode indicated an ACSC. We excluded patients resident outside England and those with an invalid age or sex (<0.1%).

3.2. Statistical Analyses

We described the demographics of patients admitted for ACSC care and counted the number of admissions and bed days for each condition. We used hierarchical Poisson models to quantify geographic variation (see Appendix 2). These models include a normally-distributed random effect which allows for differences in admission rates between PCTs and appropriately accounts for random variation. The models estimate the inter-PCT standard deviation (SD) for each ACSC; a high SD indicates substantial variability in admission rates between PCTs. To improve interpretability, we calculated ‘utilisation ratios’ defined as the admission rate in a high utilisation PCT (at the 90th centile of the random effects distribution) divided by the admission rate in a low utilisation PCT (at the 10th centile). We defined conditions with a utilisation ratio greater than two as ‘highly variable’.

We adjusted for differences between PCT populations in a two-step process. We calculated expected admission counts using indirect standardisation (using quinary age groups and gender) to account for differences in the size and age-sex composition of PCT populations. We used standard Poisson regression to further adjust for PCT-level deprivation, ethnicity, chronic disease prevalence as a proxy for comorbidity (asthma, atrial fibrillation, congestive heart disease, chronic kidney disease, dementia, diabetes, hypertension, stroke and cancer) and markers of unhealthy lifestyle (smoking, binge drinking and obesity) using data from the Office of National Statistics, Public Health England and compendium of population health indicators. We calculated the rank for each ACSC and used Markov Chain Monte Carlo (MCMC) simulation to estimate uncertainty. Our analysis was undertaken in WinBUGS 1.4.3.(10)

3.3. Differences by length of stay

We calculated utilisation ratios separately for four LOS groups (0-1, 2-7, 8-30 and 31-90 days) using the methods described above. We used LOS as a proxy for clinical severity as an association between these has been found previously.(11-13) We excluded subgroups containing fewer than 1,000 admissions to ensure precise estimates of inter-PCT variation. We calculated the percentage difference between the utilisation ratio in the shortest LOS group and those in longer groups. We used MCMC simulation to estimate uncertainty.

3.4. Scenario Analyses

For each condition we separated PCTs into admission rate quintiles and estimated the potential bed day savings under three scenarios:

1. **Lowest Rates:** Rates in the four highest quintiles reduce to those in the lowest group
2. **Lower Rates:** Rates in the four highest quintiles reduce to those in the group below
3. **Target High Use:** Rates in the highest quintile reduce to those in the group below

We estimated the number of admissions avoided in each PCT and multiplied this by the average LOS to calculate the potential bed days saved. We summed across all PCTs to calculate condition totals. We re-estimated bed-day savings under the more conservative assumption that avoided admissions were short-stay (<2 day).

4 Results

4.1. Descriptive Statistics

There were 1.8 million admissions for ACSCs accounting for 11.1 million bed days during 2011/2 (Table 1). Patients admitted for ACSCs were generally older (mean age=56), from more deprived areas (27% lowest quintile), had at least one comorbidity (58%) and were admitted through A&E (75%). The number of admissions varied substantially by condition; there were 322,094 for angina and only 3,449 for peripheral vascular disease (Table 2). Mean LOS varied so that in some cases relatively rare ACSCs contributed a large number of bed days (e.g. senility / dementia).

4.2. Geographic Variation

Substantial differences existed between PCT admission rates for the majority of ACSCs (Table 2, Figure 1). For all ACSCs combined the utilisation ratio was 1.26 (95% CI: 1.23, 1.30) indicating that the admission rate in a high utilisation PCT was 26% higher than that of a low utilisation PCT. Conditions related to mental health (schizophrenia, neuroses, senility / dementia) were particularly variable however geographic variation existed across a range of clinical specialities. For the most variable condition, schizophrenia, admission rates in a high utilisation PCT were 5.46 times (95% CI: 4.37, 6.96) that of a low utilisation PCT and ranged from 46.7 per 100,000 residents (95% CI: 35.1, 60.4) in the Isle of Wight to only 1.7 (95% CI: 0.7, 3.1) in Buckinghamshire. In contrast fractured proximal femur the utilisation ratio was 1.11 (95% CI: 1.07, 1.15) and admission rates ranged from 114.1 (95% CI: 107.8, 121.4) in Oxfordshire to 102.6 (95% CI: 95.3, 109.5) in Plymouth.

4.3. Differences by length of stay

There were substantial differences in utilisation ratios across admissions with different LOS (Table 3). For all ACSC admissions combined, utilisation ratios were 10% (95% CI: 8, 13) and 7% (95% CI: 4, 10) lower for 2-7 and 8-30 stay lengths respectively compared to those of a day or less. Variation was highest in the subgroups with the lowest LOS for 18 (64%) of 28 conditions. Differences were largest

for stroke, where the utilisation ratio was 27% (95% CI: 21, 32) lower for stays between 2 and 7 days compared to those of a day or less, but they also were in excess of 18% lower for ENT infections, cellulitis and COPD.

4.4. Scenario Analysis

Nearly 2.8 million bed days could be saved in the ‘lowest rates’ scenario while 0.4 million could be avoided in the ‘target high use’ scenario (Table 4). The potential savings are largest for high volume (e.g. angina), long LOS (e.g. pyelonephritis) and geographically variable (e.g. ENT infection) ACSCs. Focussing attention on the eight highest variation ACSCs would lead to savings between 0.2 and one million bed days. If reductions were limited to short-stay admissions around 92,000 and 455,000 bed days could be saved annually.

5 Discussion

5.1. Summary of main findings

ACSCs accounted for 1.8 million admissions and 11.1 million bed days in England during 2011/12. Angina was the commonest ACSC although other conditions such as pyelonephritis and fractured proximal femur accounted for the largest number of bed days. There was widespread geographic variation in admission rates across most ACSCs although it was highest for mental health conditions such as schizophrenia and neuroses. Geographic variation was generally largest for short-stay admissions. Between 0.4 and 2.8 million bed days could be saved if admission rates in high use areas could be reduced.

5.2. Strength and weaknesses

The main strength of the study lies in the large nationally representative dataset on which it is based. Whilst other studies have focused on conditions that are thought to be variable *a priori* our analyses considered a wide range of ACSCs. Our model-based methods for quantifying variation appropriately account for random variation whilst the transformation to utilisation ratios aids interpretation of inter-PCT differences.

Our study has some limitations. Despite extensive case-mix adjustment it is based on observational evidence and susceptible to confounding. Geographic variation was found, albeit small, for fractured proximal femur, where GPs play a more minor role in prevention and the need for admission unequivocal, suggesting that some residual confounding might be present. Coding practices could differ between PCTs resulting in spurious variation.

The ability to prevent admission might be questionable for some of the conditions included in our study. For example, it is questionable to what extent fractured proximal femur admission rates are amenable to improved osteoporosis detection or fall avoidance interventions. We have used LOS as a proxy for

severity however, although a strong association between LOS and severity is highly plausible, it could be affected by several other factors including the quality of hospital care and discharge processes. Lastly our scenario analyses assumes that reductions in admissions can be achieved without harming patients. However in some conditions (e.g. acute stroke) admission is considered best practice, whilst in others the bed days saved through admission avoidance schemes could be offset by poorer outcomes or higher costs of care outside hospital.

5.3. Comparison with other studies

A recent international systematic review of 25 studies set across six countries (Australia, Canada, New Zealand, Spain, UK, USA) concluded that geographic variation in ACSC admission rates was ubiquitous.(8) This study adds to existing evidence by extending analyses to a wider range of ACSCs (e.g. angina, ENT infections) and applying a standardised methodology which facilitates identification of the most variable clinical areas. Our results are in agreement with a previous study demonstrating substantial geographic variation in ACSC admission rates in England.(7) While there were substantial differences in methodology, for example we used more detailed case-mix adjustment, both studies highlighted ENT infection admissions as being particularly variable.

5.4. Implications for clinicians, policymakers and researchers

Substantial variation in ACSC admission rates could be a symptom of inefficient care and should be a concern for commissioners across England. Reducing admission rates in high utilisation areas could lead to savings of between 0.4 and 2.8 million bed days however initiatives to reduce admissions should be carefully evaluated to ensure that reduced inpatient costs are not outweighed by poorer patient outcomes and/or increased community care costs. National policy makers, such as the National Institute for Care and Health Excellence, could use these results to help focus guideline development on the clinical areas where pathways are most variable. Definition and dissemination of best practice clinical pathways could help standardise care. Locally, commissioners aiming to reduce ACSC admissions could initially focus on the most variable conditions as these are likely to offer the greatest gains. Both groups should pay particular attention to mental health and short-stay admissions.

Several primary, community and secondary care factors could have contributed to the wide variation in admission rates observed in our study. Access to GP care varies substantially (14), as do the quality (e.g. disease management(15), referrals (16)) and continuity of primary care. Within emergency care, there are wide disparities in coverage by senior doctors (17) and the conveyance rates of ambulances.(18) The availability of community-based alternatives to A&E attendance (e.g. walk-in centres, minor injury units) and to admission (e.g. rapid response nursing care or crisis teams) are likely to be important driver of admission rates yet access to these services is extremely fragmented.(19) (20)

The relative importance of these factors probably varies among ACSCs. For example, community-based treatment options for mental health and alcohol-related disease are particularly variable(20) (21). Whereas chronic conditions might be more sensitive to primary care access and continuity as prevention and prompt management of exacerbations could prevent or avert admission. Variation in referral and admission thresholds could be particularly important for conditions with unclear decision-making criteria (e.g. upper GI haemorrhage) or less severe symptoms (e.g. headache and migraine). It is perhaps unsurprising that short-stay admissions exhibit consistently higher variation as patients with lower severity illness may be unsure about which health service to contact(22) meaning that the availability and awareness of community-based treatment are crucial in preventing A&E attendance. Referral and admission decisions for lower-severity patients are also likely to be more subjective and depend on clinical risk tolerance.(23)

Due to the complexity of unplanned admissions, no single intervention will reduce admission rates across all ACSCs. One systematic review of RCTs(24) found no convincing evidence that medication reviews, financial management schemes, and 'hospital at home' reduced unplanned admissions. Other interventions appear to reduce admissions for some conditions but not others; including case management (heart failure but not COPD), specialist clinics (heart failure but not asthma), and exercise and rehabilitation (COPD but not stroke). This suggests that the effectiveness of admission avoidance

schemes is context-specific and that commissioners should use local knowledge alongside a detailed understanding of what is driving high use locally when designing interventions.

Observational evidence could also provide insight into the likely success of interventions. Financial incentives to improve the management of some ACSCs have been credited with an 8% reduction in admission rates.(25) Further additions to the QOF, or other local schemes, could lead to additional decreases. Recent government initiatives to improve primary care access(26) could prove effective at containing secondary care demand.(27) These policies might also lead to lower costs as GP consultations are much less costly than A&E visits or unplanned admissions, (14, 28) however the aggregate effect of these changes on costs and outcomes remains unclear. Policymakers should ensure improved access does not come at the cost of reduced continuity of care with a GP as this has been consistently associated with reduced ACSC admissions.(6) Interventions which facilitate early senior review in A&E(29), or educate paramedics to decrease inappropriate A&E conveyance(30) have shown promising results.

There is a dearth of evidence on the cost-effectiveness of admission avoidance interventions and the little available evidence does not unequivocally support their adoption.(24) Commissioners should exercise caution when altering unplanned pathways and robustly evaluate changes to ensure the expected benefits have been realised.

5.5. Recommendations for further research

Further investigation into the underlying causes of the widespread geographic variations observed in this study is required. Such research could investigate the association between a range of plausible drivers of variation and ACSC admission rates. A better understanding of the causes of unplanned admissions will help to design and evaluate interventions aiming to improve and standardise care.

5.6. Conclusion

Widespread geographic variations in admission rates for conditions where admission is potentially avoidable should concern commissioners and could be symptomatic of inefficient care. Variation is highest for mental health and short-stay admissions. The causes of these differences are unknown but disparities in access, awareness and operations of community and hospital services could be important. Reducing rates in the highest use areas could lead to savings of between 0.4 and 2.8 million bed days however a better understanding of the causes of geographic variations is needed to evaluate how these reductions would impact on patient care and costs in other parts of the healthcare system.

6 Notes

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Author contributions: All authors conceived the study. JB conducted the analysis and drafted the manuscript. WH and SP critically revised the article for intellectual content. All authors read and approved the final manuscript.

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8 Tables and figures

Table 1: Admission details for all ACSCs admissions

Characteristics	Count (%)
Number Admissions	1,803,097
Bed Days	11,104,873
Mean Age	55.9
0-19	269,660 (15.0)
20-39	217,389 (12.1)
40-59	346,929 (19.2)
60-79	518,980 (28.8)
80+	450,139 (25.0)
Male	865,559 (48.0)
Ethnicity	
White	1,520,126 (84.3)
Asian	103,674 (5.8)
Black	43,738 (2.4)
Mixed	15,123 (0.8)
Missing	120,436 (6.7)
Deprivation	
0 (Most Deprived)	489,567 (27.2)
1	395,513 (21.9)
2	345,816 (19.2)
3	307,121 (17.0)
4 (Least Deprived)	265,080 (14.7)
Comorbidities	
Any	1,047,729 (58.1)
Chronic Pulmonary Disease	472,202 (26.2)
Diabetes	292,451 (16.2)
Congestive Heart Failure	196,935 (10.9)
Cerebrovascular Disease	188,549 (10.5)
Renal Disease	135,440 (7.5)
Admission Source	
The usual place of residence	1,704,137 (94.6)
Other	97,549 (5.4)
Admission Method	
Emergency: via Accident and Emergency	1,355,462 (75.2)
Emergency: via general practitioner	294,182 (16.3)
Other	153,453 (8.5)
Discharge Destination	
The usual place of residence	1,629,471 (90.4)
Patient died	81,625 (4.5)
Nursing Home	35,779 (2.0)
Other	56,222 (3.1)

Table 2: Magnitude of inter-PCT admission rate variation

Condition	Number of CIPS	Mean LOS (Days)	Bed Days (1,000s)	Utilisation Ratio (95% CI)	National Rank (95% CI)
Schizophrenia	10,530	29.0	306	5.46 (4.37,6.96)	1 (1,1)
Peripheral vascular disease	3,449	10.7	37	3.19 (2.66,3.88)	2 (2,2)
Neuroses	21,303	10.5	224	2.67 (2.38,3.04)	3 (3,3)
Ear, nose and throat inf	83,993	0.9	72	2.39 (2.17,2.65)	4 (4,5)
Senility / dementia	56,557	14.1	796	2.33 (2.12,2.60)	5 (4,6)
Alcohol-related diseases	38,840	3.6	140	2.25 (2.06,2.48)	6 (5,6)
Dyspepsia / otr stomach function	19,281	1.3	25	2.04 (1.87,2.26)	7 (7,8)
Dental condition	10,270	2.0	20	2.03 (1.84,2.26)	8 (7,8)
Hypertension	6,671	2.2	15	1.81 (1.65,2.02)	9 (9,11)
Ruptured appendix	10,522	5.3	56	1.78 (1.63,1.97)	10 (9,11)
Pelvic inflammatory disease	4,757	3.6	17	1.78 (1.59,2.00)	11 (9,11)
Constipation	42,511	3.4	145	1.66 (1.56,1.78)	12 (12,13)
Iron-deficiency anaemia	15,090	4.6	70	1.62 (1.51,1.75)	13 (12,15)
Pyelonephritis	154,467	7.7	1,186	1.61 (1.52,1.70)	14 (13,15)
Atrial fibrillation / flutter	26,963	2.0	55	1.59 (1.49,1.70)	15 (13,16)
Asthma	54,596	2.5	134	1.54 (1.46,1.64)	16 (15,17)
Migraine / acute headache	68,191	1.9	130	1.53 (1.46,1.62)	17 (16,17)
Angina	322,094	2.2	708	1.46 (1.40,1.53)	18 (18,21)
Cellulitis	90,445	5.0	453	1.45 (1.39,1.53)	19 (18,21)
Diabetes complications	23,432	7.4	172	1.44 (1.36,1.53)	20 (19,23)
COPD	115,329	6.4	735	1.44 (1.38,1.51)	21 (19,22)
Dehydration and gastro	128,751	4.5	577	1.42 (1.36,1.49)	22 (20,24)
Influenza and pneumonia	153,720	8.9	1372	1.42 (1.36,1.48)	23 (21,24)
Convulsions and epilepsy	77,802	3.0	236	1.40 (1.34,1.47)	24 (22,25)
Congest heart failure	55,571	10.3	575	1.39 (1.33,1.46)	25 (23,26)
Perforated / bleeding ulcer	75,964	4.6	346	1.39 (1.33,1.45)	26 (23,26)
Stroke	74,901	16.5	1238	1.25 (1.20,1.29)	27 (27,27)
Fractured proximal femur	57,097	22.2	1267	1.11 (1.07,1.15)	28 (28,28)
All ACSCs combined	1,803,097	5.9	11,105	1.26 (1.23,1.30)	

Figure 1: Magnitude of inter-PCT admission rate variation

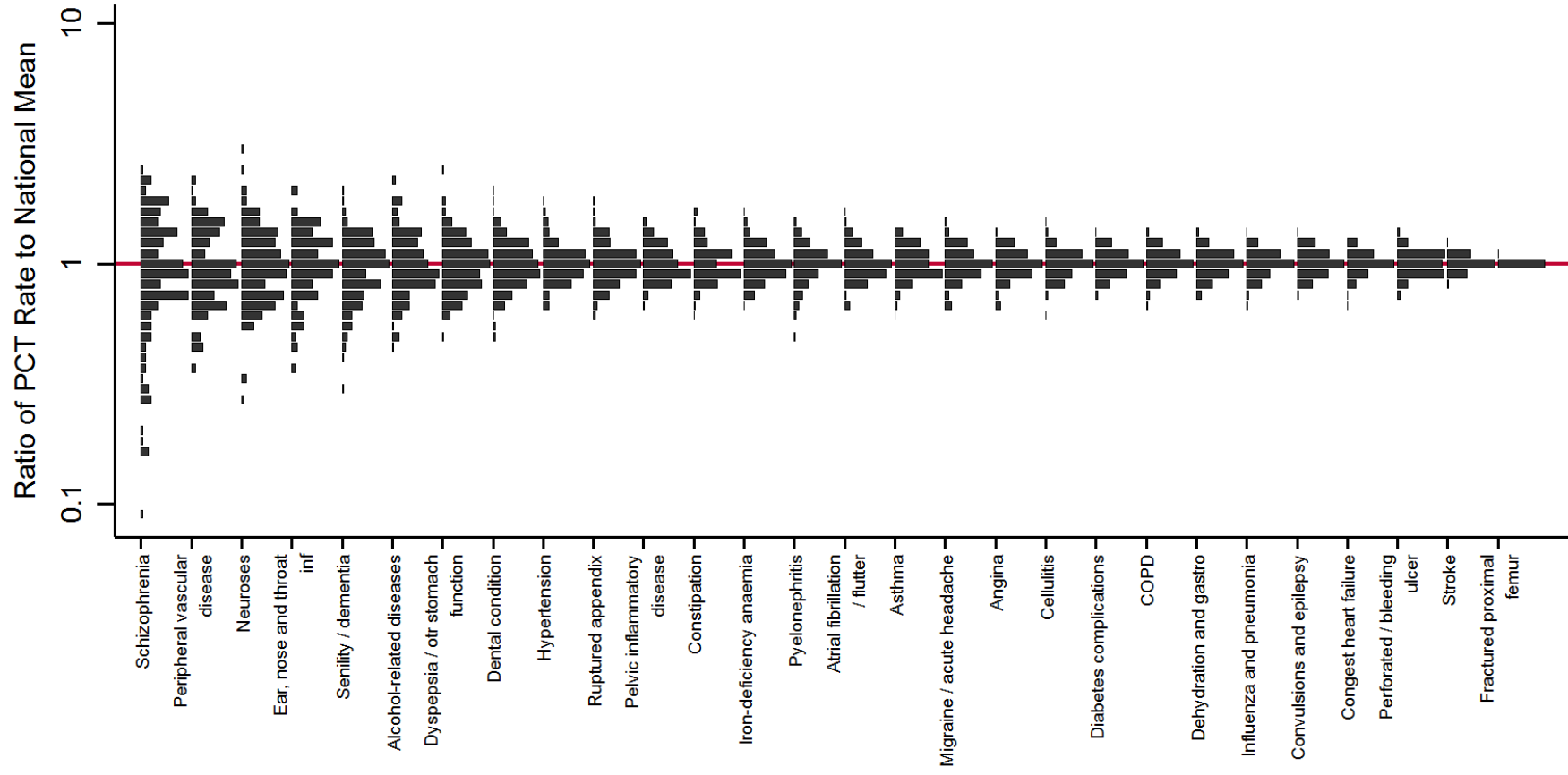


Table 3: Inter-PCT variation in admission rates for LOS subgroups^a

Condition ordered by increasing mean LOS	% change in utilisation ratio from shortest LOS Group (95% CI)			
	0-1	2-7	8-30	31-90
Ear, nose and throat inf	REF	-24 (-29,-18)		
Dyspepsia / otr stomach function	REF	-8 (-17, 2)		
Migraine / acute headache	REF	5 (-1, 10)	8 (-1, 18)	
Dental condition	REF	-13 (-21, -4)		
Atrial fibrillation / flutter	REF	-5 (-12, 1)	6 (-7, 18)	
Hypertension	REF	21 (6, 35)		
Angina	REF	3 (-1, 8)	18 (11, 25)	18 (6, 30)
Asthma	REF	-7 (-12, -3)	13 (3, 23)	
Convulsions and epilepsy	REF	-5 (-9, -1)	-1 (-8, 5)	
Constipation	REF	-12 (-17, -6)	-12 (-19, -4)	
Alcohol-related diseases	REF	-9 (-17, 0)	-5 (-15, 5)	
Pelvic inflammatory disease	REF	-23 (-34,-12)		
Dehydration and gastro	REF	-13 (-17, -9)	-7 (-12, -3)	-0 (-9, 9)
Perforated / bleeding ulcer	REF	-7 (-11, -3)	1 (-5, 7)	-9 (-22, 4)
Iron-deficiency anaemia	REF	-9 (-16, -1)	-0 (-11, 11)	
Cellulitis	REF	-18 (-22,-13)	-15 (-20, -9)	-10 (-19, 0)
Ruptured appendix		REF	-10 (-23, 2)	
COPD	REF	-18 (-22,-13)	-9 (-15, -4)	-0 (-11, 11)
Diabetes complications	REF	-5 (-12, 2)	-1 (-10, 7)	
Pyelonephritis	REF	-13 (-18, -9)	-8 (-14, -2)	11 (1, 21)
Influenza and pneumonia	REF	-13 (-17, -8)	-11 (-16, -6)	-5 (-12, 2)
Congest heart failure	REF	-13 (-20, -7)	-14 (-20, -8)	-6 (-16, 4)
Neuroses	REF	-7 (-18, 5)	2 (-11, 15)	3 (-12, 17)
Senility / dementia	REF	-14 (-24, -5)	-18 (-26,-10)	-12 (-22, -2)
Stroke	REF	-27 (-32,-21)	-25 (-31,-20)	-25 (-31,-18)
Fractured proximal femur		REF	-10 (-16, -4)	17 (7, 27)
Schizophrenia			REF	-2 (-22, 17)
All ACSCs combined	REF	-10 (-13, -8)	-7 (-10, -4)	3 (-1, 7)

^a Blank cells indicate a small number of admissions (<1.000) meaning that no precise estimate of inter-PCT variation could be calculated. REF; Reference Group

Table 4: Potential annual bed day savings (1,000s) through reduced admission rate for scenario 1 (Lowest rates), 2 (Lower rates) and 3 (Target high use)

Condition	All admissions			Short-stay admissions		
	1	2	3	1	2	3
Schizophrenia	273	114	55	1	1	1
Peripheral vascular disease	25	13	8	1	0	0
Neuroses	114	52	22	10	6	4
Ear, nose and throat inf	73	28	10	57	23	8
Senility / dementia	375	146	54	19	9	5
Alcohol-related diseases	69	33	15	19	9	5
Dyspepsia / otr stomach function	15	7	3	10	4	2
Dental condition	11	5	2	5	2	1
Hypertension	6	3	2	1	1	0
Ruptured appendix	18	8	4	2	1	1
Pelvic inflammatory disease	5	2	1	2	1	0
Constipation	42	20	7	13	6	3
Iron-deficiency anaemia	18	8	4	4	2	1
Pyelonephritis	328	119	39	35	16	7
Atrial fibrillation / flutter	16	8	4	8	4	2
Asthma	37	16	6	15	6	3
Migraine / acute headache	41	18	6	18	8	4
Angina	195	78	30	83	34	13
Cellulitis	101	39	13	22	10	5
Diabetes complications	33	14	5	3	1	1
COPD	159	70	21	23	11	6
Dehydration and gastro	129	53	15	36	15	6
Influenza and pneumonia	299	108	36	18	9	4
Convulsions and epilepsy	53	22	7	19	8	3
Congest heart failure	103	40	14	6	3	2
Perforated / bleeding ulcer	61	25	9	14	6	2
Stroke	134	58	18	11	5	3
Fractured proximal femur	44	17	8	0	0	0
All ACSCs combined	2,778	1,123	418	455	201	92

--- Highly variable ACSCs

9 Appendix

Appendix 1: Included ACSCs and ICD-10 codes used to define them

Condition	ICD-10 Codes
Angina	I20,I240,I248,I249,I25,R072,R073,R074,Z034,Z035
Asthma	J45,J46
Cellulitis	I891,L010,L011,L020,L021,L022,L023,L024,L028,L029,L03,L04,L080,L088,L089,L88,L980
Congest heart failure	I110,I130,I255,I50,J81
Convulsions and epilepsy	G253,G40,G41,O15,R56,R568
COPD	J20,J40,J41,J42,J43,J44,J47
Dehydration and gastro	A020,A04,A059,A072,A080,A081,A083,A084,A085,A09,E86,K520,K521,K522,K528,K529
Dental condition	A690,K02,K03,K04,K05,K06,K08,K098,K099,K12,K13
Diabetes complications	E100,E101,E102,E103,E104,E105,E106,E107,E108,E110,E111,E112,E113,E114,E115,E116,E117,E118,E120,E121,E122,E123,E124,E125,E126,E127,E128,E130,E131,E132,E133,E134,E135,E136,E137,E138,E139,E140,E141,E142,E143,E144,E145,E146,E147,E148,E149
Ear, nose and throat inf	H66,H67,J02,J03,J040,J06,J312
Hypertension	I10,I119
Influenza and pneumonia	A481,A70,J10,J11,J120,J121,J122,J128,J129,J13,J14,J153,J154,J157,J159,J160,J168,J18,J181,J189
Iron-deficiency anaemia	D460,D461,D463,D464,D501,D508,D509,D510,D511,D512,D513,D518,D520,D521,D528,D529,D531,D571,D580,D581,D590,D591,D592,D599,D601,D608,D609,D610,D611,D640,D641,D642,D643,D644,D648
Pelvic inflammatory disease	N70,N73,N74
Perforated / bleeding ulcer	K20,K210,K219,K221,K226,K250,K251,K252,K254,K255,K256,K260,K261,K262,K264,K265,K266,K270,K271,K272,K274,K275,K276,K280,K281,K282,K284,K285,K286,K920,K921,K922
Pyelonephritis	N10,N11,N12,N136,N159,N300,N308,N309,N390
Alcohol-related diseases	F10
Atrial fibrillation / flutter	I471,I479,I495,I498,I499,R000,R002,R008
Constipation	K590
Fractured proximal femur	S720,S721,S722
Dyspepsia / otr stomach function	K21,K30
Migraine / acute headache	G43,G440,G441,G443,G444,G448,R51
Neuroses	F32,F40,F41,F42,F43,F44,F45,F46,F47,F48
Peripheral vascular disease	I73,I738,I739
Ruptured appendix	K350,K351
Schizophrenia	F20,F21,F232,F25
Senility / dementia	F00,F01,F02,F03,R54
Stroke	I61,I62,I63,I64,I66,I672,I698,R470

Appendix 2: Estimation of inter-PCT variation

Within our model the number of admissions in PCT i for condition j , Observed_{ij} , is realisation from a Poisson model with mean μ_{ij} . We use a log link function to relate μ_{ij} to a linear predictor which includes the expected number of admissions (given the size and age-sex makeup of the PCT) as an offset term. We account for other differences in populations (e.g. prevalence of chronic disease) by including k regression coefficients, β_{jk} , which estimate the effect of each covariate, X , on the outcome. Crucially, the linear predictor includes a normally distributed random effect, termed the regional effect (RE_{ij}), which allows for differences in the linear predictor for each PCT. The main parameter of interest is σ_j which we transform to a utilisation ratio (UR) for ease of interpretation. The full model is detailed below:

$$\begin{aligned}\text{Observed}_{ij} &\sim \text{Poisson}(\mu_{ij}) \\ \log(\mu_{ij}) &= \text{Expected_Age_Sex}_{ij} + \beta_{jk}X_{jk} + \text{RE}_j \\ \text{RE}_j &\sim \text{Normal}(\theta_j, \sigma_j^2) \\ \text{UR}_j &= \frac{\exp(1.282(\sigma_j))}{\exp(-1.282(\sigma_j))} = \exp(2.564 \times \sigma_j)\end{aligned}$$