Specialised services formula

Final model agreed by ACRA for information

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Promoting equality and addressing health inequalities are at the heart of NHS England's values. Throughout the development of the policies and processes cited in this document, we have:

Given due regards to the need to eliminate discrimination, harassment and victimisation, to advance equality of opportunity, and to foster good relations between people who share a relevant protected characteristic (as cited under the Equality Act 2010) and those who do not share it;

Given regard to the need to reduce inequalities between patients in access to, and outcomes from, healthcare services and in securing that services are provided in an integrated way where this might reduce health inequalities.

Contents

1 Formula update: specialised services

1.1 Purpose

This is the final report for information on the work in 2015 to develop a formula for specialised services.

Earlier versions of the paper were presented to ACRA. Following the ACRA meeting in November 2015, and based on ACRA's advice, we made a number of refinements to the modelling which are included in this report. In order to meet the deadline for the NHS England Board meeting in December, there was insufficient time for ACRA to review these detailed changes.

The two changes following the November ACRA meeting are:

a. to use the T-stat method for selecting the attributed variables to be included in the final model, as requested by ACRA: and

b. the omission from the dependent variable of those specialised services with limited coverage in the SUS PbR dataset. The specialised services to be omitted were defined by Analytical Services (Finance) and this approach reflected ACRA's concerns about the extent of coverage of some specialised services in the SUS PbR data set.

1.2 Policy context and key conclusions

1.2.1 General approach

A similar approach, to that for the CCG formula, has been adopted in developing a draft specialised services formula. The nature of specialised services (low volume, high value, inconsistent demand and often off tariff) has made this work challenging. Of particular note is the challenge that some specialised services in certain locations may be influenced by supply side variables (proximity to a hospital will increase the likelihood of a service being provided, this is similar to the CCG formula and has been adjusted) and demand side variables (where a particular individual, family of socio-economic group specifically move close to a specialist centre for access purposes).

1.2.2 Basis of allocations

Specialist service allocations have previously been made on the basis of the total requirement of the provider and who contracts with that provider. For example, if a London specialist centre contracts with the London specialist service contracting hub, accordingly all the allocation will be made to London regardless of the fact that patients will be referred to the hospital from all over the country. By shifting to a geographic population based allocation NHS England expects there will be greater local transparency relating to specialist care and referrals which can support local integration of services.

1.2.3 Scope of analysis

The analysis of the specialist service budget at a CCG level is not intended to transfer responsibility for specialist service commissioning but to support a greater

understanding and transparency for the development of collaborative commissioning between CCGs and NHS England, where appropriate.

1.2.4 Consistency of rules

It is acknowledged that the rules for commissioning services and the designation of some treatments as specialist (therefore commissioned by specialist services) are inconsistent across the country. It is expected that from 2016-17 there will be a national rebasing of this to ensure consistent treatment. This will see allocations transferred between commissioning streams to support the redefined boundaries of commissioning in a local health economy. This will have an impact upon pace of change considerations and the proposal to utilise a place based pace of change.

1.2.5 Data accuracy

Data accuracy, the differing treatment of some services and issue of inconsistent local tariffs for some services have made the development of the target formula for specialised services difficult. Before developing the formula NHS England had to conclude that the baseline activity data being used to drive the modelling is appropriate and accurate.

1.2.6 Appropriate use

Whilst the availability of patient level data and the econometric modelling could be further improved in the future, NHS England are confident that the current iteration of this formula is appropriate to support the functions for which it has been developed. To mitigate the potential risk inherent in the availability of patient level specialised data, an additional “target formula” option (the second option below) is considered here (reflecting ACRA’s concerns about the degree of specialised service coverage in the SUS PbR data):

- taking the defined output from the new econometric specialised services approach and extrapolating across the whole specialised expenditure base; or
- taking the defined output from the new econometric specialised services modelling and using actual expenditure for some areas not in scope for the econometric modelling.

1.2.7 Limits

The purpose of the formula development is not to support immediate widespread changes in commissioning responsibility but to best highlight the actual and target spend within a geography. The total specialised budget has been established through high level allocations. The in-year split and financial management remains the responsibility of NHS England, pending the development and agreement of collaborative commissioning proposals.

1.2.8 Changes in funding streams

However, the revision of the IR rules between CCG and specialist commissioning planned for 2016-17 brings challenges. Previous experience of the disaggregation of the PCT baseline indicates that there a risk of perverse incentives when there are major funds flowing between commissioning streams. It is currently anticipated that funds will be transferred between the CCG commissioning stream and specialised Commissioning. This transfer will be based upon actual expenditure, not linked to the target formula at all. With a material change to the quantum and this being linked to

disproportionate adjustments between CCGs this will impact both actual and target positions for CCGs and specialised allocations.

Such a transfer highlights the risk of material changes to distance from target within the CCG commissioning stream. To ensure that the objective of a multiyear allocation is achievable requires us to consider methods of mitigating this risk through the development of a suitable pace of change policy.

This paper considers only the development of and issues arising from the development of a target formula. Note that section 6 contains a summary of the technical issues covered in this paper.

2 Introduction

2.1.1 CCG level specialised services allocations

Previous allocation rounds have not made a CCG level specialised services allocation. In the past such allocations have been based on historic expenditure at an area team level for all prescribed specialised services undertaken by providers in their geographical area[1].

For the 2016-17 round, the scope to make a more quantitative approach to specialised services allocations is being explored. This will focus on applying and developing the PBRA framework to estimate needs-based weights for specialised services at a CCG level.

There are two key aspects in this workstream:

- Identify specialised services; and
- Estimate target allocation weights for specialised services for each CCG.

This paper presents summary statistics and comparisons to confirm that the available data are in line with expectations; the econometric methodology; econometric modelling results; the specialised services weights resulting from this work; and comparisons of these weights to other CCG level weights.

3 Data

3.1.1 Available data

The identification of specialised services has been conducted using the SUS PbR data for 2013-14 provided by the Health and Social Care Information Centre (HSCIC), and the application of the (publically available) 2014-15 PSS tool to this data[2,3]. The 2014-15 PSS tool has been run partly because the 2015-16 tool is not ready for use but mainly because the implications of identification rule changes are being assessed and adjusted for as part of a separate exercise by another internal

[1] *http://www.england.nhs.uk/wp-content/uploads/2013/10/comm-intent.pdf

[2] The HSCIC has developed a tool which can be applied to SUS PbR data (the 'PSS tool') to identify specialised services episodes. It uses an episode's procedure, diagnosis and other relevant data field to match a list of codes documents in the specialised services identification rules.

[3] No adjustments have been made to the identified specialised services arising from the PSS tool.

team. Given this separate exercise it is preferable for target allocation weights to be generated based on the previous identification rules, to provide a baseline against which further adjustments for the new identification rule changes can be made.

3.1.2 Initial analysis of data

Prior to conducting analysis to generate target allocations for specialised services using the identified data, a number of high level comparisons have been made to check whether the identified services are in line with expectations. This has involved various 'cuts' of data (activity count comparisons across age, gender, national programme of care and clinical reference group) which have been compared to the tNR data held by the Specialised Services Intelligence Team[4,5]. These comparisons show that the specialised services data used by the Allocations Project Team are very similar to that held by the Specialised Services Intelligence Team. Across various comparisons of the characteristics of both specialised services data, the average absolute difference was less than 3%.

3.1.3 Incomplete coverage

Overall the SUS PbR data shows that around 4% of the registered population received a specialised service in 2013-14 (inpatient, outpatient or both). At the November meeting ACRA raised concerns about the limited coverage of some specialised services in the SUS PbR dataset. NHS England has therefore excluded such services from the sample used for the econometric modelling. The identification of services for exclusion was made following discussions with key analytical and clinical colleagues: specialised services for which the PSS tool identifies a small proportion of total Clinical Reference Group (CRG) spend were excluded from the modelling sample[6]. Approximately 2.5% of the registered population received a specialised service in the *remaining* subsample of CRGs in 2013-14. Unless otherwise specified, the remainder of this paper refers to this sub-sample of identified specialised services. This subset is referred to as the 'restricted CRG sample'.

3.1.4 Description of data

The tables and figures below provide further information on the nature of specialised services identified in the data[7]. The data was costed in line with the methodology for general and acute services[8]. This analysis was conducted for both inpatient spells and outpatient episodes and shows that:

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[4] The tNR is a data repository hosted by Arden & GEM CSU which contains patient-level data for all providers and commissioners from SUS.

[5] These comparisons were conducted on the data for all specialised services (not the restricted set of Clinical Reference Groups for which econometric analysis has been conducted (see later discussion in section 2). This comparison using all data was used to assess the identification of specialised services such that later selection and modelling decisions could be been made with a view to all available data.

[6] The retained CRG codes are: A10, A09, A03D, A12, A04, A07, A02, A05, A13, A06, B03, B04, B09, B08, D03, D04, D14, D12, A03A, D05, D11 and D02.

[7] Additional summary statistics are provided in the appendix.

[8] Further information on the costing methodology can be found "ACRA(2015)28 Refreshing the current CCG formula".

- approximately 10% of inpatient spells and 7% of outpatient attendances are identified as specialised in the dataset used in the analysis (Table 3.1)[9];
- the age profile of specialised services utilisation is different to that of core services in that there is higher relative utilisation of specialised services by adults aged 35 to 75 for inpatient services (Figure 3.1: Inpatient cost – proportion of specialised cost by each age category relative to all PSS identified specialised cost) and 45 to 80 for outpatient services (Figure 3.2: Outpatient cost – proportion of specialised cost by each age category relative to all PSS identified specialised cost)[10,11]; and
- the average cost of specialised services is higher than core services and this difference is more pronounced for younger patients with particular variability between younger patients of different ages for inpatient treatment[12] (Figure 3.3: Inpatient cost – average cost of treatment and Figure 3.4).

3.1.5 Summary of checks

Overall, the high level checks suggest that the data provided and the application of the PSS tool to the data appear sensible. While a full quality assurance of the HSCIC's source data and the PSS tool are beyond the scope of this workstream, quality assurance of the source data was conducted as part of a separate exercise involving other colleagues and the HSCIC.

Table 3.1: Number of inpatient spells and outpatient attendances identified for specialised services versus total services

	Inpatients	Outpatients
Total spells/attendances	12,279,368	67,666,585
Specialised spells/attendances	1,181,626	4,412,738
Specialised percentage of total spells/attendances	9.62%	6.52%
Average cost of all spells/attendances	£1,686	£117
Average cost of specialised spells/attendances	£2,646	£143

[9] Specific types of spells and appointments have been excluded from the analysis, such as observations without an age variable or cancelled appointments.

[10] For older patients this varies from 55 to 70 for inpatient and outpatient services.

[11] The same comparison for all specialised services (rather than the restricted CRG dataset) shows a higher relative utilisation of inpatient specialised services for patients up to 20 and between 45 and 75; for outpatients there is higher relative utilisation of outpatient services for patients up to 19 and between 60 and 74.

[12] The variability between children's ages is likely driven by differences in the intensity of services required (support services for babies) and higher costs for older children who can receive more extensive inpatient treatment than younger children.

Figure 3.1: Inpatient cost – proportion of specialised cost by each age category relative to all PSS identified specialised cost

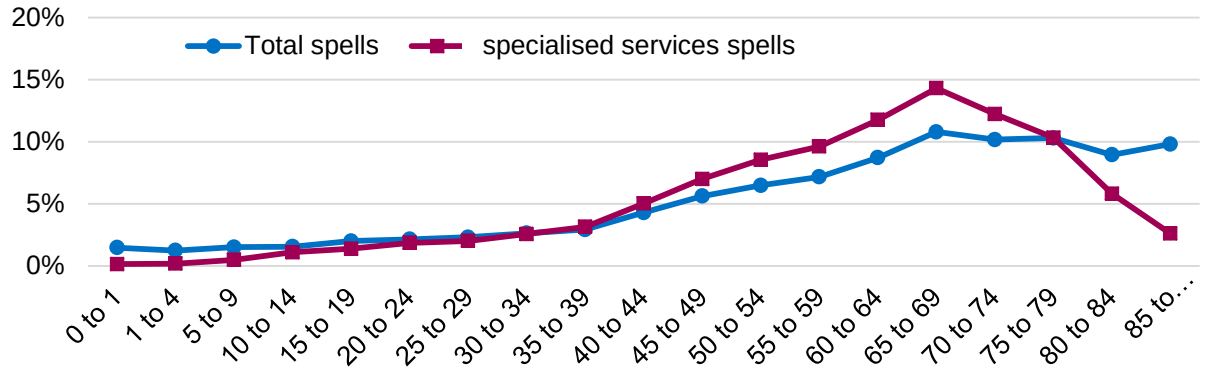


Figure 3.2: Outpatient cost – proportion of specialised cost by each age category relative to all PSS identified specialised cost

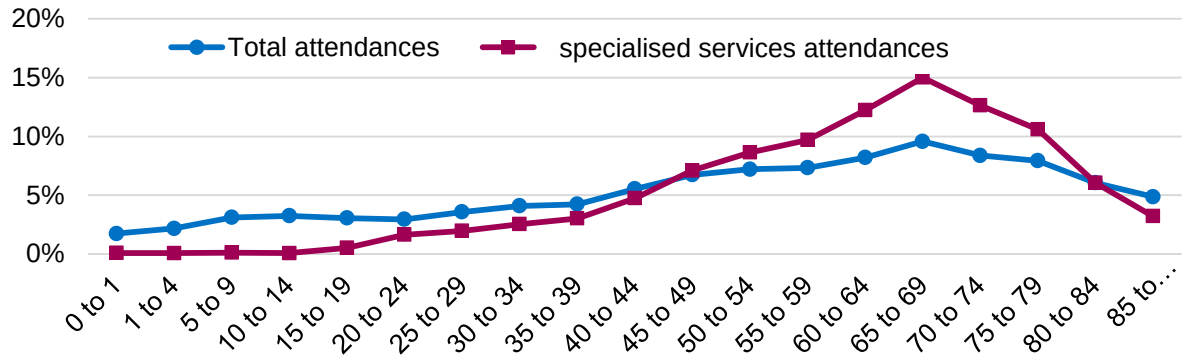


Figure 3.3: Inpatient cost – average cost of treatment

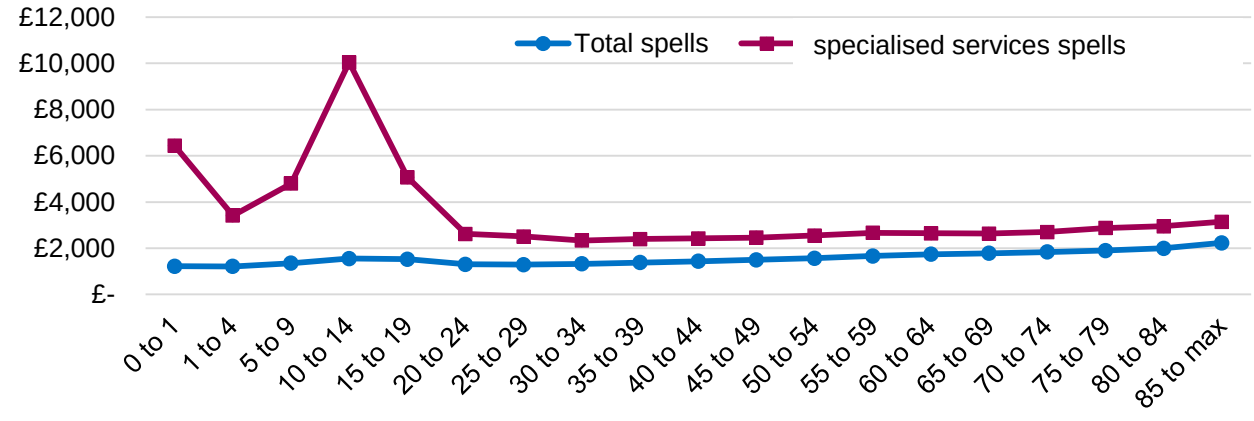
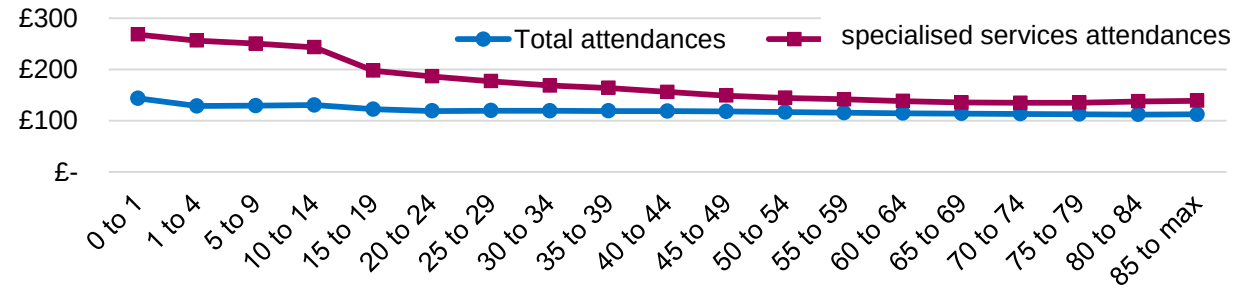


Figure 3.4: Outpatient cost – average cost of treatment



4 Modelling

This section discusses the econometric methodology, technical challenges and model results. The main conclusion is that although modelling and predicting utilisation of specialised services is challenging, the econometric models are able to fit and forecast cost data relatively well.

4.1 Methodology and key challenges

4.1.1 Person-based resource allocation (Nuffield PBRA)

The PBRA modelling approach has been applied on specialised services data, which uses patient level information to model utilisation of health care service (proxied by cost) as a function of a range of variables including:

- Demographic information associated with patient age and sex;
- Attributed need variables (for example average deprivation, claimant benefits);
- Morbidity flags that indicate whether a patient received specialised services treatment in previous years;
- Morbidity counts (that is, number of morbidity flags per patient);
- Co-morbidity flags which reflect whether a patient has experienced multiple specialised service conditions in the past; and
- Supply side variables such as average distance from an acute provider[13].

4.2 Challenges

Modelling and predicting relative need for specialised services is challenging for two main reasons.

4.2.1 Zero values

In 2013-14 approximately 2.5% of the registered population received some form of specialised care (either APC, outpatient, or both) with the majority of patients having zero utilisation of specialised services.

4.2.2 Extreme values

The distribution of patients utilising specialised services is not (statistically) normal and costs vary significantly within these non-zero observations. For instance, the bottom decile of the patient cost distribution is £93 whereas the top decile is £8,100. Within this there are some very high cost patients - the top 1% of the distribution is £29,222 with some patients' costs exceeding £100,000. By comparison, the respective figures for core services are narrower (see A2 for details).

Models applied on data that are dominated by zero values and/or have a non-normal distribution often have low explanatory power and poor forecasting performance. The modelling performance on the available data is an empirical issue which is addressed in the next section.

[13] Supply side factors control for differences in access to services across CCGs.

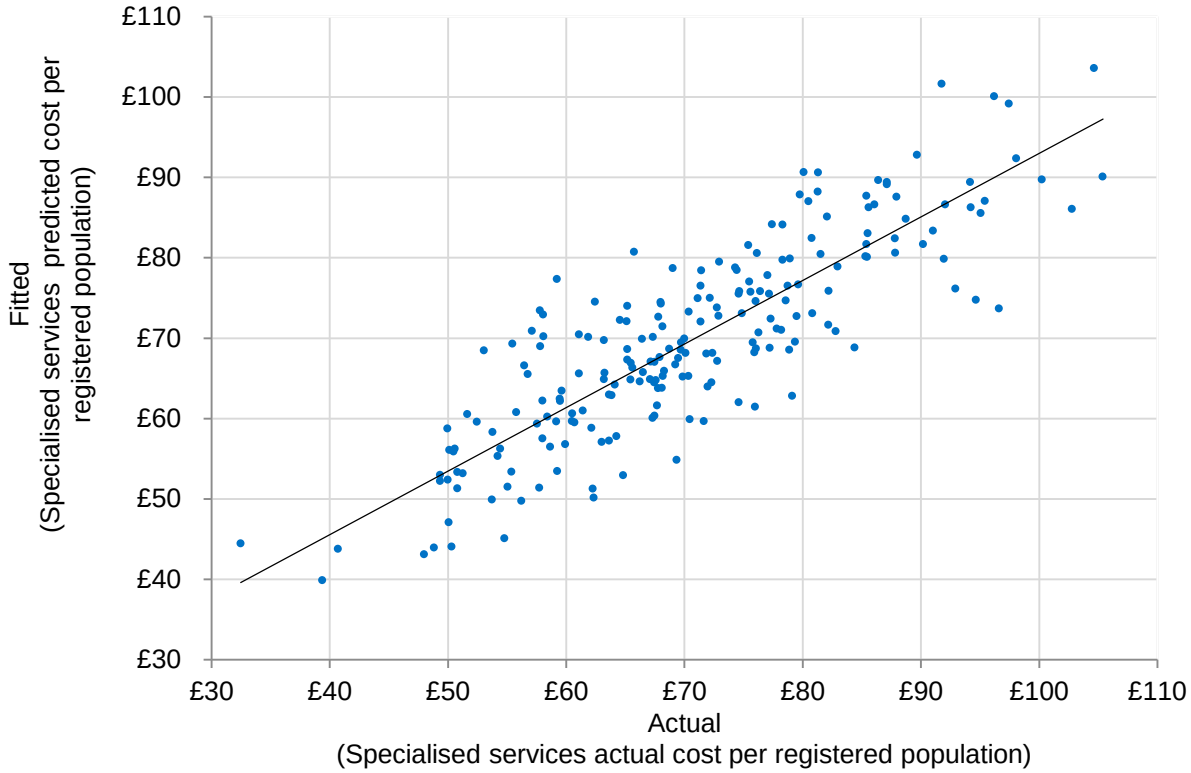
4.3 Results

Various econometric models have been fitted on specialised services patient data using a general specification, similar to the one used for core services in the previous allocation round. The model includes around 500 explanatory variables mainly reflecting demographic and morbidity information. It has been estimated by Ordinary Least Squares ("OLS")[14].

Full model results are presented in the Appendix. This section focuses on the in-sample and out-of-sample performance of the specialised services models.

Figure 4.1: Model versus actual forecasted average cost per registered population summarises the forecasting performance of the model at CCG level[15]. The x-axis (*actual*) is the actual average cost per registered population in a CCG and y-axis (*fitted*) reflects the model forecasted average cost per registered population. The best fit line indicates that the model fits the actual cost data reasonably well.

Figure 4.1: Model versus actual forecasted average cost per registered population



[14] Tobit models, which are in principle designed to model data that are dominated by zeros, have also been estimated. However, they yield results that are inferior to those from OLS in terms of R-square and forecast accuracy and were therefore disregarded.

[15] The models have been estimated using a sample of approximately15% of the total GP registrations. These models are in turn fitted out-of-sample, on a validation sample representing another 15% of the GP registration population, and aggregated to GP practice and CCG level. The estimation of the models is time consuming because of the large dataset of over 56 million patients, and a smaller sample was chosen to increase computational speed. This is consistent with the approach adopted by Nuffield as part of previous allocation estimations.

4.3.1 Model fit and forecast performance

Table 4.1 sets out the model fit (in terms of R-squared[16]) and forecast performance (in terms of mean absolute percentage error[17] (MAPE)) for five alternative model specifications. The higher the R-squared the greater the proportion of variation in the cost data explained by the model. R-squared is relatively low at patient level, ranging from 3.75% to 8.41% but this is expected given the nature of the data (with many patients having zero costs). Interestingly, when the actual and fitted data are aggregated at GP practice and CCG level, the model fit increases significantly. These results suggest that although it is difficult to predict specialised services utilisation at patient-level, model errors partly cancel out when the predictions are aggregated to GP practice and especially CCG level.

4.3.2 T-statistic

The t-stat model selection procedure that has been applied to the core services data has also been applied to the specialised services data, as requested by ACRA. This model, after stratification across different age-categories, produces the best fit at patient and GP practice level, which is consistent with the core services modelling results[18].

4.3.3 Mean absolute percentage error (MAPE)

Finally, the MAPE indicates a reasonable forecast performance – average forecast error is approximately 8%. Notwithstanding this, there are a significant number of CCGs where the model significantly over or under predicts costs.

[16] The R-squared value measures the degree of correlation between actual and model fitted values and indicates how well the model explains the variability of actual data. The higher the R-squared value, the greater the fit. For instance, an R-squared of 60% suggests that the model can explain 60% of the variability of actual cost data.

[17] The mean absolute percentage error (MAPE) is the mean absolute percentage difference between the observed cost of specialised care and the predicted cost of specialised care. A lower MAPE indicates better predictive power.

[18] t-stat model selection starts with a general model and sequentially removes attributed and supply side variables with t-statistics below a pre-defined value.

Table 4.1: Model fit

Model	Specification	R^2 Patient level	R^2 GP practice level	R^2 CCG level	MAPE CCG level	Actual cost not within 10% CCG level
Model 0	PBRA Nuffield	3.75%	50.41%	70.48%	8.43%	29.86%
Model 90	PBRA Nuffield + specialised services service line dummies - core morbidity flags + additional supply side variables + additional needs variables	5.12%	50.54%	72.83%	7.99%	27.96%
Model 91	Model 90 without CCG dummies	5.12%	46.30%	56.32%	10.36%	39.34%
Model 92	Age stratified Model 90	5.43%	50.95%	72.85%	7.99%	29.86%
Model 13	PBRA Nuffield + specialised services service line count variable + NPOC QQ 2012	8.22%	55.20%	72.36%	8.11%	27.49%
Model 14	Age stratified Model 13	8.41%	55.35%	72.42%	8.08%	28.91%
t-stat model	t-stat selection	8.22%	55.44%	72.37%	8.11%	27.49%
t-stat model stratified	Age stratified t-stat selection model	8.41%	55.67%	72.43%	8.08%	28.91%

Table 4.2 shows the coefficients and significance of the attributed need and supply side variables for the Nuffield model specification and the t-stat selection model. The results suggest that only a small number of attributed need and supply variables with the correct sign are statistically significant. This, together with the results in the Appendix, indicates that relative need for specialised services is mainly driven by age-sex and morbidity variables.

Table 4.2: Attributed need and supply variables

Analysis based on the CRG restricted dataset	PBRA Nuffield (Specialised Services)				T-Stat Selection			
Description	**All ages**	**0-20**	**20-40**	**Over 40**	**All ages**	**0-20**	**20-40**	**Over 40**
NEED VARIABLES								
Proportion Non White	0.05	-0.02	0.02	0.08				
2012-13 QOF Asthma Prevalence	-0.61	0.52	-0.92*	-1.16				
Persons in social rented housing	0.09**	-0.09*	0.12**	0.17*				
All disability living allowance (DLA) claimants (proportion)	0.06	0.78	1.65	-1.36				
Proportion of population aged 20-24	-27.82***	7.48	-16.51**	-36.83				
Log population variance	-6.38	0.8	-5.05	-8.1	-5.2	-0.12	-4.73	-7.38
Proportion of students living away from home (MSOA variable)	-10.34**	4.12	-5.1	-17.4*				
Proportion in semi routine occupations aged 16-74	-0.12	0.25	-0.05	-0.32				
2012-13 QOF Thyroid Prevalence	0.75	-0.67	3.21***	-0.62				
Persons aged 65 and over living alone (MSOA level)	0.15	0.11	0.31	0.1				
Population claiming DLA mobility award at higher rate	0.28	-3.95*	0.28	2.11				
Dummy for if the patient has changed practice	3.34**	-1.26	2.87*	9.48**	5.08***	-0.7	4.5***	11.69***
Dummy for if the patient utilised private health care	45.84	-41.07	16.06	53.18	27.65	-97.98**	17.61	38.25
All usual residents 16 and over with no qualifications (unstandardised)					0.27***	-0.01	0.25***	0.43***
Average with (long term) medical condition for those with at least one					5.57**	0.29	3.7	10.04*
SUPPLY VARIABLES								
2012-13 QOF Asthma Weighted Achievement Score	0.01	0.07	0.02	-0.02				
Number of operating theatres, June 2012	0.77	-0.26	0.91	1.23				
2012-13 QOF Thyroid Unweighted Achievement Score	-0.24	-0.01	-0.55**	-0.16				
Average distance travelled to outpatient	0.11	0.09	0.05	0.18				
Constant	83***	-23.57	-54.8	131.19***	38.6***	1.42	-64.89***	66.92***
Observations	8,286,935	1,888,909	2,323,925	4,074,101	8,286,944	1,888,910	2,323,932	4,074,102
R-Squared (estimation sample)	3.83%	2.77%	4.47%	3.89%	8.60%	8.70%	13.19%	8.21%
Adj. R-Squared (estimation sample)	3.82%	2.75%	4.45%	3.88%	8.60%	8.68%	13.17%	8.20%
Significance stars: *p<0.05, **p<0.01 and ***p<0.001								

5 Target allocation weights

5.1.1 Generated weights

This section presents the weights generated from one of the econometric models discussed in the previous section[19]. In order to contextualise these weights, comparisons are made against:

1. Core services CCG weights (these are preliminary); and
2. Each CCG's share of specialised services cost in 2013-14.

It is not expected that the PBRA specialised services weights will match either of these comparators but a broad similarity is expected. Differences to the core services CCG weights are anticipated as the demographic profile of need varies between these and specialised services (as discussed in section 3). Differences to CCG specialised services cost shares are expected as cost shares reflect utilisation rather than need.

5.1.2 Comparison to known need factors

Beyond these contextual comparisons, this section also looks at how the estimated PBRA weights relate to known need factors, to explore whether the results are in line with what the existing data show about specialised services need. The need factors examined here relate to age demographics.

5.1.3 Specialised services versus core services target allocation weights

Figure 5.1 shows the relationship between specialised services and Core Services target allocation weights. Although the correlation between the two sets of weights is high (99%), there are some large differences between the two sets of weights (also see Table 5.1Table 5.1). However, the high correlation is partly driven by population size: larger CCGs have higher weights because they serve larger populations. In addition, there are 6 CCGs for which the percentage difference between the specialised services and core services weights is greater than 15% in absolute terms (see Table 5.2). Figure 5.2 presents the correlation between specialised services and core services target allocations after controlling for differences in registered population (target allocations per capita). The correlation is still high (60%) albeit not as strong as in the case of the total target allocations.

[19] The model with the best forecasting performance at CCG level has been used to generate these draft weights.

Figure 5.1: Target allocation weights - difference between specialised services weights and core services weights[20]

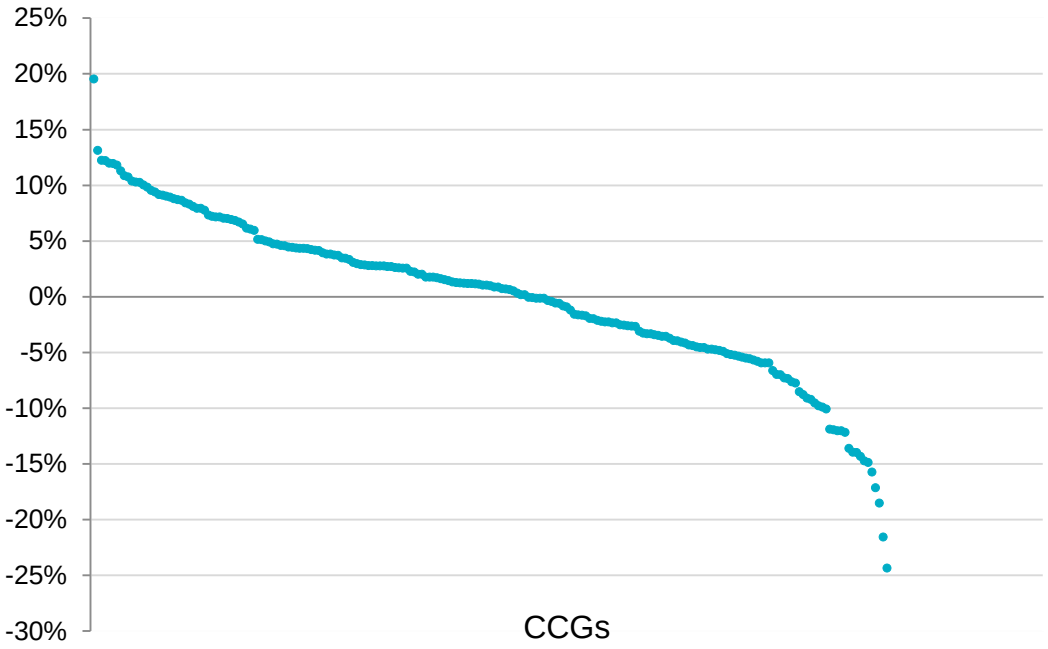
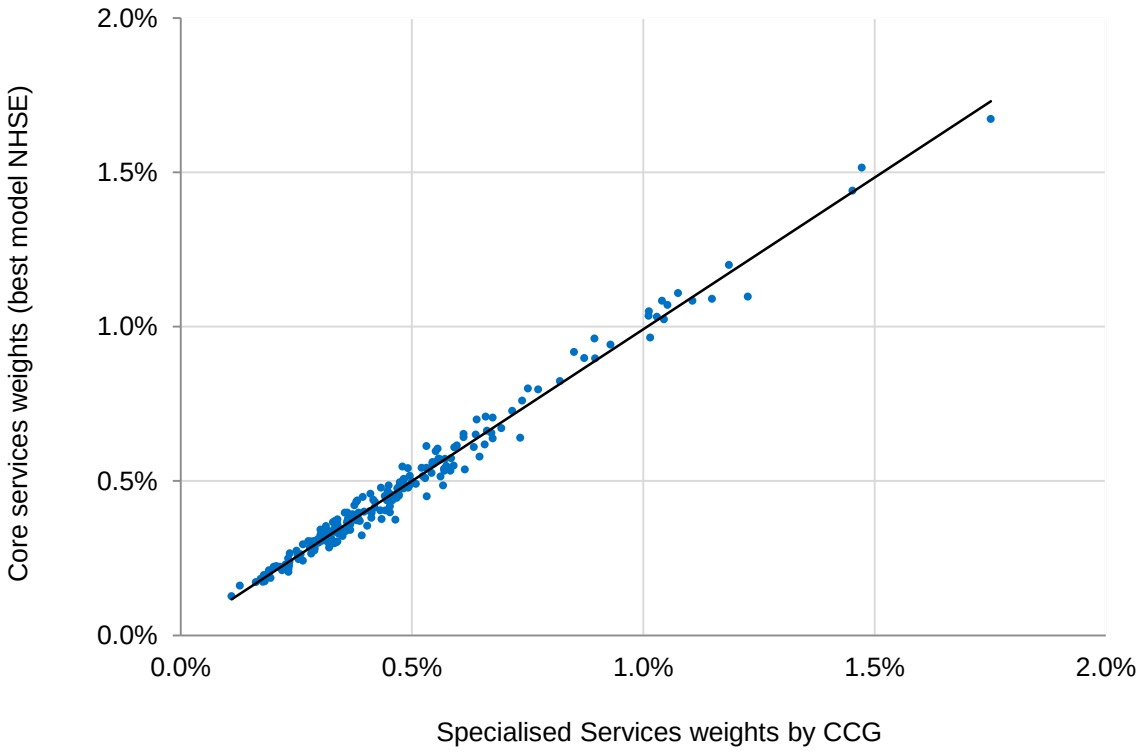


Figure 5.2: Target allocation weights per capita – core services against specialised services



[20] The percentage difference in weights is calculated as: (core services weights – specialised service weights)/core services weights.

Table 5.1: Distribution of the difference between specialised services weights and comparator weights

Percentile	Percentage difference between specialised services weights and:		
	Core services weights	CCG shares implied by the SUS PbR data	CCG shares implied by the Aggregate specialised services data
1%	-18%	-30%	-96%
5%	-13%	-21%	-61%
25%	-4%	-10%	-20%
50%	1%	-3%	0%
75%	4%	5%	9%
95%	10%	16%	29%
99%	12%	23%	42%
Interquartile range	9%	16%	28%

Table 5.2: Identified differences between specialised services and core services target allocation weights for CCGs with an absolute difference greater than 15%[21]

SS target allocation weights	% difference between specialised services and core service weights
0.13%	19.5%
0.43%	-15.8%
0.57%	-17.2%
0.53%	-18.6%
0.39%	-21.6%
0.46%	-24.4%

5.1.4 Specialised services weights versus actual CCG specialised services spend shares

This section compares the PBRA generated specialised services weights with the 2013-14 utilisation of specialised services across CCGs.

Two comparisons are made:

- To specialised services CCG expenditure shares as identified in the SUS PbR data using the PSS tool; and
- To the CCG expenditure shares as identified in the total specialised services spend data collected by the Specialised Commissioning Finance team.

The PBRA specialised services weights are expected to differ from the above measures as the former reflect relative need whereas the latter reflect utilisation. There is a high correlation between the weights and actual utilisation shares (the correlation is 98% and 90% for the SUS PbR data and total specialised services spend data respectively)[22] . However, the percentage differences for these comparisons (as seen in columns 3 and 4 of Table 5.1) are larger than the comparison against core CCG weights: the interquartile range is higher than that for the core CCG range in both instances. This may reflect the close affinity of the PBRA specialised services weights with other needs based weights (that is, the core CCG weights) rather than weights based on utilisation (the two specialised services comparators in this example).

[21] Calculated as: (core weight – specialised services weight)/ core weight

[22] See Appendix, section A4.

5.1.5 Relationship between relative need and age demographics

Figure 5.3 and Figure 5.4 show the relationship between specialised services relative need (that is, average cost per registered population) predicted by the model and the proportion of population that is 20-44 and 45-79 years of age. Given the distribution of specialised services utilisation by age groups and varying costs by age category discussed in section 2, it is expected that GP practices with a higher proportion of 20 to 44 year olds will incur lower average costs per registered patient[23]. The relationships in these figures are consistent with the predictions of the econometric model.

Figure 5.3: Relative specialised services need against percentage of 20-44 years old population by GP practice

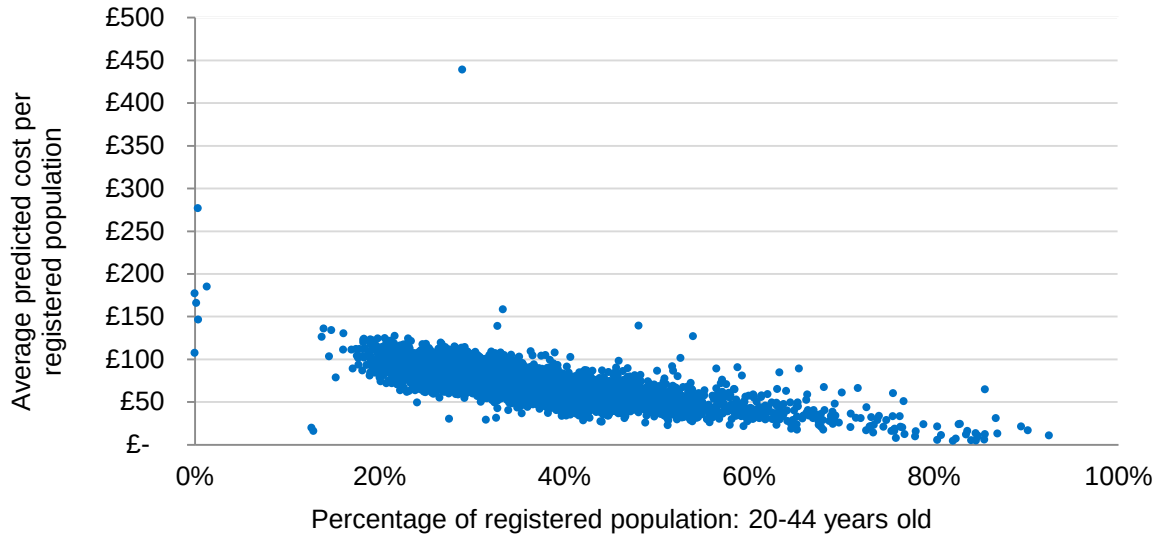
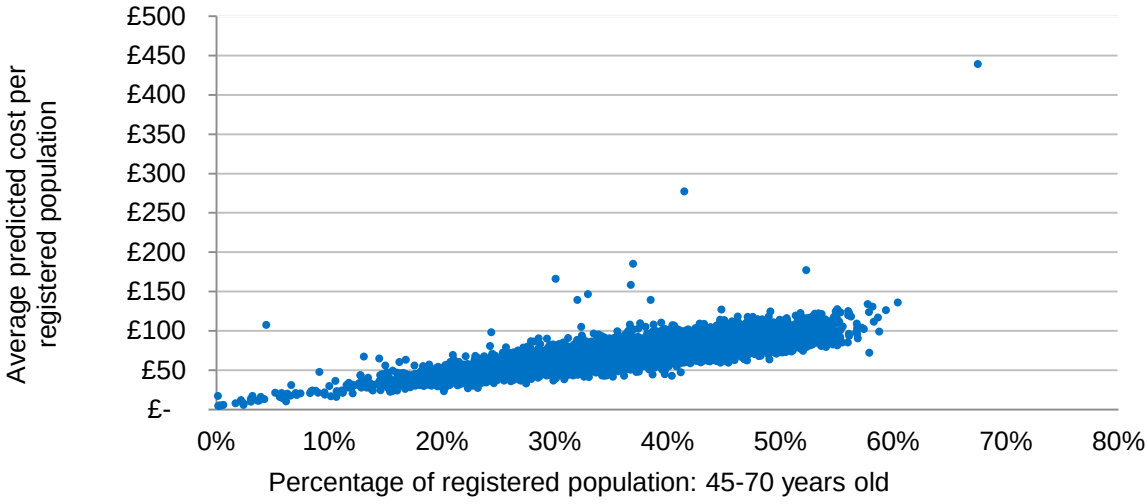


Figure 5.4: Relative specialised services need against percentage of 45-79 years old population by GP practice



[23] This is predicted given that the data show children up to 20 utilise more costly specialised services, and adults from their mid-40s onwards utilise more specialised services. Therefore the higher the proportion of adults aged 20-44, the lower the average cost per registered patient.

6 Application considerations

6.1.1 Patient level data

In order to conduct PBRA modelling, patient level data is needed. Similarly, identification of specialised services (using the PSS tool) requires patient level data. This is generally only available for specialised services which are covered by The National Tariff. Data on these services is available in SUS PbR but stakeholder engagement undertaken for this workstream indicated that around half (between 40% and 60%) of overall specialised services spend might be covered by this data.

6.1.2 Representative data

This raises the question of whether a total specialised services allocation weight can be determined on the basis of PBRA estimates if the latter are based on around half of specialised services spend. If the services covered by the available patient level data are representative of the rest of specialised services, allocation weights could be generated on the former and applied to the whole specialised services quantum. Previous discussion with ACRA and its TAG has highlighted their concerns about the representativeness of these services if a total specialised services allocation were to be based on the PBRA weights.

6.1.3 Types of treatment

This representativeness issue is particularly important given that the nature of services covered by the SUS PbR data differs from 'other specialised services . For example, the former category is primarily compromised of episodic hospital-based care with higher volumes; whilst the latter category constitutes other services including those which are episodic based, non-acute based services, and pathway based specialties. Services in the latter category are usually higher cost and lower volume than (on-tariff) services captured in the SUS PbR data.

6.1.4 Assessment

It is not currently possible to make a robust empirical assessment of the degree to which the available patient level data is representative of total specialised services spend. The data currently available on 'other specialised services' (those services not covered by the patient level dataset) is such that it is not possible to draw meaningful comparisons. It is however possible to assess the *proportion* of total specialised services spend which is identified with the available patient level data.

6.1.5 Proportion of spend identified with data

What proportion of total specialised services spend is identified with patient level data for 2013-14? To assess the proportion of total specialised services identified by the available data, the 2014-15 PSS Tool has been used to identify specialised inpatient episodes and outpatient attendances using 2013-14 SUS PbR extracts. The tool was able to identify approximately £5.1 billion of spend, which is around 40% of the £12.5 billion of total specialised services expenditure in 2013-14[24]. This is consistent with

[24] The £12.5bn baseline is derived by subtracting £0.8bn of `National Level Specialised Services' from the £13.3bn `Total Specialised Services Outturn'. Figures available from https://www.england.nhs.uk/wp-content/uploads/2014/12/annx-d-spec-serv.pdf). National Level Specialised Services are subtracted because they are not commissioned on a CCG level.

the lower bound of the 40% to 60% range of identification predicted by stakeholders who were engaged on this issue. For the CRG-restricted dataset, approximately £3.8 billion of spend remained of the initial £5.1 billion originally identified by the tool. This lowers the proportion of services identified to around 30% of the total specialised services expenditure in 2013-14.

6.1.6 CCG level

To illustrate this degree of identification at a more granular level, this is shown for each CCG in Figure 6.1 below. The same analysis is shown in Figure 6.2 and Figure 6.3 but at area team and regional levels respectively. To determine the proportion of specialised services identified at this more granular level, total specialised services spend at CCG level is taken from data collected by the Specialised Commissioning Finance team. To the extent that this data (especially that on overall specialised services spend at CCG level) is subject to data collection challenges and associated measurement error, the representativeness examined here is also subject to measurement error.

Figure 6.1 to Figure 6.3 show that there is a wide range in the proportion of PSS-identified specialised services. This is most pronounced at CCG level and least pronounced at regional level.

6.1.7 Variability

The variability of the percentage of specialised services identified raises concerns around both representativeness and the quality of the data available for specialised services more generally. There are a number of factors that might drive this variability. Genuine underlying structural drivers could relate to differences in the utilisation of on-tariff (SUS PbR) and off-tariff specialised services; other drivers could relate to the accuracy of the total spend and PSS-identified spend data.

6.1.8 Potential drivers

A high level assessment of a number of potential drivers is set out in Table 6.1 below. While explanatory power is associated with some of these drivers, the overall assessment is that attribution of the various effects is not straightforward. As the data available at CCG level on the breakdown of specialised services spend is improved in the future, updated analysis of this issue may identify less variability.

6.1.9 Appropriate application

In summary, it is not possible to empirically determine whether the PBRA specialised services weights generated can be applied to all specialised services specialised services or just those specialised services their estimation is based on. This remains a consideration for policy judgement as to whether and how the PBRA specialised services weights could be used in setting target specialised services allocations.

Figure 6.1: Percentage of PSS-identified specialised services spend by CCG

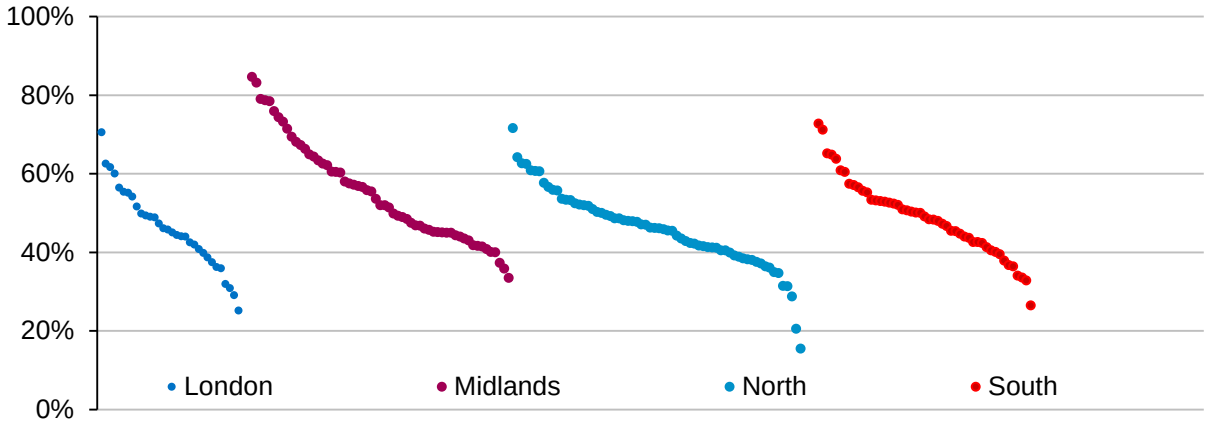


Figure 6.2: Percentage of PSS-identified specialised services spend by area team

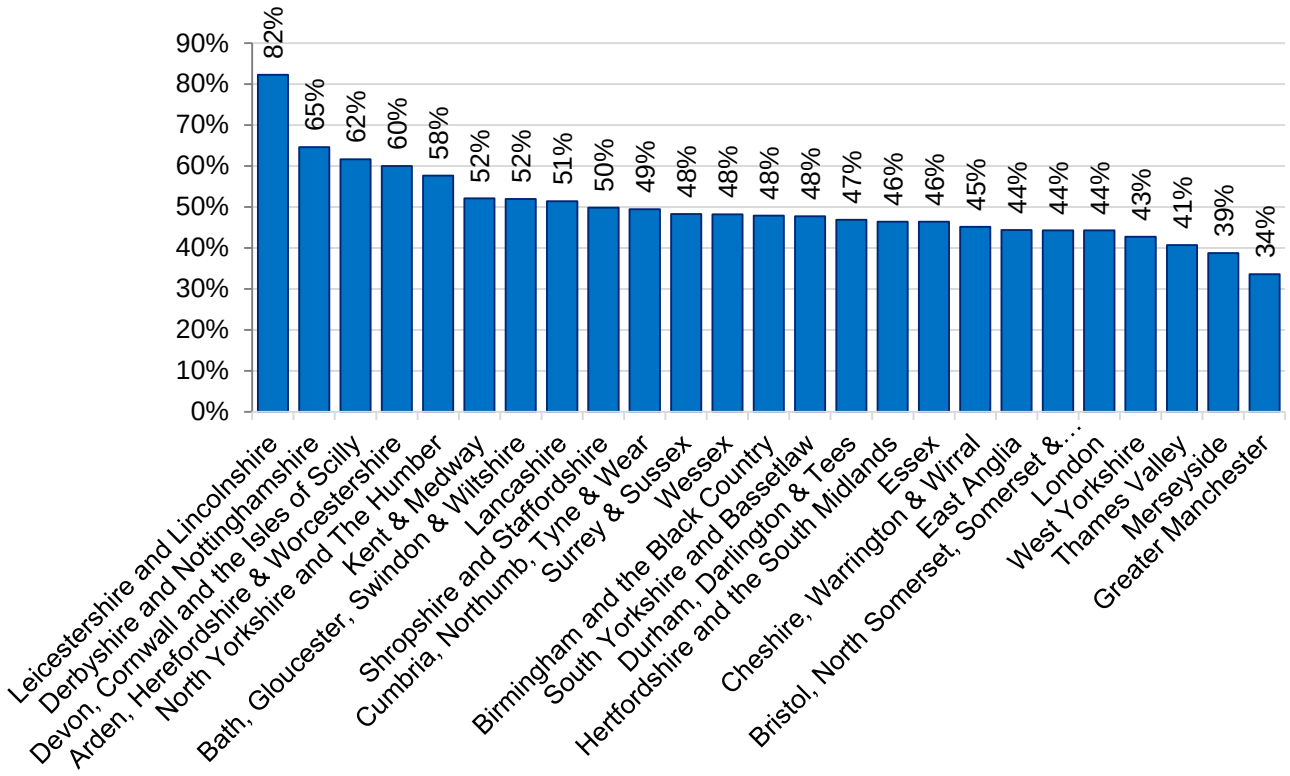


Figure 6.3: Percentage spend identified by regional team

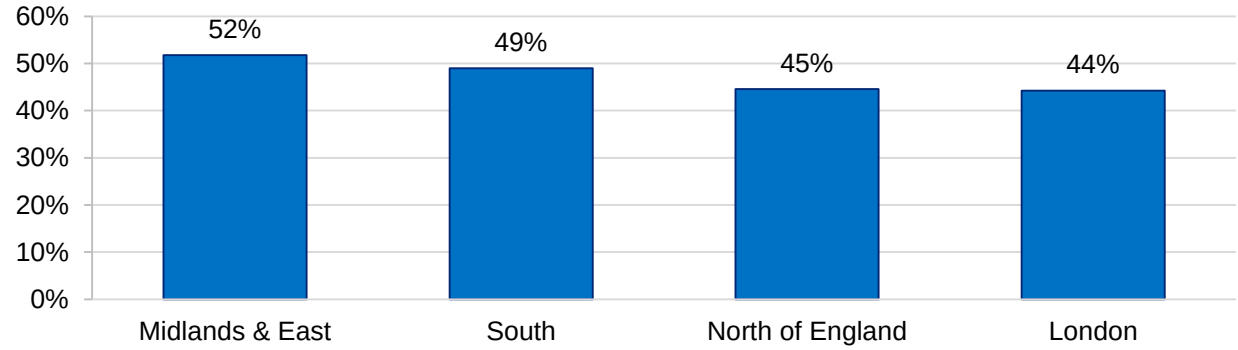


Table 6.1: High level testing of potential drivers of CCG level variation in the proportion of PSS-identified specialised services spend

Hypothesis	Description	Outcome
Hypothesis 1a: Removal of less related areas of spend (Mental Health and apportioned data) might improve the degree of 'variable representativeness'	Some of the difference between the aggregate and PSS identified data could be explained by MH and "apportioned" specialised services expenditure in aggregate data	The variance in Aggregate and PSS cost distributions remains even after removing these items from the aggregate data
Hypothesis 1b: Removal of less related areas of spend (Other non-CCG cost in aggregate expenditure might improve the degree of 'variable representativeness')	Differences between the aggregate and PSS identified data could be further explained by high level cost that are not assigned to individual CCGs, for example certain drugs or highly specialised services	Removing specific types of cost from aggregate spend does not reduce the difference between aggregate and PSS identified cost data
Hypothesis 2: Poorer data quality for the 2013-14 aggregate data might drive the 'variable representativeness'	Comparisons between the (improved) 2014-15 aggregate data and 2013-14 PSS identified data have been performed	Using the improved data for the aggregate baseline does not improve the degree of 'variable representativeness'
Hypothesis 3.1: Differences in access to tariff and non-tariff specialised services result in different uptake of these services	Some CCGs might have differential access for tariff and nontariff specialised services, resulting in different uptake of these	Hypotheses 3.1 and 3.2 can be potentially tested by looking at the degree of health care provision by Specialist providers across CCGs. It was found that the higher the provision of services by Specialist providers in a CCG the greater the difference between aggregate and PSS shares
Hypothesis 3.2: Postcode dumping	Some CCGs may have higher spend if postcode dumping occurs (w hereby their local provider/s find it difficult to accurately cross-charge care back to the patient's originating CCG and therefore charge their local CCG rather than the patient's originating CCG	
Hypothesis 4: Differences in data quality/ missing data for SUS PbR	CCGs with poor data quality might have fewer identified specialised services episodes given the w ay the PSS tool works. There w ere 2% of the total episodes (CCG and specialised services) that could not be processed by the PSS tool.	The distribution of errors is not evenly distributed across CCGs whereas there are several CCGs for which significant errors were reported. However, the correlation between errors and the representativeness metric is relatively low (approximately 6%)
Hypothesis 5: Differences in CCG size	Low level of specialised services activity at smaller CCGs may result in more volatile specialised services utilisation/data flows.	Correlation between population size and our representativeness metric is low (5%)
Hypothesis 6: Different IR rule application	The aggregate CCG spend may reflect differential IR application	No data available to test this hypothesis

7 Technical summary

7.1 Data requirements

7.1.1 PBRA approach

The Allocations Project Team were asked to empirically explore whether a PBRA approach could be applied to specialised services and what the CCG level weights are which result from the PBRA approach. This approach requires patient level data. However, the consensus from stakeholder engagement was that such data would only be available for between 40% and 60% of specialised services. In practice, the patient level data available for 2013-14 identifies around 40% of total specialised services spend[25]. After the exclusion of several clinical reference groups, this proportion drops to approximately 30% of total specialised services spend.

7.1.2 Challenging

Modelling specialised services is challenging given that only a small percentage (approximately 2.5%) of patients utilise specialised services, and also given the very wide range of costs associated with this care. The application of the PBRA approach to specialised services (where patient level data is available) indicates that while the data is more difficult to model than core CCG services, there are systematic patterns in specialised services utilisation that an econometric model can capture.

7.1.3 Explanatory power

The preliminary results presented in this paper show that the core PBRA OLS model applied to specialised services has reasonable explanatory power -the R^2 for specialised services is around 0.7 at CCG level. Alongside this the forecasting performance of the specialised services model is also reasonable - the MAPE for specialised services is 8.4%. While these results are encouraging, future work should explore the application of alternative models to further reduce forecast error[26].

7.1.4 Context and sense check

In order to contextualise and sense check the draft PBRA specialised services weights, comparisons can be made to other weights (such as core CCG services, the proportion of CCG level specialised services spend identified in the patient level data, and the allocation weights implied by the 2014-15 allocations which use historical specialised services expenditure). While it is not expected that the new specialised services weights will be very similar to these comparative weights, large unexpected differences would caution against the use of the new specialised services weights.

7.1.5 PBRA weights

Overall these comparisons indicate that the PBRA specialised services weights for most CCGs are broadly similar to other weights, falling within a +/-15% range.

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[25] Cross-checks have been conducted on this data (using data held by the Specialised Commissioning Intelligence Team) and consistency was found in the identification of specialised services. This provides a reasonable degree of confidence that an appropriate identification has occurred.

[26] Initial application of alternative models as part of this workstream did not find performance improvements but these are anticipated in theory.

However, there are a number of CCGs where the difference is larger than this. Future application of alternative econometric models may alter these comparisons.

While the new PBRA specialised services weights generated appear initially to be broadly in line with core CCG weights, caution should be exercised in their use as target allocations for several reasons.

7.1.6 Issues

A key issue relates to ‘representativeness’. If the generated weights are to be applied to all specialised services, it needs to be determined whether the services which have been modelled as representative of the services which have not been modelled (that is, those services for which no patient level data exists). Given that the nature of services varies between these two groups, this is especially important.

7.1.7 Representative

The data currently available on ‘other specialised services (those services not covered by patient level data) is such that it is not possible to determine how representative the identified services are of the ‘other specialised services spend. It is, however, possible to examine the probable degree of specialised services identified at a CCG level (subject to the degree of incomplete data on specialised services generally). The data shows a wide variation in the degree of identification at CCG level.

7.1.8 Drivers

There are a number of drivers which may contribute to this variability and which were examined, but identification and attribution of these various effects is not straightforward. Furthermore, it is possible that part of this variability may be driven by quality issues with the available data on ‘other specialised services’ spend at CCG level.

7.1.9 Application

Overall it is not possible to empirically assess whether the PBRA specialised services weights generated can be applied to all specialised services, or just those specialised services their estimation is based on. This is one of the considerations that must be accounted for when making a policy judgement about whether and how the PBRA specialised services weights could be used in setting target specialised services allocations.

7.1.10 Forecast error

Another key issue relates to forecast error. While the average forecast error is 8%, there are CCGs where the error is significantly higher. In practice, this means that there could be CCGs which could be significantly over or under-funded. A longer-term work programme on specialised services could work to improve model fit and reduce forecast error. In the interim, the application of these results carries the risk of the current level of forecast error. This is particularly pertinent in the context of multi-year allocations and when further changes in identification rules are due to take place.

8 Quality Assurance

This section describes the quality assurance (QA) that has been conducted on the specialised services econometric modelling workstream. At a high level QA has been conducted on an ongoing internal basis (culminating in a formal QA exercise) and also on an ongoing external basis as part of engagement with external advisory committees ACRA and TAG.

8.1 Internal review

Throughout the specialised services modelling process, regular checks have been conducted to examine the accuracy of the modelling work being undertaken. This included discussions and internal review among specialised services team members as well as with the core services team. Internal review included, but was not limited to, cross-checking of code by different team members, sense-checking the descriptives, and review of the estimation results. The internal review also included benchmarking against external measures such as the notional target allocations for core services and the data provided by the Specialised Commissioning Finance Team within NHS England. Key areas of review (discussed below) were the identification of specialised services and a formal review of the econometric modelling.

8.1.1 Specialised Services Identification

Specialised services were identified by applying the 2014-15 PSS Tool on the raw SUS PbR extracts for inpatient episodes and outpatient attendances, using the data provided by the HSCIC. In order to check whether the correct episodes were identified as specialised, comparisons were made to the same results generated by the Specialised Commissioning Team using the Temporary National Repository (tNR) dataset.

The comparison was conducted across different dimensions to gauge the similarity in the characteristics of the two specialised services datasets. These dimensions included the distribution of activity across specialised service category, age group, CCG, and sex. This comparison against the tNR indicated that both specialised service datasets identify very similar data. While recognising that some differences in the identification of specialised services will arise, this process provided assurance that no material errors were made in the identification of specialised activity using the 2013-14 PSS tool[27].

8.1.2 Formal review of econometric modelling

A formal review of the econometric modelling conducted for the specialised services modelling was undertaken by a senior colleague who was independent of the day to day team working on specialised services. This review covered both the code and methodology used in the analysis.

[27] Note that the scope of these checks did not include checking the veracity of the identification rules inherent in the PSS tool itself.

8.1.3 Coding errors

With respect to coding, this review did not find any coding errors or incorrect uses of built in commands. With respect to the methodology used, recommendations were made regarding the application of a mixed-effects model to capture random effects across CCGs, as well as Hurdle and Tobit models to account for the non-linear distribution of costs. Hurdle and Tobit models had been tested by the specialised services team, however, the performance of the Tobit model did not exceed that of the original ordinary least squares specification. The application of Hurdle models is noted for future development of the work on specialised services modelling. This was not adopted within this modelling workstream given the recommendation of ACRA (see below) that a parsimonious approach should be adopted where possible.

8.2 External review

8.2.1 External engagement

External engagement has been conducted with numerous stakeholders on an ongoing basis throughout this work programme. This external engagement included recommendations from the ACRA, the TAG and the Allocations Steering Group (ASG) as well as further stakeholder engagement with key specialised service personnel at NHS England and Commissioning Support Units.

8.2.2 Recommendations

Recommendations from these groups and stakeholders included making comparisons to the tNR dataset to check the identification of specialised services; using appropriate responses to the limited data available for some specialised services; making comparisons to existing allocation weights to triangulate the new specialised services weights; using a more parsimonious approach to modelling relative need for specialised care; and adopting as similar an approach to core services as possible. These recommendations have been adopted by the specialised services modelling team.

8.2.3 Expert consultation

An external academic subject matter expert has been consulted to provide recommendations for the econometric modelling aspect of this workstream. His recommendations included non-linear econometric modelling of the relative need for specialised care. The suggested models included Hurdle and two-part models. Given the ACRA recommendation for a parsimonious approach and the time constraints on this workstream, these models have been noted for future development of the work on specialised services modelling.

9 Appendix

9.1 Summary statistics

This section provides additional summary statistics of the specialised services identified and suggest that:

- male utilisation of specialised services is slightly higher than female utilisation for inpatient services but not outpatient settings;
- about 42% of total inpatient spend identified relates to “Digestion, renal and hepatobiliary and circulatory system” NPoC and 25% refers to “Infection, cancer, immunity and haematology”; and
- relatively similar distributions of spend across the regions are found for core CCG and specialised services.

Figure 9.1: Inpatient and outpatient gender cost splits for PSS identified specialised services and total services

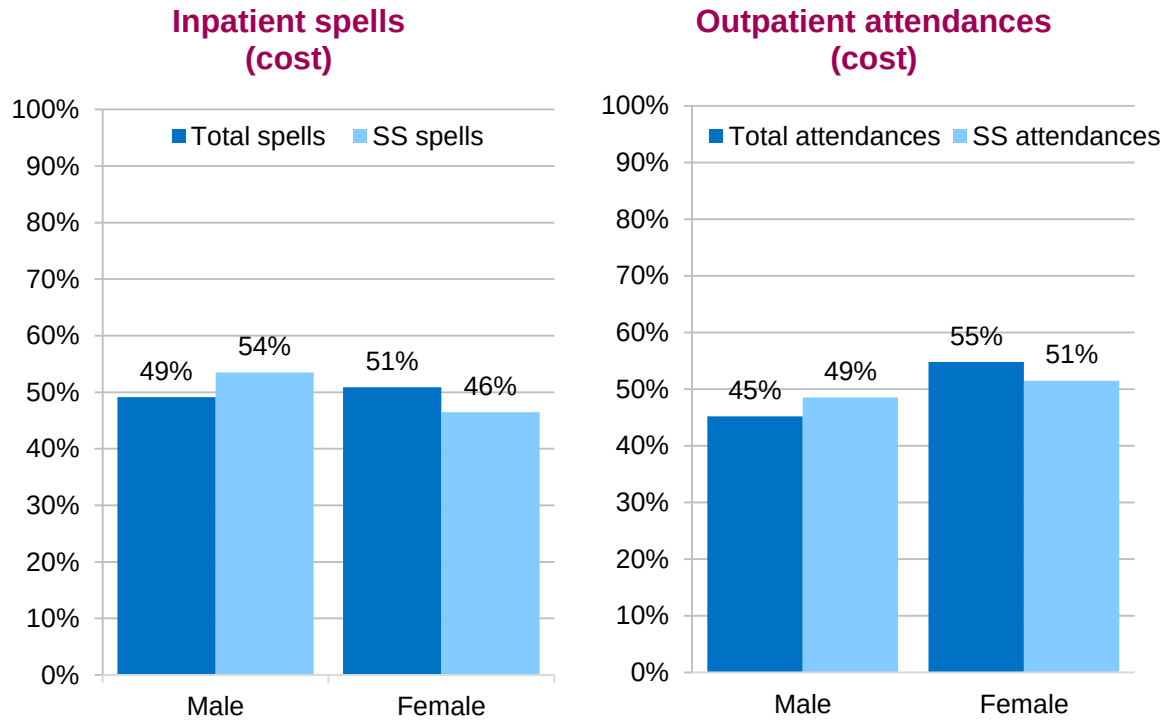


Figure 9.2: Cost distribution by National Programme of Care for PSS-identified specialised services

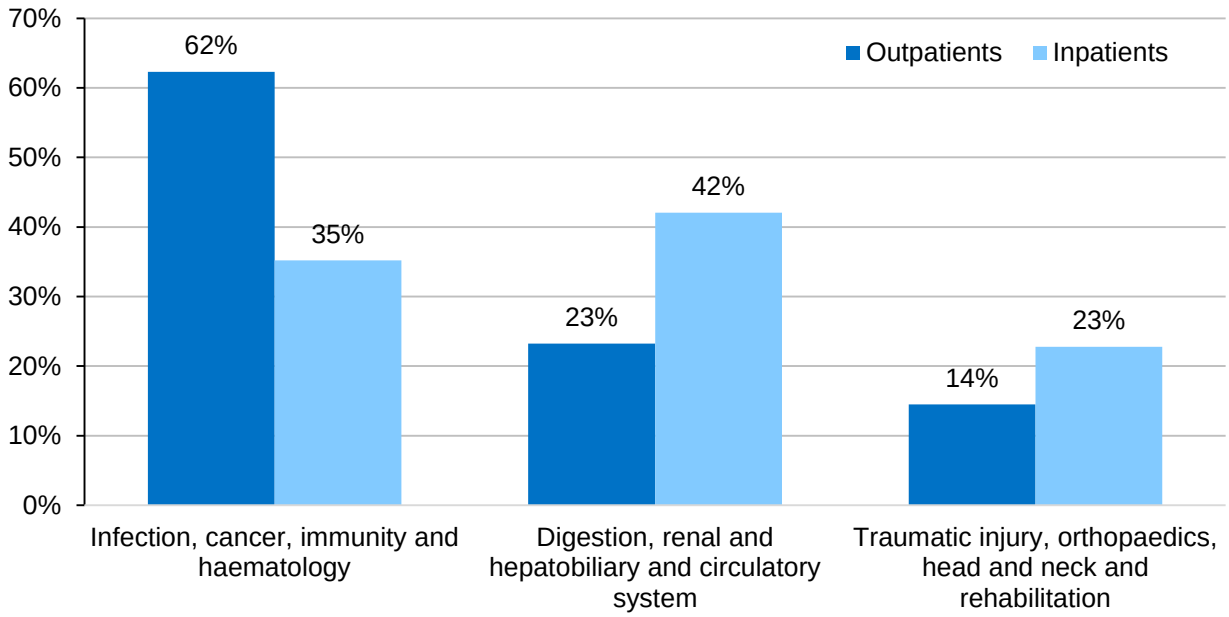
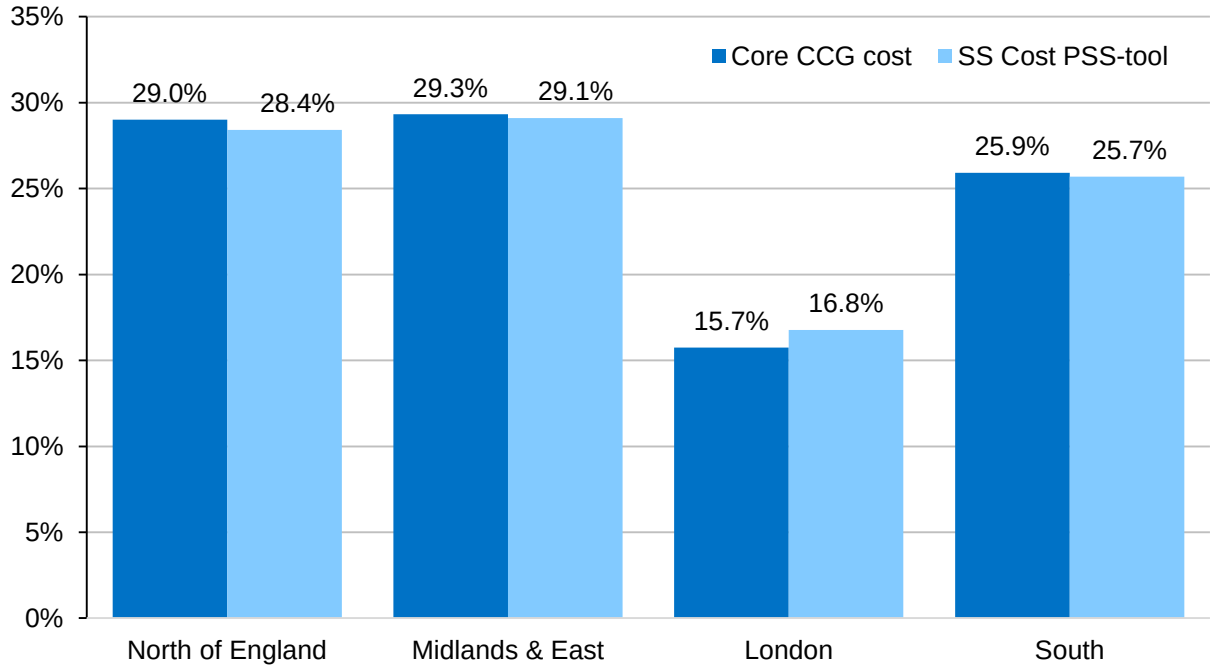


Figure 9.3: Proportion of spend for core services and PSS identified specialised services by region[28]



[28] Spend shares for core CCG costs are based on the SUS PBR data and the spend shares for specialised services are based on services identified using SUS PbR data and the PSS tool.

9.2 Persistence of specialised services utilisation

This section investigates two issues have been explored: 1) the degree of 'persistence' in the utilisation of specialised services over time; 2) variation in the proportion of specialised services used to total services used at a CCG level.

9.2.1 Persistence

If there is a degree of persistence in the use of specialised services (for instance, patients that have a specialised treatment in 2012 are likely to have a treatment in 2013) then specialised services utilisation is more amenable to prediction on the basis of past utilisation. Figure 9.4 below shows the proportion of patients receiving a specialised services in each of the three years 2011, 2012 and 2013 (the first three bars) in inpatient and outpatient settings. It also shows how many patients received a specialised service treatment in combinations of two or more years (the remaining four bars). Overall the figure indicates some persistence in the utilisation of specialised services, especially for outpatient appointments.[29] This is consistent with the econometric modelling results (presented in section 3), which indicate that past specialised services utilisation has some forecasting power.

9.2.2 CCG variability

Another way of examining the characteristics of specialised services utilisation over time is to look at CCG level variability in the proportion of specialised services episodes to total episodes. This is shown in Figure 9.5 covering the period 2011-12 to 2013-14. The figure is ordered with those CCGs demonstrating the largest changes being toward the left axis. The largest variations for CCGs range between around 4% to 8%.[30] The majority of CCGs have a variation of less than 2%. This shows that the relativity of specialised services episodes to total episodes is relatively stable across most CCGs for the services covered by the patient level data. Annex A lists the CCGs in this figure.

[29] The degree of persistence varies by type of treatment. For instance, renal dialysis is expected to be highly persistent.

[30] The CCGs in the group with the largest variation are all near each other and have key specialist providers like the JR in Oxford within reach. The wider variation in this group may therefore be driven by a local anomaly in this area.

Figure 9.4: Patient-level persistence in the utilisation of specialised services over the period 2011 – 2013

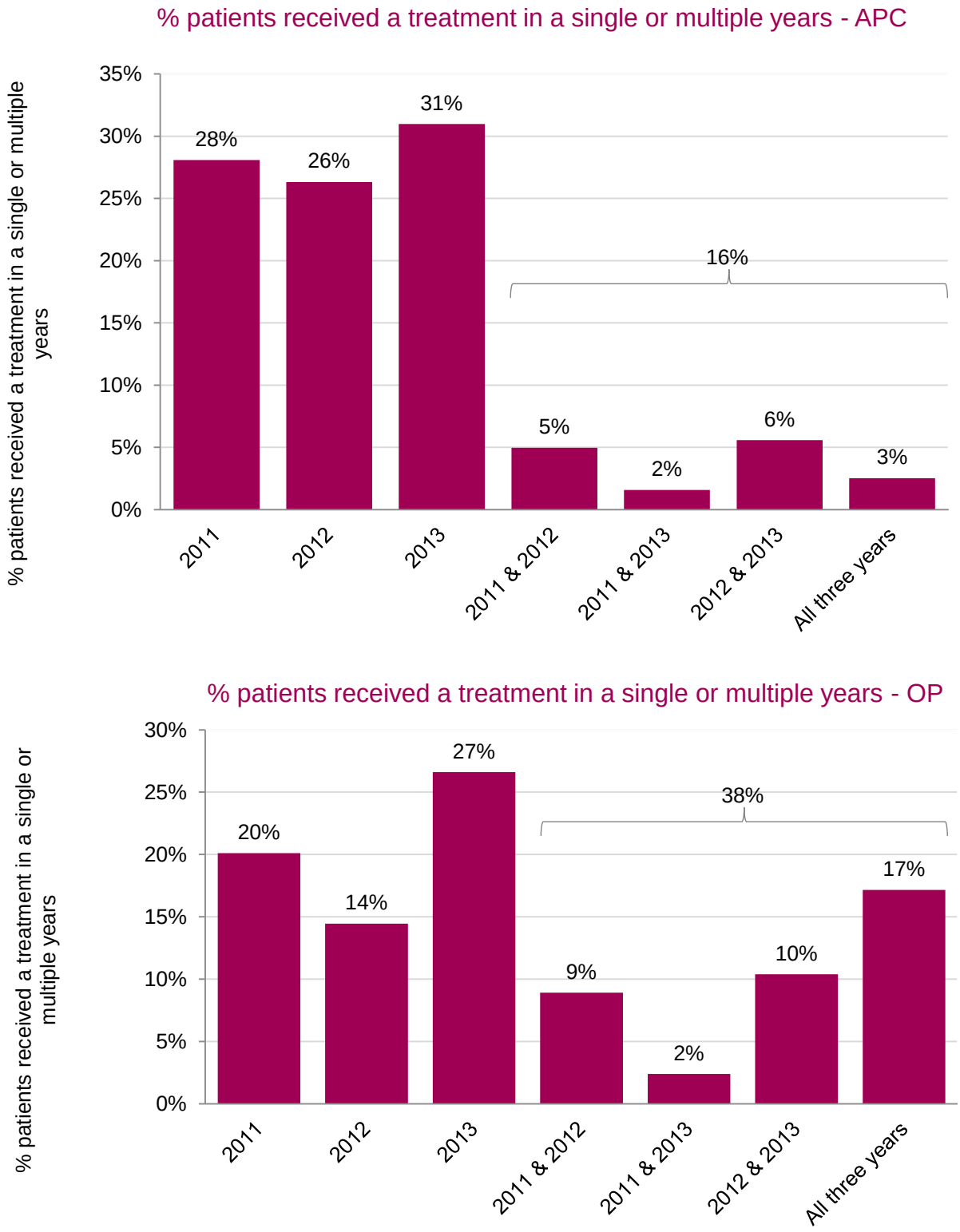
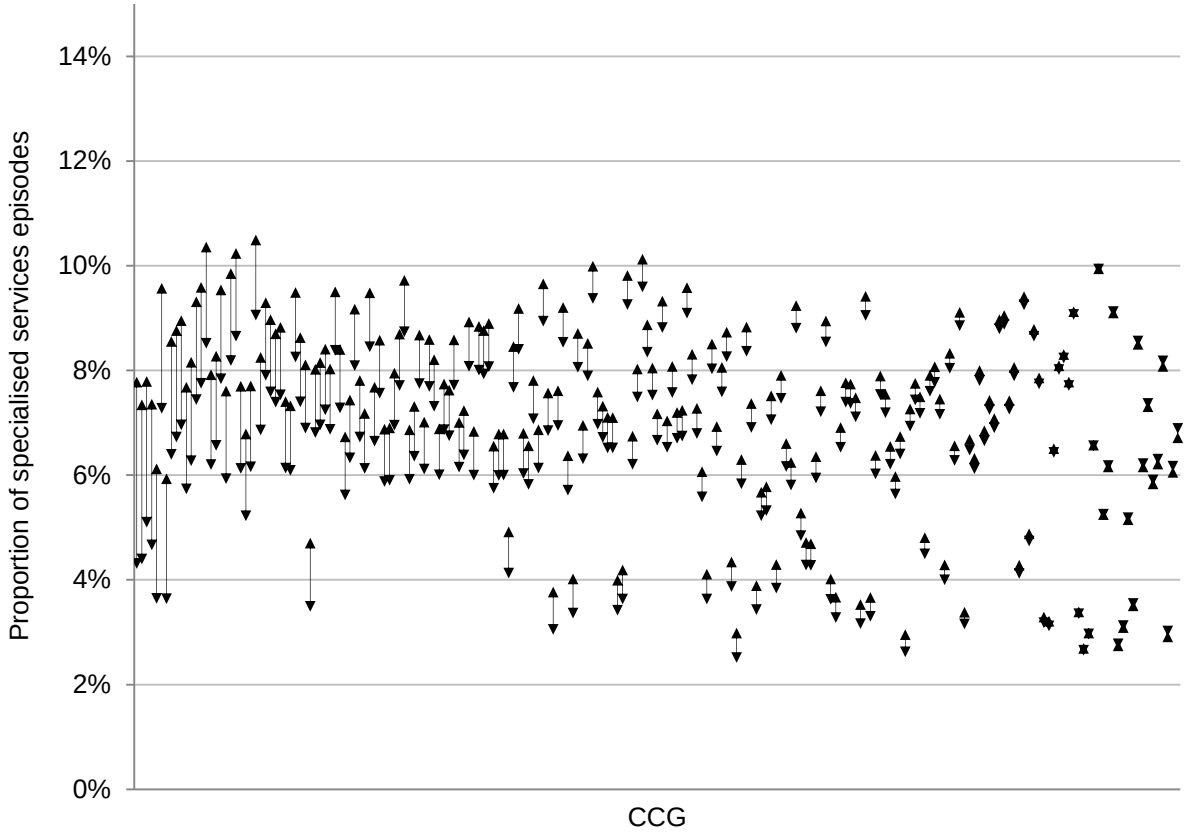


Figure 9.5: CCG variability in the proportion of specialised services episodes (out of total episodes) between 2011-12 and 2013-14 for APC[31]



9.3 Patient cost distribution

Table 9.1: Patient-level cost distribution shows the distribution of specialised services cost by patient alongside the core services distribution.

Table 9.1: Patient-level cost distribution

Percentile	Specialised Services	Core services
1%	£92	£29
5%	£92	£58
10%	£93	£78
25%	£184	£121
50%	£400	£316
Mean	£2,816	£1,200
75%	£2,326	£988
90%	£8,100	£2,915
95%	£14,697	£5,261
99%	£29,222	£13,166

[31] A detailed list of the CCGs variability in APC specialised services episodes is provided in the annex.

9.4 Target allocation weights against utilisation

Figure 9.6: 2013-14 specialised services CCG cost share against Target allocation weights using PSS identified data

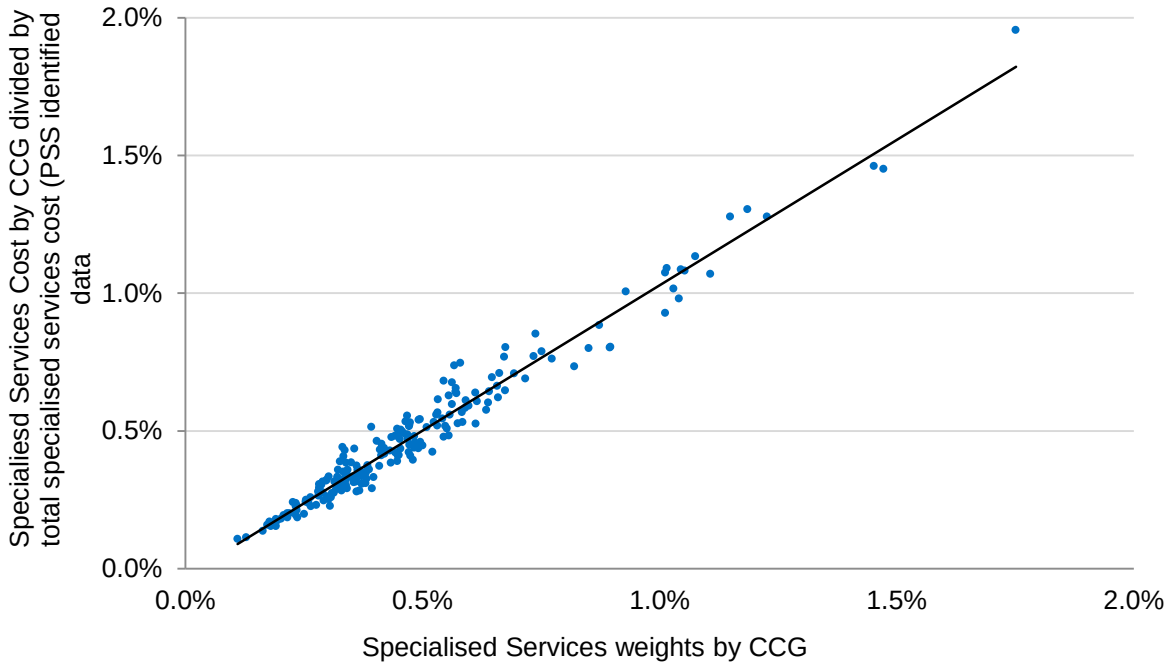
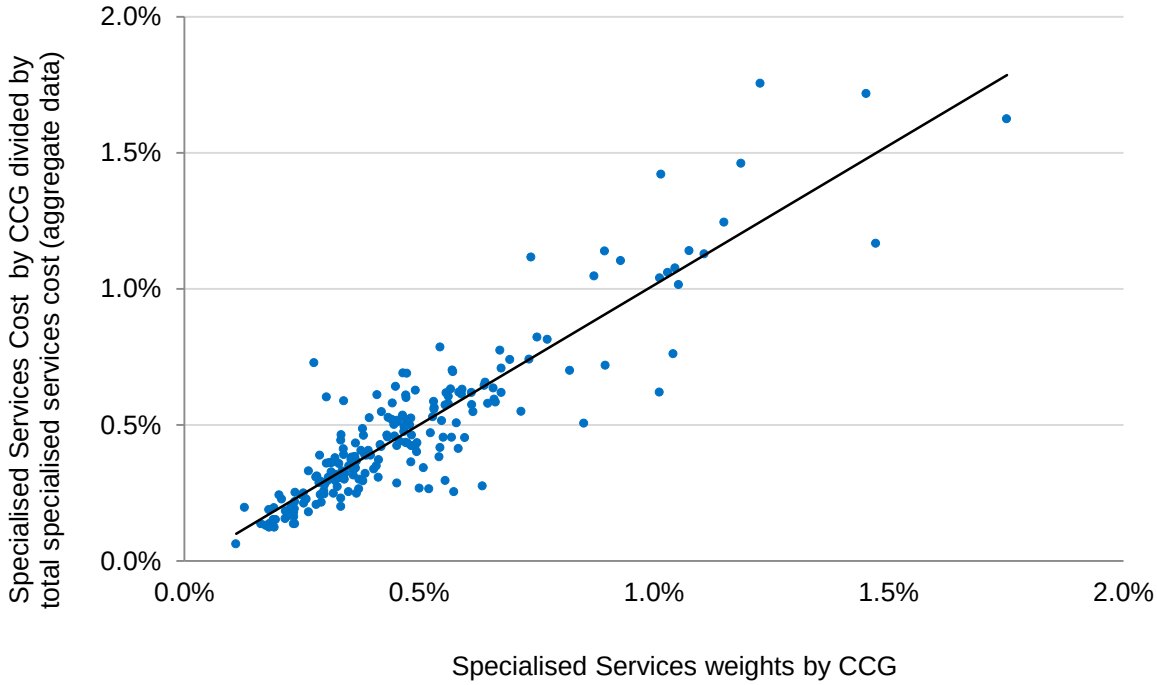


Figure 9.7: 2013-14 specialised services CCG cost share against Target allocation weights using total specialised services spend data



9.5 Model results

Table 9.2: Model coefficients (T-Stat selection non-stratified)

Variable (type)	Coefficient
Age-sex	
males 1 to 4	-4.33
males 5 to 9	-0.46
males 10 to 14	3.21
males 15 to 19	12.27***
males 20 to 24	9.67***
males 25 to 29	10.29***
males 30 to 34	10.56***
males 35 to 39	13.8***
males 40 to 44	19.19***
males 45 to 49	32.07***
males 50 to 54	51.75***
males 55 to 59	76.4***
males 60 to 64	103.01***
males 65 to 69	133.58***
males 70 to 74	161.17***
males 75 to 79	157.63***
males 80 to 84	107.27***
males 85 and over	25.44***
females <1	-2.27
females 1 to 4	-2.41
females 5 to 9	0.73
females 10 to 14	11.23***
females 15 to 19	9.64***
females 20 to 24	7.33**
females 25 to 29	6.54*
females 30 to 34	10.21***
females 35 to 39	18.87***
females 40 to 44	26.19***
females 45 to 49	39.48***
females 50 to 54	52.19***
females 55 to 59	56.04***
females 60 to 64	68.54***
females 65 to 69	84.53***
females 70 to 74	90.96***
females 75 to 79	75.86***
females 80 to 84	31.84***
females 85 and over	-11.97**
Core morbidity flag	
A00-A09 Intestinal infectious diseases	-14.26
A15-A19 Tuberculosis	-105.01
A20-A49 Certain bacterial diseases	62.14
A50-A64 Infections with predominantly sexual mode of transmission	478.89
A65-A79 Other infectious and parasitic disorders	-21.4
A80-A89 Viral infections of the central nervous system	-117.3*
A90-A99 Arthropod-borne viral fevers & viral haemorrhagic fevers	497.26
B00-B09 Viral infections characterized by skin & mucous membrane lesions	-72.57*
B15-B19 Viral hepatitis	30.89
B20-B24 Human immunodeficiency virus [HIV] disease	0
B25-B34 Other viral diseases	-49.14***
B35-B49 Mycoses	11.78
B50-B64 Protozoal diseases	-119.69
B65-B83 Helminthiases	20.33

Variable (type)	Coefficient
B85-B99 Other infectious and parasitic diseases	-118.33
C00-C14 Malignant neoplasm of lip oral cavity and pharynx	81.11
C15-C26 Malignant neoplasm of digestive organs	846.86***
C30-C39 Malignant neoplasms of respiratory & intrathoracic organs	446.7***
C40-C41 Malignant neoplasm of bone and articular cartilage	1143.11**
C43-C44 Malignant neoplasms of skin	-8.25
C45-C49 Malignant neoplasms of mesothelial and soft tissue	1815.43***
C50 Malignant neoplasm of breast	725.79***
C51-C58 Malignant neoplasms of female genital organs	819.39***
C60-C63 Malignant neoplasms of male genital organs	154.29***
C64-C68 Malignant neoplasms of urinary tract	-615.35***
C69-C72 Malignant neoplasms of eye, brain & other parts of CNS	248.39
C73-C80, C97 Malignant neoplasm of thyroid and other endocrine glands etc.	11.87
C81-C96 Malignant neoplasms of lymphoid, haematopoietic & related tissue	606.42***
D00-D48 In situ & benign neoplasms and others of uncertainty	18.8
D50-D64 Anaemias	27.13
D65-D89 Diseases of the blood and blood-forming organs	745.59***
E00-E07 Disorders of thyroid gland	-27.41**
E10-E14 Diabetes Mellitus	11.88
E15-E90 Endocrine nutritional and metabolic diseases	19.85*
F00-F03 Dementia	-145.32***
F04-F09 Other organic including symptomatic mental disorders	-94.96***
F10-F19 Mental and behavioural disorders due to psychoactive subst.	-7.85
F20-F29 Schizophrenia, schizotypal and delusional disorders	-14.06
F30-F39 Mood [affective] disorders	-15.03
F40-F69 Neurotic, behavioural & personality disorders	-37.02***
F70-F79 Mental retardation	-39.39
F80-F99 Other mental and behavioural disorders	0.25
G00-G09 Inflammatory diseases of the central nervous system	-46.77
G10-G13, G30-G32 Other degenerative diseases (incl. Alzheimer).	-19.98
G20-G26 Extrapyramidal & movement disorders (incl. Parkinsonism).	-96.51***
G35-G37 Demyelinating diseases (including Multiple Sclerosis) of the CNS.	6.75
G40-G47 Epilepsy migraine & other episodic disorders	-2.1
G50-G73 G90-G99 Other diseases & disorders of the nervous syst.	50.81***
G80-G83 Cerebral palsy & other paralytic syndromes	28.75
H00-H06, H15-H22, H30-H36, H43-H59 Other disorders of the eye etc.	-8.98
H10-H13 Disorders of conjunctiva (including conjunctivitis)	-51.28
H25-H28 Disorders of lens (including cataracts)	-26.34**
H40-H42 Glaucoma	-31.89*
H60-H95 Diseases of the ear and mastoid process	-39.19***
I00-I09 Rheumatic heart disease	221.64***
I10-I15 Hypertensive diseases	-12.28
I20-I25 Ischaemic heart diseases	73.76***
I26-I28 Pulmonary heart disease & diseases of pulmonary circulation	15.55
I30-I52 Other forms of heart disease	70.54***
I60-I69 Cerebrovascular diseases	-69.32***
I70-I79 Diseases of arteries, arterioles & capillaries	138.84***
I80-I89 Diseases of veins & lymphatic system not elsewhere classified.	-31.1***
I95-I99 Other & unspecified disorders of the circulatory system	-50*
J00-J06 Acute upper respiratory infections	-31.78***
J10-J18 Influenza & pneumonia	-30.78*
J20-J22 Other acute lower respiratory infections	1.16
J30-J39 Other diseases of upper respiratory tract	-14.6
J40-J47 Chronic lower respiratory diseases	-21.08***
J60-J70 Lung diseases due to external agents	10.05
J80-J99 Other diseases of the respiratory system	87.37***
K00-K14 Diseases of oral cavity, salivary glands & jaws	-20.8**

Variable (type)	Coefficient
K20-K31 Diseases of oesophagus stomach & duodenum	-1.29
K35-K38 Diseases of appendix	-37.24***
K40-K46 Hernia	-41.02***
K50-K52 Non infective enteritis & colitis	-43.2***
K55-K63 Other diseases of intestines	-14.22*
K65-K67 Diseases of peritoneum	3.37
K70-K77 Diseases of liver	114.47***
K80-K87 Disorders of gall bladder, biliary tract & pancreas	-25.34*
K90-K93 Other diseases of the digestive system	-29.89**
L00-L14 L55-L99 Other infections and disorders of the skin	-13.52
L20-L30 Dermatitis and eczema	-7.46
L40-L45 Papulosquamous disorders (including Psoriasis)	22.72
L50-L54 Urticaria and erythems	26.25
M00-M25 Arthropathies	-46.55***
M30-M36 Systemic connective tissue disorders	-13.53
M40-M54 Dorsopathies	6.35
M60-M79 Soft tissue disorders	-26.59***
M80-M94 Osteopathies and chondropathies	-14.99
M95-M99 Other disorders of the musculoskeletal system & connective tissue	-25.45
N00-N08, N10-N16 Diseases of the kidney	76.24***
N17-N19 Renal failure	95.57***
N20-N23 Urolithiasis	-38.47*
N25-N29 Other disorders of kidney & ureter	127.64***
N30-N39 Other diseases of the urinary system	-38.72***
N40-N51 Diseases of male genital organs	-27.65**
N60-N64 Disorders of breast	-44.04
N70-N77 Inflammatory diseases of female pelvic organs	-35.98**
N80-N98 Non-inflammatory disorders of female genital tract	-32.92***
N99 Other disorders of the genitourinary system	-93.8*
O00-O08 Pregnancy with abortive outcome	-28.5***
O10-O75, O85-O92, O95-O99 Complications of labour and delivery	-27.86***
O80-O84 Delivery	-26.24***
P00-P04 Complications of foetus/neonate affected by maternal	-132.05
P05-P96 Other conditions originating in the perinatal period	-53.33
Q00-Q89 Congenital malformations	118.53***
Q90-Q99 Chromosomal abnormalities not elsewhere classified	3.35
R00-R09 Symptoms & signs inv. the circulatory/respiratory system	0.24
R10-R19 Symptoms & signs inv. the digestive system & abdomen	-12.89*
R20-R23 Symptoms & signs inv. the skin & subcutaneous tissue	23.56
R25-R29 Symptoms & signs inv. the nervous & musculoskeletal sys.	-46.01***
R30-R39 Symptoms & signs involving the urinary system	-30.08**
R40-R46 Symptoms & signs inv. Cognition, perception etc.	-50.51***
R47-R49 Symptoms & signs inv. speech & voice	-43.79
R50-R68 General symptoms & signs	10.41
R69 Unknown & unspecified causes of morbidity	-96.67
R70-R89 Abnormal findings of bodily fluids or samples without diag.	20.91
R90-R94 Abnormal findings on diagnostic imaging/function studies	64.92**
R95-R99 Ill-defined & unknown causes of mortality	1566.53
S00-S09 Injuries to the head	-11.32
S10-S19 Injuries to the neck	2.11
S20-S29 Injuries to the thorax	32.33
S30-S39 Injuries to abdomen, lower back, lumbar spine & pelvis	-42.43**
S40-S49 Injuries to the shoulder & upper arm	-6.66
S50-S59 Injuries to the elbow & forearm	0.91
S60-S69 Injuries to the wrist & hand	-19.88*
S70-S79 Injuries to the hip & thigh	-38.09**
S80-S89 Injuries to the knee & lower leg	-28.33**

Variable (type)	Coefficient
S90-S99 Injuries to the ankle & foot	-40.12*
T00-T07 Injuries involving multiple body regions	14.41
T08-T14 Injuries to unspecified part of trunk limb or body	70.95
T15-T19 Effects of foreign body entering through natural orifice	25.25
T20-T32 Burns and corrosions	-8.1
T33-T35 Frostbite	-36.25
T36-T50 Poisonings by drugs medicaments & biological substances	10.58
T51-T65 Toxic effects of substances. chiefly non-medicinal as to source	-30.97
T66-T78 Other and unspecified effects of external causes	-51.96*
T79 Certain early complications of trauma	-24.31
T80-T88 Complications of surgical & medical care not elsewhere classified	50.49**
T90-T98 Sequelae of injuries of poisoning & other consequences	-28.09
VVV	-48.97***
WWW	-55.03***
XXX	-30.87*
YYY	-26.65*
Z00-Z13 Examination and investigation	-39.14***
Z20-Z29 Potential health hazards related to communicable diseases	-5.26
Z30-Z39 Health services in circumstances related to reproduction	-36.26***
Z40-Z54 Persons encountering health services for specific care	82.62***
Z55-Z65 Potential health hazards related to socioeconomic & psychosocial	-40.14*
Z70-Z76 Persons encountering health services in other circs.	-16.41
Z80-Z99 Persons with potential health hazards related to family	-8.68
U Unclassified	-55.22
CCG dummy	
00D NHS Durham Dales, Easington and Sedgefield CCG	0.18
00F NHS Gateshead CCG	1.07
00G NHS Newcastle North and East CCG	11.22
00H NHS Newcastle West CCG	0.73
00J NHS North Durham CCG	5.05
00K NHS Hartlepool and Stockton-on-Tees CCG	-5.54
00L NHS Northumberland CCG	-0.29
00M NHS South Tees CCG	3.11
00N NHS South Tyneside CCG	8.66
00P NHS Sunderland CCG	14.1
00Q NHS Blackburn with Darwen CCG	-10.29
00R NHS Blackpool CCG	-5.69
00T NHS Bolton CCG	-14.06
00V NHS Bury CCG	-12.43
00W NHS Central Manchester CCG	-10.07
00X NHS Chorley and South Ribble CCG	4.62
00Y NHS Oldham CCG	-12.78
01A NHS East Lancashire CCG	-1.69
01C NHS Eastern Cheshire CCG	-8.79
01D NHS Heywood, Middleton and Rochdale CCG	-9.17
01E NHS Greater Preston CCG	1.29
01F NHS Halton CCG	-10.03
01G NHS Salford CCG	-8.24
01H NHS Cumbria CCG	-0.18
01J NHS Knowsley CCG	-13.86
01K NHS Lancashire North CCG	9.48
01M NHS North Manchester CCG	-6.05
01N NHS South Manchester CCG	-2.11
01R NHS South Cheshire CCG	-0.02
01T NHS South Sefton CCG	-9.04
01V NHS Southport and Formby CCG	-7.66
01W NHS Stockport CCG	-7.44

Variable (type)	Coefficient
01X NHS St Helens CCG	-14
01Y NHS Tameside and Glossop CCG	-0.31
02A NHS Trafford CCG	4.7
02D NHS Vale Royal CCG	-19.54
02E NHS Warrington CCG	-15.06
02F NHS West Cheshire CCG	-5.17
02G NHS West Lancashire CCG	-14.41
02H NHS Wigan Borough CCG	-13.09
02M NHS Fylde and Wyre CCG	-12.49
02N NHS Airedale, Wharfedale and Craven CCG	-8.56
02P NHS Barnsley CCG	-7.86
02Q NHS Bassetlaw CCG	-14.84
02R NHS Bradford Districts CCG	-6.01
02T NHS Calderdale CCG	-9.77
02V NHS Leeds North CCG	9.28
02W NHS Bradford City CCG	-18.46*
02X NHS Doncaster CCG	0.2
02Y NHS East Riding of Yorkshire CCG	10.76
03A NHS Greater Huddersfield CCG	8.19
03C NHS Leeds West CCG	7.82
03D NHS Hambleton, Richmondshire and Whitby CCG	2.84
03E NHS Harrogate and Rural District CCG	6.34
03F NHS Hull CCG	2.16
03G NHS Leeds South and East CCG	-4.32
03H NHS North East Lincolnshire CCG	3.29
03J NHS North Kirklees CCG	9.29
03K NHS North Lincolnshire CCG	9.84
03L NHS Rotherham CCG	-2.03
03M NHS Scarborough and Ryedale CCG	5.63
03N NHS Sheffield CCG	3.15
03Q NHS Vale of York CCG	11.85
03R NHS Wakefield CCG	1.06
03T NHS Lincolnshire East CCG	-12.03
03V NHS Corby CCG	0.35
03W NHS East Leicestershire and Rutland CCG	-13.69
03X NHS Erewash CCG	-2.42
03Y NHS Hardwick CCG	-18.2
04C NHS Leicester City CCG	-9.82
04D NHS Lincolnshire West CCG	-0.14
04E NHS Mansfield and Ashfield CCG	-12.9
04F NHS Milton Keynes CCG	4.15
04G NHS Nene CCG	-4.16
04H NHS Newark and Sherwood CCG	-20.99*
04J NHS North Derbyshire CCG	-11.2
04K NHS Nottingham City CCG	0.25
04L NHS Nottingham North and East CCG	-2.77
04M NHS Nottingham West CCG	-9.82
04N NHS Rushcliffe CCG	-11.07
04Q NHS South West Lincolnshire CCG	-6.41
04R NHS Southern Derbyshire CCG	-3.73
04V NHS West Leicestershire CCG	-3.11
04X NHS Birmingham South and Central CCG	7.14
04Y NHS Cannock Chase CCG	-1.44
05A NHS Coventry and Rugby CCG	-5.06
05C NHS Dudley CCG	-7.31
05D NHS East Staffordshire CCG	2.92
05F NHS Herefordshire CCG	-1.7

Variable (type)	Coefficient
05G NHS North Staffordshire CCG	14.23
05H NHS Warwickshire North CCG	3.23
05J NHS Redditch and Bromsgrove CCG	-12.71
05L NHS Sandwell and West Birmingham CCG	-2.56
05N NHS Shropshire CCG	-4.08
05P NHS Solihull CCG	11.94
05Q NHS South East Staffs and Seisdon Peninsular CCG	10.05
05R NHS South Warwickshire CCG	2.86
05T NHS South Worcestershire CCG	-6.32
05V NHS Stafford and Surrounds CCG	11.33
05W NHS Stoke On Trent CCG	6.29
05X NHS Telford and Wrekin CCG	5.27
05Y NHS Walsall CCG	-1.47
06A NHS Wolverhampton CCG	8.87
06D NHS Wyre Forest CCG	-8.96
06F NHS Bedfordshire CCG	1.7
06H NHS Cambridgeshire and Peterborough CCG	5.99
06K NHS East and North Hertfordshire CCG	3.32
06L NHS Ipswich and East Suffolk CCG	3.79
06M NHS Great Yarmouth and Waveney CCG	-10.95
06N NHS Herts Valleys CCG	-1.58
06P NHS Luton CCG	5.31
06Q NHS Mid Essex CCG	0.1
06T NHS North East Essex CCG	-8.2
06V NHS North Norfolk CCG	-5.03
06W NHS Norwich CCG	0.55
06Y NHS South Norfolk CCG	-13.97
07G NHS Thurrock CCG	-11.08
07H NHS West Essex CCG	-0.74
07J NHS West Norfolk CCG	-9.92
07K NHS West Suffolk CCG	10.8
07L NHS Barking and Dagenham CCG	3.59
07M NHS Barnet CCG	2.6
07N NHS Bexley CCG	-0.11
07P NHS Brent CCG	6.43
07Q NHS Bromley CCG	1.72
07R NHS Camden CCG	11.51
07T NHS City and Hackney CCG	9.89
07V NHS Croydon CCG	6.94
07W NHS Ealing CCG	14.24
07X NHS Enfield CCG	5.44
07Y NHS Hounslow CCG	14.31
08A NHS Greenwich CCG	8.27
08C NHS Hammersmith and Fulham CCG	7.64
08D NHS Haringey CCG	10.56
08E NHS Harrow CCG	2.1
08F NHS Havering CCG	3.74
08G NHS Hillingdon CCG	3.42
08H NHS Islington CCG	4.24
08J NHS Kingston CCG	10.71
08K NHS Lambeth CCG	7.09
08L NHS Lewisham CCG	11.87
08M NHS Newham CCG	-0.84
08N NHS Redbridge CCG	-6.68
08P NHS Richmond CCG	21.58
08Q NHS Southwark CCG	2.71
08R NHS Merton CCG	20.74*

Variable (type)	Coefficient
08T NHS Sutton CCG	1.78
08V NHS Tower Hamlets CCG	0.37
08W NHS Waltham Forest CCG	-1.02
08X NHS Wandsworth CCG	11.78
08Y NHS West London (Kensington and Chelsea, Queen's Park and Paddington) CCG	6.27
09A NHS Central London (Westminster) CCG	9.37
09C NHS Ashford CCG	3.11
09D NHS Brighton and Hove CCG	-12.41
09E NHS Canterbury and Coastal CCG	9.42
09F NHS Eastbourne, Hailsham and Seaford CCG	-9.42
09G NHS Coastal West Sussex CCG	-8.24
09H NHS Crawley CCG	-13.71
09J NHS Dartford, Gravesham and Swanley CCG	5.85
09L NHS East Surrey CCG	-2.22
09N NHS Guildford and Waverley CCG	-10.22
09P NHS Hastings and Rother CCG	-16.48
09W NHS Medway CCG	-7.58
09X NHS Horsham and Mid Sussex CCG	-16.39
09Y NHS North West Surrey CCG	3.2
10A NHS South Kent Coast CCG	6.71
10C NHS Surrey Heath CCG	-1.59
10D NHS Swale CCG	-10.77
10E NHS Thanet CCG	-2.71
10G NHS Bracknell and Ascot CCG	-6.39
10H NHS Chiltern CCG	-4.62
10J NHS North Hampshire CCG	-6.65
10K NHS Fareham and Gosport CCG	-2.94
10L NHS Isle of Wight CCG	-16.97
10M NHS Newbury and District CCG	-7.6
10N NHS North and West Reading CCG	-1.83
10Q NHS Oxfordshire CCG	0.89
10R NHS Portsmouth CCG	-6.06
10T NHS Slough CCG	-7.23
10V NHS South Eastern Hampshire CCG	-9.05
10W NHS South Reading CCG	1.32
10X NHS Southampton CCG	-1.27
10Y NHS Aylesbury Vale CCG	1.89
11A NHS West Hampshire CCG	-1.48
11C NHS Windsor, Ascot and Maidenhead CCG	2.29
11D NHS Wokingham CCG	-10.73
11E NHS Bath and North East Somerset CCG	1.46
11H NHS Bristol CCG	8.69
11J NHS Dorset CCG	-1.68
11M NHS Gloucestershire CCG	1.97
11N NHS Kernow CCG	4.64
11T NHS North Somerset CCG	0.54
11X NHS Somerset CCG	8.58
12A NHS South Gloucestershire CCG	5.82
12D NHS Swindon CCG	2.71
12F NHS Wirral CCG	-7.57
13P NHS Birmingham CrossCity CCG	-0.92
99A NHS Liverpool CCG	-8.75
99C NHS North Tyneside CCG	-3.18
99D NHS South Lincolnshire CCG	-23.15*
99E NHS Basildon and Brentwood CCG	-9.73
99F NHS Castle Point and Rochford CCG	-20.8*
99G NHS Southend CCG	-16.17

Variable (type)	Coefficient
99H NHS Surrey Downs CCG	26.02*
99J NHS West Kent CCG	-7.84
99K NHS High Weald Lewes Havens CCG	-15.53
99M NHS North East Hampshire and Farnham CCG	-10.89
99N NHS Wiltshire CCG	-10.37
99P NHS North, East, West Devon CCG	5.49
99Q NHS South Devon and Torbay CCG	8.53
Attributed need	
Dummy for if the patient has changed practice	5.08***
Dummy if the patient utilised private health care	0
Core morbidity count 6	
No morbidities	-55.46***
1 morbidity	-27.22***
3 morbidities	27.93***
4 morbidities	47.25***
5 morbidities	63.74***
6 morbidities and over	92.72***
Core co-morbidity interactions	
"Certain infectious and parasitic diseases" - "Diseases of the nervous system"	26.38
"Certain infectious and parasitic diseases" - "Diseases of the eye and adnexa"	38.31
"Certain infectious and parasitic diseases" - "Pregnancy, childbirth and the puerperium"	32.47
"Certain infectious and parasitic diseases" - "Congenital malformations, deformations and chromosomal abnormalities"	5.23
"Certain infectious and parasitic diseases" - "Factors influencing health status and contact with health services"	17.71
"Neoplasms" - "Diseases of the eye and adnexa"	-114.97***
"Neoplasms" - "Diseases of the skin and subcutaneous tissue"	-36.88
"Neoplasms" - "Diseases of the genitourinary system"	-145.1***
"Neoplasms" - "Certain conditions originating in the perinatal period"	-201.07*
"Neoplasms" - "Factors influencing health status and contact with health services"	46.01**
"Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism" - "Diseases of the digestive system"	-97.6***
"Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism" - "Pregnancy, childbirth and the puerperium"	-69.64
"Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism" - "Factors influencing health status and contact with health services"	110.71***
"Endocrine, nutritional and metabolic diseases" - "Diseases of the nervous system"	20.52
"Endocrine, nutritional and metabolic diseases" - "Diseases of the eye and adnexa"	24.28
"Endocrine, nutritional and metabolic diseases" - "Diseases of the circulatory system"	-10.87
"Endocrine, nutritional and metabolic diseases" - "Diseases of the skin and subcutaneous tissue"	11.01
"Endocrine, nutritional and metabolic diseases" - "Pregnancy, childbirth and the puerperium"	-30.82***
"Endocrine, nutritional and metabolic diseases" - "Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified"	-8.43
"Mental and behavioural disorders" - "Diseases of the circulatory system"	37.19***
"Mental and behavioural disorders" - "Pregnancy, childbirth and the puerperium"	-12.14*
"Mental and behavioural disorders" - "Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified"	4.93
"Diseases of the eye and adnexa" - "Diseases of the skin and subcutaneous tissue"	79.1*
"Diseases of the circulatory system" - "Diseases of the digestive system"	2.09
"Diseases of the circulatory system" - "Diseases of the skin and subcutaneous tissue"	-35.98
"Diseases of the respiratory system" - "Pregnancy, childbirth and the puerperium"	12.65
"Diseases of the digestive system" - "Congenital malformations, deformations and chromosomal abnormalities"	-9.2
"Diseases of the skin and subcutaneous tissue" - "Diseases of the musculoskeletal	16.09

Variable (type)	Coefficient
system and connective tissue"	
"Diseases of the skin and subcutaneous tissue" - "Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified"	19.56
"Diseases of the musculoskeletal system and connective tissue" - "Diseases of the genitourinary system"	23.34
"Diseases of the musculoskeletal system and connective tissue" - "Pregnancy, childbirth and the puerperium"	-5.41
"Diseases of the genitourinary system" - "Congenital malformations, deformations and chromosomal abnormalities"	77.51*
"Diseases of the genitourinary system" - "Injury, poisoning and certain other consequences of external causes"	39.61*
"Diseases of the genitourinary system" - "Factors influencing health status and contact with health services"	-4.33
"Pregnancy, childbirth and the puerperium" - "Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified"	-7.22
"Pregnancy, childbirth and the puerperium" - "Factors influencing health status and contact with health services"	-0.81
"External causes of morbidity and mortality" - "Factors influencing health status and contact with health services"	0.26
Specialised morbidity count	
Chemotherapy	457.82***
Stereotactic Radiosurgery	-391.62*
Teenage and Young Adults Cancer	215.02**
Rare Cancers (Adult)	31.76***
BMT	353.57***
Spinal - Spinal Surgery	2820.22***
Neurosciences - Neurology	685.99***
Neurosciences - Neurophysiology	210.94**
Neurosciences - Neuroradiology	-131.07***
Neurosciences - Neurosurgery	402.08***
Renal Services - Access for dialysis	1125.53***
Renal Services - Renal Transplantation	276.69**
Cardiac - Cardiac electrophysiology	-0.12
Cardiac - Inherited heart disorders	460.43*
Cardiac - Cardiac surgery	-111.92**
Cardiac - PPCI and Structural Heart Disease (Complex Invasive Cardiology)	49.19
Cardiac - Cardiovascular magnetic resonance	386.07
Cardiac - Other	494.1***
Adult Congenital Heart Disease	555.49***
Cardiac - Specialised Cardiology and Cardiac Surgery	178.51***
Immunology	1211.03***
Allergy	107.24***
Hepatology & Pancreatic	133.29***
Endocrinology Services	83.47***
Hyperbaric Oxygen Treatment	0
Respiratory - Pulmonary vascular services	-127.33*
Respiratory - Complex thoracic surgery	337.55*
Respiratory - Management of central airway obstruction	1418.89**
Respiratory - Interstitial lung disease	822.12**
Respiratory - Other	387.62***
Thoracic Surgery	202.07
Vascular Services	104.41***
Morbid Obesity Surgery	-14.01
Ophthalmology	60.41**
Haemoglobinopathy - Sickle Cell	1019.54***
Haemoglobinopathy - Thalassaemia	891.1***

Variable (type)	Coefficient
Specialised morbidity interactions	
Comorbidity "Digestion, renal and hepatobiliary and circulatory system" and "Infection, cancer, immunity and haematology"	287.75**
Comorbidity "Digestion, renal and hepatobiliary and circulatory system" and "Secure and specialised mental health"	-272.56**
Comorbidity "Infection, cancer, immunity and haematology" and "Secure and specialised mental health"	654.71***
Attributed need	
Log population variance between ONS and PDS	-5.2
Dummy for if the patient has changed practice	0
Dummy if the patient utilised private health care	27.65
All usual residents aged 16 and over with no qualifications (unstandardised)	0.27***
Average with (long-term) medical condition for those with at least one	5.57**
Constant term	
Constant	38.6***
Significance stars: *p<0.05, **p<0.01 and ***p<0.001	