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How Much Should Be Paid For Prescribed Specialised Services?

Chris Bojke, Katja Grašič, Andrew Street

CHE Research Paper 118

How much should be paid for Prescribed Specialised Services?

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October 2015

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Acknowledgements

This project was funded by Monitor. Particular thanks are due to Silvio Daidone, Jake Gommon, Leo Li, Paula Monteith, Pedro Oliveira, Bela Prasad, Eileen Robertson, Ceri Townley, Andrew Wade, and members of the Payment for Specialised and Complex Care Working Group. The views expressed are those of the authors. The Hospital Episode Statistics are copyright © 2011/12 - 2013/14, re-used with the permission of The Health & Social Care Information Centre. All rights reserved.

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Executive summary

Overview

Current policy in the English National Health Service (NHS) promotes concentration of the specialised treatment of relatively rare and complex conditions into a limited number of specialist centres. However if a more complex patient case-mix leads to specialised treatments being systematically more costly than non-specialised treatment, then the national tariff payment system based on Healthcare Resource Groups (HRGs) may punitively penalise centres that perform this activity.

Data and methods

We apply the Prescribed Specialised Services (PSS) definitions of specialised care, both for the original 13/14 tool and the 14/15 shadow monitoring tool (PSS-SMT), to patient-level data from the Hospital Episode Statistics mapped to reference cost data for three financial years, from 2011/12 to 2013/14. We use ordinary least squares (OLS) and random effects (RE) models to ascertain the cost differential associated with receipt of specialised care for patients allocated to the same HRG.

We analyse costs for each individual patient to determine whether the receipt of specialised care is associated with higher costs relative to patients allocated to the same HRG who did not receive specialised care.

We specify six analytical models:

- Model 1: cost analysis of the full sample, with the dependent variable defined as the full set of costs, including excess bed day and unbundled costs.
- Model 2: cost analysis of a reduced sample, where patients allocated to fully specialised and fully non-specialised HRGs are dropped, as their costs are reflected in the base tariffs.
- Model 3: core HRG cost analysis of the reduced sample, with the dependent variable capturing only the core HRG cost, not excess bed day and unbundled costs, as these are reimbursed separately.
- Model 4: as model 3, but with PSS eligibility criteria also used to identify whether a patient has received specialised care.
- Model 5: Excess bed day cost model: analysis of variation in excess bed costs, only for those patients that stay beyond their HRG tripoint.
- Model 6: analysis of LoS of the full sample, as a sensitivity analysis given concerns about Reference Cost not being truly patient-level costs.

We calculate the total additional costs associated with each specialised service at national level and examine the extent to which specialised services are concentrated within or spread across hospitals and HRGs.

Results

Out of 16,964,893 patients treated in English hospitals in 2013/14, 10.5% were identified as having received specialised care under PSS rules and 11.8% under PSS-SMT rules. Estimated cost differentials are generally stable over years and across different models. For 2013/14 data:

- For 29 of the 69 PSS markers, we find cost differentials in excess of 10% when analysing the cost of the core HRG to which patients are allocated (Model 3 RE).
- Only 24 of these 29 PSS markers have cost differentials in excess of 10% when the updated PSS-SMT rules are applied.

- We find that 6 of the 35 new PSS-SMT markers have cost differentials in excess of 10%.
- We observe fewer cost differentials when considering excess bed day costs (Model 5 RE), the differential being in excess of 10% for only 9 PSS markers.

The additional costs associated with the provision of specialised care to the entire patient population are estimated to amount to £572m in 2011/12, £628m in 2012/13 and £589m in 2013/14.

Conclusions

For those markers for which the estimated cost differential is deemed to have a material impact, we suggest two ways in which payment policy might be refined.

First, in cases where patients are distributed across many HRGs, top-up payments might be made to reflect the additional costs associated with receipt of specialised care. We identify 20 of the original PSS markers as candidates for top-ups, including several cardiac and children's services. The following new PSS-SMT markers implemented in the PSS Shadow Monitoring Tool are also candidates for top-up arrangements: Sarcoma, Head and Neck cancer – Sarcoma; Upper GI Surgery; Specialised Urology - Penile cancer; Specialised Urology - Testicular cancer; Spinal cord injury; and Paediatric Surgery - Trauma and Orthopaedics.

Second, HRGs might be re-defined, so that they better separate higher cost patients that receive specialised care from those that do not. PSS markers identified as candidates for HRG split include Radiotherapy, Cardiac - PPCI and Structural Heart Disease Ears - Cochlear Implants; and Colorectal - Transanal Endoscopic Microsurgery. The four PSS markers that might subject to a sub-division of their HRGs are recommended for top-up payments in the interim before this sub-division is implemented.

For some specialised services there is a case for re-visiting the identification rules, notably Neurosciences – Neurosurgery.

1. Introduction

There is evidence that outcomes following treatment are superior in places that perform more of the treatment in question (Bachmann et al., 2003, Hillner et al., 2000, Skipworth et al., 2010, Smith, 2002). Although a general causal link between the volume of activity and outcomes has not been established definitively (Harrison, 2012), in England there is a move toward concentrating the provision of some types of service in specialist centres rather than having them delivered in general hospitals (NHS England, 2014a). For instance, from 2011 onwards stroke patients in London have been admitted into one out of 8 hyperacute stroke units, providing more specialised care to stroke patients, which led to improved overall outcomes (Morris et al., 2014). Concentration is particularly important for specialised services, which invariably, and often by definition, are provided to people with relatively rare conditions. Delivery of such services requires a skilled team of staff and concentrating services in dedicated units is deemed the only way to ensure that volumes are sufficient to ensure best possible outcomes (NHS Specialised Services, 2010).

Concentration of services in this way means that specialised providers will treat patients that differ systematically from those treated in general hospitals, differences that may impact on the cost of treatment. If the reimbursement system does not account for such differences, hospitals that treat more costly patients will be financially disadvantaged, at the risk of undermining the policy toward greater concentration. In many countries, hospitals are reimbursed according to the amount and type of activity that they perform, with the type of activity described using some form of Diagnosis-Related Groups (DRGs) (Busse et al., 2013), the English version being known as Healthcare Resource Groups (HRGs). Grašič et al describe how HRGs are constructed (Grašič et al., 2015).

HRGs are intended to be both clinically meaningful and resource homogenous. Resource homogeneity implies that all patients allocated to the same HRG have the same expected resource requirement, with any variation in actual costs from the expected level being entirely random. This provides the rationale for reimbursing hospitals using HRGs (O'Reilly et al., 2012) under a prospective payment system, formerly termed Payment by Results (PbR) but now called the National Tariff Payment System. The tariffs reflect average costs, reported by all hospitals as part of the annual Reference Cost (RC) data collection.

This payment arrangement works well if variation in costs within HRGs is, indeed, entirely random across patients and hospitals. But if there is systematic variation in costs associated with particular groups of patients, problems arise: the payment system may either deter hospitals from treating these patients or punitively penalize hospitals that do so. The policy of concentrating specialised services in particular providers may give rise to or accentuate such problems.

To overcome these problems, it is necessary to ascertain by how much costs are higher for patients that receive specialised care than for other patients allocated to the same HRG. This requires defining what is meant by specialised care and a means of determining whether individual patients have received such care. Having done this, it is then possible to compare the costs of hospital treatment of those in the same HRG payment category who received specialised care with those that did not. If there is evidence of a cost differential, there is a case for refining the payment system in some way so that these differences do not impact negatively on the care that patients receive or the payments made to hospitals that provide specialised services.

There are two broad policy options. The first, and easiest to implement, is to introduce a top-up payment that it is paid to a hospital for each of its patients that has received the particular type of specialised care. The size of these top-up payments would reflect the estimated cost differential.

The second option, which would take longer to implement, is to refine the underlying HRGs to which patients are allocated. This option is most appropriate when patients that receive the particular type of specialised care in question are concentrated in a small number of HRGs. To assess this, we calculate concentration ratios to show the concentration of specialised activity among HRGs (Siegfried, 1975).

In England it is possible to identify whether a patient received specialised care and, if so, what type of care was received. In section 2 we describe identification rules known as Prescribed Specialised Services (PSS). We apply these rules to patient-level data for each of the financial years 2011/12, 2012/13 and 2013/14, allowing us to identify the type of specialised care provided to each patient, if any. We then analyse cost differentials associated with receipt of specialised care, using patient-level data described in section 3. In section 4 we outline our empirical strategy to investigate the extent to which variations in the cost of hospital treatment are explained by whether or not a patient received a specialised service and for our analyses of the concentrations of specialised care among hospitals and HRGs. Section 5 focuses on the results, derived from six analytical models. Section 6 considers the overall financial impact of paying for Prescribed Specialised Services, the concentration of specialised activity among hospitals and HRGs, and how payment arrangements might be refined for specific PSS markers. The policy implications of the results are discussed, limitations acknowledged and conclusions drawn in section 6.

2. Data

In order to assess the costs associated with hospitalized patients receiving specialised services, we analyse data from the patient level Hospital Episode Statistics (HES) matched to Reference Cost (RC) data reported by all English hospitals for each of the three financial years 2011/12, 2012/13 and 2013/14. The HES contains details about every patient treated in the English National Health Service (NHS) during the financial year. There are various issues regarding the data that need to be addressed:

- Cleaning the HES data.
- How to determine whether or not a patient received specialised care.
- How to assign costs to each patient record, defined as a Finished Consultant Episode (FCE) in the Hospital Episode Statistics.
- How to determine the cost of a provider spell for those patients who have multiple FCEs.

2.1 Cleaning the HES data

Each observation in HES comprises a Finished Consultant Episode (FCE), measuring the time the patient spends under the care of a particular consultant. From the initial sample of HES records, our analytical sample is reduced to episodes after cleaning.

- Patients with duration errors (with missing or implausible start and end dates) are dropped.
- Duplicate records are removed.
- We consider only those patients treated in NHS acute hospitals. Hence, patients treated in mental health, ambulance and primary care trusts (with the exception of the Isle of Wight) are excluded.

Details of the number of observations before and after cleaning are shown in Table 1.

Table 1 Raw and cleaned from Hospital Episodes Statistics

	2011/12	2012/13	2013/14
	FCEs	FCEs	FCEs
Raw HES	18,889,329	19,112,187	19,578,568
Duration errors, duplicates and coding problems	134,948	55,139	30,230
Cleaned HES	18,754,381	19,057,048	19,548,338

2.2 Identifying whether a patient received specialised care

In England, specialised services are generally defined as:

those services provided in relatively few hospitals, to catchment populations of more than one million people. The number of patients accessing these services is small, and a critical mass of patients is needed in each treatment centre in order to achieve the best outcomes and maintain the clinical competence of NHS staff. These services tend to be located in specialist hospital Trusts in major towns and cities. Concentrating services in this way ensures that specialist staff can be more easily recruited and their training maintained. It is also more cost-

effective and makes the best use of resources such as high tech equipment and staff expertise (NHS England, 2014b).

This general definition is now operationalised through the set of identification rules known as the PSS, which replaced the Specialised Services National Definition Sets (SSNDS) which we have described elsewhere (Bojke et al., 2014). The replacement was driven by changes in commissioning responsibilities brought about by the Health and Social Care Act 2012 which meant that some specialised services would be commissioned nationally, and others locally. The Act transferred responsibility for commissioning specialised services from Primary Care Trusts (PCTs) to the newly established NHS Commissioning Board, since renamed NHS England. As part of the transfer of responsibility, the opportunity was taken to review the rules used to determine what constituted specialised care, leading to the new set of identification rules being drawn up by which to determine what should constitute Prescribed Specialised Services (NHS England, 2014b).

In addition to the above general definition of specialised services, four additional factors were explicitly set out for determining whether services should be directly commissioned by NHS England instead of by the Clinical Commissioning Groups (CCGs) that replaced PCTs as commissioners of health services for geographically defined populations:

1. The number of individuals who require the service or facility.
2. The cost of providing the service or facility.
3. The number of organisations able to provide the service or facility.
4. The financial implications for CCGs if they were required to arrange for the provision of the service or facility.

These changes were argued to result in “a much clearer description of the services which would be appropriate ... to commission” (NHS Information Centre for health and social care, 2010). The PSS manual and accompanying spreadsheet published in 2014 set out identification rules for 143 groups of specialised services, of which 69 relate to services for patients admitted to hospital (NHS England, 2014b). There were a further 20 services identified, but not included in the PSS identification toolkit (e.g. Tier 4 CAMHS Inpatients). The Prescribed Specialised Services 2013-14 Identification Tool is available online^a. The rules and ICD10 and OPCS codes are described in a spreadsheet that is also publicly available^b.

In May 2015 the National Casemix Office (NCO) published an update to the Prescribed Specialised Services Identification tool – the 2015/16 Shadow Monitoring tool (PSS-SMT). The PSS-SMT is intended for commissioning use in 2016/17.

The PSS-SMT represents a fairly substantial revision of the original PSS identification rules, there being two main types of revision:

- (i) changes to the codes used to identify whether a patient has received specialised care and
- (ii) changes to the eligibility criteria used to determine whether a hospital should be providing a particular type of specialised care.

Specialised services are labelled as a combination of one of the six National Programmes of Care (NPoC) clinical reference groups (CRG) and a unique code/flag with an associated descriptive

^a <http://www.hscic.gov.uk/casemix/prescribedspecialisedservices>

^b http://www.hscic.gov.uk/media/11878/PS-201314-Identification-Code-Sets/xls/PS_2013_14_Prescribed_Services_Identification_Code_Sets_v1.1.xlsx.

Prescribed Service Line text. Each NPoC CRG features a three digit code followed by a general description e.g. D06 – Burns. The first letter indicates which of the six functional categories the CRG belongs to, in this example D refers to trauma. There are 75 CRGs in total, not all of which are represented in the PSS or SMT-PSS. Full details of the NPoC CRGs are available at <http://www.england.nhs.uk/commissioning/spec-services/npc-crg/>

Individual specialised services sit within a 2-level hierarchy with all services nested in one of the NPoC CRGs. Thus a CRG does not necessarily identify a specific specialised service, but any specialised service can only belong to one NPoC CRG. However, the Prescribed Service Line (PSL) text and associated code/flag does uniquely identify a specialised service. The code/flag is an 8 digit alphanumeric text string which begins with 'NCBPS', with the remaining 3 digits uniquely identifying a service. For example the following code/flags and PSL text all belong to the D09 – Ear Surgery NPoC CRG: NCBPS32A Ears- Cochlear implants; NCBPS32B Ears – Bone anchored hearing aids and NCBPS32D Ears – Middle ear implants.

The exception to the above coding classification is the Highly Specialised service (NCBPS99Z) which has its own eponymous NPoC category that is not part of the standard six NPoC categories.

The PSS-SMT changes can be summarised as follows:

1. 31 PSS markers are unchanged, the original PSS identification rules remaining the same under PSS-SMT.
2. Three PSS markers have been dropped completely under PSS-SMT, namely 04C fetal medicine, 04E specialised maternity and 13K Cardiac Surgery – other.
3. 35 new PSS-SMT markers have been added, the following of which are of note:
 - a. 4 belonged to the set of 20 admitted patient care services that were identified but not implemented in the original PSS (e.g. Tier 4 CAMHS Inpatients).
 - b. 14 of the new PSS-SMT markers are a refinement of cancer services, most of which involve further disaggregation of the original PSS 01Y rare cancer definition.
 - c. Specialised dermatology is now included with 4 new service lines.
 - d. Mental health categories are expanded from 1 service line to 6.
4. The identification rules for 35 PSS markers have been revised
 - a. The most extensive changes are to PSS marker 01T Teenage and Young cancer, with an additional 325 diagnosis codes originally omitted from the rules and the identification of 108 eligible providers.
 - b. At the other extreme, the PSS-SMT adds just 1 additional procedure code for 13F PPCI and Structural Heart Disease.

We have applied the identification rules embodied in the PSS 2013-14 Identification Tool to the HES data for each of the financial years and the PSS-SMT to 2013/14 data. This allows us to identify the specific type of specialised care, if any, received by each patient in the data.

2.3 Mapping of reference costs to HES records

We match each patient's HES record to the RC reported by their hospital in order to establish the cost of the core HRG to which they are allocated. Matching is done through a combination of hospital code, point of delivery (PoD) (e.g. day case, elective, non-elective), speciality (e.g. 300: General Surgery) and HRG code (e.g. EB07H: Arrhythmia or Conduction Disorders, with CC).

All Reference Costs are adjusted by the market forces factor (MFF), this being an index of geographical variation in the prices of land, buildings, and labour, designed to account for unavoidable differences in factor prices incurred by different hospitals.

Some HES records are dropped from the analysis because RC information is unavailable. These are:

- (i) NHS patients treated at private providers because private providers do not report costs.
- (ii) Patients without the requisite information or coding errors in their HES record to determine HRG allocation. These are assigned to the undefined HRG code 'UZ01Z', and for whom no payment is made.
- (iii) Patients allocated to HRGs that have a zero cost attached to them, in accordance with the Reference Cost requirements.^c Hospitals are paid for these activities either via local arrangements or through other HRGs (e.g. payment is made for the maternity care provided to the mother (eg NZ11B) but there is no separate payment made for delivery of a healthy baby (PB03Z)).

Details of the number of FCEs dropped for each of these reasons are shown in Table 2, together with information about the proportion of these that are identified as having received specialised care.

Hospitals are paid extra for patients with length of stay beyond the HRG specific trimpoint; we add the hospital's HRG-specific excess per diem cost for each additional day. For 4.1% of FCEs length of stay exceeds their HRG trimpoint.

While all FCEs have a core HRG, around 1.9m FCEs have 'unbundled' HRGs associated with them, these being high cost services or procedures counted separately for reporting and payment purposes. Unbundling "helps to make HRGs 'setting independent' so that healthcare can be provided and funded across a variety of settings".^d For 73% of these 1.9m FCEs we can attach a cost to each of the constituent unbundled HRGs. For the remainder, no additional costs are added to the core HRG costs because no costs are reported for their 'unbundled' activity.

Table 2 Summary of original and analytical samples

	2011/12		2012/13		2013/14		
	N Spells	% PSS	N Spells	% PSS	N Spells	% PSS	% PSS-SMT
Cleaned HES	16,599,033	9.71	16,592,681	9.97	16,964,893	10.53	11.76
Private providers	346,362	1.15	357,164	1.12	360,712	1.14	1.11
UZ01Z	193,288	7.19	150,342	2.44	151,809	2.05	2.50
Zero Cost HRGs	2,069,316	32.92	2,023,553	37.78	1,635,554	50.53	78.61
Analytical sample	12,286,246	6.21	12,544,761	6.45	12,474,184	6.36	6.20
Those with Excess Bed Days	724,771	11.73	654,916	9.07	625,769	10.62	9.68
Those with Unbundled Costs	2,488,289	40.98	2,710,035	40.44	2,699,727	43.40	44.01

Note: patients that receive multiple types of specialised service are counted only once in the counts of FCEs

2.4 Assessing the cost of provider spells

To be able to determine the number of individuals that received specialised care we need to convert the FCEs that comprise the unit of observation in the HES data into "provider spells". Around 90% of

^c Zero cost HRGs include: DZ13* and PA13* - (both Cystic Fibrosis with the star indicating that there are HRG splits), LA08E (dialysis), PB03Z (Healthy Baby), SB97Z (Same Day Chemotherapy), SC97Z (Radiotherapy).

^d <http://www.hscic.gov.uk/hrg4/>

patients remain under the care of a single consultant during their entire hospital stay. The remainder are cared for by more than one consultant, most usually because they are transferred from one specialty to another. We track the consultant episodes pertaining to each individual patient, allowing us to construct a provider spell for each patient, measuring the time from admission to discharge.

Multi-episode spells are likely to be more costly than single-episode spells, but there is no agreed method for determining the additional cost. In our previous work (ADD REF) we found that estimation results were not sensitive to whether the cost of multi-episode spells was based on the Sum, Maximum or First of the costs of the constituent FCEs. Consequently, in the analysis that follows, the cost of a provider spell is calculated as the Sum of the cost of each FCE comprising the patient's spell in hospital.

The patient's core HRG is defined as that which proves most costly among the alternatives to which the patient is assigned across the constituent FCEs. After re-structuring the HES data so that it comprises observations defined as patient spells, we have an analytical sample of 12,286,246 observations, 6.21% of which received specialised care in 2011/12. In 2012/13 we have 12,544,761 spells, 6.45% of which are specialised and in 2013/14 we have 12,474,184 spells, 6.64% of which are specialised with 6.35% specialised under the shadow tool specifications.

2.5 Changes to the HRG classification system

Our analyses are designed to assess whether patients who received specialised care have different costs to other patients allocated to the same HRG. Observed cost differentials may vary from one year to the next, partly because over the three years there have also been changes to the HRG classification system used to describe and pay for patients admitted to hospital.

The HRG system is subject to continual development to accommodate changes in clinical practice and to further improve the classification of patients (Grašič et al., 2015). The HRG system used in 2011/12, HRG4, comprised approximately 1600 different HRG groups in 21 chapters. In 2012/13 HRG4 was replaced by a new system, HRG4+, developed to better differentiate high cost patients. HRG4+ is radically different to HRG4, expanding the number of groups by approximately 25% to 2100 HRGs, only around 600 of which are common to both HRG4 and HRG4+.

HRG4+ is argued to provide better recognition of the resources used in treating sicker patients, those that undergo multiple complex procedures and a more sophisticated treatment of age (Monteith, 2013). The most significant change to the HRG structure was the level to which complications and comorbidities (CC) were incorporated: HRG4 tended to adopt a binary approach with a basic category with or without CC, whereas HRG4+ introduces a hierarchical system of graded CCs and HRG categories determined on the underlying condition/procedure and the summed value of the additional CCs. This allows for greater differentiation between patients with additional needs and in some cases may explicitly capture those comorbidities which define a treatment as specialised.

Figure 1 shows the number of HRGs according to the proportion of patients identified as having received specialised care, as defined under the original PSS identification rules and also, for 2013/14, by the PSS-SMT. There has been an increase in HRGs over time, from 1600 in 2011/12 to 2100 in 2013/14. Although the number of HRGs in which all patients received specialised care (100%) has increased slightly over time, including a relatively large jump from 2011/12 (when HRG4 was last in use), the vast majority of HRGs contain a mixture of patients who did and did not receive specialised care.

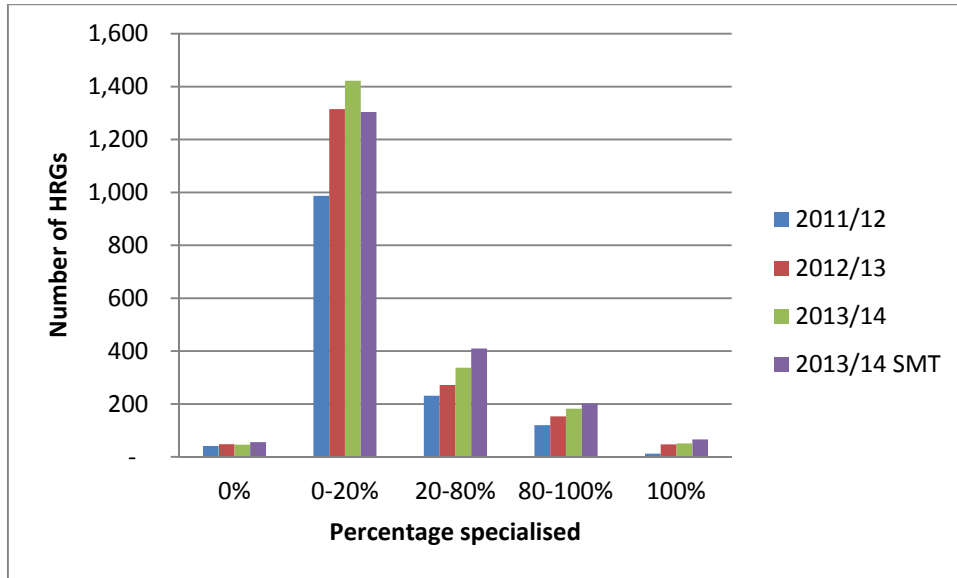


Figure 1 HRGs by the proportion of patients receiving specialised care

3. Estimation models

3.1 Dependent variables

We construct four dependent variables for our analyses, all of which are specified as ratios. There are two reasons for defining the dependent variable as a ratio:

1. We avoid having to include a set of more than 1600 (or 2100) dummy variables in the regression equation to represent each HRG4 (or HRG4+). Including so many variables would make estimation unwieldy, to say the least.
2. With some manipulation, we can calculate the percentage difference associated with receipt of specialised care.

The first dependent variable is defined as the patient's standardised cost $y_{ik} = c_{ihk} / \hat{c}_h$ where c_{ihk} is the MFF-adjusted cost of patient i in HRG h in hospital k and \hat{c}_h is the national average cost of all patients allocated to HRG4 h . The cost for each patient includes that of their core HRG and any other to which they are assigned if they had multiple episodes, and includes unbundled costs and excess bed day costs if their length of stay (LoS) exceeded the trimpoint of their core HRG.

The second dependent variable is of a similar form, except that it captures only the cost of the patient's core HRGs, notated as c_{ihk}^* , with the patient's re-standardised cost now defined as $y_{ik}^* = c_{ihk}^* / \hat{c}_h^*$.

The third dependent variable captures only the cost of excess bed days, such that c_{ihk}^e , with the patient's re-standardised cost now defined as $y_{ik}^e = c_{ihk}^e / \hat{c}_h^e$.

The fourth dependent variable is constructed so as to analyse LoS rather than costs, with $y_{ik}^l = LoS_{ihk} / \widehat{LoS}_h$ where LoS_{ihk} is the length of stay of patient i in HRG h in hospital k and \widehat{LoS}_h is the

national average length of stay of all patients allocated to the patient's core HRG h .

3.2 Independent variables

If no account is taken of the possibility that costs may be partly related to the hospital in which care is provided, the additional costs associated with receipt of specialised care are estimated by regressing each patient's standardised cost against the PSS definition sets ($p=1\dots P$), which comprise the 69 specialised care markers (R) indicating the type of specialised care received (if any). So, for any individual i , $R_{pi} = 1$ if the patient received specialised care of type p , and 0 otherwise. Estimated using Ordinary Least Squares (OLS), the model takes the form:

$$y_i = \alpha + \sum_{p=1}^P \beta_p R_{pi} + \varepsilon_i \quad (\text{EQ1})$$

where β are the parameters to be estimated: if positive and significant, a patient with the specialist care marker has higher costs than do other patients allocated to the same HRG. ε_i captures random error.

This model fails to recognise that costs may be driven partly by the hospital in which the patient is treated. This can be examined by specifying a hierarchical model of the form:

$$y_{ik} = \alpha + \sum_{p=1}^P \beta_p R_{pik} + u_k + v_{ik} \quad (\text{EQ2})$$

This is a multi-level model that recognises that patients ($i=1\dots I$) are clustered within hospitals ($k=1\dots K$). u_k is the hospital random effect: patients treated in hospitals with higher effects have higher costs than those treated elsewhere. v_{ik} captures random measurement error.

In order to derive the percentage difference in costs associated with receipt of specialised care, g_p , we compute the marginal mean for both specialised and non-specialised services:

$$g_p = \frac{E(y_i|S_p=1,S) - E(y_i|S_p=0,S)}{E(y_i|S_p=0,S)} * 100 \quad (\text{EQ3})$$

In May 2015, PSS-SMT was released, refining and expanding the original set of PSS markers. Denoting the set of PSS-SMT markers as R' , these can be substituted for R in equations EQ1 and EQ2 when analysing the 2013/14 data.

3.3 Choice between OLS and RE models

Over and above the costs associated with receipt of specialised care, patients treated in the same hospital are likely to have similar costs to one another. This is because there will be hospital-specific factors that drive costs for all patients treated in the same hospital. This raises the question of whether and, if so, how these hospital-specific factors should be accounted for. The answer depends on what these factors are.

Analytically, there are two extreme positions that can be taken. The first is to ignore information about the hospital in which patients are treated and, in effect, consider all patients as “independent observations”, having no connection with one another. This is what the *Ordinary Least Squares* model does. This means that hospital-specific factors that might drive costs are not taken into account in the analysis.

The second approach recognises that some patients are connected to others by virtue of their being treated in the same hospital. This means that patients are not independent observations but are “clustered” within hospitals. By recognising that patients are clustered in this way it is possible to determine whether or not costs are partly related to where patients are treated. There are different ways of accounting for this clustering but with a sufficiently large dataset, as in this study, these yield equivalent results^e. We account for this clustering by estimating *Random Effects* models, with the random effect being the way to capture the effect of the particular hospital on the cost observed for each patient.

The choice between the OLS and RE models in the context of this work depends on:

- i. What explains “similar” costs among patients treated in the same hospital and
- ii. Whether and how these “similar” costs should be reimbursed.

If higher costs in a particular hospital are thought to be due solely to *inefficiency*, the RE model should be used to estimate the costs associated with specialised care. The RE model attributes this inefficiency to the hospital in which it occurs, with it being captured by the hospital’s random effect. This means that the estimates $\hat{\beta}$ of the cost of specialised care are not contaminated by the relative efficiency with which hospitals organise their services and provide care. In contrast, the OLS estimates of the costs of specialised care will be contaminated by variations in efficiency across hospitals.

^e The fixed effects and random effects estimates are identical to the fourth or fifth decimal point (policy requiring only up to the second).

But higher costs may not be due to inefficiency. Instead they could arise for reasons entirely outside the hospital's control. In other words, higher costs are driven entirely by *exogenous* factors. In this case, there are three scenarios.

First, it might be believed that higher costs are entirely due to exogenous factors, but it is not known exactly what the factors are or how to measure them. Consequently, it is not possible to allow for their influence in the analysis of costs or in reimbursement arrangements. If this is the case, the costs associated with specialised care should be based on the OLS model rather than the RE model. The reasoning is that there might be a correlation between higher exogenous costs and the provision of specialised care. If so, the OLS estimates of the cost of specialised care will be higher than the RE estimates. This is because some of the costs associated with these (unmeasured) exogenous factors will be attributed to the costs of specialised care. This would allow hospitals to receive some indirect compensation for their higher exogenous costs via payment corrections made for the provision of specialised care, even though these are not measured or paid for directly.

The second scenario is one in which it is believed that higher costs are due to exogenous factors, these factors are quantified, and hospitals are compensated for them explicitly in some way. The Market Forces Factor (MFF) is an archetypical example. It has long been established that the wages that hospitals have to pay for some types of staff and the rent and rates paid for capital inputs vary from one part of the country to another. These cost differentials have been calculated and the MFF is used to compensate hospitals accordingly.

In effect, the MFF adjustment means that the tariffs that hospitals are paid for providing care of a particular type is adjusted to take account of geographical variation in input prices. Similarly, in all of our analyses, we have adjusted Reference Costs as reported by hospitals according to each hospital's labour and capital MFF, in the same way that tariffs are adjusted. If it is believed that the MFF is correctly calculated and that differential input prices are the only exogenous cost influences that hospitals face, then the RE estimates are to be preferred to the OLS estimates of the costs of specialised care.

The third scenario is one in which there are other exogenous influences on costs over and above differential input prices, but these are not accounted for either explicitly or fully in funding arrangements. For example, teaching hospitals are often thought to have higher costs than non-teaching hospitals, and two main reasons are advanced as to why this might be so. First, teaching hospitals may attract patients of greater severity than non-teaching hospitals, and the HRG system inadequately captures these severity differences. Second, training of medical students may add to the costs of patient care. This might be because the treatment process is delayed as doctors spend longer reviewing each patient prior to surgery or discharge so that medical students can learn from the review process. In effect, the provision of patient care and medical education is a joint and complementary process and it is not straightforward to disentangle these two components.

The best way to deal with the additional costs associated with such exogenous influences is to recognise them explicitly, quantify the cost impact, and compensate hospitals for these extra costs directly. This has long been the approach taken to funding public hospitals in the Australian State of Victoria.^f If this can be achieved, the costs associated with specialised care can be estimated precisely and de-contaminated from the influence on cost of these exogenous factors. The RE model would be the most appropriate means to estimate the costs of specialised care, but would also

f

[http://docs2.health.vic.gov.au/docs/doc/4EA6AAD16FEF511ACA257D310004D57B/\\$FILE/PFG%20complete%20final%20for%20web%20150814.pdf](http://docs2.health.vic.gov.au/docs/doc/4EA6AAD16FEF511ACA257D310004D57B/$FILE/PFG%20complete%20final%20for%20web%20150814.pdf)

include variables that measure each of the exogenous factors. The RE model would take the following form:

$$y_{ik} = \alpha + \sum_{p=1}^P \beta_p R_{pik} + \sum_{m=1}^M \delta_m Z_{mk} + u_k + v_{ik} \quad (\text{EQ4})$$

With Z_{mk} representing a vector of $m=1\dots M$ different types of exogenous factor, measured for each hospital k . The estimated impact on costs $\hat{\delta}_m$ of each of these exogenous factors can themselves be used to inform how reimbursement arrangements might be modified to compensate hospitals for the unavoidable costs that they face. With all these exogenous factors taken into account, the random effect u_k for each hospital can be interpreted as capturing its cost efficiency relative to other hospitals.

Only if a payment for these exogenous influences was not to be made would estimates from the OLS model be preferred to those from the RE model in assessing the additional costs of specialised care. This second best option would at least make some allowance for the costs associated with exogenous factors, but only indirectly and rather opaquely.

It cannot be pre-determined whether the estimates of the costs of specialised care are higher for the OLS model than the RE model. OLS estimates will be higher if:

- i. Specialised care is more expensive than non-specialised care and
- ii. Specialised care is concentrated in hospitals that are either less efficient or more likely to be subject to cost-increasing exogenous factors.

In contrast, OLS estimates may be lower than RE estimates if:

- i. Specialised care is more expensive than non-specialised care but
- ii. Hospitals that concentrate (ie specialise) on providing specialised care are able to provide such care at lower cost than hospitals that do not. This may be because provision of care in such hospitals is most cost-efficient, as they benefit from economies of scale (costs fall as more patients are treated) and economies of specialisation (lower costs arise from more stream-lined activities and greater expertise).

Table 3 Summary of model options

Explanation	Choice of model
Inefficiency	RE
Different factor prices	RE + MFF adjustment
Other “unavoidable” costs	OLS if not otherwise reimbursed
	RE + specific reimbursement

3.4 Model specifications

We specify six different models, each of which is estimated as an OLS and RE model. The rationale for each model and its defining features are described below.

Model 1

The first model analyses the relationship between the PSS markers and the full cost of the patient’s stay in hospital, including excess bed day costs and unbundled costs. Thus:

- The dependent variable is the patient’s standardised cost $y_{ik} = c_{ihk} / \hat{c}_h$.

- The costs include the cost of core HRGs to which the patient is allocated, the costs of unbundled components, and the costs associated with excess bed days beyond the trimpoint of the HRG to which they are allocated.
- All patients with cost information are included in the analysis.

Model 2

Our second model takes the same form as the first, but excludes patients allocated to HRGs in which everyone receives specialised care (100% specialised) or in which nobody does (0% specialised).

In an ideal HRG-based reimbursement system all patients requiring more expensive specialised care would be grouped into the same HRG. However, in practice patients receiving a particular type of specialised service are allocated across a range of HRGs, as figure 1 indicated. Some of those HRGs are fully specialised - everyone allocated to them receives specialised care. This is because the HRG itself is defined using the ICD or OPCS codes that are also used as indicators of specialised care. Conversely, a handful of HRGs contain no patients that received specialised care. For both types of HRG the core tariff will properly account for the costs of specialised (or non-specialised) care. Consequently, retaining patients allocated to these HRGs in the analysis would be inappropriate for the estimation of the influence of specialised care for patients allocated to the other HRGs. This is because there will be no cost differential for those in fully specialised HRGs, so including them in the analysis will dilute the difference for those HRGs comprising a mix of patients that do or do not receive specialised care. Including fully non-specialised (0% specialised) HRGs in the analysis would be inappropriate, because there can be no cost differentiation for patients allocated to these HRGs simply because none of them received specialised care.

Model 3

The third model is that most appropriate to inform payment arrangements relating to compensation for the higher costs of specialised care. It has the following features:

- As for model 2, patients allocated to fully specialised or fully non-specialised HRGs are excluded, because the core tariff properly accounts for their costs, by HRG construction.
- The dependent variable is re-defined to capture only the costs associated with the core HRGs to which the patient is allocated, defined as c_{ihk}^* , with the patient's re-standardised cost now defined as $y_{ik}^* = c_{ihk}^* / \hat{c}_h^*$.

The reason for focussing solely on the costs associated with the patient's core HRG is because costs associated with excess bed days and unbundled activities are compensated separately via excess bed-day rates and unbundled payments. If cost differentials are observed when considering only the core HRG costs there are grounds for making corrections to the base HRG tariffs. As such, this is the preferred specification for informing refinement of the base HRG tariff.

Model 4

The fourth model takes the same form as the third, but introduces a further condition for identifying whether or not someone has received specialised care. This condition reflects the fact that some hospitals have been designated by the Department of Health as eligible for top-up payments for some specialised services. Such hospitals undertake more specialised spells than do other hospitals.

For the PSS and PSS-SMT service lines listed in Table 4 below, a patient is defined as receiving specialised care if one of the PSS ICD10 or OPCS codes was present in their medical record *and* they were treated at an eligible provider. We assess the sensitivity of results in Model 3 to imposition of

the “eligibility condition” that these types of specialised services have to be delivered by eligible providers.

Table 4 Eligibility criteria by type of specialised service

NPCoC CRG	Eligibility in both PSS and SMT	New service in SMT eligibility	Pre-existing in PSS but eligibility criteria only imposed in SMT
A01 - Cystic Fibrosis	10Z		
A02 – Hepatobiliary		19T, 19V	
A07 - Renal Transplantation			11T
A09 - Complex Invasive Cardiology	13F		
A10 - Cardiac Surgery	13E		
A11 - Pulmonary Hypertension	13G		
A12 - Specialised Dermatology		24A, 24B, 24Y, 24Z	
A14 - Specialised Respiratory	29M	23G,29S	
B01 – Radiotherapy	01R		
B03 – Cancer		01I	
B05 – Haemophilia	03Z		
B07 - Infectious Diseases	18A		
B09 - Immunology and Allergy			16Z, 17Z
B11 - Upper Gastrointestinal Surgery		01U	
B12 – Sarcoma		01L, 01O	
B13 – Central Nervous System Tumours		01Q	
B14 - Specialised Urology		01N, 01X, 01Z	
B16 - Complex Head and Neck		01M	
B17 - Teenage and Young Adults Cancer			01T
C02 - High and Medium Secure Mental Health		22S	
C03 - MH Services for the Deaf		22B, 22D	
D03 - Adult Neurosurgery	08S		
D04 – Neuroscience		08D	
D06 – Burns	09Z		
D07 - Cleft Lip and Palate	15Z		
D13 - Spinal Cord Injury		06A	
D14 - Spinal Surgery	06Z		
E02 - Paediatric Surgery		23Q	23X
E03 - Paediatric Medicine		23J	23S
E04 - Paediatric Cancer		01G	23A
E05 - Congenital Heart Service		13J	
E09 - Paediatric Neuroscience			23M
E10 - Complex Gynaecology		04F	

Model 5

Our fifth model analyses whether the costs associated with lengthy hospital stays are related to receipt of specialised care. The rationale for this model is that hospitals receive additional ‘excess bed day’ payments for patients that stay beyond their HRG tripoint.

The purpose of this analysis is to assess whether the cost of an extra day in hospital is higher for patients that received specialised care than for those that did not. If cost differentials are observed, there is an argument for adjusting excess bed day payments accordingly, perhaps at a different rate to the adjustment made to the corresponding base tariff. The model has the following features:

- Only patients that stay beyond their HRG tripoint are included, some 3% of the analytical sample used in Model 1.
- Only excess bed day costs are analysed, with the patient’s re-standardised cost defined

$$\text{as } y_{ik}^e = c_{ihk}^e / \hat{c}_h^e.$$

Model 6

Our sixth model explores variation in length of stay (LoS) rather than costs. Our assignment of Reference Costs means that patients from the same hospital allocated to the same HRG will have different costs if they: have different Points of Delivery, are treated in different specialties, have more than one FCE, trigger unbundled HRGs, and have excess lengths of stay beyond their HRG tripoint. But, self-evidently and as is common in many studies of hospital costs, patients that share the same characteristics used for cost assignment will have the same costs. This means that the Reference Costs are not truly patient-level costs, which limits our ability to detect and attribute differences in costs to the provision of specialised care.

Recognising this, we also analyse variation in length of stay rather than costs. LoS is sometimes used as a proxy for resource use (Street et al., 2012) and while some patients might be assigned the same RC, LoS has the advantage of being accurately measured for each individual patient. Our model for LoS follows the specification of the cost model except that the dependent variable is defined as the patient’s standardised LoS, $y_{ik}^L = LoS_{ihk} / \widehat{LoS}_h$ where LoS_{ihk} is the length of stay of patient i in HRG

h in hospital k and \widehat{LoS}_h is the national average length of stay of all patients allocated to the patient’s core HRG h . All patients are included in this analysis, including those for whom cost information is lacking.

3.5 Financial impact analysis

Having estimated cost differentials for individual patients, we then calculate the additional costs associated with each specialised service at national level. This involves multiplying the national number of cases for each specialised service by the additional cost associated with that service. Given that $R_{pi} = 1$ if the patient received PSS specialised care of type p , and 0 otherwise, the number of cases receiving specialised care is simply:

$$Q_p = \sum_{i=1}^I R_{pi} \tag{EQ5}$$

We calculate Q_p using the HES cleaned dataset, not just the subset of patients for whom costs are available.

To estimate the additional costs, we calculate the sum of national average cost across all the HRGs to which patients with a given PSS marker are allocated. For a given PSS marker p , \hat{c}_{ip}^* is the average national cost for the core HRG associated with patient i . This means that

$$C_p = \sum_{p=1}^{Q_p} \hat{c}_{ip}^* \quad (\text{EQ6})$$

indicates the total cost of patients with a given PSS marker, based on the average cost of treatment. The overall financial impact associated with the PSS markers is then calculated as:

$$F_p = C_p \times \hat{\beta}_p \quad (\text{EQ7})$$

where $\hat{\beta}_p$ are the estimates from model 3.

3.6 Concentration indices and ratios

To assess the concentration of specialised services among the 230 NHS hospitals in the dataset, we construct Gini coefficients. The Gini coefficient G_p for a particular PSS marker p is calculated according to the formula:

$$G_p = \frac{K+1}{K-1} - \frac{2 \cdot \sum_{k=1}^K \tau_{pk} X_{pk}}{K(K-1)\mu_p} \quad (\text{EQ8})$$

where K is the number of all hospitals in our sample ($K=230$) and μ_p is the mean number of specialised patients of type p across all hospitals. We rank all hospital according to the number of specialised patients, with the hospital performing the most specialised activity ranked first. τ_k is the rank of hospital k with X_{pk} patients receiving specialised care of type p .

We are also interested in the concentration of specialised services among different HRGs. Although the Gini coefficient is a relevant measure of concentration, because of the large number of HRGs, the Gini coefficient will always be very close to 1. Instead we calculate concentration ratios analogous to the Four-Firm measure used to measure industry structure (Siegfried, 1975).

The concentration ratio is the percentage of total specialised activity of type p allocated to the H HRGs that account for the largest amount of this type of specialised care and is calculated as:

$$CR_{ph} = \sum_{h=1}^H s_h \quad (\text{EQ9})$$

where s_h is the share of activity provided in the h -th largest HRG by volume of specialised activity of type p . The Four-HRG can then be written as: $CR_{4h} = \sum_{h=1}^4 s_h$.

4. Descriptive statistics

The volumes of observations in HES and in our analytical samples are provided in Table 5, including the number of patients identified as having received specialised care.

Table 5 Summary of HES and analytical samples

	2011/12		2012/13		2013/14	
	HES	Sample	HES	Sample	HES	Sample
All patients	16,599,033	12,286,246	16,592,681	12,544,761	16,964,893	12,474,184
Specialised	1,796,842	763,123	1,908,239	809,605	2,015,215	792,974

A detailed breakdown for each PSS marker is provided in Table 6. The largest volume in HES is for NCBPS01C Chemotherapy, but only a small proportion (5%) of such patients appear in the analytical sample because many of these patients are assigned to zero cost HRGs. The same is true for NCBPS01R Radiotherapy (10%) and NCBPS10Z Cystic fibrosis (3%). For other PSS markers, the difference between the HES and analytical samples is much less pronounced.

Note that some PSS markers have very low volumes, with six having fewer than 100 patients in 2013/14, namely:

- NCBPS04D Women - Complex Urinary and Faecal Incontinence & Genital Prolapse;
- NCBPS08R Neurosciences – Neuroradiology;
- NCBPS23Y Childrens services - Paediatric Pain Management;
- NCBPS28Z Hyperbaric Oxygen Treatment;
- NCBPS29A Respiratory - Pulmonary vascular services;
- NCBPS33B Colorectal - Complex Inflammatory Bowel disease

Table 6 HES and analytical samples for each PSS markers

	2011/12		2012/13		2012/13	
	HES	Sample	HES	Sample	HES	Sample
Chemotherapy	667,642	47,186	723,431	38,815	782,697	41,417
PET-CT	744	<6	1,020	455	1,290	500
Radiotherapy	79,774	7,363	95,742	11,515	101,472	10,603
Stereotactic Radiosurgery	1,397	192	1,627	1,298	1,628	1,197
Teenage and Young Adults Cancer	14,270	6,829	13,521	6,505	13,456	5,921
Rare Cancers (Adult)	60,329	29,364	62,886	30,769	64,478	30,029
Bone Marrow Transplantation	3,025	1,846	3,250	2,086	3,378	2,292
Haemophilia	6,314	5,264	5,819	4,179	5,585	3,673
Women - Complex Minimal Access	1,525	1,274	1,761	1,617	2,244	1,961
Women - Fetal Medicine	180	168	139	132	145	125
Women - Complex Urinary and Faecal	16	14	20	18	35	35
Women - Maternal Medicine	44,174	39,629	45,870	41,669	45,142	41,614
Spinal - Spinal Surgery	12,009	9,221	12,057	9,977	11,690	8,291
Neurosciences - Neurology	122,866	96,650	131,733	111,882	144,318	121,581
Neurosciences - Neurophysiology	174	87	202	158	237	232
Neurosciences - Neuroradiology	32	13	17	12	15	13
Neurosciences - Neurosurgery	75,177	56,095	77,055	64,784	79,986	61,308
Burns Care	5,725	2,948	5,852	3,493	6,797	2,009
Cystic fibrosis	14,083	747	14,268	620	13,696	426
Renal Services - Access for dialysis	15,764	13,323	16,519	13,488	17,203	12,255
Renal Services - Renal Transplantation	10,584	9,296	11,022	9,561	11,852	8,796
Cardiac - Cardiac electrophysiology	6,859	5,671	6,945	5,892	7,235	6,028
Cardiac - Inherited heart disorders	5,922	3,955	6,015	4,211	6,260	4,163
Cardiac - Cardiac surgery	45,100	27,418	43,450	29,891	43,488	28,249
Cardiac - PPCI and Structural Heart Disease	48,612	30,563	50,161	35,241	50,482	27,376
Cardiac - Pulmonary hypertension	6,239	4,389	1,937	1,225	1,153	907
Cardiac - Cardiovascular magnetic	4,517	8	5,484	1,526	6,123	1,726
Cardiac - Other	20,354	15,791	22,571	18,019	25,755	19,575
Adult Congenital Heart Disease	6,945	4,185	6,342	4,589	6,356	4,175
Cleft Lip Palate	2,969	2,811	2,851	2,559	2,930	2,276
Immunology	10,968	9,760	12,659	7,664	14,550	9,142
Allergy	2,538	1,971	3,575	2,278	3,809	2,292
Infectious Diseases Adult	343	279	221	164	379	241
Infectious Diseases Paeds	308	247	214	179	203	113
Hepatology & Pancreatic	4,036	2,342	4,030	2,834	4,178	2,847
Mental Health - Gender Dysphoria	163	160	170	168	175	175
Children - Cancer	53,896	25,405	54,366	23,117	55,693	20,860
Children - Cardiac	17,853	8,645	17,723	8,497	18,169	7,713
Children - Endocrinology	3,932	3,671	4,488	4,247	4,548	4,270
Children - Gastroenterology	74,283	62,385	78,175	67,537	82,217	65,854
Children - Haematology	2,362	1,919	2,342	1,881	2,493	1,764
Children - Neurosciences	16,521	9,071	16,904	11,948	16,824	11,014
Children - Ophthalmology	7,780	6,725	8,089	7,213	8,676	7,282
Children - Renal	13,836	9,593	17,531	6,529	19,547	7,271
Children - Respiratory	9,667	7,184	11,232	8,943	11,825	9,151
Children - Rheumatology	7,869	6,047	8,113	7,134	8,911	7,379
Children - Surgery	123,421	60,690	130,441	63,266	137,885	63,077
Childrens services - Paediatric Pain	25	25	33	33	21	18
Hyperbaric Oxygen Treatment	17	12	8	8	11	9
Respiratory - Pulmonary vascular services	274	178	49	30	33	23
Respiratory - Complex thoracic surgery	41,743	27,615	39,175	29,396	37,283	27,800
Respiratory - Management of central	3,103	1,901	3,161	2,120	3,428	2,209
Respiratory - Interstitial lung disease	10,919	8,285	11,231	9,148	12,007	9,330
Respiratory - Other	23,365	13,953	26,203	16,442	27,326	16,427
Vascular Services	7,378	4,839	7,471	5,323	7,742	5,581
Ears - Cochlear Implants	1,250	1,150	1,096	1,006	1,086	970
Ears - Bone anchored hearing aids	1,388	1,370	1,302	1,296	1,513	1,505
Ears - Middle Ear Implants	119	113	102	99	101	99
Colorectal - Incontinence	1,692	1,090	1,870	1,350	1,826	1,270
Colorectal - Complex Inflammatory Bowel	88	63	105	84	91	75
Colorectal - Transanal Endoscopic	535	503	585	525	543	497
Orthopaedic Surgery	1,999	1,637	1,957	1,655	1,942	1,628
Orthopaedic Surgery - revisions	187	176	191	180	138	123
Morbid Obesity Surgery	9,167	8,252	8,322	7,549	6,809	6,208
Ophthalmology	20,836	20,004	23,087	21,647	24,435	23,022
Haemoglobinopathy - Sickle Cell	13,941	13,553	16,962	12,663	19,947	10,827
Haemoglobinopathy - Thalassemia	8,872	8,651	9,264	7,857	9,658	8,121
Highly Specialised	16,847	11,355	16,225	11,409	12,067	8,034

5. Estimates of the costs of specialised care

5.1 Model 1

- The dependent variable is the patient's standardised full cost of treatment $y_{ik} = c_{ikh} / \hat{c}_h$.
- The costs include the cost of core HRGs to which the patient is allocated, the costs of unbundled components, and the costs associated with excess bed days beyond the trimpoint of the HRG to which they are allocated.
- All patients with cost information are included in the analysis.

Worksheet "Model1" in the accompanying spreadsheet reports the number of patient spells and percentage cost differentials for the analyses that apply Model 1 estimated using both OLS and RE for all three years.

Most of the PSS markers are positive and significant, with the differentials being higher for the OLS than RE model. The results are summarised in Figure 1, which includes only those PSS markers with more than 100 patients in the analytical sample and for which the estimated coefficient is statistically significant ($p < 0.0001$). Up to six bars appear for each marker, ordered first by year and then for the OLS and RE models.

The figure makes it clear that, generally but not universally, patients that have received specialised care tend to have significantly higher costs than other patients who have not received specialised care allocated to the same set of HRGs. Bars extending to the right of the 0% axis indicate where this is the case. For some PSS markers, notably NCBPS01S Stereotactic Radiosurgery, costs appear lower.

For most PSS markers, a positive or negative difference is found across all three years and both OLS and RE models, although the size of the difference might vary, as evidenced by variation in the heights of the six bars for each PSS marker.

For some PSS markers, there are fewer than six bars, an absence indicating a lack of statistical significance for the year or model in question. This is particularly likely for PSS markers for which there are some volumes. An example is NCBPS04C Women - Fetal Medicine.

For further ease of interpretation in Table 7, we summarise these findings according to a categorisation of the size of the differential (again only for those PSS markers that are statistically significant and for which there are at least 100 patients). Taking the RE results for 2013/14, the cost differential between those that do and do not receive specialised care is more than 50% for six PSS markers; for 18 of these the difference is more than 25%; and for 29 it is more than 10%. At the other extreme, the cost differential is more than minus 50% for one PSS marker (NCBPS01S - Stereotactic Radiosurgery), more than minus 25% for four PSS markers, and more than minus 10% for nine PSS markers. The implication is that, for these markers, patients that received the specialised care in question are less expensive than other patients assigned to the same HRG. This summary differs little for the earlier years, but there are fewer PSS markers in each category if estimating Model 1 as an RE rather than OLS model.

Table 7 Summary of Model 1 results by size of difference

	2011/12		2012/13		2013/14	
	OLS	RE	OLS	RE	OLS	RE
50	10	5	10	6	10	6
25	24	19	21	20	20	18
10	32	29	31	29	32	29
(10)	6	7	6	8	9	9
(25)	4	2	3	3	4	4
(50)	1	1	1	1	1	1

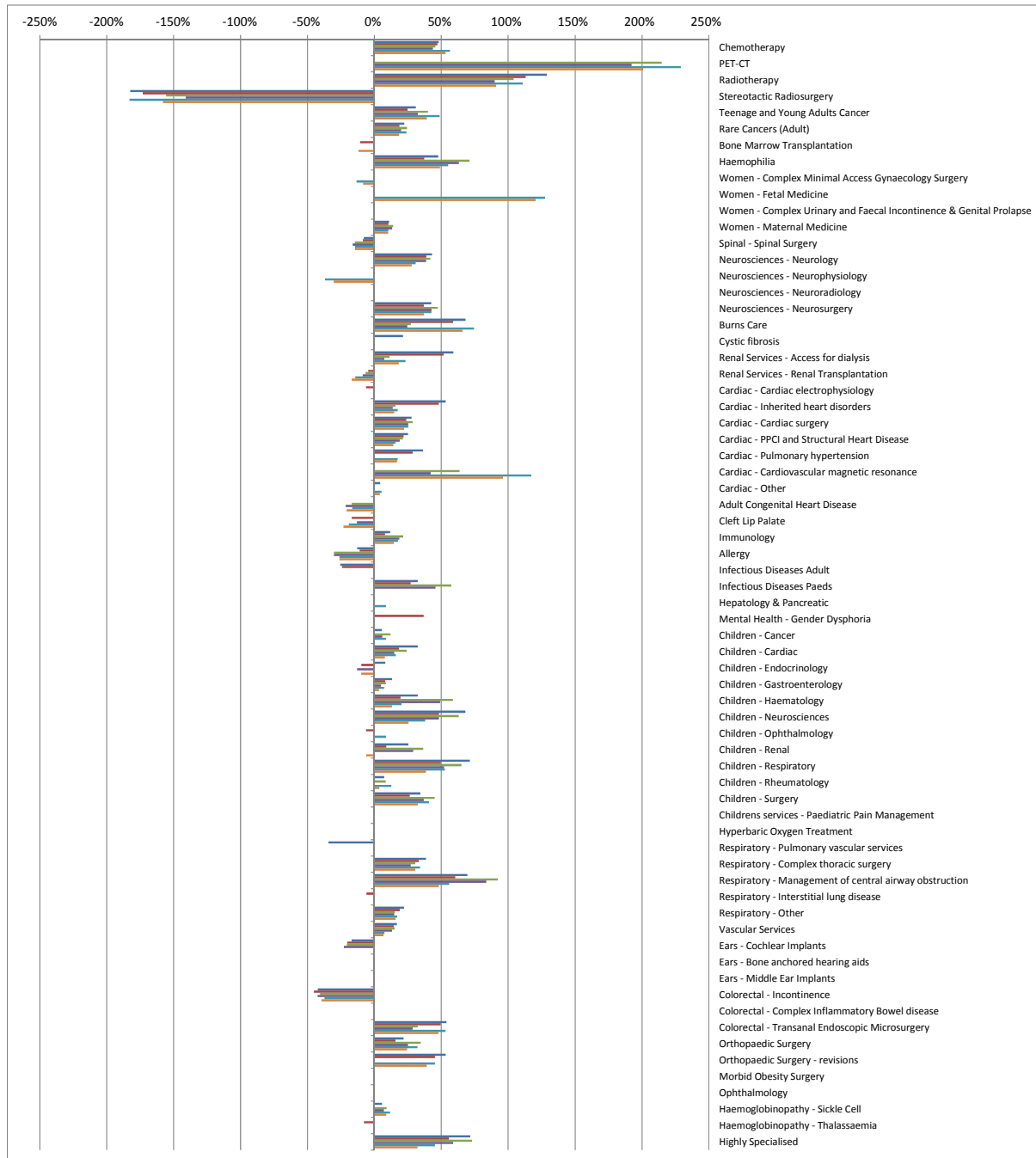


Figure 2 Summary of Model 1 results

5.2 Model 2

- The dependent variable is the patient's standardised full cost of treatment $y_{ik} = c_{ihk} / \hat{c}_h$.
- The costs include the cost of core HRGs to which the patient is allocated, the costs of unbundled components, and the costs associated with excess bed days beyond the tripoint of the HRG to which they are allocated.
- Patients allocated to fully specialised or non-specialised HRGs are dropped from the analysis.

The overall proportion of patients allocated to fully (non) specialised has increased over time, from 0.2% in 2011/12 to 0.41% in 2012/13 to 0.56% in 2013/14. The increasing proportion of patients assigned to HRGs in which everyone receives specialised care is probably a reflection of the ongoing revisions made to the HRG classification system. Omitting patients allocated to fully specialised and non-specialised HRGs from the analysis reduces the number of specialised patients in the analysis by 16,701 (2.2%) for 2011/12, 23,977 (3.0%) in 2012/13 and 25,362 (3.2%) in 2013/14.

In all three years, almost all patients are dropped for NCBPS02Z Bone Marrow Transplantation, NCBPS10Z Cystic fibrosis, NCBPS32A Ears - Cochlear Implants, and NCBPS32B Ears - Bone anchored hearing aids while 30% of those receiving specialised NCBPS35Z Morbid Obesity Surgery are dropped.

There are also reductions in numbers for some types of Children's services, notably NCBPS23F Children - Gastroenterology (17% fewer in 2013/14), NCBPS23N Children - Ophthalmology (11%) and NCBPS23X Children - Surgery (5%), the impact of dropping these patients being to increase the estimated cost differential for these services by 2%.

As might be expected given that few patients are dropped, there is little difference in the results between Model 1 and Model 2, Figures 2 and 3 showing a similar pattern and the number of PSS markers in each differential category being similar in Tables 7 and 8.

Table 8 Summary of Model 2 results by size of difference

	2011/12		2012/13		2013/14	
	OLS	RE	OLS	RE	OLS	RE
50	10	5	9	6	11	7
25	24	20	19	20	21	19
10	32	29	29	29	34	30
(10)	5	6	4	8	9	8
(25)	4	3	2	3	4	4
(50)	1	1	1	1	1	1

Where there are differences between the results from Model 1 and Model 2, these will arise for those PSS markers for which greater numbers of patients have been omitted from the analysis. For 2013/14, the PSS markers with the greatest reductions in numbers and the changes in the percentage cost differences are shown in Table 9. For only four of these were the observed cost differentials statistically significant, but for one these (NCBPS13X Adult Congenital Heart Disease), this was negative. For the other three PSS markers, the cost differential increases when patients allocated to fully (non) specialised HRGs are dropped, but never by more than 2.5%. Full details are in worksheet "Model2" in the accompanying spreadsheet.

Table 9 PSS markers subject to greatest changes in numbers between Models 1 and 2

		N (%) dropped	M1 OLS	M2 OLS	Diff	M1 RE	M2 RE	Diff
NCBPS02Z	Bone Marrow Transplantation	2,289 (99.9)	NS	NS	na	NS	NS	na
NCBPS13E	Cardiac - Cardiac surgery	895 (3.2)	25%	26%	0.8%	22%	23%	0.8%
NCBPS13X	Adult Congenital Heart Disease	668 (16.0)	-17%	-11%	6.1%	-21%	-14%	6.6%
NCBPS23F	Children - Gastroenterology	11,219 (17.0)	7%	10%	2.4%	3%	6%	2.3%
NCBPS23X	Children - Surgery	3,534 (5.6)	41%	43%	2.2%	33%	35%	2.0%
NCBPS32A	Ears - Cochlear Implants	921 (94.9)	NS	NS	na	NS	NS	na
NCBPS32B	Ears - Bone anchored hearing aids	1,426 (94.9)	NS	NS	na	NS	NS	na
NCBPS35Z	Morbid Obesity Surgery	1,907 (30.7)	NS	NS	na	NS	NS	na

NS: not significant; na not applicable

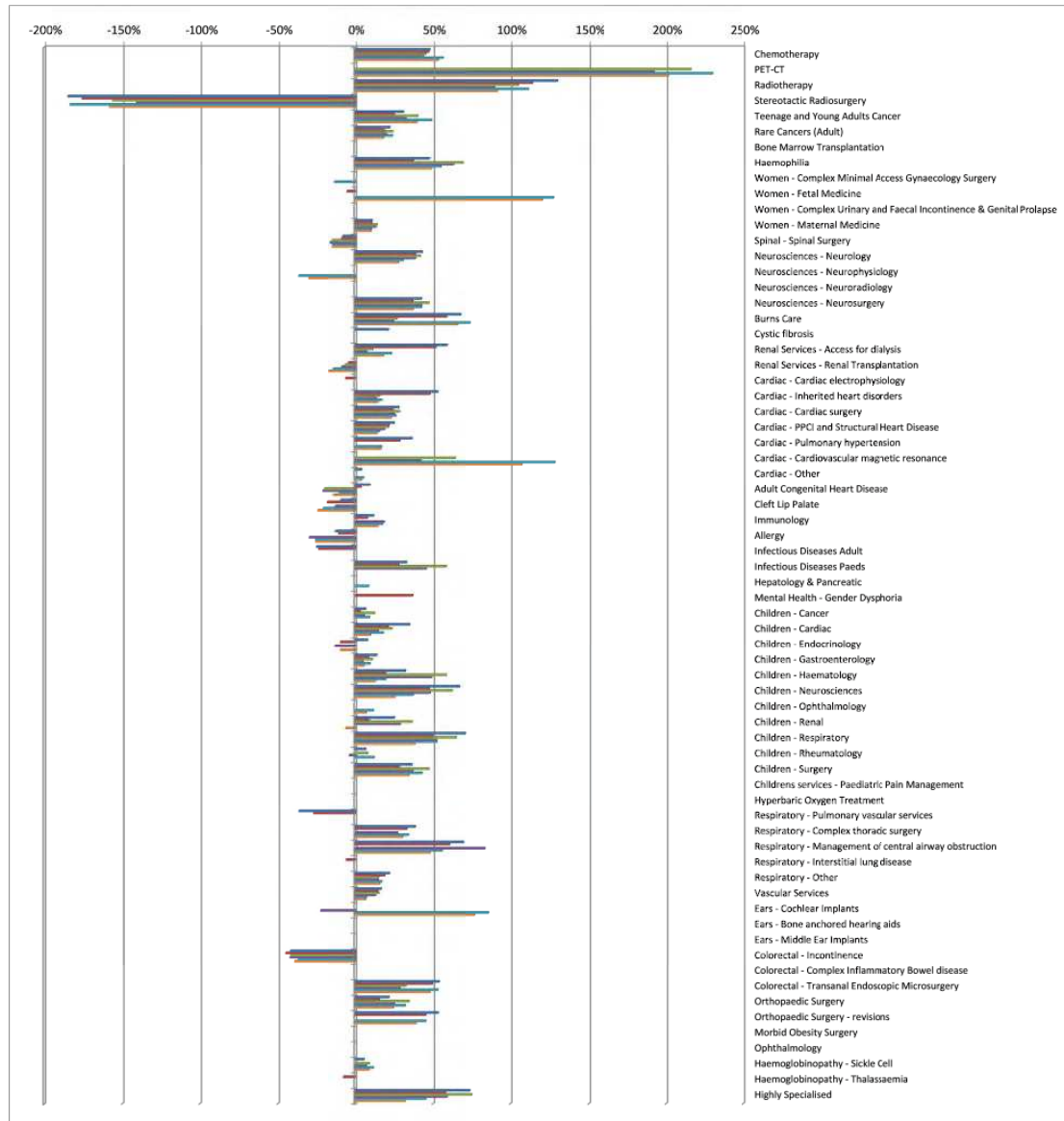


Figure 3 Summary of Model 2 results

5.3 Model 3

- The dependent variable captures only the costs associated with the core HRGs to which the patient is allocated, defined as c_{ihk}^* , with the patient's re-standardised cost defined as $y_{ik}^* = c_{ihk}^* / \hat{c}_h^*$.
- Patients allocated to fully specialised or non-specialised HRGs are dropped from the analysis.

The results for Model 3 are reported in worksheet "Model3" in the accompanying spreadsheet, this model dropping excess bed-day and unbundled costs in the construction of the dependent variable. These results (or those from Model 4) should be used as the basis for discussing corrections to the base HRG tariffs.

For two PSS markers, Chemotherapy and Radiotherapy, most costs are unbundled and reimbursed separately to the core HRG. Once these costs are removed, the cost differentials disappear almost entirely for Chemotherapy and are substantially lower for Radiotherapy (from 111% to 51% in 2013/14).

Cost differentials are also substantially lower in all three years for Neurology (from 31% to 11% in 2013/14), Pulmonary hypertension (from 17% to 11%), Cardiovascular magnetic resonance imaging (128% to 75%), Immunology (18% to -10%) and Children's Surgery (from 43% to 21%). This implies that excess bedday and unbundled payments compensate partly, but not fully, for the additional costs associated with these types of specialised care.

There are a couple of PSS markers for which the estimated cost differential increases for all three years, these being Children's cancer care (9% to 19% in 2013/14) and Children's cardiac care (18% to 26%).

Restricting the analysis only to the costs of the core HRGs generally means that cost differentials are less pronounced, the implication being that the number of PSS markers in each of the differential categories is smaller in Table 10 than it was in Table 8.

Table 10 Summary of Model 3 results by size of difference

	2011/12		2012/13		2013/14	
	OLS	RE	OLS	RE	OLS	RE
50	6	4	5	4	8	6
25	18	14	22	18	19	15
10	31	27	36	33	32	29
(10)	5	6	5	5	8	8
(25)	3	3	2	2	4	2
(50)	1	1	1	1	1	1

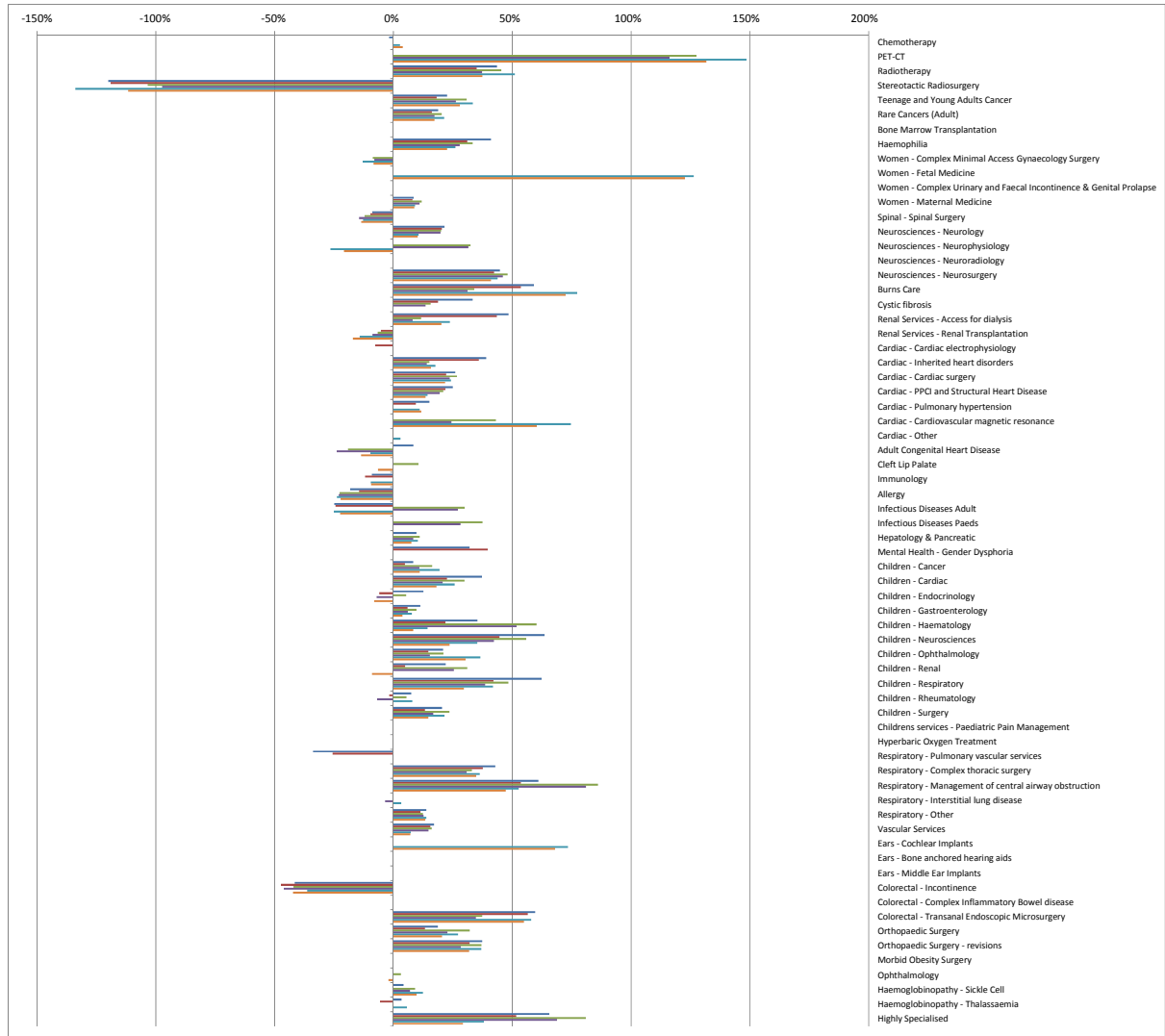


Figure 4 Summary of Model 3 results

5.4 Model 4

- The dependent variable captures only the costs associated with the core HRGs to which the patient is allocated, defined as c_{ihk}^* , with the patient's re-standardised cost defined as $y_{ik}^* = c_{ihk}^* / \hat{c}_h^*$.
- Patients allocated to fully specialised or non-specialised HRGs are dropped from the analysis.
- Patients are identified as having specialised care if the appropriate ICD10 and OPCS codes are in their medical record and they were treated at eligible providers

Model 4 involves imposition of the condition that patients have to be treated in eligible hospitals for identification of whether or not they were deemed to have received specialised care. This reduces the number of patients identified as having specialised care by 16,253 (2.18%) in 2011/12, 21,545 (2.74%) in 2012/13 and 20,534 (2.68%) in 2013/14. The results for Model 4 are reported in worksheet "Model4" in the accompanying spreadsheet.

The impact on the cost differential of imposing these "eligibility conditions" for identification of whether or not somebody had specialised care will vary from one PSS marker to another, being most pronounced in those PSS markers where the greatest number of patients are "de-identified" as having received specialised care. For 2013/14, the PSS markers with the greatest reductions in numbers and the changes in the percentage cost differences are shown in Table 11 below.

Table 11 PSS markers most affected by imposition of eligibility conditions

		N de-identified	M3 OLS	M4 OLS	Diff	M3 RE	M4 RE	Diff
NCBPS03Z	Haemophilia	770	26%	44%	18.2%	23%	36%	13.3%
NCBPS06Z	Spinal - Spinal Surgery	2,167	-13%	-13%	0.0%	-14%	-17%	2.9%
NCBPS08S	Neurosciences – Neurosurgery	1,268	44%	52%	8.1%	41%	44%	3.4%
NCBPS13E	Cardiac - Cardiac surgery	2,909	24%	26%	1.3%	22%	69%	47.3%
NCBPS13F	Cardiac - PPCI and Structural Heart Disease	5,551	14%	15%	0.7%	13%	14%	0.6%
NCBPS13G	Cardiac - Pulmonary hypertension	720	11%	NS	na	12%	NS	na
NCBPS29M	Respiratory - Interstitial lung disease	6,207	3%	-11%	-14.6%	NS	-29%	-26.6%

NS: not significant; na not applicable

For all but two of these PSS markers, the cost differential is greater for Model 4 than it was for Model 3. This implies that patients that received specialised care had more costly care if treated in eligible rather than non-eligible providers. The 29 PSS markers with differentials in excess of 10% are the same for both Models 3 and 4 under the RE specification (Table 12).

Table 12 Summary of Model 4 results by size of difference

	2011/12		2012/13		2013/14	
	OLS	RE	OLS	RE	OLS	RE
50	5	4	6	4	7	8
25	14	14	21	17	19	16
10	27	27	36	32	30	29
(10)	5	7	6	7	10	8
(25)	3	3	1	4	4	4
(50)	1	1	1	1	1	1

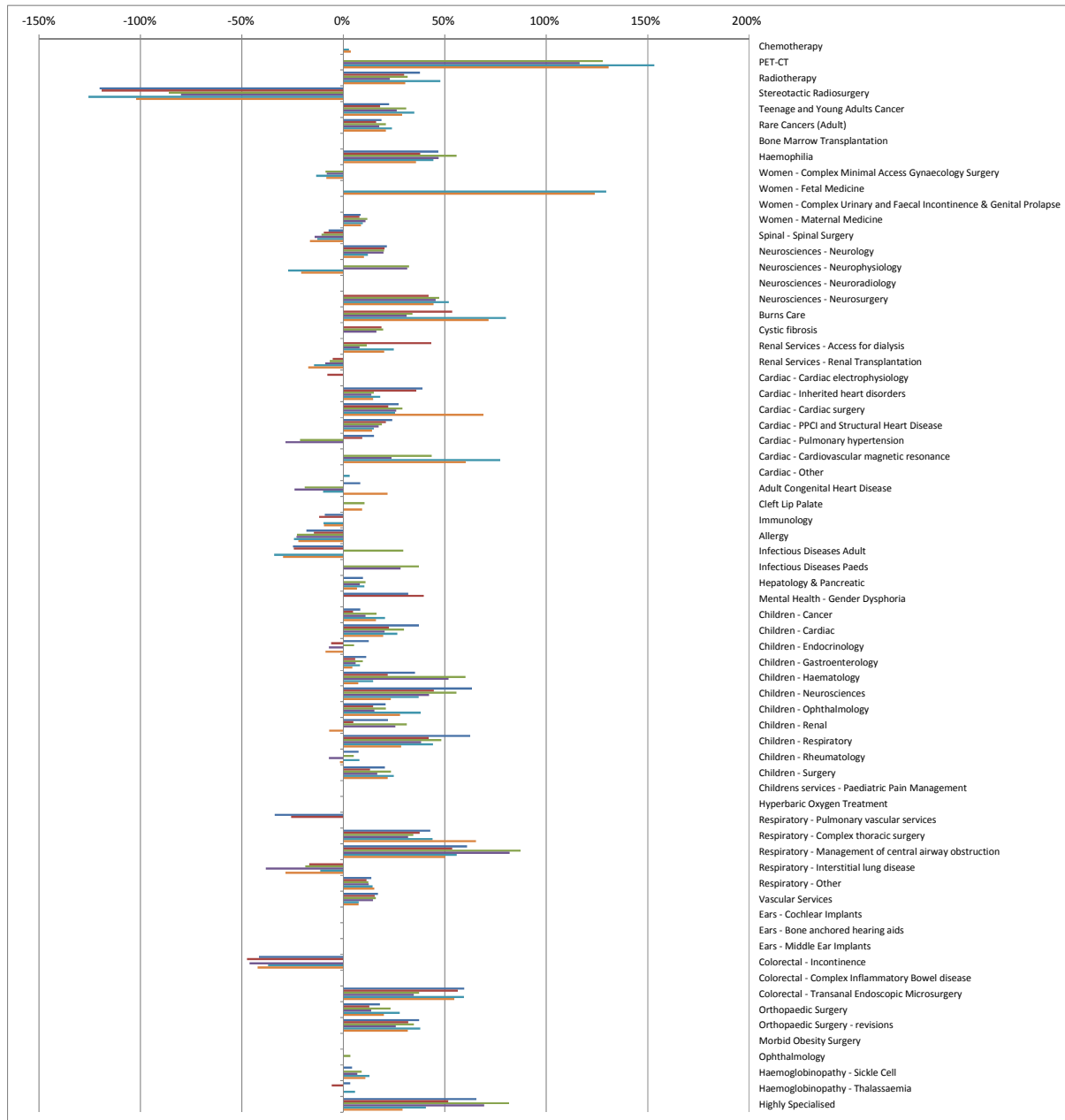


Figure 5 Summary of Model 4 results

5.5 Model 5

- Only patients that stay being their HRG tripoint are included;
- Only excess bed day costs are analysed, with the patient's re-standardised cost defined as

$$y_{ik}^e = c_{ihk}^e / \hat{c}_h^e.$$

Model 5 focusses only those patients that stayed beyond the tripoint for the core HRG to which they are allocated. This reduces the sample to 354012 (2.9% of that in Model 1) for 2011/12, 461540 (3.7%) for 2012/13 and 417866 (3.3%) for 2013/14.

The purpose of this analysis is to assess whether the cost of an extra day in hospital is higher for patients that received specialised care than for those that did not. If so, there are empirical grounds for increasing excess bed day payments for such patients accordingly.

Results are summarised in Table 13 and Figure 5. As can be seen, there are few PSS markers in which a differential excess bed day cost is observed, and for only a handful of these is the differential in excess of 25%. The policy implications of these results are that:

- For those PSS markers where a cost differential is observed, there are grounds for adjusting the excess bed day payment accordingly. The excess bed day adjustment might be at different percentage to that applied to the base tariff adjustment.
- For those PSS markers where no cost differential is observed, there is no basis for adjusting the excess bed day tariff. This implies that there are some PSS markers for which an adjustment might be made to the core tariff but for which no adjustment should be applied to the excess bed day payment.

Full results for Model 5 are reported in worksheet "Model5" in the accompanying spreadsheet.

Table 13 Summary of Model 5 results by size of difference

	2011/12		2012/13		2013/14	
	OLS	RE	OLS	RE	OLS	RE
50	1	0	2	1	2	2
25	4	1	6	6	4	4
10	7	7	13	12	8	9
(10)	0	0	0	2	0	3
(25)	0	0	0	1	0	1
(50)	0	0	0	0	0	0

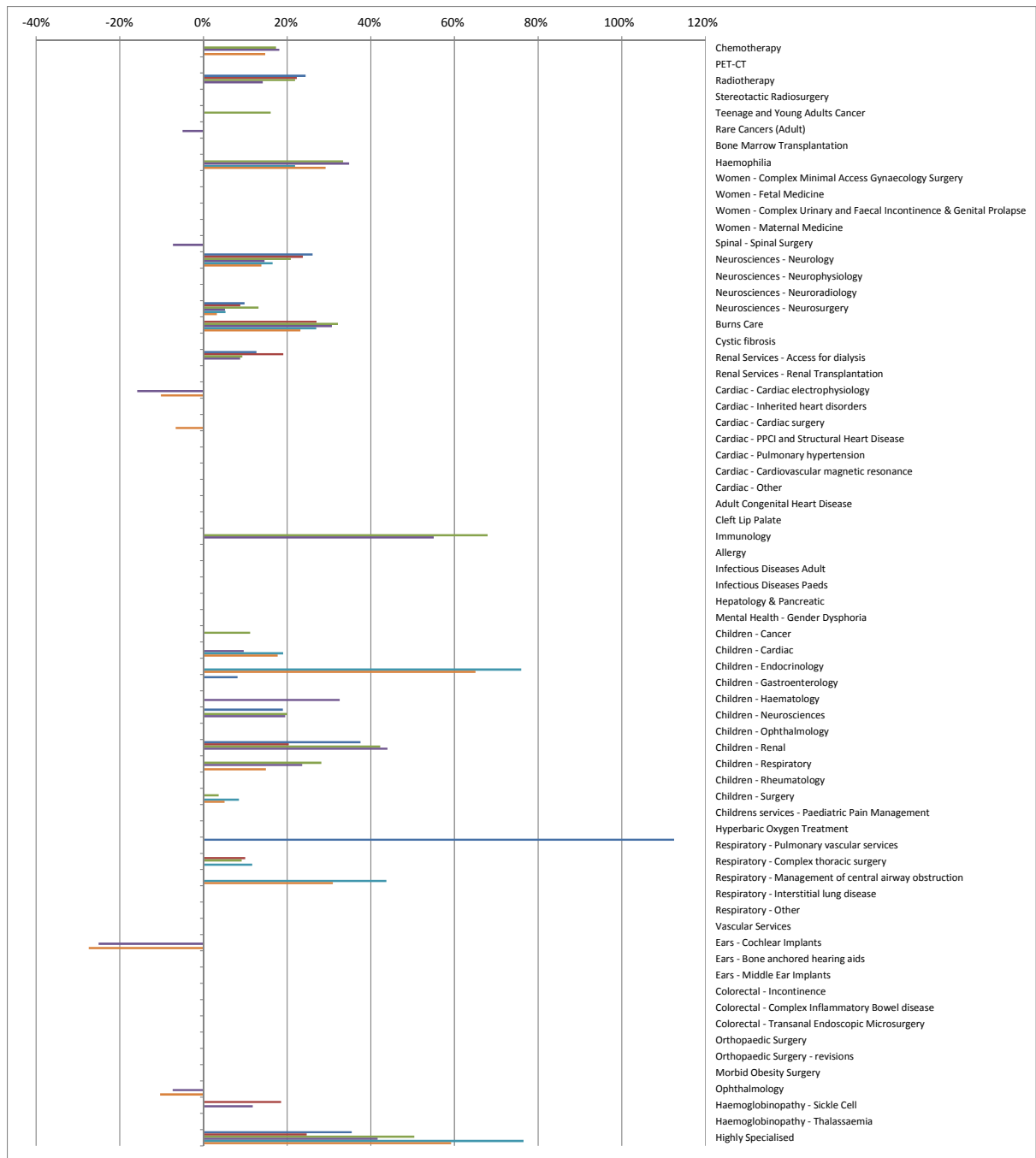


Figure 6 Summary of Model 5 results

5.6 Model 6

- the dependent variable is defined as the patient's standardised LoS, $y_{ik}^L = \text{LoS}_{ink} / \widehat{\text{LoS}}_h$
- All patients are included in the analysis, including those with missing cost information.

Our sixth model explores variation in length of stay (LoS) rather than costs. The advantage of using LoS is that it is measured specifically for each patient; the disadvantage being that LoS is only a partial measure of costs.

The results for this analysis are reported in worksheet "Model6" in the accompanying spreadsheet. We are more likely to find significant positive differentials for the PSS markers when analysing costs rather than LoS. Compare the RE results from Model 3 and Model 6, the number of PSS markers where the differential is in excess of 10% is:

- 27/69 (Model 3) and 7/69 (Model 6) in 2011/12
- 33/69 (Model 3) and 5/69 (Model 6) in 2012/13
- 29/69 (Model 3) and 15/69 (Model 6) in 2013/14

It is also notable that observed differentials in LoS are seldom of a consistent size or significance across all three years or between the OLS and RE specifications, as is evident from Figure 6. This lack of consistency suggests that it would be unwise to base pricing decisions on the basis of LoS.

Table 14 Summary of Model 6 results by size of difference

	2011/12		2012/13		2013/14	
	OLS	RE	OLS	RE	OLS	RE
50	6	4	4	4	7	5
25	6	7	4	5	10	11
10	6	7	4	5	10	15
(10)	1	1	1	0	4	4
(25)	1	1	1	0	4	3
(50)	0	0	1	0	2	2

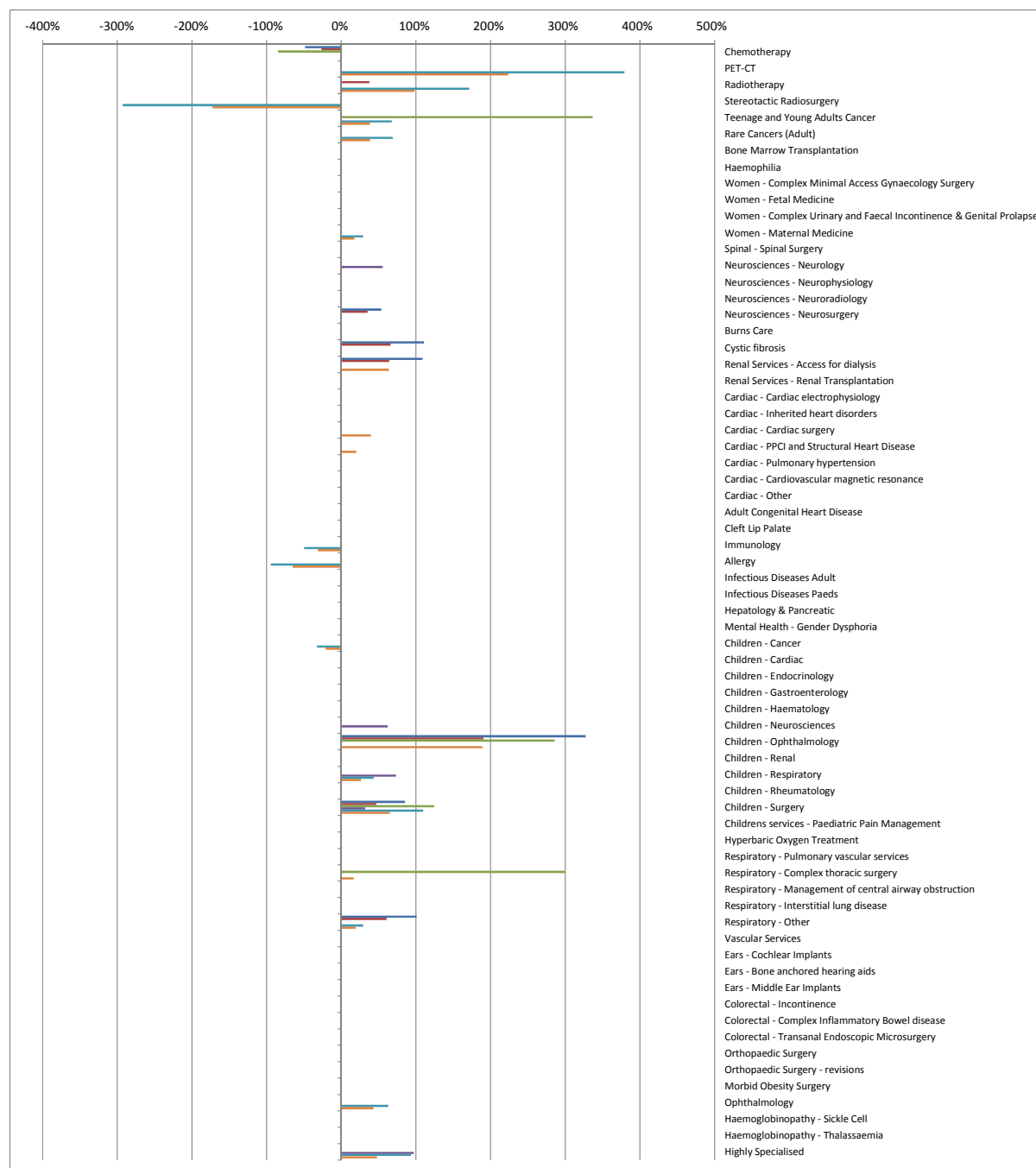


Figure 7 Summary of Model 6 results

5.7 PSS shadow monitoring tool

As described in section 2.2, an updated version of the PSS rules was released in May 2015, known as the PSS Shadow Monitoring tool (PSS-SMT). Data for 2013/14 have been run through the PSS-SMT. The analysis involves a substitution of PSS definitions with PSS-SMT definitions of specialised care. We then apply Model 1, Model 2 and Model 3 to identify cost differentials arising from applying the refined PSS-SMT system for identifying whether or not someone received specialised care.

The results are split into two parts. The first set of results is for those PSS markers for which labelling is the same under both PSS and PSS-SMT, even though each of these PSS markers may have been subject to revision of some form or another. The most significant of these revisions are summarised in Table 15. The second set is for new PSS-SMT markers.

Table 15 Changes to original PSS markers introduced by PSS-SMT

		PSS	PSS-SMT	Difference	% Difference	Reason
NCBPS04E	Women - Maternal Medicine	41,612	-	-41,612	-100%	Category dropped from SMT
NCBPS01C	Chemotherapy	41,389	74,778	33,389	81%	Expansion from 8 qualifying OPCS codes to 19
NCBPS13K	Cardiac - Other	19,567	-	-19,567	-100%	Category dropped from SMT
NCBPS01Y	Rare Cancers (Adult)	30,019	12,121	-17,898	-60%	Reduction from 166 ICD codes to 65
NCBPS23X	Children - Surgery	59,256	45,067	-14,189	-24%	Addition of eligibility criteria and slight decrease in qualifying OPCS codes
NCBPS23M	Children - Neurosciences	11,010	-	-11,010	-100%	Change from treatment speciality qualification to OPCS codes
NCBPS23B	Children - Cardiac	7,283	7	-7,276	-100%	Change from any code in ICD or OPCS list to code in ICD list and code in OPCS list
NCBPS11T	Renal Services - Renal Transplantation	8,793	1,759	-7,034	-80%	Addition of eligibility criteria
NCBPS01T	Teenage and Young Adults Cancer	5,864	12,300	6,436	110%	Increase in ICD qualifying codes from 440 to 759
NCBPS29M	Respiratory - Interstitial lung disease	3,123	3,622	499	5%	Qualifying ICD codes have increased from 7 to 27
NCBPS13F	Cardiac - PPCI and Structural Heart Disease	21,786	21,884	98	0%	Small changes to qualifying OPCS codes and eligibility criteria
NCBPS13G	Cardiac - Pulmonary hypertension	186	4,376	4,190	462%	Reason for discrepancy not apparent
NCBPS23A	Children - Cancer	20,510	18,205	-2,305	-11%	Addition of eligibility criteria
NCBPS23S	Children - Renal	7,205	5,196	-2,009	-28%	Addition of eligibility criteria
NCBPS09Z	Burns Care	2,009	3,931	1,922	96%	Increase in qualifying organisations from 22 to 28
NCBPS19Z	Hepatology & Pancreatic	2,847	2,014	-833	-29%	Reduction in qualifying ICD codes from 107 to 79
NCBPS03Z	Haemophilia	2,903	2,891	-12	0%	Reduction of 1 qualifying ICD code
NCBPS01R	Radiotherapy	10,104	10,104	-	0%	Reduction of qualifying OPCS codes from 28 to 25
NCBPS13B	Cardiac - Cardiac electrophysiology	6,028	6,375	347	6%	Increase in qualifying OPCS codes from 25 to 29
NCBPS17Z	Allergy	2,292	2,552	260	11%	Increase in qualifying OPCS codes from 6 to 9
NCBPS08R	Neurosciences - Neuroradiology	13	196	183	1408%	Increase in qualifying OPCS codes from 276 to 308
NCBPS04C	Women - Fetal Medicine	125	-	-125	-100%	Category dropped from SMT
NCBPS15Z	Cleft Lip Palate	2,161	2,192	31	1%	Increase in qualifying OPCS codes from 80 to 84
NCBPS16Z	Immunology	9,140	9,079	-61	-1%	Addition of eligibility criteria
NCBPS11C	Renal Services - Access for dialysis	12,255	12,290	35	0%	Increase in qualifying OPCS codes from 17 to 19
NCBPS23E	Children - Endocrinology	4,270	4,279	9	0%	Increase in treatment speciality qualifying codes

Costs differentials for the original PSS markers are shown in Figure 8, with changes summarised according to the size of the effect in Table 8. For these markers, applying the new PSS-SMT identification rules tends to reduction in observed cost differentials. This is evident from the reduction in the number of PSS markers in each differential category for Model 1 compared to Table 7, for Model 2 compared to Table 8, and for Model 3 compared to Table 10.

Table 16 Summary of PSS-SMT results by size of difference for original PSS markers

	Model 1		Model 2		Model 3	
	OLS	RE	OLS	RE	OLS	RE
50	7	6	8	6	4	3
25	16	14	16	15	14	13
10	29	24	30	24	26	24
(10)	10	10	10	10	11	10
(25)	5	6	4	5	5	5
(50)	1	1	1	1	1	1

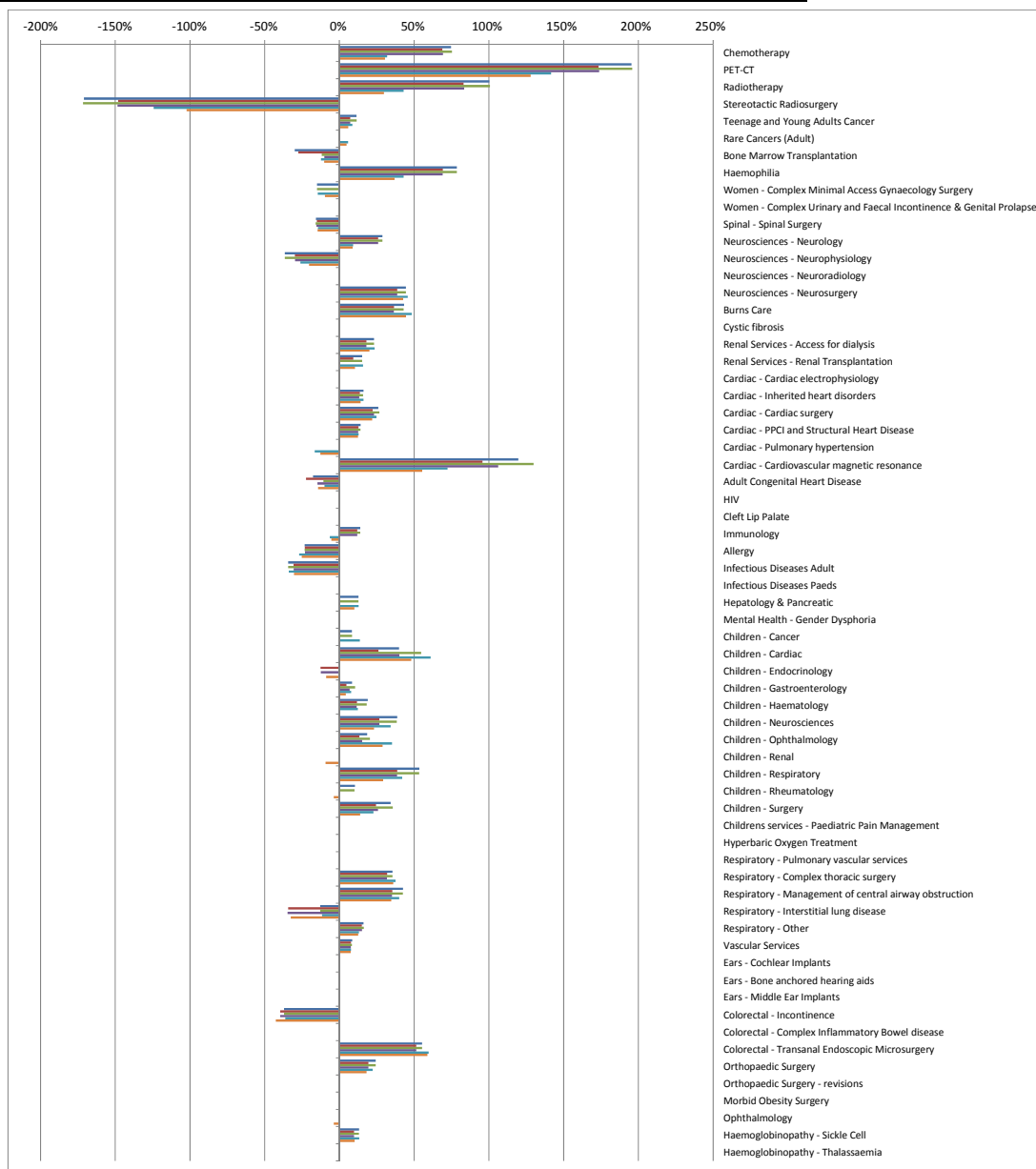


Figure 8 Summary of PSS-SMT results for original PSS markers

There are 35 new PSS-SMT markers. However, some identify very few patients. Indeed, in the 2013/14 analytical sample (ie those for whom costs are available), for six PSS-SMT markers no patients are identified as having received this type of specialised care, and for ten others there are fewer than 100 patients. The number of spells for each of the new PSS-SMT markers is shown in Table 17.

Table 17 Number of spells for the new PSS-SMT markers

Code	Label	Spells
NCBPS01G	Retinoblastoma service	23
NCBPS01I	Choriocarcinoma	21
NCBPS01J	Colorectal - Anal cancer	1,981
NCBPS01K	Thoracic surgery - Malignant mesothelioma	2,267
NCBPS01L	Sarcoma	831
NCBPS01M	Head and Neck cancer	18,432
NCBPS01N	Kidney, bladder and prostate cancer	9,311
NCBPS01O	Sarcoma	680
NCBPS01Q	Rare cancers - Brain and Central Nervous System	3,923
NCBPS01U	Upper gastrointestinal surgery	13,498
NCBPS01V	Rare cancers- biliary tract cancer	1,256
NCBPS01W	Rare cancers - liver cancer	14,312
NCBPS01X	Specialised Urology - Penile cancer	579
NCBPS01Z	Specialised Urology - Testicular cancer	1,185
NCBPS04F	Specialised Gynaecology - cancer	18,660
NCBPS06A	Spinal cord injury	1,254
NCBPS08D	Neuromyelitis optica	82
NCBPS13J	Pulmonary hypertension (children)	87
NCBPS13N	Heart and lung transplantation	<6
NCBPS19T	Hepatobiliary - liver transplant	7
NCBPS19V	Hepatobiliary - pancreatic cancer	3,671
NCBPS22C	Tier 4 CAMHS	<6
NCBPS23G	Adult ataxia telangiectasia service	<6
NCBPS23Q	Paediatric Surgery - Trauma and Orthopaedics	16,351
NCBPS24A	Dermatology - Epidermolysis bullosa	199
NCBPS24B	Xeroderma pigmentosum	<6
NCBPS24Y	Rare skin cancer	17,573
NCBPS24Z	Dermatology	3,522
NCBPS29S	Respiratory - severe and difficult to control asthma	37

The cost differentials from the three models for the new PSS-SMT markers are summarised in Table 18 and Figure 9. For the RE version of Model 3, there are only 4 markers where the cost differentials are in excess of 25%. Of the new PSS-SMT markers, the one that most stands out is NCBPS06A Spinal cord injury, for which the cost differential is upwards of 85% under each model formulation.

Table 18 Summary of PSS-SMT results by size of difference for new PSS-SMT markers

	Model 1		Model 2		Model 3	
	OLS	RE	OLS	RE	OLS	RE
50	3	2	3	2	2	1
25	6	5	6	5	5	4
10	7	7	7	7	8	6
(10)	0	0	0	1	2	2
(25)	0	0	0	0	1	1
(50)	0	0	0	0	0	0

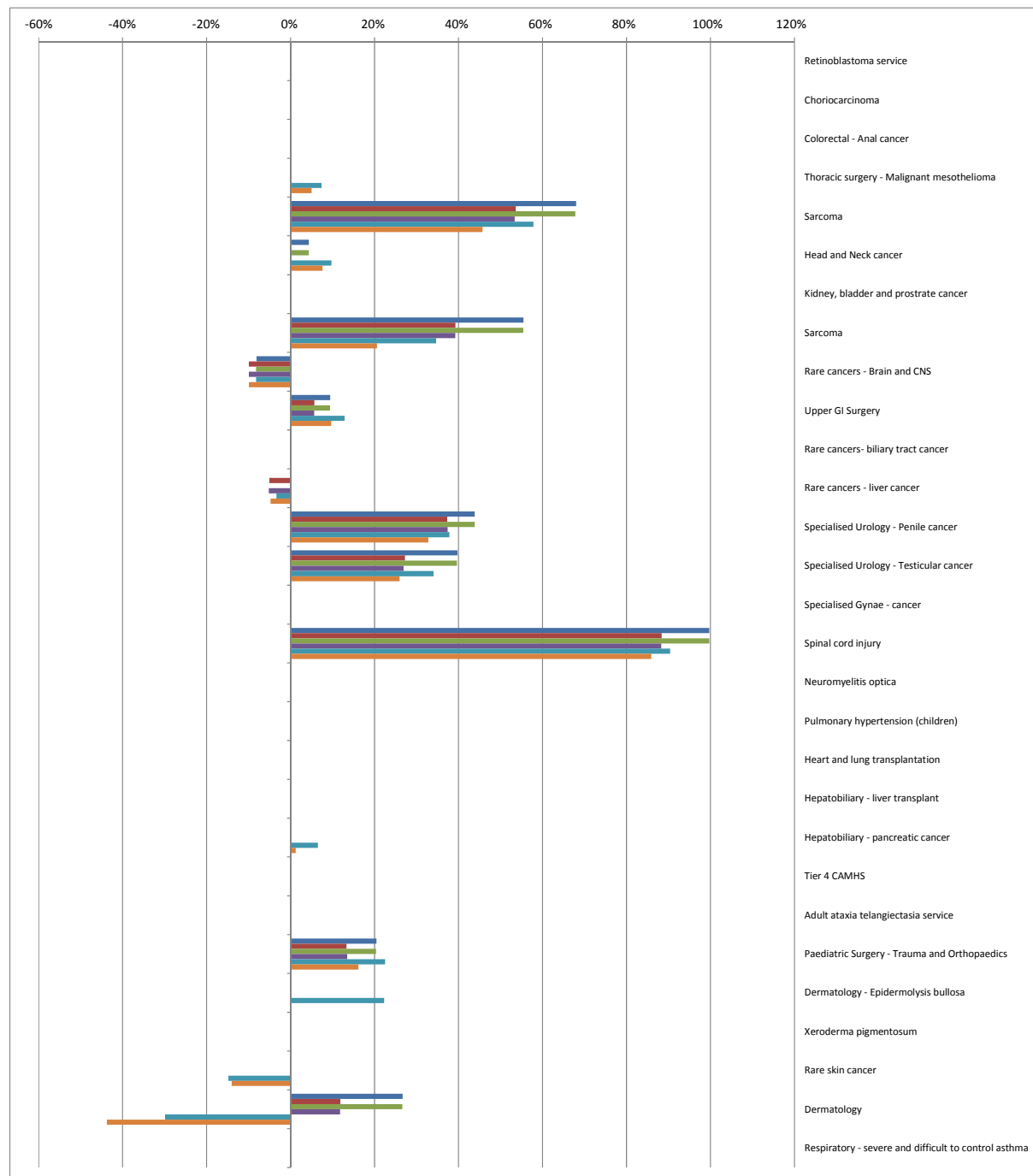


Figure 9 Summary of PSS-SMT results for new PSS-SMT markers

6. Impact analysis and payment mechanisms

In order to illustrate the practical impact of accommodating the estimated additional costs of specialised activity we take our results from the RE specification of Model 3 and calculate the financial impact. This involves taking the number of patients nationally (in HES) who have the PSS marker in question, and applying the percentage cost differential impact to the core tariff to which the patients with this PSS marker are allocated, as specified in Equation 7. In summing the amounts associated with all the positive significant markers, the overall additional costs associated with provision of specialised care are estimated to amount £572m in 2011/12, £628m in 2012/13 and £589m in 2013/14.

Of interest is not just the expected cost of the specialised activity, but also whether there are any preferred methods of payment and what impact they may have on individual providers.

In Figure 10 we plot each of the PSS markers with a significant positive cost differential in terms of its national financial impact and the Gini coefficient measuring hospital concentration. A coefficient of 0 would indicate that activity is spread out evenly across all hospitals and a value of one would indicate that all activity is concentrated in just one provider.



Figure 10 Gini coefficient and financial impact for each PSS marker

As would be expected, in general most of the specialised services seem to be relatively concentrated in a few hospitals with a mean value of Gini=0.88. The minimum Gini coefficient is 0.60 (for Respiratory - Other) to and the maximum is 1 (Gender Dysphoria, Paediatric Pain Management and Hyperbaric Oxygen Treatment). Given that specialised activity is generally highly concentrated within particular hospitals it is clear that failing to compensate for the additional costs of specialised

activity would not affect all hospitals equally. For example, three PSS markers stand out in the upper right of Figure 10: Neurosciences - Neurosurgery, Cardiac surgery and Respiratory - Complex thoracic surgery. These services are only conducted in few hospitals (Gini > 0.9) and have high costs, the national financial impact exceeding £157m, £78m and £74m for each respectively. Failure to account for the additional costs associated with their specialised care would therefore have a substantial punitive effect on those few hospitals who undertake that activity.

In view of this, there is a strong case for compensating at least some specialised activity on the basis of the observed cost differentials and the impact these higher costs may have on individual hospitals. This raises the question of how these extra costs be compensated. The current convention is to apply a top-up to existing HRGs, but it is also worth considering whether it would be preferable to further refine the underlying HRGs to which patients receiving specialised care are allocated.

To address this question we calculate a further measure of concentration, this time the concentration of specialised services across HRGs. If, on the one hand, patients receiving a particular PSS service are allocated to just a few HRGs then there may be a case for splitting those HRGs further to distinguish patients that receive specialised care from those that do not. On the other hand if patients receiving specialised services are spread across many HRGs, then a top-up would appear to be the most viable option, as sub-dividing HRGs would be unfeasible.

To assess HRG concentration we use the CR4 concentration ratio rather than the Gini coefficient. The CR4 ratio measures the proportion of services that are in the most common 4 HRGs. As with the Gini coefficient, higher numbers indicate greater concentration.

To illustrate our approach we examine the 29 services PSS markers where the cost differential was in excess of 10% under the RE specification of Model 3. In Table 19 for each year we report the number of patients nationally (in HES) who have the PSS marker in question, the percentage cost differential (in bold if statistically significant), and applying this differential to core tariff to which the patients with this PSS marker are allocated, as specified in Equation 7.

In Table 20, for the same markers, we report the Gini coefficient (Equation 8), describing the concentration of this specialised activity among hospitals, and the Concentration ratio (Equation 9), describing what proportion of this is concentrated among the four HRGs to which the patients with this PSS marker are allocated.

We use this information to suggest recommendations about how payment arrangements might be refined. Recommendations fall into four main categories:

1. Apply a top-up to the core tariff, reflecting the estimated cost differential, if:
 - The cost differential is stable over time, in terms of both statistical significance and size.
 - Activity is spread across many HRGs, indicated by a $CR4 < 0.8$.
 - If the cost differential is unstable over time, review the differential when 2014/15 data are available.
2. Apply a top-up to the core tariff in the short term, but consider sub-dividing HRGs, if:
 - The cost differential is stable over time, in terms of both statistical significance and size.
 - Activity is concentrated among few HRGs, indicated by a $CR4 > 0.8$.
3. Re-assessment of the criteria used to identify whether or not somebody has received specialised care.
4. Those where no further action appears warranted, usually because matters have changed with the introduction of the PSS-SMT.

Table 19 Financial impact by PSS marker

	Financial Impact	2011/12			2012/13			2013/14		
		HES	M3 RE %	Impact (£000)	HES	M3 RE %	Impact (£000)	HES	M3 RE %	Impact (£000)
NCBPS01P	PET-CT	744	147%	£2,362	1,020	116%	£3,883	1,290	132%	£6,040
NCBPS01R	Radiotherapy	79,774	35%	£15,069	95,742	37%	£22,385	101,472	37%	£20,430
NCBPS01T	Teenage and Young Adults Cancer	14,270	18%	£2,475	13,521	26%	£3,359	13,456	28%	£3,579
NCBPS01Y	Rare Cancers (Adult)	60,329	16%	£18,351	62,886	17%	£21,487	64,478	17%	£22,775
NCBPS03Z	Haemophilia	6,314	31%	£1,497	5,819	28%	£1,905	5,585	23%	£1,229
NCBPS04C	Women - Fetal Medicine	180	-6%	-£16	139	-14%	-£18	145	123%	£521
NCBPS08O	Neurosciences - Neurology	122,866	20%	£32,122	131,733	20%	£39,174	144,318	10%	£21,308
NCBPS08S	Neurosciences - Neurosurgery	75,177	42%	£132,255	77,055	46%	£172,147	79,986	41%	£157,190
NCBPS09Z	Burns Care	5,725	54%	£8,214	5,852	31%	£6,007	6,797	73%	£15,168
NCBPS11C	Renal Services - Access for	15,764	43%	£15,737	16,519	8%	£4,222	17,203	20%	£10,084
NCBPS13C	Cardiac - Inherited heart	5,922	36%	£7,554	6,015	14%	£3,848	6,260	16%	£4,767
NCBPS13E	Cardiac - Cardiac surgery	45,100	22%	£78,273	43,450	24%	£86,464	43,488	22%	£79,265
NCBPS13F	Cardiac - PPCI and Structural Heart	48,612	22%	£30,554	50,161	19%	£35,270	50,482	13%	£25,527
NCBPS13G	Cardiac - Pulmonary hypertension	6,239	9%	£582	1,937	5%	£256	1,153	12%	£391
NCBPS13H	Cardiac - Cardiovascular magnetic	4,517	23%	£3,108	5,484	24%	£4,921	6,123	60%	£13,612
NCBPS23A	Children - Cancer	53,896	5%	£2,508	54,366	11%	£6,360	55,693	11%	£7,210
NCBPS23B	Children - Cardiac	17,853	23%	£13,288	17,723	21%	£9,434	18,169	18%	£8,660
NCBPS23M	Children - Neurosciences	16,521	45%	£14,014	16,904	42%	£16,352	16,824	24%	£9,576
NCBPS23N	Children - Ophthalmology	7,780	15%	£1,118	8,089	15%	£1,292	8,676	30%	£2,727
NCBPS23T	Children - Respiratory	9,667	42%	£4,399	11,232	39%	£4,896	11,825	30%	£4,293
NCBPS23X	Children - Surgery	123,421	13%	£36,093	130,441	17%	£48,764	137,885	15%	£45,840
NCBPS29B	Respiratory - Complex thoracic	41,743	38%	£91,053	39,175	31%	£69,783	37,283	35%	£74,736
NCBPS29E	Respiratory - Management of	3,103	54%	£4,520	3,161	81%	£8,883	3,428	47%	£5,336
NCBPS29R	Respiratory - Other	23,365	11%	£10,123	26,203	13%	£17,262	27,326	13%	£17,791
NCBPS32A	Ears - Cochlear Implants	1,250	-29%	-£51	1,096	-28%	-£78	1,086	68%	£59
NCBPS33C	Colorectal - Transanal Endoscopic	535	57%	£583	585	35%	£529	543	55%	£789
NCBPS34A	Orthopaedic Surgery	1,999	13%	£1,619	1,957	23%	£2,203	1,942	20%	£1,992
NCBPS34R	Orthopaedic Surgery - revisions	187	32%	£433	191	28%	£354	138	32%	£318
NCBPS99Z	Highly Specialised	16,847	52%	£26,630	16,225	69%	£3,410	12,067	29%	£6,569

Table 20 Gini coefficient and concentration ratio by PSS marker

	Concentration measures	2011/12		2012/13		2013/14	
		GINI	CR4	GINI	CR4	GINI	CR4
NCBPS01P	PET-CT	0.96	0.26	0.96	0.11	0.95	0.11
NCBPS01R	Radiotherapy	0.97	0.82	0.97	0.84	0.97	0.86
NCBPS01T	Teenage and Young Adults Cancer	0.81	0.58	0.8	0.55	0.82	0.56
NCBPS01Y	Rare Cancers (Adult)	0.76	0.44	0.72	0.41	0.72	0.42
NCBPS03Z	Haemophilia	0.91	0.81	0.89	0.78	0.89	0.74
NCBPS04C	Women - Fetal Medicine	0.97	0.87	0.97	0.88	0.96	0.84
NCBPS08O	Neurosciences - Neurology	0.88	0.5	0.87	0.52	0.86	0.52
NCBPS08S	Neurosciences - Neurosurgery	0.92	0.26	0.92	0.23	0.92	0.24
NCBPS09Z	Burns Care	0.98	0.75	0.97	0.9	0.97	0.88
NCBPS11C	Renal Services - Access for dialysis	0.9	0.58	0.88	0.63	0.88	0.43
NCBPS13C	Cardiac - Inherited heart disorders	0.73	0.81	0.7	0.45	0.69	0.43
NCBPS13E	Cardiac - Cardiac surgery	0.91	0.49	0.9	0.26	0.9	0.26
NCBPS13F	Cardiac - PPCI and Structural Heart Disease	0.82	0.92	0.79	0.81	0.79	0.8
NCBPS13G	Cardiac - Pulmonary hypertension	0.95	0.94	0.95	0.69	0.93	0.7
NCBPS13H	Cardiac - Cardiovascular magnetic resonance	0.95	0.47	0.93	0.31	0.93	0.27
NCBPS23A	Children - Cancer	0.9	0.69	0.89	0.71	0.9	0.7
NCBPS23B	Children - Cardiac	0.86	0.49	0.84	0.58	0.85	0.42
NCBPS23M	Children - Neurosciences	0.96	0.27	0.96	0.26	0.96	0.24
NCBPS23N	Children - Ophthalmology	0.82	0.36	0.79	0.31	0.8	0.31
NCBPS23T	Children - Respiratory	0.97	0.46	0.95	0.51	0.95	0.46
NCBPS23X	Children - Surgery	0.81	0.36	0.78	0.37	0.79	0.38
NCBPS29B	Respiratory - Complex thoracic surgery	0.92	0.38	0.9	0.3	0.9	0.32
NCBPS29E	Respiratory - Management of central airways	0.86	0.36	0.84	0.4	0.84	0.38
NCBPS29R	Respiratory - Other	0.66	0.31	0.6	0.22	0.6	0.2
NCBPS32A	Ears - Cochlear Implants	0.96	0.99	0.95	0.99	0.95	0.99
NCBPS33C	Colorectal - Transanal Endoscopic Microsurgery	0.94	0.95	0.92	0.87	0.91	0.86
NCBPS34A	Orthopaedic Surgery	0.81	0.38	0.8	0.37	0.79	0.38
NCBPS34R	Orthopaedic Surgery - revisions	0.96	0.7	0.93	0.5	0.91	0.54
NCBPS99Z	Highly Specialised	0.95	0.16	0.94	0.16	0.99	0.16

Table 21 Recommendations by PSS marker

		Comments	Recommendation
NCBPS01P	PET-CT	This is a diagnostic imaging procedure which is an unbundled service. Patients having PET-CT appear across many HRGs, even more so given the change from HRG4 to HRG4+, and this is reflected in the decreased CR4	Consider dropping as specialised service because it is unbundled.
NCBPS01R	Radiotherapy	Stable, highly concentrated among HRGs	Top-up initially but consider HRG split
NCBPS01T	Teenage and Young Adults Cancer	Stable	Top-up
NCBPS01Y	Rare Cancers (Adult)	Revised under PSS-SMT, with only a third of PSS patients now identified under PSS-SMT	Coefficient under PSS-SMT no longer large enough to warrant action (5%)
NCBPS03Z	Haemophilia	Stable, fairly concentrated among HRGs	Top-up initially but consider HRG split
NCBPS04C	Women - Fetal Medicine	Unstable and small numbers	No action - this doesn't appear in the PSS-SMT
NCBPS08O	Neurosciences - Neurology	Unstable, with differential falling over time	Possible top-up, if differential remains in future
NCBPS08S	Neurosciences - Neurosurgery	All patients seen by a neurosurgeon are deemed specialised	Top-up initially but revise definition so that it is based on patient characteristics
NCBPS09Z	Burns Care	Unstable, highly concentrated among hospitals and HRGs. There is a clearer definition of what constitutes major burns under HRG4+	Top-up, but review when 14/15 data are available. Consider HRG split
NCBPS11C	Renal Services - Access for dialysis	Unstable	Top-up, but review when 14/15 data are available.
NCBPS13C	Cardiac - Inherited heart disorders	Increase from 52 HRGs in HRG4 to 145 in HRG4+ cardiac sub-chapters, so CR4 has fallen	Top-up
NCBPS13E	Cardiac - Cardiac surgery	Increase from 52 HRGs in HRG4 to 145 in HRG4+ cardiac sub-chapters, so CR4 has fallen	Top-up
NCBPS13F	Cardiac - PPCI and Structural Heart Disease	Increase from 52 HRGs in HRG4 to 145 in HRG4+ cardiac sub-chapters, so CR4 has fallen. Differentials falling over time	Possible HRG split if differential remains in future
NCBPS13G	Cardiac - Pulmonary hypertension	Increase from 52 HRGs in HRG4 to 145 in HRG4+ cardiac sub-chapters, so CR4 has fallen	Top-up
NCBPS13H	Cardiac - Cardiovascular magnetic resonance	Increase from 52 HRGs in HRG4 to 145 in HRG4+ cardiac sub-chapters, so CR4 has fallen	Top-up

NCBPS23A	Children - Cancer	Stable	Top-up
NCBPS23B	Children - Cardiac	Increase from 52 HRGs in HRG4 to 145 in HRG4+ cardiac sub-chapters, so CR4 has fallen	Top-up, but note fewer patients identified under PSS-SMT
NCBPS23M	Children - Neurosciences	Stable	Top-up
NCBPS23N	Children - Ophthalmology	Stable	Top-up
NCBPS23T	Children - Respiratory	Stable	Top-up
NCBPS23X	Children - Surgery	Stable	Top-up, but note fewer patients identified under PSS-SMT
NCBPS29B	Respiratory - Complex thoracic surgery	Stable	Top-up
NCBPS29E	Respiratory - Management of central airway obstruction	Unstable	Top-up, but review when 14/15 data are available.
NCBPS29R	Respiratory - Other	Stable differential, but not highly concentrated among providers	Revisit definition: is this identifying rare and complex care?
NCBPS32A	Ears - Cochlear Implants	Stable, highly concentrated among HRGs	Top-up initially but consider HRG split
NCBPS33C	Colorectal - Transanal Endoscopic Microsurgery	Stable, highly concentrated among HRGs	Top-up initially but consider HRG split
NCBPS34A	Orthopaedic Surgery	Stable, increase in HRGs in subchapter HA - Orth. Trauma Procedures (goes up from 56 HRG4 to 64 HRG4+	Top-up
NCBPS34R	Orthopaedic Surgery - revisions	Stable, increase in HRGs in subchapter HA - Orth. Trauma Procedures (goes up from 56 HRG4 to 64 HRG4+	Top-up, but low numbers
NCBPS99Z	Highly Specialised	Unstable	Top-up, though not implemented under PSS-SMT

These recommendations for each of the 29 PSS markers are set out in Table 21. By way of illustration we summarise the reasoning for a selected PSS marker in each category.

NCBPS13E Cardiac surgery

The recommendation is to apply a top-up to reflect the higher costs of this specialised care.

- The cost differential is stable over time, with costs around 22% higher for patients that receive this form of specialised care than for other patients allocated to the same HRGs.
- The overall financial impact is substantial, estimated to amount to £79m in 2013/14, and activity is highly concentrated among hospitals, with the Gini>0.9, so payment arrangements will have a material impact on these hospitals.
- This activity is spread across many HRGs, even more so following the greater differential of cardiac sub-chapters in HRG4+ compared to HRG4. With a CR4=0.26, a top-up payment is recommended.

NCBPS01R Radiotherapy

The recommendation is to apply a top-up in the short-term, but to consider sub-dividing HRGs.

- The cost differential is stable over time, with costs around 37% higher for patients that receive this form of specialised care than for other patients allocated to the same HRGs.
- The overall financial impact is fairly substantial, estimated to amount to £20m in 2013/14, and activity is extremely concentrated among hospitals, with the Gini>0.97, so payment arrangements will have a material impact on these hospitals.
- This activity is concentrated within a handful HRGs, with a CR4=0.86. It is worth considering whether the rules used to identify whether or not somebody has received this form of specialised service are simply used to define a separate HRG. If this is done, the future tariff for this new HRG will correctly compensate for the cost of caring for such patients.

NCBPS08S Neurosciences – Neurosurgery

The recommendation is to apply a top-up in the short-term but to review PSS identification rules.

- The cost differential is stable over time, with costs around 41% higher for patients that receive this form of specialised care than for other patients allocated to the same HRGs.
- The overall financial impact is substantial, estimated to amount to £157m in 2013/14, and activity is highly concentrated among hospitals, with the Gini=0.92, so payment arrangements will have a material impact on these hospitals.
- This activity is spread across many HRGs, With a CR4>0.23, a top-up payment is recommended – in the short-term.
- However, patients are identified as having received specialised care if they are treated by a neurosurgeon. This is a poor way of identifying receipt of specialised care as it is not driven by characteristics of patients but by treatment decisions made by the hospital. It is recommended that these identification rules be reviewed.

NCBPS01Y Rare Cancers (Adult)

No change to payment arrangements are recommended for this PSS marker.

- This is because, with the introduction of PSS-SMT, fewer patients are identified under the revised identification rules – there were 30,019 in the analytical sample for Model 3 based on the PSS rules but only 11,740 in the analysis based on PSS-SMT rules.
- Because only a subset of the former patients is now identified under PSS-SMT, the cost differential has fallen from 17% to 5%. This differential does not warrant a top-up.
- The likelihood is that patients formerly allocated to this PSS marker are now being allocated to newly defined PSS-SMT markers, some of which merit consideration for top-up arrangements.

The new PSS-SMT markers for which top-up payments might be considered are shown in Table 22.

Table 22 PSS-SMT for consideration for top-up payments

PSS-SMT marker	OLS %	RE %
Sarcoma	58%	46%
Head and Neck cancer	10%	8%
Sarcoma	35%	21%
Upper GI Surgery	13%	10%
Specialised Urology - Penile cancer	38%	33%
Specialised Urology - Testicular cancer	34%	26%
Spinal cord injury	90%	86%
Paediatric Surgery - Trauma and Orthopaedics	23%	16%

7. Conclusion

7.1 Brief summary of findings

The policy for the English NHS of concentrating specialised services in particular providers is designed to improve outcomes for people with relatively rare conditions. But the payment system needs to be aligned with this policy ambition, so that hospitals that provide specialised care are not penalised financially for doing so. To address this we have assessed by how much costs are higher for patients that receive specialised care than for other patients allocated to the same payment group and, if so, how payment policy might be refined.

There is no universally agreed definition of what constitutes specialised hospital care, but in England attempts have been made to define specialised care according to the presence of specific diagnoses and procedures in each patient's medical record. The definition sets have been revised over time, the previous SSNDS having been replaced by the PSS. Out of 16,964,893 patients treated in English hospitals in 2013/14, 10.5% were identified as having received specialised care under PSS rules and 11.8% under PSS-SMT rules.

We have applied the PSS sets of rules to determine whether the receipt of specialised care is associated with higher costs relative to patients who have not received specialised care who are assigned to the same set of HRGs. To do this, we have matched HES records to Reference Costs reported by each NHS hospital.

- For 29 of the 69 PSS markers, we find cost differentials in excess of 10% when analysing the cost of the core HRG to which patients are allocated (Model 3 RE).
- Only 24 of these 29 PSS markers have cost differentials in excess of 10% when the updated PSS-SMT rules are applied.
- We find that 6 of the 35 new PSS-SMT markers have cost differentials in excess of 10% (Model 3 RE).
- We observe fewer cost differentials when considering excess bed day costs (Model 5 RE), the differential being in excess of 10% for only 9 PSS markers.

The additional costs associated with the provision of specialised care to the entire patient population are estimated to amount £572m in 2011/12, £628m in 2012/13 and £589m in 2013/14.

7.2 Implications for payment policy

The existence of large (>10%) cost differentials is a necessary but not sufficient condition for changing either the HRG classification system or making top-up payments.

In our work we further considered materiality, in terms of both the financial impact and the number of hospitals treating patients receiving specialised care. For those markers for which the estimated cost differential is deemed to have a material impact, we suggest two ways in which payment policy might be refined.

First, HRGs might be re-defined, so that they better separate higher cost patients that receive specialised care from those that do not. This strategy is most easily adopted for those types of specialised care where patients are concentrated in a limited number of HRGs, evaluated by calculating the proportion of specialised activity concentrated among the four largest HRGs to which these patients are assigned. PSS markers identified as candidates for HRG split include Radiotherapy, Cardiac - PPCI and Structural Heart Disease Ears - Cochlear Implants; and Colorectal - Transanal Endoscopic Microsurgery.

In cases where patients are distributed across many HRGs, payments rather than HRGs might be refined, with top-up payments made to reflect the additional costs associated with receipt of specialised care. Top-up payments can be made to the core tariff, if cost differentials are evident when analysing costs associated with the core HRG to which patients are allocated. They may also be made to the excess bed day tariff, but cost differentials are less evident in the analysis of these costs.

Top-up payments are currently made in England for four types of specialised care as defined by the SSNDS (Monitor & NHS England, 2013), namely children's specialised care, neurosciences, orthopaedics, and spinal surgery. These additional payments were informed by previous analyses of 2009/10 data (Daidone and Street, 2011a, Daidone and Street, 2011b, Daidone and Street, 2013). Our analyses of more recent data suggest that there remain grounds for making top-up payments for specialised care, as now defined using the PSS definitions.

We identify 20 of the original PSS markers as candidates for top-ups including several cardiac and children's services. The four PSS markers that might subject to a sub-division of their HRGs are recommended for top-up payments in the interim before this sub-division is implemented. The following new PSS-SMT markers implemented in the PSS Shadow Monitoring Tool are also candidates for top-up arrangements: Sarcoma, Head and Neck cancer – Sarcoma; Upper GI Surgery; Specialised Urology - Penile cancer; Specialised Urology - Testicular cancer; Spinal cord injury; and Paediatric Surgery - Trauma and Orthopaedics.

7.3 Limitations

There is a large US literature analysing hospital costs that relies on charge data (eg see (Frakt, 2011) for a review). Reference cost data are analogous to the charge data reported to the Healthcare Cost Report Information System (HCRIS). Neither US charge data nor English RC data capture precisely the costs of care for each individual patient (Dunham-Taylor and Pinczuk, 2006). The RC assigned to each patient is based on the hospital in which they were treated, their method of admission (ie Point of Delivery code: day case, elective, non-elective), the specialty in which they were treated (ie service code e.g. general surgery), the HRG to which they are assigned, their excess bed days above their HRG-specific trimpoint, any unbundled HRGs associated with their care, and if there are multiple FCEs as part of their hospital spell.

The limitation of using RC data is that patients that share the same characteristics used for assignment are assigned the same RC. As a limiting example, if all the elective patients in a particular hospital, speciality, and HRG all had single FCE spells, and no excess bed days or unbundled costs, then they would all have the same cost. For the analysis, this means that the RC data exhibit less variation than occurs in reality. If some of this unobserved variation is related to the receipt of specialised care, then the estimates of the cost differentials will be biased, most probably in a downward direction. Recognising this limitation we also analysed variation in LoS. It is reassuring that cost differentials are more likely to be observed than LoS differentials.

Patient-level information and costing services (PLICS) could alleviate the drawback of using RC, as the system used in the construction of patient-level costs ought to take account of more specific drivers of resource use than do the RC allocations. But PLICS will not resolve the problem entirely because judgments still have to be made about how to apportion shared costs among individual patients (Jackson, 2001). Also, on a practical level, PLICS will not be available in England for all patients in the near future. PLICS reporting is currently not mandatory and for the latest year of data we consider (2013/14) only 42% (68 providers) of all acute trusts were reporting patient level costs; and participating hospitals were not representative of the overall population of hospitals.

As PLICS data become available, payment arrangements can be progressively refined. Refinements might involve construction of more resource homogenous HRGs and better calculation of the core tariff and of excess bed day prices associated with each HRG. In the meantime, our analyses indicate for which types of specialised services refinements are required to current HRG tariffs so that policy ambitions to further the concentration of specialised services are not thwarted by an inadequate payment system.

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Appendix

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