Comparison of costing methodologies applied to cost profiles at the end of life

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Abstract

Background: There is no single ideal method of applying costs consistently to the follow-up of a long-term randomised controlled trial. We therefore aimed to establish a preferred method by comparing different methodologies for costing inpatient resource use identified in CAP (**C**luster randomised tri**A**l of testing for **P**rostate cancer), a long-running trial to evaluate the effectiveness and cost-effectiveness of prostate-specific antigen (PSA) testing for prostate cancer. A clinically interesting example of costs in the final year of life was used to investigate the differences between methodologies.

Methods: Cost profiles were derived for inpatient costs incurred in the final year of life using three different methodologies. Men identified as having died of or with prostate cancer in the CAP trial were selected (*n*=203), and inpatient events were extracted from medical records (MR). Two different costing mechanisms were then applied. In the first, finance departments in the eight key participating trusts were contacted to request costs for the resource use relevant to their trust. In the second, MR data were mapped to NHS reference costs via service codes. For men for whom Hospital Episodes Statistics (HES) data

were available (*n*=50), a third comparison was made with a profile derived using routine healthcare resource group (HRG) data.

Results: The end-of-life profiles all followed the recognized pattern of a noticeable rise in costs in the months leading up to death. Using MR data, the mean cost per patient in the final year of life was £9600 (95%CI:£5200,£14020) for finance department costs and £9300 (95%CI: £5290,£13320) for reference costs; however, the profiles were broadly similar. The costs derived using HRGs in the HES dataset were somewhat lower, with a mean of only £6980 over the final year before death.

Conclusions: If MR data are available, applying costs from the national NHS reference costs is unlikely to give substantially different results to those acquired by contacting finance departments, and is significantly less labour intensive; using reference costs is therefore the preferred method. Using HRG data is less labour intensive, but may underestimate the relevant costs; this could be particularly problematic in a trial with long-term follow-up if there is differential underestimation of costs between the trial arms.

Further work: We plan to extend the comparisons to total costs including outpatient appointments, apply a more granular breakdown of costs based on the location in which they were incurred and further investigate the reasons for low cost estimates using HRG data.

Introduction

While guidelines have long recommended reporting resource use and unit costs separately (NICE, 2008; Drummond and Jefferson, 1996), there is little guidance on appropriate sources of unit costs. A review of costing methodologies found that although there was consistency in the basic principles of costing, even guidelines contained disagreements about how best to apply costs to resource use (Mogyorosy and Smith, 2005). This has led to different costing methodologies being applied in different combinations on a trial-by-trial basis, making comparison between studies difficult. There has been substantial variation in costing methods applied within cost-effectiveness analyses (CEA), and a need for the influence of costing method on the results of CEA to be further studied has been identified (Neumann, 2009), as results are known to be affected by the costing methods used (Reed *et al*, 2003). Attempts have been made to improve the standardisation of costing methods to improve comparability across studies (Jacobs *et al*, 2005; Oostenbrink *et al*, 2002; Adam *et al*, 2003). However, efforts are hampered by a lack of transparency in reporting, with many studies reporting costing methodologies in an opaque fashion (Fukuda and Imanaka, 2009).

There are necessary tradeoffs between research resources available and the accuracy of the costs that can be obtained. So-called top-down gross-costing approaches based on average patients and a highly aggregated level of costs are relatively cheap to execute, but result in less accurate results, while bottom-up micro-costing data based on individual patients and a detailed breakdown of costs can be expensive to collect, but give a high level of accuracy (Tan *et al*, 2009). Between these two extreme approaches lies a continuum on which most studies will lie. It is possible that cost differences observed in rcts might be artefacts of costing methodology rather than genuine differences; however, there are few studies that quantify differences that could be attributable to methodology (Olsson, 2011). Within the social welfare field, a comparison between top-down and bottom-up approaches indicated that both produced similar results in the context of a randomised controlled trial (rct) (Olsson, 2011). For hospital services, limiting the use of costly bottom-up micro-costing to the most significant costs only is considered likely to give reliable results (Tan *et al*, 2009).

However, a further study found inconsistent results when comparing bottom-up and top-down methods in different centres, with closer agreement found in specialist units than in units with more generalist staffing models (Wordsworth *et al*, 2005). In a Canadian trial of sirolimus-eluting stents, (Clement *et al*, 2009) compared costs derived using a micro-costing method and two gross-costing methods; the three different methods gave rise to substantially variable cost estimates, to the point where the effect on incremental cost–utility ratios could have led to a change in implementation decision. A study based on Scottish data has looked at five different top-down methods of costing hospital inpatient stays, comparing two DRG-based costing methods and three methods incorporating a *per diem* approach. The authors found substantial differences in overall costs depending on the costing method employed with higher costs observed when using a *per diem* approach, and recommended using an HRG-based costing method. However, the study was restricted to acute episodes, and did not use the English HES data. In preliminary work, (Dakin *et al*, 2011) found that using HRG data resulted in lower costs than a micro-costing approach in the context of a trial studying age-related macular degeneration. A comparison of a DRG-based costing system with micro-costing in Ireland concluded that for disease areas with high-cost treatments, DRG estimates do not yield reliable results and micro-costing should be considered (Heerey *et al*, 2002).

Typically, health economists have consulted finance departments in NHS trusts to ask for cost data relating to resource use that has been identified within a trial. A recent review found that over half the HTA studies that reported an economic evaluation used costs from local sources (Ridyard and Hughes, 2010). However, this can be a time-consuming process, and may not represent the best use of research resources. Increased access to cost data in the UK is affording researchers opportunities for studying healthcare using novel methods. For example, the NHS reference costs are freely available on an unrestricted basis. Submitted annually by all trusts in England, the reference costs list the costs associated with each of the healthcare resource groups (HRG) currently in use. The same HRG is assigned to patients with similar diagnoses who undergo procedures that are considered to consume

similar levels of healthcare resources. This case mix system originated in the early 1980s based on the diagnosis-related groups (DRGs) used in the US, and has subsequently undergone substantial development (Street and Dawson, 2002).

Data relating to hospital use in England are routinely collected by hospitals and collated by the NHS Information Centre to form the Hospital Episode Statistics dataset, a national data warehouse (HES, n.d.). Covering care provided by NHS hospitals in England and for NHS hospital patients treated elsewhere, the datasets include inpatient events from 1989 onwards, outpatient events starting from 2006 and accident and emergency data from 2008 onwards. Using these data as a base from which to identify relevant resource use is very attractive from a time and cost point of view; tracking patients who may have moved round the country is substantially easier than locating medical notes in multiple centres. However, the data have not been validated for use in economic evaluation costing studies, and therefore it is not possible to say how accurate or complete they are; researchers and policy makers cannot be confident the results reported are correct without some form of validation having been undertaken (van Walraven *et al*, 2011). Whilst HES has been used as a source of resource-use data, this has tended to be in modelling studies that have not used individual data (Van Staa *et al*, 2009) or in studies where resource use has been measured for a particular patient group (Subramanian *et al*, 2009). Although HES data have been used for costing purposes (for example, (Desborough *et al*, 2011)), we are not aware of any exemplar studies in which HES data have been extensively used to measure resource use in an rct or where comparisons have been made of treatment for the same population group, which would necessitate a higher quality of data.

Data such as HES are primarily recorded for the purposes of administering the health service and, as such, are not specifically designed for research purposes. Therefore, there may be limitations to the usefulness of the dataset. A study from the US perspective found that cost estimates could vary substantially depending on source (Riley, 2009). The fact that

DRGs are non-specific could potentially render them less useful in the context of a CEA; however, they were found to be no better or worse than methods based on ICD codes or a method involving stratification by risk group in a modelling context (Chumney *et al*, 2004). As the costs associated with HRGs are used primarily to drive reimbursement, they might represent the true costs from a purchaser perspective but not the true opportunity costs to society.

Healthcare at the end of life is topically interesting, with NICE having issued additional guidance for considering interventions that might increase the length of life for patients close to death (NICE, 2009). This paved the way for treatments to be considered for funding even if their incremental cost-effectiveness ratio (ICER) exceeded the commonly applied thresholds, although recent research has suggested that society may not support this approach (Shah *et al*, 2012). A sharp increase in the costs associated with healthcare resources consumed is typically observed in the last months before death (Reed *et al*, 2012; Forma *et al*, 2007; Calver *et al*, 2006), with prostate cancer having highest costs close to diagnosis and death (Krahn *et al*, 2009). Specific to the UK, a report from the Nuffield Trust found that the inpatient costs per month increased steadily but slowly from twelve months before death to six months before death, rose more rapidly from six months to two months before death, and rose very sharply in the final two months of life (Bardsley *et al*, 2010). Inpatient costs in the final month of life represented 35% of inpatient costs over the whole of the last year.

In this study, we aim to compare costs assigned to trial data using three different costing methodologies. Two of the methods are based on resource-use data collected through medical record review, while the third utilises routinely collected HES data. In order to do this, we look at the clinically interesting problem of costs applied to patients in their final year of life. Inpatient events were analysed first as these are known to be key healthcare cost drivers (Bardsley *et al*, 2010).

Methods

Measurement of resource use

The **C**luster randomised tri**A**l of testing for **P**rostate cancer (CAP) is a large, multi-centred primary care based trial which is evaluating the effectiveness and cost-effectiveness of prostate-specific antigen (PSA) testing via a primary outcome of prostate cancer mortality at a median of 10 years follow-up. General practices in eight centres within the UK are allocated to either intensive case-finding using the PSA test as part of the ProtecT trial (see (Lane *et al*, 2010)) or usual practice. Participants are all men aged 50–69 who are registered with one of the study practices. Secondary care resource-use data for a small sample of men from the CAP trial have been made available in order to carry out this methodological study. As part of the CAP trial, and on an ongoing basis, a detailed review of medical records (MR) is conducted for men who have been diagnosed with prostate cancer or who die with prostate cancer cited on the death certificate. Trent MREC provided ethical approval for review of MR for men with prostate cancer following receipt of informed consent [05/MRE04/78]. The PIAG/NIGB ECC granted support for reviewing MR of men who potentially died of a cause related to prostate cancer before we could gain their consent (provided no objection to their MR being used for research was recorded whilst alive) [PIAG 1-05(f)/2006]. The dataset for this sub-study is made up of men in CAP who fulfil three conditions: (1) they have died, (2) they have had a diagnosis of prostate cancer and (3) MR review has been completed. As such, they represent an arbitrary, but not truly random, sample. Men from each of the eight CAP centres were included and were drawn from both intervention and usual care arms of the trial, with the researcher (JT) blinded to trial arm. HES inpatient records were also available for a subset of English men.

All inpatient events whether related to prostate cancer or not were identified in MR review; start and end dates for each event were recorded along with the type of ward in which the event took place. Hospice care and day cases were excluded. HES records included episode start dates, durations, and HRG3.5 codes. In the absence of data describing the type of stay, day cases were defined as stays of zero nights and were not included. For men for

whom HES data were available, a detailed manual cross-check of events occurring in MR review and HES records was conducted.

Application of costs

For resource use identified in MR review, costs were assigned on the basis of the type of ward in which the inpatient event had occurred and the length of stay; information on whether the admission was elective or emergency was not available. Two methods of applying costs were used.

In the first, finance departments were contacted with requests for information based on the cost of a patient's overnight stay in, for example, a urology ward. Trusts in each of the eight areas participating in CAP were sent a tailored questionnaire designed to minimise the burden on respondents by only requesting information relating to events that occurred within that trust. Questionnaires were emailed to named contacts identified by CAP researchers, with a request to return the information within four weeks. Periodic reminders were sent by email over a period of five months, and departments were contacted by telephone in order to ascertain whether there might be any problems with fulfilling the request. Returned costs were standardised to a common cost year (Curtis, 2011) and averages were calculated for each type of event; where no costs were available, an overall mean weighted by level of activity was employed.

The second method of applying costs to MR review inpatient events involved using the publicly available NHS reference costs, which are calculated on a full absorption basis. Ward types from MR review for each event were mapped to service codes describing the specialty under which the patient was treated in the NHS reference costs. For example, urology has a service code of 101, while cardiology is represented by 320. Using a dataset containing organisation-specific costs for 2010/11 (Department of Health, 2011), median national costs were derived for a patient's overnight stay in each of the listed service codes, covering

elective and non-elective inpatient (both short and long stays), but excluding PCT data and outsourced events. Where mapping was not possible, an overall mean cost was used.
For resource use identified via HES records, HRG3.5 codes were used to apply costs from the 2005/6 NHS reference costs (the most recent year for which HRG3.5 costs were published), taking elective and non-elective admissions into account. Costs were then inflated to 2010/11 levels (Curtis, 2011).

End-of-life cost profiles

Statistical analysis was carried out using Stata 12 (StataCorp, 2011). For MR review resource use, costs were assigned to the month prior to death in which they occurred on a *per diem* basis, while for HES resources, costs were assigned to the month in which the first day of the episode occurred to reflect the fixed-cost nature of HRGs. Profiles were derived for mean costs incurred on a monthly basis over the last year of life. Mean resource use over the final year of life was also calculated for each of the three costing methods.

Results

Datasets

MR review was conducted for 203 men who died between 2001 and 2011, representing all 8 centres participating in CAP in England and Wales. The mean time from diagnosis to death was 652 days, and the mean age at death was 67.26 years. 121 deaths (60%) were definitely or probably due to prostate cancer, while 82 (40%) were believed to be attributable to other causes by the MR reviewer.

HES data were available for a subset of 50 of these men who died between 2005 and 2009, covering 7 CAP centres in England only as HES does not capture Welsh data. These men died after an average of 639 days from their diagnosis of prostate cancer at an average age of 66.26 years. 39 deaths (78%) were definitely or probably due to prostate cancer, while 11 (22%) were attributed to other causes by the MR reviewer.

Full sets of requested costs were obtained from 3 out of 8 finance departments and a further partial set was received from a fourth department. Four departments had been unable or unwilling to supply costs after a period of 6 months. 26% of patients (52/203) were therefore missing costs for at least one ward type and only approximately 75% of inpatient nights were covered using this method.

MR review costing methodology comparison

End-of-life cost profiles were derived for inpatient resource use consumed in the final year of life identified during MR review and costed using finance department returns (figure 1) and national NHS reference costs (figure 2) for the full sample (*n*=203). Mean resource use over the final year was £8760 (95%CI: £6720,£10790) for finance departments and £9830 (95%CI: £7340,£12330) using reference costs.

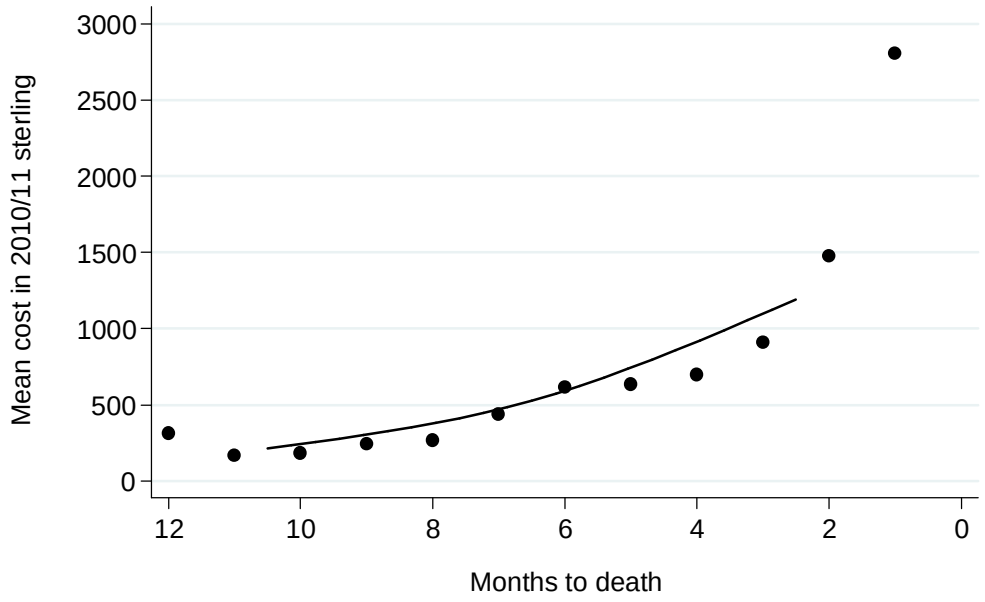


Figure 1. End-of-life cost profile for men who have been diagnosed with prostate cancer. Resource use is identified through MR review and valued with costs from finance departments.

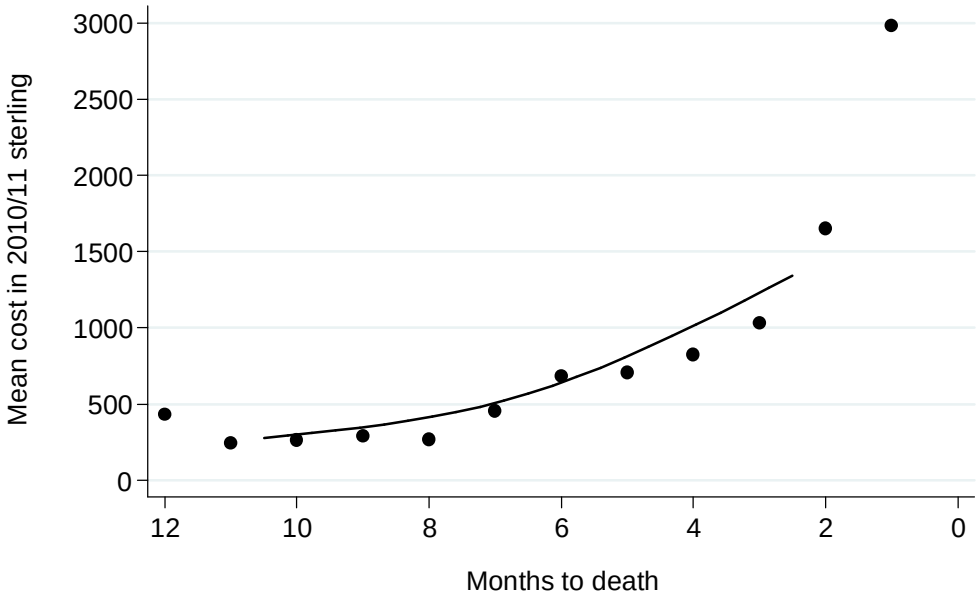


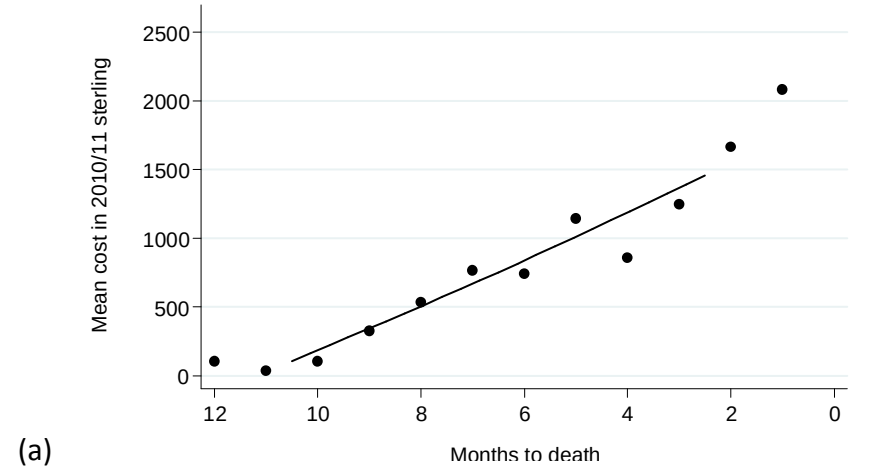
Figure 2. End-of-life cost profile for men who have been diagnosed with prostate cancer. Resource use is identified through MR review and valued with national NHS reference costs.

HES end-of-life profile comparison

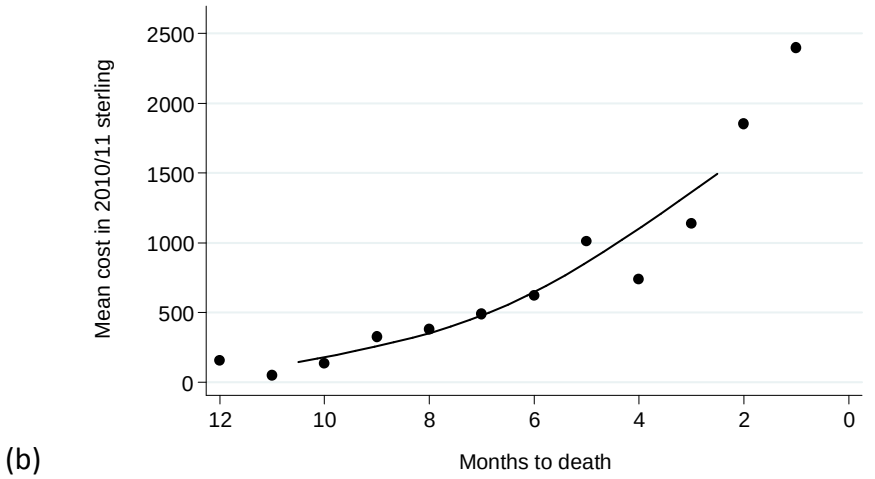
An end-of-life cost profile was constructed for the men in the HES sample (*n*=50) and, for comparative purposes, profiles using MR review finance returns and reference costs were repeated for the same men (figure 3). For these men, mean resource use per patient over the final year of life was £9600 (95%CI:£5200,£14020) using MR review coupled with finance-department costs, £9300 (95%CI: £5290,£13320) using MR review and national reference costs and £6980 (95%CI: £4830,£9130) using HES data with reference costs.

Event identification

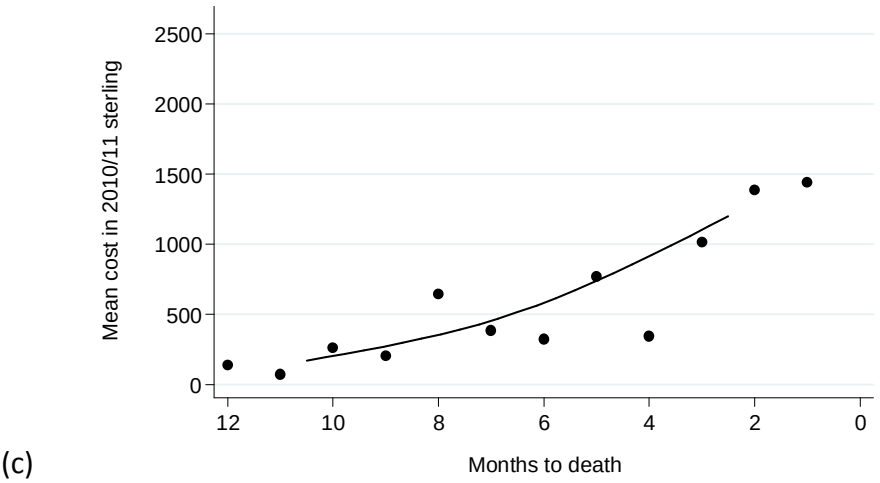
A detailed cross-check of events identified through MR review and those recorded in HES was conducted manually (*n*=50). Some episodes recorded as single events in MR review data appeared as multiple events in HES data and *vice versa*. However, 97 unique events were identified in both datasets, despite minor differences in dates and lengths of stay. Four events were identified in MR review but were absent from HES records, whilst 15 episodes recorded in HES were not picked up in MR review.



(a)



(b)



(c)

Figure 3. Comparative end-of-life cost profiles restricted to men for whom HES data are available (*n*=50). (a) Resource use identified by MR review; costed with data from finance departments. (b) Resource use identified by MR review; costed with NHS reference costs. (c) Resource use identified through HES; costed with NHS reference costs.

Discussion

The end-of-life profiles are all similar and follow the expected pattern of a substantial rise in costs in the final months leading up to death. However, the profile derived using HES data reflects somewhat lower costs than those based on MR review data, representing only around 75% of the costs displayed by MR review. The mean resource use over the final year was lower using finance-department data than using reference costs when the larger sample was used, but smaller with the smaller sample; this reversal of direction needs further investigation.

It is unlikely that the discrepancy in costs can be explained by events not having been captured in HES. More events were listed in HES than were picked up by MR review; these 15 extra events contributed an average of £836 per patient over the final year. Leaving these out would further increase the gap between HES and MR review calculations. Nine of the events occurred very close to death which suggests that hospice care may have played a part; further investigation and clarification of the inclusion of hospice care in HES is required. Of the four events that were not captured in HES, one is explained by the different cost allocation method as the event started before the time frame of interest. The remaining three events would be likely to be coded as a single event in HES, which does appear to be genuinely missing. As we do not have the HRGs for the four missing events in HES, it is not possible to assess how this would offset the lower costs observed.

The HRG system is used to drive reimbursement and create incentives for providers; as such, it does not necessarily reflect the true opportunity costs of the resources consumed. The nature of averages means that hospitals will be overcompensated for some procedures and underpaid for other, more costly, procedures. It is possible that the distribution of underpaid costly procedures is concentrated in the final year of life which would accentuate any underpayment recorded. Inevitably, however, a *per diem* costing method places considerable emphasis on the length of stay, with the same costs attributed to both the first

and all subsequent days (Geue *et al*, 2011). This may not reflect reality well, as it is more likely that there are variable living and medical costs throughout an episode with higher costs at the start of an episode.

Requesting data from finance departments proved very difficult, and was ultimately a largely unsuccessful approach. This may have been linked to the volume of information being requested, as the fastest turnaround arose with the shortest questionnaire. However, there was also some evidence of anxiety about identification of trusts supplying data. In the absence of a formal responsibility for trusts to supply the data, responding to a request appeared to be low on a list of priorities; a formal approach using the UK Freedom of Information Act (http://www.legislation.gov.uk/ukpga/2000/36/contents) might have mitigated this. The trusts all appeared to have different ways of working, and for some it appeared that the questions asked were not meaningful. Although trusts were asked to identify the different types of costs included in their estimates, it was not always apparent that the data supplied were directly comparable in terms of, for example, inclusion of procedures. The low response rate resulted in a large degree of estimation for missing data, and makes the finance-department method unappealing.

The opportunity for research cost reduction through the use of HES appears to be a compelling argument in favour of adopting this approach. MR review is currently estimated by the CAP team to take 4–6 hours at a cost of approximately £106 per review. For a study of 400 000 men, cost estimates for obtaining HES extracts are substantially lower. However, there are some limitations associated with using HES data. Coverage is restricted to England; therefore, studies with participants in other parts of the UK will need to employ further methods to supplement the HES data. Also, HRGs do not have the cost discrimination required to differentiate between, for example, two similar surgical procedures; in this instance, a micro-costing approach based on asking finance departments for costs would still be necessary. For trials with long-term follow-up, there are also specific

problems relating to changes in administrative methods over the years; for example, high cost items were included in base HRGs in HRG version 3.5, but are now unbundled and assigned their own HRG in HRG version 4.0 (NHSIC, 2009). Although it is important in terms of calculating an ICER that the costs are not understated, particular problems will arise if the understatement is differential across the two trial arms.

Conclusions that can be reliably drawn from this study are constrained by a number of limitations. The sample is currently relatively small, and was not selected completely at random; however, there is no reason to believe that any biases exist. Events identified as day cases were excluded from the study; however, there is some confusion over the definition of a day case (Audit Commission, 2011) which may have led to day cases being inaccurately identified. Excess bed days beyond the trim points are not yet included in the calculations from HES data, and may increase the costs observed.

Conclusion

If MR review data are available, applying national reference costs is the preferred costing method as it is substantially less time-consuming than contacting finance departments, and unlikely to give significantly differing results.

Using HRGs from HES data coupled with NHS reference costs appears to have major advantages over the MR review costing methodologies studied here in terms of time and research costs. However, further work is necessary to establish the reasons why the cost estimates are lower before a HES methodology can be adopted with confidence. In particular, the question of whether the diminished costs may be differential between arms needs to be addressed.

The recommendation that more than one technique should be used to measure key cost drivers in the absence of certainty over the accuracy of data collection methods (Ridyard and Hughes, 2010) still appears prudent.

Further work

With the proof of concept in place, we now intend to increase the sample size to include more men, and acquire HES data for the full larger sample. Although inpatient events are key cost drivers, we also have MR review data available for outpatient appointments, day cases and other secondary care usage, and plan to extend the study to include total costs, obtaining HES outpatient data in the process. The study currently uses national average costs, so we plan to apply a more granular breakdown of costs based on the study centre in which they were incurred to investigate regional variations (Grieve *et al*, 2010). Finally, we plan to further investigate the reasons for low cost estimates using HRG data; using data from men who are still alive, we will be able to assess whether the underestimate is particularly associated with events in the last year of life.

Open questions

- Are there any other reasons why HES estimates might be lower? Does it matter in the absence of a gold standard?
- Does anyone have any experience with using PEDW, the Welsh equivalent of HES?
- Our HES method currently uses HRG version 3.5 rather than the most current version (4.0). HES assigns and records the two most recent versions; therefore, version 3.5 is likely to be available for all events throughout the whole ten-year follow-up of the trial. However, is it preferable to use HRG3.5 for consistency throughout, or would it be better to use HRG4.0 where available?
- An alternative HES approach might involve using excess bed day costs assigned via HRGs and then applied to events on a *per diem* basis. Would this be sensible given the basis on which HRGs are defined?

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