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ABSTRACT

Optimal Price-Setting in Pay for Performance Schemes in Health Care

The increased availability of process measures implies that quality of care is in some areas de facto verifiable. Optimal price-setting for verifiable quality is well-described in the incentive-design literature. We seek to narrow the large gap between actual price-setting behaviour in Pay-For-Performance schemes and the incentive literature. We present a model for setting prices for process measures of quality and show that optimal prices should reflect the marginal benefit of health gains, providers' altruism and the opportunity cost of public funds. We derive optimal prices for processes incentivised in the Best Practice Tariffs for emergency stroke care in the English National Health Service. Based on published estimates, we compare these to the prices set by the English Department of Health. We find that actual tariffs were lower than optimal, relied on an implausibly high level of altruism, or implied a lower social value of health gains than previously used.

JEL Classification: D82, I11, I18 and L51
Keywords: optimal price-setting, Pay for Performance and provider behaviour

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1 Introduction

Pay for performance (P4P) schemes link provider payments to performance indicators of quality. They receive much attention from both policy makers and scholars. The empirical evidence on the effectiveness of P4P is mixed. However, there is an emerging consensus that the key to effective P4P schemes is in their design elements (Epstein, 2012; Maynard, 2012; Roland, 2012). These design elements include who to pay, what to pay for, the criteria for bonuses or penalties and how much to pay for each unit of increase in quality (Ryan, 2009).

The size of the performance payments (i.e. the price, or the 'power' of the incentive scheme) is obviously critical, but has received surprisingly little attention in the applied literature. It has been treated mainly as an empirical question in ex-post evaluations of implemented schemes rather than as a key parameter that could be set optimally on the basis of economic theory. In an early review of the effects of P4P, Petersen et al. (2006, p. 269) stated that the "[s]ize of the bonus is *probably also* important [our emphasis]" and suggested that "the lack of effect or small effect in some studies *may* include the small size of the bonus [our emphasis]".

Normative statements about the size of incentive payments in the literature on design choices have been extremely vague. For example, Conrad and Perry (2009 p. 361) suggested that the optimal incentive size should "follow the Goldilocks principle: not too little, but not too much", while Eijkenaar (2013 p. 124) stated that "[a]ll else equal, the higher the revenue potential for providers, the larger their response and the impact on performance, up to a certain point".

Empirically, the size of incentive payments is often measured as a percentage of provider income. For example, the largest hospital P4P scheme in the US (the Premier Hospital Quality Incentives Demonstration (HQID) program) set bonuses and penalties as percentages (1-2%) of Medicare revenue (Das and Anderson, 2007). Similarly, the English adaptation, Advancing Quality, set bonuses of 2-4% of revenue for the associated activities (Sutton et al., 2012), and the Commissioning for Quality and Innovation framework determined that 0.5% in the first year rising to 2.5% of provider income be tied to performance on locally selected performance indicators (Kristensen et al., 2013). In their review of the literature, Conrad and Perry (2009) found that incentive sizes in the US varied between 2-9% of provider income.

Setting incentive payments relative to revenue is not necessarily meaningful from an incentive perspective. Rather, as we emphasize in this paper, a regulator should focus on the expected health gains of improved performance and the costs of these performance improvements when setting payments for performance. An extensive theoretical regulation literature has investigated how to set optimal prices when health care is verifiable (Chalkley and Malcomson, 1998a, 1998b; Ellis and McGuire, 1986; Holmstrom and Milgrom, 1991; Kaarboe and Siciliani, 2011; Laffont and Tirole, 1993). The key insight is that price should be set equal to the marginal benefit of health care (discounted downwards for the opportunity cost of public funds and for altruistic motives of the provider; Ellis and McGuire, 1986; Chalkley and Malcomson, 1998a and 1998b). Given the large increase in availability of indicators of quality, the assumption that many dimensions of quality are verifiable is not unreasonable in many areas of care (Eggleston, 2005; Goddard et al., 2000; Kaarboe and Siciliani, 2011). If quality is verifiable, it is still the case that the optimal price should be basically set equal to the (adjusted) marginal benefit of the verifiable quality (Kaarboe and Siciliani, 2011).

The literature on optimal price-setting is however purely theoretical, and no attempt has been made to compare the derived optimal price solutions with incentive schemes implemented in practice. This may explain why the optimal price-setting literature appears to have been neglected by the practical P4P literature.

The aim of this paper is to bridge the gap between the theory and the applied literature. We provide a theory model of price-setting for P4P schemes, and compare it with the actual implementation of such a scheme. Our example of actual price-setting behaviour is the Best Practice Tariffs (BPT) scheme for emergency stroke—a national P4P scheme introduced in the English NHS from 2010/11. This is now the main vehicle for supplementing activity-based tariffs with performance related payments in the English NHS. We therefore build a theoretical model whose key assumptions match this scheme closely. The main feature of our model is that optimal prices should reflect the marginal benefit of the health gain associated with the incentivised dimensions of care. For our implementation, we searched the published literature for estimates of the QALY gains associated with the incentivised dimensions of care (treatment in an acute stroke unit, rapid brain imaging, and thrombolysis with alteplase). Using a monetary social value of a QALY of £50,000 (previously used by the English Department of Health), we show how the optimal prices depend on the assumed level of provider altruism and the opportunity cost of public funds.

The key insight is that the optimal price predicted by the theory is generally significantly higher than the actual one. For the price adopted by the scheme to be optimal the degree of altruism would have to be implausibly high or the opportunity cost of public funds implausibly high. Alternatively, the marginal evaluation of the health benefits of quality would have to be implausibly low, at least lower than previously used by the English Department of Health. The framework presented here bridges the gap between theory and the actual implementation of

P4P schemes and can be used to improve scholars' and policymakers' thinking about price-setting for quality.

The paper is organised as follows. In Section 2 we describe the context and background for our model. In Section 3 we provide a theory model for optimal tariff setting in a context similar to BPT, i.e. aimed at incentivising processes of health care for emergency stroke treatment. In Section 4 we simulate the theoretical model numerically and compare the result with the actual price set in the BPT incentive scheme. We end the paper with a discussion of our key results.

2 Background

In this section we review the information needed to setup a model that matches the key assumptions of the English BPT scheme including the financial incentives for quality before and after the scheme (section 2.1), the verifiability of emergency stroke care quality (Section 2.2), the details of the BPT scheme (section 2.3) and provider performance on the incentivised dimensions of care before the BPT scheme (Section 2.4).

2.1 Financial incentives for quality in the English NHS

Secondary care in the English National Health Service (NHS) is provided through an internal market in which 211 Clinical Commissioning Groups (CCGs) have the responsibility of commissioning health care for their populations from 160 Acute NHS trusts (henceforth termed "providers").

The Payment by Results (PbR) framework links hospital reimbursement to activity through a fixed tariff per admission. Hospital activity is classified into a manageable number of homogenous, clinically-meaningful healthcare resource groups (HRGs) – the English equivalent of diagnosis related groups (DRGs). The tariff or price paid per HRG is usually set equal to the national average cost of treating patients in a given HRG. The Best Practice Tariffs analysed in this paper represent a deviation from this rule (Department of Health, 2012a).

Reimbursing hospitals on the basis of the average costs has been theoretically shown to provide incentives for efficiency through cost reductions (Shleifer, 1985). If patient demand does not reflect quality it has been argued that these cost containment incentives may adversely affect the level of quality provided (Chalkley and Malcomson, 1998a). If quality is verifiable, however, a regulator can achieve the desired level of quality through contracting.

The Best Practice Tariffs (BPT) analysed in this paper can be seen as an attempt to include verifiable dimensions of quality into the agreements between commissioners and providers. BPTs were first introduced in the English NHS from April 2010 for four conditions. This was extended in the following years, and from 2013/14 BPTs cover more than 50 care procedures (Department of Health, 2013). BPTs are tariffs that have been "structured and priced to adequately reimburse and incentivise care that is high quality and cost effective" (Department of Health, 2013, p. 61). This aim is pursued using a number of different pricing regimes, of which we will focus on the payment regime known as *Paying For Best Practice.* This regime is similar to the most common type of P4P today, in which health care providers are paid on the basis of their performance on process measures of quality that are assumed to be linked to better outcomes.

In the financial year (FY) 2013-14 the *Paying for Best Practice* model was used for four different conditions: emergency stroke care; diabetic ketoacidosis and hypoglycaemia; fragility hip fracture; and transient ischaemic attack (TIA/mini-stroke[1]). This pricing model consists of a base payment for all admissions, plus one or more additional payments conditional on performance. In this paper we focus on the performance indicators for emergency stroke care.

2.2 The verifiability of emergency stroke care quality

Stroke is the second most common cause of death in the world, causing 10-12% of deaths in the western world (Donnan et al., 2008). The estimated total societal costs of stroke in the UK is £9 billion per year, including approximately £4 billion direct treatment costs, meaning that stroke treatment costs make up 5% of total UK NHS costs (Saka et al., 2009). Townsend et al. (2012) estimated that there were a total of 125,945 stroke incidences in England in 2009, while NHS England (2013), using a narrower definition of stroke, estimated that the median provider admitted about 400 stroke patients in 2012-13.

Stroke has been described as a “brain attack” and is caused by a disturbance in the blood supply to the brain. The most common type of stroke is ischaemic stroke (representing approximately 80% of emergency strokes). Ischaemic strokes are caused by a blood clot narrowing or blocking the blood supply to the brain leading to the death of brain cells due to lack of oxygen. The less common haemorrhagic stroke is caused by a bursting of blood vessels leading to damaging bleeding into the brain (Department of Health, 2007a).

Untreated stroke typically leads to a loss of 1.9 million neurons (brain cells) per minute, so stroke treatment should be initiated as early as possible (Department of Health, 2007a). The appropriate treatment of stroke depends on whether the stroke is ischaemic or haemorrhagic, which can be determined by an experienced health care professional on the basis of either a computed tomography (CT) scan or magnetic resonance imaging (MRI). If the stroke is ischaemic, within 4.5 hours from the stroke, an attempt can be made to dissolve the blood clot medically in a procedure known as thrombolysis with alteplase. It is of key importance that alteplase is *not* administered to patients with an haemorrhagic stroke, in which case the treatment could be fatal.

There is good clinical consensus on what constitutes high quality care for emergency stroke patients. In England, National Clinical Guidelines for Stroke were first published in 2000 and have recently been published in their fourth edition (Intercollegiate Stroke Working Party, 2012). The Department of Health published a National Stroke Strategy in 2007 (Department of Health, 2007a). The National Institute for Health and Care Excellence published a guideline for interventions in the acute stage of stroke and transient ischaemic attack (TIA) in 2008 based on clinical and economic evidence and expert consensus (National Collaborating Centre for Chronic Conditions, 2008) This was backed up by publication of a quality standard in 2010 (NICE, 2010) and a NICE pathway—a visual representation of the NICE guidelines and quality statements in the form of online interactive topic-based diagrams.

In addition, the verifiability of stroke care quality is high and increasing. Until recently, biennial (The National Sentinel Stroke Audit (NSSA) published from 1998 to 2010), and quarterly (The Stroke Improvement National Audit Programme (SINAP) from 2010 to 2012) reports monitored the quality of stroke on a range of key indicators for samples of patients. The Sentinel Stroke National Audit Programme (SSNAP), for which data collection started in 2012, will provide a minimum dataset with process and outcome data for all stroke patients in England, Wales and Northern Ireland which include the indicators on the NICE quality standard and the NHS Outcomes Framework.

The detailed coverage of all patients means that emergency stroke care can now reasonably be assumed to be fully verifiable in some key quality dimensions which, in principle, allows for very detailed contracts to be written. Notably, the National Clinical Guideline for stroke contains recommendations for Clinical Commissioning Groups (CCGs) on how to commission stroke care.

2.3 Best practice tariffs for emergency stroke

The BPT for stroke uses the high verifiability of stroke care quality to include quality in the contract arrangements between purchasers and providers. The BPTs for stroke are designed with the intention of supporting the key components of clinical best practice in the acute phase of the stroke following the recommendations of the NICE clinical guidelines and the National Stroke Strategy. Specifically the tariffs incentivise the treatment of patients in an acute stroke unit, rapid performance of brain imaging and administration of thrombolysis, if appropriate.

The tariffs are designed as a base tariff paid for all stroke patients irrespective of performance, and extra performance payments for a) rapid brain imaging, b) treating the patient in an acute stroke unit, and 3) alteplase (see table A.1 for a full description of the indicators). Alteplase was already paid for separately on top of the stroke tariff from 2008/09 and was not formally considered a part of the BPT scheme in the first two years of the programme. From 2012/13 the level of the separate alteplase payment was kept the same but considered a part of the BPT for emergency stroke.

2.4 Provider performance on the incentivised dimensions of stroke care quality

There is no set of indicators available that exactly match hospitals' performance on the indicators incentivised in the BPT scheme before and after its implementation. In the following, we describe performance on some indicators related to the incentivised dimensions of care. We do not attempt to evaluate whether improvements in performance after the introduction of BPT are attributable to the introduction of the P4P scheme. An earlier evaluation did not find this to be the case (McDonald et al., 2012).

2.4.1 Stroke care delivered in an acute stroke unit

In 2008, 59% of English patients spend at least 90% of their time on a stroke unit according to the NSSA (Royal College of Physicians, 2011, 2009). The number increased to 62% in 2010. Column 2 of Table 1 shows that this increase continued steadily over time. There is however, sign of a stabilisation around 85% towards the end of the period, which possibly reflects capacity constrains with the current level of acute stroke units. Note that the definition of stroke unit used for these data is broader than what is required to satisfy the requirement for the BPT (the BPT incentivises admission to *acute* stroke unit as defined in Table A.1).

2.4.2 Rapid Brain Imaging

According to the NSSA (Royal College of Physicians, 2011, 2009, 2007), the percentage of patients who had a brain scan carried out within 24 hours from arrival at hospital increased from 42% in 2006 to 59% in 2008 and to 70% in 2010. The percentage of patients who had a brain scan carried out within 3 hours increased from 9% in 2007 to 21% in 2008 and 25% in 2010. Columns 3—5 of Table 1 show some continued improvement in scanning times, but again, especially for a scan within 24 hours of arrival, performance seems to stagnate at around 90% of patients scanned within this time. Note however, that these numbers do not provide information as to whether all patients eligible according to the brain imaging guide incentivised by the BPT were scanned as quickly as possible.

2.4.3 Thrombolysis by alteplase

Column 6 of Table 1 shows an increase in the proportion of patients eligible for thrombolysis who are thrombolysed, although the increase was most rapid in the first three quarters. Due to the non-mandatory participation in SINAP, the estimates could be biased by selection into the SINAP audit on which these numbers are based.

Table 1: Hospital performance on indicators close to the quality dimensions incentivised by Best Practice tariffs

Financial year and quarter	% of patients that spend at least 90% of time on a stroke unit[a]	% of patients who receive a brain scan within		Median time (minutes) between arrival and first brain scan	% of patients eligible for thrombolysis who are thrombolised
		1 hour	24 hours		
2011-12 Q1	80	25	82	218	44
2011-12 Q2	84	28	86	237	49
2011-12 Q3	85	31	90	208	60
2011-12 Q4	83	31	91	196	58
2012-13 Q1	86	34	91	157	64
2012-13 Q2	87	36	92	135	63
2012-13 Q3	86	37	92	129	65

Source: The Intercollegiate Stroke Working Party (2013) and NHS England (2013)
Note: a) These data relate to the broad definition of stroke units, not the narrower definition of *acute* stroke units (See table A.2 for definitions)

3 A model for optimal price-setting for verifiable quality

In this section we present a model of optimal price-setting in a context similar to the BPT for emergency stroke. That is, we focus on price-setting for verifiable process indicators of quality for emergency care.

3.1 The provider

We assume that each provider receives a basic tariff p^0 for every patient admitted with a stroke. The number of patients admitted with a stroke is assumed to be exogenous since strokes require emergency treatment.

Providers provide four different dimensions of services to stroke patients where the type of care is denoted with $i=0,1,2,3$. We assume that three out of four are incentivised (when $i=1,2,3$). Type 0 can be interpreted as the basic care which is provided to all patients. The provider receives three additional payments p^1, p^2 and p^3 for three incentivised dimensions of care: rapid brain imaging (type 1), thrombolysis with alteplase (type 2) and delivery in an acute stroke unit (type 3). The number of services provided in each dimension of quality is $N^i \leq N^0$ (note that this may differ from the number of patients since a patient may receive more than one service; see below). The revenues of the hospitals are therefore

$$R = \sum_{i=0}^{3} p^i N^i.$$

The cost function of each service i is $c^i N^i + K^i(N^i) + F^i$ with c^i>0, $K^{i\prime}(N^i) > 0$, $K^{i\prime\prime}(N^i) > 0$. F^i is a fixed cost (for example the fixed cost of setting up a stroke unit or the fixed cost associated to an MRI machine). c^i is a constant marginal-cost component (for example the unit cost of administering alteplase or unit cost of a CT scan). $K^i(N^i)$ includes monetary and non-monetary costs of providing the service. The increasing marginal cost assumption is justified by capacity constraints on beds and the fixed number of personnel of the hospital.

We assume that the total cost is additively separable. The total cost function is

$$C = \sum_{i=0}^{3} c^i N^i + K(N^i) + F^i,$$

and the financial surplus is equal to $\pi=R-C$.

Patient benefits depend on the services received. There are potentially 8 possible combinations of types of care that a patient could receive: basic services (type 0), basic services and rapid brain imaging (type 1), basic and thrombolysis with alteplase (type 2), basic and delivery in an acute stroke unit (type 3), basic services, rapid brain imaging and thrombolysis with alteplase (denoted with type 12), basic services, rapid brain imaging and delivery in stroke unit (denoted with type 13), basic services, thrombolysis with alteplase and delivery in an acute stroke unit (denoted with type 23), basic services, rapid brain imaging, thrombolysis with alteplase and delivery in an acute stroke unit (denoted with type 123).

Alteplase administered to patients with an haemorrhagic stroke could be fatal. Hence, the drug should not be given without conducting rapid brain imaging first. We therefore ignore types 2 and 23. We assume that patients' benefit from basic care is b^0 and that the additional benefit (on top of the benefit from basic care) from each of the five residual combinations of services is b^i with *i = 1, 3, 12, 13, 123*. Moreover, we assume that the additional benefit from delivery in an acute stroke unit is separable so that $b^{123} = b^{12} + b^3$ and $b^{13} = b^1 + b^3$.

Define n^i as the number of patients for each of the six possible combinations of services (with *i = 0, 1, 3, 12, 13, 123)*. The total benefit for patients, denoted with *B*, is

$$B = n^0 b^0 + n^1(b^0 + b^1) + n^3(b^0 + b^3) + n^{12}(b^0 + b^{12}) + n^{13}(b^0 + b^1 + b^3)$$

$$+n^{123}(b^0 + b^{12} + b^3),$$

which can be re-written more succinctly in terms of number of services provided N^i:

$$B = N^0 b^0 + N^1 b^1 + N^2 b^{12} + N^3 b^3$$

where $N^0 = n^0 + n^1 + n^3 + n^{12} + n^{13} + n^{123}$, $N^1 = n^1 + n^{13}$, $N^2 = n^{12} + n^{123}$, $N^3 = n^3 + n^{13} + n^{123}$. In words, every patient receives the basic care. N^1 patients receive brain imaging, N^3 patients benefit from delivery in a stroke unit. N^2 patients receive both brain imaging and alteplase.

Providers are assumed to be altruistic and care about patients' benefit. We capture altruism with the parameter α. We assume that the provider's utility is separable and additive in profits and the altruistic component:

$$U = \alpha B + \pi,$$

which is in line with previous literature (Ellis and McGuire, 1986; Chalkley and Malcomson, 1998a).

The provider chooses the amount of services for each type of care N^i to maximise providers' utility U. Note that the provider does not chose N^0 because this is exogenous (the number of emergency patients admitted as stroke) but can chose to give the additional services (rapid brain imaging, alteplase and admission to acute stroke unit).

The optimality (first-order) conditions for the three incentivised services N^i are:

$$\alpha b^1 + p^1 = c^1 + K^{1\prime}(N^{1*}), \quad (1)$$

$$\alpha b^{12} + p^2 = c^2 + K^{2\prime}(N^{2*}), \quad (2)$$

$$\alpha b^3 + p^3 = c^3 + K^{3\prime}(N^{3*}). \quad (3)$$

The marginal benefit from the altruistic component and price is equated to the marginal cost. The second order conditions are given by $-K^{i\prime\prime}(N^i) < 0$. A higher price or more altruism increase the number services provided. Note that the variable cost of alteplase (c^2) also includes the cost of imaging.

3.2 The regulator

We assume that the regulator is utilitarian. It maximises the sum of patients' benefit net of transfers to the provider and the utility of the provider, $B-(1+\lambda) R+U$, where $\lambda>0$ accounts for the opportunity cost of public funds.

Substituting for U, we obtain $B(1+\alpha) - C - \lambda R$. It has been argued (e.g. Chalkley and Malcomson (1998a); Hammond (1987)) that this specification leads to double-counting of the benefits, which is due to altruistic motives. Following this suggestion, we eliminate double-counting and assume that welfare is given by $W = B - C - \lambda R$. This expression is intuitive. It gives the difference between patients' benefits and provider costs minus the cost associated with raising public funds.

We assume that the purchaser designs the optimal contract subject to (i) a participation constraint of the provider, $U \geq 0$; and (ii) a profit constraint, $\pi \geq 0$. Since the provider is altruistic, the first constraint is always satisfied when the profit constraint is satisfied. Since leaving a profit to the provider is costly for welfare (due to the assumption of positive opportunity costs of public funds), it is optimal to set $\pi=0$ and $R=C$. The welfare function reduces to $W = B - (1+\lambda) C$.

The optimality (first-order) condition for N^i is from the purchaser's perspective such that:

$$b^i = (1+\lambda)[c^i + K^{i\prime}(N^{i,f})] \qquad i=1 \ldots 3, \tag{4}$$

where f denotes first best. This suggests that the optimal number of services is such that patients' benefits equate to marginal costs.

3.3 Implementation

In the following we assume that the regulator sets prices only on the three incentivised services. We take the number of incentivised dimensions of quality as exogenous. Notice that since costs and benefits of different services are separable, the optimal price for each incentivised service can be investigated in isolation.

Comparing the optimality conditions for the provider and the purchaser, we derive the optimal prices:

$$p^{1,f} = b^1(1-\alpha) - \lambda[c^1 + K^{1\prime}(N^{1,f})] \tag{5}$$

$$p^{2,f} = b^{12}(1-\alpha) - \lambda\left[c^2 + K^{2\prime}(N^{2,f})\right] \tag{6}$$

$$p^{3,f} = b^3(1-\alpha) - \lambda[c^3 + K^{3\prime}(N^{3,f})] \tag{7}$$

The optimal price is equal to patients' benefits discounted by altruism. When altruism is higher, the regulator needs to incentivise the provider less. A higher opportunity cost of public funds implies a lower optimal price.

Moreover, from the profit constraint which has to be satisfied with strict equality, we can compute the basic tariff

$$p^{0,f} = \left\{ \sum_{i=0}^{3} [c^i N^{i,f} + K^i(N^{i,f}) + F^i] - \sum_{i=1}^{3} p^i N^{i,f} \right\} / N^0. \qquad (8)$$

This condition simply states that the basic tariff is equal to the average cost net of other transfers to the provider.

4 Comparing actual and optimal price-setting in BPT for emergency stroke

In this section we describe the implementation of our proposed (optimal) price-setting scheme, and the actual one adopted by the Department of Health. We then compare the actual tariff with the optimal tariff.

4.1 Optimal price-setting for Best Practice Tariffs for emergency stroke

4.1.1 Information requirements

Equations (5-7) show that setting the optimal tariff requires knowledge of the marginal benefit of the incentivised dimension of care, the providers' level of altruism, the opportunity cost of public funds, and the cost of the incentivised process of care. We illustrate our results for a range of levels of altruism and opportunity costs of public funds. In the following we focus on obtaining plausible estimates for the marginal benefits of the three processes incentivised in the three BPTs for emergency stroke. For assessing the marginal benefit of the interventions incentivised by the BPT we use Quality Adjusted Life Years (QALYs). As the BPT performance indicators for stroke are all based on clinical evidence, we searched the medical literature behind the national clinical guidelines and NICE guidance to find estimates of the per-patient QALY gains associated with the incentivised interventions.

We focus on studies that present estimates of per-patient QALY gains as close as possible to the counterfactual treatment, i.e. the type of care an NHS patient would have received without the incentivized process of care. Where possible, we sought studies with a lifetime perspective on the benefits associated with the incentivised dimensions of care. We adopt the monetary social value of a QALY most often used by the Department of Health in its policy Impact Assessments of £50,000[2] (Shah et al., 2012).

4.1.2 Marginal benefit of treatment delivered in an acute stroke unit

Saka et al. (2009b) used data from the South London Stroke Register and Markov modelling to assess the 10-year cost-effectiveness of emergency stroke care in a general medical ward compared to stroke unit care[3]. The study found an incremental QALY gain per patient of 0.472

QALYs associated with care in a stroke unit. As the time horizon of the study was restricted to 10 years and the average age of patients was 64 years, the QALY gain of treating patients in a stroke unit rather than in a general ward is potentially larger.

4.1.3 Marginal benefit of rapid brain Imaging

Wardlaw et al. (2004) used a decision tree and a deterministic model to compare the cost effectiveness of 12 different CT-scanning strategies.[4] Usual care at the time of the study was to scan all patients within 48 hours. The strategy included in the study that was most similar to the strategy incentivized by the BPT was to "scan patients on anticoagulants, in life-threatening condition, or candidates for thrombolysis immediately, and scan all remaining patients within 24 hours". This strategy was associated with a gain of just 0.1 QALYs per 1,000 patients over a five-year period compared to usual care. Wardlaw et al. (2004) justified the seemingly low QALY gain by the high proportion of haemorrhagic stroke patients (85%) in the study population, for whom the main treatment strategy is aspirin which only needs to be given within 48 hours. The study assumed that just 4% of patients would reach the hospital in time to be considered for thrombolysis, and suggested that the cost effectiveness of scanning all patients immediately would be higher if the proportion of potentially-eligible patients was higher.

4.1.4 Marginal benefit of thrombolysis with alteplase if clinically indicated

A deterministic cost-effectiveness analysis based on a Markov modelling simulation study of patients with emergency ischaemic stroke receiving alteplase within 4.5 hours of onset of symptoms (NICE, 2012) found an incremental per-patient gain of 0.333 QALYs from alteplase treatment.[5] The probabilistic cost-effectiveness analysis from the same study suggested an estimated 0.29 QALY gain. The study considered lifetime effects of treatment, assuming no change in health status after 12 months (other than death).

4.1.5 Marginal costs of incentivised processes

Ideally, we would use estimates of marginal costs, which according to our model depend on the provider's level of performance. For feasibility, we use instead average cost estimates from the literature, which we assume to reflect the marginal cost at the average level of performance.

For admission to a stroke unit we use the per-patient per-diem costs reported by Saka et al. (2009). Multiplying the difference in costs between the stroke unit (£164.80 per day) and the general ward (£114.80 per day) by the average length of stay (34.4 days) yields a per-patient marginal cost of treatment in an stroke unit of £1,720. Note that this price may be an underestimate, since the BPT for emergency stroke requires patients to be admitted to an *acute* stroke unit, which requires more potentially costly characteristics to be fulfilled (summarised in Table A.1 and A.2).

We assume that the direct costs to providers of achieving the stroke BPT to scan patients within 24 hours are the additional costs relative to scanning all patients within 48 hours. Wardlaw et al (2004) reported that the mean costs of a CT scan at 2000 prices were £43 in normal working hours and £79 after hours. Their model suggested that the cost of CT scanning patients was £47 if required within 48 hours for all and was £71 if all patients were required to be scanned immediately. We take the mid-point of these estimates as the per-patient cost of achieving a scan within 24 hours for all patients (£59), and therefore the additional costs to the provider per patient of achieving 24 hours compared to 48 hours is £12 (£59 minus £47).[6] For thrombolysis with alteplase we rely on the cost estimate from Saka et al. (2009) which reflects the additional cost of administering alteplase including the cost of the drug.

4.2 Optimal price-setting in Best Practice tariffs for emergency stroke

In Figures 1-3 we present our implementation of the optimal best practice tariffs for emergency stroke as described by Equations (5-7). The monetary values are provided in Tables A3-A5 in the Appendix. In all three cases, the optimal price is highest when hospitals are purely profit-maximising (altruism=0), and there is no opportunity cost of public funds (λ=0). In this case, the price should be set exactly equal to the marginal benefit associated with the incentivised intervention. For example, the maximum optimal price for care in an emergency stroke unit is £23,600, assuming a social value of a QALY of £50,000 and a per-patient gain of 0.472 QALYs.

The optimal price decreases as the level of altruism and the opportunity costs of public funds increases. The results for altruism are intuitive. A higher level of altruism implies a lower optimal tariff, as altruistic providers derive utility from patients' benefit and therefore need less of a financial incentive for performance. For treatment in an acute stroke unit and alteplase, altruism matters relatively more, because the marginal benefit is substantially higher than the cost of carrying out the intervention, while the opposite is the case for rapid brain imaging. A fully-altruistic hospital takes into account the whole patients' benefit, and therefore does not need to be additionally incentivised for carrying out the intervention.

As shown in section 2.4, hospitals provided brain imaging, treatment in acute stroke units and alteplase to some extent before the direct performance incentive was introduced, and it seems reasonable to assume some level of altruism. Moreover, since not all patients received the three services, it is reasonable that α is strictly less than one. Also, the fact that the Department of Health introduced the incentive scheme implies that the purchaser thought that the provider was not sufficiently motivated (again a level of α less than one).

Assuming a social value of a QALY of £50,000, and considering $\alpha = [0.1, 0.9]$ and $\lambda = [0,1]$, the optimal price for treatment in an acute stroke unit lies in the interval [£640, £21,240]; the optimal price for rapid brain imaging lies in the interval [£-11.5, £4.5]; and the optimal price for alteplase lies in the interval [£915, £14,985].

Figure 1: Optimal performance payment (£) for treatment in an Acute Stroke Unit at different levels of altruism and opportunity cost of public funds

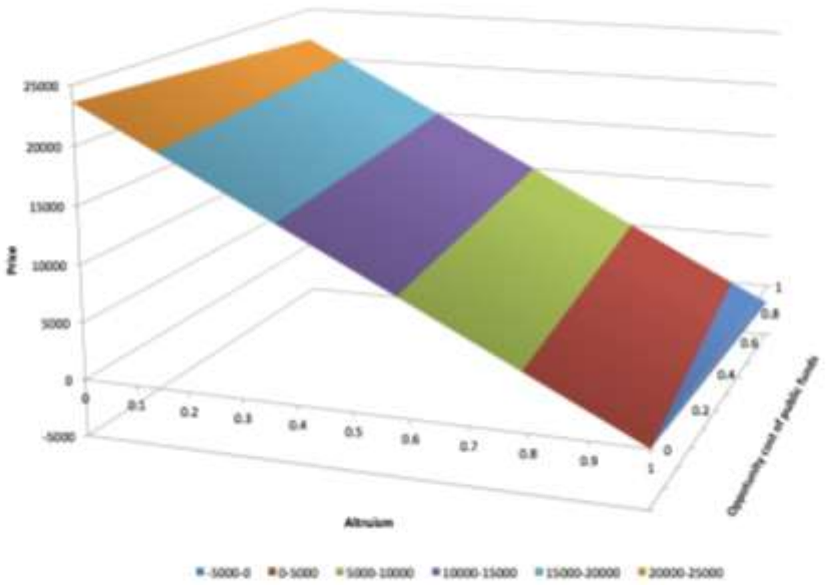


Figure 2: Optimal performance payment (£) for rapid brain imaging at different levels of altruism and opportunity cost of public funds

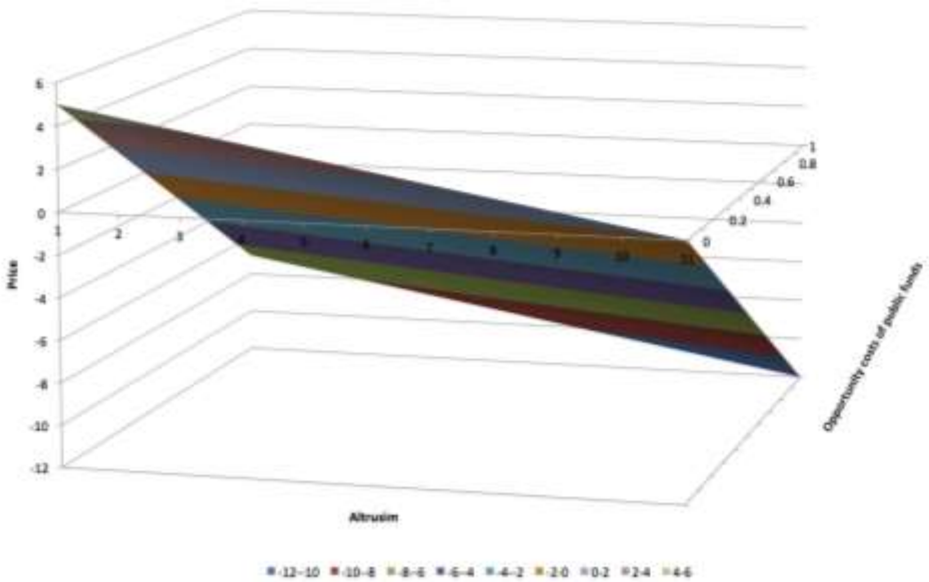
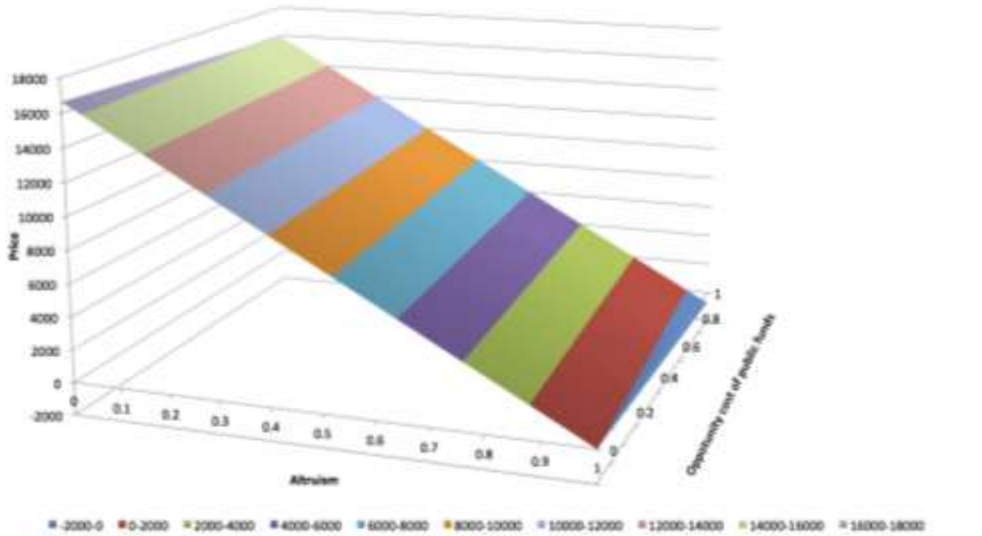


Figure 3: Optimal performance payment (£) for thrombolysis with alteplase at different levels of altruism and opportunity cost of public funds



4.3 Actual price-setting in Best Practice Tariffs for emergency stroke

When it introduced the BPT in the financial year 2010/11, the English Department of Health explained that it wished to set prices “not just at the national average but instead to better reflect the costs of delivering best practice,” with a built-in financial incentive “to encourage uptake of best practice in the early stages.” The financial incentive was expected to be removed in the future and “align[ed] … with the actual cost of best practice” (Department of Health, 2010a).

The tariffs and their development over time are described in Table 2. Initially there was two base tariffs— *AA22Z Non-Transient Stroke or Cerebrovascular Accident, nervous system infections or encephalopathy* and *AA23ZZ Haemorrhagic Cerebrovascular Disorders.* From 2013/14 new groups were introduced for patients with and without complications and co-morbidities. Co-morbidities are defined as "additional conditions that the patient might come into hospital with that increase the complexity of the primary intervention" and complications as "events during treatment that [...] increase complexity" (Department of Health, 2012a, p. 22). The tariffs for rapid brain imaging and treatment in an acute stroke unit doubled from year 1 to year 2 and tripled from year 1 to year 3. At the same time, the base tariff was lowered. While the initial BPT prices were calculated close to the costs of providing the service, the subsequent adjustments were justified by a desire to increase the incentive for delivering best practice (Department of Health, 2012b).

Table 2: Actual prices (£) for emergency stroke care and incentivised dimensions of quality 2009/10-2013/14

Component	**2009/10**	**2010/11**	**2011/12**	**2012/13**	**2013/14**
Base tariff					
AA22Z	4,348	4,095	3,712	3,005	N/A
AA22A	N/A	N/A	N/A	N/A	2,764
AA22B	N/A	N/A	N/A	N/A	2,851
AA23Z	4,411	4,158	3,579	2,987	N/A
AA23A	N/A	N/A	N/A	N/A	1,764
AA23B	N/A	N/A	N/A	N/A	1,377
Additional BPTs					
Rapid brain imaging	0	133	266	399	399
Treatment delivered in an acute stroke unit	0	342	684	1,026	1,026
Alteplase	828	828*	828*	828	828

Notes: AA22Z: Non-Transient Stroke or Cerebrovascular Accident, Nervous System Infections or Encephalopathy. AA23Z: Haemorrhagic Cerebrovascular Disorders. *A: with Co-morbidities and Complications (CC), *B: without CC
Source: Payment by Result guidance for 2009/10-2013/14

4.4 Comparison of actual and optimal price-setting

The Department of Health description of the scheme suggests that BPT tariffs are mainly set as a function of costs in combination with an added incentive that appears to be arbitrarily set.[7] Compared to the optimal prices, the BPT tariffs set by the Department of Health for treatment in an acute stroke unit and for alteplase appear to be (i) lower than optimal, or (ii) based on high levels of altruism, or (iii) a reflection of a very high opportunity cost of public funds.

The current performance payment for treatment at an acute stroke unit is £1,026. This is consistent with $\alpha = 0.9$ and $\lambda = 0.8$ which seems to imply very high levels of altruism and opportunity cost of public funds.

For alteplase, at a QALY value of £50,000, the tariff of £828 is consistent with $\alpha = 0.9$ and $\lambda = 1$. Again rather high assumed levels of altruism and opportunity costs of public funds are required to explain the current pricing level.

The performance payment for rapid brain imaging set by the Department of Health has tripled from £133 when BPT was first introduced to £399 in 2013/14. This price is not consistent with any positive levels of α or λ in our framework which suggests low or even negative optimal prices. This is because the major benefit of rapid brain imaging only arises for patients with an ischaemic stroke who can subsequently be treated with alteplase, which has a high benefit for these patients. Due to the high prevalence of ischaemic strokes (about 80%) and the high expected benefit for ischaemic patients, the incentive payment for brain imaging need not be very high.

Using experimental data from medical students acting as physicians, Godager and Wiesen (2013) found considerable heterogeneity in physician altruism. The estimated mean altruism was $\alpha = 0.5$, which is still considerably lower compared to the level implied by the prices set by the Department of Health. Although unincentivised performance levels imply some degree of altruism, it seems unlikely that providers are as altruistic as the level of the BPTs implies.

Alternatively, the opportunity costs of public funds may be considerably higher than the [0,1] range used in our calculations. Recently, Claxton et al. (2013) estimated that the marginal cost of producing a QALY in the English NHS was £18,317. If the marginal benefit of a QALY is £50,000, this implies an opportunity cost of public funds of 2.7. Even in that case, the stroke unit price of £1,026 and the alteplase price of £399 are consistent with $\alpha = 0.8$, which still seems high given that the Department of Health found it necessary to introduce the BPT to improve performance and compared to the empirical estimates from Godager and Wiesen (2013).

Aside from brain-imaging, our results suggest that the current price-setting in the BPTs for emergency stroke appear relatively low compared to the optimal price, and higher prices could be welfare-improving.

5 Discussion and concluding remarks

This paper aims at bridging the gap between the theory and the practice of pay-for-performance incentive schemes. Price-setting has been treated informally in practice with an emphasis of incentive payments related to total revenue.

We have presented a model of optimal price-setting of process measures of performance for stroke patients. We have compared the derived optimal price with the actual price set in the English NHS as part of the Best Practice Tariffs scheme from 2010/11. The main features of our model are that optimal prices should reflect the marginal benefit of the health gain associated with the incentivised dimensions of care, the level of provider altruism and the opportunity cost of public funds. In our implementation we have searched the medical literature for estimates of QALY gains of the incentivised dimensions of care. Using a monetary social value of a QALY of £50,000 (previously used by the Department of Health), we have described the optimal prices for treatment in an acute stroke unit, rapid brain imaging, and thrombolysis with alteplase in intervals depending on the assumed level of provider altruism and opportunity cost of public funds. Overall, the model provides a framework for scholars and policymakers for thinking about price-setting for quality from an incentive point of view.

Our key finding is that the tariff set by the Department of Health for the incentivised dimensions of care are either lower than optimal or correspond to very high assumed levels of altruism or opportunity cost of public funds.

We briefly discuss some limitations and avenues for further research. We have not considered the potential multitasking problem with respect to unmonitored or unverifiable aspects of quality of care. Although this cannot be excluded, the BTP incentive scheme covered all the key quality dimensions, leaving little as unmonitored. Therefore, we do not think that allowing for the minor dimensions of unmonitored quality would alter our key results. If minor unmonitored aspects of quality were complements, then we would expect the optimal prices to be marginally higher. Moreover, setting prices that take account of multitasking would require considerably more information (in addition to the heavy information requirements already included in this study), including the responsiveness of unmonitored quality to changes in prices for monitored quality and the benefits and costs of changes in unmonitored quality.

We have focused on setting prices for process indicators. This is reasonable insofar as the vast majority of performance indicators in current P4P programs measure processes with an assumed relationship to outcomes. For example, this is true for the large hospital P4P scheme in the US, the Premier Hospital Quality Incentives Demonstration (Jha et al., 2012; Lindenauer et al., 2007) and the corresponding English Advancing Quality program (Sutton et al., 2012).

Even so, payers are frequently expressing a wish to move to more outcome based payment, and our work could be extended to this setting as well. In this case, providers are free to choose process of care, but are paid for improvements in outcomes only, which entails a transfer of financial risk from the payer to the provider. In addition, the cost of an improvement in outcome is unknown to the payer and cannot be used when setting the optimal price.

There is also a strong policy interest in introducing pay for performance schemes for drugs. From 2014 the English NHS will implement so called Value-Based Pricing of pharmaceuticals with the intention of linking drug prices to their cost effectiveness (Claxton et al., 2011; Department of Health, 2011). Our model could be adapted for incentive schemes that involve the pharmaceutical sector.

References

Chalkley, M., Malcomson, J.M., 1998a. Contracting for health services when patient demand does not reflect quality. Journal of Health Economics 17, 1–19.

Chalkley, M., Malcomson, J.M., 1998b. Contracting for Health Services with Unmonitored Quality. The Economic Journal 108, 1093–1110.

Claxton, K., Martin, S., Soares, M., Rice, N., Spackman, E., Hinde, S., Devlin, N., Smith, P.C., Schulper, M., 2013. Methods for the Estimation of the NICE Cost Effectiveness Threshold, CHE Research Paper 81. University of York - Centre for Health Economics, York.

Claxton, K., Sculpher, M., Carroll, S., 2011. Value-based pricing for pharmaceuticals: Its role, specification and prospects in a newly devolved NHS (Working Paper No. 060cherp). Centre for Health Economics, University of York.

Conrad, D.A., Perry, L., 2009. Quality-Based Financial Incentives in Health Care: Can We Improve Quality by Paying for It? Annu. Rev. Public. Health. 30, 357–371.

Das, K., Anderson, G., 2007. Premier Hospital Quality Incentive Demonstration. Health Policy Monitor.

Davis, S., Holmes, M., Simpson, E., Sutton, A., 2012. Alteplase for the treatment of acute ischaemic stroke (review of technology appraisal 122). School of Health and Related Research (ScHARR), The University of Sheffield, Sheffield.

Department of Health, 2007a. National Stroke Strategy.

Department of Health, 2007b. Impact Assessment: National Stroke Strategy. London.

Department of Health, 2008a. Impact Assessment: End of Life Care. London.

Department of Health, 2008b. Implementing the National Stroke Strategy – an imaging guide. London.

Department of Health, 2010a. Payment by Results Guidance for 2010-11. Leeds.

Department of Health, 2010b. Step-by-Step Guide: Calculating the 2010/11 National Tariff.

Department of Health, 2011. A new value-based approach to the pricing of branded medicines: Government response to consultation. London.

Department of Health, 2012a. A simple guide to Payment by Results. Department of Health Payment by Results team, London.

Department of Health, 2012b. Payment by Results Guidance for 2012-13. Leeds.

Department of Health, 2013. Payment by Results Guidance for 2013-14.

Donnan, G.A., Fisher, M., Macleod, M., Davis, S.M., 2008. Stroke. Lancet 371, 1612–1623.
Eggleston, K., 2005. Multitasking and mixed systems for provider payment. Journal of Health Economics 24, 211–223.
Eijkenaar, F., 2013. Key issues in the design of pay for performance programs. Eur J Health Econ 14, 117–131.
Ellis, R.P., McGuire, T.G., 1986. Provider behavior under prospective reimbursement : Cost sharing and supply. Journal of Health Economics 5, 129–151.
Epstein, A.M., 2012. Will Pay for Performance Improve Quality of Care? The Answer Is in the Details. New England Journal of Medicine 367, 1852–1853.
Godager, G., Wiesen, D., 2013. Profit or patients' health benefit? Exploring the heterogeneity in physician altruism. Journal of Health Economics 32, 1105–1116.
Goddard, M., Mannion, R., Smith, P., 2000. Enhancing performance in health care: a theoretical perspective on agency and the role of information. Health Economics 9, 95–107.
Hammond, P., 1987. Altruism. The New Palgrave: A Dictionary of Economics. Macmillan, London 85–87.
Holmstrom, B., Milgrom, P., 1991. Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design. Journal of Law, Economics, and Organization 7, 24.
Intercollegiate Stroke Working Party, 2012. National clinical guideline for stroke. Royal College of Physicians of London.
Jha, A.K., Joynt, K.E., Orav, E.J., Epstein, A.M., 2012. The Long-Term Effect of Premier Pay for Performance on Patient Outcomes. N Engl J Med.
Kaarboe, O., Siciliani, L., 2011. Multitasking, quality and pay for performance. Health Economics, Health Economics 20, 225–238.
Kristensen, S.R., Mcdonald, R., Sutton, M., 2013. Should pay-for-performance schemes be locally designed? Evidence from the commissioning for quality and innovation (CQUIN) framework. Journal of Health Services Research & Policy Forthcomming.
Laffont, J.J., Tirole, J., 1993. A theory of incentives in procurement and regulation. the MIT Press.
Lindenauer, P.K., Remus, D., Roman, S., Rothberg, M.B., Benjamin, E.M., Ma, A., Bratzler, D.W., 2007. Public reporting and pay for performance in hospital quality improvement. N Engl J Med 356, 486.
Maynard, A., 2012. The powers and pitfalls of payment for performance. Health Economics 21, 3–12.
McDonald, R., Zaidi, S., Todd, S., Konteh, F., Hussain, K., Roe, J., Allen, T., Fichera, E., Sutton, M., 2012. A Qualitative and Quantitative Evaluation of the Introduction of Best Practice Tariffs.
National Collaborating Centre for Chronic Conditions, 2008. Stroke: national clinical guideline for diagnosis and initial management of acute stroke and transient ischaemic attack (TIA). Royal College of Physicians, London.
NHS England, 2013. Integrated Performance Measures Monitoring.
NICE, 2010. Stroke quality standard (QS2).
NICE, 2012. Alteplase for treating acute ischaemic stroke (review of technology appraisal guidance 122) (NICE technology appraisal guidance No. 264). Manchester.
Petersen, L.A., Woodard, L.D., Urech, T., Daw, C., Sookanan, S., 2006. Does Pay-for-Performance Improve the Quality of Health Care? Annals of Internal Medicine 145, 265–W71.
Roland, M., 2012. Pay-for-Performance: Not a Magic Bullet. Ann Intern Med 157, 912–913.
Royal College of Physicians, 2007. National Sentinel Stroke Audit Phase I (organisational audit) 2006 Phase II (clinical audit) 2006: Prepared on behalf of the Intercollegiate Working Party.
Royal College of Physicians, 2009. National Sentinel Stroke Audit Phase II (clinical audit) 2008: Prepared on behalf of the Intercollegiate Working Party.
Royal College of Physicians, 2011. National Sentinel Stroke Clinical Audit 2010 Round 7.
Ryan, A., 2009. Hospital-based pay-for-performance in the United States. Health Economics 18, 1109–1113.

Saka, Ö., McGuire, A., Wolfe, C., 2009. Cost of stroke in the United Kingdom. Age Ageing 38, 27–32.
Shah, K., Praet, C., Devlin, N., Sussex, J., Appleby, J., Parkin, D., 2012. Is the aim of the English health care system to maximize QALYs? J Health Serv Res Policy 17, 157–163.
Shleifer, A., 1985. A theory of yardstick competition. RAND Journal of Economics 16, 319–327.
Sutton, M., Nikolova, S., Boaden, R., Lester, H., McDonald, R., Roland, M., 2012. Reduced Mortality with Hospital Pay for Performance in England. N Engl J Med 367, 1821–1828.
The Intercollegiate Stroke Working Party, 2013. SINAP - Combined Quarterly Public Report (Quarters 1-7).
Wardlaw, J.M., Seymour, J., Cairns, J., Keir, S., Lewis, S., Sandercock, P., 2004. Immediate Computed Tomography Scanning of Acute Stroke Is Cost-Effective and Improves Quality of Life. Stroke 35, 2477–2483.

Appendix

Table A.1: Best practice tariff for emergency stroke

BPT component	Description
Stroke care delivered within an acute stroke unit	Patients are admitted directly (intending to be within 4 hours of arrival in hospital) to an acute stroke unit (Or similar facility where the patient can expect to receive the service set out in quality marker 9 of the National Stroke Strategy[8]) either by the ambulance service, from A&E or via brain imaging. Patients should not be directly admitted to a Medical Assessment Unit. Patients should then also spend the majority (Defined as greater than or equal to 90% of the patient's stay within the spell that groups to either AA22Z or AA23Z) of their stay in the acute stroke unit.
Urgent brain imaging for all suitable patients	Initial brain imaging is delivered in accordance with best practice guidelines as set out in Implementing the National Stroke Strategy – An Imaging Guide (Department of Health, 2008b) . The scan should not only be done in these timescales but immediately interpreted and acted upon by a suitably experienced physician or radiologist. A CT scan should be undertaken urgently if (a) indication for thrombolysis/anticoagulation (b) On anticoagulants and/or known bleeding tendency (c) Depressed level of consciousness (GCS<13) (d) Unexplained fluctuating or progressive symptoms (e) Severe headache at onset (e) Papilloedema, neck stiffness, fever. Otherwise a CT scan should be performed within 24 hours. An MRI scan should be performed if (a) Diagnostic uncertainty after CT (e.g. suspected non stroke pathology but unsure) (b) Atypical clinical presentation including: (b.1) "Young" stroke (<50 years) (b.1) Strong clinical suspicion of vessel dissection (c) Delayed clinical presentation (>7 days after symptom onset)
Alteplase	Patients are assessed for thrombolysis, receiving it if clinically indicated in accordance with the NICE technology appraisal guidance on alteplase. Alteplase is a drug that can dissolve the blood clot. It must be administered within 4.5 hours from the onset of symptoms and should not be given to patients if brain imaging has indicated that the patient has a bleeding in the brain.

Source: Department of Health (2012b) and Department of Health (2008b)

Table A.2: Key characteristics of stroke units and acute stroke units

Key characteristics of stroke units	Key characteristics of acute stroke units
• Consultant physician with responsibility for stroke • Formal links with patient and carer organisations • Multidisciplinary meetings at least weekly to plan patient care • Provision of information to patients about stroke • Continuing education programmes for staff	• Continuous physiological monitoring (ECG, oximetry, blood pressure) • Access to scanning within 3 hours of admission • if not 3 hours, access to 24 hour brain imaging • Policy for direct admission from A&E • Specialist ward rounds at least 5 times a week • Acute stroke protocols/guidelines

Source: Royal College of Physicians (2007)

Table A.3: Optimal performance payment (£) for treatment in an Acute Stroke Unit at different levels of altruism and opportunity cost of public funds

		Opportunity costs of public funds										
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Altruism	0	23600	23428	23256	23084	22912	22740	22568	22396	22224	22052	21880
	0.1	21240	21068	20896	20724	20552	20380	20208	20036	19864	19692	19520
	0.2	18880	18708	18536	18364	18192	18020	17848	17676	17504	17332	17160
	0.3	16520	16348	16176	16004	15832	15660	15488	15316	15144	14972	14800
	0.4	14160	13988	13816	13644	13472	13300	13128	12956	12784	12612	12440
	0.5	11800	11628	11456	11284	11112	10940	10768	10596	10424	10252	10080
	0.6	9440	9268	9096	8924	8752	8580	8408	8236	8064	7892	7720
	0.7	7080	6908	6736	6564	6392	6220	6048	5876	5704	5532	5360
	0.8	4720	4548	4376	4204	4032	3860	3688	3516	3344	3172	3000
	0.9	2360	2188	2016	1844	1672	1500	1328	1156	984	812	640
	1	0	-172	-344	-516	-688	-860	-1032	-1204	-1376	-1548	-1720

Note: Assuming per person MB of treatment in Acute Stroke Unit=0.479 QALYs, Social value of a QALY =50,000, MC of treatment in an acute stroke unit =£1720

Table A.4: Optimal performance payment (£) for rapid brain imaging at different levels of altruism and opportunity cost of public funds

		Opportunity costs of public funds										
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Altruism	0	5	3.8	2.6	1.4	0.2	-1	-2.2	-3.4	-4.6	-5.8	-7
	0.1	4.5	3.3	2.1	0.9	-0.3	-1.5	-2.7	-3.9	-5.1	-6.3	-7.5
	0.2	4	2.8	1.6	0.4	-0.8	-2	-3.2	-4.4	-5.6	-6.8	-8
	0.3	3.5	2.3	1.1	-0.1	-1.3	-2.5	-3.7	-4.9	-6.1	-7.3	-8.5
	0.4	3	1.8	0.6	-0.6	-1.8	-3	-4.2	-5.4	-6.6	-7.8	-9
	0.5	2.5	1.3	0.1	-1.1	-2.3	-3.5	-4.7	-5.9	-7.1	-8.3	-9.5
	0.6	2	0.8	-0.4	-1.6	-2.8	-4	-5.2	-6.4	-7.6	-8.8	-10
	0.7	1.5	0.3	-0.9	-2.1	-3.3	-4.5	-5.7	-6.9	-8.1	-9.3	-10.5
	0.8	1	-0.2	-1.4	-2.6	-3.8	-5	-6.2	-7.4	-8.6	-9.8	-11
	0.9	0.5	-0.7	-1.9	-3.1	-4.3	-5.5	-6.7	-7.9	-9.1	-10.3	-11.5
	1	0	-1.2	-2.4	-3.6	-4.8	-6	-7.2	-8.4	-9.6	-10.8	-12

Note: Assuming per person MB of rapid brain imaging=0.0001 QALYs, Social value of a QALY =50,000, MC of rapid brain imaging = £12

Table A.5: Optimal performance payment (£) for thrombolysis with alteplase at different levels of altruism and opportunity cost of public funds

		Opportunity costs of public funds										
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Altruism	0	16650	16575	16500	16425	16350	16275	16200	16125	16050	15975	15900
	0.1	14985	14910	14835	14760	14685	14610	14535	14460	14385	14310	14235
	0.2	13320	13245	13170	13095	13020	12945	12870	12795	12720	12645	12570
	0.3	11655	11580	11505	11430	11355	11280	11205	11130	11055	10980	10905
	0.4	9990	9915	9840	9765	9690	9615	9540	9465	9390	9315	9240
	0.5	8325	8250	8175	8100	8025	7950	7875	7800	7725	7650	7575
	0.6	6660	6585	6510	6435	6360	6285	6210	6135	6060	5985	5910
	0.7	4995	4920	4845	4770	4695	4620	4545	4470	4395	4320	4245
	0.8	3330	3255	3180	3105	3030	2955	2880	2805	2730	2655	2580
	0.9	1665	1590	1515	1440	1365	1290	1215	1140	1065	990	915
	1	0	-75	-150	-225	-300	-375	-450	-525	-600	-675	-750

Note: Assuming per person MB of alteplase =0.333 QALYs, Social value of a QALY =50,000, MC of administering alteplase = £750

[1] A TIA is a temporary disruption of the blood flow to the brain and cause similar symptoms as emergency stroke, but the symptoms resolve within 24 hours.

[2] The Impact Assessment of End of Life Care (Department of Health, 2008a) explained that the £50,000 figure was based on a projection of a 2004 estimate of willingness to pay for an additional life year of £29,000 by the Department for Environment, Food and Rural Affairs. The increase to £50,000 was justified by a wish to reflect price changes from 2004 to 2006, the older age and poorer life quality of the likely target group of DH interventions, and an upward rounding due to concern that the figure might be an under-estimate of the social value of a QALY.

[3] The Stroke unit studied in the paper admitted only stroke patients and was a mixed unit with 4 acute beds and 23 rehabilitation beds. The paper defined stroke units as units fulfilling at least 4 of the criteria set out for stroke units by the Royal College of Physicians (see the left hand side of Table A.2), but was not explicit about the configuration of the stroke unit from which the data was collected. It is unlikely that the unit fulfilled the stricter criteria of an acute stroke unit (see the right hand side of Table A.2) and the similar definition given by the DH (see Table A.1). Although this might suggest that the estimated QALY gain is in the lower end of what is being incentivised, it should be noted that the Cochrane review carried out by the Stroke Units Trialist's Collaboration did not find a statistically significant difference in the odds of death, or death or requiring institutional care or death or dependency3 when comparing acute monitoring with acute non-intensive units.

[4] The analysis was carried out for a cohort of 1000 patients (age 70-74) and repeated for 1000 60-64 year and 80-84 year old patients in teaching urban and rural general hospitals using data from a range of sources.

[5] The estimate was submitted by the manufacturer of alteplase (Boehringer Ingelheim), but reviewed by Davis et al (2012). The review noted that manufacturer failed to model the correlation between the risks of death and death or dependency but that this was unlikely to affect the incremental cost effectiveness ratio (ICER) of administering alteplase. In addition, Davis et al. (2012) commented that the utility values for patients in dependent and independent health states stays fixed over the lifetime not allowing for deterioration of health related quality of life over time. Davis et al. (2012) suggest that this may potentially favour alteplase over standard care, but also note that the model is not very sensitive to the utility values applied and so consider the effect likely to be small.

[6] Note that we assume that the price is set on the basis of the additional direct costs of increasing the rapidity of the brain scan. Wardlaw et al (2004) note that more rapid scans may reduce costs overall since "[a]lthough the costs of CT scanning are highest … because of more scanning occurring after hours, these higher costs are offset by savings in the length of inpatient stay because many management decisions and better outcomes depend on accurate early diagnosis of stroke." (Wardlaw et al, 2004, p.2481).

[7] Specifically for stroke, the PbR guidance explains that the cost of the initial CT scan was originally paid for by the conventional tariff, but that the costs relating to the scan has now been removed "so that providers will only be reimbursed for scans that are in line with best practice." The Step-by-step guide to calculating the national tariff (Department of Health, 2010b) further specified that reduction in the conventional tariff relating to delivering a CT scan was £133 and that the tariff was reduced by an additional £120 to reflect the current compliance to the delivery of care on an acute stroke unit estimated using data from the National Sentinel Stroke Audit 2008 and Vital Signs 14.

The tariff for treating patients in an acute stroke unit was derived on the basis of the cost estimate of implementing the National Stroke Strategy from the Stroke Strategy Impact Assessment (Department of Health, 2007b) using the fraction of strategy implementation costs relating to delivering care in an acute stroke unit. The impact assessment based its cost estimates on the assumption that an additional 37% acute beds were required to ensure that all stroke units would have sufficient bed capacity to be run at an

85% bed occupancy rate which was assumed to be enough to allow 95% of all stroke patients to be admitted to an Acute stroke unit

[8] (a) all stroke patients have prompt access to an acute stroke unit and spend the majority of their time at hospital in a stroke unit with high-quality stroke specialist care (b) hyper-acute stroke services provide, as a minimum, 24-hour access to brain imaging, expert interpretation and the opinion of a consultant stroke specialist, and thrombolysis is given to those who can benefit (c) specialist neuro-intensivist care including interventional neuroradiology or neurosurgery expertise is rapidly available (d) specialist nursing is available for monitoring of patients (e) appropriately qualified clinicians are available to address respiratory, swallowing, dietary and communication issues. (Department of Health, 2007a)