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TITLE PAGE

Title: How do hospitals respond to price changes in emergency departments?

Running title: Price changes in emergency departments

Key words: hospital behaviour, payment systems, hospital reimbursement, emergency department

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ABSTRACT

Little is known about how prospective provider payment affects the provision of services led by unpredictable demand. We investigate hospital responses to a 32% increase in price for two treatments in emergency departments in England in April 2011 using data on 11,532,304 attendances (79 hospitals) between 2009/10 and 2013/14. We compare changes in the volumes of these two treatments to a treatment not attracting additional reimbursement using a difference-in-differences framework. Additional reimbursement led to 76% and 152% increases in the volumes of the two incentivised treatments. Hospitals received an additional £64.4M between April 2011 and March 2014 for providing these treatments, of which 40% (£30.0M) was attributable to the unanticipated hospital response to the price increase. We use time in treatment to distinguish real increases in treatment from reductions in under-coding or increases in up-coding. The association between the recorded

receipt of these treatments and time spent in treatment was the same before and after the price increase and there was no association between hospital-specific increases in recorded treatment volumes and changes in treatment times. The persistence of the treatment time increment suggests the increase in recorded treatment was a real increase in provision of treatments.

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1. Introduction

Reimbursement systems can create powerful incentives to affect the costs, efficiency, equity, quality and quantity of health care services. One of the most commonly used reimbursement systems is activity-based financing (Busse, 2011). Under activity-based financing providers are paid a fixed price per patient treated and their income therefore increases with the volume of activity undertaken.

Activity-based financing is usually motivated by the desire to increase productivity, reduce costs, and improve the efficiency of hospitals. However, there are concerns that cost minimisation could lead to reduced quality (Ma, 1994). Hospitals may also focus their efforts on attracting profitable patients (cream-skimming) and potentially skimp or dump the most severe, and thus unprofitable, patients (Ellis, 1998; Ellis and McGuire, 1996, 1986). Another concern is whether the incentives will result in responses which benefit or harm patients, for example, if unnecessary treatment is now provided or beneficial treatment withheld because it is unprofitable for the hospital to provide it.

It is important to determine whether any observed responses to changes in the reimbursement system represent real changes to patient care or merely nominal responses in coding (Dafny, 2005). Financial incentives may induce hospitals to game the reporting system, upcoding patients to more severe diagnosis or resource groups. Though these nominal responses may not result in direct patient harm, they increase healthcare costs and provide no additional health gain, diverting resources from other potential patients and therefore having an opportunity cost.

There is a wealth of literature documenting hospitals' responses to changes in incentive systems for inpatient care, where selection of patients is possible. For elective inpatient care, competition for patients between providers based on quality may minimise negative responses. Studies of the introduction of activity-based financing tend to find reductions in the cost of care (proxied by length of stay or proportion of day cases), but little or no impact on the level of hospital activity (see, for example, Newhouse and Byrne, 1988 and Kahn et al., 1990 for the US; Moreno-Serra and Wagstaff, 2010 for Europe and Asia; and Farrar et al., 2009 for England). However, the evidence regarding responses to changes in price levels once a fixed price regime is in place is more mixed.

The seminal study by Dafny (2005) found that hospitals did not increase admission volumes or attempt to induce demand through improvements in quality in response to price increases, but did upcode patients into more lucrative diagnosis-related groups (DRGs). Upcoding by Portuguese hospitals was also found to be greater where the relative price change of a DRG was larger (Barros and Braun, 2017). Other studies have found an increase in the number of patients treated following price increases (Januleviciute et al., 2015) or increases in the intensity of care provided for patients in higher paying DRGs (Gilman, 2000).

Evidence is lacking, however, in emergency department care where providers may have less scope to engage in unintended responses. As the demand for emergency care is less predictable, providers are less able to engage in activities to attract profitable, or detract unprofitable patients. Furthermore, demand is less likely to respond to quality, as speed of attention is likely to be the most important aspect to the patient (Chalkley and Malcomson, 2000). Therefore, demand inducement and competition for patients between providers is unlikely in this setting. However, there is still potential for providers to engage in other unintended responses such as skimping on the quality of treatment for the most severe patients or upcoding or overtreating when DRGs are refined by procedures.

We exploit a 2011 policy reform within the English NHS which resulted in refinement of the prices paid for care provided in emergency departments. Prior to the reform, hospitals were paid based only on the investigations they undertook. Following the reform, hospitals were paid based on combinations of the investigations undertaken and treatments provided. This introduced an exogenous source of variation over time in the prices paid to hospitals for various treatment and investigation combinations.

This paper investigates whether hospitals' treatment policies in emergency departments are sensitive to changes in prices. We focus on treatments that are minor and non-invasive and unlikely to offer direct health benefit or harm to patients. We expect hospitals to record increased provision of the treatments subject to the price increases. We further examine the effect on time in treatment, to identify whether recorded increases reflect additional provision, reductions in under-coding or increases in over-coding. Finally, we estimate how much of the increase in hospital income following the reform was due to the response to the price change.

2. The payment reform

Payment by Results (PbR) is a fixed tariff, case-mix based payment system in England under which healthcare providers are paid for each patient seen or treated, taking into account the severity of the patient's condition and the complexity of the treatment provided. The unit of healthcare for which payment is made are called Healthcare Resource Groups (HRGs). HRGs are clinically similar groupings expected to utilise common levels of healthcare resource. The national tariff for each HRG is calculated annually based on the average costs of treating patients within that HRG reported by hospitals three years previously.

The focus of this paper is on the HRGs for emergency department attendances only. Emergency departments (called Accident and Emergency (A&E) departments in England) are hospital units which provide emergency care to patients who present without prior appointment, arriving either by their own means or in an ambulance. Patients can be referred to the emergency department from another healthcare provider (for example a

general practitioner or walk-in centre), the emergency services, or can choose to attend themselves. Following an emergency department attendance, patients can be referred to another healthcare provider for follow-up care, sent home or admitted to hospital. PbR pays providers separately for admissions and emergency department attendances.

PbR was first introduced for emergency departments in 2006 under version 3.2 of the HRG classification system. This classified emergency department attendances into 12 HRGs, based on investigation procedures and the method of discharge (technically called 'disposal'). These 12 HRGs mapped onto three price tariffs (minor, standard and high cost). The tariff was determined only by the investigation procedures that were undertaken. Until 2011, the only changes were small annual increases in tariff prices to reflect inflation and other increases in hospital costs.

PbR in emergency departments moved to HRG version 4 in April 2011. This change resulted in an increase from three to five price bands spread across 11 HRG classifications, now based on treatments as well as investigations. Each treatment and investigation on the attendance record has an associated category of resource intensity, where treatments are ranked one to five, and investigations one to three. For payment purposes these are inputted into a 'Grouper' which calculates the HRG for each treatment and investigation combination in the patient record. The most resource intensive HRG is assigned based on the dominant, or highest category, investigation and treatment in a published hierarchy (HSCIC, 2014).

This reform introduced a marginal payment consequence for certain treatments. For illustration, consider a patient attending an emergency department suffering from cardiac arrest, who received no investigations but was treated by resuscitation and subsequently admitted. In 2010/11, under HRG version 3.2, the patient would be classified under HRG V07 "No Investigation (Died/Admitted)" and would generate a reimbursement of £59. In 2011/12, under HRG version 4, the patient would be classified under HRG VB01Z "Any Investigation with Category 5 Treatment" and the hospital would receive a payment of £183. By now reimbursing hospitals for the complex treatment of resuscitation, it is clear in this example that the introduction of HRGv4 provided hospitals with payment which more accurately reimbursed them for the services they provide.

We focus on the responses of hospitals to the new payment arrangements for providing treatments. We focus on the utilisation of 'category one' treatments only. These are the lowest resource intensive category. These treatments involve monitoring and observing patients rather than directly treating them. We hypothesised there may be large incentive responses to treatments which are easy to administer and inflict little or no direct harm on patients if administered unnecessarily.

3. Data

We use individual patient-level data from Hospital Episode Statistics (HES) between 1st April 2009 and 31st March 2014. This covers a period of two years before the payment change, and three years after. We limit the analysis to attendances at major emergency departments (called Type 1 units). This excludes single specialty centres, minor injury units and walk-in centres, which were not covered by PbR.

The attendance records contain information on patient age, gender, treatment and investigation procedures received, time spent in the emergency department, mode of arrival, discharge method, type and location of incident, and hospital. The time spent in the department is the 'duration to departure', which is the time between the patient's arrival and the time the attendance has concluded and the department is no longer responsible for the care of the patient. This is the measure used to calculate achievement of the four-hour waiting time target (Kelman and Friedman, 2009). For the analysis of treatment time, we dropped observations with zero (n=32,596, 0.28%) and default maximum (1,439 minutes) treatment times (n=120, 0.001%).

HES does not specify which treatment and investigation codes on a patient's record were the dominant codes that determined the assigned HRG. However, this information is crucial in determining what treatment (or investigation) determined the HRG and thus the price paid. For example, the receipt of 'guidance' ('Category 1' treatment) is irrelevant for the HRG if a patient has also received 'oral medication' ('Category 2' treatment), as this is a higher resource use category and would dominate the HRG assignment.

To overcome this, we extracted a sample of patients that received no investigation procedures and only 'Category 1' treatments. As investigations were part of the tariff both before and after the reform, limiting the sample to patients with no investigations allowed us to isolate the impact of the inclusion of treatments in determining the payment.

This generates a sample of patients that were assigned to the lowest tariff before the reform but to two refined HRGs after the reform that attracted two different prices. One group of treatments (the unincentivised) allocated patients to the lowest tariff payment both before and after the price change, whilst the other (the incentivised) attracted considerably higher reimbursement after the reform.

We selected treatments from these incentivised and unincentivised groups based on two criteria. Treatments had to be frequently used (received by at least 5% of patients to ensure a large enough sample size) and non-invasive (manipulation of their use would not inflict direct harm on patients). We identified 'recording vital signs' and 'observation' as incentivised treatments which met these criteria. Observations and recording vital signs were, respectively, the third (6.9% of patients) and sixth (4.8% of patients) most frequently recorded treatments in 2010/11 (HSCIC, 2013). In 2011/12, observations was again the third most frequently recorded treatment (7.2%) and vital signs was fourth (6.9%) (HSCIC, 2013).

The recording of vital signs typically involves checking a set of measures such as: pulse; blood pressure; and temperature (Boulanger and Toghill, 2009). Observations involves monitoring trends in a patient's condition to indicate the need for further interventions or admission (Andrews and Nolan, 2006). Both recording vital signs and observations are non-invasive and would usually be performed by nursing staff. We identified 'written guidance' as a control treatment that met the two criteria and was not subject to the increase in tariff payment. Table I details the HRGs and tariff changes for the treatments we analyse. There was a 32% price increase because of the reform for the two incentivised treatments. The price for the unincentivised treatment initially fell by 12%, before returning to its pre-reform level.

We aggregated the attendance-level data by combinations of treatment (vital signs, observation, and written guidance), hospital and month. Our key dependent variable is the volume of each treatment recorded by each hospital in each month. Patient mix is defined by the proportions of patients who: are aged 5 years or under, are aged over 75 years; are male; arrived by ambulance; are self-referrals; and had the incident at home.

We restricted the analysis to hospitals that returned data in every month, and excluded hospitals that reported zero volumes in every period for either of the two treated activities or the control activity. This results in a sample of 11,532,304 attendances at a balanced panel of 79 hospitals. As a robustness check we also repeated the analysis on an unbalanced panel of data from all 163 hospitals.

Table I. HRG tariff changes for patients receiving different treatments before and after the reform

Treatments	Before		After		
	2009/10	2010/11	2011/12	2012/12	2013/14
Incentivised: vital signs recorded or observations performed	£59	£59	£78	£81	£78
Unincentivised: written guidance given	£59	£59	£52	£54	£59

Sources: (Department of Health, PbR Team, 2013, 2012, 2011, 2010; Department of Health PbR Team, 2009).

Before indicates periods under HRG3.2 where the tariffs correspond to the HRGs V07 No Investigation (Died/Admitted) and V08 - No Investigation (Referred/Discharged). After indicates periods under HRG4 where the tariffs correspond to VB11Z No Investigation and No Significant Treatment and VB09Z Category 1 Investigation and Category 1-2 Treatment.

Tariffs correspond to patients receiving no investigation, An investigation or treatment of "None" is classified as category 1 under HRG4. However if the dominant investigation is "None" and the dominant treatment is either (Intravenous cannula, guidance/advice only, tetanus - immune, or none) the HRG assigned will be VB11Z. Otherwise these treatments and investigations will be considered as category 1.

4. Methods

Due to the reform, hospitals are now required to record treatments thoroughly and accurately for payment purposes, which should improve the recording of all treatment codes. Therefore, to control for other confounding causes of variation in treatment utilisation or coding, we require estimates of what would have happened to the utilisation of each of the incentivised treatments if there was no increase in their reimbursement. We use 'written guidance' as the counterfactual in a difference-in-differences analysis.

4.1 Parallel pre-trends

We used data from the pre-reform period to test if the volumes of incentivised and non-incentivised treatments trend together before the reform (Angrist and Pischke, 2008). We test the significance of an interaction between the binary incentivised treatment indicator and a monthly linear time trend. The common trends assumption is satisfied if we fail to reject the null hypothesis that the coefficient on the interaction term is zero.

4.2 The effect of the reform on the recorded volume and distribution of treatments

We analyse the effects of the tariff reform on treatment volumes using a difference-in-differences methodology. We estimate the following equation using linear regression:

$$Y_{jkt} = \beta_o + \beta_1 Post_t + \beta_2 R_j * Post_t + \gamma \bar{X}_{kt} + \varphi \bar{X}_{kt} * R_j + a_{jk} + u_{jkt}$$

where Y is volume, subscript j indicates the treatment (vital signs, observations, written guidance), k the hospital and t the month. *Post* indicates the period after the reform, R indicates an incentivised treatment, a_{jk} are hospital-treatment fixed effects and u_{jkt} is the error term. $\overline{\mathrm{X}}$ are average values of patient characteristics which may affect the probability of treatment and which vary over time. These variables are also interacted with the type of treatment since the effects of these characteristics on the probability of receipt may vary across the type of treatment. The coefficient on the interaction between the indicators for the incentivised treatment and post-reform period is the effect of interest. We estimated the above model separately for each incentivised treatment (vital signs versus written guidance, and observations versus written guidance).

To assess if there was a change in the hospital distribution of the provision of treatments, we examine whether the changes in volumes of treatments were associated with initial volumes. A simple regression of the change in average monthly volume from before to after the reform on the average monthly volume before the reform may be biased due to mathematical coupling (Archie, 1981). We therefore implemented the solution recommended by Chiolero et al (Chiolero et al., 2013). For each incentivised treatment we fitted a linear random effects regression model of annual hospital volumes on an annual linear time trend indexed to zero in the first year. The correlation between the random coefficient for the intercept and random coefficient for the slope summarises the relationship between change in treatment volume and initial treatment volumes (Chiolero et al., 2013).

4.3 Effect on treatment time

There may be increases in the recorded volumes of treatments for several reasons. The increase may be real, in that hospitals accurately record the delivery of treatment in both the before and after periods, and respond to the price increase by providing more of the incentivised treatments. Alternatively, any detected increases may be false for two reasons; either hospitals were under-coding the true delivery of treatments in the before period (when it made no difference to reimbursement) and accurately record treatment in the after period, or hospitals were accurately recording treatment in the before period but falsely inflate the delivery of treatment in the after period. In these instances, any detected increases would represent changes in coding practices as opposed to real changes in activity.

We use the time that patients spent in the emergency department to distinguish between these scenarios. This should be positively correlated with real delivery of treatment but does not determine reimbursement. If hospitals accurately record delivery of treatment in both the before and after periods, and there is no significant change in technology, then the difference in treatment time between the recorded recipients and non-recipients will be an accurate indication of the time associated with treatment in both periods and should not change after the reform.

However, inaccurate coding of treatment delivery will distort the difference in treatment time between patients recorded as receiving treatment and patients coded as not receiving treatment. If hospitals are under-coding treatment delivery in the before period, some patients who receive treatment will be incorrectly recorded as in the non-treatment group, falsely inflating the treatment time in the non-treated group in the before period. More accurate coding in the after period should then widen the difference in treatment time between the groups recorded as receiving and not receiving treatment between the before and after period. Conversely, if hospitals are accurately recording delivery in the before period and up-code some patients in the after period in response to the price change, then the average treatment time for the group recorded as receiving treatment will be falsely deflated in the after period and the difference in treatment time between recorded recipients and non-recipients should narrow.

Using patient level data from the restricted sample as described in section 3, we first test for parallel trends in treatment time between patients receiving the incentivised treatments and patients not receiving the incentivised treatments in the pre-reform period, by testing the significance of an interaction between the binary receipt of treatment indicator and a monthly linear time trend. We then regress time spent in the emergency department (π) on patient characteristics, recorded receipt of treatment, a post period indicator, and an interaction between treatment and the post period:

$$\pi_{ikt} = \beta_o + \beta_1 X_{ikt} + \beta_2 Treatment_i + \beta_3 Post_t + \beta_4 Treatment_i * Post_t + a_k + u_{ikt}$$

The β_2 coefficient indicates whether receiving vital signs/observations is associated with longer treatment time in the before period once we control for patient characteristics. The β_4 coefficient indicates whether the difference in treatment time increases or decreases in the after period. If β_2 is positive or $\beta_2 + \beta_4$ is positive, this is evidence to support the use of treatment time as an indicator of true receipt of treatment. If β_4 equals zero, this is evidence suggesting that any recorded changes in the volume of treatment over time are real as there is no change in the time differential associated with recording of treatment receipt after the reform. If β_4 is positive, this suggests under-coding in the before period. If β_4 is negative, this suggests up-coding in the after period.

We expect heterogeneity in response to the incentives across hospitals. We therefore estimate a pooled model with hospital fixed effects and then a model for each hospital separately. The β_4 coefficients for each hospital are an indication of whether the hospital was under-coding in the before period or up-coding in the after period. The model can only be estimated on the subset of hospitals for which we can estimate an incremental treatment time because they recorded some of each treatment in both the before and after periods.

We examine the relationship between the increases in hospital volumes of treatment recorded between the before and after periods and the hospital-specific β_4 coefficients. Positive β_4 coefficients for the hospitals who had low volumes of recorded treatment in the

before period and average monthly volumes of recorded treatment in the after period would be consistent with under-coding by these hospitals in the before period. Negative β_4 coefficients for the hospitals who had average monthly volumes of recorded treatment in the before period and high volumes of recorded treatment in the after period would be consistent with up-coding by these hospitals in the after period. A lack of relationship between incremental treatment time and increase in treatment provision after the reform across hospitals would be consistent with increases in recorded treatment volumes being real.

The length of time that patients spend in the emergency department is a direct, process indicator linked to the receipt of treatments. As robustness checks, we also repeat the same analyses for the probabilities of admission and of re-attendances within 30 days.

4.4 Intended and unintended cost consequences

The reform was intended to better align reimbursement with the costs incurred by emergency departments. Payers would therefore have expected an increase in costs because of the increase in per-unit reimbursement for the treatments that were being provided. However, they may not have anticipated additional utilisation of treatments because of the price increases. We estimate the additional expenditure resulting from the price change, and the proportion of this new expenditure that was due to hospitals increasing treatment volumes.

We calculated the total additional reimbursement for the two newly-reimbursed treatments by multiplying the number of patients for which 'recorded vital signs' and/or 'observations' determined their HRG tariff with the average difference in price between the unincentivised and incentivised treatments in the after period. We estimated the cost consequences to the payer of the hospital responses to the price incentives using the difference-in-differences estimates multiplied by the 36 months in the post reform period and the number of hospitals. We adjusted this estimate to avoid double-counting patients who received both observations and vital signs, and the proportion of patients that received other 'category one' treatments that would have resulted in additional reimbursement without the utilisation of vital signs and/or observation. For patients that received both or other 'category one' treatments, we can attribute the additional utilisation of recording vital signs or performing observations to the reform, but we cannot be sure it was the recording of vital signs or the performing of observations that resulted in the increase in payment.

5. Results

5.1 Descriptive statistics

The average monthly hospital volumes of recording vital signs is 53 patients in 2009/10 and increases each year to 404 patients in 2013/14 (Table II). The average volume of performing observation starts at 140 patients per hospital per month in 2009/10 and increases to 413 in

2013/14. The average monthly hospital volumes of the non-incentivised treatment, written guidance, is 155 patients in 2009/10 and increases to 253 in 2013/14.

The trends in the aggregate monthly volumes of the incentivised and unincentivised treatments are shown in Figure 1. The vertical line indicates the month before the reform was implemented (24th month, March 2011). The volume of both vital signs and observation treatments follow similar trends to the volume of unincentivised written guidance prior to the pricing reform. There is an increase in the utilisation of all treatments around the time of the reform, with the volume of the two incentivised treatments continuing to trend upwards over the following three years while the volume of unincentivised written guidance remains constant. The gap in the volumes of vital signs and observation after the reform compared to that of written guidance shows the potential impact of the reform.

The average patient age in the whole sample is around 30 years, falling slightly year on year (Table II). The average proportion of male patients is 53%. The average proportion of patients arriving by ambulance falls from 18% to 15%, whilst the proportion of self-referrals remains relatively constant at around 70%. The average proportion of patients whose incident occurred at home increases from 50% to 54% over time.

The average total time spent in the emergency department for all patients increased over the analysis period from 108 minutes in 2009/10 to 116 minutes in 2013/14 (Table II). The average time spent in the emergency department for patients who had their vital signs recorded was higher than the overall average at 118 minutes in 2009/10, increasing to 128 minutes in 2013/14. For patients on whom observations were undertaken, the average time spent in the emergency department was 123 minutes in 2009/10, increasing to 130 minutes in 2013/14. The average time spent in the emergency department for patients who received written guidance was lower than the overall average at 98 minutes in 2009/10, increasing to 110 minutes in 2013/14.

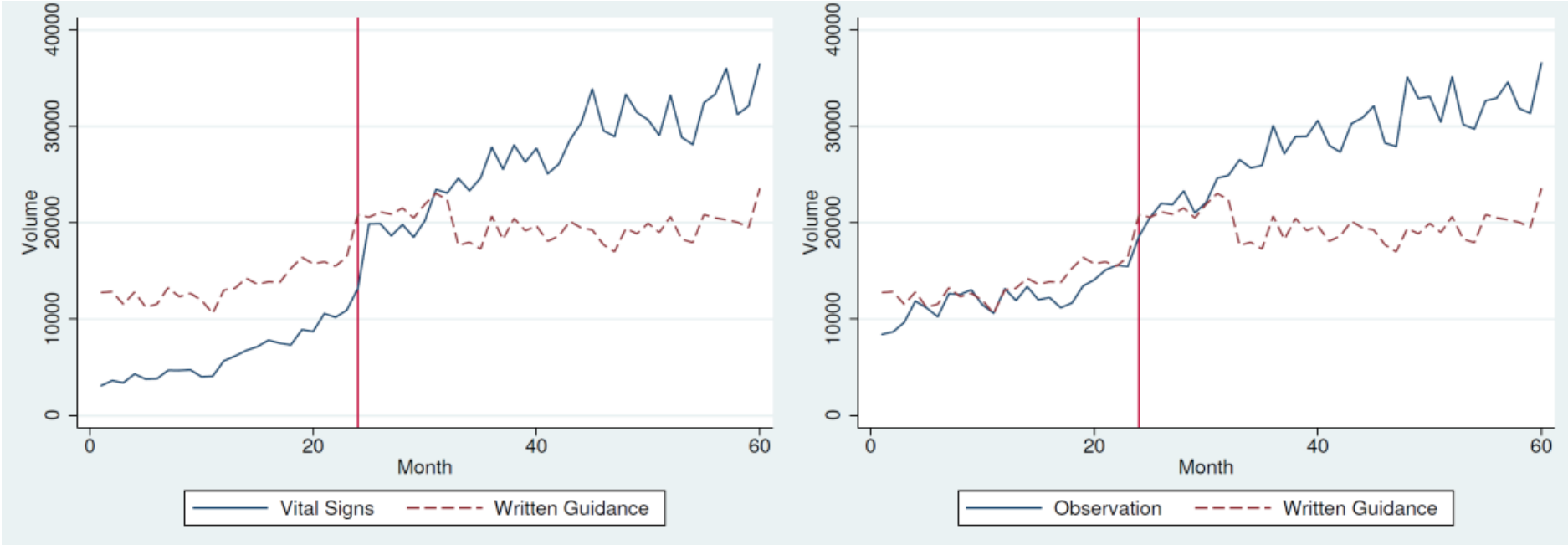
Table II. Descriptive statistics

Financial year	2009/10	2010/11	2011/12	2012/13	2013/14
			All Patients		
Average age (years)	30.608	30.192	29.838	29.462	29.133
Proportion aged 0-5 years	0.237	0.245	0.252	0.265	0.271
Proportion aged 75+ years	0.039	0.037	0.034	0.033	0.031
Proportion male	0.532	0.530	0.528	0.521	0.521
Proportion arrived by ambulance	0.179	0.186	0.161	0.153	0.150
Proportion self-referred	0.690	0.708	0.692	0.687	0.672
Proportion of incidents occurring at home	0.503	0.518	0.511	0.535	0.541
Time spent in emergency department (minutes)	107.763	110.940	107.462	112.431	115.497
			Patients with vital signs recorded		
Average hospital monthly volume	52.621	110.976	278.395	362.248	404.041

Average age (years)	26.575	26.325	25.314	24.694	23.186
Proportion aged 0-5 years	0.338	0.350	0.366	0.382	0.410
Proportion aged 75+ years	0.036	0.037	0.031	0.029	0.024
Proportion male	0.524	0.519	0.523	0.517	0.523
Proportion arrived by ambulance	0.252	0.234	0.219	0.204	0.202
Proportion self-referred	0.627	0.687	0.686	0.677	0.671
Proportion of incidents occurring at home	0.503	0.527	0.572	0.578	0.581
Time spent in emergency department (minutes)	117.572	122.780	119.338	123.166	127.677
Patients with observations performed					
Average hospital monthly volume	140.839	173.687	304.465	375.091	412.924
Average age (years)	29.655	27.731	26.851	26.489	25.490
Proportion aged 0-5 years	0.287	0.321	0.341	0.353	0.369
Proportion aged 75+ years	0.047	0.042	0.039	0.037	0.034
Proportion male	0.521	0.514	0.518	0.514	0.516
Proportion arrived by ambulance	0.261	0.270	0.240	0.220	0.220
Proportion self-referred	0.584	0.633	0.644	0.643	0.646
Proportion of incidents occurring at home	0.612	0.587	0.570	0.592	0.583
Time spent in emergency department (minutes)	123.228	125.365	122.682	127.495	129.838
Patients who received written guidance					
Average hospital monthly volume	154.610	194.997	258.988	239.724	252.614
Average age (years)	26.910	26.858	25.737	24.297	23.905
Proportion aged 0-5 years	0.288	0.297	0.313	0.362	0.369
Proportion aged 75+ years	0.026	0.029	0.022	0.021	0.020
Proportion male	0.554	0.551	0.558	0.549	0.550
Proportion arrived by ambulance	0.140	0.160	0.138	0.120	0.122
Proportion self-referred	0.695	0.687	0.708	0.734	0.732
Proportion of incidents occurring at home	0.409	0.419	0.436	0.508	0.519
Time spent in emergency department (minutes)	98.024	106.856	101.932	107.885	110.216

Figures refer to the panel of hospitals used in the main analysis (n=79)

Figure I. Trends in aggregate monthly volumes of treatments



Notes: months are numbered from April 2009 until March 2014. Vertical line is placed at April 2011, when the price change was introduced for recording vital signs and undertaking observations but not providing written guidance.

5.2 Pre-trends

We fail to reject the null hypothesis that the volumes of incentivised and unincentivised treatments experience common trends in the period before the implementation of the policy. For vital signs, the magnitude of the differential trend is an additional 0.6 patients treated per month in each hospital (p=0.636). For observations, the magnitude of the differential trend is a decrease of 0.7 patients per month in each hospital (p=0.687).

5.3 The effect of the reform on the recorded volume and distribution of treatments

Table III presents the difference-in-differences estimation results for the impact of the pricing reform on the volume of vital signs and observation utilisation. We find that the reform resulted in a significant increase in the average utilisation of vital signs by approximately 169 patients treated per month in each hospital (p=0.002). This is a 152% increase on the baseline volume of 111 patients per month in the year before the reform. Similarly, on average, hospitals provided observations to 132 more patients because of the reform (p=0.019). This is a 76% increase on the baseline volume of 174 patients per month in the year before the reform.

The results are robust to the use of data from all hospitals, with estimates of similar magnitude and statistical significance to estimates from the balanced panel. In the full sample, hospital volumes of recording vital signs and performing observations increased by an average of 147.9 (p=0.0001) and 101.3 (p=0.007) patients per month, respectively (Table A1).

There is substantial hospital variation in the volume of treatments recorded in the pre-reform period and in the response to the price change. We find little correlation between the random coefficients on the intercepts and the random coefficients on the trends, for both the volume of vital signs (corr=0.008, 95%CI: -0.325, 0.339) and the volume of observations (corr=-0.039, 95%CI: -0.318, 0.247), which suggests no association between initial volume and change in volume.

Table III. Difference-in-differences regression of the effect of the price change on the volume of treatments provided

	Recorded vital signs		Observations performed	
Difference-in-differences	190.8***	168.6**	131.3*	132.3*
	[49.04]	[53.42]	[49.78]	[55.40]
Average patient characteristics	No	Yes	No	Yes
Number of observations	9480	9218	9480	9218
Number of hospitals	79	79	79	79
R^2	0.151	0.167	0.104	0.115

Notes: Observations are hospital-months. Hospital cluster robust standard errors in parentheses.
All models include hospital-treatment interactions.
Average patient characteristics are the proportions of patients: aged 0-5 years, aged 75 years and over, male, arrived by ambulance or helicopter, self-referred, and whose incident occurred at home.
* p<0.05 ** p<0.01 *** p<0.001.

5.4 Effect on treatment time

We fail to reject the null hypothesis that patients receiving incentivised treatments and patients not receiving incentivised treatments experience common trends in treatment time in the period before the implementation of the policy. The p-values for the coefficients on the differential trends equal 0.510 and 0.648 for the two incentivised treatments, vital signs and observations, respectively. Adjusted for patient characteristics, receipt of vital signs is associated with a 22.6 minute longer treatment time and receipt of observations is associated with a 21.8 minute longer treatment time across the period we examine (Table IV). There is no statistically significant change in the time associated with receipt of these treatments after the reform, adjusted for patient characteristics. The coefficients on the interaction term between receipt of treatment and the post reform period are both negative, but are small compared to the main effect of treatment receipt and are not statistically significant.

When investigating the heterogeneity in response to the incentives across hospitals, we find the correlations between the hospital-specific incremental treatment time and the increase in hospital-specific monthly volumes of recorded treatments between the before and after periods is 0.07 (p=0.64, N=48) for vital signs and 0.13 (p=0.32, N=63) for observations. These show no association between increases in treatment volumes and changes in incremental treatment times.

The same analyses for the probabilities of admission and re-attendance provide supporting evidence. Receipt of vital signs and observations is associated with a higher probability of admission and a lower probability of re-attendance (Table IV), and these associations do not change in the post reform period. The changes in hospital volumes of vital signs are not associated with changes in the incremental probabilities of admission (corr=0.23, p=0.12, n=48) and only weakly associated with changes in the incremental probabilities of re-attendance (corr=0.29, p=0.04, n=48). The changes in hospital volumes of observations are associated neither with changes in the incremental probabilities of admission (corr=0.12, p=0.35, n=63) nor re-attendance (corr=0.005, p=0.97, n=63).

Table IV: Regression of treatment time and probabilities of admission and re-attendance on receipt of incentivised treatments before and after the price change

Variable	Treatment time		Admitted		Re-attended	
	Vital signs	Observations	Vital signs	Observations	Vital signs	Observations
Post * receipt of treatment	-6.905	-3.462	-0.00606	0.00465	0.00319	0.00102
	[4.726]	[3.345]	[0.0109]	[0.0128]	[0.00173]	[0.00151]
Receipt of treatment	22.56***	21.83***	0.0377***	0.0696***	-0.00563**	-0.00316*
	[5.173]	[3.324]	[0.00913]	[0.00931]	[0.00172]	[0.00139]
Post period	1.382	1.464	-0.0230***	-0.0293***	-0.000377	-0.000494
	[2.284]	[2.494]	[0.00504]	[0.00550]	[0.00153]	[0.00154]
Age 0-5	-2.251	-2.353	0.0197***	0.0169**	-0.00209*	-0.00210*
	[1.375]	[1.364]	[0.00597]	[0.00595]	[0.000956]	[0.000959]
Age 75+	20.26***	20.15***	0.0961***	0.0947***	-0.00170*	-0.00169*
	[2.169]	[2.192]	[0.00499]	[0.00511]	[0.000820]	[0.000823]
Male	0.389	0.419	-0.0125***	-0.0121***	0.00164***	0.00164***
	[0.346]	[0.353]	[0.00219]	[0.00201]	[0.000228]	[0.000227]
Arrived by ambulance	29.35***	28.92***	0.0712***	0.0674***	-0.00390***	-0.00387***
	[1.733]	[1.744]	[0.00527]	[0.00560]	[0.00112]	[0.00109]
Self-referred	-6.601***	-6.366***	-0.0940***	-0.0924***	-0.00177	-0.00183
	[1.802]	[1.848]	[0.00633]	[0.00642]	[0.00122]	[0.00123]
Incident at home	6.339***	6.204***	0.0450***	0.0432***	0.000536	0.000550
	[1.041]	[0.983]	[0.00562]	[0.00518]	[0.00129]	[0.00128]
N	10,090,967	10,090,967	10,133,812	10,133,812	10,140,055	10,140,055
R^2	0.082	0.084	-	-	-	-
Pseudo R^2	-	-	0.152	0.161	0.056	0.056

Notes: Treatment time is time between arrival and departure. Admitted indicates that this attendance concludes with hospital admission. Re-attendance is 'follow-up' re-attendance within 30 days.
Observations are attendances. Regression model for treatment time is OLS. Regression models for probabilities of admission and re-attendance are probit regressions and marginal effects are reported. All models include hospital fixed effects. Hospital cluster robust standard errors in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.5 Intended and unintended cost consequences

Our difference-in-differences results suggest that an additional 301 patients per month received vital signs and/or observations at the 79 hospitals included in our main analysis because of the reform (Table V). Approximately 15.4% of patients received both treatments and 16.4% received other additional category 1 treatments. Adjusting for these, we estimate that these hospitals received additional reimbursement for 580,718 patients because of their response to the price change. Multiplying this by the average difference in reimbursement

between the incentivised and unincentivised treatments of £24, we estimate that the unanticipated cost of the reform to the payer associated with increased utilisation of the incentivised treatments was £13.9 million for the 79 hospitals in our analysis. This is 40% of the additional £34.6 million paid because of the introduction of the £24 price differential. Scaled up to all 147 hospitals nationally which were active in 2013/14, the total cost implication would be £64.4 million over three years, of which £30.0 million would be due to the hospital response to the price increase.

Table V. Estimation of the expected and unexpected costs of the reform

Calculation	Value
A: Difference-in-differences estimate of effect on treatment volume per month	300.9†
B: Months after reform	36
C: Number of hospitals in the difference-in-differences analysis	79
D: Increase in treatment volume associated with the price increase (A x B x C)	855,759
E: Proportion of patients receiving both treatments	15.4%
F: Proportion of patients receiving other category 1 treatment	16.8%
G: Increase in treatment volume adjusted for double-counting (D x (1 - E - F))	580,718
H: Price difference between incentivised and unincentivised treatments	£24
K: Total number of patients for whom the incentivised treatments determined price	1.44M‡
I: Total additional cost to payer for incentivised treatments (K x H) *(expected + unexpected cost)*	£34.6M
L: Cost of incentive effect for provision of incentivised treatments (G x H) *(unexpected cost)*	£13.9M
M: Proportion of total additional cost due to hospital responses (D ÷ G)	40.3%

Notes: †The sum of difference-in-differences coefficients in Table III.
‡ The number of patients assigned to higher paying HRG (VB09Z Category 1 Investigation and Category 1-2 Treatment) that had 'recorded vital signs' and/or 'observations' but no other category 1 treatment.

6. Discussion

Reimbursement systems have the potential to generate powerful incentives to alter hospital behaviour and can result in both intended and unintended responses. Most studies to date have examined responses to payment system changes for admissions to hospital. We analysed the effects of a payment reform for emergency department attendances which involved a refinement of the definitions of HRGs to take account of treatment procedures. This study provides insight into how the incentives of a prospective payment system present themselves in an environment when care is predominantly demand-led.

Our results suggest that the reform incentivised hospitals to provide significantly more of the treatments that were subject to the price increase relative to those that were not. The analysis of treatment time suggests that the recorded increases in delivery of treatment were real and not the result of systematic eradication of under-coding or adoption of up-coding.

Our results are consistent with those of Januleviciute et al (2015), who find the supply of medical services is sensitive to changes in prices. However, this contradicts evidence found in Gilman (2000), that hospitals were either not willing or able to increase the rate of the high-priced treatment-based DRGs following changes in the marginal reimbursement incentives. Gilman suggests this may be due to lack of physician discretion over how people with HIV are treated. This may explain our opposing results, since we find evidence of a strong response to price incentives in a situation where professionals have more discretion over what treatments to provide.

Our findings suggest that the introduction of increased prices affected the treatment policy of hospitals. Payers of emergency services therefore face a crucial difficulty in developing an optimal payment mechanism that manages the trade-off between the various intended and unintended incentives effectively. Hospitals need to be paid an adequate and sufficient amount to cover the costs of supplying treatment. If payment does not reflect costs to a sufficient degree, hospitals are incentivised to undersupply more intensive treatments (Siciliani, 2006) and may 'skimp' on the care of the most severe patients (Ellis, 1998). An optimal payment system must therefore accurately capture the heterogeneity of resource use in emergency care, which the HRG4 refinement attempted to do. However, by splitting HRGs and their tariffs by treatment intensity, this provided an incentive to over-provide treatments with a higher price. We estimate that nearly half of the reimbursement for the treatments analysed in the post-reform period was due to unintended responses from hospitals in terms of increased utilisation. We cannot determine whether these treatments were being under-provided before the reform, or over-provided after it. It is therefore difficult to ascertain which reimbursement system delivered the most efficient and equitable outcomes for patients.

This is the first study to analyse the incentive effects of payment reforms in emergency departments. We utilised national administrative data at the individual level and focused on attendances where a minor change in treatment led to a clear difference in price. Limitations of the study include the improvements in the completeness of treatment records over time, with 9.9% of all attendances in the before-reform period having entirely missing treatment records. We accounted for variations across hospitals in data quality by limiting the main analysis to the 79 of 163 hospitals that returned data in every period, and checked that the results were robust to including more hospitals.

Our results may not generalise to other care settings or more intensive treatments within emergency departments. Future research could usefully focus on the impact of the reform on the utilisation of treatments that are more intensive and less likely to be under the discretion of hospitals. The benefits of these additional treatments to patients are also an important area for future investigation. We have also found substantial variation in responses to the reform across hospitals and future research might explore the hospital characteristics that predict these responses to the policy reform.

Whilst the treatments we analysed represent a small proportion of total hospital income, we found a substantial increase in treatment volume in response to a 32% increase in price. We estimate that 38% of the increase in expenditure incurred by payers was due to the hospitals' volume responses. As the sample of patients we examine represents just 13.6% of the total population of patients attending emergency departments, and the pricing reform created price incentives for additional treatments not examined in this study, the full impact of the reform is likely to be even larger. Analysis of treatment time suggests that this increase in activity was predominantly real rather than a coding artefact, despite very large variation in response across hospitals. In this case, activity-based financing acted as a financial incentive scheme as opposed to a reimbursement mechanism.

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