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RESEARCH ARTICLE

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How do hospitals respond to payment unbundling for diagnostic imaging of suspected cancer patients?

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Abstract

Payments for some diagnostic scans undertaken in outpatient settings were unbundled from Diagnosis Related Group based payments in England in April 2013 to address under-provision. Unbundled scans attracted additional payments of between £45 and £748 directly following the reform. We examined the effect on utilization of these scans for patients with suspected cancer. We also explored whether any detected effects represented real increases in use of scans or better coding of activity. We applied difference-in-differences regression to patient-level data from Hospital Episodes Statistics for 180 NHS hospital Trusts in England, between April 2010 and March 2018. We also explored heterogeneity in recorded use of scans before and after the unbundling at hospital Trust-level. Use of scans increased by 0.137 scans per patient following unbundling, a 134% relative increase. This increased annual national provider payments by £79.2 million. Over 15% of scans recorded after the unbundling were at providers that previously recorded no scans, suggesting some of the observed increase in activity reflected previous under-coding. Hospitals recorded substantial increases in diagnostic imaging for suspected cancer in response to payment unbundling. Results suggest that the reform also encouraged improvements in recording, so the real increase in testing is likely lower than detected.

KEYWORDS
cancer, Diagnosis Related Groups (DRGs), diagnostic imaging, medical coding, payment methods

1 | INTRODUCTION

The level and structure of provider reimbursements can have significant impacts on the costs, quality and efficiency of healthcare services supplied (Ellis & McGuire, 1996). Fee-for-service involves a retrospective payment for each element of services delivered, encouraging increased activity and creating incentives to increase costs. Conversely, global budgets comprise a prospectively-determined fixed payment for a specified volume of activity, providing incentives for

reduced activity and cost containment. Many countries have now moved away from these two payment methods, instead adopting Diagnosis Related Group (DRG)-based payment systems (Aragón et al., 2022; Busse et al., 2011). These provide a standardized prospective payment, based on clinical diagnosis and interventions for a "typical patient." Elements of care (treatments, procedures, etc.) are combined into one episode that is paid for with a given price (i.e., bundled). DRG-based payment systems create incentives to provide more episodes of care but reduce the costs of the treatment or diagnostic activity provided within those DRG episodes for each patient (Aragón et al., 2022).

There is a wealth of empirical literature on the effect of adopting a DRG-based payment system on efficiency and activity, but results are mixed. Some country-specific studies find that moving to a system of DRG-based payments is associated with increases in the volume of activity (Farrar et al., 2007, 2009; Or, 2014; Street et al., 2007). However, others have found no effect or a decrease in activity following the introduction of DRG-based systems (Moreno-Serra & Wagstaff, 2010; Palmer et al., 2014; Wubulihasimu et al., 2016). Effects are likely to vary depending on the specific organization of the DRG-based payment system and the type of payment system previously in place.

There is an additional, growing literature on other forms of bundled payments which go beyond episodes of care to encompass full care pathways. Studies generally find that these bundled payment models have the desired effect of reducing spending, but the effects on quality of care are less clear (Struijs et al., 2020).

DRG-based payments encourage providers to reduce costs within a DRG-category, which can generate undesirable incentives. When providers are paid on the basis of an expected or typical package of care, this creates incentives to skimp on the care provided to patients, with incentives to cut back on the more costly elements of the care bundle. This has led policymakers in England, concerned about underutilization of costly but essential services, to separate certain high-cost elements of a bundled payment back out. This is known as "unbundling." Similar payment adjustments are seen in other countries such as France and Germany where supplementary payments are available for high-cost services, separate from the main DRG grouping process (Busse et al., 2011). Whilst there is a wealth of evidence on the effects of implementing DRG-based payments, and a growing literature on other types of bundled payment, the impact of unbundling once such payment systems are in place has not yet been explored.

DRG-based payments rely on recording activity which takes place during an episode of care. However, incentives to accurately code each specific element of care provided may not be as strong in DRG-based systems as in a fee-for-service where providers are directly reimbursed for each procedure. Furthermore, previous research has shown that DRG-based systems can result in "upcoding" (Barros & Braun, 2017; Dafny, 2005). Upcoding occurs when providers merely record more severe diagnoses or procedures in order to move patients to a higher paying DRG code.

In this paper, we explore the effects of unbundling on activity, using a reform to the DRG-payment system in England in 2013. Certain diagnostic imaging services provided in an outpatient setting were unbundled from the previous DRG classification. Previously, diagnostic imaging scans would have been included in the DRG for an outpatient attendance. For example, in 2012 the tariff for an outpatient first attendance with one medical oncology professional was £228 regardless of how many diagnostic imaging scans were undertaken during the attendance. In 2013, separate national prices were introduced for diagnostic imaging services in addition to the core outpatient attendance tariff, generating additional reimbursements per scan delivered. These additional reimbursements were substantial, ranging from £45 to £748 per scan in the first year depending on the type of scan delivered.

The reform was intended to increase diagnostic imaging activity to address concerns raised by the sector that including diagnostic imaging within the bundled outpatient attendance tariffs was leading to "under-payment of diagnostic imaging delivered for complex patients and under-provision of imaging services in some local areas" (Department of Health and Social Care, 2013a). This reform was intended to "support early diagnosis and efficient pathways for patients" (Department of Health and Social Care, 2013a), targeting the apparent skimping taking place.

The consequences of unbundling may be most important for specific conditions. Early detection and diagnosis of cancer is a key goal in England, due to the improved patient outcomes achieved when cancers are diagnosed and treated at an earlier stage (NHS England, 2021). Cancer shares symptoms with many other common conditions, meaning that symptoms are often indiscriminate upon presentation. Diagnostic imaging therefore plays a vital role in detecting, diagnosing or ruling out, and staging of cancer (The American Cancer Society, 2015).

We examine the effects of the policy change on utilization of services for patients with suspected cancer, as changes to the efficiency of diagnostic services in an outpatient setting could have important implications for early detection of cancer. Finally, we explore whether any detected effects represent a real increase in the use of scans, or improvements in hospital coding of existing activity.

This paper contributes to the literature in three main ways. Firstly, it adds to the bundled and DRG-based payments literature by examining what happens when elements of these payments are subsequently unbundled. Responses to

financial incentives depend upon the existing incentives and barriers operating in the system at the time (Parkinson, Meacock, Sutton, et al., 2019), and in particular we do not know whether providers respond symmetrically to the removal as opposed to introduction of bundled payments.

Secondly, it contributes to the early diagnosis literature, specifically the link between payment methods and hospital responsiveness in diagnosing suspected cancer patients. Early detection and diagnosis of cancer is a policy focus in many Organisation for Economic and Development countries, yet waiting times in the UK are increasing, with many patients experiencing delays in access to diagnostics (Wickens, 2022). Provider reimbursement systems offer a mechanism through which policy makers might attempt to increase access to these diagnostic services. Health service processes and symptom investigation were identified as key themes in a recent priority setting exercise for detecting cancer early (Badrick et al., 2019). We investigate whether changes to the way that the NHS in England paid for key diagnostic tests impacted the use of these for symptom investigation, providing evidence as to whether financial incentives can act as an effective mechanism to pursue early detection goals. Whilst financial incentives to increase cancer screening rates have shown minimal effects in primary care settings (Mauro et al., 2019), their impact on early detection activities for detecting symptomatic cancer amongst secondary care providers, who face different resource constraints, is unknown.

Finally, we contribute to literature on coding accuracy in DRG-based payments. Policymakers will inevitably be interested in whether the extra activity reported in response to incentivizes is real. Previous research exploring coding responses to a payment change focused on the occurrence of upcoding (Barros & Braun, 2017; Dafny, 2005). In contrast, this paper examines whether the introduction of incentives reduces the occurrence of under-coding. Under-coding may impact directly on individual patient outcomes if it creates potential patient safety issues, but more broadly inaccurate reporting of activity may distort strategic and planning decisions.

2 | INSTITUTIONAL BACKGROUND AND THE REFORM UNDER EXAMINATION

2.1 | The 2-week wait diagnostic process for cancer in England

Referrals via the 2-week wait pathway are the most common route to a cancer diagnosis, covering 38% of cancer diagnoses (National Cancer Registration and Analysis Service, 2018). For suspected cancer, primary care physicians request an urgent referral for the patient to see a specialist hospital doctor. The 2-week wait target, introduced in 2000, states that this appointment should take place within 2 weeks of referral. When patients are referred via a 2-week wait the hospital will often carry out diagnostic scans to further investigate symptoms. These scans may take place during or before the specialist appointment (Cancer Research UK, 2023). The type of scan undertaken will depend on the symptoms and the area of the body which is affected.

The 2-week target refers to the time between urgent referral by a GP, and the first specialist appointment. The time between urgent referral and receiving a definitive diagnosis can be longer. The median time between first presentation in primary care and receipt of diagnosis was 40 days in 2014 (interquartile range 15–86 days) (Swann et al., 2018).

2.2 | Hospital payments in England

In England, hospitals are reimbursed using a DRG-based tariff system called Payment by Results (PbR; Wright et al., 2017). Providers receive a standard national price for an episode of care, which varies according to the complexity of treatment and is set prospectively. Prices are based on historical national average provider costs from 3 years previous (Grašič et al., 2015) and are adjusted to reflect changes to costs over time (e.g., inflation or technological improvements), cost-effectiveness guidelines, and unavoidable differences in area-level costs (Marshall et al., 2014).

DRGs for inpatient episodes categorize patients into groups based on diagnosis, treatment and procedures, and length of hospital stay. Following Shleifer's theory of yardstick competition (Shleifer, 1985), the price is based on the average cost for groups of providers, which creates incentives for socially-optimal levels of cost reduction.

For outpatient attendances, DRGs are determined solely by the medical specialty, whether it is a single or multi-professional attendance, and whether it is a first or subsequent attendance (Department of Health, 2012).

As in other DRG-based payment systems, PbR in England relies on hospital recording of information about the episode such as diagnosis and procedures delivered. In an inpatient setting, accurate recording of procedures is

incentivized as this may lead to a higher paying DRG code. However, historically, in an outpatient setting, the procedures that were undertaken during an outpatient attendance did not contribute to determining the DRG grouping. Prior to the unbundling reform, DRG-based payments in an outpatient setting in England therefore did not directly incentivize complete coding on the use of procedures.

2.3 | The reform under examination

Prior to April 2013, diagnostic imaging scans that were undertaken during an outpatient attendance were part of the care package reimbursed within the general tariff for an outpatient attendance. There was therefore no nationally mandated additional payment for the provision of these diagnostic scans.

In April 2013, these services were unbundled from the core DRGs to address concerns of under-provision (Department of Health and Social Care, 2021). The following scans were unbundled: computerized tomography (CT), magnetic resonance imaging (MRI), dual-energy X-ray absorptiometry (DEXA), contrast fluoroscopy, ultrasound, nuclear medicine, and echocardiogram. Standard X-rays were not unbundled from the core tariff, meaning that they did not attract additional reimbursement after the reform.

This unbundling meant that an attendance resulted in additional payments over and above the core outpatient tariff if it included any unbundled elements. The unbundled component became a separate, additional tariff to the core DRG, effectively introducing a fee-for-service add-on to the payment. This reform meant that hospital Trusts were directly incentivized to report their diagnostic imaging procedures in order to receive the additional reimbursement for any scans delivered. Whilst hospital staff are salaried, this incentive at the hospital level would be translated to the staff ordering and recording diagnostic scans through its potential impact on the budget available to their service, for example, making more money available to invest in the service (McDonald et al., 2015). The reform was introduced to address concerns raised by the sector that under-payment of diagnostic imaging was resulting in under-provision, an acknowledgment that skimping was taking place. Healthcare staff act as agents both for the hospital which employs them and for the patients they treat (Ellis & McGuire, 1986). The impact on hospital profits and patient welfare are therefore both assumed to enter their utility function. A relaxation of the financial constraints as a result of increased reimbursement would therefore be predicted to result in an increase in provision of diagnostic imaging through its effects on both hospital profits and patient welfare.

Previous studies in the UK have shown that hospital Trusts have responded strongly to financial incentives introduced in both emergency departments (Parkinson, Meacock, & Sutton, 2019) and elective care settings (Gaughan et al., 2019), providing evidence that these incentives do pass through to medical professionals, even though hospital staff are salaried.

Table 1 presents a detailed timeline of the changes to the outpatient attendance tariff and the size of the tariffs during the period of interest. For example, for a first outpatient attendance with one medical oncology professional during which one MRI scan was delivered, hospital reimbursement increased from £228 in the year before the reform to £353 the year after. This represents a 55% price increase due to the unbundling of diagnostic imaging scans. The reimbursement for a first outpatient attendance with one medical oncology professional and one unbundled scan increased by between 13% and 321% in the first year of the reform, depending upon the type of scan delivered.

Diagnostic imaging services were not unbundled for inpatient admissions, but instead remained within the core inpatient DRG-based tariffs. We will therefore use scans delivered in an inpatient setting as a control group in our analyses.

2.3.1 | The direct access year

Before the full unbundling reform was introduced in April 2013, a mandatory tariff was introduced for direct access diagnostic imaging services in April 2012. Direct access services refer to outpatient diagnostic scans which have been directly ordered by a GP. In general, patients who are referred via the 2-week wait pathway are referred to an appointment with a specialist, who will then determine what diagnostic scans to undertake, if any. However, it is possible for GPs to refer 2-week wait patients straight for a test before the specialist appointment (Cancer Research UK, 2015; NHS England, 2022).

TABLE 1 Changes to the outpatient attendance tariff over the study period.

	Pre-period			Post-period				
	2010/2011	**2011/2012**	**2012/2013**	**2013/2014**	**2014/2015**	**2015/2016[a]**	**2016/2017**	**2017/2018**
Core outpatient attendance tariff for medical oncology	£119–£282	£114–311	£98–290	£92–223	£91–220	£92–213	£93–£215	£105–231
Unbundled diagnostic imaging tariffs								
MRI	£0	£0	£0	£140–£304	£138–£299	£123–£288	£124–£292	£114–£222
CT	£0	£0	£0	£78–£138	£77–£136	£77–£127	£78–£129	£71–£196
DEXA	£0	£0	£0	£63	£62	£60	£62	£58
Contrast fluoroscopy	£0	£0	£0	£79–£143	£78–£141	£75–£135	£76–£137	£78–£160
Ultrasound	£0	£0	£0	£45–£57	£44–£56	£43–£55	£43–£56	£40–£54
Nuclear medicine	£0	£0	£0	£145–£748	£143–£347	£138–£408	£139–£414	£133–£930
Echocardiogram	£0	£0	£0	£75	£74	£65–91	£67–£92	£64–£89
Combined tariff for a suspected cancer patient first attendance, seen by a single medical oncology professional, receiving one MRI scan (one area, no contrast, aged 19 and over)	£282	£252	£228	£353	£348	£348	£333	£328

Note: Core outpatient tariffs vary based on the details of the attendance (medical specialty, first or follow-up, number of medical professionals). We present core outpatient tariffs for medical oncology for reference, however suspected cancer patients can be seen under many different medical specialties. Unbundled diagnostic imaging tariffs vary based on details of the scan (e.g., the number of areas, with or without contrast, duration). Appendix 17 provides the full list of tariffs within each of these ranges. The final row in the table illustrates the tariff change with an example of a medical oncology patient receiving one MRI scan.

Abbreviations: CT, computerized tomography; DEXA, dual-energy X-ray absorptiometry; MRI, magnetic resonance imaging.

[a]The Enhanced Tariff Option (ETO) was offered in 2015/2016 where an enhanced version of the originally proposed 2015/2016 tariff, outlined in this table, was offered (NHS England, 2015). 210 out of 241 trusts accepted the ETO. For the remaining 31 providers which did not accept the ETO, the 2014/2015 tariff was rolled over.

Source: Department of Health (2010, 2011) and Department of Health and Social Care (2013b, 2013c, 2021).

Payments for diagnostic scans were unbundled for direct access patients in April 2012, which amounted to an early introduction of the payment reform we examine for a small proportion of patients. Unfortunately the data does not distinguish which patients have been sent straight for a test by the GP from others on the 2-week wait pathway, and so we are unable to determine which patients attracted the unbundled payment in the direct access year. We therefore removed all observations during the direct access year (April 1, 2012 to March 31, 2013) from our analysis. We also conducted sensitivity analyses to check the robustness of our results to including the direct access year, outlined in section "Sensitivity analyses."

3 | METHODS

3.1 | Data

We used data from outpatient and inpatient Hospital Episodes Statistics on 180 NHS Hospital Trusts in England between April 2010 and March 2018.

We focused on a defined period of care for each patient. In the outpatient data, we used outpatient attendances that we defined to be attributed to diagnosing a suspected cancer patient, who has been urgently referred via the 2-week wait pathway. We used this attendance-level data to construct a patient-level data set, capturing an individual's first 2-week wait attendance (an attendance where the variable "priority" indicates "2-week wait") and all subsequent outpatient attendances (with any priority) within 60 days of this index attendance. This interval is intended to cover that of initial diagnosis, and we based the timeframe on previous research on the upper bound of the interquartile range of the cancer diagnostic interval (the time between the first relevant presentation of a symptom in primary care and receiving a diagnosis), net of the upper bound of the interquartile range for the time between first presentation of a symptom in primary care and date of first suspected cancer GP referral (Swann et al., 2018). Appendix 1 outlines how the patient-level data set is constructed from the original attendance data in more detail.

Use of diagnostic imaging may systematically differ for a patient who has had previous referrals onto the 2-week wait pathway or has previously been diagnosed for a different type of cancer compared to those referred onto the 2-week wait pathway for the first time. If a patient undergoes multiple 2-week wait referral pathways during our analysis period, we keep only their first 2-week wait referral period.

For the inpatient data we again defined a period of care for each patient and constructed a patient-level data set from the original episode-level data. Amongst inpatients we examined the use of scans during the first inpatient admission for cancer during our study period. Cancer patients were defined by the main specialty of the treating consultant.

We examined whether the unbundling of diagnostic imaging scans from the outpatient attendance tariff resulted in a change in the utilization of the unbundled scans. The post period therefore included patients whose first (i.e., index) 2-week wait outpatient attendance took place on or after April 1, 2013. Patients whose defined 60 days of outpatient care spanned the policy introduction window were dropped from the analysis. We also excluded all observations for hospitals which did not appear at least once in the pre and at least once in the post-period due to hospital closures, openings or mergers. Our analysis therefore includes 2 years of pre-period data and 5 years of post-period data. Our final sample size for the main analysis comprises 6,212,816 patients.

3.1.1 | Treatment and control groups

For our treatment group, we examined the use of unbundled diagnostic scans for suspected cancer outpatients. Diagnostic scans delivered in an inpatient setting were not unbundled, and we therefore use cancer inpatients as the control group in our primary analysis.

3.1.2 | Outcome variable

Our outcome variable was the number of unbundled scans delivered for each patient during their defined period of care: the 60-day period from first 2-week wait attendance for outpatients, and during the first admission for cancer for inpatients. This excludes X-rays, which were not unbundled from the core tariff.

3.1.3 | Covariates

Covariates included patient-level characteristics observed during the first episode (outpatient attendance or inpatient admission) for each patient. These were: a male dummy indicator; an urban/rural indicator based on the patient's postcode of residence; age categories (0–14; 15–24; 25–34; 35–44; 45–54; 55–64; 65–74; 75–84; 85+); interactions between male and age categories; deprivation of the patient's lower-layer super output area of residence, given by the Index of Multiple Deprivation (IMD) 2010 score (Ministry of Housing, C & LG, 2010).

3.2 | Empirical strategy

Our analysis is split into three main sections. First, we estimate the impact of the reform on the utilization of unbundled scans, and undertake sensitivity analyses around this estimated main effect. Secondly, we estimate the impact of the reform on provider payments for outpatient attendances amongst patients with suspected cancer. Thirdly, we explore whether any detected effects on utilization reflect real increases in scan use or are instead the result of coding improvements.

3.2.1 | Utilization analysis

Main analysis

We use difference-in-differences regressions, estimated using ordinary least squares (OLS):

$$\text{Tests}_{iht} = \beta_1 \text{Treated}_i + \beta_2 \text{Treated}_i \times Post_t + \beta_3 \boldsymbol{X_{it}} + \alpha_h + \tau_t + \varepsilon_{iht} \quad (1)$$

where i denotes an individual patient, h denotes hospital Trusts, and t denotes the month-year of the observation. Tests_{iht} indicates a count of the number of unbundled scans provided to individual i during their defined period of care. Treated_i is a binary indicator equal to 1 for treated observations (suspected cancer outpatients), and 0 for control observations (cancer inpatients defined by the medical specialty, not subject to the unbundling reform). Post_t is a dummy variable equal to 1 for observations in the treated period, from April 2013 and onwards, and zero otherwise. $\boldsymbol{X_{it}}$ are patient characteristics at the first observed episode. α_h are hospital Trust fixed effects and τ_t are month-year fixed effects. ε_{iht} is the error term. We estimated robust standard errors clustered at the hospital Trust level.

We carried out two formal tests for the presence of pre-trends using only observations in the pre-period. In the first test, we regressed the number of scans on the interaction of a linear time trend with the treatment dummy. We conducted a second stricter test, which tests for the joint significance of the interactions of pre-period month-year dummies with the treatment dummy.

Analysis by scan type

We also look at the variation in hospitals' responses by different scan type. Hospital responses to the reform will depend upon the costs and benefits of each scan type. We therefore hypothesized that hospitals may respond differently depending on a number of factors including the invasiveness of the scan, the expected clinical benefit, and the size of the additional reimbursement. For this analysis, we repeat Equation (1) on the full sample but now analyzing counts of each scan type separately as the outcome of interest for CT, MRI, DEXA, contrast fluoroscopy, ultrasound, nuclear medicine, and echocardiogram. The comparison group for this analysis is the use of the same scan type provided for inpatients, where these scans remained within the core DRG bundled tariff.

Sensitivity analyses

We undertake a number of analyses to examine the sensitivity of our main estimates to the various assumptions made regarding the definition of the comparator group and the timing of the reform's effects.

Alternative comparators. Firstly we examine the sensitivity of our results to the definition of the control group, examining two alternative comparators. In our main analysis, we compare utilization of the same scans amongst a control group of cancer patients treated in an inpatient setting, where these scans were not unbundled from the core

DRG tariff. In our main analysis, cancer patients are defined by the main specialty of the treating consultant (medical and clinical oncology). First, we implement an alternative definition of cancer-related inpatient admissions, now defining these instead based on the main diagnosis code of the patient. See Appendix 2 for a full list of the ICD-10 diagnosis codes used for this definition (World Health Organization, 2015). This definition includes more patients, as cancer patients can be treated in other specialties than medical or clinical oncology.

Secondly, we define a totally different comparator, using diagnostic scans delivered in an outpatient setting which were not unbundled from the core outpatient tariff. This comparator enables us to examine the use of unbundled scans versus scans which remain bundled, amongst the same group of suspected cancer patients in the same outpatient setting. For this analysis we compare the utilization of unbundled scans to that of plain film X-rays, which remained within the core outpatient tariff and therefore did not attract any additional reimbursement after the reform.

The direct access year. In our main analysis we exclude all observations from the financial year 2012/2013 because we are unable to determine which patients were subject to additional reimbursement under the direct access tariff, and therefore subject to an early version of the reform. We examine the sensitivity of our results to this assumption, now including observations from the year in which the direct access tariff was implemented for a subsample of patients.

$$\text{Tests}_{iht} = \beta_1 \text{Treated}_i + \beta_2 \text{Treated}_i \times \text{DirectAccess}_t + \beta_3 \text{Treated}_i \times \text{postFullReform}_t + \beta_4 \boldsymbol{X_{it}} + \alpha_h + \tau_t + \varepsilon_{iht} \quad (2)$$

The first sensitivity check we carried out follows Equation (2). DirectAccess_t is a dummy variable equal to 1 for all month-years between April 2012 and March 2013 (i.e., during the direct access year), and 0 otherwise. PostFullReform_t is a dummy variable equal to 1 for observations from April 2013 onwards, and 0 otherwise, equivalent to Post_t in Equation (1). This analysis is similar to that from Equation (1), but with the added interaction term of $\text{Treated}_i \times \textit{DirectAccess}$. The inclusion of this interaction term formally tests for an effect of the introduction of the reform in the direct access year, on all suspected cancer patients (some of whom would have been subject to the direct access tariff during this period). This will represent a diluted effect of the direct access reform as it only applied to a subset of patients during this period, and is akin to testing for an anticipation effect of the reform.

$$\text{Tests}_{iht} = \beta_1 \text{Treated}_i + \beta_2 \text{Treated}_i \times \text{postDirectAccess}_t + \beta_3 \boldsymbol{X_{it}} + \alpha_h + \tau_t + \varepsilon_{iht} \quad (3)$$

Next, we apply an alternative definition of the treatment period, now including the direct access year within the post period. Under this scenario we estimate Equation (3), where $\text{PostDirectAccess}_t$ is equal to 1 for all observations from April 1, 2012 onwards, and 0 otherwise.

Additional sensitivity analyses. To check whether the results are sensitive to the estimated length of the diagnostic period, we repeated the main analysis using an alternative period of 86-days. This is the upper limit of the IQR of the diagnostic interval following first presentation in primary care (Swann et al., 2018).

To address concerns of overlap between treatment and comparator group due to 2-week wait outpatients who subsequently are treated as inpatients, we repeat the main analysis, excluding inpatients from the comparator group who were previously recorded as 2-week wait outpatients.

The majority of patients do not receive any of the incentivized scans we examine during their defined period of care. In our main sample, 83.88% receive zero scans, 12.27% receive one scan, 2.76% receive two scans, and a very small proportion (<1%) receive three or more scans, up to a maximum of 52. To address concerns over the skewed nature of the data and ensure that our estimates are not influenced by the small number of outliers receiving a large number of scans, we trim the sample at the 99th percentile of incentivized scan volumes, and repeat our main analysis on this trimmed sample.

Finally, to address concerns that the financial incentive applied at hospital rather than patient level, we repeat the analysis with aggregate hospital-level data. Firstly, we use an OLS model where the dependent variable is the hospital-average number of scans per patient during their 60-day defined period of care. This is constructed by aggregating the patient-level data set used in our main analysis to hospital-month level, and calculating the mean number of scans per patient, where patients are assigned to months based on the date of their index attendance. This hospital-level analysis controls for the percentage of patients in each age category, percentage of patients who are male, percentage in each age category interacted with percentage male, percentage of patients in an urban area, average deprivation score, hospital Trust and month-year fixed effects. Secondly, as the distribution of the number of scans is skewed, we then examine

whether the findings are sensitive to the use of non-linear regression models instead of linear regression models. Using the aggregate hospital-level dataset, we repeated the analysis using Poisson and negative binomial models and presented the results as marginal effects.

3.2.2 | Payments analysis

Next, we estimated the magnitude of the reform in terms of its cost to the NHS. We first expressed this in terms of an estimate of the total extra payment on unbundled scans for suspected cancer patients in the post period, excluding the core outpatient tariff. We estimated the unit cost of each type of unbundled scan in the post-period, separately, and multiplied the unit cost of each scan type by the total number of each type of scan recorded in the post period. We added together the estimates for each scan type for an estimate of the total payment on unbundled scans.

We then expressed the utilization response to the reform in terms of an estimate of the payment increase in response to the reform. This is calculated by taking the coefficient of the utilization treatment effect (β_2 in Equation 1), multiplied by the number of patients in the post period, multiplied by the unit cost of an unbundled scan, excluding the core outpatient tariff, in the post period.

3.2.3 | Coding analysis

Finally, we tried to explore whether any detected effects on utilization represented real changes in diagnostic scan provision or simply better coding of existing activity. We undertake a number of descriptive analyses to explore whether any changes we observe are real changes to treatment provision versus coding.

Comparing each hospital's average use of unbundled scans before and after the reform

We compared each hospital's mean use of unbundled scans per patient in the pre-period to their mean use of unbundled scans in the post-period. We pay particular attention to hospitals with no or very low reported use of scans in the period before unbundling, when there were no direct financial incentives to accurately record scans provided. We hypothesize that all hospitals will have provided some level of provision of unbundled scans before the reform, and so increases from a baseline of zero (or close to zero) are likely to reflect at least in part improvements in coding rather than solely real activity increases. We then calculate the percentage of total scans reported across all hospitals in the post-period that are reported by hospitals with no or very low use of scans in pre-period.

Examining utilization in the direct access year

Finally, a closer look at the utilization of scans in the financial year 2012/2013 may provide evidence on whether a change in coding occurred. In this year, additional reimbursement was only provided to hospitals for scans directly ordered for a patient by their GP. As it is GPs rather than hospitals who determine the volume of these eligible scans ordered, we would not expect to see a real increase in the level of provision of unbundled scans to eligible patients during the direct access year. From the hospital perspective, the direct access tariff change introduced financial incentives to improve the coding of unbundled scans provided to eligible patients when these were ordered by a patient's GP. We therefore hypothesized that any increases in unbundled scans detected during this direct access year were likely to represent improvements in coding rather than real increases in scan provision.

4 | RESULTS

4.1 | Descriptive results

Descriptive statistics for the treatment and control samples used in the main analysis are presented in Table 2. Utilization of the unbundled scans grew over time in both the outpatient (treated) and inpatient (control) settings, with this increase being substantially larger in the outpatient setting where these scans attracted additional reimbursement post-reform. On average, before the payment reform was introduced, each suspected cancer patient received 0.102 unbundled scans in an outpatient setting during their defined 60 day period of care. After the reform, this rose to an average of 0.260 unbundled scans. In an inpatient setting, where these scans remained within the core DRG tariff

TABLE 2 Descriptive statistics by treatment and control, and pre-period and post-period.

	Outpatients (treated)		Inpatients (control)	
	Pre-period	**Post-period**	**Pre-period**	**Post-period**
Outcome variables				
Total number of unbundled scans undertaken per patient, mean (SD)	0.102	0.260	0.080	0.093
	(0.372)	(0.636)	(0.339)	(0.379)
Covariates				
Male, mean (SD)	0.361	0.377	0.456	0.469
	(0.480)	(0.485)	(0.498)	(0.499)
Index of multiple deprivation score, mean (SD)	20.193	20.521	20.475	20.227
	(14.882)	(15.040)	(14.802)	(14.690)
Urban, mean (SD)	0.781	0.800	0.774	0.770
	(0.414)	(0.400)	(0.418)	(0.421)
Age categories, % in each category				
0–14	0.638%	1.208%	0.839%	0.598%
15–24	3.797%	4.634%	0.907%	0.907%
25–34	7.419%	9.487%	2.442%	2.595%
35–44	12.241%	12.291%	6.509%	5.697%
45–54	17.000%	17.408%	15.007%	14.208%
55–64	18.571%	17.385%	25.675%	22.925%
65–74	18.987%	18.833%	30.060%	31.920%
75–84	15.497%	13.559%	16.117%	18.059%
85+	5.850%	5.195%	2.445%	3.092%
Number of patients	1,039,891	4,579,805	167,041	426,079

Note: A higher deprivation score indicates more deprived. The covariates are defined at the first observed episode for each patient.

throughout, cancer patients received an average of 0.080 of these scans during their inpatient stay in the pre-period and 0.093 in the post-period.

Figure 1 shows the trends over time in the utilization of unbundled scans in the outpatient (treated) and inpatient (control) settings. The trends in utilization in the inpatient control group appear relatively stable over time. Conversely, amongst the treated outpatient group, we observe a sharp jump in utilization levels at the start of the reform followed by an upward trend over time during the post period. Visual inspection of the pre-trends in Figure 1 suggests that the parallel trends assumption appears to be feasible.

The results of the formal pre-trends tests are presented in Appendix 3. Column (1) of Appendix 3 shows that the interaction between a linear time trend and the treatment dummy is statistically insignificant at the 10% level, which suggests that trends are not diverging systematically in the pre-period. The results of the stricter joint significance tests are presented in column (2). These show that the treatment and time dummy interactions are jointly statistically insignificant at the 5% significance level.

4.2 | Utilization analysis

4.2.1 | Main analysis

Table 3 presents the difference-in-differences estimation results for the impact of the reform on the utilization of unbundled scans. We find that the reform resulted in a significant increase in the average utilization of unbundled

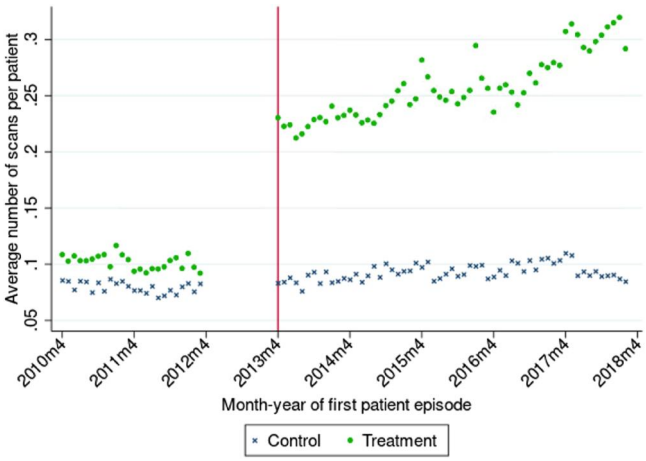

FIGURE 1 Adjusted plot over time of average number of scans by treatment and control group. The red vertical line indicates the month-year of the payment reform (April 2013). Data for period April 1, 2012–March 31, 2013 not shown because of the introduction of partial unbundling for some outpatients under the direct access tariff policy. Graphs are adjusted for patient-level covariates.

scans by 0.137 scans per patient ($p < 0.01$), from a baseline of 0.102. This effect corresponds to 37% of a standard deviation, and represents a 134% increase in the use of unbundled scans in comparison with the pre-period average.

4.2.2 | Analysis by scan type

When we examine the impact on each type of unbundled scan separately (Table 4), we detect statistically significant increases in utilization for CT (0.0339 scans per patient, $p < 0.01$), MRI (0.0207, $p < 0.01$), DEXA (0.00117, $p < 0.01$), contrast fluoroscopy (0.000453, $p < 0.05$), ultrasound (0.0696, $p < 0.01$) and nuclear medicine (0.0103, $p < 0.01$).

These effect sizes correspond to 27% of a standard deviation for CT; 32% of a standard deviation for MRI; 6% of a standard deviation for DEXA; 3% of a standard deviation for contrast fluoroscopy; 23% of a standard deviation for ultrasound; and 14% of a standard deviation for nuclear medicine (see Appendix 4 for pre- and post-period descriptive statistics by scan type). The only unbundled scan for which we did not detect an impact of the reform was echocardiogram.

4.2.3 | Sensitivity analyses

Alternative comparators

The trends in utilization of scans in the alternative comparators also exhibited relatively stable trends over time (Appendix 5 and 6). Formal tests of pre-trends show that for both alternative comparators, trends in the pre-period did not appear to be systematically diverging for treatment and comparators, shown by the insignificant interaction term between a linear time trend and the treatment dummy (Appendix 7). However, neither alternative comparator passed the stricter pre-trends test which interacts the treatment dummy with month-year dummies.

Table 5 presents the difference-in-differences estimation results for the impact of the reform on the utilization of unbundled scans using two alternative comparators. The reform is estimated to have resulted in a significant increase in the average utilization of unbundled scans by between 0.133 and 0.135 scans per patient, depending upon the alternative comparator used. These sensitivity analyses support the results of the main analysis in terms of direction, magnitude and statistical significance.

The direct access year

Visual inspection of the trends suggests there was a small rise in the utilization of unbundled scans amongst suspected cancer outpatients between April 2012 and March 2013, when the scans were unbundled for the subset of direct access

TABLE 3 Did estimates of the effect of the payment unbundling on the utilization of diagnostic imaging scans.

	Number of scans per patient
Treated × post	0.137***
	(0.0254)
Treated	0.0994**
	(0.0393)
IMD score	0.000313***
	(0.0000794)
Urban	−0.00189
	(0.00176)
Male	−0.120***
	(0.0199)
Age categories (reference category = 35–44)	
0–14	−0.111***
	(0.0403)
15–24	−0.0386***
	(0.0101)
25–34	−0.0200***
	(0.00706)
45–54	−0.0292***
	(0.00706)
55–64	−0.0659***
	(0.0134)
65–74	−0.0653***
	(0.0146)
75–84	−0.0622***
	(0.0147)
85+	−0.0914***
	(0.0154)
Male × age categories (reference category = 35–44)	
15–24	0.106***
	(0.0211)
25–34	0.0491***
	(0.0106)
35–44	0.0216***
	(0.00725)
45–54	0.0512***
	(0.00852)
55–64	0.110***
	(0.0154)
65–74	0.128***
	(0.0164)

TABLE 3 (Continued)

	Number of scans per patient
75–84	0.123***
	(0.0161)
85+	0.120***
	(0.0160)
Adjusted R^2	0.146

Note: We also control for sex and age category interactions, hospital Trust fixed effects and month-year fixed effects. $N = 6{,}212{,}816$. Cluster-robust standard errors clustered at the hospital Trust level in parentheses.

Abbreviation: IMD, Index of Multiple Deprivation.

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

TABLE 4 Did estimates of the effect of unbundling on utilization stratified by scan type.

	Number of scans						
	CT	MRI	DEXA	Contrast fluoroscopy	Ultrasound	Nuclear medicine	Echocardiogram
Treated × post	0.0339***	0.0207***	0.00117***	0.000453**	0.0696***	0.0103***	0.00112
	(0.00763)	(0.00455)	(0.000318)	(0.000208)	(0.0142)	(0.00265)	(0.00258)
Treated	−0.0103	−0.00394	0.00136*	0.000300	0.0888***	0.0191	0.00408***
	(0.0113)	(0.00676)	(0.000770)	(0.000237)	(0.0178)	(0.0144)	(0.00152)
Adjusted R^2	0.0633	0.0371	0.00655	0.00282	0.119	0.0631	0.0120

Note: All regressions control for age categories, gender, age interacted with gender, deprivation, rurality, hospital Trust and month-year fixed effects. $N = 6{,}212{,}816$. Cluster-robust standard errors clustered at the hospital Trust level in parentheses.

Abbreviations: CT, computerized tomography; DEXA, dual-energy X-ray absorptiometry; MRI, magnetic resonance imaging.

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

TABLE 5 Sensitivity analyses did estimates of the effect of the payment unbundling on the utilization of diagnostic imaging scans, using alternative comparators.

	Main analysis: Inpatient comparison group with medical or clinical oncology as the main specialty	Alternative comparator 1: Inpatient comparison group with cancer as the main diagnosis code	Alternative comparator 2: Outpatient comparison group (plain film X-rays)
Treated × post	**0.137*** **	0.133***	0.135***
	(0.0254)	(0.0245)	(0.0224)
Treated	**0.0994** **	−0.116***	0.0883***
	(0.0393)	(0.0226)	(0.0145)
Adjusted R^2	**0.146**	0.0987	0.142
N	**6,212,816**	7,385,824	11,861,442

Note: All regressions control for age categories, gender, age interacted with gender, deprivation, rurality, hospital Trust and month-year fixed effects. Cluster-robust standard errors clustered at the hospital Trust level in parentheses. Main analysis results are highlighted in bold.

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

patients (Appendix 8). The difference-in-differences estimation results, however, suggest that this effect was not statistically significant (0.0146 increase in scans per patient, $p > 0.10$, Table 6 column 1). Furthermore, the estimated effect of the full reform is robust to the inclusion of the direct access year in this analysis (0.138 scans per patient, $p < 0.01$, compared to 0.137, $p < 0.01$, detected in the main analysis).

TABLE 6 Sensitivity analyses did estimates of the effect of the payment unbundling on the utilization of diagnostic imaging scans when including the direct access year in the analyses.

	Estimating the impact of the reform in the direct access year separately	Including the direct access year in the treatment period
Treatment × direct access year dummy	0.0146	
	(0.0117)	
Treatment × post full reform	0.138***	
	(0.0252)	
Treatment × post direct access reform		0.117***
		(0.0219)
Treatment	0.0933*	0.0938*
	(0.0367)	(0.0368)
Adjusted R^2	0.138	0.137
N	6,983,237	6,983,237

Note: All regressions control for age categories, gender, age interacted with gender, deprivation, rurality, hospital Trust and month-year fixed effects. Cluster-robust standard errors clustered at the hospital Trust level in parentheses.

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 6 Column 2 shows the estimated effect of the reform when the post period is defined as starting 1 year earlier, at the point when the direct access tariff was introduced for a subset of suspected cancer outpatients only. Under this scenario we estimate that the reform resulted in an increase of 0.117 scans per patient. This is slightly smaller in magnitude than the main effect estimate, but consistent in terms of the direction of the effect and statistical significance.

Additional sensitivity analyses

The analysis which extends the length of the defined diagnostic period to 86 days results in a slightly larger effect size and supports the main analysis in terms of the significance and direction of the effect (Appendix 9 and 10).

The analysis which removes previous 2-week wait outpatients from the inpatient comparator group supports the main analysis in terms of the sign, significance, and direction of the effect (Appendix 11 and 12).

The analysis which removes outliers beyond the 99th percentile of scan volumes supports the main analysis in terms of the sign, significance, and magnitude of the effect (Appendix 13).

The hospital level analysis produces a slightly larger effect size and supports the main analysis in terms of the significance and direction of the effect (Appendix 14 and 15). The distribution of the number of scans is skewed (see Appendix 16). Nonetheless, the estimated effects of the payment reform display the same sign and statistical significance in the Poisson and negative binomial regression models as in the linear models (Appendix 17). The estimates are larger in magnitude when modeled using count as opposed to linear models. The results of the Poisson and begative binomial regressions are identical, suggesting that the data do not suffer from overdispersion.

4.3 | Payments analysis

Based on calculations of unit costs and the number of attendances and each type of scan, the total extra payment for diagnostic imaging scans for suspected cancer patients in the post period (not including the core tariff) is estimated as £108,388,181.64 (Appendix 18 and 19).

The payment change resulted in a 0.137 increase in the number of scans per patient. There were 4,579,805 treated patients in the post period. The unit cost of an unbundled scan in the post period was £126.26 (see Appendix 18). Therefore, the increase in payment associated with the utilization response to the reform for suspected cancer patients in the 5 years after unbundling is estimated to be £79,219,726.56. This accounts for 73% of the extra government spending on unbundled scans in the post-period.

4.4 | Coding analysis

4.4.1 | Comparing each hospital's average use of unbundled (treated) scans before and after the reform

Figure 2 plots each hospital's average use of the unbundled scans in the post period against their average use of the unbundled scans in the pre-period. Observations on the 45° line indicate equal use of scans in the pre and the post-periods.

We see that the majority of hospitals report equivalent or higher use of the unbundled scans in the post-period compared to the pre-period, with only approximately 13% of observations falling to the right of the 45° line.

There are a number of hospitals which go from zero, or very low levels of, scan provision in the pre-period to high levels in the post-period in comparison with other hospitals.

Table 7 presents hospital average use of scans per year, where hospitals are split into different categories based on their pre-period and post-period average utilization. It shows that 29% of hospitals went from a zero average use of scans in the pre-period to a non-zero average in the post period.

Annual total unbundled scans in the pre-period and the post-period per year, are also reported in Table 7. 38,796.1 scans were recorded in the zero to non-zero group in the post-period per year. Therefore 15% of total recorded scans in the post-period were at providers which were not reporting any scans before the payment reform. The increase in this group between the pre-period and the post-period accounts for 20% of the total increase in use of scans per year between the before and after period.

4.4.2 | Examining utilization in the direct access year

Appendix 8 shows a small increase in the utilization of scans in the year 2012/2013, where the main change to hospital incentives in this year was to improve the coding of direct access diagnostic imaging scans, rather than a real change to the number of scans. However, the sensitivity analysis presented in Table 6 suggests that this effect was not statistically significant. We therefore do not find evidence of a significant response to the reform during the year in which hospitals could only feasibly respond by increasing coding as opposed to eligible activity.

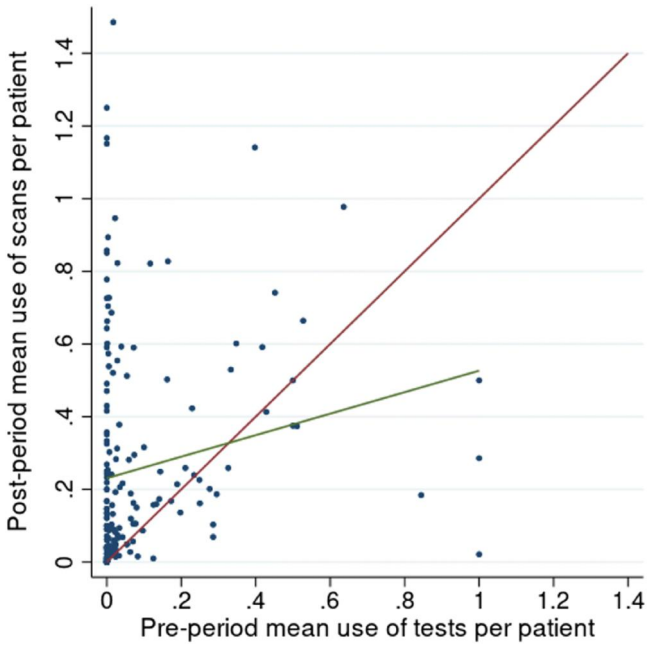

FIGURE 2 Hospital average use of scans in the pre-period versus the post-period. Only data in the treatment group are used. The red line is the 45° line. The green line is the line of best fit.

TABLE 7 Hospital use of unbundled scans, grouped by pre-period and post-period utilization.

Group	Proportion of hospitals in each group (%)	Total incentivized scans in the pre-period per year	Total incentivized scans in the post-period per year	Proportion of the total per year increase between the pre- and post-period attributable to each group (total per year increase = 198,962.9) (%)
Zero to zero	4.4	0.0	0.0	0.0
Zero to non-zero	28.9	0.0	38,796.1	19.5
Non-zero to approx. the same	2.2	3846.5	4601.2	0.4
Non-zero and increased	51.7	32,520.1	192,640.7	80.5
Non-zero and decreased	12.8	17,544.6	16,836.2	−0.4
Total	100	53,911.2	252,874.1	100.0

Note: Totals are average annual totals. Only data in the treatment group are used. Zero to zero; zero pre-period average to zero post-period average; zero to non-zero: zero pre-period average to non-zero post-period average; non-zero to approximately the same non-zero pre-period average to approximately the same post-period average (within 5% of the pre-period average); non-zero and increased: non-zero pre-period average and increased post-period average; non-zero and decreased: non-zero pre-period average and decreased post-period average.

5 | DISCUSSION

The level and structure of provider reimbursements can have significant impacts on the costs, quality and efficiency of healthcare services supplied. Whilst there is a wealth of literature studying the impact of moving to bundled payment systems, little is known about the effects of unbundling. We examine the effects of unbundling diagnostic scans from the standard outpatient DRG tariff for patients with suspected cancer. We discuss the findings of the study in relation to the three main objectives of our evaluation of unbundling: the effect on reported utilization, payments, and coding.

5.1 | Utilization

We find a large increase in recorded utilization of diagnostic imaging scans for suspected cancer patients in response to the unbundling of payments for diagnostic imaging services from the outpatient attendance tariff. In our main analysis, we find that the number of scans per patient increased by 0.137 (134%, $p < 0.01$). This result is in line with the aims of the policy, which expressed concern over the under-provision of these services (Department of Health and Social Care, 2013a). Our estimates across all sensitivity analyses ranged from an increase of 0.117 to 0.272 scans per patient, depending upon the sample and model specification, with all of our analyses detecting a positive and statistically significant effect of the reform. Figures on the use of scans per patient appear to be low, however many urgent suspected cancer referrals are for cancers which may not require a scan, such as skin cancer, which constituted 18% of all urgent suspected cancer referrals in 2013/2014 (National Cancer Registration and Analysis Service, 2023). A high proportion of referrals are also for cancers which generally require diagnostic tests which are not included in the unbundled diagnostic imaging scans, for example, endoscopy for lower gastrointestinal cancers (15% of all urgent referrals) and upper gastrointestinal cancers (10% of all urgent referrals), and mammogram for breast cancers (19% of all urgent referrals).

We find significant increases in reported utilization for all scan types with the exception of echocardiogram. The economic significance of the effects for CT, MRI, ultrasound, and to a lesser extent, nuclear medicine, are larger than that of DEXA scans or contrast fluoroscopy.

There does not appear to be an association between the size of the effects on recorded utilization and the size of the payment increase. However, a hospital's decision to increase utilization will depend upon a comparison of the marginal costs and marginal benefits of each scan type under the new payment system, rather than just the size of the payment increase. These comparisons will be driven by a number of factors including the clinical appropriateness and benefit to patients of each scan type, the potential harm to patients from unnecessary exposure to each scan, the marginal costs of each scan compared to the marginal payment, and hospital capacity to deliver each scan type (in terms of both the availability of machines and qualified staff to operate them). We may, for example, see smaller increases in the use of nuclear medicine scans due to the risk of harm from unnecessary exposure. Full information on these marginal costs and benefits is not available.

5.2 | Payments

We also calculate that the increase in payments associated with the utilization response to unbundling in our sample of suspected cancer patients is estimated at £79.2 million. This accounts for 73% of the estimated extra spending on unbundled payments in the post period.

5.3 | Coding

Descriptive analysis suggests that a proportion of the utilization effect we detect may be explained by increased coding of scans. A considerable proportion of hospitals went from zero average use of scans per patient in the pre-period to non-zero in the post-period (29% of hospitals in our sample), which seems unlikely given this would mean a significant concomitant change in scanning equipment (with large start-up costs). This corresponded to 15% of unbundled scans for suspected cancer patients in the post-period being recorded at providers which reported no use of these scans before the payment unbundling. This suggests that some hospitals may have been under-coding use of scans before the payment change, and therefore the effect we find is likely to represent an overestimate of the real increase in use of scans. Amongst the group of hospitals reporting positive scan volumes in the pre-period, we estimate that the reform resulted in an increase of 160,120 scans per year. This may provide an indication of the lower bound of the estimated impact of the reform, after removing hospitals which were most likely to have been under-coding their activity before the payment reform was introduced.

The small increase in the use of scans observed in the descriptive in the direct access year suggests that there may have been a change in coding, however this increase was not found to be statistically significant. Any effect on coding in the direct access year will be diluted in our analyses, as the reform only applied to a subset of patients during this period. Whilst examination of this period adds to the overall picture on the impact of the reform, it is therefore not possible to draw firm conclusions on the magnitude of coding increases from this, and so these results should be interpreted with caution.

5.4 | Strengths and limitations

We provide, to our knowledge, the first empirical investigation of the effect of unbundling payments from previously bundled tariffs. This study uses a large, whole country, patient-level dataset which allows us to control for patient characteristics, and hospital Trust and time fixed effects. The data are the information that is used to determine provider payments. We control for all patient characteristics available in the outpatient data, with the exception of ethnicity which we do not include due to a high degree of missingness. We were unable to control for comorbidities as the outpatient data generally only contains diagnosis codes relating to the conditions being investigated or treated during the appointment.

In our main difference-in-differences analysis, utilization in the comparator group is similar to the treated group in levels in the pre-period, and the common trend assumption appears to be satisfied. Furthermore, our main results are robust to the use of two alternative comparators. All comparators used in our analyses represent patient groups where use of scans are also likely. All comparators exhibit stable trends in the absence of a payment reform. In the inpatient control groups, this provides reassurance that there did not appear to be any major technological changes to diagnostic imaging services over the period which could have driven the changes in utilization we detect. Importantly, the need for scans did not change differentially between our treatment group of interest and comparator groups at the time of the payment unbundling.

In the year prior to the reform, the payment was unbundled for direct access patients only. Unfortunately, we were unable to identify and exclude direct access patients from our data, so we instead removed all observations from the direct access year from our main analysis. Reassuringly, these results are robust to different sensitivity analysis which also account for the inclusion of the direct access year.

The PbR documents do not state which local areas were of concern, and we were therefore unable to examine the impact of the reform in relation to the areas where skimping was thought to be taking place. As an alternative, our coding analysis examines the strength of the response across different hospitals.

In our main analyses, we account for the application of the incentive at hospital level by clustering the standard errors at this level, whilst adjusting for covariates at patient level. In supplementary analysis, we repeated the estimation using aggregate hospital-level data and found similar results. The results were also similar qualitatively when we used count data rather than linear regression models.

We are unable to determine the extent to which the increase in utilization we detect reflects real increases in activity versus improvements in coding. We conduct multiple descriptive analyses to investigate this issue, concluding that at least some of the detected effect is likely to represent coding improvements, meaning that our estimates represent the upper bound of the true impact on scan utilization.

5.5 | Findings in relation to other studies

To our knowledge, the impact of unbundling has not yet been explored in the payments literature. The unbundling of diagnostic imaging scans effectively introduced a fee-for-service element to the payment, which is known to encourage increased activity when there are weak cost restrictions. Our finding, of an increase in service use in response to introducing a fee-for-service element to the payment, is therefore also in line with the previous fee-for-service literature (Devlin & Sarma, 2008; Gosden et al., 2000; Moreno-Serra & Wagstaff, 2010).

Zabrodina et al. (2020) found that a payment reform which moved from separate reimbursements for diagnostic imaging services to a DRG-based payment system in the inpatient sector in Switzerland led to supplier-induced demand for imaging services in the outpatient sector, where reimbursements remained fee-for-service. Our descriptives show that the trends in scan use remained fairly stable in the unaffected inpatient sector, suggesting that hospitals were not discharging patients from inpatient care and ordering their diagnostic scan to take place in an outpatient setting instead. Therefore, shifting between settings did not occur in our case. We cannot, however, infer whether the additional scans delivered to outpatients were of benefit to patients.

A systematic review of the effect of financial incentives to increase cancer screening rates in primary care found only minimal effects at best (Mauro et al., 2019). By contrast, we find increases in payments to secondary care providers resulted in substantial increases in the delivery of diagnostic imaging for cancer detection. These contrasting results may suggest that the barriers to uptake of screening in primary care are more complex, with a larger part determined by the patient. Whereas in the setting we examine, concerns had been raised over skimping due to under-payment for complex patients, suggesting that financial constraints were the main factor limiting care deliver in that setting. The contrasting results could also be explained by the differing degrees of concern regarding overdiagnosis, which is more prevalent when considering asymptomatic cancer in primary care.

Our findings also suggest that some hospitals may have changed their coding practices in response to the payment reform. Previous studies in the coding literature examine the occurrence of upcoding of severity (Barros & Braun, 2017; Dafny, 2005). We were unable to find studies which specifically evaluate the effect of bundled payments on completeness of coding or under-coding. Our study contributes to the coding literature by showing that new incentives can reduce the under-coding that occurs when providers have no incentive to record this activity.

The reimbursement for a first outpatient attendance with one medical oncology professional and one unbundled scan increased by between 13% and 321% in the first year of the reform, depending upon the type of scan delivered. We find a 134% increase in the use of all unbundled scans, in comparison with the pre-period average. By comparison, Parkinson et al. estimated that a 32% price increase for treatments delivered in the emergency department led to an increase in utilization of between 76% and 152% depending upon the treatment (Parkinson, Meacock, & Sutton, 2019). Together this suggests that hospitals are highly responsive to price changes across multiple settings.

5.6 | Implications for policymakers and researchers

DRG-based bundled payment methods are a commonly adopted method of hospital payment globally, however in recent years some countries have adopted supplementary, unbundled elements to the payments (Busse et al., 2011). This study provides important evidence on what happens when payments are unbundled. Our results provide further evidence that hospitals respond strongly to increases in reimbursement, suggesting that this is an effective mechanism through which commissioners can increase levels of care provision. However, we also highlight the need to consider the potential for unintended responses when designing such schemes.

Exploratory analysis suggests that the large increase in diagnostic scans we find may be attributed in part to under-coding of scans delivered in the pre-period. Our estimates therefore represent the upper bound of the true increase in activity encouraged by the reform. Whilst improvements in coding accuracy may also be desirable in that this increases transparency in the use of these scans, if the goal is to increase provision of services, policymakers should consider the incentives of a payment reform on changes to coding, especially when introducing a fee-for-service element. This study highlights the difficulty of measuring the real impact of a payment change on utilization when such reforms create incentives for both increases in activity and coding completeness. It also highlights the uncertainty that commissioners may face over the true costs of such changes to reimbursement schemes, as recorded activity levels of various elements of the care bundle in the absence of direct financial incentives to code these may significantly underestimate the level of care being delivered prior to any reform.

However, the patterns of results suggest that it is unlikely that the entire detected effect can be explained by coding, providing evidence that the reform did achieve its aim of increasing the provision of diagnostic imaging. Incentive theory suggests that prices should be set at or above the level of providers' marginal costs to enable and encourage delivery, but not so high as to induce unnecessary demand (Kristensen et al., 2016; Parkinson, Meacock, & Sutton, 2019). It is unclear from policy documents how the price levels for unbundled scans were set in this instance. Whilst the effects we detect suggest that prices were set high enough to induce substantial responses from providers, we are unable to judge whether the reform has resulted in an optimal level of scan delivery. Future policies should set prices based on expected provider costs and the value of care to encourage optimal levels of provision. Furthermore, further research is needed into the marginal costs and benefits associated with different scan types, to explain the differences in effect sizes by scan type.

The specific aims of the reform we examine were to address "under-payment of diagnostic imaging delivered for complex patients and under-provision of imaging services in some local areas" (Department of Health and Social Care, 2013a). Though our analysis suggests that an increase in the provision of diagnostic imaging took place, we are unable to evaluate whether these increases happened where skimping was previously thought to be taking place. Future research should investigate the impact of the reform on patient outcomes, such as survival, to determine whether the payment reform improved early detection or resulted in unnecessary exposure to invasive or potentially harmful procedures and overdiagnosis.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Research data are not shared.

ETHICS STATEMENT

No ethics approval was necessary for this study.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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