Healthcare quality in NHS and private hospitals in England

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A thesis submitted to the Department of Health Policy of the London School of Economics and Political Science for the degree of Doctor of Philosophy, London, June 2023

Declaration

I certify that the thesis I have presented for examination for the Health Policy and Economics PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it). The copyright of this thesis rests with the author. Quotation from it is permitted, provided that full acknowledgement is made. This thesis may not be reproduced without my prior written consent. I warrant that this authorisation does not, to the best of my belief, infringe the rights of any third party. I declare that my thesis consists of 56, 963 words excluding references and appendices.

London, June 2023

Michael James Anderson

Statement of conjoint work

This PhD is paper-based, and parts of the work presented have been published in peer-reviewed academic journals. The first paper (in chapter 2) was co-authored with Dr Aoife Molloy, Dr Laia Maynou, Dr Ilias Kyriopolous, Professor Alistair McGuire, Professor Elias Mossialos. It has been published by BMJ Quality & Safety.

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> Author contributions: MA undertook the analysis and drafted the manuscript. AM, LM, IK, EM, and AM were collaboratively involved in the design of the analysis and provided comments and edits to iterative versions of the manuscript. MA is the guarantor for this manuscript.

Sections of the literature review for the first paper have also been used as part of a chapter on low value care which is planned for inclusion in an updated version of a volume on healthcare financing.

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The second paper (in chapter 3) was single authored by the PhD Candidate. It has been published by the British Journal of Surgery.

> **Anderson, M.**, 2023. Changes in publicly and privately funded care in England following a national programme to reduce provision of low value elective surgery. British Journal of Surgery, 110(2), 209–216. https://doi.org/10.1093/bjs/znac390
>
> Author contributions: MA conceived the study. MA analysed the data and interpreted the findings. MA drafted the manuscript. MA is the guarantor for this manuscript.

The third paper (in chapter 4) was co-authored with Professor Alistair McGuire, Professor Elias Mossialos, Dr Rocco Friebel, and Dr Laia Maynou. It is yet to be submitted for publication. I plan to submit this paper to a journal focused on health economics.

> Citation: **Anderson, M.**, Friebel, R., Maynou, L., Mossialos, E., McGuire, A., 2023. A comparison of patient outcomes, adverse events, and efficiency of private and NHS hospitals in England for primary hip and knee replacements. (To be submitted)
>
> Author contributions: MA undertook the analysis and drafted the manuscript. RF, LM, EM, and AM were collaboratively involved in the design of the analysis and provided comments and edits to iterative versions of the manuscript. MA is the guarantor for this manuscript.

I have edited the text in the papers where required to fit the narrative and flow of the thesis, and therefore some wording and ordering of paragraphs slightly differs in this thesis from what is found in the published manuscripts. None of the empirical content or results differ to what is contained in published manuscripts. However, it cannot be guaranteed that the empirical content in the paper yet to be submitted will not change prior to publication.

Other relevant work

During my PhD studies, I also co-authored several peer-reviewed articles, and editorials on healthcare quality and financing in the English healthcare system drawn on and referred to within the thesis. This work is appropriately referenced throughout this PhD thesis and informed my understanding and insights on healthcare quality in NHS and private hospitals in the English healthcare system.

- **Anderson, M.**, Pitchforth, E., Asaria, M. et al., 2021. LSE-Lancet Commission on the future of the NHS: re-laying the foundations for an equitable and efficient health and care service after COVID-19 2021 May 22; 397(10288):1884]. Lancet. 2021; 397(10288):1915–1978. https://doi:10.1016/S0140-6736(21)00232-4
- **Anderson, M.**, Pitchforth, E., Edwards, N., Alderwick, H., McGuire, A., Mossialos, E., 2022. United Kingdom: Health System Review. Health Syst Transit. 24(1), 1–194 https://eurohealthobservatory.who.int/publications/i/united-kingdom-health-system-review-2022
- **Anderson, M**., Pitchforth, E., Vallance-Owen, A., et al., 2022. Misconceiving patient-reported outcome measures (PROMs) as primarily a reporting requirement rather than a quality improvement tool: perceptions of private healthcare sector stakeholders in the UK. J Patient Rep Outcomes 6, 101. https://doi.org/10.1186/s41687-022-00511-5
- **Anderson, M.** and Mossialos, E., 2022. Are we heading for a two-tier healthcare system in the UK? BMJ , 376 :o618 doi:10.1136/bmj.o618
- **Anderson, M.,** Cherla, A., Wharton, G., Mossialos, E., 2020. Improving transparency and performance of private hospitals. BMJ 368 https://doi.org/10.1136/bmj.m577
- Charlesworth, A., **Anderson, M.**, Donaldson, C. et al., 2021. What is the right level of spending needed for health and care in the UK? Lancet 397(10288), 2012–2022. https://doi:10.1016/S0140-6736(21)00230-0
- Friebel, R., Fistein, J., Maynou, L., **Anderson, M**., 2022. Emergency contracting and the delivery of elective care services across the English National Health Service and independent sector during COVID-19: a descriptive analysis. BMJ Open, 12(7): e055875. https://doi:10.1136/bmjopen-2021-055875

- **Anderson M.,** McGuire, A., Street, A., 2022. How to shape a "proper" long-term workforce plan for health and social care. BMJ 378: e072977 doi:10.1136/bmj-2022-072977
- **Anderson, M.**, O'Neill, C., Macleod Clark, J. et al., 2021. Securing a sustainable and fit-for-purpose UK health and care workforce. Lancet, 397(10288), 1992–2011. https://doi:10.1016/S0140-6736(21)00231-2
- Pitchforth, E., **Anderson, M.,** Thomas, C., Edwards, N., 2021. Sustainability and Resilience in the English Health System. Partnership for Health System Sustainability and Resilience. http://www3.weforum.org/docs/WEF_PHSSR_England_Report.pdf
- Sheikh, A., **Anderson, M.**, Albala, S. et al., 2021. Health information technology and digital innovation for national learning health and care systems. Lancet Digit Health, 3(6):e383–e396. https://doi:10.1016/S2589-7500(21)00005-4

Abstract

Elective care in England is provided by NHS and private hospitals through a combination of public and private funding. There are concerns regarding healthcare quality in private hospitals and the need to ensure value for money in the context of increasing provision of publicly funded care in private hospitals. Private hospitals also may engage with risk selection, treating less complicated patients than NHS hospitals highlighting the complex interaction between the public and private sectors in servicing NHS patients. Against this background, the Evidence-Based Interventions (EBI) programme was implemented in April 2019 to reduce the provision of low value procedures, produce cost-savings and improve healthcare quality. This thesis focuses on these developments through several perspectives.

Paper I focuses on publicly funded care and uses a difference-in-difference analysis to conclude the EBI programme did not accelerate disinvestment for the procedures under its' remit in the first year after implementation. Using triple difference estimation, this paper shows that reductions in provision of low value procedures were larger in NHS hospitals than in private hospitals.

Paper II focuses on privately funded care in private hospitals and identifies evidence of substitution after the implementation of the EBI programme, in the reductions in publicly funded care, and increases in privately funded care. This paper produces stronger evidence of substitution for procedures classified as low value in certain circumstances and beneficial in others, and weaker evidence of substitution for procedures classified as low value in any circumstances.

Paper III focuses on publicly funded care and uses methods to adjust for observable confounders to show that elective orthopaedic care in private hospitals is safer, produces better outcomes, and is more efficient. Using an instrumental variable approach to account for both observable and unobservable confounders, there are contrasting results and no evidence of differences in relation to patient safety and outcomes. Using this approach, treatment in private hospital is also associated with longer post-operative length of stay.

Contents

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Throughout my PhD studies, I have benefited from opportunities to undertake two separate fellowships. First, I am grateful to Dr Aoife Molloy who facilitated my fellowship at NHS England with the Evidence-Based Interventions programme (EBI) team. This was crucial to access relevant data on publicly funded care, and provided me with important insights into national policy making and implementation challenges. Second, I am grateful to Dr Jon Fistein who facilitated my fellowship at the Private Healthcare Information Network (PHIN). This was again crucial to access relevant data on privately funded care, and my experiences with his team gave me a deeper understanding of the complexities associated with the private healthcare sector in the United Kingdom.

On a personal level, I would also like to thank my wife, Helen, for her ongoing patience and understanding. This made completing this thesis possible during an exciting period of lives when we have welcomed our daughter, Emily, to the world.

Abbreviations

Alternative Quality Contract (AQC)
Any Qualified Provider (AQP)
Aid to Families with Dependent Children (AFDC)
Agency for Healthcare Research and Quality (AHRQ)
Average treatment effect on treated (ATT)
British Association of Endocrine & Thyroid Surgeons (BAETS)
British Association of Urological Surgeons (BAUS)
Benign prostatic hypertrophy (BPH)
British Spine Registry (BSR)
Care Quality Commission (CQC)
Charlson Comorbidity Index (CCI)
Chief Medical Officer (CMO)
Choosing Wisely (CW)
Clinical commissioning groups (CCGs)
Commission for Healthcare Audit and Inspection (CHAI)
Commission for Health Improvement (CHI)
Competition and Markets Authority (CMA)
Current Population Survey (CPS)
Department of Health & Social Care (DHSC)
Difference in difference (DiD)
Evidence-Based Interventions programme (EBI)
Exercise electrocardiogram (ECG)
Generalised linear model (GLM)
Getting It Right First Time (GIRFT)
Healthcare-associated infection (HAI)
Healthcare Quality Improvement Partnership (HQIP)
Healthcare Resource Groups (HRGs)
Hospital Episode Statistics (HES)
International Classification of Diseases 10th Revision (ICD-10)
Independent Healthcare Providers Network (IHPN)
Independent sector treatment centres (ISTC)
Index of Multiple Deprivation (IMD)

Integrated care boards (ICBs)

Interrupted time series analysis (ITSA)

Inverse probability weighting matching with regression adjustment (IPWRA)

Learn from patient safety events service (LFPSE)

Length of stay (LOS)

London School of Economics and Political Science (LSE)

Lower urinary tract symptoms (LUTS)

National Bariatric Surgery Registry (NBSR)

National Health Service (NHS)

National Clinical Audit and Patient Outcomes Programme (NCAPOP)

National Institute of Health and Care Excellence (NICE)

National Joint Registry (NJR)

National Reporting and Learning System (NRLS)

Obstructive sleep apnoea (OSA)

Organisation for Economic Co-operation and Development (OECD)

Oxford hip score (OHS)

Oxford knee score (OKS)

Payment by results (PbR)

Private Health Information Network (PHIN)

Private medical insurance (PMI)

Procedures of low clinical value (POLCV)

Patient-reported outcome measures (PROMs)

Patient Safety Indicator (PSI)

Propensity score matching (PSM)

Randomised control trial (RCT)

Regression discontinuity in time (RDiT)

Society for Cardiothoracic Surgery in Great Britain and Ireland (SCTS)

Secondary Uses Service (SUS)

Survey of Income and Program Participation (SIPP)

US Agency for Healthcare Research and Quality (AHRQ).

World Health Organization (WHO)

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1. Chapter 1: Introduction

This PhD thesis focuses on the healthcare quality in NHS and private hospitals for elective care in England. Elective care is defined by the NHS as non-urgent healthcare services, usually delivered in a hospital setting (NHS England, 2022b). While many types of elective care exist, this PhD thesis is focused exclusively on elective surgical care. Non-elective care is healthcare services provided on an urgent basis such as emergency surgery or medical treatment.

The purpose of this introduction is to provide context and background regarding the development of public-private mix and interface for elective care in England over the last two decades, clarify definitions of the public-private interface, and then outline concepts and definitions related to healthcare quality.

1.1.Public-private interface in the English healthcare system

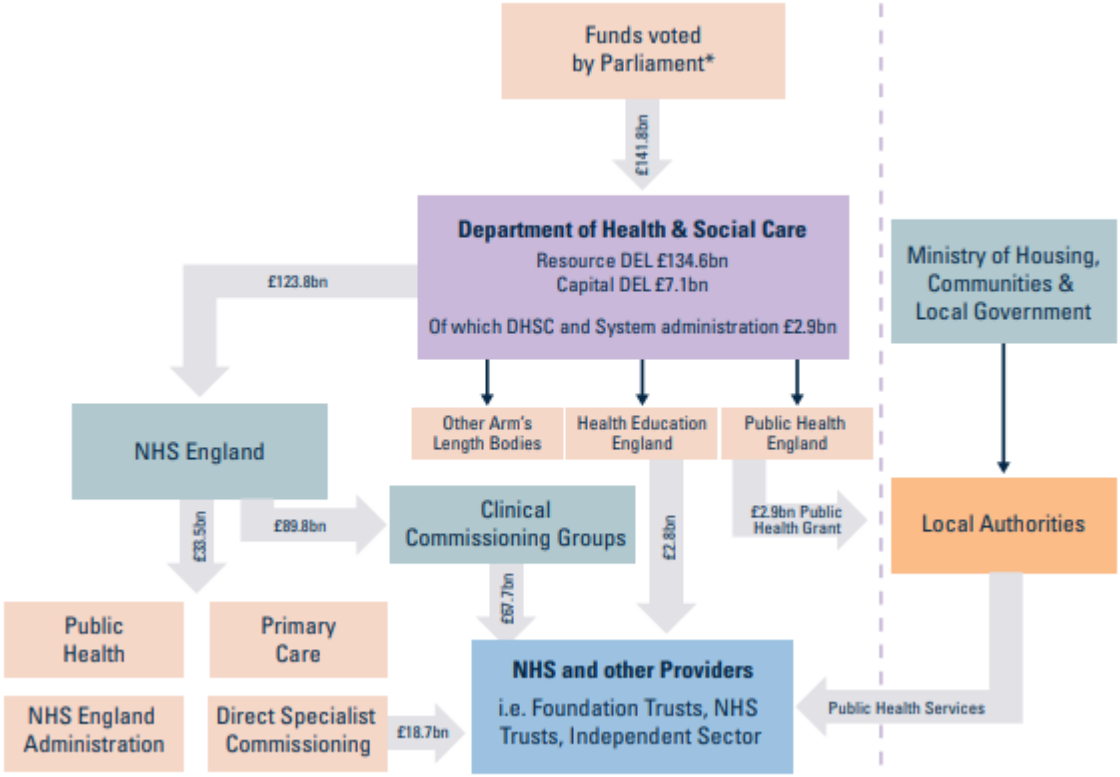
1.1.1. The origins and structure of the English NHS

The National Health Service (NHS) was established on 5 July 1948, with the National Health Service Act, with the purpose of providing healthcare, free at the point of use, based on clinical need and not ability to pay. Despite some resistance from the medical profession, policy makers were able to successfully replace a system of voluntary public and private hospitals and independent practitioners with a universal health system delivered by organisations which have subsequently evolved to share similar institutional structures, cultures and behaviours (Anderson, Pitchforth, *et al.*, 2022). The NHS originally was envisaged as a collective healthcare service across the United Kingdom, but the devolution settlement in 1999 saw powers for health transferred from the Westminster (United Kingdom) Parliament to the Scottish Parliament, Welsh Assembly and the Northern Ireland Assembly. As a result, the last two decades have seen a divergence of policies between UK constituent countries and the evolution of four distinctive healthcare systems. Policies pursued in England such as encouraging competition between healthcare providers, and facilitating the provision of publicly funded care in private hospitals (see section 1.1.2.), have not been pursued in Wales, Scotland, and Northern Ireland. There is also a much more limited role for privately funded care in these countries than in England (Anderson,

Pitchforth, *et al.*, 2022). Given my central focus on the private-public interface, for these reasons, this PhD thesis focuses exclusively on the English healthcare system.

In England, the Department of Health & Social Care (DHSC) allocates funds to NHS England, which then distributes funds to local commissioning bodies known as Integrated Care Boards (ICBs) (prior to July 2022 these were known as clinical commissioning groups, CCG), as well as to specialist and primary care services (Figure 1). The DHSC makes further allocations of funds to arm's-length bodies, such as the National Institute for Health and Care Excellence (NICE) (NICE, 2023), the Care Quality Commission (CQC) (CQC, 2023a), and NHS Resolution (NHS Resolution, 2023).

Figure 1: Funding flows in the health and social care system, 2019/20†



Source: (Anderson, Pitchforth, *et al.*, 2022)
† This figure refers to the private healthcare sector as the "independent sector"

Local commissioning bodies receive block grants from NHS England that are calculated according to local needs and market forces, and subsequently contract for emergency and elective hospital services, as well as community and mental health services for their respective local populations. ICBs may contract services from either NHS or private

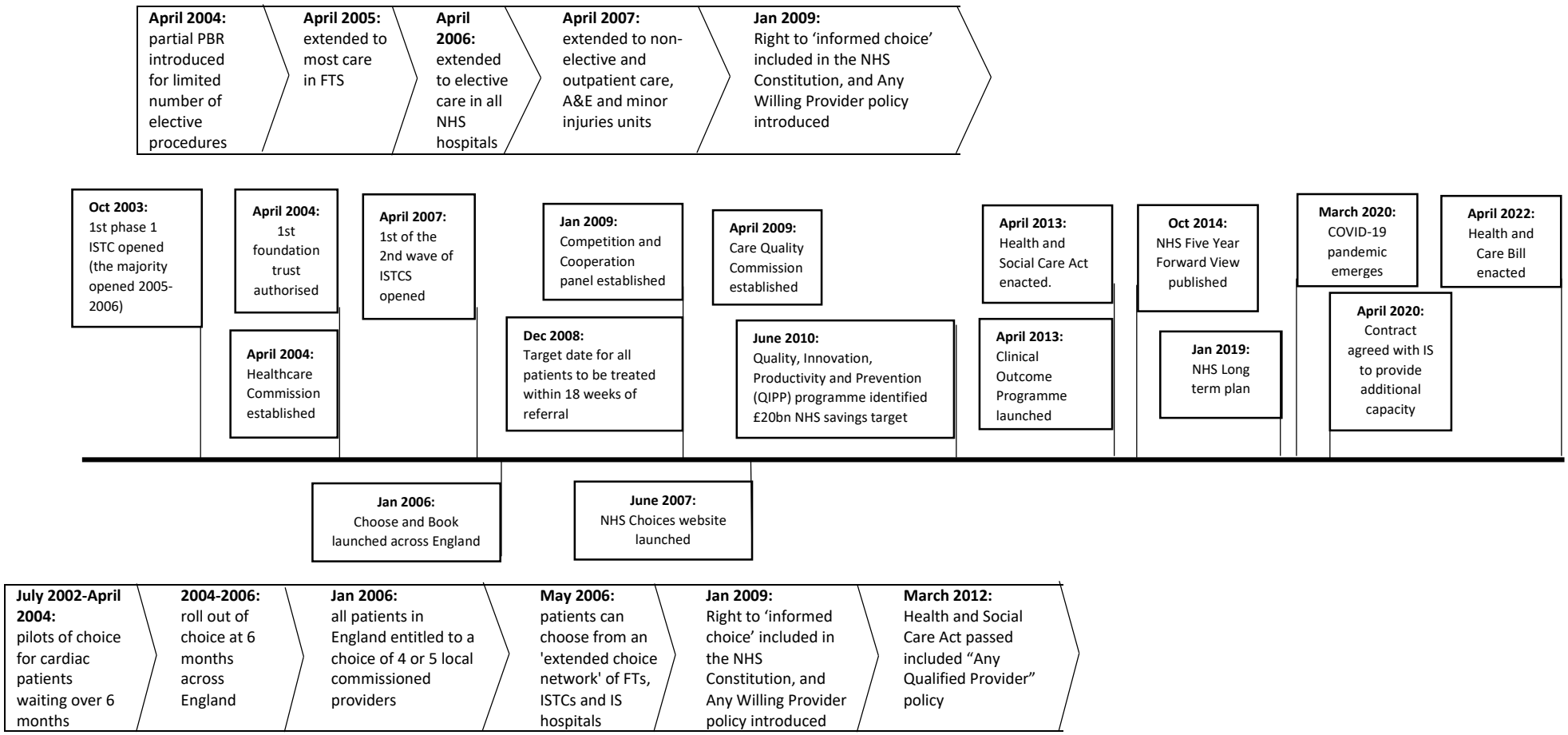
hospitals, and since 2009 patients have a right to choose where they receive elective care services (see section 1.1.2.1.). As a result, there has been a growing expansion of publicly funded care in private hospitals in England (see section 1.1.2.), and in 2019/20 private hospitals undertook approximately 6% of total publicly funded elective episodes (Figure 4). This proportion dropped slightly in 2020/21 to 5% (Figure 4), although is expected to increase further as the government has openly pledged to use the private sector to assist in reducing waiting lists for NHS funded elective care (Calver, 2023).

NHS England monitors the performance of NHS organisations in relation to financial management, waiting times, and patient safety. In certain cases, NHS England may set targets for performance and use financial incentives to encourage improved performance. While these general principles apply to all NHS organisations, some NHS hospitals have successfully achieved "Foundation Trust" status whereby they enjoy a degree of financial and operational autonomy from NHS England. However, in recent years there has been an increased convergence in performance management approaches to both NHS trusts and NHS foundation trusts after a sustained period in the mid-2010s when the majority of NHS hospitals (irrespective of their status) posted financial deficits (King's Fund, 2021b). NHS England also monitors the performance of local commissioning bodies. As with NHS hospitals, this includes monitoring waiting times, and financial performance. NHS England does not have a mandate to monitor the performance of private hospitals, although the mandate of the Care Quality Commission (CQC) to regulate the quality and safety of healthcare providers does extend to both NHS and private hospitals.

1.1.2. Healthcare market policies from the 2000s onwards

In the late 1990s, waiting lists for many types of elective care were approaching over a year (Murray, 2021), and health spending per capita was significantly below the EU average (Wanless, 2002). Over the following decade, the incumbent Labour government made a commitment to significantly increase health spending to a sum closer to the EU average and introduced policies to facilitate patient choice and promote greater competition between healthcare providers (Figure 2). The rationale was that this would improve healthcare quality, efficiency, and responsiveness in the public sector (Appleby, Harrison and Delvin, 2003). Collectively, these policies facilitated the rapid expansion of provision of publicly funded elective care services in private hospitals (see section 1.2). In this section, I review key policies and reforms that drove these changes.

Figure 2: Policy timeline for public-private interface for elective care from 2000 onwards[†]



[†] PbR: Payment by Results, FT: foundation trust, A&E: accident and emergency department, ISTC: independent sector treatment centre, IS: independent sector, DES: directed enhanced service, GP: general practitioners, GMS: general medical services

Source: Updated previous analysis contained in (Dixon *et al.*, 2010)

1.1.2.1.Patient choice of provider

Enabling patient choice for their healthcare provider was a key component of health policy promoted by the Labour government throughout the 2000s. In 2000, the NHS Plan outlined policies that patients should be able to choose the times and dates of their hospital appointments (NHS England, 2000). In 2002, the associated implementation plan titled "Delivering the NHS Plan: Next steps on investment, next steps on reform", was more specific and included a commitment to offer patients the choice of an alternative provider if they could not be treated within six months by the NHS (NHS England, 2002). This was originally framed as a way of reducing waiting times but in subsequent years patient choice was increasingly promoted as a mechanism to facilitate competition between healthcare providers and to create incentives to improve healthcare quality. In 2006, the NHS in England introduced a policy of choice of provider at point of referral in primary care. The intention was that all patients were to be offered a choice of several providers at the point of referral, including choice of private healthcare providers. In 2009, patient choice of healthcare provider was embedded as a formal right for all patients within the NHS Constitution (Department of Health & Social Care, 2015). The "free choice" policy was maintained by the subsequent Coalition government, which introduced the "Any Qualified Provider (AQP)" contractual system in 2012 that expanded the range of services that private healthcare providers could compete for with NHS providers (NHS Confederation, 2011). Despite these policy changes, patients continue to have limited choice of healthcare providers unless they are willing to travel large distances. For most patients this is not the case, demonstrated by an analysis of patients undergoing elective hip replacement between 2010-13 that found over 90% of patients received care within their three nearest hospitals, and for patients that did bypass their nearest hospital they only travelled an additional 5.0km on average to receive care (Gutacker *et al.*, 2016). Moreover, patient surveys have indicated that most patients prioritise geographical location and convenience as the most important factors when choosing healthcare provider (Dixon, 2010).

1.1.2.2.Independent sector treatment centres

There was consensus among the Labour governments of the 2000s that due to years of underinvestment in healthcare capital and workforce, there was limited capacity in NHS hospitals to clear waiting lists and meet growing demand. One strategy promoted among

policy makers was to develop treatment centres that could specialise in high-volume and low complexity elective care procedures, many of which could be done as day cases. They were originally intended to be developed by NHS hospitals, but this model was expanded in 2003 to allow private healthcare providers to develop treatment centres, known as "Independent Sector Treatment Centres (ISTCs)" (Naylor and Gregory, 2009). Many ISTCs specialise in one type of procedure, for example cataract surgery. In contrast, private hospitals would provide a broad range of surgical operations and outpatient appointments. By 2010/11, there were 161 ISTCs operating in England (Kelly and Tetlow, 2012). By 2021/22, there had been further growth with over 250 ISTCs operating in England (Peytrignet *et al.*, 2022). The policy was perceived as a practical way to significantly increase capacity for elective care within the healthcare system in a relatively short period of time. However, it was also a controversial policy as several stakeholders raised concerns such as the quality of care within ISTCs, the availability of appropriately trained staff, and the potential that ISTCs would engage in risk selection which would leave NHS hospitals with on-average sicker patients and higher costs (Pollock and Godden, 2008).

1.1.2.3.Activity-based payments

At the same time, the NHS in England introduced reforms to the hospital reimbursement system (Grašič, Mason and Street, 2015). From 2003, the NHS launched an activity-based payment system for hospitals known as the Payment by Results (PbR). The PbR programme is a national tariff system involving fixed costs for thousands of Healthcare Resource Groups (HRGs) based on the public sector average costs for relevant individual procedures or hospital episodes. Each HRG is refined further when calculating the final reimbursement for each hospital episode based on a range of factors such as patient characteristics and local healthcare labour markets. This system was originally introduced solely for elective care, but was soon expanded to acute, emergency and outpatient care. The PbR system successfully created incentives to improve efficiency (Farrar *et al.*, 2009), and also provided a standardised framework that could be used when contracting with private hospitals (Savva, Tezcan and Yıldız, 2019). However, there have been criticisms of the PbR reimbursement system including evidence of up-coding by hospitals through a process known as "HRG creep" (Yi, Pugh and Farrar, 2007), and an absence of mechanisms to incentivise healthcare quality and patient experiences of care (Grašič, Mason and Street, 2015).

1.1.2.4.Greater emphasis on targets

During the early 2000s, there were substantial increases in healthcare spending (Wanless, 2002). However, there was also increased pressure to ensure value for money for this additional spend of tax-payer monies. In response, the NHS in England became increasingly focused on performance management and implemented a range of targets to reduce waiting times for elective care. The 2000 NHS plan introduced two new targets: 3 months for a first outpatient appointment across all medical and surgical specialities, and 6 months for inpatient treatment (NHS England, 2000). In 2004, the NHS introduced the 18-week referral-to-treatment target (which continues to be used – see section 1.1.3.2.). This changed the way in which waiting times were measured, with waiting times beginning from referral by a GP and only ending once a patient started treatment or was discharged (Charlesworth, Watt and Gardner, 2020). Waiting times were routinely published and increasingly became the focus of media attention. Meeting targets was incentivised through penalties – for example, the dismissal of managers of hospitals or local commissioning bodies (Propper *et al.*, 2007). This period of centrally imposed targets and penalties created a culture of mistrust and has been described by policy commentators and academics as the era of "targets and terror" (Bevan and Hood, 2006; Propper *et al.*, 2007). The urgency in achieving these targets at both the national and local level provides further insights into why NHS commissioners increasingly looked to private healthcare providers for additional capacity to clear waiting lists.

1.1.2.5.Strengthened regulation

Another important factor which facilitated the introduction of private healthcare providers of publicly funded care was strengthened regulation to ensure that all healthcare providers, irrespective of whether they were NHS or private, met minimum quality of care and patient safety standards. In 2004, the Commission for Healthcare Audit and Inspection (CHAI) was established (replacing the Commission for Health Improvement (CHI)). In acknowledgement that private hospitals were providing an increasing amount of publicly and privately funded care (– see Figure 4), the mandate of CHAI included regulation of private healthcare providers , by means of registration, inspection, monitoring of complaints, and enforcement activities (Commission for Healthcare Audit and Inspection, 2009). In 2009, CHAI was replaced by the CQC (i.e. the Care Quality Commission), which was an amalgamation of the existing inspectorates responsible for physical healthcare, mental health and social care. The CQC conducts regular inspections and provides ratings for all health and social care

providers, both public and private, in England (see section 1.1.5. for comparative analysis of CQC reports of private and NHS hospitals).

1.1.2.6.Structural changes to promote an internal market for healthcare

Alongside the reforms described above to facilitate patient choice (see section 1.1.2.1), there have been several structural reforms over the last four decades that established and strengthened the internal market for healthcare in England and facilitated the provision of publicly funded care in private hospitals. In the early 1990s, the incumbent Conservative government introduced the 1990 NHS and Community Care Act that created a split between the purchasers (District Health Authorities (DHAs)) and providers of services (NHS Trusts) (UK Government, 1990). The successive Labour government that came to power in 1997 with mandate to abolish the internal market, but retained the separation between purchasers and providers, and the term "purchasing" was replaced by "commissioning" to reframe the relationship between purchasers and providers as working together to improve the quality of healthcare services. Primary Care Trusts (PCTs) were established in 2002, with budgets allocated according to local needs, and responsibility for commissioning NHS services for geographically defined populations (Walshe *et al.*, 2004). The reorganisation of DHAs to PCTs was widely understood as costly and disruptive (Smith, Walshe and Hunter, 2001), and there were no further top-down reorganisations of the NHS until the 2012 Health and Social Care Act was introduced by the Coalition (Conservative and Liberal Democrat) government that came to power in 2010 (UK Government, 2012). The Act replaced PCTs with Clinical Commissioning Groups (CCGs), and included several measures which consolidated and accelerated the internal market for healthcare in England. The most controversial aspect of the Act was "Section 75", that stated CCGs must protect the right of patients to choose healthcare providers, not engage in anti-competitive behaviour, and introduce competitive tendering for provision of services (UK Government, 2012). In combination with reforms related to facilitating patient choice (see section 1.1.2.1), the Health and Social Care Act 2012 created an environment where private healthcare providers could compete for CCG contracts on an equal statutory footing as existing NHS providers.

1.1.2.7.Movement away from market-orientated healthcare to co-operation and integration

In more recent years, there has been less focus on promoting market-orientated healthcare and more emphasis on the role of co-operation and integration across all healthcare services including the private healthcare sector. Within the confines of the 2012 Health and Social Care Act, many CCGs moved away from promoting competition between healthcare providers towards "place-based commissioning' whereby CCGs, local authorities, NHS hospitals, and the independent sector work together to integrate and improve the quality of services for local populations (Wenzel and Robertson, 2019). The public discourse on the role of the private healthcare sector in the NHS has also been reframed as not just a vehicle to promote competition and patient choice but also an important policy tool to provide additional healthcare capacity and support the NHS. For example, 2019 NHS Long-term plan discussed the role of private healthcare sector in the context of delivering improved waiting times, and committed to "continue to provide patients with a wide choice of options for quick elective care, including making use of available independent sector capacity" (NHS England, 2019). The 2022 Health and Care Act also included several measures that reframed the relationship between the private healthcare sector and the NHS (UK Government, 2022). The Act repealed the aforementioned "Section 75" of the 2012 Health and Social Care Act (Anderson, Pitchforth *et al,* 2021a), and allowed membership of representatives from private hospitals on newly formed Integrated Care Boards (ICBs) alongside representatives from NHS hospitals, local authorities, and primary care services. Looking to the future, there appears to be acknowledgement from both Conservative and Labour politicians that there will be a need for ongoing co-operation between the NHS and private healthcare sector to address growing backlogs of elective care. In April 2023, Prime Minster Rishi Sunak stated one of the mechanisms to reduce waiting lists was to "use the private sector more" and that the policy had "worked in the past and we are going to do more of that going forward" (Hughes, 2023). In January 2023, the Leader of the Labour Party Kier Starmer stated that the NHS "will always have to be free at the point of use, it of course should be a public service. But that doesn't mean we shouldn't use effectively the private sector as well" (Morton, 2023).

1.1.3. Structure and organisation of the private healthcare sector

Alongside the publicly funded NHS, there has always been a private healthcare sector in the United Kingdom (Maynard, 2005; Blackburn, 2021). Historically, it has always constituted a lesser part of the health system: in 2000 it accounted for 23.9% of total healthcare expenditure, compared to an OECD average of 28.9% (OECD, 2022). Whereas, in 2019 it accounted for 21.5% of total healthcare expenditure, compared to an OECD average of 26.0% (OECD, 2022). Accessed through a combination of -out-of-pocket payments private medical insurance and NHS funded activities, private healthcare services are provided by a variety of different organisations. However, private medical insurance is supplementary to the NHS, and typically covers certain types of elective and ambulatory care services and faster access to private providers. In 2021, the Independent Healthcare Providers Network (IHPN) reported there were 270 private hospitals and 282 NHS hospitals delivering elective surgical care in England (IHPN, 2021). There are no data available for the average number of beds in each hospital, but private hospitals are typically considerably smaller than NHS hospitals. As a result, proportionally, in terms of volume the private healthcare sector is much smaller than the NHS. In 2019, the private sector provided approximately 1.4 million elective procedures compared to 9.6 million elective procedures delivered by the NHS hospitals (Table 1). There is a greater concentration of privately funded care in London and the south east of England than other parts of the country, reflecting the higher rates of private medical insurance coverage in these populations. These two regions account for approximately half of total revenue from privately funded care (Blackburn, 2021; Charlesworth *et al.*, 2021), and approximately half of total volumes of privately funded elective care in private hospitals (Table 1). In contrast, private hospitals in London provide small quantities of publicly funded care, accounting for 5.44% of total volumes of publicly funded elective care in private hospitals in 2019, despite 15.92% of the English population residing in London.

Table 1: Volumes of elective care spells in NHS and private hospital by funding mechanism, 2019

Region	NHS hospital/ publicly funded	Vol per 1,000 population	Private hospital/ publicly funded	Vol per 1,000 population	Private hospital/ privately funded	Vol per 1,000 population	Population
East Midlands	641,969 (6.68%)	132.75	95,198 (12.99%)	19.69	25,863 (4.06%)	5.35	4,835,928 (8.59%)
East of England	965,684 (10.05%)	154.85	98,996 (13.51%)	15.87	79,849 (12.55%)	12.80	6,236,072 (11.08%)
London	1,705,023 (17.74%)	190.25	39,853 (5.44%)	4.45	196,639 (30.90%)	21.94	8,961,989 (15.92%)
North East	440,202 (4.58%)	164.87	33,679 (4.60%)	12.61	10,957 (1.72%)	4.10	2,669,941 (4.74%)
North West	1,506,989 (15.68%)	205.28	113,629 (15.51%)	15.48	58,846 (9.25%)	8.02	7,341,196 (13.04%)
South East	1,363,078 (14.19%)	148.48	125,013 (17.06%)	13.62	143,565 (22.56%)	15.64	9,180,135 (16.31%)
South West	970,049 (10.10%)	172.46	96,426 (13.16%)	17.14	47,274 (7.43%)	8.40	5,624,696 (9.99%)
West Midlands	1,089,621 (11.34%)	183.62	55,971 (7.64%)	9.43	41,320 (6.49%)	6.96	5,934,037 (10.54%)
Yorkshire and The Humber	926,536 (9.64%)	168.37	74,054 (10.11%)	13.46	32,126 (5.05%)	5.84	5,502,967 (9.78%)
Total	9,609,151	170.72	732,819	13.02	636,439	11.31	56,286,961

Source: Elective care volumes provided by the Private Healthcare Information Network (PHIN) and population data taken from (ONS, 2020)

In contrast to the NHS, where most hospitals are organised in a similar manner and share familiar cultures and objectives, the private healthcare sector consists of a broader variety of healthcare providers. They include both for-profit and not-for-profit organisations and range from large national hospital groups to small specialist local providers. Most private healthcare providers specialise in performing low complexity and high-volume procedures such as cataract surgeries, hernia repair, hip replacement, and knee replacement (Stoye, 2019). There are a few private hospitals that can provide a broader range of specialist services, including most types of cancer and critical care. Most of these are located in London, with prominent examples including the Cromwell Hospital, the Cleveland Clinic, St John & St Elizabeth Hospital, and King Edward VII's Hospital (Townsend, 2021). In 2019, the highest-volume procedure conducted in private hospitals was cataract surgery (Table 2). However, this was closely followed by knee and hip replacement, and joint injections for pain.

Table 2: Top 20 highest-volume elective procedures in private hospitals in England by funding mechanism, 2019

Private hospital/ publicly funded		**Private hospital/ privately funded**	
Cataract surgery	131,300	Cataract surgery	54,139
Knee replacement (primary)	28,147	Knee arthroscopy	20,994
Joint injections for pain	27,589	Epidural injection	18,664
Hip replacement (primary)	26,111	Hip replacement (primary)	16,084
Epidural injection	24,996	Bladder examination under anaesthetic	13,721
Knee arthroscopy	17,098	Knee replacement (primary)	11,292
Skin lesion removal	13,064	Breast enlargement	9,732
Inguinal hernia repair (laparoscopic)	12,348	Skin lesion removal	9,073
Carpal tunnel release	11,698	Inguinal hernia repair (laparoscopic)	8,752
Spinal injection	9,779	Spinal injection	8,638
Bladder examination	9,463	Joint injections for pain	8,126
Eye operations (vitrectomy)	7,653	Spinal decompression	6,650
Gallbladder surgery	7,146	Gallbladder surgery	6,290
Tooth or teeth extraction	7,034	Breast prosthesis	5,628
Haemorrhoid treatment	6,369	Tonsillectomy	5,566
Spinal decompression	6,091	Subacromial joint decompression	5,398
Extraction of wisdom tooth	5,509	Carpal tunnel release	5,123
Subacromial joint decompression	5,110	Knee ligament reconstruction	4,850
Inguinal hernia repair (open)	4,228	Extraction of wisdom tooth	4,818
Umbilical hernia repair	4,197	Inguinal hernia repair (open)	4,610
Total	364,930	Total	228,148

Source: Data provided by the Private Healthcare Information Network (PHIN)

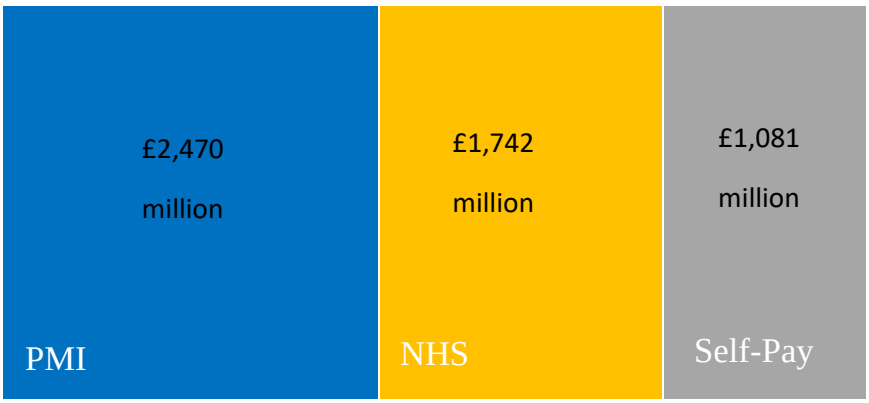
Private hospitals are predominantly staffed by consultants who also hold NHS salaried contracts. These consultants are reimbursed by the private hospital on a fee-for-service basis for the number of patients they see in outpatient clinics and procedures they perform. Fees for insured patients are determined by fixed fee schedules maintained by insurers, and fees for self-pay patients are determined by each consultant and private hospital. Nurses and other allied healthcare professionals, in contrast, tend to be employed solely by private hospitals on a salaried basis. Establishing precisely how many consultants are working in the private healthcare sector is challenging, particularly as the number is constantly changing with many consultants entering and suspending private practice multiple times throughout their career. Moreover, some consultants work across multiple private hospitals in their local area. The Private Healthcare Information Network (PHIN) reports how many consultants are active in the private healthcare sector for admitted patient care on a monthly basis, typically ranging between 10,000 and 12,000 between 2019 and 2021 (PHIN, 2022). In comparison, as of 2021

there were approximately 55,000 consultants working in the NHS (NHS Digital, 2021). However, the proportion of consultants that work exclusively in the private healthcare sector is not known.

1.1.4. Trends in provision of publicly and privately funded elective care in private hospitals

Privately funded revenues for the private hospitals are generated from two sources. First, around 1 in 10 people in the UK have some form of private health insurance, rising to 1 in 4 people in London and the South East (Blackburn, 2017). Policies are mostly employer sponsored (Foubister *et al.*, 2006), and can be used to access certain specialist outpatient and elective care services. The number of private medical insurance (PMI) policies peaked in 2008 at 4.4 million, but this has since declined to just under 4 million in 2020 (Blackburn, 2020). Even with this decline, claims on PMI policies still generate approximately half of total revenues for private hospitals (Figure 3). Second, some individuals opt to access private healthcare services through their own means (King and Mossialos, 2005). Prior to the pandemic, in the face of growing NHS waiting lists, the self-pay private healthcare market grew by approximately 7% per year between 2010 and 2019 (Heath, 2021), and constituted around 20% of private hospital revenues (Blackburn, 2021). In addition, publicly funded patients constituted approximately 30% of private hospitals revenues in 2019 (Blackburn, 2021)

Figure 3: Private healthcare sector revenues split in England, 2019[§]

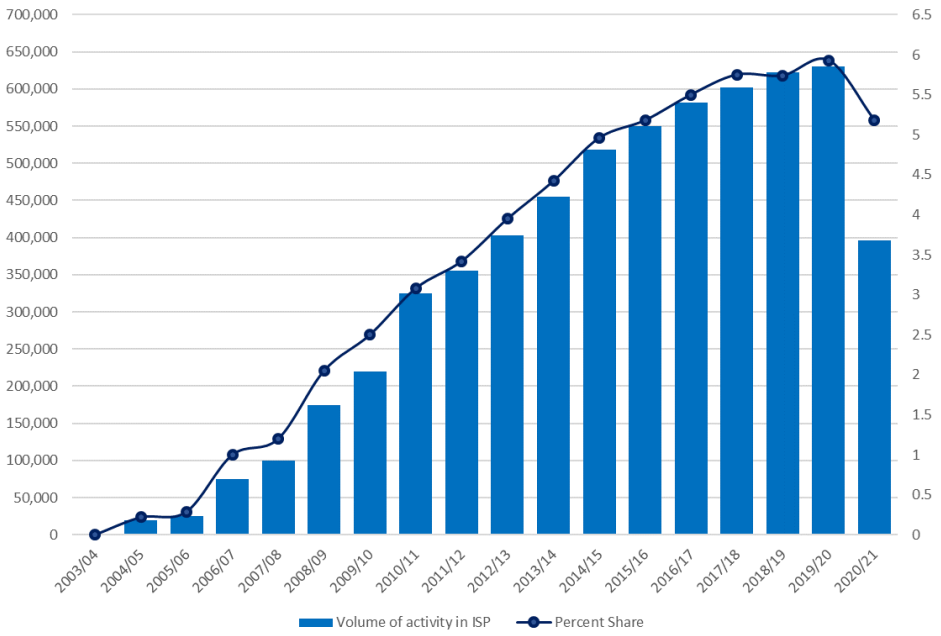


Source: (Blackburn, 2021)

[§] PMI: Private Medical Insurance, NHS: National Health Service.

Collectively, the policies outlined in section 1.1.2 have facilitated a significant expansion of publicly funded care in private hospitals over the last two decades. From almost nothing in 2003/04, the provision of elective care by private hospitals had increased to over 600,000 episodes by 2019/20 and accounted for just under 6% of total publicly funded elective episodes (Figure 4). Despite access to multiple sources of revenue, total revenue in the private healthcare sector actually deceased in real-terms by 0.5% and 2.1% in 2018 and 2017 respectively, followed by a 3% increase in 2019 (Blackburn, 2021).

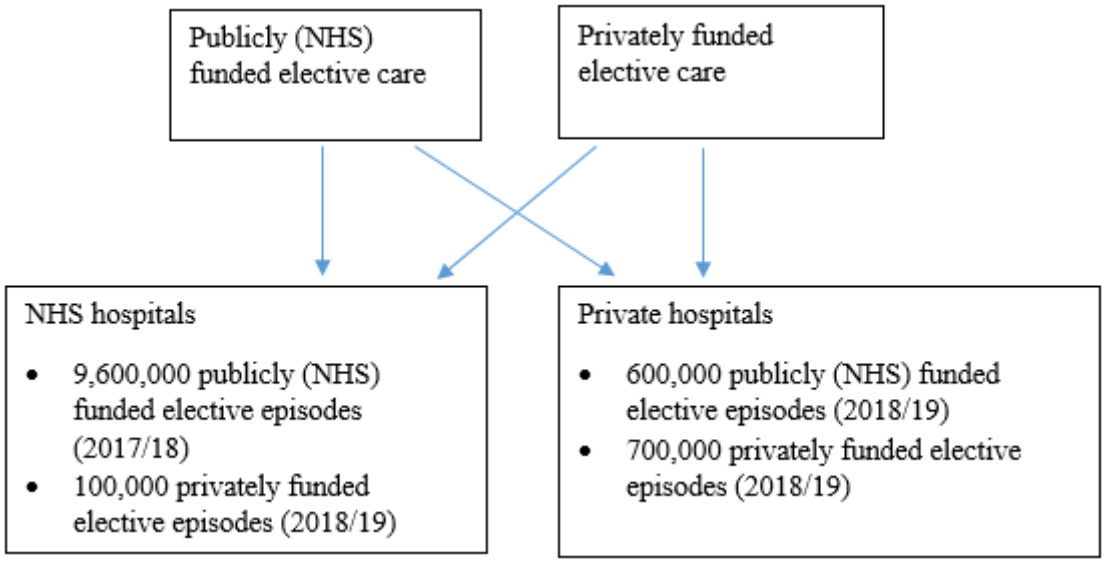
Figure 4: Share of publicly funded elective treated in the private healthcare sector, 2003/04 to 2020/21



Source: Reproduced from (BMA, 2022)

In terms of volumes, private hospitals conduct similar amounts of privately and publicly funded procedures per year (Figure 5). However, NHS hospitals almost exclusively undertake publicly funded procedures, with small numbers of privately funded procedures taking place in a select number of specialist NHS hospitals predominantly based in London.

Figure 5: Distribution of elective care between NHS and private hospitals



Source: Author, based on data from (Stoye, 2019) and (PHIN, 2020a)

1.1.5. Defining the public-private interface in the English healthcare system

For the purposes of this PhD thesis, it is important to define what is meant by the terms "public", "private", and "public-private interface".

"Public" is used either in the context of "public" healthcare providers or "public" funding of healthcare services. "Public" providers in England are institutions owned by NHS organisations such as NHS hospitals. They are non-profit organisations, with any financial surplus reinvested into improving services. "Public" funding refers to funding of healthcare services using monies allocated by the government to the Department of Health & Social Care, and subsequently NHS England (Figure 1). "Private" is also used either in the context of "private" healthcare providers or "private" funding of healthcare services. As discussed in section 1.1.3., private healthcare providers are organisations that are independent of the NHS. Most private healthcare providers are for-profit organisations, and therefore accountable to their shareholders. However, there are a number of not-for-profit private healthcare organisations run as charitable organisations such Nuffield Health (Nuffield Health, 2023), and Benenden Health (Benenden Health, 2023). Although, data on the proportion of privately funded spending on for-profit and non-for-profit private healthcare providers is not freely available. "Private" funding refers to the funding of healthcare services using monies from

either private medical insurance, or out-of-pocket payments (also known as self-pay), when the patient will be exposed to the full cost of healthcare services.

In the PhD thesis, the "public-private interface" refers to the interaction between public and private healthcare sectors when providing elective care. There are several ways in which this happens, some more subtle than others. The most prominent example includes the provision of publicly funded care in private hospitals, or vice versa (discussed in section 1.1.4.). However, another area which has received less attention due to limited data availability, is how changes in publicly funded care influence changes in privately funded care. These dynamics are particularly important to investigate as there has been a gradual withdrawal of publicly funded care for some NHS services, such as surgical procedures classified as low value, optometry services, and dental care, since the establishment of the NHS, and significant corresponding increases in privately funded care may be a signal of unmet need for healthcare services. Finally, another important aspect of this interface is how national healthcare quality initiatives and guidance are implemented across the public and private healthcare sectors. This includes considerations of how healthcare quality is monitored, and how best practice is shared. There are of course many other ways in which the public and private healthcare sectors interact, for example private investment in NHS infrastructure (i.e. through private financing initiatives) or public-private partnerships focused on research and development. but these are outside the remit of this PhD thesis.

1.2. Healthcare quality

1.2.1. Definitions and domains

As this PhD thesis is concerned with the healthcare quality in NHS and private hospitals for elective care in the English healthcare system, it is important to define healthcare quality. There is almost universal consensus that improving healthcare quality should be a priority for all healthcare systems (WHO, 2006; Busse, Panteli and Quentin, 2019), but there remains a plethora of different interpretations of the meaning of healthcare quality. One of the earliest attempts to develop a structured definition of healthcare quality was the Donabedian framework, developed in the 1960s (Donabedian, 2005). This framework conceptualised healthcare quality across three domains: structural measures, processes and clinical outcomes, and was ground breaking in that it was the first framework to consider a production function of healthcare quality that acknowledged that the end result of healthcare services (i.e. clinical outcomes) are influenced by a combination of factors such as processes of care, physical infrastructure and workforce characteristics. Avedis Donabedian himself later expanded on this framework by outlining seven attributes of healthcare which define its quality: efficacy, effectiveness, efficiency, optimality, acceptability, legitimacy and equity (Donabedian, 1990). This work heavily influenced further definitions developed since, the most prominent of which include those developed by the US Institute of Medicine (Institute of Medicine (US), 2001), and the World Health Organization (WHO, 2006). Bringing together the most commonly used domains (Busse, Panteli and Quentin, 2019), I define healthcare quality as care which is effective, equitable, efficient, accessible and timely, patient-centred and responsive, and safe (Table 3). This definition is heavily based upon the most commonly cited definition developed by the US Institute of Medicine, but also reflects how accessibility is a key priority in the English healthcare system. This is because the NHS was founded on the basic principle that access is based on clinical need, and not ability to pay. This remains one of the prevailing objectives of the English NHS, and is a fundamental principle outlined with the NHS Constitution (Department of Health & Social Care, 2015).

Table 3: Frequently used dimensions of definitions of quality in healthcare

Safe	Provision of services that minimises the potential for avoidable harm to patients
Effective	Providing services to all those likely to benefit based on high quality evidence, and minimising provision of services to those not likely to benefit (avoiding underuse of effective care and minimising provision of low value care)
Efficient	Providing services in a manner that makes best use of available resources to maximise health benefits and avoids unnecessary waste and overuse
Equitable	Ensuring that provision of services does not vary in quality because of personal characteristics such as gender, ethnicity, geographical location, disability or socioeconomic status
Accessible and timely	Provision of services based on clinical need that limits financial and practical barriers to access, and minimises sometimes harmful delays in providing needed care
Patient-centred and responsive	Providing services that are respectful of and responsive to individual patient preferences, needs and values

Source: Adapted from Institute of Medicine, 2001

Through this definition, it becomes clear that, in practice, there are often trade-offs between different dimensions of healthcare quality. For example, more effective and safe care may not always be more efficient, particularly if safer care requires a longer length of stay or more intensive human resources (Hussey, 2013; Burgess, 2018). Moreover, the reduced provision of low value care, which is not considered as clinically or cost-effective (beyond a certain threshold), may be considered by some as restricting access to care or not being responsive to patient preferences. This is a particular challenge when certain interventions may have some psychological benefits for patients which are not as easily reflected in clinical or cost-effectiveness research than other more regularly used surrogate or outcome measures. Therefore, it is important to map out potential trade-offs when developing initiatives to improve healthcare quality, and to consider perspectives from all relevant stakeholders when defining what are acceptable trade-offs that can be made in the pursuit of improved healthcare quality (Dixon-Woods *et al.*, 2014). Evaluations must also be planned in a manner that incorporates metrics that reflect alternative dimensions of healthcare quality, and reduces the risk of suboptimal trade-offs.

1.2.2. Healthcare quality in the English National Health Service

When the NHS was established, grand claims were made, with its founding health minister Aneurin Bevan declaring it would "make Great Britain the envy of all other nations in the world" (Mossialos *et al.*, 2018). Indeed, for many decades the English NHS had a reputation as one of the most comprehensive healthcare systems in the world delivering high quality and safe care to millions of people based on clinical need, and not ability to pay. As recently as 2017, the Commonwealth Fund rated the UK healthcare system as having the best performance internationally (Schneider *et al.*, 2017). However, while the UK healthcare system continues to score highly in domains of healthcare quality such as accessibility and efficiency, it consistently scores poorly in terms of health outcomes. The UK performs poorly in terms of life expectancy, infant mortality, and cancer survival compared to several other high-income countries (Anderson, Pitchforth, *et al.*, 2021b); moreover, increases in life expectancy have been stalling. At the same time, it is important to note that these health outcomes are also heavily influenced by the social determinants of health, and the UK compares favourably to other high-income countries for many chronic disease outcomes (which are more amenable to being influenced by quality of healthcare than other broader health outcomes), such as those for diabetes and chronic kidney disease (Anderson, Pitchforth, *et al.*, 2021b).

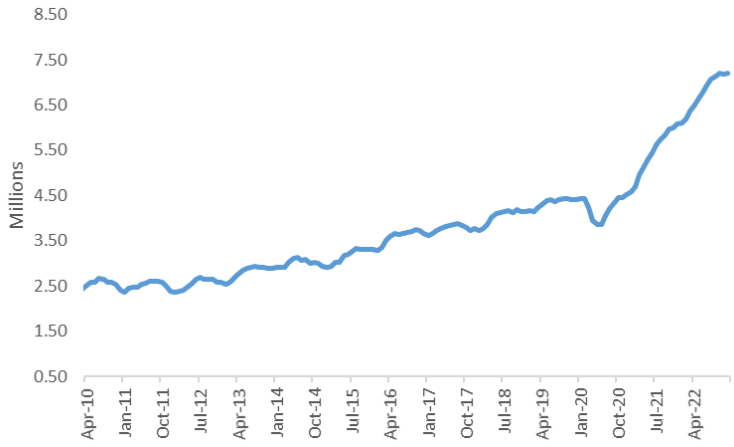
1.2.2.1.Concerns regarding healthcare quality in the NHS

Notwithstanding its reputation as a high performing healthcare system, there have also been repeated concerns raised regarding healthcare quality and patient safety in the English NHS. There have been several high profile instances of poor quality or unsafe care exposed over many decades. They include (but are not limited to) the Bristol Royal Infirmary and Gosport War Memorial Hospital in the 1990s (Walshe, 2018), the Bristol Children's Hospital in the 1990s (Dyer, 2001; Walshe and Offen, 2001), Mid Staffordshire NHS Foundation Trust in the 2000s (Francis, 2013), and the Morecambe Bay and Royal Shrewsbury maternity units in the 2000s and early 2010s (Kirkup, 2015; Ockenden, 2022). There have also been instances where individual health professionals (e.g. Dr Harold Shipman between the 1970s and 1990s, and Mr Ian Paterson in the 2000s and 2010s) have been responsible for significant and serious harm to patients (Dixon-Woods, Yeung and Bosk, 2011). These scandals are typically uncovered by higher than expected levels of mortality or adverse events, whistleblowing by

healthcare staff, or consistent reports of poor quality of care by patients. Despite numerous inquiries conducted over the past half century into safety and quality issues in the NHS, all these reports tend to identify similar problems, such as a lack of systems to monitor or respond to adverse events; the ignoring or discounting of patient concerns and complaints; a culture of secrecy, blame and defensiveness that limits opportunities to learn from mistakes; and a lack of clarity in roles and responsibilities for addressing poor quality or unsafe care (Walshe and Shortell, 2004; Martin and Dixon-Woods, 2014; Walshe, 2018).

Variable accessibility to care is also a key healthcare quality issue in the English NHS. The UK scores highly in terms of accessibility in international comparisons because access to care is largely free at the point of use and based on clinical need, but waiting lists for elective and outpatient care have been growing over the last decade and it is not uncommon for some patients to wait over a year to receive some types of elective surgery. This also has significant implications for the public-private interface in healthcare, as many patients who struggle to access NHS care then seek to access care through private funding mechanisms, either through insurance or self-pay mechanisms. The COVID-19 pandemic has exacerbated this issue with growing backlogs for elective care. Prior to the pandemic there were just above 4 million people on a waiting list for elective care in England, and as of April 2022 this figure had reached over 7 million (Figure 6). This has contributed to a 35% increase in the number of patients accessing care privately through the self-pay mechanism in the third quarter of 2021 compared to 2019 (PHIN, 2022).

Figure 6: Numbers waiting for publicly funded treatment following referral from primary care in England, 2010–22



Source:(NHS England, 2022a)

1.2.3. Healthcare quality in the English private healthcare sector

1.2.3.1.Concerns regarding healthcare quality in the private healthcare sector

There have been several high profile instances of poor quality, unsafe, and harmful care in the private healthcare sector in the UK. The most recent high profile case is that of Ian Paterson, a breast surgeon who provided non-evidence-based surgery throughout the 2000s and 2010s. It has been estimated that he subjected more than 1,000 women to unnecessary and dangerous surgery, and a fund of £50 million has been established to compensate patients (Lintern, 2021). The subsequent inquiry highlighted many concerns regarding quality of care in the private healthcare sector including the poor quality of the systems in place to monitor consultant activity and outcomes; ineffective governance and regulatory arrangements to monitor healthcare quality; limited critical care support in private hospitals; and a vacuum of responsibility for responding to adverse events among hospital leadership (DHSC, 2020). Despite an increased awareness of the quality issues in the private healthcare sector highlighted by the Paterson Inquiry, there have been further instances of malpractice in the private healthcare sector since the report's publication, specifically instances of non-evidence-based oncology care provided by Justin Stebbing (Lydall, 2021), which has raised questions about obtaining informed consent for treatments in the private healthcare sector that are not routinely provided on the NHS because of limited or uncertain evidence of clinical or cost effectiveness.

There have also been concerns regarding transparency and reporting in the private healthcare sector generally (M. Anderson *et al.*, 2020). This has created a barrier to analysing healthcare quality between private hospitals and identifying potential instances of unsafe or non-evidenced care. The UK government, through the Competition and Markets Authority (CMA), intervened in 2014, and published an order that mandated the collection and reporting of activity and outcome data for privately funded care to a nominated information organisation (known as the Private Health Information Network (PHIN)) (Competition and Market's Authority, 2014).

Despite the development of extensive national clinical audits focused on monitoring and improving healthcare quality, there has been limited engagement from private hospitals with most clinical audits and registries. For some smaller private hospitals with low volumes for

certain procedures, it has been challenging to justify the investment in the necessary staff training and health information technology infrastructure. There have been exceptions, such as the National Joint Registry (NJR) (NJR, 2023), which benefits from high engagement by private hospitals. There are also other registries which have evidence of some engagement by private hospitals including the British Spine Registry (BSR) (BSR, 2023), the British Association of Urological Surgeons (BAUS) registry (BAUS, 2023), the British Association of Endocrine & Thyroid Surgeons (BAETS) registry (BAETs, 2023), the United Kingdom National Bariatric Surgery Registry (NBSR) (NBSR, 2023), the National Audit of Percutaneous Coronary Interventions (NAPCI) (HQIP, 2022), and the Society for Cardiothoracic Surgery in Great Britain and Ireland (SCTS) registry (SCTS, 2023). However, these registries typically only include a select number of private hospitals and do not incorporate broader coverage of private healthcare sector. Moreover, these 7 registries only represent a fraction (6.19%) of the 113 national clinical audits in England and Wales as of February 2023 (HQIP, 2023).[1]

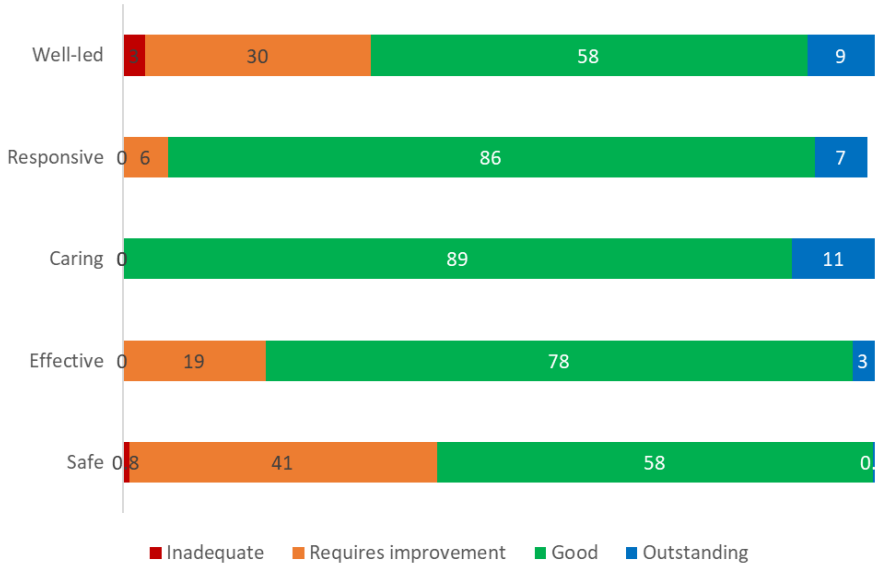
1.2.4. Comparative Care Quality Commission (CQC) ratings for NHS and private hospitals

The Care Quality Commission is responsible for the regulation and inspection of both NHS and private hospitals (see section 1.2.2.5). The most recent sector-specific report for private healthcare sector was published in 2018, and collated findings from inspections across 206 private hospitals. Hospitals are rated according to five domains: whether they are considered safe; effective; caring; responsive; and well-led. In terms of overall ratings, 24% of private hospitals were rated as "Requires improvement" (Care Quality Commission, 2018). Within the different domains, private hospitals were predominantly failing in relation to patient safety (42% of private hospitals rated as either "Requires improvement" or "Inadequate") and leadership (33% of private hospitals rated as either "Requires improvement" or "Inadequate") (Figure 7). In relation to patient safety, many instances of unsafe practice were discovered such as poor cleanliness and infection control, a lack of formal processes to learn from patient safety incidents, and not abiding by recommended surgical checklists. In relation to

[1] During the clinical fellowship undertaken with the Private Healthcare Information Network (PHIN), I was asked to reviewed private healthcare sector engagement with national clinical audits funded by the Healthcare Quality Improvement Partnership (HQIP). This exercised revealed evidence of private hospital engagement with 6.19% (7/113) national clinical audits operating in England.

leadership, the report highlighted a lack of formalised governance and risk management processes, limited effective oversight of practising privileges, and an absence of auditing, reporting and benchmarking outcomes. The CQC commented that many private hospitals perceive consultants as "customers", that bring business to the hospital, and therefore they are reluctant to challenge them. Moreover, the CQC indicated that many private hospitals assume that consultants monitor their own outcomes, and therefore it was not necessarily the hospital's responsibility to engage with these efforts.

Figure 7: Private hospital overall ratings, in 2018 Care Quality Commission Report†

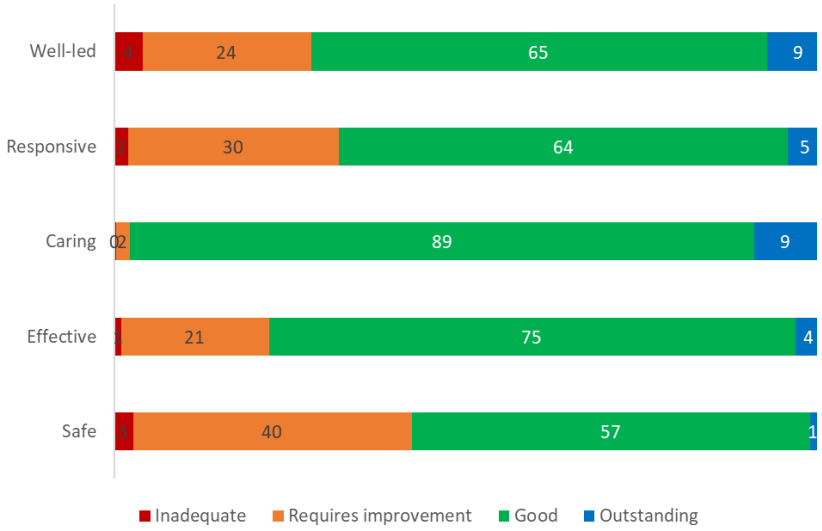


Source: (Care Quality Commission, 2018)

† This figure shows CQC ratings for 206 private hospitals assessed in 2018.

When comparing private to NHS hospitals in the same year (2018), I find very similar results for patient safety, effectiveness, leadership and caring (Figure 8) but there was a much higher proportion of NHS hospitals rated as "Requires improvement" or "Inadequate" for responsiveness. However, in making comparisons between CQC ratings in private and NHS hospitals we need to be conscious that they are not necessarily directly comparable as many private hospitals exclusively undertake elective care while NHS hospitals typically provide a wider variety of care including emergency and medical admissions. This explains some of the disparity in ratings for responsiveness, as in NHS hospitals this measurement takes into account issues in accessing care in emergency departments, for example.

Figure 8: NHS hospital overall ratings in 2018 Care Quality Commission Report[†]



Source: (CQC, 2018)

[†] The figure shows CQC ratings for 1,752 NHS acute core services assessed in 2018.

1.3. PhD Objectives, structure, methods, and novel contributions

1.3.1. Objectives

The objective of this PhD is to examine the healthcare quality implications of the relationship between the public and private sector for elective care in England. To undertake this examination each paper can be understood contributing to this in terms of overall objective as well as having paper specific secondary objectives (Table 4). The objective of the first paper is to evaluate the impact of a nationally led initiative, the Evidence Based Interventions (EBI) programme (see section 3.2.1), to improve healthcare quality by reducing the provision of procedures classified as low value in certain circumstances, and the relative response of NHS and private hospitals to this policy. The objective of the second paper is to establish whether a relationship exists between reductions in publicly funded care and increases in privately funded care for a series of procedures classified as low value care by the EBI programme. The objective of the third paper is to ascertain if there are differences in healthcare quality between private and NHS hospitals for patients undergoing elective orthopaedic surgery. Collectively, these papers provide insights into healthcare quality in NHS and private hospitals for elective care in England from multiple perspectives (see section 1.1.5 for definitions of "public", "private" and "public-private interface"), including the relative response of NHS and private hospitals to a nationally led initiative to improve healthcare quality (Paper I), the relationship between changes in publicly and privately funded care following NHS disinvestment from several surgical procedures (Paper II), and differences in healthcare quality between private and NHS hospitals (Paper III).

Table 4: PhD objective and objectives of PhD papers

	Primary Objective	**Secondary objectives**
Overall Objectives of PhD thesis	To examine the healthcare quality implications of the relationship between the public and private sector for elective surgical care in England.	• To establish the relative response of NHS and private hospitals to a national healthcare quality initiative (Paper I) • To examine if evidence exists for substitution between changes in publicly and privately funded care following NHS disinvestment (Paper II) • To identify evidence of differences in healthcare quality between private and NHS hospitals (Paper III)
Paper I: Evaluation of the NHS England evidence-based interventions programme: a difference-in-difference analysis	To evaluate the impact of the first phase of the EBI programme in reducing the provision of low value procedures	• To evaluate the relative impact of the first phase of the EBI programme in private and NHS hospitals • To evaluate the relative impact of the first phase of the EBI programme in local commissioning groups of different levels of financial performance • To evaluate the relative impact of the first phase of the EBI programme in local commissioning groups that volunteered to trial the guidance as part of a "demonstrator" community compared to those which did not • To establish if the impact of the programme varies according to whether low value procedures are considered high or low cost procedures
Paper II: Evidence of substitution between publicly and privately funded low value elective procedures in private hospitals in England	To establish if there is evidence of substitution in reductions in publicly funded care and increases in privately funded care for procedures classified as low value by the NHS in England	• To establish if there is stronger evidence of substitution between publicly and privately funded care for different groups of procedures based upon their classification as low value in all or only certain circumstances • To establish if there is stronger evidence of substitution between publicly and privately funded care for patients accessing care through private health insurance and self-pay funding mechanisms • To establish if there is stronger evidence of substitution between publicly and privately funded care in different regions of England
Paper III: A comparison of patient outcomes, adverse events, and efficiency of private and NHS hospitals in England for primary hip and knee replacements	To establish if there are differences in healthcare quality performance between private and NHS hospitals for patients undergoing elective primary hip and knee replacement surgery	• To ascertain if treatment in a private hospital for patients undergoing elective hip and knee replacement is associated with poor patient outcomes compared to those in NHS hospitals • To establish if receiving treatment in a private hospital for patients undergoing elective hip and knee replacement is associated with reduced efficiency compared to NHS hospitals • To ascertain if the risk of experiencing several potentially avoidable adverse events is high for patients undergoing elective hip and knee replacements in private hospitals compared to those in NHS hospitals. • To estimate the association between different adverse events and patient outcomes and efficiency in private and NHS hospitals

1.3.2. Thesis requirements

This PhD thesis adheres to the LSE Department of Health Policy guidelines for a "Thesis by Publishable Papers", which should "consist of at least three papers, an introduction, conclusion, and any other linking papers that might be appropriate" and "have a minimum of 50,000 words and a maximum of 100,000 words including figures and tables in the overall count". The LSE Department of Health Policy guidelines further state: "The papers concerned should actually have been published in high quality refereed journals, be submitted for publication to such a journal, or be of a quality to be published in such a journal" and that "At least one paper should be single authored, and any other papers should be primarily authored, by the student". The full requirements for PhD theses within the Department of Health Policy are available on request from the LSE Library.

1.3.3. Structure of the thesis

This PhD is paper-based, with an introduction and a discussion chapter that consider themes and principles common across all the papers. Collectively, the papers provide interrelated insights regarding healthcare quality in NHS and private hospitals for elective care in England (Table 5).

The first and second papers take advantage of a nationally led initiative to improve healthcare quality and reduce the provision of low value care (NHS England Evidence-Based Interventions (EBI) programme – see section 3.2.1.) for their analyses, but focus on very different research questions (Table 5). The first paper is focused on publicly funded care and examines the relative effectiveness of the policy in private and NHS hospitals, whereas the second paper is focused on identifying potential substitution effects between withdrawal of publicly funded care and increases in privately funded care. As both papers focus on the prevalence of procedures classified as low value or harmful in certain circumstances, they both provide insights regarding the effectiveness, efficiency, and safety of care delivered in NHS and private hospitals. The first paper also considers equity as the associations between different patient characteristics, such as age, gender, and deprivation, and provision to low value care are examined.

The third paper is a comparative analysis of healthcare quality between private and NHS hospitals for patients undergoing hip and knee replacement and considers several outcomes of interest that encompass patient outcomes, adverse events, and efficiency. The focus on patient outcomes provides insights into the effectiveness and efficiency of the care delivered by private and NHS hospitals. The focus on adverse events also provides insights into patient safety. As I focus on differences in patient characteristics, the third paper also considers how equitable access to publicly funded care in NHS hospitals is in relation to gender, age and deprivation.

Table 5: Research papers and potential implications for healthcare quality

Paper	**Dimensions of healthcare quality considered**
Paper I: Evaluation of the NHS England evidence-based interventions programme: a difference-in-difference analysis	• Effectiveness • Efficiency • Safety • Equity
Paper II: Evidence of substitution between publicly and privately funded low value elective procedures in private hospitals in England	• Effectiveness • Efficiency • Safety
Paper III: A comparison of patient outcomes, adverse events, and efficiency of private and NHS hospitals in England for primary hip and knee replacements	• Effectiveness • Efficiency • Safety • Equity

1.3.4. Methods and datasets

Table 6 provides an overview of the methods and datasets used within this PhD thesis. The PhD draws upon the main hospital administrative datasets in England for publicly and privately funded care in both NHS and private hospitals. The NHS Digital Secondary Uses Service (SUS) data set contains patient level information for all publicly funded hospital admissions. The data is initially collected by healthcare providers and then submitted to NHS Digital for processing and collation into Healthcare Resource Groups (HRGs) for reimbursement purposes. The NHS Digital SUS dataset is updated continuously and available to access by NHS hospitals, commissioners, and NHS England staff. I was able to analyse this dataset during a part-time fellowship with NHS England between January 2021 and January 2022, and access was granted on the understanding it would be used for service

evaluation of the EBI programme. The same data contained within the NHS Digital SUS dataset is also collated for non-clinical purposes, such as research, within the Hospital Episode Statistics (HES) dataset. Extracts of this dataset are provided to researchers by NHS Digital for specific research projects through a process known as a Data Access Request Service (DARS) application (NHS Digital, 2023b). Transfers of each individual data field and relevant time periods have to be clearly justified by researchers, and updated extracts of HES are subject to further DARS applications. I was able to access this data up to December 2019 for this PhD thesis as the pre-existing DARS agreement between the Department of Health Policy, LSE and NHS Digital involves undertaking projects related to productivity in the NHS, and the third paper is concerned with two key dimensions of productivity, specifically outcomes and efficiency of NHS and private hospitals. The Private Healthcare Information Network (PHIN) admitted patient care (APC) dataset contains patient level information for all privately funded hospital admissions. The information is submitted by private hospitals and processed by PHIN since January 2016, and submission by private hospitals is mandatory according to an order published by the Competitions Market Authority (CMA) in 2014 (Competition and Market's Authority, 2014). Hospitals that do not submit information on hospital admissions to PHIN can be subject to legal intervention and financial penalties issued by the CMA. Since data collection began, data flows have been modelled on the NHS Digital SUS dataset to ensure individual data fields are identical due to ambitions to collate both datasets into one complete dataset on publicly and privately funded care in England through the Acute Data Alignment Programme (ADAPt) programme (NHS Digital, 2023a). I was able to the access PHIN APC dataset during a part-time fellowship between January 2021 and July 2022 arranged with the PHIN clinical informatics team.

A major strength of this PhD thesis is the application of several robust approaches to causal inference including difference-in-difference (DID) analyses (Paper I), instrumental variable (IV) analyses (Paper III), and propensity score matching (PSM) (Paper III). While similar methods could not be applied within Paper II, I acknowledge this paper only explores associations between changes in publicly and privately funded care in the context of multiple interacting trends and changes in policy rather than the casual impact of any specific policies. While Paper I and II are both focused on examining changes in volume of procedures classified as low value by the NHS in England, they analyse different categories of procedures within their primary analyses. This is because the application of DiD methods in Paper I requires that the parallel trend assumption between the treatment and control group

prior to implementation of the EBI programme is satisfied (Blundell and Dias, 2000). The first phase of the EBI programme focused on two categories of procedures: Category 1 procedures have been shown to be ineffective and should no longer be offered to patients; whereas Category 2 interventions are only appropriate in certain circumstances. The control group used in Paper I is another group of procedures (Category A procedures) subsequently identified by the NHS as low value in certain circumstances but unaffected by the EBI programme during my period of analysis. I choose to not include Category 1 procedures within the treatment group for Paper I as reductions in provision were greater than Category 2 and Category A procedures prior to implementation of the EBI programme. This is likely because there was already broad consensus among the clinical and academic community that Category 1 procedures are not clinically indicated in any circumstances prior to implementation of the EBI programme. The requirement to satisfy the parallel trend assumption was not necessary for Paper II, which does not use DiD analyses and instead examines associations between changes in volumes of publicly and privately funded procedures under the remit of the EBI programme before and after implementation. For this reason, changes in volume of both Category 1 and Category 2 procedures are examined in the primary analysis within Paper II.

Table 6: Research papers, datasets, methods and outcomes of interest[§]

Paper	**Dataset**	**Method**	**Outcomes of interest**
Paper I: Evaluation of the NHS England evidence-based interventions programme: a difference-in-difference analysis	NHS Digital SUS data	Difference-in-difference analysis Triple difference estimators	• Publicly funded volumes of Category 2 procedures (treatment group – primary analysis) • Publicly funded volumes of selected Category A procedures (control group – all analyses) • Publicly funded volumes of Category 1 and 2 procedures (treatment group – supplementary analyses)
Paper II: Evidence of substitution between publicly and privately funded low value elective procedures in private hospitals in England	NHS Digital SUS data PHIN Admitted Patient Care (APC) dataset	OLS with fixed effects estimators	• Privately funded volumes of Category 1 and 2 procedures • Publicly funded volumes of Category 1 and 2 procedures
Paper III: A comparison of patient outcomes, adverse events, and efficiency of private and NHS hospitals in England for primary hip and knee replacements	NHS Digital HES	OLS with fixed effects estimators Instrumental variable analysis Propensity score matching	• Outcomes (mortality, readmissions, transfers) • Adverse events (hospital-associated infections, adverse drug reactions, pressure ulcers, venous thromboembolism) • Efficiency (pre-operative LOS, post-operative LOS)

[§] SUS: Secondary Uses Service, PHIN: Private Health Information Network, HES: Hospital Episode Statistics, LOS: length of stay, OLS: ordinary least squares. Category 1 procedures are surgical procedures with no evidence of clinical effectiveness or cost effectiveness in any circumstances. Category 2 and Category A procedures are surgical procedures which have evidence of clinical effectiveness and cost effectiveness in certain circumstances.

1.3.5. Novel contributions

This PhD thesis makes several novel contributions (Table 7).

The first paper evaluates a nationally led initiative to improve healthcare quality and establishes differences in response between private and NHS hospitals. This is a novel contribution as most previous evaluations either focus exclusively on NHS hospitals, or do not distinguish between hospital type based on hospital ownership. Historically, this may have been appropriate when only low volumes of publicly funded care took place in private hospitals but this is not currently the case (see section 1.1.4.). This paper is, to my knowledge, the only quantitative analysis of the NHS England EBI programme. This continues to be policy relevant as the programme has subsequently expanded through two separate additional phases, and the findings of this analysis have been used to inform this expansion.[2] The final novel contribution of this analysis is the use of a control group of other procedures considered as low value in certain circumstances to establish the impact of the EBI programme. This is a particular strength of this analysis as most previous analyses of national healthcare quality initiatives have used weaker methods such as pre-post and interrupted time analyses.

The second paper of this PhD is, to my knowledge, the first academic analysis that has focused on the relationship between the withdrawal of publicly funded care and trends in privately funded care. This has important implications as, dependent upon the context for each individual procedure or healthcare intervention, increases in privately funded care could indicate overprovision of low value care in the private healthcare sector or signal unmet need in the public healthcare sector. I also conduct regional analyses to establish in which regions substitution between publicly and privately funded care may be concentrated.

The third paper focuses on several healthcare quality indicators that encompass effectiveness, efficiency and patient safety. While these patient safety indicators have been applied previously to NHS hospital administrative datasets, they have never been applied in a

[2] Paper I concludes that the EBI programme did not accelerate disinvestment for procedures under its remit during the first phase of implementation. There have been two further phases of the EBI programme, and following recommendations made in this analysis the programme has been relocated from NHS England to the Academy of Medical Royal Colleges to encourage greater healthcare professional ownership and awareness of the programme.

comparative analysis of NHS and private hospitals in England. Moreover, a further novel contribution of this paper is the use of an instrumental variable approach to account for unobserved confounding at the patient-level. For example, by selection into unobservable differences in patient morbidity or attitudes. While one previous analysis has used this approach (Moscelli *et al.*, 2018), the authors only focused on a single healthcare quality indicator, readmission to hospital within 28 days, whereas this analysis, given that healthcare quality is a multidimensional concept, focuses on nine healthcare quality indicators.

Table 7: Novel contributions of each PhD paper

Paper	**Novel contribution**
Paper I: Evaluation of the NHS England evidence-based interventions programme: a difference-in-difference analysis	• Evaluates the relative impact of a nationally led initiative to improve healthcare quality by hospital type based on hospital ownership • To my knowledge, the only quantitative analysis of the NHS England EBI programme
Paper II: Evidence of substitution between publicly and privately funded low value elective procedures in private hospitals in England	• To my knowledge, the first analysis to consider the relative association between withdrawal of publicly funded care and subsequent activity levels for privately funded care in England (previous analyses have considered consequences of increases in publicly funded care)
Paper III: A comparison of the patient outcomes, adverse events, and efficiency of private and NHS hospitals in England for primary hip and knee replacements	• To my knowledge, the first paper to analyse comparative prevalence of several potentially avoidable adverse events (hospital-associated infections, adverse drug reactions, pressure ulcers, and venous thromboembolism) in private and NHS hospitals in England • Applies instrumental variable approach to account for unobserved confounding at the patient-level to a variety of healthcare quality indicators to reflect multidimensional nature of healthcare quality

2. Chapter 2 (Paper I): Evaluation of the NHS England Evidence-Based Interventions programme: a difference-in-difference analysis

2.1. Abstract

Background: The NHS EBI programme, launched in April 2019, is a novel nationally led initiative to encourage disinvestment from low value care.

Method: I sought to evaluate the effectiveness of this policy by using a difference-in-difference approach to compare changes in volume between January 2016 and February 2020 in a treatment group of low value procedures against a control group unaffected by the EBI programme during the period of analysis but subsequently identified as candidates for disinvestment.

Results: I found only small differences between the treatment and control group post implementation, with reductions in volumes in the treatment group 0.10% (95% CI 0.09%, 0.11%) smaller than in the control group (equivalent to 16 low value procedures per month). During the month of implementation, reductions in volumes in the treatment group were 0.05% (95% CI 0.03%, 0.06%) smaller than in the control group (equivalent to 7 low value procedures). Using triple difference estimators, I found that reductions in volumes were 0.35% (95% CI 0.26%, 0.44%) larger in NHS hospitals than private hospitals (equivalent to 47 low value procedures per month). I found no significant differences between clinical commissioning groups (CCGs) that did or did not volunteer to be part of a demonstrator community to trial EBI guidance, but found reductions in volume were 0.06% (95% CI 0.04%, 0.08%) larger in clinical commissioning groups that posted a deficit in the financial year 2018/19 before implementation (equivalent to 4 low value procedures per month).

Conclusions: This analysis shows that the EBI programme did not accelerate disinvestment for procedures under its remit during my period of analysis. However, I find that financial and organisational factors may have had some influence on the degree of responsiveness to the EBI programme.

2.2.Introduction

Low value care can be defined as the "use of an intervention where evidence suggests it confers no or very little benefit on patients, or risk of harm exceeds likely benefit, or, more broadly, the added costs of the intervention do not provide proportional added benefits" (Scott and Duckett, 2015). Minimising low value care and tackling unwarranted clinical variation are major issues for all healthcare systems. It has been estimated that 25% of healthcare expenditure in the United States is spent on low value procedures (Shrank, Rogstad and Parekh, 2019). Equivalent figures for the UK do not exist, but like many other countries, disinvestment in low value care has been high on the policy agenda over the last two decades. The issue gained widespread prominence after Sir Liam Donaldson, then Chief Medical Officer (CMO), highlighted the cost implications of low value procedures in his 2004 annual report by revealing that unnecessary tonsillectomies and hysterectomies cost the NHS £21 million per year (Donaldson, 2005). The government responded by asking the National Institute for Health and Care Excellence (NICE) to pilot an "ineffective treatment programme", and NICE soon began publishing regular guidance on candidates for disinvestment. However, subsequent analyses have indicated that guidance alone is often not sufficient to encourage disinvestment (Ryan, Piercy and James, 2004; Dietrich, 2009; Chamberlain *et al.*, 2013). The imperative to disinvest in low value care increased during austerity, and following the challenge to NHS England to make efficiency savings of £20 billion between 2010 and 2015 (National Audit Office, 2012), local commissioning bodies were asked to draw up lists of procedures of limited clinical value as candidates for disinvestment. However, significant reductions were only seen for some procedures and there was variation in approach to disinvestment between local commissioning bodies (Coronini-Cronberg *et al.*, 2015). More recent efforts have focused on gaining increased engagement and shared decision making between patients and healthcare professionals, such as the Choosing Wisely initiative, which in conjunction with the Royal Colleges, has issued a number of evidence-based recommendations in 2016 and 2018 on when certain tests and procedures may be appropriate, intended for discussion between clinicians and patients (Choosing Wisely UK, 2023).

2.2.1. The NHS England EBI programme

Over the last few years, NHS England has sought to develop a more coordinated and structured approach to disinvestment in low value care by developing the EBI programme, which aims to reduce avoidable harm to patients, maximise value, and avoid waste by reducing unnecessary interventions. After undertaking a review of evidence and consulting with the public, commissioners and healthcare professionals, the first phase of the programme identified 17 low value procedures within two categories (Table 8). Category 1 interventions have been shown to be ineffective and should no longer be offered to patients. Category 2 interventions are only appropriate in certain circumstances. Targets have been set for each local commissioning organisation, known as clinical commissioning groups (CCGs), to reduce the number of Category 1 interventions to "near zero" and Category 2 interventions to 25% of current levels nationally. Statutory guidance was published in November 2018 (NHS England, 2018b), and the programme was officially launched in April 2019. Baseline activity levels reveal large variation across CCGs (Table 16). The EBI programme is distinctly different to previous nationally led initiatives to disinvest in low value care in the UK which have predominantly focused on the publication of guidance and education of healthcare professionals and patients (Ryan, Piercy and James, 2004; Dietrich, 2009; Chamberlain *et al.*, 2013; Coronini-Cronberg *et al.*, 2015; Chambers *et al.*, 2017). Instead, the EBI programme involves introducing a no reimbursement policy, with a zero tariff for Category 1 interventions, and asks all CCGs to implement a prior approval process for reimbursement of Category 2 interventions. Alongside this, progress in meeting the aforementioned targets is monitored and fed back to hospitals and CCGs using a publicly available dashboard to allow benchmarking.

Table 8: Baseline activity levels for all phase one Evidence Based Intervention programme procedures, 2017/18[§]

Intervention		No. of spells Activity	CCG variation (#-fold variation)
Category 1 interventions			
A	Intervention for snoring (not OSA)	812	—
B	Dilatation and curettage for heavy menstrual bleeding	236	—
C	Knee arthroscopy with osteoarthritis	3,437	11.3
D	Injection for nonspecific low back pain without sciatica	13,165	31.4
Total:		**17,650**	—
Category 2 interventions			
E	Breast reduction	2,388	8.4
F	Removal of benign skin lesions	116,255	4.1
G	Grommets	8,669	6.2
H	Tonsillectomy	32,238	3.0
I	Haemorrhoid surgery	8,474	4.3
J	Hysterectomy for heavy bleeding	27,660	3.3
K	Chalazia removal	6,026	29.7
L	Shoulder decompression	13,930	9.1
M	Carpal tunnel syndrome release	44,497	5.3
N	Dupuytren's contracture release	14,376	4.1
O	Ganglion excision	6,219	6.4
P	Trigger finger release	7,789	5.7
Q	Varicose vein surgery	28,846	8.0
Total:		**317,367**	—

Source: (NHS England, 2018a)

[§] The variation is the ratio between the 10th highest and 10th lowest age-gender standardised rate between CCGs. — a number of CCGs have no activity recorded for interventions, and it was therefore not possible to calculate an age-gender standardised variation rate for this intervention. OSA: obstructive sleep apnoea.

Since the launch of phase one of the EBI programme, a second phase has been developed involving 31 low value procedures split into three categories:

- Category A: Interventions where data are sufficiently robust to determine rates of variation and set national activity goals
- Category B: Interventions including those in diagnostic and outpatient settings where data are available but further exploration of additional datasets is proposed (e.g. colonoscopy, low back pain imaging, hip and knee magnetic resonance imaging, and helmet therapy for positional plagiocephaly in children)

- Category C: Interventions where data are not currently available but their inclusion is proposed because best available evidence suggests they are clinically ineffective unless performed in certain circumstances (e.g. pre-operative chest x-ray or electrocardiogram, prostate-specific antigen test, and blood transfusion)

The consultation for phase two of the EBI programme was launched in July 2020, and the statutory guidance was published in November 2020 (Academy of Medical Royal Colleges, 2020). By focusing on trends in Category A interventions prior to July 2020 (Table 9), which are more directly comparable to phase one of the EBI programme, there is an opportunity to construct a control group to evaluate the effectiveness of phase one of the EBI programme.

Table 9: Baseline activity levels for all phase two Category A Evidence-based Interventions programme procedures, 2018/19

Intervention		**No. of spells** **Activity**	**CCG variation (#-fold variation)[§]**
2A	Diagnostic angiogram	26,629	3.2
2B	Repair of minimally symptomatic inguinal hernia	54,764	1.5
2C	Surgical intervention for chronic rhinosinusitis	12,610	1.7
2D	Adjuvant adenoidectomy for treatment of glue ear	2,778	5.5
2E	Arthroscopic surgery for meniscal tears	38,088	2.4
2G	Kidney stone surgery	14,456	2.1
2H	Cystoscopy for men with uncomplicated lower urinary tract symptoms (LUTS)	43,703	14.1
2I	Surgical intervention for benign prostatic hypertrophy (BPH)	14,561	2.2
2J	Lumbar discectomy	2,291	8.7
2K	Radiofrequency facet joint denervation	1,612	23.215
2L	Exercise electrocardiogram (ECG)	45,745	13.4
2M	Upper gastrointestinal endoscopy	644,038	1.6
Total:		901,275	-

Source: (Academy of Medical Royal Colleges, 2020)

[§] The variation is the ratio between the 10th highest and 10th lowest age-gender standardised rate between CCGs.

2.3. Objectives

The EBI programme is one of the few examples of a structured and nationally led disinvestment programme internationally (Chambers *et al.*, 2017). There is therefore value in understanding the impact of the EBI programme to inform the second phase of development, and for international audiences who may seek to replicate the approach taken by the EBI programme in their respective countries. From the English perspective, it is also important to establish the relative response of NHS and private hospitals. This is because private hospitals are distinctly different to NHS hospitals in terms of their structure, provision of care and motivations (as discussed in sections 1.1.4.1 and 2.5), and therefore they may respond differently to nationally led initiatives to reduce the provision of low value care and improve healthcare quality. As the EBI programme involves the local implementation of prior approval processes by local commissioning groups, there is also value is assessing the relative response of CCGs according to different characteristics: first, according to different levels of financial performance, because CCGs which have larger deficits may more be motivated to reduce provision of low value care to produce cost-savings; second, according to whether CCGs volunteered to be part of a demonstrator community that trialled EBI guidance before implementation, as these CCGs may have already adapted to the policy. Finally, there is value is analysing the impact of EBI according to whether procedures are classified as high or low cost. This is because there may have been more intensive efforts to reduce the provision of low value procedures with higher budget impact. To summarise, the research objectives of this paper are as follows:

- Research Objective 1: To evaluate the impact of the first phase of the EBI programme in reducing the provision of low value procedures compared with a control group of other low value procedures unaffected by the EBI programme during my period of analysis.
- Research Objective 2: To evaluate the relative impact of the first phase of the EBI programme in private and NHS hospitals.
- Research Objective 3: To evaluate the relative impact of the first phase of the EBI programme in local commissioning groups of different levels of financial performance.

- Research Objective 4: To evaluate the relative impact of the first phase of the EBI programme in local commissioning groups that volunteered to trial the guidance as part of a “demonstrator” community compared to those which did.
- Research Objective 5: To establish if the impact of EBI varies according to whether low value procedures are considered a high or low cost.

2.4.Literature review

2.4.1. Pre-existing national or regional initiatives to disinvest from low value care

As discussed in section 2.2, healthcare systems across the globe has increasingly recognised the importance of disinvestment from low value and ineffective care to control healthcare costs and protect patients from harm. As a result, there are many examples of national or regional initiatives to disinvest from low value care. For example, the aforementioned NICE "do not do" list of low-value procedures (Garner and Littlejohns, 2011), targets by NHS England to reduce provision of "procedures of limited clinical value" (Coronini-Cronberg *et al.*, 2015), and the Choosing Wisely Campaign implemented in the United States, Canada, Australia, the UK, and other countries internationally with the aim of reducing unnecessary medical tests, procedures, and treatments (Malhotra *et al.*, 2015). Despite several different approaches to disinvestment from low value care, there is no consensus on what approaches are more likely to lead to successful and sustainable implementation (Patey and Soong, 2023). To map pre-existing national or regional initiatives to disinvestment from low value care, I conducted an umbrella review of existing reviews focused on evaluations of national or regional initiatives to disinvest in low value care. Umbrella reviews are commonly used to summarise a large body of literature when multiple different intervention types exist across different populations (Cant, Ryan and Kelly, 2022). The aim of this review was two-fold. First, to identify different types of interventions have been used at the national or regional level (rather than organisational level) to encourage disinvestment from low value care. Second, to review previous methodological approaches used to inform the development of methods for my own evaluation of the EBI programme.

2.4.1.1.Method

Articles were systematically identified by searching PubMed up to 28 October, 2020, using the search terms: "disinvestment", "decommission", "delist", "health technology reassessment", "low value", "reallocation". The full query for PubMed is shown below.[3] Articles were initially screened using abstracts and titles to identify articles suitable for full-text screening. This search was also supplemented with a non-systematic search for grey

[3] (((((((disinvestment) OR (decommission)) OR (delist)) OR (health technology reassessment)) OR (low-value)) OR (reallocation)). Up to October 28th 2020, reviews and systematic reviews, in English

literature using internet search engines and Google Scholar. The inclusion criteria were any review that included empirical analyses of national or regional initiatives to disinvest from low value care. No exclusion criteria were used on type of review, with the exception of narrative reviews. The search was also limited to reviews published in English. My definition of low value care included any type of health care service established to not be cost effective or clinically effective, including surgical procedures, medicines, medical devices, imaging and diagnostic tests. For feasibilities purposes, I excluded reviews focused on evaluation of disinvestment from low value care in individual or groups of hospitals or primary care clinics. This decision was also made to ensure studies identified within reviews were more relevant to my proposed evaluation of the EBI programme, a national initiative to disinvestment from low value care. The reference list of each identified review was reviewed to identify further examples of published empirical analyses of national or regional initiatives to disinvest from low value care. Once each review was identified, I recorded the country setting, type of intervention, study design and findings. No second reviewer was involved in screening articles, and no quality assessment of identified reviews was undertaken.

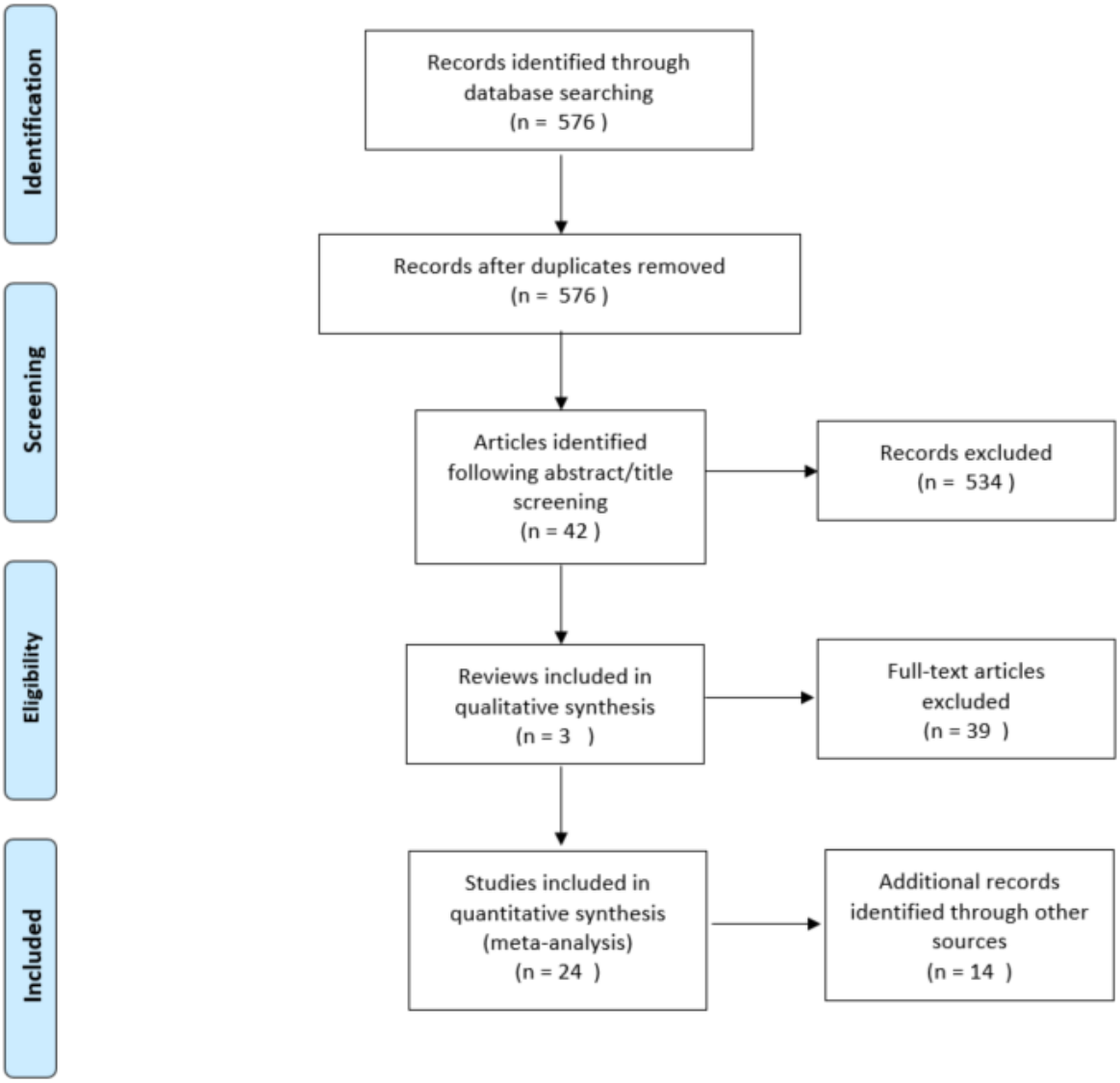
2.4.1.2.Search results

The PubMed search created 576 results, and after screening abstracts and titles, 42 reviews were selected for full-text review (Figure 9). In total, 3 reviews were identified which included studies that evaluated national or regional initiatives to disinvest from low value care (Mayer and Nachtnebel, 2015; Chambers *et al.*, 2017; Colla *et al.*, 2017). Chambers et al. (2017) is a scoping review that reviewed empirical analyses of disinvestment initiatives for low value care published up to May 2016. Chambers et al. (2017) identified 18 empirical analyses of disinvestment initiatives, of which 8 were at national or regional level (Ryan, Piercy and James, 2004; Dietrich, 2009; Thornhill *et al.*, 2011; Chamberlain *et al.*, 2013; Coronini-Cronberg *et al.*, 2015; Dehkordy *et al.*, 2015; Rosenberg *et al.*, 2015; Lasser *et al.*, 2016). Colla et al. (2017) is a systematic review that identified evaluations of interventions that aim to reduce the use of low value care up to spring 2015.[4] Colla et al. (2017) predominantly identified interventions at the organisational or local level, but their review did identify 2 studies at the national level (Makarov *et al.*, 2013; Bussières *et al.*, 2014). Mayer and Nachtnebel (2015) is a systematic review that searched for scientific articles and grey

[4] Colla et al 2017 does not specify the specific date in Spring 2015 that their search ran up to.

literature up to May 2013 focused on national, and regional programmes that identify ineffective technologies to inform resource allocation. Mayer and Nachtnebel (2015) included only 1 relevant study previously identified within Chambers et al. (2017) (Chamberlain *et al.*, 2013). In addition to the 10 studies identified within these 3 reviews, reviewing reference lists and additional searches using internet search engines found an additional 14 individual studies that were empirical analyses of national or regional initiatives to disinvest from low value care.

Figure 9: PRISMA flow diagram for identification, screening, eligibility and inclusion of reviews



2.4.1.3.Summary of findings from individual studies

The 24 studies identified within the 3 reviews and from other sources produced mixed findings (Table 10). In total, 12 studies found initiatives to disinvest from low value care were associated with a significant reduction in low value care, 7 studies found no significant reduction, and 5 studies had mixed results for individual healthcare interventions. Most studies were either set in the US or UK, accounting for 18 studies. Of the 24 studies, 20 analysed the impact of guidance, of which 13 involved Choosing Wisely guidance, and 4 involved NICE guidance. There were mixed findings for the impact of clinical guidance, with 7 studies finding no significant impact (Ryan, Piercy and James, 2004; Chamberlain *et al.*, 2013; Dehkordy *et al.*, 2015; Lasser *et al.*, 2016; Welk *et al.*, 2018; Bruno *et al.*, 2020; T. S. Anderson *et al.*, 2020); 9 studies finding a significant reduction in low value care (Thornhill *et al.*, 2011; Bussières *et al.*, 2014; Hong *et al.*, 2017; Prochaska *et al.*, 2017; Zambrana-García *et al.*, 2017; Rodin *et al.*, 2018; Calderon *et al.*, 2019; Ong *et al.*, 2019; Wu *et al.*, 2020) ; and 4 studies producing mixed findings for different medical interventions (Dietrich, 2009; Rosenberg *et al.*, 2015; Neuner *et al.*, 2019; Reyes *et al.*, 2020). Findings did not vary significantly according to which country or organisation issued guidance or which methodological approach was used for evaluation. Of the 24 studies, 4 studies evaluated an initiative that went beyond guidance. Two of these 4 studies evaluated the impact of a letter sent by the Chief Medical Officer to GP practices in the top 10% of rates for antibiotic prescriptions, and found antibiotic prescription rates subsequently significantly reduced (Hallsworth *et al.*, 2016; Ratajczak *et al.*, 2019). One of these 4 studies concluded that the introduction of clinical guidance combined with feedback and benchmarking at the provider level using registry data reduced unnecessary use of prostate cancer imaging (Makarov *et al.*, 2013). The remaining study concluded that an initiative by the NHS in England that set efficiency savings targets for local commissioning bodies achieved by disinvestment in locally determined procedures of low clinical value (POLCV) found significant reductions in 3 out of 6 targeted procedures (Coronini-Cronberg *et al.*, 2015).

In terms of methodological approach, the 3 most common approaches comprised interrupted time series analysis (ITSA) (12 studies), simple pre-post comparison analysis (6 studies) and time trend analysis (4 studies). The effect of the CMO letter to GP practices with high antibiotic prescription rates was first evaluated using a pragmatic randomised controlled trial (RCT) in a sample of GP practices (Hallsworth *et al.*, 2016), and once expanded nationwide it

was evaluated using a regression discontinuity in time (RDiT) design (Ratajczak *et al.*, 2019). Only 3 studies included some type of control group: 2 studies that used an ITSA design repeated their analyses with a supposedly unaffected control group (Coronini-Cronberg *et al.*, 2015; Bruno *et al.*, 2020); and as mentioned above, 1 study involved a pragmatic RCT design (Hallsworth *et al.*, 2016).

Table 10: Studies identified within reviews of national or regional disinvestment initiatives[§]

Study	Country	Intervention	Focus	Study design	Finding
(Ryan, Piercy and James, 2004)	UK	NICE guidance	Wisdom tooth extraction, hip replacement	ITSA	No significant impact on either procedure
(Dietrich, 2009)	UK	NICE guidance	31 drugs not recommended or restricted by NICE	ITSA	Significant reduction for only 1 drug
(Thornhill *et al.*, 2011)	UK	NICE guidance	Antibiotic prophylaxis for prevention of infective endocarditis	Pre-post analysis	Significant reduction in prescriptions
(Chamberlain *et al.*, 2013)	UK	NICE guidance	Varicocele operations, endometrial biopsies, caesarean sections	Time trend analysis using joint point regression	No significant impact
(Makarov *et al.*, 2013)	Sweden	Guidance + feedback via registry data	Prostate cancer imaging	Time trend analysis using GLM	Significant reduction
(Bussières *et al.*, 2014)	US	Guidance	Spine imaging	ITSA	Significant reduction
(Coronini-Cronberg *et al.*, 2015)	UK	NHS England initiative (involving efficiency savings targets)	Spinal surgery, myringotomy, hernia repair, cataract removal, hip replacement, hysterectomy	ITSA (repeated analysis with a control)	Significant reduction for 3 procedures
(Dehkordy *et al.*, 2015)	US	USPSTF guidance	Breast screening in women younger than 50	Pre-post analysis	No significant change
(Rosenberg *et al.*, 2015)	US	CW guidance	Imaging, HPV testing, antibiotics, anti-inflammatories	Time trend analysis using Poisson regression with offsets	Significant reductions for 2 recommendations Significant increases for 2 recommendations
(Hallsworth *et al.*, 2016)	UK	CMO letter to GPs with high prescription rates	Antibiotic prescriptions	Pragmatic RCT	Significant reduction
(Lasser *et al.*, 2016)	US	CW guidance	Use of DEXA (bone density) scans in young women	ITSA	No significant change
(Hong *et al.*, 2017)	US	CW guidance	Low back pain imaging	ITSA	Significant reduction
(Prochaska *et al.*, 2017)	US	CW guidance	Myoglobin or creatine kinase-MB (CK-MB) tests	Time trend analysis	Significant reduction

(Zambrana-García *et al.*, 2017)	Spain	National guidelines	12 laboratory tests	Pre-post analysis	Significant reduction in all 12 tests
(Rodin *et al.*, 2018)	US	CW guidance	Imaging in low risk prostate and breast cancer	ITSA	Significant reductions
(Welk *et al.*, 2018)	Canada	CW guidance	Imaging prior to orchiplexy, testosterone tests, bone scans	ITSA	No significant impact
(Calderon *et al.*, 2019)	US	CW guidance	Unnecessary breast cancer treatment in low risk groups	Pre-post analysis	Significant reduction
(Neuner *et al.*, 2019)	US	CW guidance	Breast cancer treatment and surveillance	Pre-post analysis	Significant reduction in 2 out of 4 treatment metrics and 4 out of 6 surveillance metrics
(Ong *et al.*, 2019)	Australia	CW guidance	Unnecessary radiation therapy for breast cancer patients with brain metastases	Pre-post analysis	Significant reduction
(Ratajczak *et al.*, 2019)	UK	CMO letter to GPs with high prescription rates	Antibiotic prescriptions	RDiT	Significant reduction
(T. S. Anderson *et al.*, 2020)	US	CW guidance	Carotid imaging	ITSA	No significant impact
(Bruno *et al.*, 2020)	Australia	CW guidance	Acid suppression medications	ITSA (repeated analysis with a control)	No significant impact
(Reyes *et al.*, 2020)	US	CW guidance	Imaging in asthma or bronchiolitis, inhalers for bronchiolitis, steroids for chest infections, and acid suppression medication	ITSA	Non-significant impact for 3 recommendations Significant impact for 2 recommendations
(Wu *et al.*, 2020)	Australia	CW guidance	Acid suppression medications	ITSA	Significant reduction in prescriptions

§ NICE: National Institute of Health and Care Excellence, USPSTF: United States Preventive Services Task Force, CW: Choosing Wisely, CMO: Chief Medical Officer, ITSA: interrupted time series analysis, GLM: generalised linear model, RCT: randomised control trial, RDiT: Regression Discontinuity in Time.

2.4.1.4. Implications for EBI programme evaluation

The findings from these 24 studies indicate that publishing clinical guidance in isolation is unlikely to guarantee sustainable disinvestment from low value care. The limited number of studies that evaluated initiatives that go beyond just publishing clinical guidance, for example by setting targets, individualised provider feedback and benchmarking, indicate multicomponent interventions can more reliably achieve reductions in the provision of low value care. The EBI programme is unique in that it incorporates multiple supply-side (clinical guidance, prior approval processes, data feedback and targets, removal of tariffs), and demand-side (patient information leaflets, and videos to encourage shared decision making) interventions to encourage reductions in low value care. This is a major development in England's approach to disinvesting in low value care, which had previously heavily relied on the dissemination of clinical guidance and targets for efficiency savings (see section 2.2.).

While these 24 studies used several different methodological approaches to evaluate national initiatives to disinvest from low value care, the most commonly used method was an uncontrolled ITSA design. However, if a suitable control group can be identified then more robust approaches to casual inference can be deployed, for example pragmatic RCT (Hallsworth *et al.*, 2016), controlled ITSA (Coronini-Cronberg *et al.*, 2015; Bruno *et al.*, 2020), or RDiT (Ratajczak *et al.*, 2019). A suitable control group must meet the conditions of being similar to the treatment group but not influenced by the treatment intervention during the period of analysis (Matthay *et al.*, 2020). As the EBI programme was implemented nationwide simultaneously, identifying a suitable control group may be challenging. Ratajczak et al, (2019) was able to use a RDiT as the authors argue that their treatment (a letter to GP practices) would result in an abrupt change in prescribing patters and therefore the time period just before implementation can function as a control. The same is not possible with the EBI programme, as there was a period of consultation before implementation that could have resulted in anticipatory behaviour change. Bruno et al, (2020), and Coronini-Cronberg et al, (2015) use trends in high value procedures as a control group when evaluating the impact of policies to disinvest from low value procedures (Coronini-Cronberg *et al.*, 2015; Bruno *et al.*, 2020). However, trends in high value procedures are an imperfect control group as you would expect activity for these procedures to increase relative to low value procedures irrespective of any disinvestment intervention. An alternative approach would be

to use a control group of other low value procedures not subject to or influenced by the policy being evaluated.

2.5.Method for EBI analysis

2.5.1. Study design

To test my primary research objective, I used a DiD approach which is a quasi-experimental method commonly used to estimate the causal effect of a policy intervention against a comparator group that can adjust for both observable and non-observable confounding factors (Blundell and Dias, 2000). While I cannot evaluate the effectiveness of the second phase of the EBI programme in this paper (the period of analysis ends in February 2020 which is several months before the second phase of EBI begins), the second phase does create an opportunity to construct a control group of low value procedures which were unaffected by the EBI programme during the period of analysis (as discussed in section 2.4.2.4). To ascertain if there is evidence of adaptation after implementation of the EBI programme, the methodology used by Cooper et al. (2011) was adapted to apply spline regression to analyse differences in trends between the treatment and control group (Cooper *et al.*, 2011).

The two key assumptions which underlie the use of DiD analysis are that the treatment and control group have parallel trends before implementation of the policy intervention, and that the control group remains unaffected by the treatment after implementation (Blundell and Dias, 2000). I relied upon visual inspection of trends to test the parallel trend assumption. While data-driven approaches to test for parallel trends do exist, there is consensus within the literature that there is no perfect approach to test the parallel trend assumption and pre-trend testing is not a substitute for logical reasoning as to why parallel trends should hold for treatment and control group (Kahn-Lang and Lang, 2019; Roth, 2019; Jaeger, Joyce and Kaestner, 2020). In this paper, it can be argued that the parallel trend assumption should hold as both the treatment and control group are considered low value procedures. Moreover, one review of DiD studies found that pre-trend testing is rarely used in studies with large numbers of observations as even small differences in pre-implementation trends are likely to be significant (Roth, 2019). Roth highlights how pre-trend testing is more often used in studies with small numbers of observations when the test could fail to reject parallel trends because it is underpowered rather than due to parallel trends (Roth, 2019). For the second assumption, a

control group was constructed using other low value procedures that should not have been impacted by the EBI programme during my period of analysis.

To test my secondary and tertiary research objectives, a method developed to ascertain the difference between two DiD estimators known as triple difference estimation was used (Olden and Møen, 2022). This was used to expand on the DiD model to ascertain whether the EBI programme is associated with a larger decrease in the provision in low value procedures in certain groups including between NHS hospitals compared with private hospitals, CCGs with different levels of financial performance, and CCGs that were or weren't part of a demonstrator community that volunteered to trial EBI guidance before implementation. Even though triple difference estimators calculate the difference between two difference-in-differences estimators, it has been shown that triple difference estimation does not require two parallel trend assumptions to have a causal interpretation (Olden and Møen, 2022). This is because the difference between two biased difference-in-differences estimators will be unbiased as long as the bias is the same in both estimators.

2.5.2. Study cohort and data sources

Pseudonymised individual patient-level data were analysed between 1 January 2016 and 28 February 2020 retrieved from the NHS Digital SUS database. Data were not analysed beyond this point as elective care activity was significantly impacted by the COVID-19 pandemic. Data access was provided by the NHS England EBI programme team to myself during a clinical fellowship with NHS England as part of a service development evaluation exercise. The identification of low value procedures was undertaken using combinations of primary and secondary procedure and diagnosis codes for each low value procedure, developed by the EBI programme, based upon feedback from stakeholders including local commissioning groups, hospitals, and specialty organisations. These codes are publicly available and contained within EBI guidance (NHS England, 2018b; Academy of Medical Royal Colleges, 2020). A summary of these codes is also contained in the appendices (Appendix B, Tables 1 and 2). The NHS SUS database is classified according to finished consultant episodes, which relate to the clinician responsible for the respective aspect of care, and hospital spells, which encompass all activity from hospital admission to discharge, including ward transfers of patients. To avoid multiple counting of low value procedures, procedures were identified by applying these criteria to each hospital spell rather than finished consultant episode. For each

low value procedure, information on individual patient characteristics was extracted including age, gender, level of deprivation, and comorbidities. Comorbidities were classified according to the Charlson Comorbidity Index (CCI), based upon code written by Quan et al. that utilises International Classification of Diseases (ICD-10) codes (Quan *et al.*, 2005). Level of deprivation was classified according to the English Index of Multiple Deprivation (IMD 2019) (UK Government, 2020).

The primary treatment group for this analysis was activity data for Category 2 procedures under the remit of phase one of the EBI programme (Appendix B, Table 3), with the exception of removal of benign skin lesions. Removal of benign skin lesions was taken out of the primary analysis as it was seen as not comparable to other procedures under the remit of the EBI programme. It is a relatively minor procedure that often takes place in outpatient clinics rather than in surgical theatres, and as a relatively high-volume procedure its inclusion could bias results. The decision was made not to include Category 1 procedures in the primary analysis as Category 1 procedures are recommended not to be conducted in any circumstances, and therefore likely to have experienced a significantly larger decline than Category 2 procedures before implementation of the EBI programme. To ascertain if these omissions significantly alter the results, both removal of benign skin lesions and Category 1 procedures were included in the treatment group in separate robustness analyses.

Separate treatment groups for procedures grouped according to whether they were classified as high cost or low cost procedures were also constructed for supplementary analyses. This was determined by whether estimated potential annual savings for each procedure exceed £10,000,000 per annum. High cost procedures in the primary treatment group included hysterectomy for heavy menstrual bleeding, shoulder decompression, carpal tunnel syndrome release, and Dupuytren's contracture release (Appendix B, Table 4). Estimated savings were calculated by the EBI team using baseline expenditure for each procedure (total expenditure for each procedure in 2017/18 divided by the number of associated hospital spells), and the assumption that all CCGs meet their targets to reduce provision. These estimated savings are contained within the appendices (Appendix B, Table 4).

The control group for this analysis consists of four Category A procedures: repair of minimally symptomatic inguinal hernia, surgical intervention for chronic rhinosinusitis, kidney stone surgery, and surgical intervention for benign prostatic hypertrophy. These

procedures were selected from Category A low value interventions that are subject to phase two of the EBI programme (Table 11). Other Category A procedures were not included in the control group as they are either diagnostics rather than surgical procedures, or considered to be vulnerable to potential spill over effect of the first phase of the EBI programme. Category B or C interventions were excluded as the EBI programme team have not yet developed reliable definitions to publish activity levels (Academy of Medical Royal Colleges, 2020).

Table 11: Category A Evidence-based Interventions programme procedures included and excluded from control group

Intervention		**Included in control group**	**Rationale**
2A	Diagnostic angiogram	No	Diagnostic rather than surgical procedure
2B	Repair of minimally symptomatic inguinal hernia	Yes	No spill over effect from Category 1 or 2 procedures
2C	Surgical intervention for chronic rhinosinusitis	Yes	No spill over effect from Category 1 or 2 procedures
2D	Adjuvant adenoidectomy for treatment of glue ear	No	Potential spill over effect from disinvestment from grommets (Category 2 procedure)
2E	Arthroscopic surgery for meniscal tears	No	Potential spill over effect from disinvestment from knee arthroscopy with osteoarthritis (Category 1 procedure)
2G	Kidney stone surgery	Yes	No spill over effect from Category 1 or 2 procedures
2H	Cystoscopy for men with uncomplicated lower urinary tract symptoms (LUTS)	No	Diagnostic rather than surgical procedure
2I	Surgical intervention for benign prostatic hypertrophy (BPH)	Yes	No spill over effect from Category 1 or 2 procedures
2J	Lumbar discectomy	No	Potential spill over effect from injection for nonspecific low back pain without sciatica
2K	Radiofrequency facet joint denervation	No	
2L	Exercise electrocardiogram (ECG)	No	Diagnostic rather than surgical procedure
2M	Upper gastrointestinal endoscopy	No	Diagnostic rather than surgical procedure

Data on CCG financial performance were retrieved from NHS England (NHS England, 2022c). CCGs were coded as being in deficit if their expenditure exceed their allocation in the financial year before the implementation of the EBI programme. During my period of analysis, many CCGs underwent mergers and the number of CCGs reduced from 191 in

2018/19 to 135 in 2019/20 (NHS England, 2021). To overcome this, CCGs were consistently coded according to their CCG status in 2019/20 and the financial performance of CCGs that underwent a merger in 2019/20 was estimated using the total surplus or deficit for merged CCGs. The EBI team provided information on whether a CCG was coded as part of the demonstrator community that volunteered to trial EBI guidance before implementation. Hospital providers were coded as either NHS or private hospitals according to their organisation code classified by the NHS Digital Organisation Data Service (NHS Digital, 2022).

2.5.3. Statistical analysis

Equation 1 shows the regression model for my DiD analysis that tests the primary aim:

$$[1] \quad logY_{ccgt} = \beta_0 + \beta_1 t + \beta_2 \{t \geq EBI\} + \beta_3 (Phase1 \times t) + \beta_4 (Phase1 \times \{t \geq EBI\}) + \beta_5 Phase1 + \beta_6 EBI + \beta_7 (EBI \times Phase1) + \beta_8 yeardummy_t + \beta_9 monthdummy_t + \beta_{10} Z_{ccgt} + \varepsilon_{ccgt}$$

$logY_{ccgt}$ is the dependent variable, the log of the number of total low value procedures undertaken at clinical commissioning group, *ccg,* during month *t*. $Phase1$ is the number of low value procedures in the treatment group. t indicates a running counter of months from January 2016 to February 2020. EBI is the break point in time corresponding to the policy start point, which is 1 from April 2019, and 0 before (the month in which phase one of the EBI programme was launched). $\{t \geq EBI\}$ indicates a running counter of months from April 2019 to February 2020. Z_{ccgt} is a vector of CCG controls including aggregate patient characteristics (age, gender, CCI, and index of multiple deprivation (IMD)). The model was run using fixed effects which differenced all time-invariant CCG characteristics from the equation. Year and month dummies were also added to account for year and seasonal variation.

Setting $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$ gives rise to my preferred standard DiD specification when the coefficient β_7 captures the treatment effect of the EBI programme, specifically the difference in the average change in volumes of low value procedures in the treatment group before and after the implementation of the EBI programme minus the difference in the

average change in volumes of low value procedures in the control group. This model was run with all phase one Category 2 low value procedures, with the exception of the removal of benign skin lesions, and then separately according to whether procedures were classified as high or low cost. Setting $\beta_6 = \beta_7 = 0$ gives rises to my spline-based DiD regression specification when the coefficient β_4 captures the difference in the average monthly rate of change in volumes of low value procedures in the treatment group before and after the implementation of the EBI programme minus the difference in the average monthly rate of change in volumes of low value procedures for the control group. I included a spline-based regression as implementation of the EBI programme may have occurred over a gradual period as hospitals, commissioners, consultants, and patients became more aware of the policy. Relaxing these assumptions allows a combination of these estimators. This specification allows a step-change in policy, and a change in trends. As these additional specifications did not show significantly different results, these specifications were not repeated with procedures classified according to whether they are high or low cost.

A number of robustness checks were performed to test the reliability of the results: first, with the treatment group including volumes for both Category 1 and 2 procedures; second, with the treatment group including volumes for removal of benign skin lesions. Third, to account for potential anticipatory behaviour change before implementation of the EBI programme, the implementation period was changed to November 2018 (the month in which the statutory guidance for the EBI programme was published).

Equation 2 shows the regression model which utilises a triple difference estimator to test my secondary aims:

$$[2] \quad logY_{it} = \beta_0 + \beta_1 Phase1 + \beta_2 EBI + \beta_3 X + \beta_3(EBI \times Phase1) + \beta_4(EBI \times X) + \beta_5(Phase1 \times X) + \beta_6(EBI\ x\ Phase1 \times X) + \beta_7 yeardummy_t + \beta_8 monthdummy_t + \beta_9 Z_{it} + \varepsilon_{it}$$

$logY_{it}$ is the dependent variable, the log of the number of total low value procedures undertaken at CCG or hospital, *i*, during month *t*. *X* is a binary variable which reflects different CCG or hospital characteristics. The equation was run three separate times: first, with *X* being 1 for CCGs which posted in financial year 2018/19 and 0 for those which did not; second, with *X* being 1 for CCGs which were part of the demonstrator community that

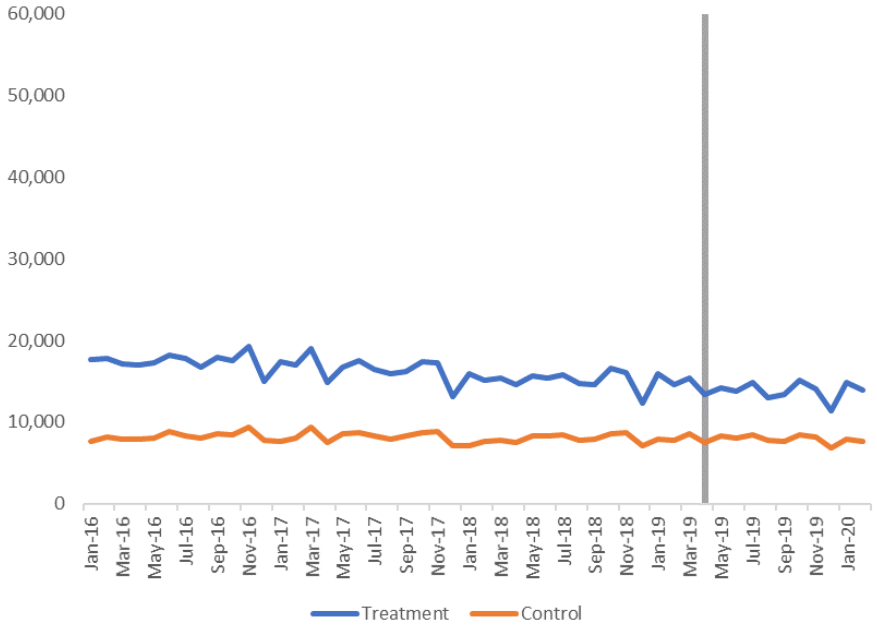
volunteered to trial EBI guidance before implementation and 0 for those which were not; third, with X being 1 for NHS hospitals and 0 for private hospitals. The coefficient β_6 captures the difference in the average change in low value procedures in the treatment group between these CCG and hospital characteristics. The other components of equation 2 are the same as equation 1. The same robustness checks were repeated for equation 1 and 2. As classifying procedures in the treatment group according to their cost did not produce significantly different results in my standard DiD specification, this analysis was not repeated with the triple difference estimator.

2.6. Results

2.6.1. Descriptive statistics

When visually inspecting pre-implementation trends between the treatment and control group (Figure 10), the assumption of parallel trends appears to hold in the pre-treatment period. Similarly, the pre-implementation trends between treatment and control group do not appear to significantly differ for alternative compositions of the treatment group as robustness checks discussed in the methods section (Appendix B, Figures 1–4).

Figure 10: Trends in EBI treatment and control group procedures§



§The grey line represents the implementation date of the EBI programme

When focusing on the 11 months before and after the implementation of the EBI programme (Table 12), the proportion of procedures undertaken after implementation was similar in the treatment group (48.44%), and control group (49.17%). There was more variation in the proportion of individual procedures undertaken after implementation in the treatment group (41.31% – 53.43%), compared to the control group (48.49% – 50.88%).

Table 12: Number of procedures for phase one and phase two of EBI programme[§]

	Before EBI	**After EBI**	**Total**
Phase 1 procedures (treatment)			
Category 1			
Intervention for snoring (not OSA)	667 (56.14%)	521 (43.86%)	1,188
Dilatation and curettage for heavy menstrual bleeding	217 (46.57%)	249 (53.43%)	466
Knee arthroscopy with osteoarthritis	3,966 (55.76%)	3,147 (44.24%)	7,113
Injection for nonspecific low back pain without sciatica	13,022 (58.69%)	9,164 (41.31%)	22,186
Total	17,872 (57.74%)	13,081 (42.26%)	30,953
Category 2			
Breast reduction	938 (53.78%)	806 (46.22%)	1,744
Removal of benign skin lesions	94,427 (50.29%)	93,347 (49.71%)	187,774
Grommets	7,007 (53.13%)	6,182 (46.87%)	13,189
Tonsillectomy	28,382 (53.92%)	24,260 (46.08%)	52,642
Haemorrhoid surgery	7,929 (51.41%)	7,495 (48.59%)	15,424
Hysterectomy for heavy bleeding	17,790 (51.40%)	16,822 (48.60%)	34,612
Chalazia removal	4,761 (52.90%)	4,239 (47.10%)	9,000
Shoulder decompression	8,947 (56.60%)	6,860 (43.40%)	15,807
Carpal tunnel syndrome release	39,162 (50.97%)	37,677 (49.03%)	76,839
Dupuytren's contracture release	13,965 (51.69%)	13,050 (48.31%)	27,015
Ganglion excision	5,035 (50.97%)	4,844 (49.03%)	9,879
Trigger finger release	7,264 (51.41%)	6,865 (48.59%)	14,129
Varicose vein surgery	25,693 (52.72%)	23,044 (47.28%)	48,737
Total	261,300 (51.56%)	245,491 (48.44%)	506,791
Total (Category 1 & 2)	279,172 (51.92%)	258,572 (48.08%)	537,744
Phase 2 procedures (control)			
Hernia repair	50,748 (51.51%)	47,771 (48.49%)	98,519
Sinus surgery	11,712 (49.70%)	11,853 (50.30%)	23,565
Kidney stone surgery	13,483 (51.11%)	12,896 (48.89%)	26,379
Benign prostatic hypertrophy surgery	13,502 (49.12%)	13,988 (50.88%)	27,490
Total	89,445 (50.83%)	86,508 (49.17%)	175,953

[§] Throughout the table, percentages in parentheses indicate the proportion of procedures undertaken in the 11 months before and after the implementation of EBI in April 2019 for illustrative purposes. However, it should be noted that my DiD analysis considers a longer pre-implementation trend from 1 January 2016 to 31 March 2019.

There were no significant changes in the proportion of patients that was male or female before and after the implementation of the EBI programme for any of the groups of procedures (Appendix B, Table 5). Most patients in the control group were male, which

likely reflects how prostate surgery is performed exclusively for male patients and hernia repair is performed more frequently for male patients. There were significant increases in the average age of patients within all groups of procedures, with the largest increases in Category 1 procedures at 1.42 years (95% CI 1.07, 1.77), and the smallest increase in the control group at 0.79 years (95% CI 0.64, 0.94). The average IMD score decreased for all groups of procedures, although this increase was not significant in any groups of procedures. There were significant increases in average CCI for all groups of procedures. However, these increases were very small and the largest increase was only 0.09 points (95% CI 0.07, 0.10) in Category 1 procedures.

While 38 out of 135 CCGs (28.1%) posted a deficit in the financial year 2018/19 before implementation, a higher proportion of low value procedures was undertaken in these CCGs for both the treatment (37.0%), and control group (39.0%) (Appendix B, Table 6). 48 out of 135 CCGs (35.6%) were coded as having volunteered to be part of the demonstrator community to trial EBI guidance before implementation, and a similar proportion of low value procedures was undertaken in these CCGs for both the treatment (36.2%), and control group (35.6%). While 226 out of 388 hospitals (58.2%) were private hospitals, only 18.2% of procedures in the treatment group and 20.5% of procedures in the control group were conducted in these hospitals (although it should be noted that private hospitals are typically smaller than NHS hospitals and have much less capacity).

2.6.2. Difference-in-difference analysis

In my primary DiD model, the coefficient that reflects the treatment effect of the EBI programme was 0.10 (95% CI 0.09, 0.11), and significant at the $p<0.001$ level (Table 13). This indicates that reductions in the provision of low value procedures in the treatment group were 0.10% smaller than reductions in the control group, which is equivalent to 16 low value procedures per month. This coefficient remained positive for the high cost and low cost treatment groups, indicating that the effectiveness of the EBI programme was not influenced by estimated potential annual savings for individual procedures. In my spline-based and combination-based DiD, the coefficients that reflect differences in monthly changes in volume were not significant. The coefficient that reflects differences in the step-change in policy was 0.05 (95% CI 0.03, 0.06) and significant at the $p<0.001$ level. This indicates the step-change reduction in the provision of low value procedures in the treatment group was

0.05% smaller than the control group, which is equivalent to 7 low value procedures. These findings are consistent across all robustness analyses outlined in my methods section (Appendix B, Tables 7–9).

Table 13: Results table for difference-in-difference analysis (%)[§]

	Model 1 (standard DiD)	**Model 2 (standard DiD)**	**Model 3 (high cost procedures)**	**Model 4 (low cost procedures)**	**Model 5 (time trend analysis)**	**Model 6 (combination)**
Phase1	0.54*** (0.53, 0.56)	0.55*** (0.54, 0.57)	0.92*** (0.89, 0.94)	0.92*** (0.89, 0.94)	0.53*** (0.52, 0.54)	0.54*** (0.52, 0.55)
EBI	-11.82*** (-12.89, -10.75)	-12.50*** (-14.01, -10.99)	-8.65*** (-10.40, -6.90)	-11.21*** (-13.00, -9.42)	—	-4.98** (-7.20, -2.75)
EBI x phase1	0.10*** (0.09, 0.11)	0.10*** (0.09, 0.11)	0.15*** (0.13, 0.16)	0.17*** (0.16, 0.19)	—	0.05*** (0.03, 0.06)
t	—	—	—	—	-0.27*** (-0.37, -0.16)	-0.22*** (-0.33, -0.12)
t ≥ EBI	—	—	—	—	-0.87 (-1.15, -0.59)	-0.36* (-0.71, -0.02)
t x phase 1	—	—	—	—	0.00*** (0.00, 0.00)	0.00** (0.00, 0.00)
t ≥ EBI x phase1	—	—	—	—	0.01 (0.00, 0.01)	0.00 (-0.00, 0.00)
Controls	No	Yes	Yes	Yes	Yes	Yes
Year Dummies	No	Yes	Yes	Yes	Yes	Yes
Month Dummies	No	Yes	Yes	Yes	Yes	Yes
Constant	4.31*** (4.29, 4.32)	4.18*** (4.08, 4.29)	3.89*** (3.78, 4.01)	3.85*** (3.75, 3.96)	4.21*** (4.10, 4.32)	4.20*** (4.09, 4.32)
Observations	6,750	6,750	6,750	6,750	6,750	6,750
Units of Observation	135 CCGs	135 CCGs	135 CCGs	135 CCGs	135 CCGs	135 CCGs

[§] Coefficients are reported as percentages, and can be understood as follows*: Phase1* is the percentage difference in change in volumes between the treatment and control group. *EBI* is the percentage difference in volumes for all procedures before and after the implementation of the EBI programme. In Models 1–4, *EBI x phase1* represents the treatment effect of the EBI programme and is the percentage difference-in-difference of volumes before and after implementation between the treatment and control group. In Model 6, *EBI x phase1* is the percentage difference in changes in volumes between the treatment and control group during implementation of the EBI programme. *t* reflects monthly percentage change in volumes for all procedures. *t ≥ EBI* reflects the monthly percentage change in volumes for all procedures after the implementation of the EBI programme. *t ≥ EBI x phase1* reflects the difference difference-in in-differences in the monthly percentage change in volumes between the treatment and group control after the implementation of the EBI programme. 95% confidence intervals are contained in parentheses, *** p<0.001, ** p<0.01, * p<0.05, — not applicable to this model. All models used fixed effects and therefore errors are clustered at the CCG level.

2.6.3. Triple difference estimation

When focusing on the results of the triple difference estimation, I find that the coefficient which reflects differences in reductions in the treatment group after implementation of the EBI programme for CCGs that posted a deficit in the financial year 2018/19 is -0.06 (95% CI -0.08, -0.04), and significant at the $p<0.001$ level (Table 14). This indicates that reductions in low value procedures after the implementation of the EBI programme were 0.06% larger in CCGs posting a deficit in the baseline year (2018/19) than those which did not, which is equivalent to 4 low value procedures per month. I find no significant differences after implementation of the EBI programme for CCGs that were part of the demonstrator community compared with those that were not. The coefficient which reflects differences in reductions in the treatment group after implementation of the EBI programme is -0.35 (95% CI -0.45, -0.26), and significant at $p<0.001$ level. This indicates that reductions in low value procedures after the implementation of the EBI programme were 0.35% larger in NHS hospitals compared with private hospitals, which is equivalent to 47 low value procedures per month. These findings are consistent according to all robustness analyses outlined in my methods section (Appendix B, Tables 10–12).

Table 14: Results table for triple difference estimation (%)[§]

	Model 1 (CCG deficit)	Model 2 (CCG demonstrator)	Model 3 (NHS hospitals)
Phase1	0.69*** (0.67, 0.71)	0.57*** (0.56, 0.59)	3.90*** (3.79, 3.99)
EBI	-13.07*** (-14.74, -11.40)	-12.03*** (-13.75, -10.31)	-9.69*** (-12.48, -6.90)
EBI x phase1	0.13*** (0.11, 0.14)	0.10*** (0.09, 0.11)	0.48*** (0.39, 0.56)
EBI x X	2.26 (-0.02, 4.53)	-1.24 (-3.43, 0.94)	-2.79 (-6.85, 1.27)
Phase1 x X	-0.30*** (-0.32, -0.28)	-0.05*** (-0.07, -0.02)	-3.08*** (-3.19, -2.98)
EBI x phase1 x X	-0.06*** (-0.08, -0.04)	0.00 (-0.02, 0.02)	-0.35*** (-0.45, -0.26)
Constant	4.15*** (4.05, 4.25)	4.18*** (4.08, 4.29)	2.84*** (2.76, 2.93)
Observations	6,750	6,750	16,559
Units of observation	135 CCGs	135 CCGs	382 hospitals

[§] Coefficients are reported as percentages, and can be understood as follows: *Phase1* is the percentage difference in change in volumes between the treatment and control group. *EBI* is the percentage difference in volumes for all procedures before and after the implementation of the EBI programme. *EBI x phase1* is the percentage DiD of volumes before and after the implementation of the EBI programme between the treatment and control group. *EBI x X* is the average percentage difference-in-difference in volumes for all procedures before and after the implementation of the EBI programme between different organisational characteristics defined by *X*. *Phase1 x X* is the average percentage difference in changes in volumes for the treatment group for different organisational characteristics defined by X. *EBI x phase1 x X* is the average percentage difference in difference in volumes before and after the implementation of the EBI programme for the treatment group between different organisational characteristics defined by *X*. In Model 1, *X* is 1 for CCGs which posted in financial year 2018/19, and 0 for those which did not. In Model 2, *X* is 1 for CCGs which were part of the demonstrator community, and 0 for those which were not. In Model 3, *X* is 1 for NHS hospitals and 0 for private hospitals. 95% confidence intervals are in parentheses, *** p<0.001, ** p<0.01, * p<0.05. All models used fixed effects, and therefore errors are clustered at the CCG or hospital level.

2.7. Discussion

2.7.1. Summary of findings

This analysis indicates that for the first 11 months after implementation the EBI programme did not achieve its aim of accelerating disinvestment for low value procedures under its remit. Conversely, on the understanding that the control group provides a counterfactual scenario whereby the EBI programme did not exist, I found statistically significant evidence that the implementation of the EBI programme was associated with a small increase in the volumes of low value procedures under its consideration. This finding is consistent irrespective of whether the composition of the treatment group is changed according to procedures with estimated potential annual savings of above or below £10,000,000. When analysing organisational and financial factors which may have influenced implementation of the EBI programme, I find that CCGs that posted a deficit in the financial year before implementation had larger reductions in low value procedures than CCGs that did not. This may be because CCGs that posted a deficit in the year before implementation felt the need to more proactively engage with the EBI programme as one mechanism to save costs and reduce their deficit in the subsequent year. Despite approximately a third of CCGs volunteering to be part of a demonstrator community that trialled EBI recommendations before implementation, there were no significant differences between changes in volumes of low value procedures between demonstrator and non-demonstrator CCGs. Finally, I found that NHS hospitals had significantly larger reductions in low value procedures than private hospitals. This may be because NHS hospitals have an institutional culture which is more amenable to NHS England-led national quality improvement initiatives, whereas private hospital hospitals may be more motivated by their respective corporate-level objectives and strategies. These findings were consistent across all my robustness analyses that included both Category 1 and Category 2 procedures within the treatment group, included removal of benign skin lesions within the treatment group, and changed implementation to November 2018 (the month in which the statutory guidance for the EBI programme was published).

2.7.2. Strengths and limitations

There are several strengths to this analysis. First, to my knowledge this is the only quantitative evaluation of the impact of the EBI programme. This provides important

information on the impact of the EBI programme so far which can be used to inform its planned expansion. Second, this evaluation uses a DiD analysis which is a robust method for casual inference. This is a valuable addition to the literature on empirical evaluations of national disinvestment initiatives which typically use weaker methods such as interrupted time series, or before and after analyses (Chambers *et al.*, 2017). Third, the analysis was extended to focus on a range of organisational and financial factors which may have influenced implementation and a series of robustness tests was utilised to assess the reliability of my findings.

Despite these strengths, the robustness of this analysis is heavily dependent on the ability of my selected control group to meet the two key assumptions to undertake a DiD (Blundell and Dias, 2000). These assumptions are, first, that there are parallel trends before implementation; second, that the control group remains unaffected by the treatment after intervention. For the first assumption, the degree to which parallel trends exist is frequently debated in DiD analyses (Roth, 2019). However, it is reassuring that on visual inspection of pre-implementation trends the assumption of parallel trends appears to hold. Moreover, the coefficient which reflects differences in trends between the treatment and control group is very small (Table 13). For the second assumption, the control group was constructed to minimise the potential for any spillover effect of the EBI programme. However, I cannot completely exclude any possibility of a spillover effect as the EBI programme may have generally encouraged a culture of disinvestment in hospitals and CCGs.

There are other minor limitations of this analysis to consider when interpreting the findings of this study. First, a coding algorithm was used for the CCI developed by Quan and colleagues (Quan *et al.*, 2005). There is a modified version developed for use with hospital administrative data collected by the NHS in England which is arguably more applicable, but this was not available on STATA (Bottle and Aylin, 2009). Second, the classification of hospital spells used does not take account of transfers between hospitals. Therefore, it is possible that some procedures were counted twice if an inter-hospital transfer occurred, although this is unlikely to have substantially impacted the results as inter-hospital transfers are rare for procedures of this level of complexity.

2.7.3. Policy implications and conclusions

The findings of this analysis are consistent with many other empirical analyses of national disinvestment initiatives that often conclude they have not achieved their aims (Chambers *et al.*, 2017). Despite broad consensus within the healthcare community in the United Kingdom on the importance of disinvestment in low value care (Malhotra *et al.*, 2015), other evaluations of the effectiveness of interventions such as NICE guidance and "do not do" recommendations have also found limited impact (Ryan, Piercy and James, 2004; Dietrich, 2009; Chamberlain *et al.*, 2013). While it is frustrating that early evidence from the EBI programme has indicated limited effectiveness, the EBI programme still represents a major step forward as it has developed a structured and transparent approach to identify candidates for disinvestment that involved broad consultation with specialty organisations, patient groups and CCGs. It is possible that the EBI programme has taken an approach to implementation that is too top-down. The barriers to disinvestment in low value care are complex and involve a range of patient, clinician, organisational and health system factors (Norton and Chambers, 2020). Moreover, the success of the EBI programme is heavily reliant upon successful collaboration between CCGs, hospitals and primary care in developing and effectively implementing prior approval processes. Moving forward, the EBI programme will need to focus on developing strategies to facilitate and monitor these collaborations at the local level to balance both bottom-up and top-down implementation in a manner that could foster more sustainable and consistent reductions in low value care.

3. Chapter 3 (Paper II): Evidence of substitution between publicly and privately funded low value elective procedures in private hospitals in England

3.1. Abstract

Background: This study assesses whether substitution between publicly and privately funded elective care exists for surgical procedures identified as low value by the NHS England Evidence-Based Interventions (EBI) programme. Category 1 procedures should not be conducted and are no longer reimbursed by the NHS. Category 2 procedures are only reimbursed by the NHS in specific circumstances.

Methods: Changes in volumes of publicly and privately funded procedures per month were analysed in 2019/20 to 2018/19 at the hospital and local healthcare market level and adjusted for patient case mix, region and volume of procedures. Supplementary analyses focused on changes in volume accessed through the self-pay and insurance funding mechanisms, and according to individual regions.

Results: There was significant evidence of substitution between publicly and privately funded care for Category 2 procedures at the hospital site (-0.19, 95% CI -0.25, -0.08) and local market level (-0.24, 95% CI -0.32, -0.15). However, evidence of substitution for Category 1 procedures at hospital site level (-0.19, 95% CI -0.30, -0.08) did not hold at the local market level (-0.11, 95% CI -0.28, 0.07). There were similar findings in the self-pay and insurance private healthcare markets. A sensitivity analysis comparing 2019/20 to 2017/18 also found similar results. When analysing individual regions, I found evidence that substitution between publicly and privately funded care is concentrated in Greater London, the South East, and West Midlands.

Conclusions: Stronger evidence of substitution for Category 2 procedures may exist as these procedures are clinically indicated in certain circumstances and NHS disinvestment may have created unmet need in patient populations. It is also possible that substitution is being driven by supplier-induced demand as healthcare providers seek to recoup lost revenues from publicly funded care.

3.2. Introduction

This paper takes advantage of two developments to explore the dynamic between publicly funded and privately funded low value care in England. First (as discussed in section 1.1.4.2.), the Competition and Markets Authority (CMA) published an investigation in 2014 that introduced a mandatory requirement for private hospitals to collect and submit data to a nominated healthcare information organisation (the Private Health Information Network (PHIN)) from January 2016 (Competition and Market's Authority, 2014). Data flows have been modelled on pre-existing datasets for publicly funded care such as NHS Digital Hospital Episode Statistics (HES) and Secondary Uses Service (SUS) datasets. This has meant that for the first time reliable data on hospital activity in the private healthcare sector is now available across England. Second (as discussed in section 2.2.1), NHS England launched a national initiative to disinvest from low value care in April 2019 called the Evidence-Based Interventions (EBI) programme that has classified a series of procedures as low value in certain circumstances.

It is important to investigate the dynamic between changes in publicly and privately funded care following the implementation of disinvestment policies in procedures considered as low value as significant increases in privately funded care may signal unmet need among patients. This is because many procedures considered as low value are beneficial for patients in certain circumstances. Conversely, particularly if there is limited evidence of clinical or cost-effectiveness for the procedure in any circumstances, significant increases in privately funded care may signal inappropriate supplier-induced demand. For private hospitals in England, it is reasonable to assume there may be some relationship between changes in publicly and privately funded care. This is because private hospitals provide a similar proportion of publicly and privately funded elective care (PHIN, 2020a). Since the mid-2000s, national efforts to clear waiting lists and promote competition have resulted in private hospitals providing an increasing quantity of publicly funded care (Stoye, 2019). Moreover, there continues to be a significant market for privately funded care, with approximately 10% of the population being covered by some form of private health insurance (Blackburn, 2020), and the self-pay market for private healthcare growing by approximately 7% per year between 2010 and 2019 (Heath, 2021).

3.3. Objectives

The primary aim of this study is to establish if there is evidence of substitution in the reductions of publicly funded care and increases in privately funded care for procedures classified as low value by the NHS England EBI programme. There also several secondary aims of this paper. The first of these is to establish if there is greater evidence of substitution for Category 1 or 2 procedures. This is because Category 1 procedures are not considered cost- or clinically effective in any circumstance. Therefore, significant evidence of substitution in changes in publicly and privately funded care would indicate increased provision of low value care in the private healthcare sector. In contrast, Category 2 procedures are considered cost- and clinically effective in specific circumstances. Therefore, significant evidence of substitution in changes in publicly and privately funded care could either indicate increased provision of low value care in the private healthcare sector or unmet need in the NHS sector. Second, there is value in analysing the potential for substitution according to different funding mechanisms as a stronger relationship between changes in publicly funded care and privately funded care accessed through the self-pay mechanism (i.e. out-of-pocket payments) can provide stronger evidence of unmet need in the NHS sector. Lastly, there is value in analysing the potential for substitution between publicly and privately funded care according to different regions as there is a significantly higher concentration of privately funded care in Greater London and the South East than other regions in England (Table 1). This study does not attempt to evaluate the effectiveness of the NHS England EBI programme on trends in publicly funded care as this was the focus of the first paper. To summarise, the research objectives of this paper are as follows:

- Research Objective 1: To establish if there is evidence of substitution in reductions of publicly funded care and increases in privately funded care for procedures classified as low value by the NHS in England.
- Research Objective 2: To establish if there is stronger evidence of substitution in changes in publicly and privately funded care for different groups of procedures based upon their classification as low value in all or only certain circumstances.
- Research Objective 3: To establish if there is stronger evidence of substitution in changes in publicly and privately funded care for patients accessing care through private health insurance and self-pay funding mechanisms.

- Research Objective 4: To establish if there is stronger evidence of substitution in changes in publicly and privately funded care in different regions of England.

3.4. Literature review

There have been fewer studies on privately funded healthcare than on publicly funded healthcare in the UK, due to a relative lack of data. Nevertheless, there are examples where researchers have negotiated access to insurance data or conducted surveys of private hospitals (Table 15). Williams and others conducted a survey of private hospitals in 1997/98 and found that over half of privately funded elective procedures were for day-case surgery with common procedures including abortion, endoscopy of the gastrointestinal tract, cataract surgery and hernia repair (Williams *et al.*, 2000). The overall in-hospital mortality rate in private hospitals was 0.3%, and the hospital transfer rate was 0.2%. Williams et al. did not analyse the relationship between different funding mechanisms in private hospitals but noted there had been an expansion in the numbers of patients receiving care through all funding mechanisms in comparison to a previous survey in 1992/93. The largest increases were for publicly funded patients (an overall increase in volume of 193.5%), and self-pay patients (an overall increase in volume of 69.0%). The authors' further article the following year analysed demographic characteristics, NHS activity and private medical insurance (PMI) coverage (Williams *et al.*, 2001). They found NHS activity was targeted on areas with lower PMI coverage and a higher proportion of patients with life-limiting, long-lasting illness. In areas of relatively lower NHS activity there was higher PMI coverage. Suleman and colleagues analysed tonsillectomy rates in NHS hospitals and a major provider of private healthcare (BUPA) between 2000 and 2005 (Suleman *et al.*, 2010). They found a seven-fold variation in NHS hospitals, and no significant correlation between NHS activity and private sector activity. However, this analysis is limited as BUPA only accounted for 40% of private hospital activity during the period of analysis. Kelly and Stoye (2020) used data from the National Joint Registry to assess the impact of the expansion of private hospital provision of publicly funded hip replacements between 2002/3 and 2012/13 on the provision of both publicly and privately funded care (Kelly and Stoye, 2020). They first conducted a DiD analysis to compare local healthcare markets with high and low exposure to private hospital presence. They also conducted separate OLS regressions to assess if there was evidence of substitution in increases in publicly funded admissions and decreases in privately funded admissions in private hospitals. The DiD analysis found private hospital presence was associated with an increase in publicly funded admissions and reductions in median waiting times, but no association with readmission rates, whereas the OLS analysis did not find any evidence of substitution between publicly and privately funded care.

Table 15: Published studies on relationship between publicly and privately funded care in England and Wales

Study	Outcome of interest	Study design	Findings
(Williams *et al.*, 2000)	Frequency of procedures by funding mechanism In-hospital mortality, hospital transfer	Hospital survey, and sample weighting	Expansion of publicly, insurance and self-pay funded markets between 1992/93 and 1997/98 0.3% in-hospital mortality rate 0.2% hospital transfer rate
(Williams *et al.*, 2001)	% with limiting longstanding illness, NHS waiting times, NHS acute beds per 1,000 pop, NHS consultants per 1,000 pop, NHS elective admissions, % with PHI coverage, privately funded admissions	Descriptive analysis of correlation between need, hospital capacity, and funding mechanisms using two-tailed Pearson correlation tests	Non-significant inverse correlation between publicly and privately funded admissions Significant inverse correlation between % of population with PHI coverage and NHS activity Significant positive correlation between % with limiting longstanding illness and NHS activity
(Suleman *et al.*, 2010)	Tonsillectomy rate in NHS and private hospitals per 100,000 for each local authority	Comparison of NHS and private hospital activity using Kendall Tau rank correlation coefficient	No significant correlation between NHS and private hospital activity
(Kelly and Stoye, 2020)	Number of publicly funded admissions (DiD, OLS) Median waiting times (DiD) 30-day readmission rate (DiD) Number of privately funded admissions (OLS)	DiD analysis comparing areas with high and low exposure to private hospital presence OLS regression to analyse impact of private hospital entry on publicly and privately funded volumes in local healthcare markets	Private hospital presence associated with increases in publicly funded admissions and reductions in median waiting times No evidence of substitution between publicly and privately funded care

As there are generally few studies on the dynamic between publicly and privately funded healthcare in the UK, it is important to consider other literature which may be relevant. There has been much greater attention in the US paid to the public-private interface in healthcare, particularly the investigation of potential "crowding out" of private health insurance coverage as a result of several expansions in public health insurance through Medicaid over the last four decades. While this is a significantly different issue, it is still useful to review these studies to ascertain what methodologies were used and whether a relationship between changes in publicly and privately funded care existed. Table 16 summarises several prominent and much cited papers that were identified by the literature review on this topic conducted by Gruber and Simon (2008), and Gresenz et al. (2012), and a narrative review of the papers' findings follows.

Cutler and Gruber (1996) examined the impact of Medicaid expansions between 1987 and 1992 that dramatically increased the number of children eligible for publicly funded health insurance using the Current Population Survey (CPS), which provides information on insurance coverage by state. They originally wished to model coverage of any individual as a function of their eligibility, but realised there was significant potential for measurement error as Medicaid eligibility was calculated in the study using reported past-calendar year income, which may be a poor predictor of current income, particularly for low income families who typically have greater income variability than other income groups. To overcome this challenge, the authors used a "simulated instrument", calculated by applying each state's eligibility rules to a fixed national population and then using the average eligibility by state, year and age as an instrument. Using this approach, they estimated the rate of crowd-out as 31% between 1987 and 1992 (i.e. for every 100 children joining Medicaid due to the expansions of eligibility, 31 lost access to private health insurance). This rate of crowd-out increased to 50% when analysing family spillover effects, as some parents chose to drop private health insurance coverage for the whole family once their child joined Medicaid. Several other studies adapted a similar approach to analyse different datasets, further expansions of Medicaid or additional controls (such as using state dummies and interactions between age, state and year), and produced estimates of crowd-out varying between 33% and 77% (Lo Sasso and Buchmueller, 2004; Hudson, Selden and Banthin, 2005; Shore-Sheppard, 2005; Gruber and Simon, 2008; Dubay and Kenney, 2009; Gresenz *et al.*, 2012). A study by Ham and Shore-Sheppard (2005) is the exception, which replicates the approach used by Cutler and Gruber (1996) but finds no evidence of crowd-out. However, this may be because

Ham and Shore-Sheppard used a different dataset (Survey of Income and Program Participation (SIPP)) and analysed an earlier time period, between 1985 and 1995.

Dubay and Kenney (1996) also used CPS data and analysed changes in coverage of children relative to changes in coverage of adult men to control for secular declines in private health insurance coverage. They subcategorised their analysis according to different income levels and found that for families with incomes below the federal poverty line, the crowd-out rate was 15% (i.e. 15 children lost coverage with private health insurance for every 100 joining Medicaid), and for families with incomes between 100 and 133% of the federal poverty line, the crowd-out rate was 22%. Dubay and Kenney (1997) repeated this analysis using CPS data between 1988 and 1992, but focused on changes in coverage of pregnant women relative to changes in coverage of adult men. They found that for families with incomes below the federal poverty line, the crowd-out rate was 0%; for families with incomes between 100 and 133% of the federal poverty line, the crowd-out rate was 27%; and for families with incomes between 133 and 185% of the federal poverty line, the crowd-out rate was 59%.

Thorpe and Florence (1998) used the National Longitudinal Survey of Youth to undertake a descriptive analysis of trends and used the percentage of those entering Medicaid with privately insured parents as their definition of crowd-out, finding that 16% of children entering Medicaid met this definition. Blumberg et al. (2000) used data from the 1990 panel of the SIPP to compare changes in insurance coverage of children made eligible by expansions to Medicaid with a control group of older children not made eligible. They used linear probability models and adjusted for region and a range of family characteristics to estimate that 4.4% of children who joined Medicaid would have had private health insurance without the expansions in coverage for publicly funded private health insurance. Yazici and Kaestner (2000) used data from the National Longitudinal Survey of Youth to undertake a DiD analysis comparing children who became eligible for Medicaid due to expansions in coverage against children who were never eligible. Depending upon the definition of crowd-out used, they found varying estimates of crowd-out with a weight average of 18.9%. Aizer and Grogger (2003) used CPS data and logistic regression to compare families above and below the income threshold for Aid to Families with Dependent Children (AFDC) benefits in states before and after expansion of Medicaid eligibility and their likelihood of having different types of insurance. Using this approach, they found no statistically significant effect of Medicaid expansion on the likelihood of private coverage for mothers and for children. They did not produce an estimate of crowd-out, as in their study Medicaid expansion was a

dummy variable. Card and Shore-Sheppard (2004) used SIPP data between 1990 and 1993 to undertake DiD and regression discontinuity analyses to analyse changes in insurance coverage in groups of children just above and under the age and family income thresholds for eligibility for Medicaid coverage. They found no evidence of crowd-out in response to expansions of Medicaid to families with incomes below the poverty line or within 100–133% of the poverty line. However, they did find some evidence of crowd-out in children from families below the poverty line when the eligibility for Medicaid was expanded to 133% of the poverty line, which they suggested may be due to informational spillovers.

In summary, there is a breadth of evidence on the relationship between changes in coverage of public and private health insurance in the US. The findings of these analyses vary according to the dataset used, time frame analysed and statistical method applied. Most of the studies acknowledge there is potential for endogeneity and measurement error when analysing these trends, and the different methods they use to overcome these issues include instrument variable, DiD and regression discontinuity analyses. However, these studies rely upon using eligibility for public health insurance as an instrument, and the availability of suitable control groups. Unfortunately, these approaches cannot be translated to the English healthcare system which is structurally different to the US healthcare system in respect of funding mechanisms (see section 1.2). Instead, the analyses in this paper will focus on exploring evidence of associations rather than causations between changes in publicly and privately funded care (in a similar manner to Kelly and Stoye, 2020).

Table 16: Crowd-out literature relevant to Medicaid expansion

Study	Outcome of interest	Study design	Findings
(Cutler and Gruber, 1996)	(Δ Privately insured/ Δ publicly insured) or (1-(Δ uninsured/ Δ publicly insured)	Instrument eligibility with simulated eligibility based on entire nation; control for state, year, age	31–50%
(Dubay and Kenney, 1996)	(Δ Privately insured/ Δ publicly insured)	Change in insurance coverage of children relative to change for adult men	Below poverty line: 15% Incomes between 100 and 133% of poverty line: 22%
(Dubay and Kenney, 1997)	(Δ Privately insured/ Δ publicly insured)	Change in insurance coverage of pregnant women relative to change for men	Incomes below poverty line: 0% Incomes between 100 and 133% of poverty line: 27% Incomes between 100 and 133% of poverty line: 59%
(Thorpe and Florence, 1998)	% of those entering Medicaid with privately insured parents	Measure movement from private insurance onto Medicaid among children with privately insured parents	16%
(Blumberg, Dubay and Norton, 2000)	% of children made eligible losing private coverage relative to gaining public coverage	Compare change in insurance coverage of children made eligible by expansions to those not made eligible	4%
(Yazici and Kaestner, 2003)	(1-(Δ uninsured/ Δ publicly insured) or (Δ Privately insured/ Δ publicly insured)	Compare change in insurance coverage of children becoming eligible to those not becoming eligible	0%–47%
(Aizer and Grogger, 2003)	Coefficient on private coverage equation (no crowd-out calculations)	Compare change in insurance, for those above Aid to Families with Dependent Children (AFDC) eligibility vs below, in states with adult expansion, before vs after expansion	Statistically insignificant effect on private coverage for mothers and for children
(Card and Shore-Sheppard, 2004)	(Δ Privately insured/ Δ publicly insured)	Compare changes in insurance coverage of children around income and age limits for eligibility	Expansion of eligibility to below poverty line: 0% Expansion of eligibility below 133% of poverty line: 50% below poverty line

			income, 0% for 100–133% income of poverty line
(Lo Sasso and Buchmueller, 2004)	(Δ Privately insured/ Δ publicly insured)	Instrument eligibility with simulated eligibility based on entire nation; control for state, year, age, state × year; interact with state waiting periods	50% but the crowd-out varied significant between states with different waiting periods
(Shore-Sheppard, 2005)	(1-(Δ uninsured/ Δ publicly insured) or (Δ Privately insured/ Δ publicly insured)	Same as Cutler and Gruber, but add additional controls – children only	33% (age/year controls) to 59% (all controls)
(Ham and Shore-Sheppard, 2005)	(Δ Privately insured/ Δ publicly insured)	Instrument eligibility with simulated eligibility based on all other states; control for state, year, age	No evidence of crowd-out
(Hudson, Selden and Banthin, 2005)	(Δ Privately insured/ Δ publicly insured)	Compare changes in children made eligible and remaining ineligible; also instrument with simulated eligibility	25–55%, Instrumental variable analysis: 39–70%
(Sommers *et al.*, 2007)	% of those joining Medicaid who previously had private health insurance in last 6 months	Comparison of characteristics of recent enrolees into Medicaid	28% (half of whom did not lose private health coverage involuntarily)
(Gruber and Simon, 2008)	(Δ Privately insured/ Δ publicly insured) or (1-(Δ uninsured/ Δ publicly insured)	Instrument eligibility with simulated eligibility in same manner as Cutler and Gruber but with additional controls	60%
(Dubay and Kenney, 2009)	(Δ Privately insured/ Δ publicly insured)	Compare changes in children made eligible and those already eligible; also instrument with simulated eligibility	44% Instrumental variable analysis: 33%
(Gresenz *et al.*, 2012)	(Δ Privately insured/ Δ publicly insured) or (1-(Δ uninsured/ Δ publicly insured)	Same as Cutler and Gruber (1996), but only focusing on children from families 200–400% above federal poverty line	3–46%

Source: Adapted from Gruber and Simon (2008) and Gresenz et al. (2012)

3.5. Method

3.5.1. Study cohort and data sources

The study cohort analysed was all patients in England who underwent 16 of the 17 procedures under the remit of the EBI programme in either NHS or private hospitals between 1 April 2017 and 28 February 2020. This study does not analyse data beyond this point as elective care activity was significantly impacted by the COVID-19 pandemic. Removal of benign skin lesions was excluded from the analysis as it is a relatively minor procedure that often takes place in outpatient clinics rather than in surgical theatre, and as a relatively high-volume procedure its inclusion could also bias results (these exclusion criteria were also applied in Paper I – see section 2.7.2). Data for publicly funded care were retrieved from the SUS database provided by NHS Digital (i.e. the non-departmental public body responsible for information, data and IT systems in England). This national administrative database contains pseudonymised and unidentifiable information on all patients accessing care in the English NHS. Privately funded care data were retrieved from PHIN, the mandated health information organisation responsible for data collection and the reporting of activity in the private health care sector since January 2016 (Competition and Market's Authority, 2014). As mentioned above, the PHIN dataset is modelled on NHS Digital datasets. Both the PHIN and SUS datasets contain patient information including demographics, diagnosis and treatment. The data are recorded in finished episodes of care, each of which relates to the clinician responsible for the respective aspect of care. To avoid counting single low value procedures multiple times, procedures were identified according to each unique hospital spell rather than completed consultant episode.

Procedures were identified using different combinations of OPCS Classification of Interventions and Procedures codes (OPCS-4) and International Classification of Diseases 10th Revision (ICD-10) codes. Relevant hospital spells were first extracted using groups of OPCS-4 codes and then inclusion criteria based on ICD-10 codes were applied to reflect indications when each procedure is classified as low value. These combinations of OPCS-4 and ICD-10 codes were developed by the EBI programme based on a literature review and feedback from stakeholders including CCGs, hospitals and specialty organisations. These codes are publicly available (NHS England, 2018b) and a summary of these codes is also contained in supplementary material (Appendix C, Table 1). To illustrate the impact of using

ICD-10 codes to identify EBI procedures, volumes of procedures from the PHIN dataset before and after the application of the ICD-10 inclusion criteria were reported (Appendix C, Table 2). This analysis was not undertaken for the SUS dataset as NHS Digital provided an extract of relevant hospital spells after the inclusion criteria had already been applied. As the PHIN dataset is relatively newly established, the percentage of hospital spells with an ICD-10 code present for dominant diagnosis was also reported to establish if this changed over time (Appendix C, Table 3).

3.5.2. Study outcomes

The primary study outcome was monthly changes in volumes of both Category 1 and Category 2 privately funded procedures under the remit of the EBI programme following implementation between April 2019 and February 2020 compared to the same month in the previous year. I was unable to analyse changes in volume at the physician level, as I did not have corresponding physician identifiers across both datasets. I was also unable to analyse changes in volume at CCG level as this is not recorded in the PHIN dataset. To account for potential heterogeneity in trends for individual procedures, all analyses were repeated at the individual procedural level. As a robustness analysis, the monthly change in volume between April 2019 and February 2020 and the same month two years previously was also calculated to account for potential anticipatory change as the commissioning guidance for the EBI programme was published in November 2018 (NHS England, 2018b).

The primary study outcome was analysed at both the hospital and local healthcare market level. Hospitals of interest were private hospitals, rather than NHS hospitals which perform only small volumes of privately funded procedures and therefore unlikely to experience significant substitution. In 2019, only 1% of elective care admissions in NHS hospitals were privately funded (PHIN, 2020a). In contrast, approximately 47% of elective care admissions in private hospitals were funded by the NHS in the same year (PHIN, 2020a). Local healthcare markets were defined as changes in volumes of the provision of privately and publicly funded care, including NHS hospitals, within 30 kilometers of any private hospital. This definition of local healthcare markets has been used several times previously in literature focused on competition in local healthcare markets in England (Cooper *et al.*, 2012; Cooper, Gibbons and Skellern, 2018a). This was estimated using the STATA code *geonear* (Picard, 2019), which uses Vincenty's formulae to calculate the direct distances between two

points. The postcode of each hospital was geocoded into longitude and latitude coordinates using a freely available batch geocoding service (Doogal, 2022). Each local healthcare market was not mutually exclusive, meaning that changes in volume in hospitals could be included in multiple local healthcare markets. This definition reflects how NHS and private hospitals function in practice in England as local healthcare markets do not operate independently of one another and typically overlap (OHID, 2022).

Secondary outcomes included changes in volume of both Category 1 and 2 procedures accessed through either the self-pay or insurance funding mechanisms. This analysis was conducted as changes in volumes of self-pay care are reflective of individual willingness to pay, and therefore potentially more representative of unmet need for NHS care than changes in insurance funded care. In contrast, changes in volume of insurance funded care can be influenced by a variety of factors including unmet need for NHS care, trends in the number of insurance policies nationally, and the coverage policies by individual insurers for specific procedures. As the PHIN dataset does not include data on the specific insurer associated with each hospital spell, it was not possible to explore the impact of these different factors on trends for insurance funded care.

3.5.3. Statistical analysis

An OLS with fixed effects estimator was used to analyse the association between changes in volume of privately funded and publicly funded procedures at hospital, and local healthcare market level, using STATA SE v.16. The regression model used at both the hospital and local healthcare market level of analysis is below:

[1] $$\Delta Y_{xt} = \beta_0 + \beta_1 \Delta PFlowvalue_{xt} + \beta_2 Z_{xt-1} + \varepsilon_{xt}$$

ΔY_{xt} is the dependent variable, the change in volume of privately funded procedures undertaken by hospital or local healthcare market, x, for each month, *t*, in 2019/20 compared to the same month in 2018/19. $\Delta PFlowvalue_{it}$ is the change in volume of publicly funded procedures by the same hospital or local healthcare market, x, for each month, *t*, in 2019/20 compared to the same month in 2018/19. March was removed from the data to account for the influence of the emergence of the COVID-19 pandemic. Z_{xt-1} is a number of controls reflecting baseline characteristics for each hospital, such as total volume of procedures,

region, and aggregate patient characteristics (age, gender, charlson index, and IMD score). Fixed effects estimators were used to difference all time-invariant hospital characteristics from equation, and standard errors were also clustered at the hospital level. Multicollinearity and Hausman assumption tests were performed to ensure the models were correctly specified (Appendix C, Tables 4, and 5) (Hausman, 1978; Belsley, Kuh and Welsch, 2005). Scatter plot graphs were also produced to ensure there was no evidence of non-linear trends between the dependent and independent variables (Appendix C, Figures 1 and 2).

The model was repeated for both Category 1 and 2 procedures separately. This model was also run separately according to changes in volume of each individual procedure, and for procedures accessed either through the self-pay or insurance funding mechanisms. As mentioned above, further robustness analyses included repeating all models to compare changes in publicly and privately funded volume in month, *t*, in 2019/20 compared to the same month in 2017/18. The model was also run separately for all nine regions of England, because there is significant regional variation in the provision of privately funded care (Table 1).

3.6. Results

3.6.1. Descriptive statistics

The trends between publicly and privately funded volumes for procedures under the remit of the EBI programme undertaken in private hospitals reveal that from November 2018 the number of privately funded procedures exceeds and remains consistently above the number of publicly funded procedures (Figure 11). These trends are similar at the regional level, with all regions experiencing an increase in privately funded care in 2019/20 compared to 2018/19 (Appendix C, Table 6). The overall trends are reflected for several individual procedures when comparing financial years (Table 17). There are reductions in publicly funded volumes for all procedures except grommets and Dupuytren's contracture release.

In contrast, trends in privately funded volumes are mixed. There were increases in privately funded volumes for many procedures including knee arthroscopy for osteoarthritis, injections for nonspecific low back pain without sciatica, breast reduction, carpal tunnel syndrome release, Dupuytren's contracture release, ganglion excision and trigger finger release. However, volumes also remained steady for many procedures including surgical intervention for snoring, grommets, tonsillectomy, haemorrhoid surgery, hysterectomy for heavy bleeding and shoulder decompression. There was no evidence that diagnostic coding in the PHIN dataset varied significantly between procedures or over time (Appendix C, Table 3), with completeness of dominant diagnosis coding above 95% for all procedures in every financial year.

Figure 11: Trends in NHS and privately funded low value procedures undertaken at private hospitals between April 2017 and February 2020

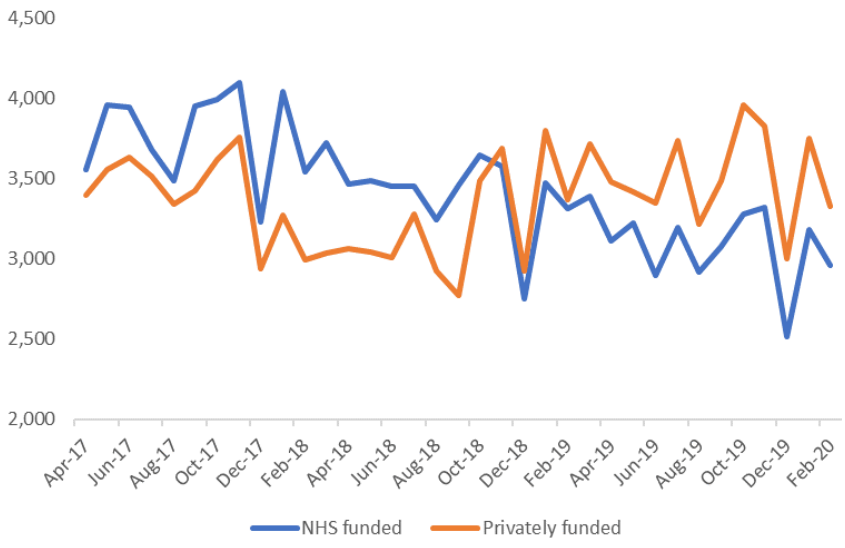


Table 17: Volumes of procedures in private hospitals in England by funding mechanism 2017/18 to 2019/20 [§]

	2017/18		2018/19		2019/20	
Procedure	Privately funded	NHS funded	Privately funded	NHS funded	Privately funded	NHS funded
Category 1 procedures						
Surgical intervention for snoring (not OSA)	47	56	35	51	45	40
Dilatation and curettage for heavy menstrual bleeding	60	88	57	40	75	52
Knee arthroscopy with osteoarthritis	220	1,349	339	871	424	763
Injection for nonspecific low back pain without sciatica	8,645	7,860	8,540	7,470	9,276	6,546
Total	8,972	9,353	8,971	8,432	9,820	7,401
Category 2 procedures						
Breast reduction	2,630	*	2,701	9	2,852	*
Grommets	355	221	329	230	380	227
Tonsillectomy	4,051	1,750	3,945	1,688	4,007	1,264
Haemorrhoid surgery	1,399	1,680	1,356	1,655	1,359	1,611
Hysterectomy for heavy bleeding	2,910	1,793	2,820	1,728	2,906	1,693
Chalazia removal	134	205	137	188	206	187
Shoulder decompression	2,867	5,309	2,446	3,795	2,563	2,613
Carpal tunnel syndrome release	2,960	11,384	2,988	10,307	3,861	9,968
Dupuytren's contracture release	869	3,625	1,056	3,710	1,223	3,583
Ganglion excision	623	1,926	728	1,537	849	1,522
Trigger finger release	670	2,323	801	2,248	868	2,061
Varicose vein surgery	9,017	1,922	7,082	1,804	7,665	1,563
Total	28,485	32,144	26,389	28,899	28,739	26,298

[§]These volumes reflect the number of hospital spells that meet inclusion criteria for EBI procedures based on International Classification of Diseases 10th Revision (ICD-10) codes developed to reflect instances of low value care. Therefore, the total number of procedures that do not meet these criteria is much higher. March has been removed from the above data to account for the influence of the emergence of the COVID-19 pandemic.
*PHIN applies a policy of small number suppression for any activity levels <8.

I found that average patient characteristics indicate that privately funded patients receiving the procedures under the remit of the EBI programme are consistently younger, have a lower number of comorbidities, and reside in less deprived areas (Table 18). Large volumes of privately funded care are accessed through employer funded insurance (Appendix C, Table 7), which is unsurprising as patients accessing privately funded care are more likely to be of working age and have higher incomes than publicly funded patients. A higher proportion of both privately funded and publicly funded Category 1 procedures were female. This aligns with pre-existing literature which indicates the prevalence of low back pain, and a higher

incidence of knee arthritis in the female population (Srikanth *et al.*, 2005; Wáng, Wáng and Káplár, 2016; Cui *et al.*, 2020; Palacios-Ceña *et al.*, 2021). Similarly, a higher proportion of both privately funded and publicly funded Category 2 procedures were for female patients. This is likely a reflection of the fact that two Category 2 procedures are performed exclusively for female patients, specifically breast reduction and hysterectomy for heavy bleeding (Table 17).

Table 18: Mean patient characteristics for patients treated in private hospitals by funding mechanism, 2017/18 to 2019/20[§]

	2017/18		2018/19		2019/20	
Procedure	Privately funded	NHS funded	Privately funded	NHS funded	Privately funded	NHS funded
Category 1 procedures						
Age	56.10 (55.76, 56.43)	58.31 (58.00, 58.62)	56.49 (56.16, 56.82)	58.67 (58.34, 59.00)	56.13 (55.81, 56.45)	58.51 (58.16, 58.85)
Gender	0.53 (0.52, 0.54)	0.62 (0.61, 0.63)	0.54 (0.53, 0.55)	0.62 (0.61, 0.63)	0.53 (0.52, 0.54)	0.62 (0.61, 0.63)
CCI	0.11 (0.10, 0.12)	0.24 (0.23, 0.26)	0.12 (0.11, 0.12)	0.26 (0.25, 0.27)	0.11 (0.10, 0.11)	0.23 (0.22, 0.25)
IMD score	13.69 (13.48, 13.89)	21.04 (20.73, 21.36)	13.28 (13.08, 13.48)	21.33 (21.01, 21.66)	13.31 (13.12, 13.50)	21.62 (21.26, 21.97)
Category 2 procedures						
Age	48.61 (48.40, 48.83)	54.98 (54.80, 55.15)	48.82 (48.59, 49.05)	55.10 (54.91, 55.28)	49.07 (48.84, 49.29)	55.76 (55.56, 55.96)
Gender	0.66 (0.66, 0.67)	0.58 (0.58, 0.59)	0.66 (0.65, 0.66)	0.57 (0.57, 0.58)	0.64 (0.64, 0.65)	0.58 (0.58, 0.59)
CCI	0.08 (0.07, 0.08)	0.20 (0.19, 0.20)	0.09 (0.08, 0.09)	0.21 (0.21, 0.22)	0.09 (0.09, 0.09)	0.21 (0.21, 0.22)
IMD Score	13.69 (13.57, 13.81)	19.68 (19.52, 19.84)	13.27 (13.15, 13.39)	19.52 (19.35, 19.69)	13.47 (13.35, 13.59)	19.50 (19.33, 19.68)
Total						
Age	50.40 (50.22, 50.59)	55.73 (55.57, 55.88)	50.77 (50.57, 50.96)	55.91 (55.74, 56.07)	50.86 (50.68, 51.05)	56.36 (56.19, 56.54)
Gender	0.63 (0.63, 0.64)	0.59 (0.59, 0.59)	0.63 (0.62, 0.63)	0.58 (0.58, 0.59)	0.61 (0.61, 0.62)	0.59 (0.58, 0.59)
CCI	0.09 (0.08, 0.09)	0.21 (0.20, 0.21)	0.09 (0.09, 0.10)	0.22 (0.22, 0.23)	0.09 (0.09, 0.10)	0.22 (0.21, 0.22)
IMD Score	13.69 (13.59, 13.79)	19.99 (19.84, 20.13)	13.27 (13.17, 13.37)	19.93 (19.78, 20.08)	13.44 (13.34, 13.54)	19.97 (19.81, 20.13)

[§]95% confidence intervals in parentheses, CCI: Charlson Comorbidity Index, IMD: Index of Multiple Deprivation. Gender, 1= female, 0 = male. March has been removed from the above data to account for the influence of the emergence of the COVID-19 pandemic.

3.6.2. Primary analysis

Table 19: Association between publicly and privately funded monthly volume change between 2019/20 and 2018/19 for EBI elective procedures[§]

	(Total) Private hospital	(Category 1) Private hospital	(Category 2) Private hospital	(Total) Local healthcare market	(Category 1) Local healthcare market	(Category 2) Local healthcare market
Δ NHS volume	-0.17*** (-0.24, -0.10)	-0.19*** (-0.30, -0.08)	-0.19*** (-0.25, -0.12)	-0.28*** (-0.41, -0.15)	-0.11 (-0.28, 0.07)	-0.24*** (-0.32, -0.15)
Gender	2.71 (-0.81, 6.21)	-1.35 (-4.64, 1.94)	3.72* (0.61, 6.83)	8.10 (-90.53, 106.74)	-17.44 (-59.21, 24.33)	-6.63 (-97.21, 83.96)
CCI	-0.29 (-4.56, 3.99)	-6.18*** (-9.35, -3.02)	-0.99 (-4.82, 2.30)	-27.33 (-113.53, 58.86)	-31.65 (-64.69, 1.39)	-20.42 (-91.23, 50.38)
Age	-0.02 (-0.14, 0.09)	0.01 (-0.09, -0.10)	-0.07 (-0.17, 0.02)	-2.71* (-4.80, -0.61)	-0.77 (-2.45, 0.91)	-2.82** (-4.79, -0.85)
IMD	-0.09 (-0.20, 0.03)	-0.12** (-0.20, -0.03)	0.00 (-0.09, 0.10)	-1.84 (-6.24, 2.57)	-0.61 (-1.93, 0.71)	0.10 (-4.30, 4.50)
Total volume	0.46*** (0.39, 0.53)	0.53*** (0.40, 0.67)	0.48*** (0.41, 0.55)	0.68*** (0.44, 0.93)	0.82** (0.33, 1.31)	0.59*** (0.48, 0.71)
Constant	-16.12*** (-23.63, -8.6 1)	-6.59* (-12.17, -1.01)	-12.41*** (-18.83, -5.99)	-657.86*** (-1003.76, -311.96)	-426.31** (-714.25, -138.38)	-370.78*** (-575.74, -165.82)
Observations	1,336	357	1,290	2,123	1,150	2,105
Adjusted R^2	0.195	0.295	0.193	0.353	0.416	0.255
Number of unit of observations	142	68	141	216	164	212

§ 95% confidence intervals in parentheses, CCI: Charlson Comorbidity Index, IMD: Index of Multiple Deprivation. *** p<0.001, ** p<0.01, * p<0.05. March has been removed from the above data to account for the influence of the emergence of the COVID-19 pandemic.

In the primary regression model, which used monthly change for all privately funded procedures in 2019/20 compared to 2018/19 as the dependent variable (Table 20), there was significant evidence of substitution between NHS and privately funded procedures at the hospital level (-0.17, 95% CI -0.24, -0.10), with similar findings for both Category 1 (-0.19, 95% CI -0.30, -0.08), and Category 2 procedures (-0.19, 95% CI -0.25, -0.08). This is approximately equivalent to an increase of one privately funded low value procedure for every five fewer publicly funded low value procedures. At the local healthcare market, there was significant evidence for all procedures (-0.28, 95% CI -0.41, -0.15), although this finding was only significant for Category 2 procedures (-0.24, 95% CI -0.32, -0.15), and not significant for Category 1 procedures (-0.11, 95% CI -0.28, 0.07). When focusing on total changes in volumes in procedures, this is approximately equivalent to an increase of one privately funded low value procedure for every four fewer publicly funded low value

procedures. These findings were replicated in the sensitivity analysis which compared monthly change in 2019/20 with monthly change in 2017/18 (Appendix C, Table 8), although in this model there was a significant finding for Category 1 procedures at the local healthcare market level (-0.43, 95% CI -0.84, -0.02).

Additional supplementary analyses included assessing whether there was an association between changes in publicly funded procedures and privately funded procedures accessed through either the self-pay or insurance funding mechanisms (Appendix C, Tables 9, and 10). These models produced similar findings to the primary analysis, with significant evidence of substitution at both the hospital and local healthcare market level and no significant evidence of substitution in Category 1 procedures at the local healthcare market level. When analysing monthly change in volume between 2019/20 and 2017/18 for these different funding mechanisms, there were similar findings to the primary analysis (Appendix C, Tables 11, and 12).

3.6.3. Individual procedure analysis

When focusing on individual procedures it is possible to gain a better understanding regarding which procedures are driving the overall trends for Category 1 and 2 procedures (Table 20). For Category 1 procedures, the highest-volume procedure is injection for nonspecific low back pain without sciatica (Table 17). For this procedure, there is significant evidence of substitution at the private hospital level for all privately funded care (-0.21, 95% CI -0.35, -0.07), the insurance market (-0.16, 95% CI -0.30, -0.02) and the self-pay market (-0.16, 95% CI -0.26, -0.06) (Table 20). For all privately funded care, this is approximately equivalent to an increase of one privately funded injection for nonspecific low back pain for every five fewer publicly funded injections. However, when focusing on local markets there is no significant evidence of substitution. Unsurprisingly, as the highest-volume Category 1 procedure, this echoes the findings outlined above for all Category 1 procedures (Table 19). For other individual Category 1 procedures, there were too few observations to produce coefficient estimates, with the exception of knee arthritis for osteoarthritis at the local healthcare market level (-0.32, 95% CI -0.64, 0.00). This is approximately equivalent to an increase of one privately funded knee arthroscopy for osteoarthritis for every three fewer publicly funded knee arthroscopies.

Table 20: Association between publicly and privately funded monthly volume change for individual EBI procedures between 2019/20 and 2018/19[§]

	Private hospitals Δ Total private volume	Private hospitals Δ Insured volume	Private hospitals Δ Self-pay volume	Local healthcare market Δ Total private volume	Local healthcare market Δ Insured volume	Local healthcare market Δ Self-pay volume
Category 1 procedures						
Surgical intervention for snoring (not OSA)	—	—	—	—	—	—
Dilatation and curettage for heavy menstrual bleeding	—	—	—	—	—	—
Knee arthroscopy with osteoarthritis	—	—	—	-0.32* (-0.64, -0.00)	0.14 (-0.41, 0.12)	—
Injection for nonspecific low back pain without sciatica	-0.21** (-0.35, -0.07)	-0.16* (-0.30, -0.02)	-0.16** (-0.26, -0.06)	-0.10 (-0.30, 0.09)	-0.09 (-0.27, 0.09)	-0.01 (-0.05, 0.03)
Category 2 procedures						
Breast reduction	—	—	—	—	—	—
Grommets	—	—	—	-0.87*** (-1.03,-0.72)	-0.82*** (-1.03,-0.62)	—
Tonsillectomy	-0.38*** (-0.50, -0.27)	-0.30*** (-0.41, -0.19)	-0.17* (-0.33, -0.01)	-0.52*** (-0.75, -0.30)	-0.42*** (-0.62, -0.22)	-0.05 (-0.15, 0.05)
Haemorrhoid surgery	-0.16 (-0.42, 0.11)	-0.18 (-0.45, 0.08)	—	-0.33*** (-0.41, -0.25)	-0.29*** (-0.40, -0.17)	—
Hysterectomy for heavy bleeding	-0.42*** (-0.58, -0.26)	-0.38*** (-0.53, -0.23)	-0.26 (-0.80, 0.29)	-0.34** (-0.55, -0.14)	-0.34*** (-0.51, -0.17)	-0.04 (-0.08, 0.00)
Chalazia removal	—	—	—	-0.01 (-0.04, 0.02)	-0.02 (-0.05, 0.02)	0.00 (-0.01, 0.01)
Shoulder decompression	-0.16* (-0.30, -0.02)	-0.18* (-0.35, -0.01)	0.05 (-0.15, 0.26)	-0.06 (-0.23, 0.12)	-0.01 (-0.19, 0.17)	-0.03 (-0.05, 0.00)
Carpal tunnel syndrome release	-0.18*** (-0.25, -0.12)	-0.15*** (-0.24, -0.07)	-0.04 (-0.12, 0.04)	-0.13*** (-0.20, -0.06)	-0.08** (-0.13, -0.03)	-0.00 (-0.02, 0.01)
Dupuytren's contracture release	-0.21*** (-0.29, -0.13)	-0.14* (-0.26, -0.01)	—	-0.15* (-0.26, -0.03)	-0.05* (-0.09, -0.00)	—
Ganglion excision	-0.09 (-0.22, 0.03)	-0.09 (-0.28, 0.10)	—	-0.27 (-0.55, 0.02)	-0.12 (-0.24, 0.01)	—
Trigger finger release	-0.26** (-0.44, -0.07)	-0.13 (-0.45, 0.19)	—	-0.23** (-0.39, -0.06)	-0.19 (-0.39, 0.01)	—
Varicose vein surgery	-0.13 (-0.28, 0.02)	-0.06 (-0.21, 0.09)	-0.13* (-0.26, -0.01)	-0.36*** (-0.49, -0.23)	-0.35*** (-0.48, -0.21)	-0.33*** (-0.49, -0.16)

[§] Standard errors in parentheses, *** p<0.001, ** p<0.01, * p<0.05. — observations in changes in volume for this procedure or financial mechanism were not sufficient to produce coefficient estimates. March has been removed from the above data to account for the influence of the emergence of the COVID-19 pandemic

For Category 2 procedures, the coefficient which represents the association between changes in publicly funded and privately funded care at the private hospital level is largest for tonsillectomy (-0.38, 95% CI -0.50, -0.27) and hysterectomy for heavy bleeding (-0.42, 95% CI -0.58, -0.26) (Table 20). This is approximately equivalent to an increase of one privately funded low value procedure for every three fewer publicly funded procedures. When focusing on local healthcare markets, the coefficient is largest for grommets (-0.87, 95% CI -1.03, -0.72), which is almost equivalent to one-to-one substitution between reductions in publicly funded care and increases in privately funded care. For tonsillectomy the degree of substitution is approximately equivalent to an increase of one privately funded procedure for every two fewer publicly funded procedures (-0.52, 95% CI -0.75, -0.30). In contrast, for haemorrhoid surgery (-0.33, 95% CI -0.41, -0.25), hysterectomy for heavy bleeding (-0.34, 95% CI -0.55, -0.14) and varicose vein surgery (-0.36, 95% CI -0.49, -0.23), the degree of substitution is approximately equivalent to an increase of one privately funded procedure for every three fewer publicly funded procedures (Table 20).

The findings for Category 2 procedures accessed through insurance mechanisms (Table 20), are similar to changes in total volumes for all privately funded care (Table 19), but for the self-pay market there is only significant evidence of substitution for varicose vein surgery at the private hospital level (-0.13, 95% CI -0.26, -0.01) and local healthcare market level (-0.33, 95% CI -0.49, -0.16), and tonsillectomy at the private hospital level (-0.17, 95% CI -0.33, -0.01) (Table 20). However, this discrepancy may simply reflect the fact that volumes of procedures accessed through self-pay mechanisms are generally lower than those accessed through insurance mechanisms (Appendix C, Table 7), and therefore for many individual procedures, rather than demonstrating lack of substitution, the coefficients are likely to be statistically underpowered as there are too few observations.

3.6.4. Regional analysis

When analysing individual regions at the private hospital level (Table 21), it becomes clear that the strongest evidence of substitution between publicly and privately funded care exists in the West Midlands (-0.33, 95% CI -0.55, -0.10), South West (-0.31, 95% CI -0.53, -0.08) and Greater London (-0.27, 95% CI -0.45, -0.09). This is approximately equivalent to an increase of one privately funded low value procedure for every three fewer publicly funded procedures in the West Midlands and the South West, and every four fewer privately funded procedures in Greater London.

Table 21: Association between NHS and privately funded monthly volume change between 2019/20 and 2018/19 for individual EBI procedures by region[§]

Region	(Total) Private Hospital	(Category 1) Private hospital	(Category 2) Private hospital	(Total) Local healthcare market	(Category 1) Local healthcare market	(Category 2) Local healthcare market
East Midlands	-0.15 (-0.34, 0.05)	-0.12 (-0.49, 0.25)	-0.17 (-0.35, 0.02)	-0.12 (-0.31, 0.06)	-0.14 (-0.42, 0.14)	-0.06 (-0.26, 0.13)
East of England	-0.12 (-0.27, 0.03)	-0.00 (-0.13, 0.13)	-0.36*** (-0.51, -0.21)	-0.15*** (-0.16, -0.13)	0.01 (-0.01, 0.02)	-0.13 (-0.32, 0.07)
Greater London	-0.27** (-0.45, -0.09)	-0.63*** (-0.85, -0.41)	-0.17* (-0.33, -0.00)	-0.41*** (-0.59, -0.23)	-0.75*** (-1.08, -0.42)	-0.27** (-0.45, -0.10)
North East	0.04 (-0.35, 0.43)	—	-0.01 (-0.43, 0.40)	0.11 (-0.31, 0.52)	-0.05*** (-0.07, -0.04)	-0.01 (-0.33, 0.32)
North West	-0.12* (-0.23, -0.01)	-0.21* (-0.42, -0.01)	-0.06 (-0.18, 0.07)	-0.09 (-0.22, 0.04)	-0.21 (-0.52, 0.09)	-0.05 (-0.13,0.03)
South East	-0.22 (-0.44, 0.01)	-0.25 (-0.54, 0.03)	-0.29** (-0.47, -0.11)	-0.41*** (-0.53, -0.29)	-0.36*** (-0.50, -0.22)	-0.35*** (-0.45, -0.24)
South West	-0.31* (-0.53, -0.08)	-0.07 (-0.36, 0.23)	-0.32* (-0.56, -0.08)	-0.23* (-0.41, -0.05)	-0.05 (-0.18, 0.07)	-0.21** (-0.32, -0.09)
West Midlands	-0.33** (-0.55, -0.10)	-0.60** (-0.89, -0.31)	-0.28** (-0.47, -0.08)	-0.25*** (-0.38, -0.12)	-0.61*** (-0.84, -0.37)	-0.20** (-0.32, -0.07)
Yorkshire and the Humber	-0.04 (-0.28, 0.21)	-0.18 (-0.42, 0.06)	-0.01 (-0.19, 0.16)	-0.02 (-0.18, 0.15)	-0.09 (-0.41, 0.23)	-0.03 (-0.15, 0.09)

[§]95% Confidence intervals in parentheses, *** p<0.001, ** p<0.01, * p<0.05. — observations in changes in volume for this procedure or financial mechanism were not sufficient to produce coefficient estimates. March has been removed from the above data for all financial years to account for the influence of the emergence of

These significant findings may also be driven by a higher number of private hospitals in these regions, and therefore units of observation. Significant evidence of substitution between publicly and privately funded care only exists for Category 1 procedures in Greater London (-0.63, 95% CI -0.85, -0.41), the North West (-0.21, 95% CI -0.42, -0.01) and the West Midlands (-0.60, 95% CI -0.89, -0.31). In contrast, significant evidence of substitution between publicly and privately funded care exists for Category 2 procedures in the East of England (-0.36, 95% CI -0.51, -0.21), Greater London (-0.17, 95% CI -0.33, -0.00), the South East (-0.29, 95% CI -0.47, -0.11), the South West (-0.32, 95% CI -0.56, -0.08) and the West Midlands (-0.28, 95% CI -0.47, -0.08). When analysing local healthcare markets which take account of changes of publicly funded care in NHS hospitals, the only regions with consistent evidence of substitution between publicly and privately funded care were Greater London (-0.41, 95% CI -0.59, -0.23), the South East (-0.41, 95% CI -0.53, -0.29) and the West Midlands (-0.25, 95% CI -0.38, -0.12). For Greater London, and the South East, this is approximately equivalent to an increase of two privately funded low value procedures for every five fewer publicly funded procedures. For the West Midlands, the substitution is approximately equivalent to an increase of one privately funded low value procedure for every four fewer publicly funded procedures. The strongest evidence of substitution between publicly and privately funded care existed for Category 1 procedures in Greater London (-0.75, 95% CI -1.08, -0.42) and the West Midlands (-0.61, 95% CI -0.84, -0.37). This is approximately equivalent to an increase of two privately funded procedures for every three fewer publicly funded procedures in Greater London, and an increase of three privately funded procedures for every five fewer privately funded procedures in West Midlands. There were broadly similar findings when analysing individual regions according to funding mechanism (Appendix C, Tables 13 and 14), although there were fewer significant coefficients when analysing changes in privately funded care accessed through self-pay mechanisms. As mentioned above, this may reflect how volumes of procedures accessed through self-pay mechanisms are generally lower than those accessed through insurance mechanisms (Appendix C, Table 7), and therefore, rather than lack of substitution, many of these coefficients are likely to be statistically underpowered as there are too few observations.

3.7. Discussion

3.7.1. Summary of findings

This study indicates that, following the implementation of the EBI programme, there is an association between reductions in the provision of publicly funded care and increases in privately funded care for a series of procedures classified as low value by NHS England. These findings are more consistent at the private hospital level, and for both Category 1 and 2 procedures the degree of substitution is approximately equivalent to an increase in one privately funded procedure for every five fewer publicly funded procedures conducted. When focusing on local healthcare markets, which also take account of reductions in publicly funded care at NHS hospitals within a 30 kilometer radius of private hospitals, I find mixed results. For Category 2 procedures, the extent of substitution is stronger and approximately equivalent to an increase in one privately funded procedure for every four fewer publicly funded procedures conducted. For some individual procedures the extent of substitution is bigger, including for grommets, tonsillectomy, haemorrhoid surgery, hysterectomy for heavy bleeding, and varicose vein surgery. In contrast, there is less significant evidence of substitution at the local healthcare market level for Category 1 procedures. This may be because many Category 2 procedures are clinically appropriate in certain circumstances, and it is therefore more plausible that physicians in NHS hospitals would direct patients to access these procedures in the private healthcare sector than for Category 1 procedures which are understood as not cost- or clinically effective in any circumstances. Moreover, the target set by NHS England to reduce provision of Category 2 procedures to 25% of baseline levels is not evidence based or based upon estimates of appropriate demand. Therefore, there is a risk that disinvestment by NHS providers may result in unmet need in patient populations. However, the overall findings for Category 1 and 2 procedures obscure trends within individual regions which suggests that the most substitution between publicly and privately funded care is concentrated in Greater London, the South East, and the West Midlands. In these regions, substitution between publicly and privately funded care is actually larger for Category 1 than for Category 2 procedures. Even though Category 1 procedures are considered less necessary than Category 2 procedures, patients in these regions are likely to have a lower threshold to seek privately funded care for Category 1 procedures than in other regions as populations in these regions are more affluent, and have greater coverage of private medical insurance.

3.7.2. Strengths and limitations

There are a number of important strengths to this analysis. To begin with, this is the first analysis from the United Kingdom that has explored whether an association exists between changes in publicly funded and privately funded care for procedures undergoing disinvestment by the NHS. Second, while this analysis focuses specifically on private hospitals, the impact of changes in volumes for publicly funded care in NHS hospitals is captured through the local healthcare market analysis. Third, through its additional supplementary analysis, this study explores changes in the volume of procedures accessed by means of different financial mechanisms, specifically either insurance or out-of-pocket payments. However, there are also potential limitations associated with this analysis. First, this study has only analysed data for a limited time period. This is because PHIN has only collected data on privately funded care since January 2016, and it was not possible to conduct analyses beyond February 2020 because of the COVID-19 pandemic. Second, there are limitations in using NHS Digital and PHIN datasets to identify procedures because relevant codes are typically determined by clinical coders who work from patient notes and have little contact with frontline clinical staff. Consequently, misinterpretations and omissions can occur (Burns *et al.*, 2012; Herbert *et al.*, 2017). Moreover, the PHIN dataset is newly established and has been used less for research purposes than NHS Digital datasets. Nonetheless, this study shows that the quality of diagnostic coding in the PHIN dataset is high and did not change significantly over time during the period of analysis of this study. Third, there is potential for reverse causation in this analysis. Specifically, increased provision of privately funded care may result in reductions in publicly funded care, rather than vice versa. However, this is unlikely as trends in elective care provision were analysed following the implementation of a national policy that actively sought to reduce publicly funded care for specific procedures. Fourth, it was not possible to analyse data at the physician level of analysis as consistent identifiers were not available across PHIN and NHS Digital datasets. As most hospital consultants working in private hospitals also hold contracts in NHS hospitals, analysing changes in volume at the physician level of analysis would have potentially identified strong evidence of supplier-induced demand. Finally, this study cannot disentangle the impact of the several concurrent changes that were happening during the period of analysis. NHS waiting lists to access publicly funded care grew from 3.8 million in April 2017 to 4.4 million in February 2020 (NHS England, 2022a), and hospitals may have deprioritised procedures understood to be low value in favour of more urgent and high value

procedures even without the EBI programme. There was also a slight expansion of the number of private health insurance policies in the United Kingdom, from 3.98 to 4.10 million between 2017 and 2020 (Laing, 2022), which may have contributed to increases in privately funded care. Conversely, some insurers may have anticipated the impact of the EBI programme and tightened coverage policies to restrict access to certain procedures. Hospitals or physicians may have engaged with selective coding of diagnoses to avoid procedures being classified as low value, potentially influencing trends in both publicly and private funded care. Therefore, this study cannot demonstrate the causal impact of the EBI programme and instead only analyses the relative association between changes in publicly and privately funded care, while acknowledging multiple factors were driving these trends.

3.7.3. Policy implications and conclusion

This study indicates that reductions in publicly funded care were associated with increases in privately funded care following a national initiative to reduce the provision of procedures classified as low value in certain circumstances. However, this study cannot conclusively state to what extent this increased demand in the private healthcare sector is driven by patients, suppliers, or trends in coverage with private medical insurance. Therefore, further qualitative and operational research is needed to gain a more complete understanding of the associations in this study. This will involve mapping referral pathways for patients accessing privately funded care and structured interviews with patients and hospital consultants to ascertain the underlying decisions to seek care outside the NHS. As it is ultimately hospital consultants who consent patients and provide access to surgical procedures, there may be a role for increased regulation and penalties for hospital consultants that continue to provide procedures classified as low value in all circumstances that can expose patients to unnecessary harm and risk of adverse events.

Further investigation is also needed to establish if the target set by the NHS in England to reduce provision of EBI procedures to 25% of baseline levels is appropriate or evidence-based for all procedures. There is also scope to develop more appropriate region-specific targets that reflect disease epidemiology rather than just the age and gender of local populations. Moving forward, this study highlights there is a need for greater collaboration between the NHS, private healthcare providers and private medical insurers to ensure a

coordinated response to disinvestment from low value care, including mitigation of the potential risk of unmet healthcare need when such a procedure is clinically indicated.

4. Chapter 4 (Paper III): A comparison of patient outcomes, adverse events and efficiency of private and NHS hospitals in England for primary hip and knee replacements

4.1. Abstract

***Objective*:** To undertake a comparative assessment of patient outcomes, efficiency and adverse events in private and NHS hospitals in England when providing elective orthopaedic surgery.

***Data sources*:** Hospital administrative data were used for all elective primary hip and knee replacements undertaken between January 2016 and December 2019. Patient records for the English National Health Service were provided by the NHS Digital Hospital Episode Statistics (HES) database. Total volumes for publicly and privately funded care were provided by the Private Healthcare Information Network (PHIN). Patient-reported outcome measures (PROMs) were provided by the NHS England PROMs programme.

***Study design*:** Comparative probability was estimated for three outcome measures (in-hospital mortality, readmissions with 28 days, hospital transfers), and four adverse events (hospital-acquired infection, adverse drug reactions, pressure ulcers, venous thromboembolism). The association between treatment in a private hospital and two further efficiency measures were also estimated (pre-operative and post-operative length of stay (LOS)). To account for unobserved confounding at the patient-level, differential distance between nearest NHS and private hospitals was used as an instrumental variable (IV). The robustness of the results was assessed using ordinary least squares (OLS) with fixed effects, and propensity score matching. Further supplementary analyses included analysing hospitals exclusively located in Greater London, individual reimbursement codes, and hospitals classified according to their status, whether as treatment centres or for-profit. Finally, the implications for outcomes and efficiency of experiencing adverse events in private and NHS hospitals was estimated.

***Data collection/extraction methods*:** Patients were identified based on procedural codes for primary and hip replacements defined by the National Joint Registry (NJR). Adverse events

were identified using diagnostic codes and translated Patient Safety Indicators developed by the US Agency for Healthcare Research and Quality.

***Principal findings*:** Between January 2016 and December 2019, 31.04% of elective primary hip replacements and 31.28% of knee replacements were undertaken in private hospitals rather than NHS hospitals. When using differential distance between NHS and private hospitals as an IV for hospital choice, there were no significant differences in probability of any patient outcome or adverse event. There were no significant differences in pre-operative LOS, but treatment in private hospital was associated with longer post-operative LOS. There were contrasting results to those produced with IV analyses when using OLS with fixed effects, and propensity score matching, with treatment in private hospital associated with better outcomes, lower probability of adverse events, and shorter post-operative LOS. This indicates there are important unobservable confounding at the patient-level between private and NHS hospitals not adjusted for in these models. The supplementary analyses produced broadly similar results. Propensity score matching revealed an association between experiencing adverse events and poorer outcomes and greater LOS in both private and NHS hospitals.

***Conclusions*:** Despite previous literature indicating that private hospitals provide higher quality of care than NHS hospitals, I find no evidence of differences in quality of care between private and NHS hospitals when using an IV approach to account for both observable and unobservable confounding at the patient-level. This suggests that weaker methods that only adjust for observable confounders overlook unobserved confounding at the patient-level between private and NHS hospitals in England.

4.2. Introduction

Since the implementation of market-based healthcare reforms in the mid-2000s (Dixon *et al.*, 2010), private hospitals have provided a larger proportion of publicly funded care for many common elective procedures. The overall contribution of private hospitals to publicly funded care in 2018/19 was estimated to be around 6% of total NHS elective activity (see section 1.1.5). For some elective procedures, such as cataract repair, inguinal hernia repair and hip and knee replacement, close to one in every three publicly funded treatment is performed by private hospitals (Stoye, 2019). In total, it is estimated that NHS commissioners spent £9.7 billion on services delivered by private healthcare providers in 2019/20, accounting for approximately 7.2% of the annual health care budget (King's Fund, 2021a). Irrespective of whether care is privately or publicly funded, there have been considerable concerns regarding the safety and quality of care delivered in private hospitals (see section 1.2.4.2). These include concerns regarding lack of oversight and transparency in the reporting of activity and outcome data raised by the Paterson Inquiry (DHSC, 2020), and many instances of unsafe practice discovered by the CQC such as poor cleanliness and infection control, a lack of formal processes to learn from patient safety incidents, and not abiding by recommended surgical checklists (Care Quality Commission, 2018).

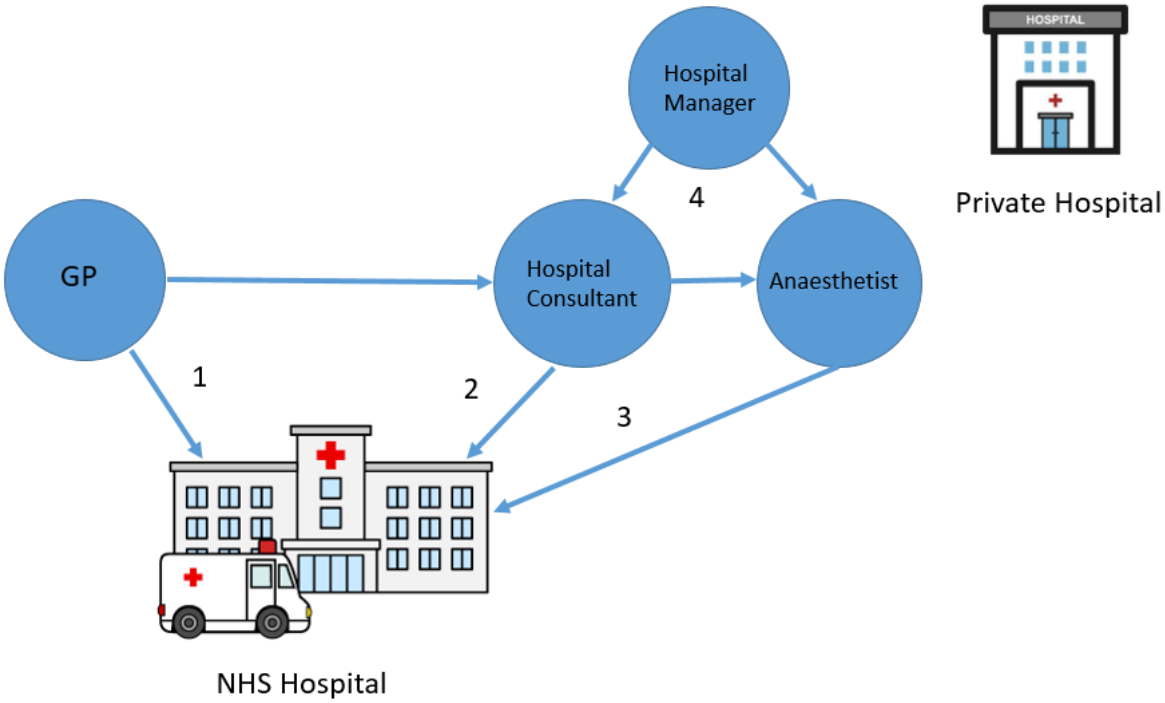
Despite these concerns, the literature to date has mainly indicated that private hospitals generally have better outcomes and greater efficiency than NHS hospitals. The largest and most comprehensive study so far, which analysed just under half a million operations conducted in private hospitals, concluded that elective surgery in private hospitals is associated with shorter length of stay and lower readmission rates than in NHS hospitals (Crothers *et al.*, 2021). These findings replicate those of earlier studies (Browne *et al.*, 2008; Chard *et al.*, 2011; Siciliani, Sivey and Street, 2013; Syed *et al.*, 2015; Appleby, 2020), and a recent commentary has discussed how the evidence base as a whole provides reassurance that outsourced publicly funded care in private hospitals is at least as safe as that provided in NHS hospitals (Bottle and Browne, 2021). However, this commentary did overlook one study. Moscelli et al. (2018), which used differential distance to NHS and private hospitals as an instrumental variable to account for unobserved confounding at the patient-level and found no significant differences in readmission rates between NHS and private hospitals. This is particularly important, as it is known that private hospitals treat less complex patients than NHS hospitals (Browne *et al.*, 2008; Mason, Street and Verzulli, 2010; Street *et al.*, 2010;

Chard *et al.*, 2011), and this may not be fully reflected when adjusting for only observable confounders for individual patients (See section 4.2.1). However, Moscelli et al. (2018) focused on one quality indicator only, specifically readmission rates. Moreover, no previous analyses have explored the relationship between different healthcare quality indicators. This is particularly important as there is strong evidence that experiencing adverse events, such as hospital-associated infections, adverse drug reactions, pressure ulcers and venous thromboembolism, results in increased risk of hospital mortality, readmission and prolonged length of stay (Shalchi *et al.*, 2009; Davies *et al.*, 2010; Hoogervorst-Schilp *et al.*, 2015; Morris, 2018; Wassel *et al.*, 2020; Friebel, Henschke and Maynou, 2021). Therefore, relative differences in the prevalence of adverse events may be a contributory factor in the differences in outcomes and efficiency observed between private and NHS hospitals.

4.2.1. Rationale for unobserved confounding at the patient-level between private and NHS hospitals

Patients with more complex health needs are typically referred to NHS hospitals rather than private hospitals for several reasons. First, most private hospitals have limited or no critical care facilities and less medical cover during non-working hours (Anandaciva, 2020). This is important as it is understood that patients with complex health needs, such as frailty or poor fitness for surgery, are at higher risk of developing post-operative complications and subsequent support from critical care services (Hackett *et al.*, 2015; Kastanis *et al.*, 2016; Li *et al.*, 2021). Second, there are often conditions within local commissioning contracts that specify that patients with complex health needs should not be referred to private hospitals (Mason, Street and Verzulli, 2010). Third, individual GPs and clinicians also refer patients with complex health needs to NHS rather than private hospitals as they wish to minimise the risk of transfers between private and NHS hospitals which occur when patients experience post-operative complications that cannot be managed within private hospitals (Gallagher, 2021). In summary, there are multiple stages of patient pathways that can result in patients with more complex health needs being triaged or referred to NHS hospitals rather than private hospitals (Figure 12). These involve interactions with GPs, hospital consultants, anaesthetists. In addition, hospital managers routinely conduct audits of patients listed for surgery and when patients with more complex health needs are identified they may discuss this with relevant hospital consultants and anaesthetists to establish if treatment in a NHS hospital may be more appropriate.

Figure 12: Stages of patient pathways when patients with complex health needs may be triaged to NHS hospitals§



§ This figure outlines different stage of patient pathways when patients with complex health needs may be triaged to NHS hospitals. Stage 1 is the point of referral from GP, when a GP may encourage patients with complex health needs to seek care in a NHS hospital. Stage 2 is when the patient is reviewed by the hospital consultant in an outpatient clinic to consent for surgical intervention. This will include detailed discussions of risks and benefits of surgery, and potentially a recommendation that surgery takes place in a NHS hospital if there are considerable risks and potential for critical care admission in the post-operative period. Stage 3 is when patients undergo pre-operative assessment by an anaesthetist which can include breathing tests, and assessment of cardiac function. If the results of these tests indicate a suboptimal fitness for surgery, the anaesthetist may recommend treatment in a NHS hospital. Stage 4 is when hospital managers routinely conduct audits of patients listed for surgery, and these audits may identify elderly patients with multiple health conditions. Hospital managers may choose to discuss with hospital consultants or anaesthetists whether it may be more suitable for the patient to receive treatment in a NHS hospital.

There are good reasons why assessments of health needs and fitness of surgery may not be observable. First, clinical assessments of fitness of surgery, such as American Society of Anesthesiologists (ASA) score (Mayhew, Mendonca and Murthy, 2019), lung function, and cardiac function (NICE, 2016), are not consistently captured within the NHS Digital HES dataset. Instead, previous assessments of quality differences between private and NHS hospitals in England have relied upon adjustment of age, gender, deprivation, and number of comorbidities to adjust for differences in case-mix (Browne *et al.*, 2008; Chard *et al.*, 2011; Siciliani, Sivey and Street, 2013; Moscelli *et al.*, 2018; Crothers *et al.*, 2021). However, these

patient characteristics are not perfect predictors of fitness of surgery with several studies concluding that age and number of comorbidities do not explain all the variation in fitness for surgery particularly when fitness for surgery is very poor (Mannion *et al.*, 2020; Li *et al.*, 2021). Conceptually this makes sense, as two patients of the same age and number of comorbidities can have very different levels of exercise tolerance which is used to classify fitness for surgery (Mayhew, Mendonca and Murthy, 2019). For example, patients that have medical conditions associated with breathing issues, such as heart failure and chronic obstructive pulmonary disease, will have difference levels of exercise tolerance than patients with medical conditions not associated with breathing issues, such as peptic ulcer disease and diabetes mellitus. Despite this, these medical conditions are weighted equally in comorbidities scores such as the Charlson Comorbidity Score (CCI) (Austin *et al.*, 2015). Therefore, we can conclude that fitness for surgery is not completely observable because there are only imperfect substitutes available for this important predictor of triage or referral to NHS hospital, there is significant potential for unobserved confounding at the patient-level between private and NHS hospitals when using the NHS Digital HES dataset.

4.3.Objectives

This paper aims to build on the approach developed by Moscelli et al. (2018) by analysing a broader range of healthcare quality indicators, including several patient outcomes (in-hospital mortality, readmissions within 28 days, hospital transfers), two efficiency measures (pre-operative length of stay, post-operative length of stay), and four potentially avoidable adverse events (hospital-associated infections, adverse drug reactions, pressure ulcers and venous thromboembolism), In addition, this paper aims to estimate the implications of experiencing different adverse events in private and NHS hospitals for outcomes and efficiency. The rationale for this is that private and NHS hospitals may have different strategies for the management of adverse events that result in different implications for outcomes and efficiency. To summarise, the research objectives of Paper III are as follows:

- Research Objective 1: To ascertain if treatment in a private hospital for patients undergoing elective hip and knee replacement is associated with poor patient outcomes compared to those in NHS hospitals.
- Research Objective 2: To ascertain if treatment in a private hospital for patients undergoing elective hip and knee replacement is associated with reduced efficiency compared to NHS hospitals.
- Research Objective 3: To ascertain if the risk of experiencing several potentially avoidable adverse events is high for patients undergoing elective hip and knee replacements in private hospitals compared to those in NHS hospitals.
- Research Objective 4: To estimate the association between experiencing different adverse events, and patient outcomes and efficiency in private and NHS hospitals.

4.4.Literature review

4.4.1. Evidence from England

To inform the subsequent comparative analysis of healthcare quality across private and NHS hospitals, I reviewed the pre-existing literature on differences in healthcare quality between private and NHS hospitals in England. This was achieved by supplementing a recently undertaken literature review (Crothers *et al.*, 2021) with additional studies identified from reference lists. I focused on several dimensions of healthcare quality including effectiveness, efficiency, accessibility and responsiveness. The results of this exercise are summarised in Table 22.

Table 22: Comparative analyses of healthcare quality across private and NHS hospitals in England[§]

Paper	Focus	Methodology	Outcomes	Findings
(Browne *et al.*, 2008)	Hernia repair, varicose vein surgery, cataract extraction, hip/knee replacement	Case mix adjustment using linear and logistic regression (disease severity, duration of symptoms, age, gender, socioeconomic status, general health, previous similar surgery, comorbidity)	PROMs at 3–6 months post-op Patient-reported post-operative complications	Private hospitals associated with better PROMs for cataract surgery and hip replacement NHS hospitals associated with better PROMs for hernia repair No significant difference in PROMs for other two procedures Private hospitals were associated with fewer post-op complications for cataract surgery, hernia repair and knee replacement.
(Mason, Street and Verzulli, 2010)	30 high-volume reimbursement groups	T-tests, and Forrest plots	Patient complexity (age, number of diagnoses, number of procedures, and deprivation)	Private hospitals treated patients that were less deprived, and had lower numbers of comorbidities, and procedures No significant differences in age.
(Owusu-Frimpong, Nwankwo and Dason, 2010)	Patient experience	Semi-structured face-to-face interviews Patient surveys with Likert scale questionnaires	Accessibility (getting attention from doctors, time taken to get appointments, opening hours)	Patients accessing care in private hospitals report easily to obtain care at short notice, more agreeable opening hours, and easier-to-get appointments
(Street *et al.*, 2010)	29 high-volume reimbursement groups	T-tests and Forrest plots	Patient complexity (age, number of diagnoses, number of procedures, deprivation) LOS Transfers	As above in Mason et al., 2010 LOS is shorter in private hospitals for hip and knee replacement, and foot procedures Lower rate of transfers in private hospitals for hip and knee replacements
(Chard *et al.*, 2011)	Hernia repair, varicose vein surgery, hip/knee replacement	Case mix adjustment using linear regression (disease severity, duration of symptoms, age, gender, socioeconomic status, general health, previous similar surgery, comorbidity)	PROMs at 3–6 months post-op Patient-reported post-operative complications	Private hospitals associated with better PROMs for hip/knee replacement, and hernia surgery NHS hospitals associated with more post-op complications for hip/knee replacement No significant differences for varicose vein surgery
(Barbiere *et al.*, 2012)	Prostate cancer	Logistic regression and case mix adjustment (deprivation, age, disease stage)	Probability of surgery use, probability of radiotherapy use	Diagnosis in private hospitals was associated with increased probability of surgery use and lower probability of radiotherapy use

(Pérotin *et al.*, 2013)	Patient experience	NHS and ISTC inpatient survey Probit regression	CQC domains (access, coordination, information, relationships, comfort	No significant difference in patient experience between private and NHS hospitals with aggregated sample
(Siciliani, Sivey and Street, 2013)	Hip replacements	Case mix and regional adjustment using linear regression (age, gender, comorbidities, deprivation, regional dummies)	LOS	After controlling for case mix and region, NHS treatment centres and private treatment centres have 18% and 40% shorter LOS than NHS hospitals
(Syed *et al.*, 2015)	Cataract surgery	Chi-squared and Fisher tests	Intra-operative and post-operative complications	Lower rates of intra-operative and post-operative complications in private hospitals
(Moscelli *et al.*, 2018)	All activity and sub-analyses using 15 high-volume reimbursement groups	Linear regression differential distance as an instrumental variable	Readmissions	Lower readmission rate in private hospitals when using linear regression No significant findings when using instrumental variable approach
(Appleby, 2020)	Hip replacements	Comparison of means Funnel plot	PROMs at 6 months	Private hospitals associated with small but statistically significant difference in improvement in PROM scores At hospital site level, only 12% have statistically significant changes
(Crothers *et al.*, 2021)	18 high-volume operation codes covering 10 procedures	PSM Survival analysis and Cox proportional hazards models	In-hospital outcomes (LOS, emergency transfers, mortality) Post-hospital outcomes (readmission or mortality < 28 days)	Private hospitals associated with shorter LOS and lower readmission rate for all operation codes No significant differences for mortality. Private hospitals associated with increased risk of transfers for four operation codes

[§] LOS: length of stay, PROMs: patient-reported outcome measures, PSM: propensity score matching.

Much of the pre-existing evidence on comparative performance of NHS and private hospitals is focused on the independent sector treatment centres (ISTCs). As discussed in section 1.1.2, there was a significant expansion of ISTCs from 2003 onwards as part of wider efforts to reduced waiting lists for elective care. From the beginning of this policy, concerns were raised by professional bodies regarding the safety and quality of these centres, and whether they represented value for money considering the significant investment of public funds (Pollock and Godden, 2008; Pollock and Kirkwood, 2009). It was also emphasised there was a lack of systematic data collection and evaluation of the roll-out of the ISTCs, including potential economic consequences such as ISTCs engaging with risk selection and leaving NHS hospitals with sicker and more costly patients (Pollock and Godden, 2008). This resulted in the Department of Health (now known as the Department of Health & Social Care (DHSC)) commissioning several studies that are summarised below.

Brown et al. conducted a prospective cohort study in 6 ISTCs and 20 NHS hospitals involving approximately 2,600 patients undergoing either inguinal hernia repair, varicose vein surgery, cataract surgery, hip replacement or knee replacement (Brown et al., 2008). Pre-operative and post-operative procedure-specific and general PROMs were collected alongside patient-reported complications. Following case mix adjustment, this study found that private hospitals were associated with greater improvement in PROM scores for cataract surgery and hip replacement, and the opposite was true for hernia repair. Private hospitals were associated with lower likelihood of post-operative complications for cataract surgery, hernia repair and knee replacement. Chard et al. expanded this study to 25 ISTCs and 72 NHS hospitals involving approximately 24,000 patients undergoing either inguinal hernia repair, varicose vein surgery, hip replacement or knee replacement (Chard *et al.*, 2011). With adjustment for patient characteristics, private hospitals were associated greater improvement in PROMs for hip and knee replacement, with no significant differences for varicose vein and hernia surgery. Private hospitals were associated with lower likelihood of post-operative complications for hip replacement, knee replacement, and hernia repair.

Mason et al. investigated patient complexity and quality of clinical coding in private hospitals. For quality of data coding, they used absence of information about a patient's primary diagnosis as indicative of poor coding (Mason, Street and Verzulli, 2010). For patient complexity, they focused on age, number of comorbidities, number of procedural

codes, and deprivation. They discovered that, for the year 2007/08, 36% of patients treated in private hospitals had poor quality of coding compared to <1% in NHS hospitals, and that patients treated in NHS hospitals were on average more complex across all measures except for age. Street et al. then expanded on the aforementioned analysis by also analysing differences in length of stay and transfers to other hospitals (Street *et al.*, 2010). Their study focused on comparing treatment centres (both public and private) and NHS hospitals, although the large majority of treatment centres were private. They found that there were no significant differences in length of stay and transfers for simple procedures, but there was significant evidence of shorter length of stay and fewer transfers in private hospitals for more complex, non-day-case procedures such as hip and knee replacements.

Owusu-Frimpong et al.'s study combined semi-structured face-to-face interviews with patient surveys to determine patients' level of satisfaction following treatment in private and NHS hospitals (Owusu-Frimpong, Nwankwo and Dason, 2010). They collated findings from 16 interviews and 90 questionnaires and discovered that patients treated in private hospitals generally had higher levels of satisfaction and found it easier to access healthcare services at short notice. Pérotin et al. analysed data for a large sample of patients (approximately 22,000 NHS hospital patients and 17,000 ISTC patients) from the annual NHS hospital inpatient and ISTC inpatient and day-case surveys (Pérotin *et al.*, 2013). Using a probit regression model that adjusted for observable patient characteristics including age, gender and state of health, and time-invariant hospital factors using fixed effects, their findings among different specialties were mixed but, when all specialties were aggregated, showed no significant difference in patient satisfaction between private and NHS hospitals.

Barbiere et al. analysed data from a prostate cancer registry in England to establish differences in case mix between private and NHS hospitals, and probability of surgery and radiotherapy use (Barbiere *et al.*, 2012). They analysed data for approximately 16,000 patients collected between 1998 and 2006, and discovered that patients treated in private hospitals were significantly more affluent, younger, and were diagnosed at an earlier disease stage. They adjusted for the above factors using logistic regression and found that patients treated in private hospitals had an increased probability of surgery use and a lower probability of radiotherapy use.

Siciliani et al. focused on differences in length of stay as an efficiency measure between NHS hospitals, NHS treatment centres and ISTCs, for patients receiving hip replacements in the financial year 2006/07 (Siciliani, Sivey and Street, 2013). They used a linear regression model, and found that NHS treatment centres and ISTCs have, on average, a respectively 18% and 40% shorter length of stay compared with NHS hospitals, even after adjusting for differences in age, gender, number and type of diagnoses, deprivation and region. Syed et al.'s study focused specifically on outcomes for three ISTCs delivering cataract surgery (Syed *et al.*, 2015). They compared several intra-operative and post-operative complication rates for these ISTCs against NHS hospitals, using benchmarks established by the Cataract National Dataset, and established that there were lower complication rates in ISTCs. Moscelli et al. focused on all publicly funded activity in private hospitals and compared readmission rates for 133 high-volume procedures in NHS hospitals (Moscelli *et al.*, 2018). They initially used linear regression but acknowledged there was likely unobserved confounding due to unobserved confounding at the patient-level between NHS and private hospitals. To overcome this challenge, they used differential distance to nearest NHS and private hospital as an instrumental variable. Through this method, they showed that significant differences in readmission rates produced by the linear regression model were not replicated when using an instrumental variable approach.

More recently, Appleby undertook a comparison of PROMs for hip replacements for patients treated in private and NHS hospitals (Appleby, 2020). The PROMs were already risk-adjusted by NHS England reflecting age, gender, patient-reported conditions, symptom period and ethnicity (NHS England, 2013). There was a small, statistically significant difference in improvements in PROMs score. However, this was considered as not clinically meaningful. Crothers et al. analysed 18 high-volume operation codes conducted in private hospitals that reflect 10 procedures (wisdom tooth extraction, cholecystectomy, prostate resection, hysterectomy, inguinal hernia repair, umbilical hernia repair, ventral hernia repair, lumbar decompression, hip replacement and knee replacement) (Crothers *et al.*, 2021). To account for differences in patient characteristics between private and NHS hospitals, they used propensity score matching to match similar patients according to gender, age, ethnicity, deprivation and comorbidities. Treatment in private hospitals was associated with shorter length of stay and lower readmission rate for all procedures, but there were no significant differences for mortality. Treatment in private hospitals was also associated with increased

risk of transfers for four operation codes, specifically prostate resection, cemented hip replacement, and knee replacement (cemented and uncemented).

In summary, the evidence on differences in healthcare quality between private hospitals and NHS hospitals in England either suggests that private hospitals perform better than NHS hospitals, or that there are no significant differences in healthcare quality. However, only a few studies used robust methods to overcome the challenge of differences in case mix between private and NHS hospitals (Moscelli *et al.*, 2018; Crothers *et al.*, 2021). While most studies adjusted for age, gender, comorbidities and deprivation, only two studies adjusted for other factors such as PROMs (Browne *et al.*, 2008; Appleby, 2020). Appleby (2020) found a small, significant but not clinically meaningful difference in PROMs between private and NHS hospitals. In contrast, Browne et al. (2008) found contrasting results between different procedures when analysing differences between private and NHS hospitals. Moscelli et al. (2018) is the only study that accounted for unobservable confounding at the patient-level through the use of an instrumental variable approach and found no statistically significant differences between private and NHS hospitals. Therefore, it is possible that some of the other studies that only adjusted observable confounders have overestimated healthcare quality gains from being treated in private hospitals. To explore this hypothesis, it will be important that future analyses strive to adjust for a broad range of observable confounders that reflect the health status of patients, such as PROMs, and unobservable confounders through the use of methods such as instrumental variable analyses.

4.4.2. International evidence

There is also a breadth of international evidence on comparative outcomes and efficiency for public and private hospitals. From the European perspective, Kruse et al. undertook a systematic review of comparative analyses of private and public hospitals in relation to efficiency, accessibility and quality of care (Kruse *et al.*, 2018). The review identified studies from Italy, Germany, the United Kingdom, France, Greece, Austria, Spain and Portugal. As regards to efficiency, most evidence indicated that private hospitals were less efficient that public hospitals (Barbetta, Turati and Zago, 2007; Herr, 2008; Daidone and D'Amico, 2009; Tiemann and Schreyögg, 2009, 2012; Berta *et al.*, 2010; Herr, Schmitz and Augurzky, 2011; Herwartz and Strumann, 2012; Czypionka *et al.*, 2014; Lindlbauer and Schreyögg, 2014; Sommersguter-Reichmann and Stepan, 2015). The exceptions included Italy, England and

France, where treatment in private hospitals was associated with shorter length of stay (Siciliani, Sivey and Street, 2013; Fattore, Petrarca and Torbica, 2014; Gusmano *et al.*, 2015; Gobillon and Milcent, 2016). The authors hypothesised that this may be because the reimbursement in these countries was not weighted significantly towards per diem, and therefore private hospitals were financially incentivised to discharge patients earlier. In relation to accessibility, the review identified studies from Greece, Spain and Italy that consistently showed that patients admitted to private hospital were more affluent (Pappa and Niakas, 2006; Siskou *et al.*, 2008; Río *et al.*, 2010; Tountas *et al.*, 2011; Souliotis *et al.*, 2016). Two studies from Italy also showed evidence that private hospitals were prioritising access for more simple, less complex and therefore potentially more profitable patients (Berta *et al.*, 2010; Preti *et al.*, 2010), a finding that echoes similar analyses undertaken in England (Mason, Street and Verzulli, 2010; Street *et al.*, 2010). In terms of patient outcomes, the review found conflicting evidence across countries. There is evidence from Germany and Italy that private hospitals have better mortality rates than public hospitals (Tiemann and Schreyögg, 2009; Berta *et al.*, 2010; Moscone, Tosetti and Vittadini, 2012). In France, the opposite is the case: one study indicated poorer mortality rates following myocardial infarction in private hospitals (Gobillon and Milcent, 2016), and another indicated a higher rate of readmissions (Gusmano *et al.*, 2015).

From the North American perspective, there is a long history of studies focused on the relationship between hospital ownership and quality of care in the US and Canada. There is a greater variety of healthcare provider-type in these healthcare systems, specifically not-for-profit private providers, for-profit private provider and public providers. There have been several systematic reviews which have collated findings from these studies (Eggleston *et al.*, 2008; Konetzka, Yang and Werner, 2019). Focusing specifically on adult inpatient physical health services, the most cited and relevant review and meta-analysis remains (Eggleston *et al.*, 2008). The review identified 31 observational studies and found that the majority of studies find no statistically significant differences between not-for-profit and for-profit private hospitals, and between not-for-profit private hospitals and public hospitals. The majority of studies explored associations using OLS or generalised linear models (GLM) analyses. Gowrisankaran and Town used distance to nearest hospital as an instrumental variable when analysing quality of pneumonia care in public and private, and for-profit and not-for-profit, hospitals, and found that public hospitals had lower mortality than private hospitals, and private not-for-profit hospitals had lower mortality than for-profit private

hospitals (Gowrisankaran and Town, 1999). They found contrasting results when using an GLM model, attributing to this to unobserved confounders. Konetzka et al. reviewed different applications of differential distance as an instrumental variable for hospital type between 2010 and 2018 and identified two relevant studies on hospital ownership (Konetzka, Yang and Werner, 2019). Lee et al. found that hospital bed days per patient were lower in non-profit rather than for-profit dialysis facilities, with lower hospital bed days indicative of higher quality care (Lee, Chertow and Zenios, 2010). Grabowski et al. found that not-for-profit nursing homes had fewer 30-day hospitalisations and greater improvement in mobility, pain and functioning than for-profit nursing homes (Grabowski *et al.*, 2013). However, Konetzka et al. emphasised that the patient-level instrumental variables such as differential distance to nearest hospital do not adequately account for omitted variable bias due to unobserved provider level attributes (Konetzka, Yang and Werner, 2019). These findings have two important implications for this analysis. First, there is an argument to explore differences in healthcare quality between private hospitals based on their classification as for-profit or not-for-profit. Second, it should be acknowledged that patient-level instrumental variables do not overcome omitted variable bias due to unobserved hospital level attributes.

4.5. Theory

Before considering what impact hospital ownership may have on hospital quality. It is important to consider what factors may contribute to healthcare quality. For the purposes of this analysis, I adapt theory from Moscelli et al. (2018), and Brekke et al. (2011), and consider quality of hospital, *i*, with a function equation as below:

[1] $$q_i = q(A, M, W, K)$$

where A is the degree of altruism or intrinsic motivation in hospital i associated with providers receiving welfare from the treatment benefits accrued by patients, M is investment in managerial capability in hospital i, which can improve quality of care through internal audits, better coordination, and clinical governance processes, W is the amount hospital i invests in human capital, such as staffing levels and capabilities through training, and K is the amount hospital i invests in physical capital to improve quality, such as hospital beds and information technology.

Most of these factors can be self-determined by hospital i. This is in keeping with a broad literature that supports the argument that the quality of care can be chosen by hospitals (i.e., it is not exogenous), including the theoretical literature on hospital competition (Gaynor, 2006; Gravelle and Sivey, 2010; Gaynor, Moreno-Serra and Propper, 2013), and pay-for-performance schemes (Ellis and McGuire, 1986; Ma, 1994). With this in mind, I consider the financial surplus (profit) for hospital i choosing quality q, and facing the demand function $D(q), (D' > 0)$, which is assumed to be increasing with increased quality. This is supported by literature that indicates that demand for hospital services in England increases with increased quality (Beckert, Christensen and Collyer, 2012; Gutacker *et al.*, 2016; Moscelli *et al.*, 2016; Santos, Gravelle and Propper, 2017).

In this scenario we have the hospital's profit function as,

[2] $$P(q)_i = [t - c(q_i)]D(q_i) - x(q_i)$$

where P is the profit, t is fixed reimbursement for hip or knee replacement, c is the unit cost of a hip or knee replacement for quality q; D is for demand for hip and knee replacements at

hospital i for quality q With; $x(q_i)$ being the investments in managerial, workforce, and physical capital and capabilities to deliver quality q at hospital i.

While equation 2 provides insights into the monetary costs and benefits from the provider perspective, it is important to consider the overall provider and patient, monetary and non-monetary benefits and costs. These can be summarised as follows:

[3] $$V(q)_i = Ab(q)_i - \varphi(q)_i + \delta P(q)_i$$

$V(q)_i$ is the overall monetary and non-monetary costs and benefits at quality q for hospital i. $Ab(q)_i$ captures altruistic or intrinsically motivated behaviour, with $A > 0$ reflecting the degree of altruism, and $b(q)_i, (b' > 0)$ reflecting patient treatment benefits With; $\varphi(q)_i$ reflecting the non-monetary cost of the effort that hospital staff exert to provide quality q at hospital i Here; $\delta P(q)_i$ also incorporates a weight, δ, which reflects the weight that hospital i places on profit. This may be dependent upon the financial objectives of the hospital, i.e. whether it is for-profit or not-for-profit.

Hospitals will aim to choose an optimal quality that balances the marginal monetary and non-monetary costs and benefits as follows:

[4] $$V'(q^*)_i = Ab(q^*)_i - \varphi(q^*)_i + \delta p(q^*)_i = 0$$

and:

[5] $$P'(q^*)_i = [t - c(q^*)]D'(q^*) - c'(q^*)D(q^*) - x(q^*)$$

Therefore, we see that the quality chosen by hospital i is dependent upon the degree of altruism, the weight the hospital places on profits, and investments in managerial, workforce, and physical capital.

There are good reasons to assume these may differ between NHS and private hospitals. Empirical literature has indicated that the degree of altruism can be influenced by the payment system, with patients typically being over-treated in fee-for-service reimbursement systems, indicating that weight on profits can be outweighed by altruistic motivations in

comparison to prospective reimbursement systems (Hennig-Schmidt, Selten and Wiesen, 2011; Martinsson and Persson, 2019; Moscelli, Gravelle and Siciliani, 2021). In England, hospital consultants are largely employed on salaries in NHS hospitals and reimbursed through fee-for-service in private hospitals. Therefore, this may be one dimension where NHS consultants have less control over the reimbursement level than in the private sector, possibly allowing greater freedom to be given to altruistic behaviour than in for private hospitals. It can also be argued that, as the majority of private hospitals are for-profit organisations, they place a higher weight on profit than NHS hospitals, or even not-for-profit private hospitals. In reality, there are also significant pressures on NHS hospitals to meet financial performance targets, with penalties for not doing so (NHS England, 2016). Nonetheless, they are unlikely to place the same weight on turning a profit than private hospitals do, evidenced by many NHS hospitals with longstanding deficits (King's Fund, 2021b).

This has important implications for quality, as hospitals that place a higher weight on financial surplus and more muted altruistic motivations may opt for a stronger cost-containment scenario. In such a scenario, if quality is not fully observable hospitals may reduce quality by reducing short-term costs for each episode of care and dampening long-term investments in human and physical capital. The risk of this scenario emerging will increase when the presumed association between quality and demand is weak, or has a non-linear relationship. There are good reasons to assume this could be the case in the English healthcare system. For example, the 2010 National Patient Choice survey in England indicated that, possibly as quality is not fully observable, patients give the least weight to quality as a choice factor when choosing healthcare providers, and instead prioritised other factors such as geographical location (Dixon, 2010).

However, there is an alternative scenario whereby hospitals that place a higher weight on turning a profit will be more motivated to improve healthcare quality if there is presumed to be a strong relationship between healthcare quality and demand for healthcare services. There is a body of literature from England that supports the existence of this relationship using a range of healthcare quality indicators such as hospital mortality, readmissions and PROMs (Gaynor, Propper and Seiler, 2016; Gutacker *et al.*, 2016; Santos, Gravelle and Propper, 2017).

In summary, as noted by Moscelli et al. (2018), the theoretical relationship between hospital ownership and healthcare quality is indeterminate. Different weights may be put on profit and altruistic behaviour, leading to different quality provision, and therefore there is a strong rationale to evaluate the relationship empirically.

4.6. Method

4.6.1. Study cohort

To obtain patient-level information for all publicly funded elective primary hip and knee replacements undertaken in England between January 2016 and December 2019, I used the Hospital Episode Statistics (HES) database provided by NHS Digital. I chose to analyse primary hip and knee replacements specifically as they are high-volume procedures in private hospitals (Section 1.1.3., Table 2), which have readily available data on PROMs that can be used to adjust for differences in case mix between hospitals. I retrieved relevant records according to specific procedural codes for primary hip and knee replacements defined by the National Joint Registry (National Joint Registry, 2016). The full list of these procedural codes is contained in appendices (Appendix D, Tables 1 and 2). The HES database contains detailed information from pseudonymised patient records for all publicly delivered elective care in England in both NHS and private hospitals. For each patient, information on demographic characteristics, diagnosis information, discharge destination, readmissions, length of stay, and in-hospital death were retrieved. Each patient record was also linked to available PROMs data collected between January 2016 and March 2018 through the national NHS England PROMs programme, which is applicable to both NHS and private hospitals (NHS England, 2022d). However, I was unable to link PROMs data beyond March 2018 as this was unavailable. HES data are structured in finished episodes of care, which are linked to a clinician responsible for a respective aspect of the care pathway. To assess the risk of adverse events during the entirety of the hospital stay, all hospital episodes were combined from day of admission to the day of discharge into hospital spells. Once volumes of hip and knee replacements in each hospital site were calculated, patient episodes were removed from the sample if they were conducted in a hospital site that undertook less than 30 elective hip or knee replacements between January 2016 and December 2019.

4.6.2. Study outcomes

This study investigates three outcome measures (in-hospital mortality, readmissions within 28 days, and inter-hospital transfer), two efficiency measures (pre-operative and post-operative length of stay), and four common and potentially preventable adverse events (hospital-acquired infections, adverse drug reactions, pressure ulcers and venous

thromboembolism). Identification of adverse events was based on relevant diagnosis codes according to the International Statistical Classification of Diseases and Related Health Problems, 10th edition (ICD-10) (Appendix D, Table 3). The selection of codes followed those used in previous studies as they have shown high validity and specificity in the detection of adverse events from electronic health records (Bahl *et al.*, 2008; Romano *et al.*, 2009; Rosen *et al.*, 2013; Friebel, Henschke and Maynou, 2021). The relevant inclusion and exclusion criteria set out in the Patient Safety Indicators (PSI) of the US Agency for Healthcare Research and Quality (AHRQ) were used to identify hospital-associated adverse events from administrative patient records. The AHRQ PSI indicators have been translated and validated for use in England (Bottle and Aylin, 2009). The coding for adverse drug reactions (which is not a PSI developed by AHRQ) was retrieved from a much cited manuscript focused on the prevalence of adverse drug reactions in a Australian hospital dataset (Hauck and Zhao, 2011), which has since been applied to HES in England (Friebel, Henschke and Maynou, 2021). Patients who died during their hospital stay or were transferred to another hospital were identified based on the record of the discharge method. Readmissions were identified by using unique patient identifiers and defined as admission to any hospital within 28 days of discharge. Pre-operative length of stay was calculated as the difference between day of admission and day of surgical procedure, and post-operative length of stay was calculated as the difference between day of surgical procedure and day of discharge. This is an approach previously used to analyse the impact of competition on efficiency in private and NHS hospitals (Cooper, Gibbons and Skellern, 2018b). Patients that were admitted and discharged on the same day or without staying overnight were recorded with a zero pre-operative and post-operative length of stay (e.g. when patients died on the admission day).

4.6.3. Covariates

The HES database includes information on patient characteristics, including age, gender, deprivation and comorbidities. Deprivation is recorded according to the English Indices of Multiple Deprivation 2015 and classified by quintiles, with quintile 1 representing the most deprived and quintile 5 representing the least deprived (UK Government, 2020). The Charlson Comorbidity Index (CCI) was used as a measure for patient complexity based on the number of comorbidities recorded in each admission (Austin *et al.*, 2015). This index is widely used for risk stratification in health services research and was calculated based on diagnostic codes.

The specific PROMs included in this analysis are the Oxford Hip Score (OHS) (Dawson *et al.*, 1996), and the Oxford Knee Score (OKS) (Dawson *et al.*, 1998), categorised according to score 0 to 19 (severe arthritis), score 20 to 29 (moderate to severe arthritis), score 30 to 39 (mild to moderate arthritis), and score 40 to 48 (satisfactory joint function). Total volumes of hip and knee replacements at each hospital were calculated using data from both HES and the PHIN admitted patient care datasets.

4.6.4. Statistical analysis

4.6.4.1. Descriptive statistics

Descriptive statistics were produced using t-tests to compare the prevalence of outcome measures (mortality, readmission, inter-hospital transfer), efficiency measures (pre-operative and post-operative length of stay), adverse events (hospital-associated infection, adverse drug reaction, pressure ulcers and venous thromboembolism), and patient characteristics (age, gender, comorbidities, deprivation, PROMs) for elective primary hip and knee replacements undertaken in NHS and private hospitals during my period of analysis.

4.6.4.2. OLS with fixed effects estimators

OLS with fixed effects estimators were initially used to analyse the comparative probability of experiencing different adverse events and outcome measures in private and NHS hospitals, and the association between treatment in private hospitals and different efficiency measures. To account for week/weekend and seasonal variation, two time-variables were added (i.e. weekdays versus weekend, and winter versus non-winter period). Binary variables for each year of the analysis were included to difference out any year to year variation. Robust standard errors were used, clustered at the Healthcare Resource Group (HRG) level. The model was run using fixed effects which also differenced all time-invariant HRG characteristics out of the equation. Fixed effects were not used at the hospital level, as this was attempted and the relevant variable that distinguished between private and NHS hospitals was dropped from the regression model as it was constant within groups of analysis. P values were reported with 0.05 considered as a threshold for statistical significance.

The OLS with fixed effects model had the following specification [1]:

[1] $$Y_{ij} = \alpha_i + \delta H_{ij} + \beta X_{ij} + \gamma Z_{ij} + \mu V_{ij} + e_{ij}$$

where Y_{ij} indicates the dependent variable, whether the patient *i* experienced an outcome, efficiency measure, or adverse event in hospital *j*; α_i is the fixed effects of relevant HRGs, H_{ij} is a binary variable that is equal to 1 if hospital *j* is a private hospital and 0 if a NHS hospital; X_{ij} is a vector of patient characteristics (i.e. age, gender, deprivation, CCI), Z_{ij} denotes the time-variables (i.e. year, weekdays versus weekend, and winter period); V indicates the total volume of hip and knee replacements conducted within hospital H_j . $\alpha, \delta, \beta, \gamma$ and μ are unknown parameters and e_{ij} is the normally distributed disturbance term. The coefficient of interest is specifically the difference in the probability of an adverse event, outcome, or efficiency measure following an elective hip or knee replacement in a private hospital compared to an NHS hospital.

4.6.4.3.Instrumental variable (IV) analysis

As already discussed, it is known there are considerable differences in patient morbidity between NHS and private hospitals (Browne *et al.*, 2008; Mason, Street and Verzulli, 2010; Chard *et al.*, 2011). While it is possible to adjust for some observable patient characteristics, if significant unobserved confounding exists in the above OLS model then subsequent results are likely to be biased (see section 4.2.1.). An instrumental variable (IV) design was used to overcome this issue, using the "ivreg2" user-written STATA command (Baum, Schaffer and Stillman, 2007). IV designs are a commonly used causal inference method that reduces bias by accounting for both unobserved and observable confounding (Baiocchi, Cheng and Small, 2014). A valid instrument must be associated with the treatment exposure (e.g. choice of hospital) and have no relationship to the outcome of interest except through the treatment exposure (Baiocchi, Cheng and Small, 2014). IV analyses use two-stage least squares (2SLSs) regression. The first stage involves predicting the exposure variable using the relevant IVs and the predicted values from this regression are then used in the second stage regression to ensure the predictor variables are not correlated with the error terms. There are also two tests routinely undertaken to assess whether coefficients produced from IV models are valid. First, the strength of instruments is tested by the accompanying F-statistic, which should exceed at least 16.38 for an instrument to be considered strong enough to interpret the results of an IV analysis (Stock and Yogo, 2005). Second, the Hausman endogeneity test is

used to test the null hypothesis that an IV is exogenous (Hausman, 1978). The Hausman test involves running the second stage regression with the residual from the first stage regression added to establish if the coefficient of the residual is zero. If the p value from the Hausman test is less than 0.05, this null hypothesis is rejected and the IV coefficients are considered as unbiased. If the p value is more than 0.05, this null hypothesis is not rejected and the IV coefficients are considered biased.

My preferred specification uses differential distance between NHS and private hospitals from the centroid of a patient's Lower Layer Super Output Areas as an instrument for hospital choice. This instrument was also utilised by Moscelli et al. (2018), and has been used by several other studies that analyse the association between hospital ownership and quality of care (McClellan, McNeil and Newhouse, 1994; Newhouse and McClellan, 1998; Sloan *et al.*, 2001; Shen, 2002; Lien, Chou and Liu, 2008). This IV has the advantage of taking account of selection on any unobservable characteristics at the patient-level including differences in morbidity and attitudes between patients treated in private and NHS hospitals. As most of these previous studies have also included further specifications of IVs to assess the robustness of their results, the respective distances to the nearest NHS and private hospital were included as two instruments in a further analysis to ascertain if this alternative specification changed the results. It was judged these were appropriate instruments as there is likely to be a positive correlation between distance to nearest NHS hospital and choice of private hospital, and a negative correlation between distance to nearest private hospital and choice of private hospital. Moreover, this alternative specification was also used by Moscelli et al. (2018). The equation for the first stage linear regression is outlined below [2]:

[2] $$H_i = \alpha_i + \emptyset D_i + \beta X_i + \gamma Z_i + \mu V_i + e_i$$

where H_i indicates the dependent variable, whether the patient i is treated in a private or NHS hospital; α_i is the fixed effects of relevant HRGs, D_i is the instrument, specifically differential distance between the nearest NHS and private hospital for patient i; X_i is a vector of patient characteristics (i.e. age, gender, deprivation, CCI), Z_i denotes the time-variables (i.e. year, weekdays versus weekend, and winter period); V indicates the total volume of hip and knee replacements conducted within hospital H; $\alpha, \emptyset, \beta, \gamma$ and μ are unknown parameters and e_i is the normally distributed disturbance term.

There is a logical reason as to why differential distance to NHS and private hospitals is a good instrument, and is correlated with choice of hospital. First, as mentioned in section 4.5, surveys have indicated that patients prioritise geographical location as the single most important factor when choosing healthcare providers in England (Dixon, 2010). Moreover, analyses have indicated that traditional measures of healthcare quality such as mortality and readmission rates have little impact on demand for hospital care in England (Gutacker *et al.*, 2016). Second, as Moscelli et al. (2018) emphasise, it does not seem plausible that quality of care for planned treatments significantly impacts patient decisions about where to live as this would require patients to prospectively plan what treatments they require and anticipate the future quality of care for these treatments in different hospitals (Gravelle, Santos and Siciliani, 2014; Moscelli, Gravelle and Siciliani, 2016). While it is more plausible that patients would move closer to hospitals with better quality of care for emergency care, analyses indicate that quality of emergency care is also poorly correlated with quality of elective care in hospitals in England (Gravelle, Santos and Siciliani, 2014; Moscelli, Gravelle and Siciliani, 2016; Skellern, 2017).

4.6.4.4.Supplementary analyses

Several further supplementary analyses were conducted using the above specifications, to assess the robustness of the results. First, different approaches to functional form of the regression model were used. Probit models were not used in my analysis as they cannot be used with fixed effects. However, it was possible to run a probit model without fixed effects and this was undertaken (with an analogous specification to equations 1 and 2) to ascertain if this produced significantly different results. Logit models were not used as the group sizes meant that different combinations resulted in numeric overflow and therefore producing results was not computational possible, therefore this was not included as a supplementary analysis. Poisson regression models were not used for length of stay as it was not possible to use fixed effects with the "ivpoisson" STATA command for IV analysis (see section 4.6.4.3.). However, it was possible to use a Poisson regression model without fixed effects and this was undertaken (with an analogous specification to equations 1 and 2) to ascertain if this produced significantly different results. Second, patients' pre-operative PROM scores were included as a patient characteristic in the OLS with fixed effects and IV models to ascertain if this significantly changed the results. However, PROMs data were only available up to March 2018, and therefore the sample size for this analysis is smaller. Third, NHS

treatment centres were compared against ISTCs, and NHS acute hospitals compared against private hospitals (excluding ISTCs). The rationale for these comparisons was that NHS treatment centres only deliver elective care and therefore are more directly comparable to ISTCs than NHS acute hospitals which provide a combination of elective and emergency care. Fourth, NHS hospitals were compared against for-profit private hospitals, and against not-for-profit hospitals. The rationale for these comparisons was that for-profit private hospitals may be more motivated to maximise profits than not-for-profit private hospitals, and are therefore more likely to opt for the cost-containment scenario outlined in section 4.5 that involves maximising profits through reductions in quality of care. Fifth, the OLS and IV were repeated for private and NHS hospitals in the Greater London area. This was because higher volumes of elective care take place in private hospitals in London (see section 1.1.3.) and there may be less variation in quality of care there than in other regions.

4.6.4.5. Propensity score matching

In addition to the OLS and IV models, propensity score matching was used for two purposes (Austin, 2011a). First, to estimate the average treatment effect on treated (ATT) of treatment in a private versus NHS hospital on outcomes, efficiency, and adverse events. Second, to estimate the ATT of experiencing different adverse events on outcomes and efficiency separately in private and NHS hospitals. The latter analysis was conducted as private hospitals may have different strategies to NHS hospitals for the management of adverse events that result in different implications for outcomes and efficiency.

Propensity score matching is a commonly used method for causal inference in non-randomised populations, and has been applied previously in a variety of contexts when analysing PSIs and adverse events (Encinosa and Hellinger, 2008; Kronman *et al.*, 2008; Bjertnaes, 2014; Khavanin *et al.*, 2015; Friebel, Henschke and Maynou, 2021). Propensity score matching calculates propensity scores as the conditional probability of being treated (i.e. those treated in a private versus NHS hospital) using a probit model based on a combination of patient and organisational characteristics. Patients are matched in the treatment and control group to estimate the average effect on outcomes of interest from being treated. Two approaches to propensity score matching were used.

First, inverse probability weighting matching with regression adjustment (IPWRA) was used. Inverse probability weighting involves assigning weights to each patient based on the inverse of their probability of receiving treatment, and then re-estimating the average effect on outcomes of interest from being treated (Austin and Stuart, 2015). In both models, adjustment is made for patient covariates including age, gender, CCI, and level of deprivation. IPWRA is a commonly used method to overcomes sample selection issues (Wooldridge, 2002), and an advantage of using IPWRA is that it produces doubly robust estimators, meaning that even if one of the models (treatment or outcome) is mis-specified, the estimator is still consistent (Funk *et al.*, 2011).

Second, one-to-one nearest neighbour matching with replacement was used as a robustness analysis, which involves matching each treatment observation to a single nearest neighbour in the control group according to their propensity score. A caliper distance of 0.001 was used, which is the predefined width by which propensity scores can differ for any one match (Austin, 2011b). To calculate confidence intervals, bootstrapping was performed with 1,000 iterations. For both approaches, data were pooled through all available years for each separate outcome of interest to increase the sample size and the quality of matching. Covariate balancing before and after matching was assessed graphically and is reported in the appendices.

The IPWRA and nearest neighbour matching analyses were run using three specifications. First, the basic specification matched patients according to age, gender, CCI, and level of deprivation. Second, the PROMs specification also matched patients according to individual oxford hip or knee score. Third, the HRG specification also matched patients according to individual hospital reimbursement groups (and not individual PROMs scores). When using propensity score matching to estimate the ATT of experiencing adverse events in private and NHS hospitals on outcomes and efficiency, only the basic specification was used. This is because individual PROMs scores and HRG classifications perfectly predicted assignment to treatment in many cases. Therefore, it was not possible to run the PROMs or HRG specification.

4.7. Results

4.7.1. Descriptive statistics

Table 23: Descriptive: patient characteristics and outcomes for elective hip replacements in NHS and private hospitals[§]

	Hip replacement		
	NHS hospitals	**Private hospitals**	**P value**
	164,132 (68.96%)	**73,885 (31.04%)**	
Outcomes			
In-hospital mortality (%)	0.07 (0.05, 0.08)	0.01 (0.00, 0.01)	0.000
Readmissions (%)	7.22 (7.10, 7.34)	4.90 (4.75, 5.06)	0.000
Hospital transfers (%)	0.88 (0.83, 0.92)	0.19 (0.16, 0.22)	0.000
LOS			
Pre-operative LOS	0.05 (0.05, 0.05)	0.15 (0.14, 0.15)	0.000
Post-operative LOS	4.15 (4.14, 4.17)	2.80 (2.79, 2.81)	0.000
Adverse events			
HAI (%)	0.70 (0.66, 0.74)	0.04 (0.02, 0.05)	0.000
Adverse drug reaction (%)	0.72 (0.68, 0.76)	0.22 (0.19, 0.26)	0.000
Pressure ulcer (%)	0.28 (0.26, 0.31)	0.08 (0.06, 0.10)	0.000
Venous thromboembolism (%)	0.28 (0.25, 0.31)	0.08 (0.06, 0.10)	0.000
Patient characteristics			
Gender (=1 male) (%)	40.18 (39.94, 40.42)	39.63 (39.28, 39.98)	0.055
Age (mean)	68.48 (68.43, 68.54)	68.00 (67.93, 68.07)	0.000
IMD (mean)	3.17 (3.17, 3.18)	3.41 (3.40, 3.42)	0.000
CCI (mean)	0.64 (0.64, 0.65)	0.40 (0.40, 0.41)	0.000
Weekdays discharge (%)	75.69 (75.48, 75.90)	69.11 (68.78, 69.44)	0.000
Winter discharge (%)	34.52 (34.30, 34.75)	35.82 (35.47, 36.16)	0.000
PROMs			
Participation (%)	65.50 (65.22, 65.77)	65.90 (65.49, 66.32)	0.945
Hip/knee score (mean)	16.49 (16.43, 16.55)	19.01 (18.92, 19.10)	0.000
Score 0 to 19 (%)	66.08	54.82	
Score 20 to 29 (%)	27.04	34.06	
Score 30 to 39 (%)	6.45	10.40	
Score 40 to 48 (%)	0.43	0.72	

[§] LOS: length of stay, HAI: healthcare-associated infection, IMD: index of multiple deprivation (quintile 1 = most deprived, quintile 5 = least deprived), CCI: Charlson Comorbidity Index, PROMs: patient-reported outcome measures.

Table 24: Descriptive: patient characteristics and outcomes for elective knee replacements in NHS and private hospitals[§]

	Knee replacement		
	NHS hospitals	**Private hospitals**	**P value**
	203,124 (68.72%)	**92,443 (31.28%)**	
Outcomes			
In-hospital mortality (%)	0.05 (0.04, 0.06)	0.00 (0.00, 0.01)	0.000
Readmissions (%)	7.57 (7.46, 7.69)	5.23 (5.08, 5.37)	0.000
Hospital transfers (%)	0.81 (0.77, 0.84)	0.18 (0.15, 0.20)	0.000
LOS			
Pre-operative LOS	0.04 (0.04, 0.04)	0.16 (0.15, 0.16)	0.000
Post-operative LOS	4.22 (4.21, 4.24)	2.82 (2.81, 2.82)	0.000
Adverse events			
HAI (%)	0.75 (0.72, 0.79)	0.05 (0.04, 0.07)	0.000
Adverse drug reaction (%)	0.64 (0.60, 0.67)	0.21 (0.18, 0.24)	0.000
Pressure ulcer (%)	0.17 (0.15, 0.19)	0.05(0.03, 0.06)	0.000
Venous thromboembolism (%)	0.45 (0.42, 0.48)	0.15 (0.13 0.18)	0.000
Patient characteristics			
Gender (=1 male) (%)	42.71 (42.50, 42.92)	44.80 (44.48, 45.12)	0.000
Age (mean)	69.12 (69.08, 69.16)	68.61 (68.55, 68.66)	0.000
IMD (mean)	3.09 (3.09, 3.10)	3.31 (3.31, 3.32)	0.000
CCI (mean)	0.67 (0.66, 0.67)	0.46 (0.45, 0.46)	0.000
Weekdays discharge (%)	75.58 (75.39, 75.76)	69.43 (69.14, 69.73)	0.000
Winter discharge (%)	34.58(34.38, 34.79)	36.58 (36.27, 36.89)	0.000
PROMs			
Participation (%)	60.85 (60.60, 61.11)	60.26 (59.88, 60.64)	0.058
Hip/knee Score (mean)	17.76 (17.73, 17.84)	20.27 (20.19, 20.34)	0.000
Score 0 to 19 (%)	59.97	47.47	
Score 20 to 29 (%)	32.38	40.11	
Score 30 to 39 (%)	7.30	11.66	
Score 40 to 48 (%)	0.35	0.76	

[§] LOS: length of stay, HAI: healthcare-associated infection, IMD: index of multiple deprivation (quintile 1 = most deprived, quintile 5 = least deprived), CCI: Charlson Comorbidity Index, PROMs: patient-reported outcome measures.

The study sample for the calendar years 2016 to 2019 included a total of 73,885 hip replacements and 92,443 knee replacements in private hospitals; and 164,132 hip replacements and 203,124 knee replacements in NHS hospitals (Tables 23 and 24). In total, the sample consists of patients treated at 250 NHS hospital sites and 165 private sites (Appendix D, Table 4). ISTCs comprised 16.36% of the private hospitals in the sample (27/165), and conducted 25.75% (43,490/168, 893) of publicly funded care in private hospitals (Appendix D, Table 4). Non-profit hospitals comprised 19.39% of the private hospitals in the sample (32/165); they conducted 19.39% (32,754/168,893) of publicly funded hip and knee replacements in private hospitals. NHS treatment centres comprised 2.40% of the NHS hospitals in the sample (6/250), although they conducted 4.26% (15,506/363,917) of publicly funded hip and knee replacements in NHS hospitals. The sample was heavily concentrated within six HRGs, which account for 99.71% of the total sample (Appendix D, Table 5). Of these HRGs, 92.18% of the remaining sample consist of four HRGs for "very major" or "major" knee or hip procedures for non-trauma. The remaining HRGs are for "reconstruction procedures" and for "complex, hip or knee procedures for non-trauma". The proportion of these HRGs conducted by private and NHS hospitals is broadly similar (Appendix D, Table 5), except only 12.91% of "complex, hip or knee procedures for non-trauma" took place in private hospitals. Descriptive statistics for hospitals categorised as treatment centres or by financial objectives, and for individual HRGs, are reported in supplementary material (Appendix D, Tables 6-10).

When focusing on unadjusted rates (Tables 23 and 24), patients undergoing treatment in private hospitals had significantly better outcomes than those treated in NHS hospitals, both in terms of in-hospital mortality, readmissions, and hospital transfers. Differences for in-hospital mortality were small in absolute terms for hip replacement (0.07% in NHS hospitals vs 0.01% in private hospitals) and knee replacement (0.05% in NHS hospitals vs 0.00% in private hospitals). However, these are considerable differences relatively as in-hospital mortality is a very rare event for elective hip and knee replacement. Patients in private hospitals had shorter post-operative length of stay, and longer pre-operative length of stay for both hip and knee replacement. The small differences in average pre-operative length of stay for hip replacement, and (0.05 days in NHS hospitals vs 0.15 days in private hospitals) and knee replacement (0.04 days in NHS hospitals vs 0.16 days in private hospitals), are likely to reflect a greater proportion of patients in private hospitals admitted the night before surgery. The prevalence of all adverse events was lower in private hospitals compared to NHS

hospitals. The largest difference in prevalence was for hospital-associated infections for both hip replacement (0.70% in NHS hospitals vs 0.04% in private hospitals), and knee replacement (0.75% in NHS hospitals vs 0.05% in private hospitals). This considerable difference is consistent with the available literature on the prevalence of hospital-associated infections in NHS and private hospitals. For example, the prevalence of hospital-associated infections was 0.76% of all NHS hospital admissions in Scotland in 2018/19 (Stewart *et al.*, 2021),[5] and data reported to PHIN revealed 318 hospital-associated infections took place in 2019 for approximately 639,000 privately funded hospital admissions in private hospitals in the same year (equivalent to 0.05%) (PHIN, 2020b).

There were small differences in age of patients treated in NHS and private hospitals, with patients, on average, approximately 6 months older in NHS hospitals for both hip replacement, and knee replacement (Tables 23 and 24). Patients in NHS hospitals were from lower socioeconomic groups, and also had more comorbidities. Patients in NHS hospitals had poorer pre-operative functional status than private hospitals, with pre-operative PROM scores lower in NHS hospitals for both hip replacement, and knee replacement. I found no evidence of differing approaches to the collection of PROMs as participation rates were similar between NHS hospitals and private hospitals for both hip replacement and knee replacement. A higher proportion of patients in NHS hospitals were discharged on a weekday compared to private hospitals for both hip replacement, and knee replacement. Again, this may reflect a tendency of hospitals consultants to work in private hospitals during the weekend rather than weekdays as their private work is typically in addition to their NHS contracts. There was also a slightly lower proportion of winter discharges from NHS hospitals than from private hospitals for both hip, and knee replacement. This could reflect how NHS hospitals are often forced to cancel or delay elective procedures in the winter period due to increased hospital admissions from emergency patients (Herrod *et al.*, 2019). Analyses including PROM scores as individual patient covariates only included data between January 2016 and March 2018. For this reason, descriptive statistics for this time period are reported in supplementary material (Appendix D, Tables 11, 12). Despite a different time period of analysis, there were no meaningful differences in descriptive statistics when compared to Tables 23, 24. The only exception were smaller differences in pre-operative LOS between NHS and private hospitals for hip replacement (0.04 vs 0.01 days), and knee replacement (0.04 vs 0.01 days).

[5] Equivalent data do not exist for publicly funded hospital admissions in England as rates of hospital-associated infections are published per 100,000 bed days rather than hospital admission

4.7.2. Primary analysis

4.7.2.1.Strength of differential distance as an instrumental variable

Focusing on mean distances, it is possible to gain some understanding of the strength of differential distance between the nearest NHS and private hospital as an instrument for receiving treatment in an NHS hospital (Table 25). While NHS hospitals tended to be nearer to patients than private hospitals, the average differential distance was over five times smaller for patients who opted to receive treatment in private hospitals (0.62 kilometers vs 3.31 kilometers).

Table 25: Mean distance to nearest NHS and private hospitals in kilometers

	All patients (532,747)	Patients who received treatment in NHS hospitals (363,861)	Patients who received treatment in private hospitals (168,886)
Nearest hospital (km)	9.70	11.64	11.02
Nearest NHS hospital (km)	8.57	8.33	9.08
Nearest private hospital (km)	11.02	11.64	9.70
Differential distance between nearest NHS and private hospital	-2.46	-3.31	-0.62

Focusing on the results of the first stage linear regression (Table 26), the differential distance between nearest NHS and private hospital is strongly correlated with choice of private hospital indicating that this differential distance is a good instrument for treatment in private hospital. For every 1 kilometer closer that the nearest private hospital is located relative to the nearest NHS hospital, the probability that a patient will be treated in a private hospital increased by 0.007 (95% CI 0.006–0.008). When focusing on the alternative specification of the IV analysis that used distance to nearest NHS and private hospitals as two instruments, I find that for every 1 kilometer further away that the nearest NHS hospital is located, the probability of patients receiving treatment in a private hospital increased by 0.011 (95% CI 0.010–0.011). For every 1 kilometer further away that the nearest private hospital is located, the probability that a patient will be treated in a private hospital reduces by -0.007 (95% CI -0.007, -0.006).

Table 26: Results of first stage regression for 2SLS IV analysis[§]

	IV First stage ($D_{NHS} - D_{private}$ IV)	IV First stage (D_{NHS}, $D_{private}$ IV)
$D_{NHS} - D_{private}$	0.007*** (0.006, 0.008)	
D_{NHS}		0.011*** (0.010, 0.011)
$D_{private}$		-0.007*** (-0.007, -0.006)
Age 18–40	—	-
Age 41–60	0.051*** (0.025, 0.078)	0.048*** (0.023, 0.073)
Age 61–80	0.197*** (0.174, 0.221)	0.190*** (0.167, 0.213)
Age >80	0.131*** (0.109, 0.154)	0.124*** (0.101, 0.147)
Gender	0.012* (0.000, 0.023)	0.011 (-0.000, 0.022)
IMD 1	—	-
IMD 2	0.004*** (0.002, 0.006)	0.004*** (0.002, 0.007)
IMD 3	0.013*** (0.010, 0.016)	0.012*** (0.009, 0.015)
IMD 4	0.063*** (0.058, 0.068)	0.058*** (0.053, 0.063)
IMD 5	0.071*** (0.064, 0.078)	0.069*** (0.062, 0.076)
CCI 0	—	-
CCI 1	-0.076*** (-0.081, -0.071)	-0.075*** (-0.080, -0.070)
CCI 2	-0.104*** (-0.126, -0.083)	-0.105*** (-0.126, -0.083)
CCI 3	-0.134*** (-0.152, -0.116)	-0.134*** (-0.153, -0.116)
CCI 4	-0.178*** (-0.197, -0.160)	-0.178*** (-0.196, -0.160)
CCI 5	-0.216*** (-0.239, -0.194)	-0.216*** (-0.239, -0.193)
CCI 6	-0.206*** (-0.278, -0.134)	-0.206*** (-0.278, -0.134)
Vol Q1	—	-
Vol Q2	-0.026*** (-0.040, -0.013)	-0.028*** (-0.042, -0.014)
Vol Q3	-0.008*** (-0.013, -0.003)	-0.011*** (-0.016, -0.006)
Vol Q4	-0.111*** (-0.127, -0.095)	-0.119*** (-0.134, -0.102)
Constant	0.234 (0.210, 0.259)	0.233 (0.210, 0.258)
Observations	526,266	526,266
R^2	0.0490	0.0490
F Stat	118.205	204.27

[§] IMD: index of multiple deprivation, CCI: Charlson Comorbidity Index, Q: quintile (quintile 1 = most deprived, quintile 5 = least deprived).

4.7.2.2. OLS and instrumental variable analyses

The results of the OLS with fixed effects models are outlined in Table 27 (Model 1 and 2). The inclusion of observable patient-level confounders within the regression model slightly reduced the size of the co-efficient that represented differences in patient outcomes, efficiency, and adverse events between private and NHS hospitals (Model 2). Treatment in private hospital was associated with a significantly reduced probability of in-hospital mortality (-0.000, 95% -0.000,-0.000), readmission (-0.018, 95% -0.020, -0.016) and hospital transfer (-0.005, 95% -0.005, -0.005). Treatment in a private hospital was associated with no significant difference in pre-operative length of stay, but significantly shorter post-operative length of stay (-1.163 days, 95% CI -1.377, -0.950 days). The probability of all adverse events were also significantly lower in private hospitals, including for hospital-associated infection (-0.006, 95% -0.006, -0.005), adverse drug reaction (-0.004, 95% CI -0.004, -0.003), pressure ulcer (-0.001, 95% CI -0.001, -0.001), and venous thromboembolism (0.002, 95% CI -0.003, -0.002).

My preferred specification uses differential distance to nearest NHS and private hospitals as an IV for hospital choice to account for both unobservable and observable confounding at the patient-level between private and NHS hospitals (Table 27- Model 3). This appears to be a strong instrument as the F-statistic was 118.205. In contrast to the results produced with OLS and fixed effects, this model produces no significant differences in probability of in-hospital mortality (-0.000, 95% -0.001, 0.000), readmission (-0.000, 95% -0.011, 0.011) and hospital transfer (0.004, 95% -0.002, 0.010), hospital-associated infection (0.000, 95% -0.002, 0.003), adverse drug reaction (0.002, 95% CI -0.001, 0.005), pressure ulcer (-0.000, 95% CI -0.001, 0.001), and venous thromboembolism (0.000, 95% CI -0.001, 0.002). The only significant difference between private and NHS hospitals was longer post-operative length of stay associated with treatment in private hospital (0.734 days, 95% CI 0.296, 1.172). There were no significant differences in pre-operative length of stay (0.226 days, 95% CI -0.069, 0.522). The Hausman endogeneity test was passed for readmissions (p=0.0205), hospital transfers (p=0.0316), and post-operative length of stay (p=0.0438), indicating the null hypothesis that hospital type is exogenous was rejected for these models. The Hausman endogeneity test was failed for other healthcare quality indicators, indicating the null hypothesis that hospital type is exogenous was not rejected and there is an element of bias associated with these coefficients. However, Moscelli et al. (2018) argue that the direction of this bias is known as

Table 27: Results of OLS with fixed effects and IV models [§]

	OLS (1)	OLS and case-mix (2)	$D_{NHS} - D_{private}$ IV (3)	D_{NHS} , $D_{private}$ IV (4)
Mortality	-0.001*** (-0.001, -0.000)	-0.000*** (-0.000, -0.000)	-0.000 (-0.001, 0.000)	-0.000* (-0.001, 0.000)
R^2: Endog test p value: Overid test p value	0.000	0.002	0.002 0.2665	0.002 0.9863 0.0329
Readmission	-0.023*** (-0.024, -0.021)	-0.018*** (-0.020, -0.016)	-0.000 (-0.011, 0.011)	-0.013** (-0.029, -0.004)
R^2: Endog test p value: Overid test p value	0.002	0.015	0.011 0.0205	0.012 0.3894 0.0264
Hospital transfer	-0.006*** (-0.007, -0.006)	-0.005*** (-0.005, -0.005)	0.004 (-0.002, 0.010)	0.006 (-0.001, 0.013)
R^2: Endog test p value: Overid test p value	0.002	0.008	0.005 0.0316	0.003 0.4871 0.0215
Pre-op LOS	0.112 (-0.037, 0.260)	0.111 (-0.034, 0.256)	0.226 (-0.069, 0.522)	0.243 (-0.055, 0.541)
R^2: Endog test p value: Overid test p value	0.007	0.019	0.006 0.1272	0.004 0.1951 0.0780
Post-op LOS	-1.342*** (-1.573, -1.111)	-1.163*** (-1.377, -0.950)	0.734*** (0.296, 1.172)	-0.255 (-0.628, 0.118)
R^2: Endog test p value: Overid test p value	0.048	0.106	0.029 0.0438	0.088 0.2990 0.0350
HAI	-0.007*** (-0.007, -0.006)	-0.006*** (-0.006, -0.005)	0.000 (-0.002, 0.003)	-0.003* (-0.005,-0.000)
R^2 Endog test p value: Overid test p value	0.002	0.006	0.004 0.0865	0.005 0.8515 0.0381
Adverse drug reaction	-0.005*** (-0.005, -0.004)	-0.004*** (-0.004, -0.003)	0.002 (-0.001, 0.005)	0.000 (-0.002, 0.002)
R^2 Endog test p value: Overid test p value	0.001	0.002	0.000 0.0511	0.001 0.0821 0.0476
Pressure ulcer	-0.002*** (-0.002, -0.001)	-0.001*** (-0.001, -0.001)	-0.000 (-0.001, 0.001)	-0.001* (-0.002, -0.000)
R^2 Endog test p value: Overid test p value	0.000	0.003	0.003 0.2802	0.003 0.9778 0.0460
Venous thrombo-embolism	-0.002*** (-0.003, -0.002)	-0.002*** (-0.003, -0.002)	0.000 (-0.001, 0.002)	-0.001 (-0.003, 0.001)
R^2 Endog test p value: Overid test p value	0.001	0.001	0.000 0.1129	0.001 0.2680 0.2547
1st-stage F stat: Observations:	532,810	526,294	118.205 526,266	204.27 526,266

[§]*** p<0.001, ** p<0.01, * p<0.05. Endog test: Hausman endogeneity test, Overid test: Sargan-Hansen overidentification test, HAI: healthcare-associated infection, LOS: length of stay.

private hospitals can select unobservably healthier patients and biased results will overestimate any quality-of-care gains from treatment in a private hospital. As a result, we can still be reasonably confident that quality of care for elective hip and knee replacements in NHS hospitals is at least as good as in private hospitals as these coefficients indicate there are no significant differences in quality of care between NHS and private hospitals.

As a robustness check, Model 4 uses distance to nearest private and NHS hospital as two separate instruments for hospital choice (Table 27). However, the Sargan-Hansen overidentification test rejected the validity of the instruments in model 4 for all patient outcomes, efficiency measures and adverse events (except for venous thromboembolism), indicating that Model 4 was incorrectly specified (Hansen, 1982; Sargan, 1988). For this reason, Model 4 is not repeated in any of the further supplementary analyses.

4.7.3. Supplementary analyses

4.7.3.1. Probit and Poisson regression

Changing the functional form of my model specification to either a Probit or Poisson regression rather than linear regression did not substantively alter results produced by my primary analysis (Appendix D, Table 13). Using Probit regression and differential distance between nearest NHS and private hospital as an instrument for hospital choice, there were no significant differences between private and NHS hospitals for probability of in-hospital mortality (-0.001, 95% CI -0.001, 0.000), readmission (-0.002, 95% CI -0.012, 0.009), hospital transfer (-0.002, 95% CI -0.002, 0.006), hospital-associated infection (-0.005, 95% CI -0.010, 0.000), adverse drug reaction (0.002, 95% CI -0.002, 0.005), pressure ulcer (-0.001, 95% CI -0.002, 0.001), or venous thrombo-embolism (-0.000, 95% CI -0.002, 0.002). Using Probit regression and no instrumental variable, there was a lower and significant probability in private hospitals of in-hospital mortality (-0.001, 95% CI -0.001, -0.001), readmission (-0.026, 95% CI -0.029, -0.023), hospital transfer (-0.010, 95% CI -0.014, -0.016) hospital-associated infection (-0.024, 95% -0.034, -0.014), adverse drug reaction (-0.005, 95% CI -0.006, -0.005), pressure ulcer (-0.004, 95% CI -0.006, -0.002), and venous thrombo-embolism (-0.004, 95% CI -0.005, -0.002). Using Poisson regression meant that co-efficients were expressed as incidence rate ratios (IRRs), rather than differences in length of stay. Using Poisson regression and differential distance between nearest NHS and private hospital as an instrument for hospital choice, treatment in private hospital was associated with

greater length of stay pre-operatively (2.292, 95% CI 1.544, 3.403) and post-operatively (1.374, 95% CI 1.315, 1.437). Using Poisson regression and no instrumental variable, treatment in private hospital was associated with greater length of stay pre-operatively (3.838, 95% CI 1.667, 8.837), and shorter length of stay post-operatively (0.709, 95% CI 0.668, 0.752). Similar to my primary analysis, these findings indicate that using an instrumental variable for hospital choice accounts for confounding at the patient-level between private and NHS hospitals that is not reflected when using regression without an instrumental variable.

4.7.3.2.Inclusion of PROMs as patient-level covariate

As PROMs data were only available until March 2018, including PROMs as a patient-level covariate resulted in a different sample size than my primary analysis that used data up to December 2019 (Appendix D, Tables 11, and 12). The results produced were broadly similar results to the primary analyses with some exceptions when using differential distance between nearest NHS and private hospital as an instrument for hospital choice (Appendix D, Tables 14). These included treatment in private hospital associated with increased probability of readmission (0.012, 95% CI 0.008, 0.016), and adverse drug reaction (0.003, 95% CI 0.001, 0.006), and greater post-operative length of stay (0.446 days, 95% CI 0.116, 0.776 days). The Hausman endogeneity test was passed for all healthcare quality indicators, with the exception of in-hospital mortality (p=0.5511), pressure ulcer (p=0.1030), and venous thromboembolism (p=0.0889). This suggests that the inclusion of pre-operative PROMs as a covariate resulted in less unexplained variance between private and NHS hospitals for the healthcare quality indicators than in the primary analysis.

4.7.3.3.Greater London Analysis

Restricting my analysis to hospitals exclusively located in the Greater London produced very similar results to my primary analysis (Appendix D, Table 14), with the exception of increased probability of pressure ulcer in private hospitals when using differential distance between nearest NHS and private hospital as an instrument for hospital choice (0.016, 95% CI 0.004, 0.027). The Hausman endogeneity test was passed for pre-operative length of stay (p=0.0000), post-operative length of stay (p=0.0000), and adverse drug reaction (p=0.0196). This indicates there are unlikely to be significant differences in healthcare quality between private hospitals in Greater London and elsewhere in England. Although, this aggregate regional finding overlooks the significant heterogeneity in type and size of private hospitals

located in London (see section 1.1.3.). Following improved data collection on private hospital characteristics, further examination of healthcare quality differences in private hospitals in London is required.

4.7.3.4.Treatment centre analysis

ISTCs were compared to NHS treatment centres, as NHS treatment centres were considered more similar to ISTCs than NHS hospitals. The OLS with fixed effects model produced similar results to my primary analysis, except that treatment in ISTCs was associated with shorter pre-operative length of stay (-0.011 days, 95% CI -0.019, -0.004 days). Using differential distance to nearest NHS and private hospital produced contrasting results to my primary analysis, with treatment in ISTCs associated with reduced probability of in-hospital mortality (-0.000, 95% CI -0.001, -0.000), hospital transfer (-0.005, 95% CI -0.008, -0.002), hospital-associated infection (-0.003, 95% CI -0.003, -0.002), adverse drug reaction (-0.014, 95% CI -0.017, -0.009), pressure ulcer (-0.002, 95% CI -0.003, -0.001) and venous thromboembolism (-0.003, 95% CI -0.004, -0.002) (Appendix D, Table 15). Treatment in ISTCs was also associated with reduced pre-operative length of stay (-0.012 days, 95% -0.021, -0.004), and post-operative length of stay (-1.173 days, 95% CI -1.358, -0.987). However, the Hausman endogeneity test was failed for all healthcare quality indicators, with the exception of readmission (p=0.000), and post-operative length of stay (p=0.000). Therefore, these findings could be overestimated as the Hausman endogeneity tests expose significant unexplained endogeneity.

4.7.3.5.For-profit and not-for-profit private hospital analysis

Treatment in for-profit and not-for-profit private hospitals were compared to NHS hospitals separately. Treatment in for-profit private hospitals compared to NHS hospitals produced very similar results to the primary analysis (Appendix D, Table 16). Whereas, treatment in not-for-profit private hospitals compared to NHS hospitals produced contrasting results when using differential distance between nearest NHS and private hospital as an instrument for hospital choice. These included treatment in not-for-profit private hospitals associated with reduced probability of readmission (-0.019, 95% CI -0.034, -0.003), hospital-associated infection (-0.006, 95% CI -0.010, -0.002), adverse drug reaction (-0.010, 95% CI -0.014, -0.005) and pressure ulcers (-0.004, 95% CI -0.006, -0.002). Treatment in not-for-profit hospitals was also associated with reduced pre-operative length of stay (-0.132 days, 95% CI

-0.172, -0.092) and reduced post-operative length of stay (-0.663 days, 95% CI -0.818, -0.508). The differences in findings between for-profit and not-for-profit private hospitals could reflect how not-for-profit hospitals have fewer incentives to engage with the cost-containment scenario by reducing healthcare quality (discussed in section 1.4). However, the Hausman endogeneity test was failed for all healthcare quality indicators except for hospital transfers (p=0.0496). Therefore, these findings could also be overestimated.

4.7.4. Propensity score matching

As mentioned in my methods section, propensity score matching was used for two purposes. First, to establish the robustness of results from my primary analysis. Second, to assess the relationship between experiencing adverse events and outcomes and efficiency in private and NHS hospitals. The results are expressed as Average Treatment Effect On Treated (ATT) of private hospital treatment, rather than changes in probability (Table 28). The basic specification includes patients matched according to their probability of receiving treatment using age, gender, CCI and level of deprivation. The PROMs specification also matches patients according to individual oxford hip or knee score, and therefore only uses data until March 2018. The HRG specification also matches patients according to individual reimbursement group. Two approaches to propensity score matching were used, beginning with inverse probability weighting matching with regression adjustment (IPWRA). Then nearest-neighbour matching was used to ascertain if a different approach to propensity score matching changed results. The covariate balancing test was fulfilled for all models (Appendix D, Figures 1–14).

4.7.4.1.Patient outcomes in private and NHS hospitals

Focusing on the basic specification (Table 28), the ATT of private hospital treatment was negative and significant for in-hospital mortality for both hip replacement (-0.044%, 95% CI -0.053, -0.034), and knee replacement (-0.034%, 95% CI -0.043, -0.026), readmissions for both hip replacement (-1.851%, 95% CI -2.048, -1.653), and knee replacement (-1.998%, 95% CI -2.180, -1.814), and hospital transfers for both hip replacement (-0.590%, -0.643, -0.537), and knee replacement (-0.538%, 95% CI -0.583, -0.493). The ATT of private hospital treatment was very similar when also matching according to individual HRGs. However, the size of ATT of private hospital treatment for all outcome measures were smaller when including PROM scores as a covariate. This indicates that PROM scores explained some of the variation in in-hospital mortality, readmission, and hospital transfer rates. There were also

very similar results when using nearest neighbour propensity score matching (Appendix D, Table 17), although larger 95% confidence intervals meant the ATT of private hospital treatment for in-hospital mortality in private hospitals was not always significant across model specifications. These results are also consistent with the results produced by my primary analysis when using OLS with fixed effects (Table 27), but contrast with results produced when using differential distance to nearest NHS and private hospital as an instrument for hospital choice.

4.7.4.2.Efficiency in private and NHS hospitals

The ATT of private hospital treatment for pre-operative length of stay was positive and significant (Table 28): largest when including PROMs as a covariate for both hip replacement (0.209 days, 95% CI 0.199, 0.218) and knee replacement (0.208 days, 95% CI 0.199, 0.217); and smallest when using the basic specification for both hip replacement (0.106 days, 95% CI 0.100, 0.1111) and knee replacement (0.116 days, 95% CI 0.111, 0.121). The ATT of private hospital treatment for post-operative length of stay was positive, significant, and a similar magnitude across all model specifications: when using the basic specification, this was approximately equivalent to one day shorter for both hip replacement (-1.207 days, 95% -1.226, -1.187) and knee replacement (-1.270 days, 95% CI -1.288, -1.253). There were also very similar results when using nearest neighbour propensity score matching (Appendix D, Table 17), with a positive and significant ATT of private hospital treatment for pre-operative length of stay across all model specifications. These findings are consistent with my primary analysis when using OLS with fixed effects (Table 27), although in my primary analysis the association between treatment in private hospitals and greater pre-operative length of stay was not statistically significant. Similar to patient outcomes, these results contrast with results produced when using differential distance to nearest NHS and private hospital as an instrument for hospital choice.

4.7.4.3.Adverse events in private and NHS hospitals

The ATT of private hospital treatment for all adverse events was negative for both hip replacement and knee replacement (Table 28). There were also consistent results across all model specifications. Focusing on the basic specification (Table 28), the ATT of private hospital treatment was largest for hospital-associated infection for both hip replacement (-0.556%, 95% CI -0.594, -0.518) and knee replacement (-0.599%, 95% CI -0.636, -0.562).

The ATT was smallest for venous thromboembolism for hip replacement (-0.161%, 95% CI -0.192, -0.130), and for pressure ulcer for knee replacement (-0.094%, 95% -0.114, -0.007). There were similar results when using nearest neighbour propensity score matching (Appendix D, Table 17), although larger 95% confidence meant that the ATT for adverse drug reaction, pressure ulcers and venous thromboembolism was not always significant across model specifications. These results are also consistent with the results produced by my primary analysis when using OLS with fixed effects (Table 27), but contrast with results produced when using differential distance to nearest NHS and private hospital as an instrument for hospital choice.

Table 28: Results of inverse probability weighting with regression adjustment comparing adverse events, outcome and efficiency measures between private and NHS hospitals[§]

	Model 1: Basic specification		Model 2: PROMs		Model 3: HRG	
	Hip	Knee	Oxford hip score	Oxford knee score	Hip	Knee
ATT on Mortality	-0.044*** (-0.053, -0.034)	-0.034*** (-0.043, -0.026)	-0.031*** (-0.045, -0.016)	-0.031*** (-0.045, -0.017)	-0.042*** (-0.052, -0.033)	-0.037*** (-0.048, -0.003)
ATT on Readmissions	-1.851*** (-2.048, -1.653)	-1.998*** (-2.180, -1.814)	-1.457*** (-1.747, -1.167)	-1.458*** (-1.736, -1.179)	-1.829*** (-2.027, -1.631)	-1.975*** (-2.161, -1.789)
ATT on Transfers	-0.590*** (-0.643, -0.537)	-0.538*** (-0.583, -0.493)	-0.361*** (-0.437, -0.285)	-0.333*** (-0.400, -0.266)	-0.577*** (-0.630, -0.524)	-0.523*** (-0.569, -0.477)
ATT on Pre-Op LOS	0.106*** (0.100, 0.111)	0.116*** (0.111, 0.121)	0.209*** (0.199, 0.218)	0.208*** (0.199, 0.217)	0.109*** (0.103, 0.114)	0.117*** (0.112, 0.122)
ATT on Post-Op LOS	-1.207*** (-1.226, -1.187)	-1.270*** (-1.288, -1.253)	-1.283*** (-1.156, -1.101)	-1.196*** (-1.219, -1.173)	-1.171*** (-1.190, -1.152)	-1.280*** (-1.307, -1.253)
ATT on HAI	-0.556*** (-0.594, -0.518)	-0.599*** (-0.636, -0.562)	-0.435*** (-0.488, -0.381)	-0.515*** (-0.569, -0.461)	-0.545*** (-0.584, -0.507)	-0.586*** (-0.624, -0.549)
ATT on Adverse Drug Reactions	-0.442*** (-0.495, -0.389)	-0.378*** (-0.422, -0.333)	-0.405*** (-0.483, -0.327)	-0.375*** (-0.441, -0.308)	-0.442*** (-0.495, -0.389)	-0.387*** (-0.433, -0.341)
ATT on Pressure Ulcer	-0.168*** (-0.196, -0.135)	-0.094*** (-0.114, -0.007)	-0.135*** (-0.172, -0.098)	-0.079*** (-0.109,-0.050)	-0.153*** (-0.183, -0.123)	-0.099*** (-0.121, 0.076)
ATT on VTE	-0.161*** (-0.192, 0.130)	-0.263*** (-0.301, -0.225)	-0.141*** (-0.184, -0.098)	-0.257*** (-0.313,-0.200)	-0.158*** (-0.190, -0.127)	-0.252*** (-0.290, -0.214)

[§]Columns report the average treatment effect on the treated (ATT) and the standard errors. Significance: *** p<0.01, ** p<0.05, * p<0.1. Propensity score matching on age, gender and Charlson Comorbidity Index. Balance test fulfilled for all models. HRG: health resource groups, PROMs: patient-reported outcome measures, LOS: length of stay, HAI: Hospital associated infection, VTE: venous thromboembolism.

4.7.4.4.Implications of experiencing adverse events on patient outcomes in private and NHS hospitals

The ATT of experiencing an adverse event on outcomes and efficiency varied between NHS and private hospitals and across individual adverse events (Table 29). As mortality was such a rare event in private hospitals, there were not sufficient observations to estimate an ATT for most adverse events. The ATT of experiencing an adverse event on mortality in NHS hospitals was largest for hospital-associated infections (1.90%, 95% CI 1.37%, 2.44%), and the smallest for adverse drug reactions (0.21%, 95% CI -0.00%, 0.43%). While this indicates there is an association between experiencing adverse events in NHS hospitals and mortality in NHS hospitals, it is not possible to conclude that experiencing an adverse event contributed to death because information regarding cause of death is not contained within the HES database. The ATT of experiencing an adverse event for readmission was similar between private and NHS hospitals, except for venous thromboembolism. The ATT of experiencing venous thromboembolism for readmissions was three times higher in private hospitals (25.48%, 95% 19.08%, 31.81%), than in NHS hospitals (8.11%, 95% CI 6.11%, 10.10%). The ATT of experiencing an adverse event in NHS hospitals for hospital transfers was the largest for pressure ulcers (3.81%, 95% 2.20%, 5.42%), and the smallest for adverse drug reactions (0.74%, 95% CI 0.22%, 1.23%). In private hospitals, the ATT of experiencing an adverse event for hospital transfers was the largest for venous thromboembolism (6.74%, 95% CI 3.22%, 10.26%), but not statistically significant for other individual adverse events. While information on the cause of readmission or hospital transfer was not retrieved in my dataset, the significantly increased rate of readmission and hospital transfer for patients that experience venous thromboembolism in private hospitals suggests that private hospitals may not have adequate pathways or guidance to manage patients that experience this adverse event.

Nearest neighbour matching produced wider confidence intervals than IPWRA (Appendix D, Table 18), and this meant the ATT of experiencing most adverse events in private hospital were not significant for most outcome measures. The exception was the ATT of experiencing venous thromboembolism in private hospitals, which was significant for readmissions (24.10%, 95% CI 16.39%, 31.81%), and hospital transfers (7.18%, 95% CI 2.62%, 11.74%).

Table 29: Average treatment effect on treated (ATT) of experiencing adverse events on outcome and efficiency measures for patients undergoing primary hip and knee replacement in NHS and private hospitals (inverse probability weighting doubly robust estimation)[§]

	Hospital-associated infections		Adverse drug reactions		Pressure ulcer		Venous thromboembolism	
	NHS	Private	NHS	Private	NHS	Private	NHS	Private
Model 1: Basic specification								
ATT on Mortality	1.90*** (1.37, 2.44)	1.35 (-1.29, 3.98)	0.21 (-0.00, 0.43)	—	1.46*** (0.58, 2.35)	—	0.95*** (0.41, 1.50)	—
ATT on Readmission	8.50*** (7.03, 9.97)	8.07* (0.07, 16.07)	3.95*** (2.65, 5.25)	4.54** (1.47, 7.62)	9.63*** (6.82, 12.44)	11.93** (4.10, 19.76)	8.11*** (6.11, 10.10)	25.48*** (19.08, 31.81)
ATT on Hospital Transfers	2.58*** (1.84, 3.32)	—	0.74*** (0.22, 1.23)	1.18 (-0.02, 2.39)	3.81*** (2.20, 5.42)	—	1.82*** (0.92, 2.72)	6.74*** (3.22, 10.26)
ATT on Pre-Op LOS	0.11*** (0.06, 0.16)	0.40 (-0.08, 0.89)	0.04 (-0.04, 0.08)	-0.05 (-0.13, 0.02)	0.33* (0.16, 0.65)	-0.17*** (-0.18, -0.16)	0.10** (0.05, 0.16)	-0.04 (-0.14, 0.06)
ATT on Post-Op LOS	7.51*** (7.06, 7.95)	2.41*** (1.42, 3.41)	2.57*** (2.28, 2.87)	0.90*** (0.66, 1.14)	8.49*** (7.52, 9.45)	5.86*** (4.06, 7.66)	5.15*** (4.71, 5.60)	2.26*** (1.77, 2.75)

[§] ATT: Average treatment effect on treated, LOS: length of stay, pre-op: pre-operative, post-op: post-operative, — means there were insufficient observations to allow the calculation of ATT. 95% CI in parentheses. *** p<0.001, ** p<0.05, * p<0.1

4.7.4.5.Implications of experiencing adverse events on efficiency in private and NHS hospitals

The ATT of experiencing an adverse event on pre-operative length of stay for all adverse events was small, and in many cases not significant. However, most adverse events are experienced post-operatively and therefore we are unlikely to produce any meaningful findings by focusing on pre-operative length of stay. The ATT of experiencing an adverse event on post-operative length of stay was largest for pressure ulcers for both NHS hospitals (8.49 days, 95% CI 7.52, 9.45 days), and private hospitals (5.86 days, 95% CI 4.06, 7.66 days). In contrast, the ATT of experiencing an adverse drug reaction for post-operative length of stay was smallest for both NHS hospitals (2.57 days, 95% CI 2.28 days, 2.87 days), and private hospitals (0.90 days, 95% CI 0.66, 1.14 days). While there is clearly a relationship between experiencing adverse events and post-operative length of stay, it is not possible to dissect the direction of causation when analysing adverse events because prolonged post-operative length of stay can expose patients to a higher risk of experiencing adverse events. In particular, the risk of pressure ulcers and of venous thromboembolism exponentially increases the longer patients remain in hospital (Allman *et al.*, 1999; Graves, Birrell and Whitby, 2005; Amin *et al.*, 2019; Salomon *et al.*, 2021). Nearest neighbour matching produced similar results to IPWRA, with the ATT of experiencing all adverse events being positive and significant in both NHS and private hospitals (Appendix D, Table 18).

4.7.4.6.Summary of findings using propensity score matching

When using propensity score matching to assess the robustness of my primary analysis, the results are consistent with results produced using OLS with fixed effects (Tables 27, 28). While propensity score matching is often understood to be a more robust method for casual inference than OLS, these two methods are both subject to the same limitation that they only account for observable differences between patients. Therefore, it is not surprising that using differential distance to nearest NHS and private hospitals as an instrument for hospital choice in my primary analysis produces different results. This only further builds the rationale for more routine use of casual inference methods that account of unobserved confounding such as instrumental variable analyses.

When using propensity score matching to examine the association between adverse events and outcomes and efficiency, there are some interesting findings. As expected, experiencing an adverse event exposes patients to higher risk of poorer patient outcomes in both private and NHS hospitals. However, the substantially increased risk of readmission and hospital transfer in private hospitals compared to NHS hospitals following venous thromboembolism warrants further examination. This may indicate that private hospitals do not have adequate pathways or guidance to manage patients that experience this adverse event. There is also a strong association between the ATT of experiencing an adverse event and greater post-operative length of stay. However, I can only demonstrate an association rather than causation as it is also possible that prolonged post-operative length of stay can expose patients to a higher risk of experiencing adverse events.

4.8. Discussion

4.8.1. Summary of overall findings

This analysis provides a comprehensive comparative assessment of patient outcomes, efficiency measures and adverse events in private and NHS hospitals for patients undergoing elective hip and knee replacement in England. Using OLS with fixed effects methods to adjust for observable confounding, treatment in private hospitals was associated with a significantly lower probability of in-hospital mortality, readmission, hospital transfer and several adverse events. Treatment in private hospitals was also associated with longer pre-operative length of stay and shorter post-operative length of stay. There were similar results when using propensity score matching to match similar patients based on observable differences in patient characteristics.

In contrast, using differential distance between nearest NHS and private hospital as an IV for hospital choice to adjust for both observable and unobservable confounding at the patient-level, I find there are no significant differences in the probability of any patient outcome or adverse event between private and NHS hospitals. I also find no significant differences in pre-operative length of stay, but treatment in private hospital was in fact associated with increased post-operative length of stay. Contrary to previous evidence, this indicates that NHS hospitals are more efficient than private hospitals when providing elective hip and knee replacements. Results of Hausman endogeneity tests varied across healthcare quality indicators, and the test was only passed for readmissions, hospital transfers, and post-operative length of stay. For the other healthcare quality indicators, the Hausman endogeneity test failed to reject the null hypothesis that hospital choice was exogenous, indicating that these coefficients are biased. However, the direction of this bias is likely to overestimate any quality-of-care or efficiency gains in favour of private hospitals because private hospitals can select unobservably healthier patients. For these reasons, we can be confident that quality of care for elective hip and knee replacements in NHS hospitals is at least as good as in private hospitals.

Using propensity score matching to match similar patients, an association between experiencing adverse events and poorer outcomes and longer post-operative length of stay was identified. However, it was not possible to state conclusively to whether these adverse

events were the primary cause of poorer outcomes because no data was available regarding cause of death, readmission or hospital transfer. It was also not possible to disentangle the direction of the relationship between adverse events and post-operative length of stay, as it is known to be bi-directional.

4.8.2. Strengths and limitations

There are several strengths to this analysis. First, a broad spectrum of healthcare quality indicators was analysed, that collectively reflect differences in patient outcomes, efficiency and adverse events between private and NHS hospitals. In contrast, other studies analysed either one or only a few healthcare quality indicators (Browne *et al.*, 2008; Moscelli *et al.*, 2018). To my knowledge, this is also the first study which has compared the prevalence and probability of several, potentially avoidable, adverse events in private and NHS hospitals in England. Second, several supplementary analyses were conducted including procedures classified according to individual reimbursement codes, and hospitals subcategorised according to their status as a treatment centre and their financial objectives. Third, arguably the most significant strength of this analysis is the application of methods that take account of both observable and unobservable confounders at the patient-level between NHS and private hospitals. This is important as it is known that the case-mix varies significantly between private and NHS hospitals (Mason, Street and Verzulli, 2010), and that the scope for potential unobserved confounding at the patient-level is high due to confidential contractual arrangements agreed at the local level that typically specify how private hospitals are expected to treat less complicated patients, and that decisions made by clinicians regarding whether to refer patients to private hospitals are often based on assessments of fitness for surgery which not fully captured by observable measures of multimorbidity such as the CCI (see section 4.2.1.).

However, there are a number of limitations to this analysis. First, there are a number of hospital and workforce factors known to influence outcomes, efficiency and adverse events that are not analysed because data is not available for private hospitals in England. From the hospital perspective, important factors include the presence of critical care facilities (Hill *et al.*, 2007; Grier *et al.*, 2020), and bed occupancy (Friebel *et al.*, 2019; Bosque-Mercader and Siciliani, 2022). From the workforce perspective, important factors include surgical experience (Garriga *et al.*, 2019; Fowler *et al.*, 2021), vacancy rates (Bridges *et al.*, 2019), and nurse-to-patient ratios (Kane *et al.*, 2007). Second, the Hausman endogeneity tests did

not reject the null hypothesis that hospital choice was exogenous for only three healthcare quality indicators. These were the IV analyses for readmissions, hospital transfers and post-operative length of stay. However, it is not surprising that Hausman tests produced different results across different healthcare quality indicators, as the prevalence and variation of the chosen healthcare quality indicators vary significantly across hospitals in this analysis. Therefore, some variation in the degree of correlation between the error term from first stage regressions and different healthcare quality indicators is to be expected. It is possibly too ambitious to expect one instrumental variable to perform well across multiple different dependent variables. This may explain why Moscelli et al. (2018) only chose to analyse one dependent variable, readmissions. Third, another important potential limitation is that the findings of this study may have been influenced by differences in coding practices between NHS and private hospitals. While there are legitimate concerns that private hospitals may not input diagnostic codes as accurately as NHS hospitals (or even vice versa), we can be reassured by the nearly two decades' experience that private hospitals have in supplying admitted patient care data to NHS Digital who subsequently audit the hospitals' coding practices. Moreover, private hospitals typically outsource their coding and contract with the same private consultancy companies which support NHS hospitals in England with their clinical coding audits (Capita, 2022; CCSD, 2022; CHKS, 2022).

Finally, there are measurement issues specific to each healthcare quality indicator analysed (Table 30). In-hospital mortality was analysed as I did not have access to ONS data required to estimate out-of-hospital mortality. Ideally, I would have also measured out-of-hospital deaths within 30 or 90 days as there is consensus among the literature that measuring in-hospital mortality in isolation can overlook important differences in medium and long-term outcomes for surgical patients post-operatively (Borzecki *et al.*, 2010; Singh and Lewallen, 2012; Hirji *et al.*, 2020). For example, it is possible that some hospitals discharge patients earlier than required clinically which would negatively impact 30 or 90-day mortality but have no impact on in-hospital mortality. While I do not capture out-of-hospital mortality, I do measure one out-of-hospital outcome by analysing hospital readmissions within 28 days. One strength of this measure is that it captures readmissions to other hospitals, for example patients admitted to NHS hospitals following discharge from a private hospital. However, one limitation of this measure is that it does not capture patients that are readmitted to hospitals through privately funded mechanisms, because I was unable to track patients between NHS Digital and PHIN datasets using unique patient identifiers (see section 5.4).

The same limitation applies when analysing hospital transfers, although the absolute numbers of readmissions or hospital transfers that are not captured because of this limitation are likely to be very small, as readmissions related to surgery accessed through the NHS are not covered under private health insurance schemes. Further limitations of these measures are that I was unable to establish the cause of readmission or hospital transfer. As a result, readmissions are captured that may be unrelated to the primary hip or knee replacement, and hospital transfers captured that occur as a result of capacity constraints rather than for medical reasons. Moreover, hospital transfers are measured using discharge destination and therefore accuracy is dependent upon appropriate classification by clinical coders. Pre-operative and post-operative length of say are calculated by using admission and discharge date, which means these indicators can only be estimated in days rather than hours. This is an important limitation as it is known that discharge during the evening rather than during the morning is associated with higher risk of readmission to hospital (Wertheimer *et al.*, 2014; Jean-Sebastien Rachoin *et al.*, 2020). The identification of these adverse events is based on collections of diagnostic codes developed by the US Agency for Healthcare Research and Quality (AHRQ, 2003), which have been validated for use with HES data by several other research teams (Bottle and Aylin, 2009; Friebel, Henschke and Maynou, 2021). However, it should be acknowledged that the identification of these adverse events is dependent upon the accuracy of medical notes and the quality of diagnostic coding at the hospital level. Moreover, this measure does not capture patients that are diagnosed with adverse events in community.

Table 30: Measurement issues for individual healthcare quality indicators

Indicator	Measurement Issue
In-hospital mortality	• Does not capture out of hospital mortality (including in the community)
Inter-hospital transfer	• Estimated using discharge destination, which is reliant upon appropriate classification by clinical coders • Cause of transfer not captured
Readmissions within 28 days	• Does not capture privately funded readmissions within the same time period • Cause of readmission not captured
Pre-operative length of stay	• Estimated in days rather than hours
Post-operative length of stay	• Estimated in days rather than hours
Hospital associated infections	• Reliant upon accurate medical notes by clinicians and coding of diagnoses by clinical coders • Does not capture community associated adverse events following discharge
Adverse drug reactions	
Pressure ulcers	
Venous thromboembolism	

4.8.3. Policy implications and conclusions

Despite literature suggesting that NHS hospitals provide poorer quality of care than private hospitals, this analysis provides evidence to the contrary: that there are no significant differences in quality of care for elective primary hip and knee replacements provided in NHS and private hospitals. Conversely, evidence is generated that NHS hospitals may in fact be more efficient than private hospitals in relation to post-operative length of stay. In line with pre-existing literature, I also expose significant differences in case-mix between private and NHS hospitals. Patients treated in NHS hospitals are, on average, older, more deprived, and more medically complex. In addition, I find evidence that suggests there is unobserved confounding between NHS and private hospitals. I argue these differences are likely to reflect different levels of fitness for surgery, which is typically a clinical judgement and not observable within hospital administrative datasets. While only primary hip and knee replacements were analysed, these findings have several important policy implications that are applicable to the majority of the private healthcare sector as most private hospitals focus on similar high-volume and low complexity elective surgical procedures (see section 1.1.3.)

First, the differences in case-mix between private and NHS hospitals are important as the pre-existing system of hospital reimbursement in England does not sufficiently remove incentives for cream-skimming by hospitals. The current system of HRGs disaggregates the tariffs for hip or knee replacement into “Major”, “Very Major” or “Complex”, and this does not reflect the broad range of differences in observable patient characteristics such as multimorbidity, and unobservable patient characteristics such as frailty and fitness for surgery. While private or NHS hospitals could technically both engage in cream-skimming to avoid costly patients, private hospitals also have a market advantage as confidential contracts between local commissioners and private hospitals typically state that medically complex patients should be treated in NHS hospitals (Mason, Street and Verzulli, 2010). Moreover, clinicians avoid referring medically complex patients to private hospitals because they often perceive NHS hospitals as more appropriate locations of care due to the availability of critical care services (see section 4.2.1.). There are several policy responses which could be leveraged to address these market failures including the creation of more detailed HRGs, better data collection on patient characteristics such as frailty and fitness and surgery, and improved transparency in contracting arrangement between local commissioners and private hospitals. In acknowledgement that incentives for cream-skimming may not be completely removed, a more controversial intervention would be to introduce lower levels of reimbursement for

private hospitals to mitigate against any market advantage private hospitals may have over NHS hospitals. However, this policy could lead to the withdrawal of private hospitals from local healthcare markets perceived as not economically viable and there would need to be significant investment in NHS hospital capacity and infrastructure to mitigate against this risk.

Second, this study adds to the pre-existing literature that has so far not identified consistent concerns regarding quality of care for publicly funded care in private hospitals. This is important as, at least in the short-term, the NHS will continue to expand its' investment in publicly funded care undertaken in private hospitals to address growing backlogs of elective care (Anderson and Mossialos, 2022). Moreover, it is reasonable that the public should expect value for money for investment of public funds in the private healthcare sector and reassurance that care in private hospitals is at least as safe as in NHS hospitals. However, it should be emphasised this aggregate finding may overlook differences in healthcare quality across private hospitals when disaggregated according to differences in hospital size, surgeon experience, staffing levels, and facilities available. Therefore, it is crucial that local commissioners still undertake comprehensive assessment of the capabilities and capacity of private hospitals before establishing contracts for the provision of publicly-funded care. More generally, there need to be increased policy debate whether continued reliance of the NHS on the private healthcare sector for additional capacity is viable or preferable. It can be argued that continued investment of public funds in the private healthcare sector is diverting public funds from the capital investment required to expand NHS hospital infrastructure.

Third, my findings in relation to adverse events warrant further examination. There was substantially lower prevalence of hospital associated infections, adverse drug reactions, venous thrombo-embolism, and pressure ulcers in private hospitals. This could be because private hospitals have higher staffing levels, treat less complex patients and typically specialise in low-complexity elective care. In contrast, NHS hospitals are typically understaffed, treat more complex patients, and provide a broad range of simple and complex treatments. To understand this issue further, there is a need for operational research to understand the drivers and management of adverse events in private hospitals compared to NHS hospitals. Particular attention is needed to understand the implications of experiencing venous-thromboembolism, as I discovered patients are subject to substantially high risk of readmission and hospital transfer in private hospitals. This indicates that private hospitals do not have adequate processes to manage or prevent venous thrombo-embolism and there is a

need to improve staff training and develop protocols for the management of this adverse event. However, the prevalence of venous thromboembolism was approximately three times lower in private hospitals than in NHS hospitals which indicates there are sufficient protocols in place in private hospitals for the prevention of venous thromboembolism.

Finally, there is a need to move away from reliance on ad hoc analyses undertaken by academics to more systematic and regular monitoring of patient outcomes, efficiency and adverse events in the private health care sector. Despite positive developments such as the establishment of PHIN (see section 1.2.3.1.), there are still substantial gaps in data collection and reporting for outcomes and adverse events in the private healthcare sector (M. Anderson *et al.*, 2020). This will need to be coupled with improved data collection for organisational and workforce characteristics (see section 5.4.), and operational research regarding different patient pathways to help understand some of the observed disparities in quality of care between the two sectors.

5. Chapter 5: Discussion

5.1. Summary of findings and contributions to the literature

The papers within this PhD thesis collectively achieve the overall objective of examining healthcare quality implications of the relationship between the public and private sector for elective surgical care in England. This is accomplished through multiple perspectives including estimating the relative response of NHS and private hospitals to a national healthcare quality initiative (Paper I), establishing evidence of substitution between changes in publicly and privately funded low value care (Paper II), and analysing differences in healthcare quality for elective orthopaedic care in private and NHS hospitals (Paper III). This section provides a broad summary of findings and contributions to literature of each individual PhD paper which are also summarised within Table 31.

Table 31: Summary of findings, and contributions of each individual paper[§]

Paper	Main Findings	Evidence before study	Contribution to the literature
Paper I: Evaluation of the NHS England evidence-based interventions programme: a difference-in-difference analysis	• The EBI programme did not achieve its aim of accelerating disinvestment from the low value procedures under its remit • Reductions in provision of low value care were smaller in private hospitals than in NHS hospitals	• Mixed results from previous national initiatives to disinvest from low value care • Multicomponent interventions (guidance, targets, feedback and benchmarking) can sustainably reduce provision of low value care	• The only quantitative analysis of the EBI programme • Uses a DiD to evaluate EBI programme against a control group • Evaluates the relative impact of a national healthcare quality initiative in private and NHS hospitals
Paper II: Evidence of substitution between publicly and privately funded low value elective procedures in private hospitals in England	• Reductions in publicly funded care were associated with increases in privately funded care for a series of low value procedures • Evidence of substitution between NHS disinvestment and privately funded care were more consistent for surgical procedures considered as low value in only certain rather than all circumstances	• Strong evidence from the US that expansions in publicly funded care are associated with reductions in privately funded care • Evidence from England indicates no evidence that increases of publicly funded care in private hospitals are associated with reductions in privately funded care	• The second use of PHIN data on privately funded care in an academic analysis • The first analysis to examine the association between withdrawal of publicly funded care and privately funded care in England • Disaggregates findings by funding mechanism (self-pay and insurance)
Paper III: A comparison of patient outcomes, adverse events, and efficiency of private and NHS hospitals in England for primary hip and knee replacements	• Accounting for both observable and unobservable confounding at the patient-level using IVs, there were no significant differences in patient outcomes, and adverse events between NHS and private hospitals, and treatment in private hospital was associated with greater post-operative LOS • Accounting for only observable differences between patients using OLS and PSM, treatment in private hospital was associated with better patient outcomes, reduced adverse events, and shorter post-operative LOS	• Accounting for both observable and unobservable confounding at the patient-level, there were no significant differences in probability of readmission in private and NHS hospitals • Accounting for only observable differences between patients, treatment in private hospital was associated with better patient outcomes and reduced LOS.	• The second paper to use an instrumental variable approach to account for unobserved confounding at the patient-level between private and NHS hospitals in England • The first paper to analyse adverse events (hospital-associated infections, adverse drug reactions, pressure ulcers, and venous thromboembolism) in private and NHS hospitals in England

[§]Statements within the contribution to the literature are to my current knowledge following review of pre-existing literature. Difference-in-difference (DiD). Instrumental variable (IV). Ordinary least squares (OLS). Propensity score matching (PSM). Length of stay (LOS).

5.1.1. The relative response of NHS and private hospitals to national healthcare quality initiatives

The first paper focuses on the provision of publicly funded low value elective care in NHS and private hospitals in England, and the impact of the NHS England Evidence-Based Interventions (EBI) programme. I find that, in the early phases of implementation, the EBI programme did not successfully achieve its aim of accelerating disinvestment from the low value procedures under its remit. In fact, I find that, following implementation, the EBI programme was associated with a small increase in the volumes of low value procedures under its consideration. When analysing data for NHS and private hospitals, I find that NHS hospitals had significantly greater reductions in low value procedures than private hospitals.

At the time of writing (June 2023), the analysis remains the only published quantitative evaluation of the impact of the EBI programme. The analysis was conducted during a fellowship with NHS England, and the EBI team were provided preliminary results at various stages of analysis. There have been two further phases of the EBI programme, and following recommendations made in this analysis the programme has been relocated from NHS England to the Academy of Medical Royal Colleges, to encourage a greater sense of ownership and awareness of the programme among healthcare professionals.

Paper I makes a significant contribution to the literature as it is uses a DiD approach to evaluate the impact of the EBI programme. This is important as a review of the literature on empirical evaluations of national disinvestment initiatives found analyses typically use weaker methods such as interrupted time series, or before and after analyses (Chambers *et al.*, 2017). Another contribution to the literature of this analysis is that it comprehensively evaluates a national policy of disinvestment from low value care, including consideration of differential impact according to a range of organisational and financial factors. These include differences in treatment effect of the policy in NHS and private hospitals, CCGs with differing levels of financial performance, CCGs that volunteered to be part of a demonstrator community, and procedures classified according to their potential annual savings.

5.1.2. Evidence of substitution between changes in publicly and privately funded low value care

Using the same low value procedures analysed in Paper I, the second paper focuses on the relationship between reductions in publicly funded low value care and increases in privately funded low value care in private hospitals following the implementation of the EBI programme, to ascertain if there is evidence of substitution effects. Analyses were conducted at the private hospital level and the local healthcare market level, which also took account of changes in volume of publicly funded care in nearby hospitals. These analyses found reductions in the provision of publicly funded care were significantly associated with increases in privately funded care. These findings were more consistent at the private hospital level, with evidence of substitution for both Category 1 (no evidence of clinical or cost effectiveness in any circumstance) and Category 2 procedures (evidence of clinical or cost effectiveness only in specific circumstances). The extent of substitution was approximately equivalent to an increase in one privately funded procedure for every five fewer publicly funded procedures conducted. When focusing on local healthcare markets, there was only evidence of substitution in Category 2 procedures. The extent of substitution was approximately equivalent to an increase in one privately funded procedure for every four fewer publicly funded procedures conducted. When analysing individual procedures, the extent of substitution was much bigger, including for grommet surgery, tonsillectomy, haemorrhoid surgery, hysterectomy for heavy bleeding, and varicose vein surgery. In contrast, there was no significant evidence of substitution for Category 1 procedures at the local healthcare market level. The findings from changes in volume for insurance and self-pay funded care were broadly similar to those produced when analysing total changes in privately funded care.

Paper II offers a unique contribution to the pre-existing literature as it is, to my knowledge, the first analysis from the United Kingdom that has explored whether substitution exists between publicly funded and privately funded care for procedures undergoing disinvestment by the NHS. While the paper is focused on private hospitals, another important strength of the analysis is that, through the local healthcare market analysis, it also captures the impact of changes in volumes for publicly funded care in NHS hospitals. Changes in privately funded care in NHS hospitals were not analysed as NHS hospitals only conduct very small volumes of privately funded care. Through additional supplementary analyses, the paper also explores

changes in volume of procedures accessed through different financial mechanisms, including those accessed through private health insurance or out-of-pocket payments (also known as self-pay care).

5.1.3. Differences in healthcare quality between NHS and private hospitals

While all the papers in this PhD thesis provide insights regarding healthcare quality in NHS and private hospitals, the third paper focuses specifically on elective orthopaedic surgery and providers a comparative assessment of NHS and private hospitals in terms of health outcomes, efficiency and adverse events. Using methods to adjust for observable confounding at the patient-level between NHS and private hospitals, the findings of the third paper replicate those of several other pre-existing studies that indicate treatment in private hospital is associated with better patient outcomes and improved efficiency than in NHS hospitals. When using methods to adjust for unobservable confounding at the patient-level between NHS and private hospitals, there were no significant differences in patient outcomes, and adverse events, and treatment in private hospital was associated with greater post-operative length of stay.

As discussed in section 4.2.1, there are good reasons that unobservable cofounding at the patient-level may exist between private and NHS hospitals. This is because clinicians make decisions regarding referral of patients based on fitness for surgery and this is not observable within the HES dataset, and differences in patient complexity may not be fully captured by observable patient characteristics such as age, gender, number of comorbidities, and deprivation. Moreover, many private hospitals enter confidential contracts with local NHS commissioning bodies that detail how they are expected to treat less complicated patients (Mason, Street and Verzulli, 2010).

The third paper makes several important contributions to the literature. While other studies that compare NHS and private hospitals have analysed either one or only a few performance indicators (Browne *et al.*, 2008; Moscelli *et al.*, 2018; Crothers *et al.*, 2021), Paper III analyses a broad spectrum of performance indicators that reflect differences in multiple dimensions of healthcare quality To my knowledge, this is also the first analysis which has compared the prevalence and probability of several, potentially avoidable, adverse events in private and NHS hospitals in England. Arguably the most significant strength of this analysis

is the application of IV methods that take account of both observable and unobservable confounders at the patient-level between NHS and private hospitals. In doing so, I find that differential distance to nearest NHS and private hospital is a strong instrument for hospital choice, and use this instrument to indicate that quality-of-care gains by private hospitals are exaggerated, by means of methods such as OLS and propensity score matching that only account for observable confounders.

5.2. Key limitations

There are a number of key limitations which should be acknowledged when discussing or interpreting the findings of this PhD thesis. As each paper uses different methods to address alternative objectives, relevant limitations are discussed in detail in each individual paper. The purpose of this section if to provide a summarised overview of these limitations, and to highlight some common limitations in relation to data sources used in the thesis.

The validity of the findings from all three papers is contingent upon the consistency of coding across hospitals. Administrative hospital data were used throughout this PhD thesis, collated into Hospital Episode Statistics (HES) by NHS Digital for publicly funded care, and into the Admitted Patient Care (APC) dataset by the PHIN for privately funded care. Consistency in coding practices for diagnoses between NHS and private hospitals is particularly important, and it has been questioned whether inconsistency in coding practices may contribute to fewer comorbidities recorded for patients treated in private hospitals (Mason, Street and Verzulli, 2010). While this is a legitimate concern, private hospitals have approximately two decades' experience submitting hospital administrative data to NHS Digital who subsequently audit the hospitals' coding practices. As discussed in section 4.8.2, they are also typically supported by private consultancy companies, many of which simultaneously support NHS hospitals for similar purposes and market themselves as ensuring consistency of coding (Capita, 2022; CCSD, 2022; CHKS, 2022). Hospitals are also incentivised to include all relevant diagnostic codes as they can lead to up-grouping of HRGs and higher levels of reimbursement. While I cannot completely exclude inconsistency in coding practices between NHS and private hospitals, it is important to note that HES data have been used several times over the last decade to conduct comparative analyses of private and NHS hospitals (Mason, Street and Verzulli, 2010; Street *et al.*, 2010; Siciliani, Sivey and Street, 2013; Moscelli *et al.*, 2018; Crothers *et al.*, 2021). For privately funded care, the APC dataset is relatively newly established, with data collection beginning in January 2016. For this reason, the comparative quality of diagnostic coding was analysed and this was similar between NHS Digital and PHIN datasets and did not change significantly over time (Appendix C, Table 3). Moreover, the APC dataset was deliberately modelled on the HES dataset to ensure data flows were similar, in anticipation that the functionality to integrate the datasets may be required in the future. However, Paper II is only the second peer-reviewed application of PHIN data in an academic publication (Friebel *et al.*, 2022; Anderson, 2023). Therefore,

further research and analyses are needed to compare the consistency of the PHIN APC and NHS Digital HES datasets (see section 4.5).

The chosen outcomes of interest used in each paper also impact the validity of findings produced by this PhD thesis. Analyses conducted within Papers I and II are reliant upon the identification of procedures, classified as low value by the EBI programme, using a combination of operation and diagnostic codes. However, it is possible that some reduction in volumes of these procedures identified is the result of a gaming of the system by using alternative diagnostic codes for certain procedures to avoid them being classified as low value. There is a particularly strong incentive for hospitals to do this for Category 1 procedures, as NHS England removed the tariff for these procedures (see section 2.2.1.). Unfortunately, I was unable to test this hypothesis as NHS Digital had already applied the inclusion and exclusion criteria for EBI procedures when extracting relevant hospital episodes for analysis.

From a methodological perspective, a strength of this PhD thesis is the application of several robust approaches to causal inference including difference-in-difference (DiD) analyses (see Paper I), propensity score matching (see Paper III), and instrumental variable (IV) analyses (see Paper III). However, a limitation of this PhD thesis is that Paper II only explores associations rather than causation between changes in volume of publicly and privately funded care, using OLS regression. For this reason, Paper II is methodologically weaker than the other two papers. When reviewing pre-existing international literature, there are many examples from the US that utilise IVs to analyse changes in volume of publicly and privately funded care (Gruber and Simon, 2008). However, these analyses exploit changes in eligibility criteria for Medicaid and Medicare as an instrument for changes in volume of publicly funded care but the same is not possible in the English healthcare system as no such changes in eligibility for coverage by the NHS occurred during my period of analysis. When reviewing the limited literature from England, the only other analyses that explored the potential association between changes in volume of publicly and privately funded care also focused on associations through OLS methods rather than causation (Suleman *et al.*, 2010; Kelly and Stoye, 2020).

Lastly, a common limitation to all analyses in this PhD is the period of analysis. Most of the analyses begin from January 2016, as PHIN has only collected data on privately funded care

from January 2016 when the mandate provided by the Competition and Markets Authority (CMA) order came into effect (Competition and Market's Authority, 2014). Moreover, it was impossible to conduct analyses beyond February 2020 because the provision of the relevant procedures significantly reduced following the emergence of the COVID-19 pandemic. This means it has only been possible to evaluate the EBI programme, which launched in April 2019, during the first 11 months of implementation. However, evaluating the relative response of NHS and private hospitals during and following the COVID-19 pandemic will be an interesting topic of future research, particularly in the context of growing backlogs for elective care in the NHS sector (see section 1.2.2.1.).

5.3. Policy implications and recommendations

Drawing upon insights gained throughout my PhD thesis, this section detailed policy implications and recommendations across three separate policy areas including quality of care in private hospitals, implementation of national initiatives to disinvest from low value care, and data requirements for the private healthcare sector (Table 32)

Table 32: Overall Policy Recommendations

Policy Area	Recommendations
Quality of care in private hospitals	• Recommendation 1: Strengthen and clarify regulation of the private healthcare sector • Recommendation 2: Ensure NHS commissioning from private providers is based upon local assessments of hospital capabilities, and financial implications for NHS providers • Recommendation 3: Analyse outcomes and adverse events for high complexity procedures undertaken in the private healthcare sector
Implementation of national initiatives to disinvest from low value care	• Recommendation 1: Co-design national healthcare quality initiatives with relevant stakeholders including the private healthcare sector • Recommendation 2: Improve public and healthcare professional awareness of low value care and alternative treatments • Recommendation 3: Ensure targets to disinvest from low value care are evidence-based and specific to local populations • Recommendation 4: Develop a governance framework to identify and investigate individual hospital consultants that provide higher than expected numbers of low value procedures
Data requirements for the private healthcare sector	• Recommendation 1: Integrate the HES and PHIN dataset using unique patient and physician identifiers • Recommendation 2: To align workforce data collection requirements between NHS and private hospitals • Recommendation 3: To routinely collect information regarding hospital capacity across the private healthcare sector • Recommendation 4: To map referrals pathways for patients receiving care in the private healthcare sector • Recommendation 5: To collect complete information of hospital fees in the private healthcare sector

5.3.1. Quality of care in private hospitals

As discussed in section 1.2.3.1, there have been ongoing concerns regarding the quality of care in private hospitals emphasised by high profile instances of poor quality, unsafe and harmful care highlighted by reports such as the Paterson Inquiry report (DHSC, 2020), and through routine inspections by the CQC (Care Quality Commission, 2018). Quality of care received by patients in private hospitals is an important issue irrespective of funding mechanism, but this has become a more important issue for taxpayers over the last two decades as the absolute amount and relative proportion of publicly funded elective care episodes in private hospitals have significantly increased (see section 1.1.4.). Moreover, this PhD thesis highlights examples of non-evidence based care delivered in private hospitals (Paper I and II), and less engagement from private hospitals compared to NHS hospitals with a national healthcare quality initiative (Paper I).

5.3.1.1. Recommendation 1: Strengthen and clarify regulation of the private healthcare sector

Strengthening regulation will require ensuring the private healthcare sector is considered in national healthcare quality initiatives and not excluded from submitting data alongside NHS hospitals for national clinical audits, clinical registries and other national data collections. The ultimate aim should be equal attention to monitoring healthcare quality for publicly and privately funded care in both NHS and private hospitals, and this will require greater collaboration and coordination between healthcare regulators and healthcare information organisations such as the CQC, PHIN and NHS Digital. There would be little added value in establishing any new regulatory body as this would only serve to further complicate an already crowded regulatory environment for healthcare services in the UK. Instead, the roles of the different regulators (such as the CQC, GMC, and the NMC) needs to be clarified and more clearly explained to the public to ensure mechanisms to raise concerns regarding individual hospital consultants' practice are accessible. There are opportunities to adapt pre-existing regulatory processes to better reflect leadership structures in private hospitals. For example, corporate boards that provide leadership to private hospital groups are currently excluded from CQC inspections (DHSC, 2020), even though these boards are instrumental to shaping the institutional cultures and objectives of relevant private hospitals. This is crucial as the input of corporate boards is needed to overcome a perception across the private healthcare sector that hospital consultants "rent a room" from private hospitals and that

private hospital leadership are not accountable for oversight of hospital consultant's practice and performance.

5.3.1.2.Recommendation 2: Ensure NHS commissioning from private providers is based upon local assessments of hospital capabilities, and financial implications for NHS providers

While the findings from Paper III are reassuring that there are no significant differences between quality of care between private and NHS hospitals, the decision to increase or decrease the extent of publicly funded care in private hospitals needs to be made at the local level based upon an assessment of capabilities and performance of relevant private hospitals and staff. This is because the various sub analyses within paper III did not include information on hospital bed capacity, critical care facilities, date of hospital establishment, or surgeon experience. Improved data collection is required for these important hospital characteristics are they can influence patient outcomes, efficiency and adverse events (see section 5.4- Recommendation 2, 3), and generalisations made using the findings of this analysis may overlook important variation in determinants of healthcare quality between private hospitals at the local level. Decisions to commission services from private hospitals at the local level also need to consider the potential financial implications for NHS hospitals, as I find evidence throughout all papers in this PhD that private hospitals treat less complex patients than NHS hospitals. This could mean that higher cost patients are treated in NHS hospitals and that the entry of private hospitals in local healthcare markets may threaten the financial viability of NHS hospitals (Mason, Street and Verzulli, 2010; Street *et al.*, 2010).

5.3.1.3. Recommendation 3: Analyse outcomes and adverse events for high complexity procedures undertaken in the private healthcare sector

While Paper III is focused on elective hip and knee replacements, the findings are applicable to the majority of the private healthcare sector as most private hospitals typically focus on similar high-volume and low complexity elective surgical procedures (see section 1.1.3.). However, there is heterogeneity in type of provider and services provided in the private healthcare sector in England. As well as small hospitals that specialise in low complexity elective care, there are several larger private hospitals that provide a broad range of secondary and tertiary care services (see section 1.1.3). Many of these hospitals are located in London, with prominent examples including Cromwell Hospital (118 inpatient and 19 day-case beds) (CQC, 2023b), Hospital of St John & St Elizabeth (73 inpatient beds) (CQC,

2023c), and the Cleveland Clinic (184 inpatient beds. 29 ICU beds, 21 day-case beds) (Cleveland Clinic, 2023). Further investigation is needed to establish patient outcomes, efficiency and risk of adverse events when patients undergo high complexity procedures in these settings. An important and unexplored area of research is outcomes for patients receiving critical care services in private hospitals. The last comprehensive survey of critical care capacity in the private healthcare sector took place in 2011 (Competition and Market's Authority, 2014), and this needs to be updated and expanded to include analysis of performance and outcomes (see section 5.4.4 – recommendation 3) .

5.3.2. Implementation of national initiatives to disinvest from low value care

National healthcare quality initiatives to disinvest from low value care can improve quality of care and produce cost-savings that can be reinvested in other parts of the healthcare system. Despite broad consensus from the healthcare and policy community in the United Kingdom on the importance of this issue (Malhotra *et al.*, 2015), I conclude that the NHS England EBI programme did not achieve its aims of minimising the provision of low value procedures under its remit in the first year after implementation (Anderson, Molloy, *et al.*, 2022). Several actions are needed to improve implementation of national healthcare quality initiatives and strengthen engagement from the private healthcare sector.

5.3.2.1.Recommendation 1: Co-design national healthcare quality initiatives with relevant stakeholders including the private healthcare sector

Securing sustainable implementation of national initiatives to disinvest from low value care should involve continued collaboration and engagement between commissioners, private insurers, NHS hospitals, private hospitals and primary care to build consensus regarding implementation (Patey and Soong, 2023). It is possible the EBI programme devoted less attention to engaging with private hospital groups or health insurers during its development and implementation as there was a perception that the private healthcare sector constitutes only a small component of the English healthcare sector. However, approximately one in five publicly funded procedures classified as low value by the EBI programme were conducted in private hospitals during my period of analysis. In addition, similar volumes of privately funded procedures were also conducted. There are also implementation challenges particular to private hospitals that need to be considered. For example, private hospitals are structurally different to NHS hospitals, with most private hospitals specialising in the provision of high-volume and low complexity procedures such as tonsillectomy and varicose vein surgery. As a

result, private hospitals may have found it challenging to provide alternative procedures to make use of the theatre capacity that would have been made available by limiting the provision of EBI procedures.

5.3.2.2.Recommendation 2: Improve public and healthcare professional awareness of low value care and alternative treatments

It was not possible to determine to what extent supplier or patient induced demand for low value procedures has influenced the implementation of EBI programme, although both likely contributed to the minimal impact of the programme. There is consensus within published literature on initiatives to disinvest from low value care that improved public awareness regarding limited evidence of effectiveness, potential complications of surgery, and alternatives to surgery can help facilitate sustainable implementation (Sypes, de Grood, Clement, *et al.*, 2020; Sypes, de Grood, Whalen-Browne, *et al.*, 2020). This is a major focus of other initiatives such as Choosing Wisely that have developed public awareness campaigns and created materials to enable shared decision making (Murphy, Tanner and Komorowski, 2019). Investment in public awareness campaigns needs to incorporate efforts to improve awareness and training of healthcare professionals, including the necessary communication skills required for shared decision making (Colla *et al.*, 2017).

5.3.2.3.Recommendation 3: Ensure targets to disinvest from low value care are evidence-based and specific to local populations

Many procedures targeted by the EBI programme are considered as low value in certain circumstances, and therefore clinically indicated in other circumstances. A major flaw of the EBI programme that contributed to limited engagement was the use of arbitrary targets set by NHS England to reduce provision to 25% of pre-implementation levels nationally (with age-gender standardised targets estimated for each CCG). This is further complicated by lack of evidence on what level of provision is expected for procedures classified as low value in certain circumstances for specific populations. Developing more appropriate targets could be achieved by analysing pre-existing variation in provision across England, and modelling consequences of restricting or delaying provision on other outcomes such as absences from work, medication usage, GP attendances, and hospital admissions. While this would be a technically and labour intensive exercise, once a model was developed it could be adapted to generate evidence on appropriate levels of provision for a range of different procedures and populations. Moreover, the model could be updated throughout implementation of initiatives

to disinvest from low value care to identify potential evidence of unintended consequences. Increases in privately funded care for relevant low value procedures alongside differences in income levels could be used within these models as a signal of unmet need in specific populations.

5.3.2.4.Recommendation 4: Develop a governance framework to identify and investigate individual hospital consultants that provide higher than expected numbers of low value procedures

Paper I demonstrates that many hospital consultants continued to provide publicly funded low value procedures after the implementation of the EBI programme, and Paper II demonstrates there were also increases in privately funded care in the same period. Subsequent policy implications are dependent upon whether procedures are classified as not cost-effective or clinically effective in any circumstance (Category 1 procedures), or cost-effective or clinically effective in specific circumstances (Category 2 procedures). Increases in privately funded Category 1 procedures represent increases in non-evidence-based care and should be the subject of further investigation and potential regulatory intervention. This is important as Category 1 procedures unnecessarily expose a patient to potential complications of surgery and risk of harm. In contrast, it is difficult to establish whether provision of Category 2 procedures represent true evidence of non-evidence-based care. However, models such as those described in recommendation 3 could help estimate appropriate levels of provision for specific populations. Securing sustainable implementation of the EBI programme would require development of a governance framework to identify and investigate hospital consultants that provide higher than expected numbers of low value procedures. This would provide a mechanism for hospital managers or commissioners to challenge hospital consultants that provide high numbers of low value procedures, and processes to monitor and suspend hospital consultants if necessary.

5.4. Data requirements for the private healthcare sector

Collectively, the papers within this PhD identify a number of interrelated priorities for research and improved data collection (Table 33). In some cases, data collection has already been initiated by PHIN (for example data on NHS number, GMC number, funding mechanism and hospital consultant fees). However, in most cases there are significant gaps in our understanding of patient flows, staffing levels, and hospital capacity across the private healthcare sector.

Table 33: Data requirements for the private healthcare sector

Data Requirements	Indicators	Rationale
Integrate PHIN and HES datasets using common patient identifiers	• NHS Number	• Identify hospital transfers • Identify readmissions • Identify revision surgery
Integrate PHIN and HES datasets using common physician identifiers	• GMC Number	• Establish working patterns of hospital consultants (including dual-practice and exclusively private practice)
Workforce data	• Headcount and full time equivalent (FTE) for permanent non-clinical and clinical staff by healthcare provider • Reimbursement levels for salaried employees	• Essential inputs into workforce planning models at national level • Establish impact of private hospital entry on local healthcare labour markets
Hospital data	• Hospital beds by private hospital • Critical Care capacity (Beds, and ventilators) • Day surgery capacity	• Estimate additional capacity in private sector that can be used by NHS • Model surge capacity as part of sustainability and resilience planning
Referral pathways	• Referred by NHS or Private GP • Hospital consultant referral to NHS practice from private practice, or vice versa • No referral	• Identify evidence of supplied induced demand
Hospital and consultant fees	• Hospital fees by healthcare service • (Hospital consultant fees by healthcare service already collected by PHIN) • Fees for insurance and self-pay patients by healthcare service	• Facilitate analysis of relationship between fees and outcomes • Promote transparency and fair competition between private healthcare providers
Funding mechanism (already collected by PHIN)	• Insurance funded • Self-pay funded • NHS funded	• Increases in private care accessed through self-pay funding mechanism may indicate unmet need for NHS care

5.4.1. Recommendation 1: Integrate the HES and PHIN dataset using unique patient and physician identifiers

This PhD thesis involves the first application of PHIN data to privately funded care to evaluate policy and healthcare quality (Anderson, 2023). While I was able to explore associations between changes in volume of publicly and privately care, I was unable to monitor the pathways of individual patients or consultants. This is technically possible using common patient identifiers (NHS number) and physician identifiers (GMC number), although a third party would need to be responsible for linking the datasets. NHS Digital and PHIN have launched a joint Acute Data Alignment Programme (ADAPt) to achieve this aim and have partnered with the University of Manchester and University of York to analyse this combined dataset (PHIN, 2023). There are many avenues that could be explored when analysing this dataset, including identifying the drivers and consequences of unplanned patient transfers and readmissions to NHS hospitals following episodes of privately funded care (Williams, Whatmough and Pearson, 2001), working patterns for hospital consultants that have dual NHS and private practice (Timmins, 2005), and patients that have revision surgery in either NHS or private hospitals (Craig *et al.*, 2019) .

5.4.2. Recommendation 2: To align workforce data collection requirements between NHS and private hospitals

While workforce data for headcount and full-time equivalent is routinely reported by NHS hospitals to NHS Digital (NHS Digital, 2023c), there is no repository of workforce data for the private healthcare sector in England or the United Kingdom. This creates barriers for research into healthcare quality, as variation in staffing numbers, surgeon experience and composition of multidisciplinary teams is known to influence patient outcomes and length of stay (Rajpal *et al.*, 2020; Schuster *et al.*, 2021). The lack of data also creates barriers to planning and regulation of the collective UK healthcare workforce (Anderson, O'Neill, *et al.*, 2021), as we have no consistent understanding of the number and extent of healthcare staff that have dual roles in private and NHS hospitals, or that leave NHS practice completely (Anderson, McGuire and Street, 2022). This is also important to understand at the local level, as entry of private hospitals can be disruptive to local healthcare labour markets as they often reimburse salaried staff at higher levels than NHS hospitals.

5.4.3. Recommendation 3: To routinely collect information regarding hospital capacity across the private healthcare sector.

The only information available on hospital beds and critical care facilities is from ad-hoc surveys (Competition and Market's Authority, 2014), or from CQC hospital inspections (CQC, 2022). In contrast, detailed information on the number of hospital beds and occupancy for NHS hospitals is reported to NHS Digital on a monthly basis (NHS England, 2023a). This is important so future research on healthcare quality can fully reflect the heterogeneity of private hospitals that operate in England, ranging from small hospitals with fewer than 10 beds to large specialist hospitals with approximately 200 beds (see section 5.2.1.). From a policy perspective, this is required to inform sustainability and resilience planning as this information is required to model surge capacity in the English healthcare system effectively. The private healthcare sector supported national efforts to respond to the COVID-19 pandemic following the agreement of a national contract to make private hospital capacity available to treat patients infected with COVID-19, and clear backlogs of elective care (Oxford, 2023). However, subsequent analysis has indicated this capacity was underutilised (Friebel *et al.*, 2022). The private healthcare sector may support the NHS again during future acute health shocks, and complete information on private healthcare sector capacity would help integrate the private healthcare sector within national sustainability and resilience planning exercises.

5.4.4. Recommendation 4: To map referrals pathways for patients receiving care in the private healthcare sector

Improved data collection is needed regarding pathways for patients accessing privately funded care and qualitative research to understand their reasons for seeking care outside the NHS. Such patient interviews will help identify to what extent supplier-induced demand exists, as there is potential for dual-practice hospital consultants to refer to the private healthcare sector those patients who have been denied access to procedures through NHS funding. The proportions of patients accessing privately funded care through GP referrals needs to be accessed, which currently is not routinely collected. GP referrals are not compulsory to seek privately funded care in England, although it recommended by the British and Medical Association (BMA) and often a requirement by private health insurers (NHS England, 2023b). As the self-pay market has been growing in England (see section 1.1.4), it

is possible the proportion of patients accessing privately funded care without GP referral is increasing. This has important implications for healthcare quality and efficiency, as healthcare systems with direct access to specialists are known to have higher healthcare expenditure than healthcare systems with GP gatekeeping mechanisms (Sripa *et al.*, 2019).

5.4.5. Recommendation 5: To collect complete information of hospital fees in the private healthcare sector

LaingBuisson publishes survey data on the total costs of procedures in the private healthcare sector for self-pay patients across England within their business reports, and the most recent report published in 2023 highlighted that the cost of cataract surgery varied by £1,995 to £3,863, and the cost of knee replacement varied by £9,445 to £16,795 (Laing, 2023). This information is collated from voluntary submissions of fees from private hospitals and is not freely available to patients, thereby creating a significant barrier for fair competition across the private healthcare sector. The CMA attempted to rectify this by providing a mandate to PHIN to collect mandatory information regarding hospital consultant fees in the private healthcare sector (Competition and Market's Authority, 2014). However, the same mandate does not extend to hospital fees which account for the majority of costs for surgical procedures. It is also important to compare the fees paid by patients through self-pay funding mechanisms and the fees schedule for different private healthcare insurers, as significant disparities may provide evidence of patients being overcharged. Information on hospital fees could be routinely collected by PHIN if the CMA extended its' mandate, and this data could also facilitate research into the relationship between costs and healthcare quality.

5.5. Closing Remarks

The next decade is a pivotal time period for the future of the English healthcare system (Anderson, Pitchforth, *et al.*, 2021b). Two major priorities will be improving the quality of healthcare services, and clearing growing backlogs of elective care with approximately 7 million people currently on a waiting list. But decades of public underinvestment in healthcare workforce and lack of capital spending mean there is almost no excess capacity in the NHS sector, and at least in the short-to-medium term, engagement with the private healthcare sector will be required to deliver on these priorities.

To maximise return on investment, it is important that increased investment of public and private funds in the private healthcare sector is combined with requirements to engage with national initiatives such as the EBI programme that aim to disinvest from low value care and improve healthcare quality. Policy makers will need to take an integrated approach to the NHS and private healthcare sector when planning and regulating healthcare services, to ensure that the quality of care and governance of private hospitals is scrutinised to the same extent as that of NHS hospitals. The current regulatory environment is complex and crowded, and roles and responsibilities need to clarified. This includes ensuring corporate leadership in the private healthcare sector are subject to same scrutiny and oversight from regulators as hospital leadership in the NHS. Effective regulation of the private healthcare sector will also require capitalising upon advancements in data collection regarding privately funded care, and further developing data flows to provide information regarding patient complexity, workforce characteristics, hospital capacity, and costs. The ultimate aim should be to create integrated databases that take a whole-healthcare-system approach, reflecting dynamics between changes in volumes of publicly and privately provided care, and patient pathways that span NHS and private hospitals.

Taking a long-term perspective, policy makers need to consider whether continued public underinvestment in the healthcare workforce and physical infrastructure, and a concomitant reliance on the private healthcare sector, is a viable strategy. It leaves the NHS particularly vulnerable during acute shocks, such as the COVID-19 pandemic, and can create barriers for workforce and healthcare service planning. There is also potential that private hospitals may be more motivated by generating profits for shareholders rather than sharing the institutional values and culture of public service that characterise the NHS.

6. References

Academy of Medical Royal Colleges (2020) 'Evidence-Based Interventions List 2 Guidance'. Available at: https://www.aomrc.org.uk/wp-content/uploads/2020/12/EBI_list2_guidance_150321.pdf (Accessed: 24 April 2023).

AHRQ (2003) 'Guide to patient safety indicators'. Available at: https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=59cdc8aba5f7e39a8a2806a77e16b1bc9a8b64a0 (Accessed: 17 February 2023).

Aizer, A. and Grogger, J. (2003) Parental Medicaid expansions and health insurance coverage. National Bureau of Economic Research Cambridge, Mass., USA.

Allman, R.M. et al. (1999) 'Pressure ulcers, hospital complications, and disease severity: impact on hospital costs and length of stay', Advances in Wound Care: The Journal for Prevention and Healing, 12(1), pp. 22–30.

Amin, A. et al. (2019) 'Influence of the duration of hospital length of stay on frequency of prophylaxis and risk for venous thromboembolism among patients hospitalized for acute medical illnesses in the USA', Drugs in Context, 8, p. 212568. Available at: https://doi.org/10.7573/dic.212568.

Anandaciva, S. (2020) Critical care services in the English NHS, The King's Fund. Available at: https://www.kingsfund.org.uk/publications/critical-care-services-nhs (Accessed: 7 April 2023).

Anderson, M. et al. (2020) 'Improving transparency and performance of private hospitals', BMJ, 368. Available at: https://doi.org/10.1136/bmj.m577.

Anderson M, Pitchforth E, et al (2021a). The UK Health and Care Bill: failure to address fundamental issues of coverage and funding. Lancet. 397(10281):1259. doi:10.1016/S0140-6736(21)00525-0

Anderson, M., Pitchforth, E., et al. (2021b) 'LSE–Lancet Commission on the future of the NHS: re-laying the foundations for an equitable and efficient health and care service after COVID-19', The Lancet, 397(10288), pp. 1915–1978. Available at: https://doi.org/10.1016/S0140-6736(21)00232-4.

Anderson, M., O'Neill, C., et al. (2021) 'Securing a sustainable and fit-for-purpose UK health and care workforce', Lancet (London, England), 397(10288), pp. 1992–2011. Available at: https://doi.org/10.1016/S0140-6736(21)00231-2.

Anderson, M., Molloy, A., et al. (2022) 'Evaluation of the NHS England evidence-based interventions programme: a difference-in-difference analysis', BMJ Quality & Safety. Available at: https://doi.org/10.1136/bmjqs-2021-014478.

Anderson, M., Pitchforth, E., et al. (2022) 'United Kingdom: Health System Review', Health Systems in Transition, 24(1), pp. 1–194.

Anderson, M. (2023) 'Changes in publicly and privately funded care in England following a national programme to reduce provision of low-value elective surgery', British Journal of Surgery, 110(2), pp. 209–216. Available at: https://doi.org/10.1093/bjs/znac390.

Anderson, M., McGuire, A. and Street, A. (2022) 'How to shape a "proper" long term workforce plan for health and social care', BMJ, 378, p. e072977. Available at: https://doi.org/10.1136/bmj-2022-072977.

Anderson, M. and Mossialos, E. (2022) 'Are we heading for a two tier healthcare system in the UK?', BMJ, 376, p. o618. Available at: https://doi.org/10.1136/bmj.o618.

Anderson, T.S. et al. (2020) 'Trends in Low-Value Carotid Imaging in the Veterans Health Administration From 2007 to 2016', JAMA Network Open, 3(9), p. e2015250. Available at: https://doi.org/10.1001/jamanetworkopen.2020.15250.

Appleby, J. (2020) 'Hip replacements: do public or private providers do better?', BMJ, 368, p. m362. Available at: https://doi.org/10.1136/bmj.m362.

Appleby, J., Harrison, A. and Delvin, N. (2003) 'What is the Real Cost of More Patient Choice?' The King's Fund. Available at: https://www.kingsfund.org.uk/sites/default/files/field/field_publication_file/what-is-real-cost-more-patient-choice-john-appleby-tony-harrison-nancy-devlin-kings-fund-1-june-2003.pdf (Accessed: 30 May 2023).

Austin, P.C. (2011a) 'An Introduction to Propensity Score Methods for Reducing the Effects of Confounding in Observational Studies', Multivariate Behavioral Research, 46(3), pp. 399–424. Available at: https://doi.org/10.1080/00273171.2011.568786.

Austin, P.C. (2011b) ‘Optimal caliper widths for propensity-score matching when estimating differences in means and differences in proportions in observational studies’, Pharmaceutical Statistics, 10(2), pp. 150–161. Available at: https://doi.org/10.1002/pst.433.

Austin, P.C. and Stuart, E.A. (2015) ‘Moving towards best practice when using inverse probability of treatment weighting (IPTW) using the propensity score to estimate causal treatment effects in observational studies’, Statistics in medicine, 34(28), pp. 3661–3679. Available at: https://doi.org/10.1002/sim.6607.

Austin, S.R. et al. (2015) ‘Why Summary Comorbidity Measures Such As the Charlson Comorbidity Index and Elixhauser Score Work’, Medical Care, 53(9), pp. e65-72. Available at: https://doi.org/10.1097/MLR.0b013e318297429c.

BAETs (2023) ‘Audit – British Association of Endocrine and Thyroid Surgeons (BAETS)’. Available at: https://www.baets.org.uk/audit/ (Accessed: 31 March 2023).

Bahl, V. et al. (2008) ‘Do the AHRQ Patient Safety Indicators Flag Conditions That Are Present at the Time of Hospital Admission?’, Medical Care, 46(5), pp. 516–522.

Baiocchi, M., Cheng, J. and Small, D.S. (2014) ‘Instrumental variable methods for causal inference’, Statistics in Medicine, 33(13), pp. 2297–2340. Available at: https://doi.org/10.1002/sim.6128.

Barbetta, G.P., Turati, G. and Zago, A.M. (2007) ‘Behavioral differences between public and private not-for-profit hospitals in the Italian National Health Service’, Health Economics, 16(1), pp. 75–96. Available at: https://doi.org/10.1002/hec.1143.

Barbiere, J.M. et al. (2012) ‘The association of diagnosis in the private or NHS sector on prostate cancer stage and treatment’, Journal of Public Health (Oxford, England), 34(1), pp. 108–114. Available at: https://doi.org/10.1093/pubmed/fdr051.

Baum, C.F., Schaffer, M.E. and Stillman, S. (2007) ‘Enhanced routines for instrumental variables/generalized method of moments estimation and testing’, The Stata Journal, 7(4), pp. 465–506.

BAUS (2023) Home. Available at: https://www.baus.org.uk/ (Accessed: 31 March 2023).

Beckert, W., Christensen, M. and Collyer, K. (2012) ‘Choice of NHS-funded Hospital Services in England*’, The Economic Journal, 122(560), pp. 400–417. Available at: https://doi.org/10.1111/j.1468-0297.2012.02496.x.

Belsley, D.A., Kuh, E. and Welsch, R.E. (2005) Regression Diagnostics: Identifying Influential Data and Sources of Collinearity. John Wiley & Sons.

Benenden Health (2023) About. Available at: https://www.benenden.co.uk/about-benenden/ (Accessed: 30 March 2023).

Berta, P. et al. (2010) 'The effects of upcoding, cream skimming and readmissions on the Italian hospitals efficiency: A population-based investigation', Economic Modelling, 27(4), pp. 812–821. Available at: https://doi.org/10.1016/j.econmod.2009.11.001.

Bevan, G. and Hood, C. (2006) 'Have targets improved performance in the English NHS?', BMJ (Clinical research ed.), 332(7538), pp. 419–422. Available at: https://doi.org/10.1136/bmj.332.7538.419.

Bjertnaes, O. (2014) 'Patient-reported experiences with hospitals: comparison of proxy and patient scores using propensity-score matching', International Journal for Quality in Health Care: Journal of the International Society for Quality in Health Care, 26(1), pp. 34–40. Available at: https://doi.org/10.1093/intqhc/mzt088.

Blackburn, P. (2017) 'Health Cover UK Market Report 14ed'. LaingBuisson. Available at: https://www.laingbuisson.com/wp-content/uploads/2017/10/Health_Cover_14ed_salesflyer.pdf (Accessed: 6 March 2023)

Blackburn, P. (2020) 'Health Cover UK Market Report 16ed'. LaingBuisson. Available at: https://www.laingbuisson.com/shop/health-cover-uk-market-report-16ed/ (Accessed: 6 March 2023).

Blackburn, P. (2021) 'Private Acute Healthcare UK Market Report 7ed'. LaingBuisson. Available at: https://www.laingbuisson.com/shop/private-acute-healthcare-uk-market-report-7ed/ (Accessed: 6 March 2023).

Blumberg, L.J., Dubay, L. and Norton, S.A. (2000) 'Did the Medicaid expansions for children displace private insurance? An analysis using the SIPP', Journal of Health Economics, 19(1), pp. 33–60. Available at: https://doi.org/10.1016/s0167-6296(99)00020-x.

Blundell, R. and Dias, M.C. (2000) 'Evaluation Methods for Non-Experimental Data', Fiscal Studies, 21(4), pp. 427–468. Available at: https://doi.org/10.1111/j.1475-5890.2000.tb00031.x.

BMA (2022) ‘Outsourced: the role of the independent sector in the NHS’. Available at: https://www.bma.org.uk/media/5378/bma-nhs-outsourcing-report-march-2022.pdf (Accessed: 30 May 2023).

Borzecki, A.M. et al. (2010) ‘Comparison of In-Hospital Versus 30-Day Mortality Assessments for Selected Medical Conditions’, Medical Care, 48(12), p. 1117. Available at: https://doi.org/10.1097/MLR.0b013e3181ef9d53.

Bosque-Mercader, L. and Siciliani, L. (2022) ‘The association between bed occupancy rates and hospital quality in the English National Health Service’, The European Journal of Health Economics, pp. 1–28. Available at: https://doi.org/10.1007/s10198-022-01464-8.

Bottle, A. and Aylin, P. (2009) ‘Application of AHRQ patient safety indicators to English hospital data’, Quality & Safety in Health Care, 18(4), pp. 303–308. Available at: https://doi.org/10.1136/qshc.2007.026096.

Bottle, A. and Browne, J. (2021) ‘Outsourcing care to the private sector: some reassuring evidence on patient outcomes’, BMJ Quality & Safety [Preprint]. Available at: https://doi.org/10.1136/bmjqs-2021-014349.

Bridges, J. et al. (2019) ‘Hospital nurse staffing and staff–patient interactions: an observational study’, BMJ Quality & Safety, 28(9), pp. 706–713. Available at: https://doi.org/10.1136/bmjqs-2018-008948.

Browne, J. et al. (2008) ‘Case-mix & patients’ reports of outcome in Independent Sector Treatment Centres: Comparison with NHS providers’, BMC Health Services Research, 8(1), p. 78. Available at: https://doi.org/10.1186/1472-6963-8-78.

Bruno, C. et al. (2020) ‘Passing the acid test? Evaluating the impact of national education initiatives to reduce proton pump inhibitor use in Australia’, BMJ Quality & Safety, 29(5), pp. 365–373. Available at: https://doi.org/10.1136/bmjqs-2019-009897.

BSR (2023) The British Spine Registry: Home. Available at: https://www.britishspineregistry.com/ (Accessed: 31 March 2023).

Burgess, J.F., Jr.;. Shwartz, M.;. Stolzmann, K.;. Sullivan, J.L. (2018) ‘The Relationship between Costs and Quality in Veterans Health Administration Community Living Centers: An Analysis Using Longitudinal Data’, Health Serv Res, 53(5), pp. 3881–3897. Available at: https://doi.org/10.1111/1475-6773.12975.

Burns, E.M. et al. (2012) ‘Systematic review of discharge coding accuracy’, Journal of Public Health (Oxford, England), 34(1), pp. 138–148. Available at: https://doi.org/10.1093/pubmed/fdr054.

Busse, R., Panteli, D. and Quentin, W. (2019) An introduction to healthcare quality: defining and explaining its role in health systems. European Observatory on Health Systems and Policies. Available at: https://www.ncbi.nlm.nih.gov/books/NBK549277/ (Accessed: 18 June 2022).

Bussières, A.E. et al. (2014) ‘Impact of imaging guidelines on X-ray use among American provider network chiropractors: interrupted time series analysis’, The Spine Journal: Official Journal of the North American Spine Society, 14(8), pp. 1501–1509. Available at: https://doi.org/10.1016/j.spinee.2013.08.051.

Calderon, E. et al. (2019) ‘Are we choosing wisely in elderly females with breast cancer?’, The American Journal of Surgery, 218(6), pp. 1229–1233. Available at: https://doi.org/10.1016/j.amjsurg.2019.08.004.

Calver, T. (2023) ‘Can private hospitals really save the NHS?’, 29 March. Available at: https://www.thetimes.co.uk/article/can-private-hospitals-really-save-the-nhs-b2kwwjbd5 (Accessed: 29 March 2023).

Cant, R., Ryan, C. and Kelly, M.A. (2022) ‘A nine-step pathway to conduct an umbrella review of literature’, Nurse Author & Editor, 32(2), pp. 31–34. Available at: https://doi.org/10.1111/nae2.12039.

Capita (2022) Remote clinical coding. Available at: https://www.capita.com/expertise/industry-specific-services/health-services/healthcare-business-operations/clinical-coding/remote-clinical-coding (Accessed: 21 May 2023).

Card, D. and Shore-Sheppard, L.D. (2004) ‘Using discontinuous eligibility rules to identify the effects of the federal medicaid expansions on low-income children’, Review of Economics and Statistics, 86(3), pp. 752–766.

Care Quality Commission (2018) ‘The state of care in independent acute hospitals’. Available at: https://www.cqc.org.uk/sites/default/files/state-care-independent-acute-hospitals.pdf (Accessed: 17 April 2023).

CCSD (2022) The Clinical Coding & Schedule Development Group. Available at: https://www.ccsd.org.uk/ (Accessed: 21 May 2023).

Chamberlain, C.A. et al. (2013) 'Trends in procedures for infertility and caesarean sections: was NICE disinvestment guidance implemented? NICE recommendation reminders', BMC Public Health, 13, p. 112. Available at: https://doi.org/10.1186/1471-2458-13-112.

Chambers, J.D. et al. (2017) 'A Review of Empirical Analyses of Disinvestment Initiatives', Value in Health, 20(7), pp. 909–918. Available at: https://doi.org/10.1016/j.jval.2017.03.015.

Chard, J. et al. (2011) 'Outcomes of elective surgery undertaken in independent sector treatment centres and NHS providers in England: audit of patient outcomes in surgery', BMJ, 343. Available at: https://doi.org/10.1136/bmj.d6404.

Charlesworth, A. et al. (2021) 'What is the right level of spending needed for health and care in the UK?', The Lancet, 397(10288), pp. 2012–2022. Available at: https://doi.org/10.1016/S0140-6736(21)00230-0.

Charlesworth, A., Watt, T. and Gardner, T. (2020) 'Returning NHS waiting times to 18 weeks for routine treatment: The scale of the challenge pre-COVID-19'. The Health Foundaion. Available at: https://www.health.org.uk/publications/long-reads/returning-nhs-waiting-times-to-18-weeks (Accessed: 30 June 2022).

CHKS (2022) Clinical coding services. Available at: https://www.chks.co.uk/Clinical-coding-services (Accessed: 21 May 2023).

Choosing Wisely UK (2023) 'Recommendations', Choosing Wisely UK. Available at: https://www.choosingwisely.co.uk/i-am-a-clinician/recommendations/ (Accessed: 22 May 2023).

Cleveland Clinic (2023) About Us. Available at: https://clevelandcliniclondon.uk/about (Accessed: 16 February 2023).

Colla, C.H. et al. (2017) 'Interventions Aimed at Reducing Use of Low-Value Health Services: A Systematic Review', Medical care research and review: MCRR, 74(5), pp. 507–550. Available at: https://doi.org/10.1177/1077558716656970.

Commission for Healthcare Audit and Inspection (2009) Our statutory role. Available at: https://webarchive.nationalarchives.gov.uk/ukgwa/20090321145752mp_/http://www.healthc

arecommission.org.uk/aboutus/whatwedo/ouraims/ourstatutoryrole.cfm (Accessed: 30 June 2022).

Competition and Market's Authority (2014b) 'Private Healthcare Market Investigation Order 2014'. Available at: https://assets.publishing.service.gov.uk/media/542c1543e5274a1314000c56/Non-Divestment_Order_amended.pdf (Accessed: 16 May 2023).

Cooper, Z. et al. (2011) 'Does Hospital Competition Save Lives? Evidence from the English NHS Patient Choice Reforms', The Economic Journal, 121(554), pp. F228–F260. Available at: https://doi.org/10.1111/j.1468-0297.2011.02449.x.

Cooper, Z. et al. (2012) 'Does competition improve public hospitals' efficiency?: evidence from a quasi-experiment in the English National Health Service'.

Cooper, Z., Gibbons, S. and Skellern, M. (2018) 'Does competition from private surgical centres improve public hospitals' performance? Evidence from the English National Health Service', Journal of Public Economics, 166, pp. 63–80. Available at: https://doi.org/10.1016/j.jpubeco.2018.08.002.

Coronini-Cronberg, S. et al. (2015) 'English National Health Service's Savings Plan May Have Helped Reduce The Use Of Three "Low-Value" Procedures', Health Affairs, 34(3), pp. 381–389. Available at: https://doi.org/10.1377/hlthaff.2014.0773.

CQC (2018) 'The state of health care and adult social care in England 2017/18'. Available at: https://webarchive.nationalarchives.gov.uk/ukgwa/20190303135724mp_/https://www.cqc.org.uk/sites/default/files/20171011_stateofcare1718_report.pdf (Accessed: 24 May 2023).

CQC (2022) CQC launches consultation on the future of inspection and regulation. Available at: https://www.cqc.org.uk/news/releases/cqc-launches-consultation-future-inspection-regulation (Accessed: 17 February 2023).

CQC (2023a) About us. Available at: https://www.cqc.org.uk/about-us (Accessed: 29 March 2023).

CQC (2023b) Cromwell Hospital. Available at: https://www.cqc.org.uk/location/1-130440888/inspection-summary (Accessed: 16 February 2023).

CQC (2023c) Hospital of St John & St Elizabeth. Available at: https://www.cqc.org.uk/location/1-115480780/reports (Accessed: 16 February 2023).

Craig, R.S. et al. (2019) ‘Serious adverse events and lifetime risk of reoperation after elective shoulder replacement: population based cohort study using hospital episode statistics for England’, BMJ, 364, p. l298. Available at: https://doi.org/10.1136/bmj.l298.

Crothers, H. et al. (2021) ‘Outcomes for surgical procedures funded by the English health service but carried out in public versus independent hospitals: a database study’, BMJ Quality & Safety [Preprint]. Available at: https://doi.org/10.1136/bmjqs-2021-013522.

Cui, A. et al. (2020) ‘Global, regional prevalence, incidence and risk factors of knee osteoarthritis in population-based studies’, eClinicalMedicine, 29. Available at: https://doi.org/10.1016/j.eclinm.2020.100587.

Cutler, D.M. and Gruber, J. (1996) ‘Does Public Insurance Crowd out Private Insurance?*’, The Quarterly Journal of Economics, 111(2), pp. 391–430. Available at: https://doi.org/10.2307/2946683.

Czypionka, T. et al. (2014) ‘Efficiency, ownership, and financing of hospitals: the case of Austria’, Health Care Management Science, 17(4), pp. 331–347. Available at: https://doi.org/10.1007/s10729-013-9256-9.

Daidone, S. and D’Amico, F. (2009) ‘Technical efficiency, specialization and ownership form: evidences from a pooling of Italian hospitals’, Journal of Productivity Analysis, 32(3), p. 203. Available at: https://doi.org/10.1007/s11123-009-0137-7.

Davies, E.C. et al. (2010) ‘Emergency re-admissions to hospital due to adverse drug reactions within 1 year of the index admission’, British Journal of Clinical Pharmacology, 70(5), pp. 749–755. Available at: https://doi.org/10.1111/j.1365-2125.2010.03751.x.

Dawson, J. et al. (1996) ‘Questionnaire on the perceptions of patients about total hip replacement’, The Journal of Bone and Joint Surgery. British Volume, 78(2), pp. 185–190.

Dawson, J. et al. (1998) ‘Questionnaire on the perceptions of patients about total knee replacement’, The Journal of Bone and Joint Surgery. British Volume, 80(1), pp. 63–69. Available at: https://doi.org/10.1302/0301-620x.80b1.7859.

Dehkordy, S.F. et al. (2015) ‘Trends in Breast Cancer Screening’, American journal of preventive medicine, 49(3), pp. 419–422. Available at: https://doi.org/10.1016/j.amepre.2015.02.017.

Department of Health & Social Care (2015) The NHS Constitution for England. Available at: https://www.gov.uk/government/publications/the-nhs-constitution-for-england/the-nhs-constitution-for-england (Accessed: 11 May 2023).

DHSC (2020) Paterson Inquiry report. Available at: https://www.gov.uk/government/publications/paterson-inquiry-report (Accessed: 18 May 2023).

Dietrich, E.S. (2009) 'Effects of the National Institute for Health and Clinical Excellence's technology appraisals on prescribing and net ingredient costs of drugs in the National Health Service in England', International Journal of Technology Assessment in Health Care, 25(3), pp. 262–271. Available at: https://doi.org/10.1017/S0266462309990110.

Dixon, A. et al. (2010) Patient Choice: How Patients Choose and How Providers Respond. King's Fund. Available at: https://www.kingsfund.org.uk/sites/default/files/Patient-choice-final-report-Kings-Fund-Anna_Dixon-Ruth-Robertson-John-Appleby-Peter-Purge-Nancy-Devlin-Helen-Magee-June-2010.pdf (Accessed 10 May 2023)

Dixon, S. (2010) 'Report on the National Patient Choice Survey - February 2010 England'. Department of Health. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/216073/dh_117096.pdf (Accessed: 17 May 2023).

Dixon-Woods, M. et al. (2014) 'Culture and behaviour in the English National Health Service: overview of lessons from a large multimethod study', BMJ Quality & Safety, 23(2), pp. 106–115. Available at: https://doi.org/10.1136/bmjqs-2013-001947.

Dixon-Woods, M., Yeung, K. and Bosk, C.L. (2011) 'Why is U.K. medicine no longer a self-regulating profession? The role of scandals involving "bad apple" doctors', Social Science & Medicine (1982), 73(10), pp. 1452–1459. Available at: https://doi.org/10.1016/j.socscimed.2011.08.031.

Donabedian, A. (1990) 'The seven pillars of quality', Archives of Pathology & Laboratory Medicine, 114(11), pp. 1115–1118.

Donabedian, A. (2005) 'Evaluating the Quality of Medical Care', The Milbank Quarterly, 83(4), pp. 691–729. Available at: https://doi.org/10.1111/j.1468-0009.2005.00397.x.

Donaldson, L. (2005) ‘On the state of the public health: annual report of the chief medical officer 2005’. Department of Health.

Doogal (2022) Batch geocoding. Available at: https://www.doogal.co.uk/BatchGeocoding (Accessed: 5 May 2023).

Dubay, L. and Kenney, G. (1997) ‘Did Medicaid Expansions For Pregnant Women Crowd Out Private Coverage?’, Health Affairs, 16(1), pp. 185–193. Available at: https://doi.org/10.1377/hlthaff.16.1.185.

Dubay, L. and Kenney, G. (2009) ‘The Impact of CHIP on Children’s Insurance Coverage: An Analysis Using the National Survey of America’s Families’, Health Services Research, 44(6), pp. 2040–2059. Available at: https://doi.org/10.1111/j.1475-6773.2009.01040.x.

Dubay, L.C. and Kenney, G.M. (1996) ‘The effects of Medicaid expansions on insurance coverage of children’, The Future of Children, 6(1), pp. 152–161.

Dyer, C. (2001) ‘Bristol inquiry’, BMJ : British Medical Journal, 323(7306), p. 181.

Eggleston, K. et al. (2008) ‘Hospital ownership and quality of care: what explains the different results in the literature?’, Health Economics, 17(12), pp. 1345–1362. Available at: https://doi.org/10.1002/hec.1333.

Ellis, R.P. and McGuire, T.G. (1986) ‘Provider behavior under prospective reimbursement. Cost sharing and supply’, Journal of Health Economics, 5(2), pp. 129–151. Available at: https://doi.org/10.1016/0167-6296(86)90002-0.

Encinosa, W.E. and Hellinger, F.J. (2008) ‘The impact of medical errors on ninety-day costs and outcomes: an examination of surgical patients’, Health Services Research, 43(6), pp. 2067–2085. Available at: https://doi.org/10.1111/j.1475-6773.2008.00882.x.

Farrar, S. et al. (2009) ‘Has payment by results affected the way that English hospitals provide care? Difference-in-differences analysis’, BMJ (Clinical research ed.), 339, p. b3047. Available at: https://doi.org/10.1136/bmj.b3047.

Fattore, G., Petrarca, G. and Torbica, A. (2014) ‘Traveling for care: Inter-regional mobility for aortic valve substitution in Italy’, Health Policy, 117(1), pp. 90–97. Available at: https://doi.org/10.1016/j.healthpol.2014.03.002.

Foubister, T. et al. (2006) Private medical insurance in the United Kingdom. Copenhagen: WHO Regional Office for Europe.

Fowler, T.J. et al. (2021) 'Association between surgeon grade and implant survival following hip and knee replacement: a systematic review and meta-analysis', BMJ open, 11(11), p. e047882. Available at: https://doi.org/10.1136/bmjopen-2020-047882.

Francis, R. (2013) The Mid Staffordshire NHS Foundation Trust Public Inquiry: executive summary. Presented to Parliament pursuant to Section 26 of the Inquiries Act 2005. London: Stationery Office.

Friebel, R. et al. (2019) 'The implications of high bed occupancy rates on readmission rates in England: A longitudinal study', Health Policy, 123(8), pp. 765–772. Available at: https://doi.org/10.1016/j.healthpol.2019.06.006.

Friebel, R. et al. (2022) 'Emergency contracting and the delivery of elective care services across the English National Health Service and independent sector during COVID-19: a descriptive analysis', BMJ Open, 12(7), p. e055875. Available at: https://doi.org/10.1136/bmjopen-2021-055875.

Friebel, R., Henschke, C. and Maynou, L. (2021) 'Comparing the dangers of a stay in English and German hospitals for high-need patients', Health Services Research, 56(S3), pp. 1405–1417. Available at: https://doi.org/10.1111/1475-6773.13712.

Funk, M.J. et al. (2011) 'Doubly robust estimation of causal effects', American journal of epidemiology, 173(7), pp. 761–767. Available at: https://doi.org/10.1093/aje/kwq439.

Gallagher, P. (2021) 'Hundreds of private patients needed transfer to NHS hospitals due to treatment complications'. Available at: https://inews.co.uk/news/health/hundreds-private-patients-emergency-transfer-nhs-hospitals-treatment-complications-1342241 (Accessed: 28 April 2023).

Garner, S. and Littlejohns, P. (2011) 'Disinvestment from low value clinical interventions: NICEly done?', BMJ, 343. Available at: https://doi.org/10.1136/bmj.d4519.

Garriga, C. et al. (2019) 'Geographical Variation in Outcomes of Primary Hip and Knee Replacement', JAMA Network Open, 2(10), p. e1914325. Available at: https://doi.org/10.1001/jamanetworkopen.2019.14325.

Gaynor, M. (2006) ‘What do we Know about competition and quality in health care markets, 2006. The Centre for Market and Public Organisation (CMPO). Available at: https://www.bristol.ac.uk/media-library/sites/cmpo/migrated/documents/wp151.pdf (Accessed 10 May 2023)

Gaynor, M., Moreno-Serra, R. and Propper, C. (2013) ‘Death by Market Power: Reform, Competition, and Patient Outcomes in the National Health Service’, American Economic Journal: Economic Policy, 5(4), pp. 134–166. Available at: https://doi.org/10.1257/pol.5.4.134.

Gaynor, M., Propper, C. and Seiler, S. (2016) ‘Free to Choose? Reform, Choice, and Consideration Sets in the English National Health Service’, The American Economic Review, 106(11), pp. 3521–3557.

Gobillon, L. and Milcent, C. (2016) ‘Evaluating the Effect of Ownership Status on Hospital Quality: The Key Role of Innovative Procedures’, Annals of Economics and Statistics, (121/122), pp. 161–186. Available at: https://doi.org/10.15609/annaeconstat2009.121-122.161.

Gowrisankaran, G. and Town, R.J. (1999) ‘Estimating the quality of care in hospitals using instrumental variables’, Journal of Health Economics, 18(6), pp. 747–767. Available at: https://doi.org/10.1016/s0167-6296(99)00022-3.

Grabowski, D.C. et al. (2013) ‘Effect of Nursing Home Ownership on the Quality of Post-Acute Care: An Instrumental Variables Approach’, Journal of health economics, 32(1), pp. 12–21. Available at: https://doi.org/10.1016/j.jhealeco.2012.08.007.

Grašič, K., Mason, A.R. and Street, A. (2015) ‘Paying for the quantity and quality of hospital care: the foundations and evolution of payment policy in England’, Health Economics Review, 5(1), p. 15. Available at: https://doi.org/10.1186/s13561-015-0050-x.

Gravelle, H., Santos, R. and Siciliani, L. (2014) ‘Does a hospital’s quality depend on the quality of other hospitals? A spatial econometrics approach’, Regional Science and Urban Economics, 49, pp. 203–216. Available at: https://doi.org/10.1016/j.regsciurbeco.2014.09.005.

Gravelle, H. and Sivey, P. (2010) 'Imperfect information in a quality-competitive hospital market', Journal of Health Economics, 29(4), pp. 524–535. Available at: https://doi.org/10.1016/j.jhealeco.2010.04.003.

Graves, N., Birrell, F. and Whitby, M. (2005) 'Effect of Pressure Ulcers on Length of Hospital Stay', Infection Control & Hospital Epidemiology, 26(3), pp. 293–297. Available at: https://doi.org/10.1086/502542.

Gresenz, C.R. et al. (2012) 'Take-Up of Public Insurance and Crowd-Out of Private Insurance under Recent CHIP Expansions to Higher Income Children', Health Services Research, 47(5), pp. 1999–2011. Available at: https://doi.org/10.1111/j.1475-6773.2012.01408.x.

Grier, S. et al. (2020) 'Critical care transfer in an English critical care network: Analysis of 1124 transfers delivered by an ad-hoc system', Journal of the Intensive Care Society, 21(1), pp. 33–39. Available at: https://doi.org/10.1177/1751143719832175.

Gruber, J. and Simon, K. (2008) 'Crowd-out 10 years later: Have recent public insurance expansions crowded out private health insurance?', Journal of Health Economics, 27(2), pp. 201–217. Available at: https://doi.org/10.1016/j.jhealeco.2007.11.004.

Gusmano, M. et al. (2015) 'Comparison of rehospitalization rates in France and the United States', Journal of Health Services Research & Policy, 20(1), pp. 18–25. Available at: https://doi.org/10.1177/1355819614551849.

Gutacker, N. et al. (2016) 'Choice of hospital: Which type of quality matters?', Journal of Health Economics, 50, pp. 230–246. Available at: https://doi.org/10.1016/j.jhealeco.2016.08.001.

Hackett, N.J. et al. (2015) 'ASA class is a reliable independent predictor of medical complications and mortality following surgery', International Journal of Surgery, 18, pp. 184–190. Available at: https://doi.org/10.1016/j.ijsu.2015.04.079.

Hallsworth, M. et al. (2016) 'Provision of social norm feedback to high prescribers of antibiotics in general practice: a pragmatic national randomised controlled trial', The Lancet, 387(10029), pp. 1743–1752. Available at: https://doi.org/10.1016/S0140-6736(16)00215-4.

Ham, J.C. and Shore-Sheppard, L. (2005) 'The effect of Medicaid expansions for low-income children on Medicaid participation and private insurance coverage: evidence from the SIPP',

Journal of Public Economics, 89(1), pp. 57–83. Available at: https://doi.org/10.1016/j.jpubeco.2003.07.011.

Hansen, L.P. (1982) 'Large Sample Properties of Generalized Method of Moments Estimators', Econometrica, 50(4), pp. 1029–1054. Available at: https://doi.org/10.2307/1912775.

Hauck, K. and Zhao, X. (2011) 'How dangerous is a day in hospital? A model of adverse events and length of stay for medical inpatients', Medical Care, 49(12), pp. 1068–1075. Available at: https://doi.org/10.1097/MLR.0b013e31822efb09.

Hausman, J.A. (1978) 'Specification Tests in Econometrics', Econometrica, 46(6), pp. 1251–1271. Available at: https://doi.org/10.2307/1913827.

Heath, L. (2021) 'Private Healthcare: Self-Pay UK Market Report 3ed'. LaingBuisson. Available at: https://www.laingbuisson.com/shop/private-healthcare-self-pay-uk-market-report-3ed/ (Accessed: 6 March 2023).

Hennig-Schmidt, H., Selten, R. and Wiesen, D. (2011) 'How payment systems affect physicians' provision behaviour—An experimental investigation', Journal of Health Economics, 30(4), pp. 637–646. Available at: https://doi.org/10.1016/j.jhealeco.2011.05.001.

Herbert, A. et al. (2017) 'Data Resource Profile: Hospital Episode Statistics Admitted Patient Care (HES APC)', International Journal of Epidemiology, 46(4), pp. 1093–1093i. Available at: https://doi.org/10.1093/ije/dyx015.

Herr, A. (2008) 'Cost and technical efficiency of German hospitals: does ownership matter?', Health Economics, 17(9), pp. 1057–1071. Available at: https://doi.org/10.1002/hec.1388.

Herr, A., Schmitz, H. and Augurzky, B. (2011) 'Profit efficiency and ownership of German hospitals', Health Economics, 20(6), pp. 660–674. Available at: https://doi.org/10.1002/hec.1622.

Herrod, P.J.J. et al. (2019) 'Winter cancellations of elective surgical procedures in the UK: a questionnaire survey of patients on the economic and psychological impact', BMJ Open, 9(9), p. e028753. Available at: https://doi.org/10.1136/bmjopen-2018-028753.

Herwartz, H. and Strumann, C. (2012) 'On the effect of prospective payment on local hospital competition in Germany', Health Care Management Science, 15(1), pp. 48–62. Available at: https://doi.org/10.1007/s10729-011-9180-9.

Hill, A.D. et al. (2007) ‘Interhospital transfer of critically ill patients: demographic and outcomes comparison with nontransferred intensive care unit patients’, Journal of Critical Care, 22(4), pp. 290–295. Available at: https://doi.org/10.1016/j.jcrc.2007.06.002.

Hirji, S. et al. (2020) ‘Utility of 90-Day Mortality vs 30-Day Mortality as a Quality Metric for Transcatheter and Surgical Aortic Valve Replacement Outcomes’, JAMA Cardiology, 5(2), pp. 156–165. Available at: https://doi.org/10.1001/jamacardio.2019.4657.

Hong, A.S. et al. (2017) ‘Small Decline In Low-Value Back Imaging Associated With The “Choosing Wisely” Campaign, 2012–14’, Health Affairs, 36(4), pp. 671–679. Available at: https://doi.org/10.1377/hlthaff.2016.1263.

Hoogervorst-Schilp, J. et al. (2015) ‘Excess length of stay and economic consequences of adverse events in Dutch hospital patients’, BMC Health Services Research, 15, p. 531. Available at: https://doi.org/10.1186/s12913-015-1205-5.

HQIP (2022) National Audit of Percutaneous Coronary Intervention: 2022 Summary report. Available at: https://www.hqip.org.uk/resource/national-audit-of-percutaneous-coronary-intervention-2022-summary-report/ (Accessed: 31 March 2023).

HQIP (2023) ‘The Directory’. Available at: https://www.hqip.org.uk/resource/national-clinical-audit-and-enquiries-directory/ (Accessed: 10 February 2023).

Hudson, J.L., Selden, T.M. and Banthin, J.S. (2005) ‘The impact of SCHIP on insurance coverage of children’, Inquiry: A Journal of Medical Care Organization, Provision and Financing, 42(3), pp. 232–254. Available at: https://doi.org/10.5034/inquiryjrnl_42.3.232.

Hughes D (2023) Sunak backs greater role for private sector in providing NHS care. Evening Standard. Published 13 April 2023. Available at: https://www.standard.co.uk/news/politics/nhs-european-tories-boris-johnson-prime-minister-b1073942.html (Accessed 7 June 2023)

Hussey, P.S.; W., S.;. Mehrotra, A. (2013) ‘The association between health care quality and cost: a systematic review’, Ann Intern Med, 158(1), pp. 27–34. Available at: https://doi.org/10.7326/0003-4819-158-1-201301010-00006.

IHPN (2021) ‘Independent sector healthcare comparative performance indicators Edition 68’. Available at: https://www.ihpn.org.uk/wp-content/uploads/2019/01/IHPN-headline-indicator-summary-Feb-2021-with-data-up-to-Dec-2020.pdf (Accessed: 9 May 2023).

Institute of Medicine (US) (2001) Crossing the Quality Chasm: A New Health System for the 21st Century. Washington (DC): National Academies Press (US). Available at: http://www.ncbi.nlm.nih.gov/books/NBK222274/ (Accessed: 19 May 2023).

Jaeger, D.A., Joyce, T.J. and Kaestner, R. (2020) 'A Cautionary Tale of Evaluating Identifying Assumptions: Did Reality TV Really Cause a Decline in Teenage Childbearing?', Journal of Business & Economic Statistics, 38(2), pp. 317–326. Available at: https://doi.org/10.1080/07350015.2018.1497510.

Jean-Sebastien Rachoin, M.D. et al. (2020) 'Discharge Before Noon: Is the Sun Half Up or Half Down?', 26. Available at: https://www.ajmc.com/view/discharge-before-noon-is-the-sun-half-up-or-half-down (Accessed: 11 May 2023).

Kahn-Lang, A. and Lang, K. (2019) 'The Promise and Pitfalls of Differences-in-Differences: Reflections on 16 and Pregnant and Other Applications', Journal of Business & Economic Statistics, pp. 1–14. Available at: https://doi.org/10.1080/07350015.2018.1546591.

Kane, R.L. et al. (2007) 'Nurse staffing and quality of patient care', Evidence Report/Technology Assessment, (151), pp. 1–115.

Kastanis, G. et al. (2016) 'Is the ASA Score in Geriatric Hip Fractures a Predictive Factor for Complications and Readmission?', Scientifica, 2016, p. e7096245. Available at: https://doi.org/10.1155/2016/7096245.

Kelly, E. and Stoye, G. (2020) 'The Impacts of Private Hospital Entry on the Public Market for Elective Care in England', Institute for Fiscal Studies. Available at: https://www.ifs.org.uk/uploads/WP202001-The-Impacts-of-Private-Hospital-Entry-on-the-Public-Market-for-Elective-Care-in-England.pdf (Accessed: 10 May 2023).

Kelly, E. and Tetlow, G. (2012) 'Understanding competition and choice in the NHS: Choosing the place of care'. The Nuffield Trust. Available at: https://www.nuffieldtrust.org.uk/files/2017-01/choosing-place-of-care-web-final.pdf (Accessed: 30 May 2023).

Khavanin, N. et al. (2015) 'Assessing safety and outcomes in outpatient versus inpatient thyroidectomy using the NSQIP: a propensity score matched analysis of 16,370 patients', Annals of Surgical Oncology, 22(2), pp. 429–436. Available at: https://doi.org/10.1245/s10434-014-3785-4.

King, D. and Mossialos, E. (2005) 'The Determinants of Private Medical Insurance Prevalence in England, 1997–2000', Health Services Research, 40(1), pp. 195–212. Available at: https://doi.org/10.1111/j.1475-6773.2005.00349.x.

King's Fund (2021a) 'Is the NHS being privatised?' Available at: https://www.kingsfund.org.uk/publications/articles/big-election-questions-nhs-privatised (Accessed: 18 May 2023).

King's Fund (2021b) NHS trusts in deficit. Available at: https://www.kingsfund.org.uk/projects/nhs-in-a-nutshell/trusts-deficit (Accessed: 17 May 2023).

Kirkup, B. (2015) 'The Report of the Morecambe Bay Investigation'. The Stationery Office. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/408480/47487_MBI_Accessible_v0.1.pdf (Accessed: 31 March 2023).

Konetzka, R.T., Yang, F. and Werner, R.M. (2019) 'Use of instrumental variables for endogenous treatment at the provider level', Health economics, 28(5), pp. 710–716. Available at: https://doi.org/10.1002/hec.3861.

Kronman, M.P. et al. (2008) 'Charges and lengths of stay attributable to adverse patient-care events using pediatric-specific quality indicators: a multicenter study of freestanding children's hospitals', Pediatrics, 121(6), pp. e1653-1659. Available at: https://doi.org/10.1542/peds.2007-2831.

Kruse, F.M. et al. (2018) 'Do private hospitals outperform public hospitals regarding efficiency, accessibility, and quality of care in the European Union? A literature review', The International Journal of Health Planning and Management, 33(2), pp. e434–e453. Available at: https://doi.org/10.1002/hpm.2502.

Laing, W. (2022) 'Health Cover UK Market Report - 17th Edition'. LaingBuisson. Available at: https://www.laingbuisson.com/shop/health-cover-uk-market-report-17ed/ (Accessed: 7 May 2023).

Laing, W (2023) 'UK Healthcare Market Review 34ed'. LaingBuisson Available at: https://www.laingbuisson.com/shop/uk-healthcare-market-review-34ed/ (Accessed: 23 April 2023).

Lasser, E.C. et al. (2016) ‘Has Choosing Wisely® affected rates of dual-energy X-ray absorptiometry use?’, Osteoporosis International, 27(7), pp. 2311–2316. Available at: https://doi.org/10.1007/s00198-016-3511-0.

Lee, D.K.K., Chertow, G.M. and Zenios, S.A. (2010) ‘Reexploring Differences among For-Profit and Nonprofit Dialysis Providers’, Health Services Research, 45(3), pp. 633–646. Available at: https://doi.org/10.1111/j.1475-6773.2010.01103.x.

Li, G. et al. (2021) ‘Reliability of the ASA Physical Status Classification System in Predicting Surgical Morbidity: a Retrospective Analysis’, Journal of Medical Systems, 45(9), p. 83. Available at: https://doi.org/10.1007/s10916-021-01758-z.

Lien, H.-M., Chou, S.-Y. and Liu, J.-T. (2008) ‘Hospital ownership and performance: Evidence from stroke and cardiac treatment in Taiwan’, Journal of Health Economics, 27(5), pp. 1208–1223. Available at: https://doi.org/10.1016/j.jhealeco.2008.03.002.

Lindlbauer, I. and Schreyögg, J. (2014) ‘The relationship between hospital specialization and hospital efficiency: do different measures of specialization lead to different results?’, Health Care Management Science, 17(4), pp. 365–378. Available at: https://doi.org/10.1007/s10729-014-9275-1.

Lintern, S. (2021) New compensation scheme for victims of rogue surgeon to be set up by private hospital group, The Independent. Available at: https://www.independent.co.uk/news/health/paterson-surgeon-patients-compensation-spire-b1890629.html (Accessed: 24 May 2023).

Lo Sasso, A.T. and Buchmueller, T.C. (2004) ‘The effect of the state children’s health insurance program on health insurance coverage’, Journal of Health Economics, 23(5), pp. 1059–1082. Available at: https://doi.org/10.1016/j.jhealeco.2004.03.006.

Lydall, R. (2021) London cancer doctor suspended for 9 months after misconduct hearing, Evening Standard. Available at: https://www.standard.co.uk/news/london/justin-stebbing-london-cancer-doctor-harley-street-suspended-misconduct-b973007.html (Accessed: 24 May 2023).

Ma, C.A. (1994) ‘Health Care Payment Systems: Cost and Quality Incentives’, Journal of Economics & Management Strategy, 3(1), pp. 93–112. Available at: https://doi.org/10.1111/j.1430-9134.1994.00093.x.

Makarov, D.V. et al. (2013) ‘Prostate Cancer Imaging Trends After a Nationwide Effort to Discourage Inappropriate Prostate Cancer Imaging’, JNCI Journal of the National Cancer Institute, 105(17), pp. 1306–1313. Available at: https://doi.org/10.1093/jnci/djt175.

Malhotra, A. et al. (2015) ‘Choosing Wisely in the UK: the Academy of Medical Royal Colleges’ initiative to reduce the harms of too much medicine’, BMJ, 350. Available at: https://doi.org/10.1136/bmj.h2308.

Mannion, A.F. et al. (2020) ‘Can the Charlson Comorbidity Index be used to predict the ASA grade in patients undergoing spine surgery?’, European Spine Journal, 29(12), pp. 2941–2952. Available at: https://doi.org/10.1007/s00586-020-06595-1.

Martin, G.P. and Dixon-Woods, M. (2014) ‘After Mid Staffordshire: from acknowledgement, through learning, to improvement’, BMJ Quality & Safety, 23(9), pp. 706–708. Available at: https://doi.org/10.1136/bmjqs-2014-003359.

Martinsson, P. and Persson, E. (2019) ‘Physician behavior and conditional altruism: the effects of payment system and uncertain health benefit’, Theory and Decision, 87(3), pp. 365–387. Available at: https://doi.org/10.1007/s11238-019-09714-7.

Mason, A., Street, A. and Verzulli, R. (2010) ‘Private sector treatment centres are treating less complex patients than the NHS’, Journal of the Royal Society of Medicine, 103(8), pp. 322–331. Available at: https://doi.org/10.1258/jrsm.2010.100044.

Matthay, E.C. et al. (2020) ‘Alternative causal inference methods in population health research: Evaluating tradeoffs and triangulating evidence’, SSM - Population Health, 10, p. 100526. Available at: https://doi.org/10.1016/j.ssmph.2019.100526.

Mayer, J. and Nachtnebel, A. (2015) ‘Disinvesting From Ineffective Technologies: Lessons Learned From Current Programs’, International Journal of Technology Assessment in Health Care, 31(6), pp. 355–362. Available at: https://doi.org/10.1017/S0266462315000641.

Mayhew, D., Mendonca, V. and Murthy, B.V.S. (2019) ‘A review of ASA physical status – historical perspectives and modern developments’, Anaesthesia, 74(3), pp. 373–379. Available at: https://doi.org/10.1111/anae.14569.

Maynard, A. (2005) The Public Private Mix for Health. London: CRC Press. Available at: https://doi.org/10.1201/9781315377575.

Mays N, Dixon A, Jones L (2011). Return to the market: objectives and evolution of New Labour's market reforms. Available at: https://www.kingsfund.org.uk/sites/default/files/chapter-1-Return-to-the-market-objectives-evolution-new-labours-market-reforms-sept11.pdf (Accessed: 7 June 2023)

McClellan, M., McNeil, B.J. and Newhouse, J.P. (1994) 'Does More Intensive Treatment of Acute Myocardial Infarction in the Elderly Reduce Mortality?: Analysis Using Instrumental Variables', JAMA, 272(11), pp. 859–866. Available at: https://doi.org/10.1001/jama.1994.03520110039026.

Morche, J., Mathes, T. and Pieper, D. (2016) 'Relationship between surgeon volume and outcomes: a systematic review of systematic reviews', Systematic Reviews, 5(1), p. 204. Available at: https://doi.org/10.1186/s13643-016-0376-4.

Morris, J. (2018) Trends in emergency readmissions to hospital in England. Nuffield Trust. Available at: https://www.nuffieldtrust.org.uk/news-item/emergency-readmissions-trends-in-emergency-readmissions-to-hospital-in-england-1 (Accessed: 17 May 2023).

Morton B (2023). Keir Starmer: The NHS must reform to survive. BBC. Published 15 January 2023. Available at: https://www.bbc.co.uk/news/uk-64279654 (Accessed: 7 June 2023)

Moscelli, G. et al. (2016) 'Location, quality and choice of hospital: Evidence from England 2002–2013', Regional Science and Urban Economics, 60, pp. 112–124. Available at: https://doi.org/10.1016/j.regsciurbeco.2016.07.001.

Moscelli, G. et al. (2018) 'The effect of hospital ownership on quality of care : evidence from England', Journal of Economic Behavior & Organization, pp. 322–344.

Moscelli, G., Gravelle, H. and Siciliani, L. (2021) 'Hospital competition and quality for non-emergency patients in the English NHS', RAND Journal of Economics, 52(2), pp. 382–414.

Moscelli, G., Gravelle, H.S.E. and Siciliani, L. (2016) 'Market structure, patient choice and hospital quality for elective patients'.

Moscone, F., Tosetti, E. and Vittadini, G. (2012) 'Social interaction in patients' hospital choice: evidence from Italy', Journal of the Royal Statistical Society: Series A (Statistics in Society), 175(2), pp. 453–472. Available at: https://doi.org/10.1111/j.1467-985X.2011.01008.x.

Mossialos, E. et al. (2018) ‘The future of the NHS: no longer the envy of the world?’, The Lancet, 391(10125), pp. 1001–1003.

Mufarrih, S.H. et al. (2019) ‘Effect of hospital volume on outcomes of total hip arthroplasty: a systematic review and meta-analysis’, Journal of Orthopaedic Surgery and Research, 14(1), p. 468. Available at: https://doi.org/10.1186/s13018-019-1531-0.

Murphy, J., Tanner, T. and Komorowski, J. (2019) ‘Shared Decision-Making With Choosing Wisely’, Nursing for Women’s Health, 23(3), pp. 253–264. Available at: https://doi.org/10.1016/j.nwh.2019.03.005.

Murray, R. (2021) ‘Lessons from the 2000s: the ambition to reduce waits must be matched with patience and realism This content relates to the following topics’: The King’s Fund. Available at: https://www.kingsfund.org.uk/publications/nhs-waiting-times#waiting-times-in-the-1990s-and-2000s (Accessed: 6 May 2023).

National Audit Office (2012) Progress in Making NHS Efficiency Savings: Department of Health. The Stationery Office.

National Joint Registry (2016) ‘OPCS Codes relevant to procedures recorded on the NJR’. Available at: https://www.njrcentre.org.uk/njrcentre/Portals/0/Documents/England/Data%20collection%20forms/OPCS%20Procedure%20codes%20relevant%20to%20NJRv4.pdf (Accessed: 17 May 2023).

Naylor, C. and Gregory, S. (2009) ‘Independent sector treatment centres’. The King’s Fund. Available at: https://www.kingsfund.org.uk/sites/default/files/Briefing-Independent-sector-treatment-centres-ISTC-Chris-Naylor-Sarah-Gregory-Kings-Fund-October-2009.pdf (Accessed: 30 May 2023).

NBSR (2023) Home | Bariatric Surgeon Reporting Website. Available at: https://nbsr.e-dendrite.com/ (Accessed: 31 March 2023).

Neuner, J.M. et al. (2019) ‘Temporal trends and regional variation in the utilization of low-value breast cancer care: has the Choosing Wisely campaign made a difference?’, Breast Cancer Research and Treatment, 176(1), pp. 205–215. Available at: https://doi.org/10.1007/s10549-019-05213-z.

Newhouse, J.P. and McClellan, M. (1998) ‘Econometrics in outcomes research: The use of instrumental variables’, Annual Review of Public Health, 19, pp. 17–34. Available at: https://doi.org/10.1146/annurev.publhealth.19.1.17.

NHS Confederation (2011) ‘Any Qualified Provider: Discussion paper’. Available at: https://www.nhsconfed.org/sites/default/files/2021-05/Any-qualified-provider.pdf (Accessed: 30 May 2023).

NHS Digital (2021) NHS Workforce Statistics - April 2021 (Including selected provisional statistics for May 2021). Available at: https://digital.nhs.uk/data-and-information/publications/statistical/nhs-workforce-statistics/april-2021 (Accessed: 24 May 2023).

NHS Digital (2022) Organisation Data Service. Available at: https://digital.nhs.uk/services/organisation-data-service (Accessed: 3 May 2023).

NHS Digital (2023a) Acute Data Alignment Programme (ADAPt). Available at: https://digital.nhs.uk/services/acute-data-alignment-programme (Accessed: 11 May 2023).

NHS Digital (2023b) Data Access Request Service (DARS). Available at: https://digital.nhs.uk/services/data-access-request-service-dars (Accessed: 31 March 2023).

NHS Digital (2023c) NHS workforce statistics. Available at: https://digital.nhs.uk/data-and-information/publications/statistical/nhs-workforce-statistics (Accessed: 15 April 2023).

NHS England (2000) ‘The NHS Plan’. Available at: https://www.bsuh.nhs.uk/library/wp-content/uploads/sites/8/2020/09/The-NHS-plan-2000.pdf (Accessed: 30 May 2023).

NHS England (2002) ‘Delivering the NHS Plan: Next Steps on Investment, Next Steps on Reform’. Available at: https://webarchive.nationalarchives.gov.uk/ukgwa/20130107105354/http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/@ps/documents/digitalasset/dh_118524.pdf (Accessed: 30 May 2023).

NHS England (2013) ‘Patient Reported Outcome Measures (PROMs) in England: Update to reporting and case-mix adjusting hip and knee procedure data.’ Available at: https://www.england.nhs.uk/statistics/wp-content/uploads/sites/2/2013/10/proms-meth-prim-revis.pdf (Accessed: 26 May 2023).

NHS England (2016) Financial Performance Accountability. Available at: https://www.england.nhs.uk/publications/performance/ (Accessed: 17 May 2023).

NHS England (2018a) Evidence-Based Interventions: Activity figures. Available at: https://www.nhsbsa.nhs.uk/access-our-data-products/epact2/dashboards-and-specifications/evidence-based-interventions (Accessed: 12 May 2023).

NHS England (2018b) 'Evidence-Based Interventions: Guidance for CCGs'. Available at: https://www.necsu.nhs.uk/wp-content/uploads/2019/02/2018-11-Evidence-basedInterventions-GuideForCCGs-NHSE-2.pdf (Accessed: 12 May 2023).

NHS England (2019) NHS Long Term Plan. Available at: https://www.longtermplan.nhs.uk/ (Accessed: 7 June 2023)

NHS England (2021) Clinical commissioning group details. Available at: https://digital.nhs.uk/services/organisation-data-service/change-summary-reconfiguration-2021-ccg-mergers (Accessed: 1 May 2023).

NHS England (2022a) Consultant-led Referral to Treatment Waiting Times. Available at: https://www.england.nhs.uk/statistics/statistical-work-areas/rtt-waiting-times/ (Accessed: 24 May 2023).

NHS England (2022b) 'Delivery plan for tackling the COVID-19 backlog of elective care'. Available at: https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2022/02/C1466-delivery-plan-for-tackling-the-covid-19-backlog-of-elective-care.pdf (Accessed: 20 May 2023).

NHS England (2022c) Financial performance reports. Available at: https://www.england.nhs.uk/publication/financial-performance-reports/ (Accessed: 23 May 2023).

NHS England (2022d) Patient Reported Outcome Measures (PROMs). Available at: https://digital.nhs.uk/data-and-information/data-tools-and-services/data-services/patient-reported-outcome-measures-proms (Accessed: 17 May 2023).

NHS England (2023a) Bed Availability and Occupancy. Available at: https://www.england.nhs.uk/statistics/statistical-work-areas/bed-availability-and-occupancy/ (Accessed: 15 April 2023).

NHS England (2023b) Do I need a GP referral for private treatment? Available at: https://www.nhs.uk/common-health-questions/nhs-services-and-treatments/do-i-need-a-gp-referral-for-private-treatment/ (Accessed: 15 April 2023).

NHS Resolution (2023) About. Available at: https://resolution.nhs.uk/about/ (Accessed: 29 March 2023).

NICE (2016) Preoperative Tests (Update): Routine Preoperative Tests for Elective Surgery. National Institute for Health and Care Excellence (NICE). Available at: https://www.ncbi.nlm.nih.gov/books/NBK367899/ (Accessed: 7 April 2023).

NICE (2023) What we do. Available at: https://www.nice.org.uk/about/what-we-do (Accessed: 29 March 2023).

NJR (2023) 'Home - The National Joint Registry'. Available at: https://www.njrcentre.org.uk/, https://www.njrcentre.org.uk/ (Accessed: 31 March 2023).

Norton, W.E. and Chambers, D.A. (2020) 'Unpacking the complexities of de-implementing inappropriate health interventions', Implementation Science, 15(1), p. 2. Available at: https://doi.org/10.1186/s13012-019-0960-9.

Nuffield Health (2023) About Us. Available at: https://www.nuffieldhealth.com/about-us (Accessed: 30 March 2023).

Ockenden, D. (2022) 'Findings, Conclusions, and Essential Actions From the Independent Review of Maternity Services at The Shrewsbury and Telford Hospital NHS Trust'. Her Majesty's Stationery Office. Available at: https://www.ockendenmaternityreview.org.uk/wp-content/uploads/2022/03/FINAL_INDEPENDENT_MATERNITY_REVIEW_OF_MATERNITY_SERVICES_REPORT.pdf (Accessed: 31 March 2023).

OECD (2022) OECD Health Statistics 2022. Available at: http://www.oecd.org/els/health-systems/health-data.htm (Accessed: 4 May 2023).

OHID (2022) NHS Acute (Hospital) Trust Catchment Populations. Available at: https://app.powerbi.com/view?r=eyJrIjoiODZmNGQ0YzItZDAwZi00MzFiLWE4NzAtMzVmNTUwMThmMTVlIiwidCI6ImVlNGUxNDk5LTRhMzUtNGIyZS1hZDQ3LTVmM2NmOWRlODY2NiIsImMiOjh9 (Accessed: 13 May 2023).

Olden, A. and Møen, J. (2022) 'The triple difference estimator', The Econometrics Journal, 25(3), pp. 531–553. Available at: https://doi.org/10.1093/ectj/utac010.

O'Neill, B.R. et al. (2016) 'Do first impressions count? Frailty judged by initial clinical impression predicts medium-term mortality in vascular surgical patients', Anaesthesia, 71(6), pp. 684–691. Available at: https://doi.org/10.1111/anae.13404.

Ong, W.L. et al. (2019) 'Are We Choosing Wisely in Radiation Oncology Practice–Findings From an Australian Population-Based Study', International Journal of Radiation Oncology, Biology, Physics, 104(5), pp. 1012–1016. Available at: https://doi.org/10.1016/j.ijrobp.2019.03.048.

ONS (2020) Estimates of the population for the UK, England and Wales, Scotland and Northern Ireland. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland (Accessed: 9 May 2023).

Owusu-Frimpong, N., Nwankwo, S. and Dason, B. (2010) 'Measuring service quality and patient satisfaction with access to public and private healthcare delivery', International Journal of Public Sector Management, 23(3), pp. 203–220. Available at: https://doi.org/10.1108/09513551011032455.

Oxford, E. (2023) 'The NHS paid private hospitals £2bn in the pandemic: did taxpayers get value for money?', BMJ, 380, p. p329. Available at: https://doi.org/10.1136/bmj.p329.

Palacios-Ceña, D. et al. (2021) 'Female Gender Is Associated with a Higher Prevalence of Chronic Neck Pain, Chronic Low Back Pain, and Migraine: Results of the Spanish National Health Survey, 2017', Pain Medicine, 22(2), pp. 382–395. Available at: https://doi.org/10.1093/pm/pnaa368.

Pappa, E. and Niakas, D. (2006) 'Assessment of health care needs and utilization in a mixed public-private system: the case of the Athens area', BMC Health Services Research, 6(1), p. 146. Available at: https://doi.org/10.1186/1472-6963-6-146.

Patey, A.M. and Soong, C. (2023) 'Top-down and bottom-up approaches to low-value care', BMJ Quality & Safety, 32(2), pp. 65–68. Available at: https://doi.org/10.1136/bmjqs-2022-014977.

Pérotin, V. et al. (2013) ‘Does hospital ownership affect patient experience? An investigation into public–private sector differences in England’, Journal of Health Economics, 32(3), pp. 633–646. Available at: https://doi.org/10.1016/j.jhealeco.2013.03.003.

Peytrignet et al. (2022) ‘Waiting for NHS hospital care: the role of the independent sector’. The Health Foundation. Available at: https://www.health.org.uk/publications/long-reads/waiting-for-nhs-hospital-care-the-role-of-the-independent-sector (Accessed: 29 March 2023).

PHIN (2020a) ‘Annual Report 2019-20’. Available at: https://phproduksportalstorage.blob.core.windows.net/website-files/reports/PHIN%20Annual%20Report%202019-20.pdf (Accessed: 1 May 2023).

PHIN (2020b) ‘Publication of provisional HCAI and SSI for the reporting period 1st April 2019 to 31st March 2020’. Available at: https://www.phin.org.uk/data/infections-datasheets (Accessed: 18 May 2023).

PHIN (2022) ‘Private market update: March 2022’. Available at: https://www.phin.org.uk/news/private-market-update-march-2022 (Accessed: 5 May 2023).

PHIN (2023) ‘New research starts on quality and safety in NHS and independent hospitals’. Available at: https://www.phin.org.uk/news/new-research-starts-on-quality-and-safety-in-nhs-and-independent-hospitals (Accessed: 19 February 2023).

Picard, R. (2019) GEONEAR: Stata module to find nearest neighbors using geodetic distances. Boston College Department of Economics. Available at: https://ideas.repec.org/c/boc/bocode/s457146.html (Accessed: 18 May 2023).

Pollock, A.M. and Godden, S. (2008) ‘Independent sector treatment centres: evidence so far’, BMJ : British Medical Journal, 336(7641), pp. 421–424. Available at: https://doi.org/10.1136/bmj.39470.505556.80.

Pollock, A.M. and Kirkwood, G. (2009) ‘Independent sector treatment centres: the first independent evaluation, a Scottish case study’, Journal of the Royal Society of Medicine, 102(7), pp. 278–286. Available at: https://doi.org/10.1258/jrsm.2009.090092.

Preti, A. et al. (2010) ‘Correlates and antecedents of hospital admission for attempted suicide: a nationwide survey in Italy’, European Archives of Psychiatry and Clinical Neuroscience, 260(3), pp. 181–190. Available at: https://doi.org/10.1007/s00406-009-0037-x.

Prochaska, M.T. et al. (2017) ‘Trends in Troponin-Only Testing for AMI in Academic Teaching Hospitals and the Impact of Choosing Wisely®’, Journal of hospital medicine, 12(12), pp. 957–962. Available at: https://doi.org/10.12788/jhm.2846.

Propper, C. et al. (2007) Did ‘Targets and Terror’ Reduce Waiting times in England for Hospital Care? 07/179. The Centre for Market and Public Organisation, University of Bristol, UK. Available at: https://ideas.repec.org/p/bri/cmpowp/07-179.html (Accessed: 23 March 2023).

Quan, H. et al. (2005) ‘Coding Algorithms for Defining Comorbidities in ICD-9-CM and ICD-10 Administrative Data’, Medical Care, 43(11), pp. 1130–1139.

Rajpal, S. et al. (2020) ‘Analyzing the Correlation Between Surgeon Experience and Patient Length of Hospital Stay’, Cureus, 12(8), p. e10099. Available at: https://doi.org/10.7759/cureus.10099.

Ratajczak, M. et al. (2019) ‘The effectiveness of repeating a social norm feedback intervention to high prescribers of antibiotics in general practice: a national regression discontinuity design’, Journal of Antimicrobial Chemotherapy, 74(12), pp. 3603–3610. Available at: https://doi.org/10.1093/jac/dkz392.

Reyes, M.A. et al. (2020) ‘Impact of the Choosing Wisely® Campaign Recommendations for Hospitalized Children on Clinical Practice: Trends from 2008 to 2017’, Journal of Hospital Medicine, 15(2), pp. 68–74. Available at: https://doi.org/10.12788/jhm.3291.

Río, I. et al. (2010) ‘Caesarean section rates in immigrant and native women in Spain: the importance of geographical origin and type of hospital for delivery’, European Journal of Public Health, 20(5), pp. 524–529. Available at: https://doi.org/10.1093/eurpub/ckq067.

Rodin, D.L. et al. (2018) ‘The impact of the ASCO Choosing Wisely campaign for breast and prostate cancer on physician behavior.’, Journal of Clinical Oncology, 36(15_suppl), pp. 6592–6592. Available at: https://doi.org/10.1200/JCO.2018.36.15_suppl.6592.

Romano, P.S. et al. (2009) ‘Validity of Selected AHRQ Patient Safety Indicators Based on VA National Surgical Quality Improvement Program Data’, Health Services Research, 44(1), pp. 182–204. Available at: https://doi.org/10.1111/j.1475-6773.2008.00905.x.

Rosen, A.K. et al. (2013) ‘Examining the Impact of the AHRQ Patient Safety Indicators (PSIs) on the Veterans Health Administration: The Case of Readmissions’, Medical Care, 51(1), pp. 37–44. Available at: https://doi.org/10.1097/MLR.0b013e318270c0f7.

Rosenberg, A. et al. (2015) ‘Early Trends Among Seven Recommendations From the Choosing Wisely Campaign’, JAMA internal medicine, 175(12), pp. 1913–1920. Available at: https://doi.org/10.1001/jamainternmed.2015.5441.

Roth, J. (2019) Pre-test with Caution: Event-study Estimates After Testing for Parallel Trends. Harvard University. Available at: https://scholar.harvard.edu/files/jroth/files/roth_pretrends_20190730.pdf (Accessed: 29 May 2023).

Ryan, J., Piercy, J. and James, P. (2004) ‘Assessment of NICE guidance on two surgical procedures’, The Lancet, 363(9420), pp. 1525–1526. Available at: https://doi.org/10.1016/S0140-6736(04)16180-1.

Salomon, B. et al. (2021) ‘Hospital Length of Stay Is Associated With Increased Likelihood for Venous Thromboembolism After Total Joint Arthroplasty’, Arthroplasty Today, 8, pp. 254-257.e1. Available at: https://doi.org/10.1016/j.artd.2020.12.025.

Santos, R., Gravelle, H. and Propper, C. (2017) ‘Does Quality Affect Patients’ Choice of Doctor? Evidence from England’, The Economic Journal, 127(600), pp. 445–494. Available at: https://doi.org/10.1111/ecoj.12282.

Sargan, J.D. (1988) ‘Estimating using instrumental variables’, Contributions to econometrics, 1(1), p. 213.

Savva, N., Tezcan, T. and Yıldız, Ö. (2019) ‘Can yardstick competition reduce waiting times?’, Management Science, 65(7), pp. 3196–3215.

Schneider, E. et al. (2017) Mirror, Mirror 2017: International Comparison Reflects Flaws and Opportunities for Better U.S. Health Care. Available at: https://www.commonwealthfund.org/publications/fund-reports/2017/jul/mirror-mirror-2017-international-comparison-reflects-flaws-and (Accessed: 1 May 2023).

Schuster, K.M. et al. (2021) ‘Association of Acute Care Surgeon Experience With Emergency Surgery Patient Outcomes and Mortality’, JAMA surgery, 156(5), pp. 472–478. Available at: https://doi.org/10.1001/jamasurg.2021.0041.

Scott, I.A. and Duckett, S.J. (2015) 'In search of professional consensus in defining and reducing low-value care', The Medical Journal of Australia, 203(4), pp. 179–181. Available at: https://doi.org/10.5694/mja14.01664.

SCTS (2023) Society for Cardiothoracic Surgery in Great Britain and Ireland (SCTS) registry. Available at: https://scts.org/ (Accessed: 31 March 2023).

Shalchi, Z. et al. (2009) 'Factors influencing hospital readmission rates after acute medical treatment', Clinical Medicine, 9(5), pp. 426–430. Available at: https://doi.org/10.7861/clinmedicine.9-5-426.

Shen, Y.-C. (2002) 'The effect of hospital ownership choice on patient outcomes after treatment for acute myocardial infarction', Journal of Health Economics, 21(5), pp. 901–922. Available at: https://doi.org/10.1016/S0167-6296(02)00058-9.

Shore-Sheppard, L. (2005) Stemming the tide? The effect of expanding Medicaid eligibility on health insurance. National Bureau of Economic Research Cambridge, Mass., USA.

Shrank, W.H., Rogstad, T.L. and Parekh, N. (2019) 'Waste in the US Health Care System: Estimated Costs and Potential for Savings', JAMA, 322(15), pp. 1501–1509. Available at: https://doi.org/10.1001/jama.2019.13978.

Siciliani, L., Sivey, P. and Street, A. (2013) 'Differences in Length of Stay for Hip Replacement Between Public Hospitals, Specialised Treatment Centres and Private Providers: Selection or Efficiency?', Health Economics, 22(2), pp. 234–242. Available at: https://doi.org/10.1002/hec.1826.

Singh, J.A. and Lewallen, D.G. (2012) 'Ninety-day Mortality in Patients Undergoing Elective Total Hip or Total Knee Arthroplasty', The Journal of arthroplasty, 27(8), pp. 1417-1422.e1. Available at: https://doi.org/10.1016/j.arth.2012.03.008.

Siskou, O. et al. (2008) 'Private health expenditure in the Greek health care system: Where truth ends and the myth begins', Health Policy, 88(2), pp. 282–293. Available at: https://doi.org/10.1016/j.healthpol.2008.03.016.

Skellern, M. (2017) 'The hospital as a multi-product firm: The effect of hospital competition on value-added indicators of clinical quality'. CEP Discussion Paper. CEP, LSE. Available at: https://ideas.repec.org/p/cep/cepdps/dp1484.html (Accessed 10 May 2023)

Sloan, F.A. et al. (2001) ‘Hospital ownership and cost and quality of care: is there a dime’s worth of difference?’, Journal of Health Economics, 20(1), pp. 1–21. Available at: https://doi.org/10.1016/S0167-6296(00)00066-7.

Smith, J., Walshe, K. and Hunter, D.J. (2001) ‘The “redisorganisation” of the NHS’, *BMJl*, 323(7324), pp. 1262–1263.

Sommers, A. et al. (2007) ‘Substitution Of SCHIP For Private Coverage: Results From A 2002 Evaluation In Ten States’, Health Affairs, 26(2), pp. 529–537. Available at: https://doi.org/10.1377/hlthaff.26.2.529.

Sommersguter-Reichmann, M. and Stepan, A. (2015) ‘The interplay between regulation and efficiency: Evidence from the Austrian hospital inpatient sector’, Socio-Economic Planning Sciences, 52, pp. 10–21. Available at: https://doi.org/10.1016/j.seps.2015.09.001.

Souliotis, K. et al. (2016) ‘Informal payments in the Greek health sector amid the financial crisis: old habits die last...’, The European Journal of Health Economics, 17(2), pp. 159–170. Available at: https://doi.org/10.1007/s10198-015-0666-0.

Srikanth, V.K. et al. (2005) ‘A meta-analysis of sex differences prevalence, incidence and severity of osteoarthritis’, Osteoarthritis and Cartilage, 13(9), pp. 769–781. Available at: https://doi.org/10.1016/j.joca.2005.04.014.

Sripa, P. et al. (2019) ‘Impact of GP gatekeeping on quality of care, and health outcomes, use, and expenditure: a systematic review’, The British Journal of General Practice, 69(682), pp. e294–e303. Available at: https://doi.org/10.3399/bjgp19X702209.

Stewart, K., Bray, B. and Buckingham, R. (2016) ‘Improving quality of care through national clinical audit’, Future Hospital Journal, 3(3), pp. 203–206. Available at: https://doi.org/10.7861/futurehosp.3-3-203.

Stewart, S. et al. (2021) ‘Epidemiology of healthcare-associated infection reported from a hospital-wide incidence study: considerations for infection prevention and control planning’, Journal of Hospital Infection, 114, pp. 10–22. Available at: https://doi.org/10.1016/j.jhin.2021.03.031.

Stock, J.H. and Yogo, M. (2005) ‘Testing for weak instruments in linear IV regression. Chapter 5 in Identification and Inference in Econometric Models: Essays in Honor of Thomas

J. Rothenberg, edited by DWK Andrews and JH Stock', Rothenberg, edited by DWK Andrews and JH Stock.

Stoye, G. (2019) 'Recent trends in independent sector provision of NHS-funded elective hospital care in England'. Institute of Fiscal Studies. Available at: https://www.ifs.org.uk/publications/14593 (Accessed: 30 May 2023).

Street, A. et al. (2010) 'Are English treatment centres treating less complex patients?', Health Policy, 94(2), pp. 150–157. Available at: https://doi.org/10.1016/j.healthpol.2009.09.013.

Suleman, M. et al. (2010) 'Exploring the variation in paediatric tonsillectomy rates between English regions: a 5-year NHS and independent sector data analysis', Clinical Otolaryngology, 35(2), pp. 111–117. Available at: https://doi.org/10.1111/j.1749-4486.2010.02086.x.

Syed, Z.A. et al. (2015) 'Cataract surgery outcomes at a UK independent sector treatment centre', British Journal of Ophthalmology, 99(11), pp. 1460–1465. Available at: https://doi.org/10.1136/bjophthalmol-2014-306586.

Sypes, E.E., de Grood, C., Whalen-Browne, L., et al. (2020) 'Engaging patients in de-implementation interventions to reduce low-value clinical care: a systematic review and meta-analysis', BMC Medicine, 18(1), p. 116. Available at: https://doi.org/10.1186/s12916-020-01567-0.

Sypes, E.E., de Grood, C., Clement, F.M., et al. (2020) 'Understanding the public's role in reducing low-value care: a scoping review', Implementation Science, 15(1), p. 20. Available at: https://doi.org/10.1186/s13012-020-00986-0.

Taylor, A. et al. (2016) 'How is feedback from national clinical audits used? Views from English National Health Service trust audit leads', Journal of Health Services Research & Policy, 21(2), pp. 91–100. Available at: https://doi.org/10.1177/1355819615612826.

Thornhill, M.H. et al. (2011) 'Impact of the NICE guideline recommending cessation of antibiotic prophylaxis for prevention of infective endocarditis: before and after study', BMJ, 342. Available at: https://doi.org/10.1136/bmj.d2392.

Thorpe, K.E. and Florence, C.S. (1998) 'Health insurance among children: the role of expanded Medicaid coverage', Inquiry: A Journal of Medical Care Organization, Provision and Financing, 35(4), pp. 369–379.

Tiemann, O. and Schreyögg, J. (2009) ‘Effects of Ownership on Hospital Efficiency in Germany’, Business Research, 2(2), pp. 115–145. Available at: https://doi.org/10.1007/BF03342707.

Tiemann, O. and Schreyögg, J. (2012) ‘Changes in hospital efficiency after privatization’, Health Care Management Science, 15(4), pp. 310–326. Available at: https://doi.org/10.1007/s10729-012-9193-z.

Timmins, N. (2005) ‘Challenges of private provision in the NHS’, BMJ : British Medical Journal, 331(7526), pp. 1193–1195.

Tountas, Y. et al. (2011) ‘Sociodemographic and socioeconomic determinants of health services utilization in Greece: the Hellas Health I study’, Health Services Management Research, 24(1), pp. 8–18. Available at: https://doi.org/10.1258/hsmr.2010.010009.

Townsend, T. (2021) ‘Private Acute Healthcare Central London Market Report 7ed’. LaingBuisson. Available at: https://www.laingbuisson.com/shop/private-acute-healthcare-central-london-market-report-7ed/ (Accessed: 6 March 2023).

UK Government (1990) National Health Service and Community Care Act 1990. Available at: https://www.legislation.gov.uk/ukpga/1990/19/contents (Accessed: 07 June 2023)

UK Government (2012) Health and Social Care Act 2012. Available at: https://www.legislation.gov.uk/ukpga/2012/7#:~:text=An%20Act%20to%20establish%20and,regulating%20health%20and%20adult%20social (Accessed: 07 June 2023)

UK Government (2020) English indices of deprivation. Available at: https://www.gov.uk/government/collections/english-indices-of-deprivation (Accessed: 17 February 2023).

UK Government (2022) Health and Care Act 2022. Available at: https://bills.parliament.uk/bills/3022 (Accessed: 07 June 2023)

Walshe, K. (2018) ‘Gosport deaths: lethal failures in care will happen again’, BMJ, 362. Available at: https://doi.org/10.1136/bmj.k2931.

Walshe, K. and Offen, N. (2001) ‘A very public failure: lessons for quality improvement in healthcare organisations from the Bristol Royal Infirmary’, BMJ Quality & Safety, 10(4), pp. 250–256. Available at: https://doi.org/10.1136/qhc.0100250.

Walshe, K. and Shortell, S.M. (2004) ‘When things go wrong: how health care organizations deal with major failures’, Health Affairs (Project Hope), 23(3), pp. 103–111. Available at: https://doi.org/10.1377/hlthaff.23.3.103.

Walshe, K. et al. (2004) ‘Primary care trusts’, The BMJ, 329(7471), pp. 871–872.

Wáng, Y.X.J., Wáng, J.-Q. and Káplár, Z. (2016) ‘Increased low back pain prevalence in females than in males after menopause age: evidences based on synthetic literature review’, Quantitative Imaging in Medicine and Surgery, 6(2), pp. 199–206. Available at: https://doi.org/10.21037/qims.2016.04.06.

Wanless, D. (2002) Securing our Future Health: Taking a Long-Term View. HM Treasury, p. 179.

Wassel, C.L. et al. (2020) ‘Risk of readmissions, mortality, and hospital-acquired conditions across hospital-acquired pressure injury (HAPI) stages in a US National Hospital Discharge database’, International Wound Journal, 17(6), pp. 1924–1934. Available at: https://doi.org/10.1111/iwj.13482.

Welk, B. et al. (2018) ‘The Impact of the Choosing Wisely Campaign in Urology’, Urology, 116, pp. 81–86. Available at: https://doi.org/10.1016/j.urology.2018.03.005.

Wenzel L, and Robertson R (2019) What is commissioning and how is it changing? The King’s Fund. Available at: https://www.kingsfund.org.uk/publications/what-commissioning-and-how-it-changing (Accessed: 7 June 2023)

Wertheimer, B. et al. (2014) ‘Discharge before noon: an achievable hospital goal’, Journal of Hospital Medicine, 9(4), pp. 210–214. Available at: https://doi.org/10.1002/jhm.2154.

WHO (2006) ‘Quality of care: a process for making strategic choices in health systems’. Available at: https://apps.who.int/iris/handle/10665/43470 (Accessed 30 May 2023)

Williams, B. et al. (2000) ‘Patients and procedures in short-stay independent hospitals in England and Wales, 1997-1998’, Journal of Public Health Medicine, 22(1), pp. 68–73. Available at: https://doi.org/10.1093/pubmed/22.1.68.

Williams, B. et al. (2001) ‘Impact of private funding on access to elective hospital treatment in the regions of England and Wales. National records survey’, European Journal of Public Health, 11(4), pp. 402–406. Available at: https://doi.org/10.1093/eurpub/11.4.402.

Williams, B., Whatmough, P. and Pearson, J. (2001) ‘Emergency transfer from independent hospitals to NHS hospitals: risk, reasons and cost’, Journal of Public Health Medicine, 23(4), pp. 301–305. Available at: https://doi.org/10.1093/pubmed/23.4.301.

Wooldridge, J.M. (2002) ‘Inverse probability weighted M-estimators for sample selection, attrition, and stratification’, Portuguese Economic Journal, 1(2), pp. 117–139. Available at: https://doi.org/10.1007/s10258-002-0008-x.

Wu, J. et al. (2020) ‘Impact of NPS MedicineWise general practitioner education programs and Choosing Wisely Australia recommendations on prescribing of proton pump inhibitors in Australia’, BMC Family Practice, 21(1), p. 85. Available at: https://doi.org/10.1186/s12875-020-01158-1.

Yazici, E.Y. and Kaestner, R. (2003) ‘Medicaid expansions and the crowding out of private health insurance among children’, Inquiry: A Journal of Medical Care Organization, Provision and Financing, 37(1), pp. 23–32.

Yi, D., Pugh, E. and Farrar, S. (2007) ‘The Effect of Payment By Results on the HRG Creep in English Hospitals: An Empirical Investigation’. iHEA 2007 6th World Congress: Explorations in Health Economics Paper. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=993390 (Accessed: 30 March 2023).

Zambrana-García, J.L. et al. (2017) ‘Impact of a do-not-do intervention on 12 laboratory measurements’, Revista Clínica Española (English Edition), 217(8), pp. 454–459. Available at: https://doi.org/10.1016/j.rceng.2017.09.002.

7. Appendix A: Supplementary Material to Introduction

Table 1: Performance Measures recommended by the Competition and Market's Authority (CMA) in 2014 versus Performance Measures reported by the Private Healthcare Information Network (PHIN) in 2020

Metrics recommended by the CMA (2014) *	Progress	Current Metrics (2020)
Volumes of procedures undertaken	Delivered	Patient Numbers: Patients admitted to hospital, and number of procedures undertaken (consultant level)
Average lengths of stay for each procedure	Delivered in part	Length of Stay: Percentage of operations performed as a day case (hospital and consultant level), and average night's stay for their treatment (procedural level)
Infection rates (with separate figures for surgical-acquired and facility-acquired infection rates)	Delivered	Healthcare-Associated Infections: Total number of infections reported across all procedures (hospital level) Surgical Site Infections: Total number of infections reported across 'eligible' procedures (hospital level)
Readmission rates	Not Delivered	
Revision surgery rates	Not Delivered	
Mortality rates	Not Delivered	
Unplanned patient transfers (from either the private healthcare facility or private patient unit to a facility of one of the national health services)	Not Delivered	
A measure, as agreed by the information organisation and its members, of patient feedback and/or satisfaction	Delivered	Patient Satisfaction: % of patients likely to recommend this hospital using the Friends and Family Test (hospital level) Patient Experience: Composite score based on six questions patients are asked (hospital level)
Relevant information, as agreed by the information organisation and its members and, where available, from the clinical registries and audits	Not Delivered	
Procedure-specific measures of improvement in health outcomes, as agreed by the information organisation and its members to be appropriate	Delivered	Patient-reported Outcomes: Only available for certain procedures (procedural level)
Frequency of adverse events, as agreed by the information organisation and its members to be appropriate	Not Delivered	

* The CMA recommended each metric was reported at both hospital and consultant level

8. Appendix B: Supplementary Material to Chapter 1

Table 1: Procedure and diagnosis codes for phase one of the EBI programme (Treatment Group)

Procedure		OPCS codes	Diagnostic codes
A	Intervention for snoring (not OSA)	F324, F325, F326, Y114, F328	G473*
B	Dilatation & curettage for heavy menstrual bleeding	Q103, Y113	O00-O08*, O60-O69*, O70-O75*,N92, N95
C	Knee arthroscopy with osteoarthritis	W821 , W822, W823, W828, W829, W851, W852, W853, W858, W859, W831, W832, W833, W834, W835, W836, W837, W838, W839, W841, W842, W843, W844, W861, W879, W901	M150, M151, M152, M153, M154, M158, M159, M170, M171, M172, M173, M174, M175, M179
D	Injection for nonspecific low back pain without sciatica	A521 , A522 , A528 , A529 , A577 , A735 , V544 , Z676, Z675, Z993	M518 , M519 , M545 , M549
E	Breast reduction	B311	Z853*, D051*, D059*, D486*
G	Grommets	D151, D289	H652, H653, H661, H662, H663 , H664, H669
H	Tonsillectomy	F341, F342, F343, F344, F345, F346, F347, F348, F349, F361	G470, G471, G472, G473, G474, G478, G479, J36X
I	Haemorrhoid surgery	H511, H512, H513, H518, H519	
J	Hysterectomy for heavy bleeding	Q072, Q074, Q078, Q079, Q082, Q088, Q089	O00-O08*, O60-O69*, O70-O75*
K	Chalazia removal	C121, C122, C124, C191, C198	H001
L	Shoulder decompression	O291	M2551, M754
M	Carpal tunnel syndrome release	A651, A659	G560
N	Dupuytren's contracture release	T521, T522, T525, T526, T541, T561	M720
O	Ganglion excision	T591, T592, T598, T599, T601, T602, T608, T609	M674
P	Trigger finger release	T691, T692, T698, T699, T701, T702, T711 , T718, T719, T723, T728, T729, Z894, Z895, Z896, Z897	M653, M6530, M6531, M6532, M6533, M6534, M6535, M6536, M6537, M6538, M6539
Q	Varicose vein surgery	L832 , L838 , L839 , L841 , L842 , L843 , L844 , L845 , L846 , L848 , L849 , L851 , L852 , L853 , L858 , L859 , L861 , L862 , L868 , L869 , L871 , L872 , L873 , L874 , L875 , L876 , L877 , L878 , L879 , L881 , L882 , L883 , L888 , L889	I800 , I801 , I802 , I803 , I808 , I809 , I830 , I831 , I832 , I839

*Exclude records whereby primary diagnosis code contains this ICD-10 code

Table 2: Procedure and diagnosis codes for phase two of the EBI programme (Control Group)

	Procedure	OPCS codes	Diagnostic codes
2B	Hernia repair	T20.1, T20.2, T20.3, T20.4 T20.8, T20.9	K40.2, K40.9
2C	Sinus surgery	Y76.1, Y76.2, E12.1, E12.2, E12.3, E12.4, E12.8, E12.9, E13.1, E13.2, E13.3, E13.4, E13.5, E13.6, E13.7, E13.8, E13.9, E14.1, E14.2, E14.3, E14.4, E14.5, E14.6, E14.7, E14.8, E14.9, E15.1, E15.2, E15.3, E15.4, E15.8, E15.9, E16.1, E16.2, E16.8, E16.9, E17.1, E17.2, E17.3, E17.4, E17.8, E17.9, E08.1	J32.0, J32.1, J32.2, J32.3, J32.4, J32.8, J32.9
2G	Kidney stone surgery	M09.4, M09.8, M16.4, M26.1, M26.2, M26.3, M27.1, M27.2, M27.3, M27.8, M28.1, M28.2, M28.3, M28.4, M28.5, M28.8, M28.9	N20.0, N20.1, N20.2, N20.9
2I	Benign prostatic hypertrophy surgery	M61.1, M61.2, M61.3, M61.4, M61.8, M61.9, M64.1, M65.1, M65.2, M65.3, M65.4, M65.5, M65.8, M65.9, M66.1, M66.2, M68.1, M68.3	N40

Table 3: Procedures under phase one and two of the NHS England Evidence-Based Interventions Programme

First phase of EBI programme	Second phase of EBI programme
Category 1 Interventions	Category A Interventions
Intervention for snoring (not OSA) Dilatation & curettage for heavy menstrual bleeding Knee arthroscopy with osteoarthritis Injection for nonspecific low back pain without sciatica	Diagnostic angiogram Repair of minimally symptomatic inguinal hernia Surgical intervention for chronic rhinosinusitis Adjuvant adenoidectomy for treatment of glue ear Arthroscopic surgery for meniscal tears Kidney Stone surgery Cystoscopy for men with uncomplicated lower urinary tract symptoms (LUTS) Surgical intervention for Benign Prostatic Hypertrophy (BPH) Lumbar Discectomy Radiofrequency facet joint denervation Exercise electrocardiogram (ECG) Upper gastrointestinal endoscopy
Category 2 Interventions	Category B Interventions
Breast reduction Removal of benign skin lesions Grommets Tonsillectomy Haemorrhoid surgery Hysterectomy for heavy bleeding Chalazia removal Shoulder decompression Carpal tunnel syndrome release Dupuytren's contracture release Ganglion excision Trigger finger release Varicose vein surgery	Colonoscopy in the management of hereditary colorectal cancer Repeat colonoscopy ERCP in acute gallstone pancreatitis without cholangitis Cholecystectomy Appendicectomy without confirmation of appendicitis Low back pain imaging Knee MRI when symptoms are suggestive of osteoarthritis Knee MRI for suspected meniscal tears Vertebral augmentation for painful osteoporotic vertebral fractures Scans for Shoulder Pain and Guided Injections MRI scan of the hip for arthritis Fusion surgery for mechanical axial low back pain
	Category C Interventions
	Helmet therapy for treatment of positional plagiocephaly/brachycephaly in children Pre-operative chest x-ray Pre-operative ECG Prostate-specific antigen (PSA) test Liver function, creatinine kinase and lipid level tests Blood transfusion

Source: NHS England Evidence-Based Interventions Programme(NHS England, 2018b; Academy of Medical Royal Colleges, 2020)

*Table 4: Cost per procedure and financial opportunity if activity achieved from baseline**

Intervention	Baseline FY 2017/18	Cost per procedure	Proposed Goal	Total financial opportunity (if goal activity achieved from baseline)
A Surgery for snoring without obstructive sleep apnoea	827	£ 973	0	£ 804,671.00
B D&C for heavy menstrual bleeding	231	£ 985	0	£ 227,535.00
C Knee arthroscopy with osteoarthritis	4,943	£ 2,682	0	£ 13,257,126.00
D Injections for nonspecific lower back pain without sciatica	19,444	£ 589	0	£ 11,452,516.00
Cat 1 total	25,445		0	
E Breast reduction	988	£ 2,701	391	£ 1,613,277.36
F Removal of benign skin lesions	99,475	£ 626	61,720	£ 23,634,905.96
G Grommets	8,661	£ 727	5,415	£ 2,360,066.69
H Tonsillectomy	32,198	£ 1,172	24,951	£ 8,493,145.65
I Haemorrhoid surgery	8,517	£ 1,018	5,775	£ 2,791,399.99
J Hysterectomy for heavy menstrual bleeding	18,523	£ 2,941	14,068	£ 13,101,655.67
K Chalazia removal	6,007	£ 528	1,630	£ 2,311,318.67
L Shoulder decompression	13,647	£ 3,311	6,941	£ 22,203,480.15
M Carpal tunnel syndrome release	43,856	£ 1,204	28,902	£ 18,004,405.88
N Dupuytren's contracture release	14,938	£ 2,613	10,264	£ 12,213,245.57
O Ganglion excision	6,222	£ 1,212	3,641	£ 3,128,749.70
P Trigger finger release	7,768	£ 1,231	5,102	£ 3,281,592.07
Q Varicose vein surgery	28,776	£ 1,051	20,363	£ 8,842,041.84
Cat 2 total	289,576		189,162	
Cat 1 & 2 total	315,021		189,162	

Source: Provided by NHS England Evidence-Based Interventions Team

Figure 10: Trends in EBI treatment and control group procedures (treatment group includes only low cost procedures)

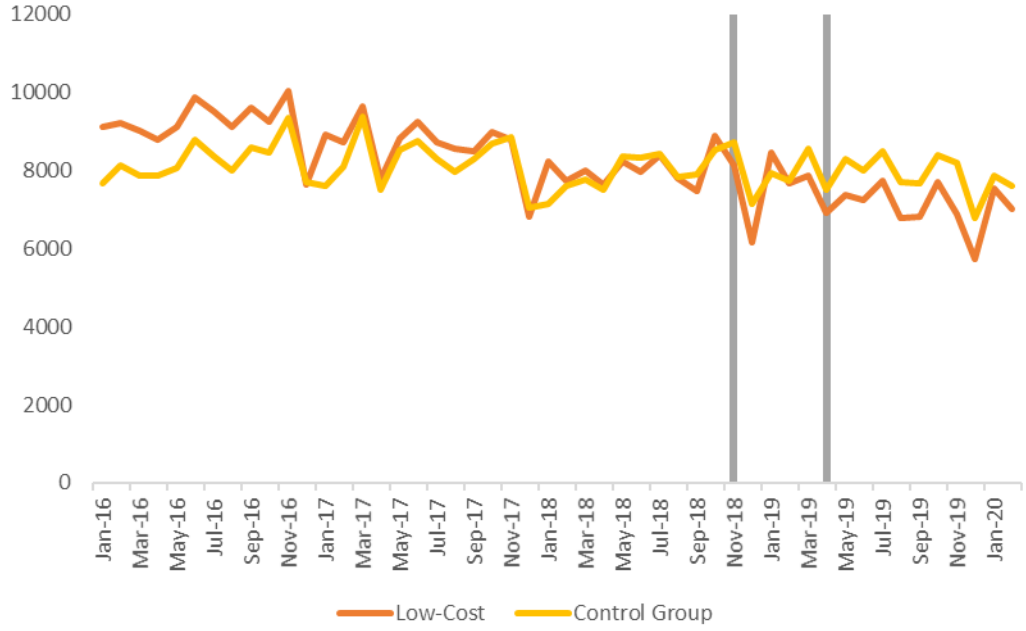


Figure 2: Trends in EBI treatment and control group procedures (treatment group includes only high cost procedures)

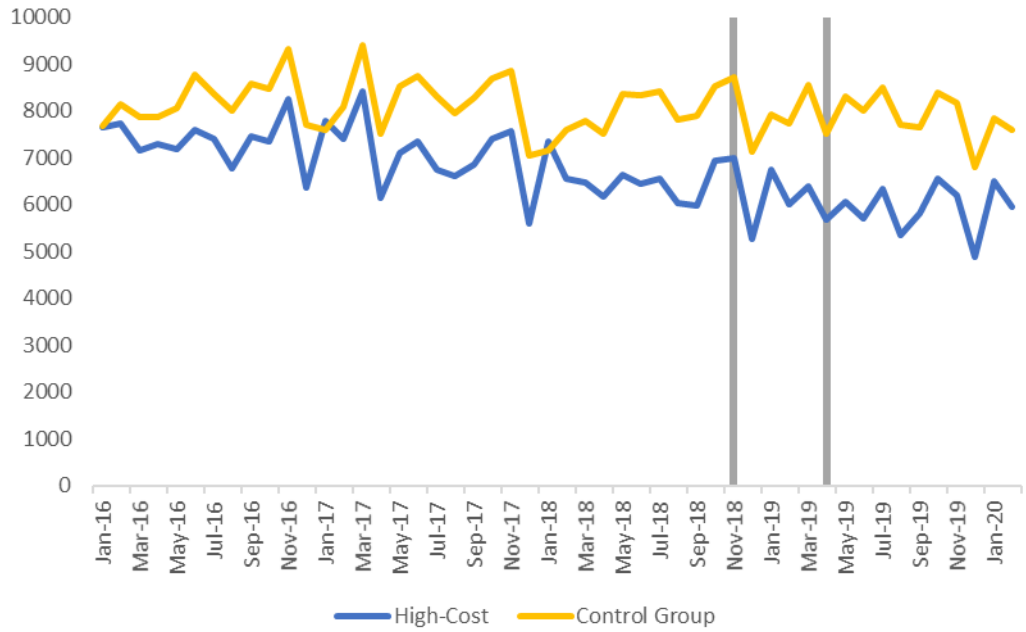


Figure 3: Trends in EBI treatment and control group procedures (treatment group includes all phase one Category 2 procedures including removal of benign skin lesions)

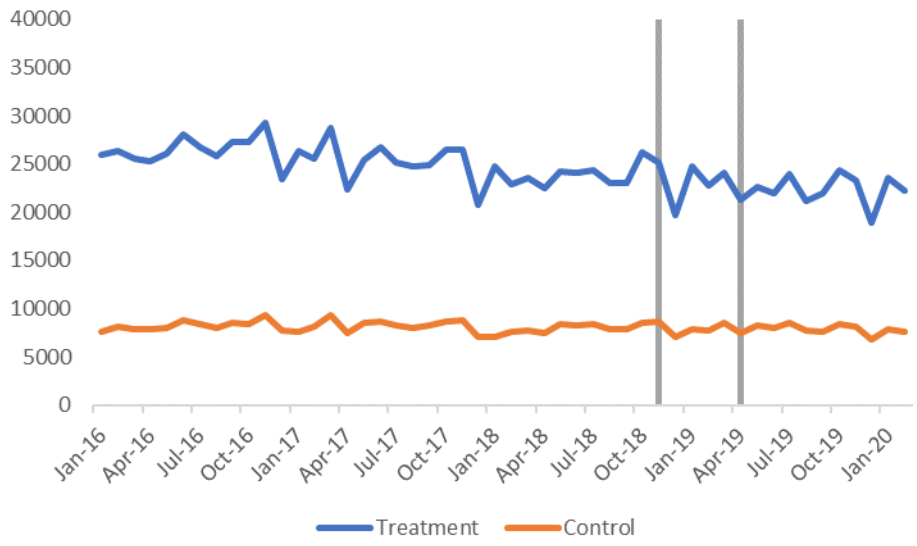


Figure 4: Trends in EBI treatment and control group procedures (treatment group includes all phase one Category 1 and 2 procedures with the exception of removal of benign skin lesions)

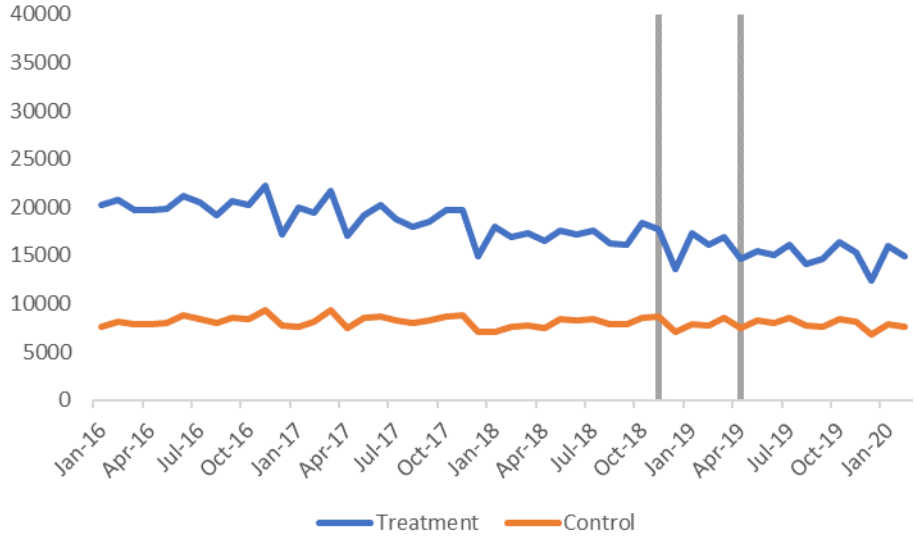


*Table 5a: Descriptive Statistics of Patient Characteristics for Phase One and Phase Two Procedures (Mean and 95% CI)**

	Gender (Female=1)			Age		
	Before EBI	After EBI	Difference	Before EBI	After EBI	Difference
Phase One Procedures (Treatment)						
Category 1	0.62 (0.62, 0.63)	0.62 (0.61, 0.63)	-0.01 (-0.02, 0.00)	65.59 (65.47, 65.72)	67.01 (66.68, 67.34)	1.42 (1.07, 1.77)
Category 2	0.60 (0.60, 0.60)	0.60 (0.60, 0.60)	0.00 (-0.00, 0.00)	57.56 (57.51, 57.62)	58.61 (58.50, 58.72)	1.05 (0.92, 1.17)
Phase Two Procedures (Control)						
Total	0.15 (0.15, 0.15)	0.15 (0.15, 0.15)	0.00 (0.00, 0.01)	67.14 (67.07, 67.21)	67.92 (67.79, 68.06)	0.79 (0.64, 0.94)

*Before the implementation of EBI covers the period Jan 1st 2016-March 31st 2019, and after EBI covers the period April 1st 2019-Feb 28th 2020

*Table 5b: Descriptive Statistics of Patient Characteristics for Phase One and Phase Two Procedures (Mean and 95% CI)**

	IMD Score			Charlson		
	Before EBI	Before EBI	Difference	Before EBI	After EBI	Difference
Phase One Procedures (Treatment)						
Category 1	22.23 (22.12, 22.33)	21.96 (21.70-22.21)	-0.27 (-0.55, 0.01)	0.39 (0.39, 0.40)	0.48 (0.46, 0.49)	0.09 (0.07, 0.10)
Category 2	22.08 (22.04, 22.12)	21.96 (21.89, 22.04)	-0.11 (-0.20, -0.03)	0.28 (0.28, 0.29)	0.32 (0.32, 0.33)	0.04 (0.04, 0.04)
Phase Two Procedures (Control)						
Total	20.42 (20.37, 20.26)	20.35 (20.25, 20.45)	0.07 (-0.18, 0.04)	0.43 (0.43, 0.43)	0.48 (0.48, 0.49)	0.05 (0.05, 0.06)

*Before the implementation of EBI covers the period Jan 1st 2016-March 31st 2019, and after EBI covers the period April 1st 2019-Feb 28th 2020

*Table 6: Number of Procedures for Clinical Commissioning Group and Hospital Characteristics for Phase One and Phase Two of the EBI programme **

	CCG Deficit (FY 2018/19)		CCG Demonstrator		NHS vs ISP Hospital	
Number of CCGs or Hospitals						
	Yes	No	Yes	No	NHS	ISP
	38 (28.1%)	97 (71.9%)	48 (35.6%)	87 (64.4%)	162 (41.8%)	226 (58.2%)
Number of Low value Procedures						
Phase 1 Procedures (Treatment)						
Category 1	41,344 (41.9%)	57,293 (58.1%)	30,630 (31.1%)	68,007 (68.9%)	82,178 (83.0%)	16,814 (17.0%)
Category 2	289,676 (37.0%)	494,181 (63.0%)	283,973 (36.2%)	499,884 (63.8%)	644,776 (81.8%)	143,567 (18.2%)
Total	331,020 (37.5%)	551,474 (62.5%)	314,603 (35.6%)	567,891 (64.4%)	726,954 (81.9%)	160,381 (18.1%)
Phase 2 Procedures (Control)						
Total	160,701 (39.0%)	251,288 (61.0%)	144,901 (35.6%)	267,088 (64.8%)	321,159 (79.5%)	82,720 (20.5%)

*Percentage in parentheses indicates the proportion of low value procedures undertaken between January 1st 2016 and February 28th 2020. This table was created by the co-authors of this manuscript.

Table 7: Difference-in-Difference Analysis Results Table for Treatment Group that includes all phase one Category 2 procedures including removal of benign skin lesions (%)

	Model 1 (Standard DiD)	Model 2 (Standard DiD)	Model 3 (High Cost Procedures)	Model 4 (Low Cost Procedures)	Model 5 (Time Trend Analysis)	Model 6 (Combination)
Phase1	0.38*** (0.37,0.39)	0.38*** (0.37,0.39)	0.51*** (0.50,0.53)	0.92*** (0.89,0.94)	0.37*** (0.36,0.38)	0.37*** (0.36,0.38)
EBI	-8.46*** (-9.43,-7.49)	-9.34*** (-10.74,-7.94)	-6.04*** (-7.56,-4.53)	-11.21*** (-13.00,-9.42)	-	-4.25*** (-6.30,-2.20)
EBI x Phase1	0.04*** (0.04,0.05)	0.04*** (0.04,0.05)	0.03*** (0.03,0.04)	0.18*** (0.16,0.19)	-	0.02*** (0.01,0.03)
t	-	-	-	-	-0.19*** (-0.29,-0.09)	-0.15** (-0.26,-0.05)
t ≥ EBI	-	-	-	-	-0.61*** (-0.87,-0.35)	-0.21 (-0.53,0.11)
t x Phase1	-	-	-	-	0.00*** (0.00,0.00)	0.00*** (0.00,0.00)
t ≥ EBI x Phase1	-	-	-	-	0.00** (0.00,0.00)	0.00 (-0.00,0.00)
Year Dummies	No	Yes	Yes	Yes	Yes	Yes
Month Dummies	No	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes	Yes
Constant	4.56*** (4.54,4.58)	4.36*** (4.25,4.47)	4.10*** (3.99,4.22)	3.85*** (3.75,3.96)	4.39*** (4.27,4.50)	4.38*** (4.27,4.50)
Observations	6750	6750	6750	6750	6750	6750
Units of Observation	135 CCGs	135 CCGs	135 CCGs	135 CCGs	135 CCGs	135 CCGs

Coefficients are reported as percentages, and can be understood as follows*: Phase1 is the* percentage difference in change in volumes between the treatment and control group. *EBI* is the percentage difference in volumes for all procedures before and after the implementation of the EBI programme. In Models 1-4, *EBI x Phase1* represents the treatment effect of the EBI programme and is the percentage difference in difference of volumes before and after implementation between the treatment and control group. In Model 6, *EBI x Phase1* is the percentage difference in changes in volumes between the treatment and control group during implementation of the EBI programme. *t* reflects monthly percentage change in volumes for all procedures. *t ≥ EBI* reflects the monthly percentage change in volumes for all procedures after the implementation of the EBI programme. *t ≥ EBI x Phase1* reflects the difference in differences in the monthly percentage change in volumes between the treatment and group control after the implementation of the EBI programme. 95% Confidence intervals are contained in parentheses, *** p<0.001, ** p<0.01, * p<0.05, - = Not applicable to this model, All models used fixed effects therefore errors are clustered at the CCG level. This table was created by the co-authors of this manuscript.

Table 8: Difference-in-Difference Analysis Results Table for Treatment Group that includes all phase one Category 1 and 2 procedures with the exception of removal of benign skin lesions (%)

	Model 1 (Standard DiD)	Model 2 (Standard DiD)	Model 3 (High Cost Procedures)	Model 4 (Low Cost Procedures)	Model 5 (Time Trend Analysis)	Model 6 (Combination)
Phase1	0.46*** (0.45,0.47)	0.46*** (0.45,0.47)	0.67*** (0.65,0.69)	0.68*** (0.66,0.70)	0.44*** (0.43,0.45)	0.44*** (0.43,0.45)
EBI	-15.06*** (-16.12,-14.00)	-15.43*** (-16.94,-13.92)	-13.53*** (-15.26,-11.80)	-15.34*** (-17.10,-13.58)	-	-5.97*** (-8.15,-3.79)
EBI x Phase1	0.11*** (0.10,0.12)	0.11*** (0.10,0.12)	0.19*** (0.17,0.21)	0.20*** (0.18,0.22)	-	0.05*** (0.04,0.06)
t	-	-	-	-	-0.40*** (-0.50,-0.30)	-0.35*** (-0.46,-0.24)
t ≥ EBI	-	-	-	-	-0.91*** (-1.19,-0.63)	-0.30 (-0.64,0.04)
t x Phase1	-	-	-	-	0.00*** (0.00,0.00)	0.00*** (0.00,0.00)
t ≥ EBI x Phase1	-	-	-	-	0.01*** (0.00,0.01)	0.00 (-0.00,0.00)
Year Dummies	No	Yes	Yes	Yes	Yes	Yes
Month Dummies	No	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes	Yes
Constant	4.43*** (4.41,4.44)	4.22*** (4.11,4.33)	3.93*** (3.81,4.05)	3.95*** (3.85,4.05)	4.27*** (4.16,4.38)	4.26*** (4.15,4.37)
Observations	6750	6750	6750	6750	6750	6750
Units of Observation	135 CCGs	135 CCGs	135 CCGs	135 CCGs	135 CCGs	135 CCGs

Coefficients are reported as percentages, and can be understood as follows*: Phase1 is the* percentage difference in change in volumes between the treatment and control group. *EBI* is the percentage difference in volumes for all procedures before and after the implementation of the EBI programme. In Models 1-4, *EBI x Phase1* represents the treatment effect of the EBI programme and is the percentage difference in difference of volumes before and after implementation between the treatment and control group. In Model 6, *EBI x Phase1* is the percentage difference in changes in volumes between the treatment and control group during implementation of the EBI programme. *t* reflects monthly percentage change in volumes for all procedures. $t \geq EBI$ reflects the monthly percentage change in volumes for all procedures after the implementation of the EBI programme. $t \geq EBI \times Phase1$ reflects the difference in differences in the monthly percentage change in volumes between the treatment and group control after the implementation of the EBI programme. 95% Confidence intervals are contained in parentheses, *** p<0.001, ** p<0.01, * p<0.05, - = Not applicable to this model, All models used fixed effects therefore errors are clustered at the CCG level. This table was created by the co-authors of this manuscript.

*Table 9: Difference-in-Difference Analysis Results Table for Original Treatment Group with Treatment Period Changed to November 2018 (%)**

	Model 1 (Standard DiD)	Model 2 (Standard DiD)	Model 3 (High Cost Procedures)	Model 4 (Low Cost Procedures)	Model 5 (Time Trend Analysis)	Model 6 (Combination)
Phase1	0.54*** (0.53,0.55)	0.55*** (0.54,0.56)	0.91*** (0.88,0.94)	0.91*** (0.88,0.93)	0.54*** (0.52,0.55)	0.54*** (0.52,0.55)
EBI	-10.71*** (-11.65,-9.77)	-13.75*** (-15.45,-12.05)	-11.58*** (-13.57,-9.59)	-12.54*** (-14.56,-10.52)	-	-6.22*** (-8.31,-4.13)
EBI x Phase1	0.09*** (0.08,0.10)	0.09*** (0.08,0.010)	0.13*** (0.12,0.15)	0.15*** (0.13,0.17)	-	0.02** (0.01,0.03)
t	-	-	-	-	-0.20*** (-0.31,-0.10)	-0.10 (-0.22,0.01)
t ≥ EBI	-	-	-	-	-0.76*** (-0.98,-0.54)	-0.70*** (-0.93,-0.47)
t x Phase1	-	-	-	-	0.00*** (0.00,0.00)	0.00*** (0.00,0.00)
t ≥ EBI x Phase1	-	-	-	-	0.00*** (0.00,0.01)	0.00*** (0.00,0.01)
Year Dummies	No	Yes	Yes	Yes	Yes	Yes
Month Dummies	No	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes	Yes
Constant	4.32*** (4.30,4.33)	4.19*** (4.08,4.30)	3.93*** (3.81,4.05)	3.87*** (3.76,3.97)	4.21*** (4.10,4.32)	4.22*** (4.10,4.33)
Observations	6750	6750	6750	6750	6750	6750
Units of Observation	135 CCGs	135 CCGs	135 CCGs	135 CCGs	135 CCGs	135 CCGs

Coefficients are reported as percentages, and can be understood as follows*: Phase1 is the* percentage difference in change in volumes between the treatment and control group. *EBI* is the percentage difference in volumes for all procedures before and after the implementation of the EBI programme. In Models 1-4, *EBI x Phase1* represents the treatment effect of the EBI programme and is the percentage difference in difference of volumes before and after implementation between the treatment and control group. In Model 6, *EBI x Phase1* is the percentage difference in changes in volumes between the treatment and control group during implementation of the EBI programme. *t* reflects monthly percentage change in volumes for all procedures. *t ≥ EBI* reflects the monthly percentage change in volumes for all procedures after the implementation of the EBI programme. *t ≥ EBI x Phase1* reflects the difference in differences in the monthly percentage change in volumes between the treatment and group control after the implementation of the EBI programme. 95% Confidence intervals are contained in parentheses, *** p<0.001, ** p<0.01, * p<0.05, - = Not applicable to this model, All models used fixed effects therefore errors are clustered at the CCG level. This table was created by the co-authors of this manuscript. *November 2018 is when the NHS England Evidence-Based Interventions Programme Statutory Guidance was published

Table 10: Triple Difference Estimation Results Table for Treatment Group that includes all phase one Category 2 procedures including removal of benign skin lesions (%)

	Model 1 (CCG Deficit)	Model 2 (CCG Demonstrator)	Model 3 (NHS hospitals)
Phase1	0.48*** (0.46,0.49)	0.39*** (0.38,0.40)	3.10*** (3.02,3.17)
EBI	-11.38*** (-12.94,-9.826)	-8.52*** (-10.09,-6.96)	-9.08*** (-11.78,-6.39)
EBI x Phase1	0.07*** (0.06,0.07)	0.03*** (0.03,0.04)	0.29*** (0.24,0.35)
EBI x X	3.19** (1.13,5.25)	-2.59* (-4.61,-0.56)	-2.75 (-6.57,1.08)
Phase1 x X	-0.21*** (-0.23,-0.20)	-0.02* (-0.04,-0.00)	-2.57*** (-2.65,-2.49)
EBI x Phase1 x X	-0.04*** (-0.05,-0.03)	0.02*** (0.01,0.03)	-0.23*** (-0.29,-0.17)
Constant	4.31*** (4.21,4.42)	4.36*** (4.24,4.47)	3.08*** (3.00,3.16)
Observations	6750	6750	16559
Unit of Observations	135 CCGs	135 CCGs	382 Hospitals

Coefficients are reported as percentages, and can be understood as follows: *Phase1 is the* percentage difference in change in volumes between the treatment and control group. *EBI* is the percentage difference in volumes for all procedures before and after the implementation of the EBI programme. *EBI x Phase1* is the percentage difference in difference of volumes before and after the implementation of the EBI programme between the treatment and control group. *EBI x X* is the average percentage difference in difference in volumes for all procedures before and after the implementation of the EBI programme between different organisational characteristics defined by *X*. *Phase1 x X* is average percentage difference in changes in volumes for the treatment group for different organisational characteristics defined by X. *EBI x Phase1 x X* is the average percentage difference in difference in volumes before and after the implementation of the EBI programme for the treatment group between different organisational characteristics defined by *X*. In Model 1, *X* is 1 for CCGs which posted in financial year 2018/19, and 0 for those which did not. In Model 2, *X* is 1 for CCGs which were part of the demonstrator community, and 0 for those which were not. In Model 3, *X* is 1 for NHS hospitals and 0 for independent sector providers. 95% Confidence intervals in parentheses, *** p<0.001, ** p<0.01, * p<0.05, All models used fixed effects therefore errors are clustered at the CCG or hospital level. This table was created by the co-authors of this manuscript.

Table 11: Triple Difference Estimation Results Table for Treatment Group that includes all phase one Category 1 and 2 procedures with the exception of removal of benign skin lesions (%)

	Model 1 (CCG Deficit)	Model 2 (CCG Demonstrator)	Model 3 (NHS hospitals)
Phase1	0.62*** (0.60,0.63)	0.45*** (0.44,0.47)	3.17*** (3.09,3.26)
EBI	-15.66*** (-17.31,-14.01)	-15.23*** (-16.96,-13.50)	-13.63*** (-16.52,-10.74)
EBI x Phase1	0.14*** (0.13,0.15)	0.11*** (0.10,0.12)	0.59*** (0.50,0.67)
EBI x X	2.64* (0.42,4.86)	-0.56 (-2.73,1.61)	-2.9 (-7.02,1.24)
Phase1 x X	-0.30*** (-0.32,-0.28)	0.01 (-0.01,0.03)	-2.45*** (-2.54,-2.36)
EBI x Phase1 x X	-0.07*** (-0.09,-0.05)	0.00 (-0.02,0.02)	-0.43*** (-0.52,-0.34)
Constant	4.19*** (4.09,4.29)	4.22*** (4.11,4.33)	2.97*** (2.88,3.05)
Observations	6750	6750	16559
Unit of Observations	135 CCGs	135 CCGs	382 Hospitals

Coefficients are reported as percentages, and can be understood as follows: *Phase1 is the* percentage difference in change in volumes between the treatment and control group. *EBI* is the percentage difference in volumes for all procedures before and after the implementation of the EBI programme. *EBI x Phase1* is the percentage difference in difference of volumes before and after the implementation of the EBI programme between the treatment and control group. *EBI x X* is the average percentage difference in difference in volumes for all procedures before and after the implementation of the EBI programme between different organisational characteristics defined by *X*. *Phase1 x X* is average percentage difference in changes in volumes for the treatment group for different organisational characteristics defined by X. *EBI x Phase1 x X* is the average percentage difference in difference in volumes before and after the implementation of the EBI programme for the treatment group between different organisational characteristics defined by *X*. In Model 1, *X* is 1 for CCGs which posted in financial year 2018/19, and 0 for those which did not. In Model 2, *X* is 1 for CCGs which were part of the demonstrator community, and 0 for those which were not. In Model 3, *X* is 1 for NHS hospitals and 0 for independent sector providers. 95% Confidence intervals in parentheses, *** p<0.001, ** p<0.01, * p<0.05, All models used fixed effects therefore errors are clustered at the CCG or hospital level. This table was created by the co-authors of this manuscript.

*Table 12: Triple Difference Estimation Results Table for Original Treatment Group with Treatment Period Changed to November 2018 (%)**

	Model 1 (CCG Deficit)	Model 2 (CCG Demonstrator)	Model 3 (NHS hospitals)
Phase1	0.68*** (0.66,0.70)	0.57*** (0.56,0.59)	3.87*** (3.77,3.97)
EBI	-14.11*** (-15.90,-12.32)	-13.31*** (-15.16,-11.47)	-6.03*** (-9.20,-2.85)
EBI x Phase1	0.11*** (0.10,0.12)	0.09*** (0.08,0.10)	0.34*** (0.27,0.42)
EBI x X	3.17** (1.15,5.18)	-1.16 (-3.08,0.76)	-4.02* (-7.65,-0.39)
Phase1 x X	-0.29*** (-0.31,-0.26)	-0.06*** (-0.08,-0.03)	-3.07*** (-3.18,-2.97)
EBI x Phase1 x X	-0.05*** (-0.07,-0.04)	-0.01 (-0.02,0.01)	-0.24*** (-0.32,-0.16)
Constant	4.15*** (4.05,4.26)	4.19*** (4.09,4.30)	2.84*** (2.75,2.92)
Observations	6750	6750	16559
Unit of Observations	135 CCGs	135 CCGs	382 Hospitals

Coefficients are reported as percentages, and can be understood as follows: *Phase1 is the* percentage difference in change in volumes between the treatment and control group. *EBI* is the percentage difference in volumes for all procedures before and after the implementation of the EBI programme. *EBI x Phase1* is the percentage difference in difference of volumes before and after the implementation of the EBI programme between the treatment and control group. *EBI x X* is the average percentage difference in difference in volumes for all procedures before and after the implementation of the EBI programme between different organisational characteristics defined by *X*. *Phase1 x X* is average percentage difference in changes in volumes for the treatment group for different organisational characteristics defined by X. *EBI x Phase1 x X* is the average percentage difference in difference in volumes before and after the implementation of the EBI programme for the treatment group between different organisational characteristics defined by *X*. In Model 1, *X* is 1 for CCGs which posted in financial year 2018/19, and 0 for those which did not. In Model 2, *X* is 1 for CCGs which were part of the demonstrator community, and 0 for those which were not. In Model 3, *X* is 1 for NHS hospitals and 0 for independent sector providers. 95% Confidence intervals in parentheses, *** p<0.001, ** p<0.01, * p<0.05, All models used fixed effects therefore errors are clustered at the CCG or hospital level. This table was created by the co-authors of this manuscript.

9. Appendix C: Supplementary Material to Chapter 2

Table 1: Procedure and diagnostic codes for Evidence-Based Interventions (EBI) procedures

Procedure	OPCS codes	Diagnostic codes
Intervention for snoring (not OSA)	F324, F325, F326, Y114, F328	G473*
Dilatation & curettage for heavy menstrual bleeding	Q103, Y113	O00-O08*, O60-O69*, O70-O75*,N92, N95
Knee arthroscopy with osteoarthritis	W821 , W822, W823, W828, W829, W851, W852, W853, W858, W859, W831, W832, W833, W834, W835, W836, W837, W838, W839, W841, W842, W843, W844, W861, W879, W901	M150, M151, M152, M153, M154, M158, M159, M170, M171, M172, M173, M174, M175, M179
Injection for nonspecific low back pain without sciatica	A521 , A522 , A528 , A529 , A577 , A735 , V544 , Z676, Z675, Z993	M518 , M519 , M545 , M549
Breast reduction	B311	Z853*, D051*, D059*, D486*
Grommets	D151, D289	H652, H653, H661, H662, H663 , H664, H669
Tonsillectomy	F341, F342, F343, F344, F345, F346, F347, F348, F349, F361	G470, G471, G472, G473, G474, G478, G479, J36X
Haemorrhoid surgery	H511, H512, H513, H518, H519	
Hysterectomy for heavy bleeding	Q072, Q074, Q078, Q079, Q082, Q088, Q089	O00-O08*, O60-O69*, O70-O75*
Chalazia removal	C121, C122, C124, C191, C198	H001
Shoulder decompression	O291	M2551, M754
Carpal tunnel syndrome release	A651, A659	G560
Dupuytren's contracture release	T521, T522, T525, T526, T541, T561	M720
Ganglion excision	T591, T592, T598, T599, T601, T602, T608, T609	M674
Trigger finger release	T691, T692, T698, T699, T701, T702, T711 , T718, T719, T723, T728, T729, Z894, Z895, Z896, Z897	M653, M6530, M6531, M6532, M6533, M6534, M6535, M6536, M6537, M6538, M6539
Varicose vein surgery	L832 , L838 , L839 , L841 , L842 , L843 , L844 , L845 , L846 , L848 , L849 , L851 , L852 , L853 , L858 , L859 , L861 , L862 , L868 , L869 , L871 , L872 , L873 , L874 , L875 , L876 , L877 , L878 , L879 , L881 , L882 , L883 , L888 , L889	I800 , I801 , I802 , I803 , I808 , I809 , I830 , I831 , I832 , I839

Source: NHS England(NHS England, 2018b) **Exclude records whereby primary diagnosis code contains this ICD-10 code*

Table 2: Privately funded Evidence-Based Interventions (EBI) procedures in private hospitals in before and after application of diagnostic code inclusion criteria [a]

	2017/18		2018/19		2019/20	
	Before	After	Before	After	Before	After
Category 1 Procedures						
Surgical intervention for snoring (not obstructive sleep apnoea)	67	47	52	35	58	45
Dilatation & curettage for heavy menstrual bleeding	65	60	65	57	79	75
Knee arthroscopy with osteoarthritis	18,734	220	17,276	339	17,223	424
Injection for nonspecific low back pain without sciatica	24,311	8,645	22,769	8,540	26,907	9,276
Total	43,177	8,972	40,162	8,971	44,267	9,820
Category 2 Procedures						
Breast reduction	2,801	2,630	2,879	2,701	3,068	2,852
Grommets	2,781	355	2,517	329	2,712	380
Tonsillectomy	4,717	4,051	4,794	3,945	5,079	4,007
Haemorrhoid surgery	1,483	1,399	1,411	1,356	1,418	1,359
Hysterectomy for heavy bleeding	3,350	2,910	3,321	2,820	3,387	2,906
Chalazia removal	966	134	982	137	1,101	206
Shoulder decompression	6,261	2,867	5,100	2,446	4,356	2,563
Carpal tunnel syndrome release	3,957	2,960	3,385	2,988	4,120	3,861
Dupuytren's contracture release	1,298	869	1,398	1,056	1,365	1,223
Ganglion excision	1,036	623	891	728	940	849
Trigger finger release	1,715	670	1,799	801	1,926	868
Varicose vein surgery	11,078	9,017	8,579	7,082	8,196	7,665
Total	41,443	28,485	37,056	26,389	37,668	28,739
All EBI Procedures						
Total	84,620	37,457	77,218	35,360	81,935	38,559

[a]*These volumes reflect the number of hospital spells identified before and after the application of inclusion criteria for EBI procedures based on International Classification of Diseases 10th Revision (ICD-10) codes developed to reflect instances of low value care. March has been removed from the above data for all financial years to account for the influence of the emergence of the COVID-19 pandemic.*

Table 3: Completeness of dominant diagnosis coding for privately funded Evidence-Based Interventions (EBI) procedures in private hospitals in England 2017/18 to 2019/20 [a]

	2017/18	2018/19	2019/20
Category 1 Procedures			
Surgical intervention for snoring (not OSA)	98.51% (95.53,101.49%)	100%	98.28% (94.82,101.73%)
Dilatation & curettage for heavy menstrual bleeding	98.46% (95.39, 101.54%)	96.92% (92.61,101.24%)	97.47% 93.93,101.01%)
Knee arthroscopy with osteoarthritis	98.38% (98.20,98.56%)	97.77% (97.54, 97.99%)	96.52% (96.25,96.80%)
Injection for nonspecific low back pain without sciatica	98.84% (98.70,98.97%)	98.06% (97.88,98.24%)	96.95% (96.75,97.16%)
Total	98.64% (98.53,98.75%)	97.93% (97.79,98.07%)	96.79% (96.62,96.95%)
Category 2 Procedures			
Breast reduction	96.61% (95.94,97.28%)	95.17% (94.39,95.96%)	95.83% (95.12,96.54%)
Grommets	98.99% (98.62,99.36%)	99.60% (99.36,99.85%)	99.74% (99.55,99.93%)
Tonsillectomy	98.56% (98.22,98.90%)	99.52% (99.32, 99.72%)	99.84% (99.73,99.95%)
Haemorrhoid surgery	98.04 % (97.34,98.75%)	99.86% (99.66,100.06%)	99.58% (99.24,99.91%)
Hysterectomy for heavy bleeding	98.84% (98.47,99.20%)	99.40% (99.13,99.66%)	99.56% (99.33,99.78%)
Chalazia removal	97.52% (96.53,98.50%)	98.68 % (97.96,99.39%)	98.46% (97.73,99.19%)
Shoulder decompression	99.30% (99.09,99.50%)	98.20% (97.83,98.56%)	95.02% (94.37,95.66%)
Carpal tunnel syndrome release	98.99% (98.68,99.31%)	99.35% (99.08,99.62%)	99.42% (99.19,99.65%)
Dupuytren's contracture release	98.84 % (98.26,99.43%)	99.28% (98.84,99.73%)	99.34% (98.91,99.77%)
Ganglion excision	99.13% (98.57, 99.70%)	99.44% (98.94,99.93%)	99.26% (98.70,99.81%)
Trigger finger release	99.24% (98.83,99.65%)	99.11% (98.68,99.55%)	98.55% (98.01,99.08%)
Varicose vein surgery	98.27% (98.02,98.51%)	98.94 % (98.72,99.16%)	99.94% (99.89,99.99%)
Total	98.56% (98.45,98.68%)	98.80% (98.69,98.92%)	98.75% (98.64,98.86%)
All EBI Procedures			
Total	98.60% (98.5266,98.68%)	98.35% (98.26,98.44%)	97.69% (97.59, 97.79%)

[a]These percentages reflect the proportion of hospital spells that contain codes for dominant diagnosis for each EBI procedure prior to the application of the inclusion criteria based on International Classification of Diseases 10th Revision (ICD-10) codes developed to reflect instances of low value care. March has been removed from the above data for all financial years to account for the influence of the emergence of the COVID-19 pandemic.

Table 4: Multicollinearity test for association between NHS and privately funded monthly volume change between 2019/20 and 2018/19 for Evidence-Based Interventions (EBI) procedures[a]

	(Total) Private Hospital	(Category 1) Private Hospital	(Category 2) Private Hospital	(Total) Local healthcare market	(Category 1) Local healthcare market	(Category 2) Local healthcare market
∆ NHS volume	1.02	1.17	1.01	1.01	1.06	1.00
Gender	1.04	1.07	1.05	1.03	1.01	1.04
CCI	1.11	1.08	1.08	1.13	1.05	1.11
Age	1.11	1.14	1.10	1.16	1.04	1.22
IMD	1.06	1.02	1.05	1.03	1.03	1.03
Total volume	1.04	1.17	1.01	1.05	1.07	1.11

CCI: Charlson Comorbidty Index, IMD: Index of Multiple Deprivation

[a]The multicollinearity test used is the inverse of the variance inflation factor for each independent variable, a VIF > 10 is understood as warranting investigation. Further information is available here:
Belsley, D. A., E. Kuh, and R. E. Welsch. 1980. Regression Diagnostics: Identifying Influential Data and Sources of Collinearity. New York: Wiley.(Belsley, Kuh and Welsch, 2005)

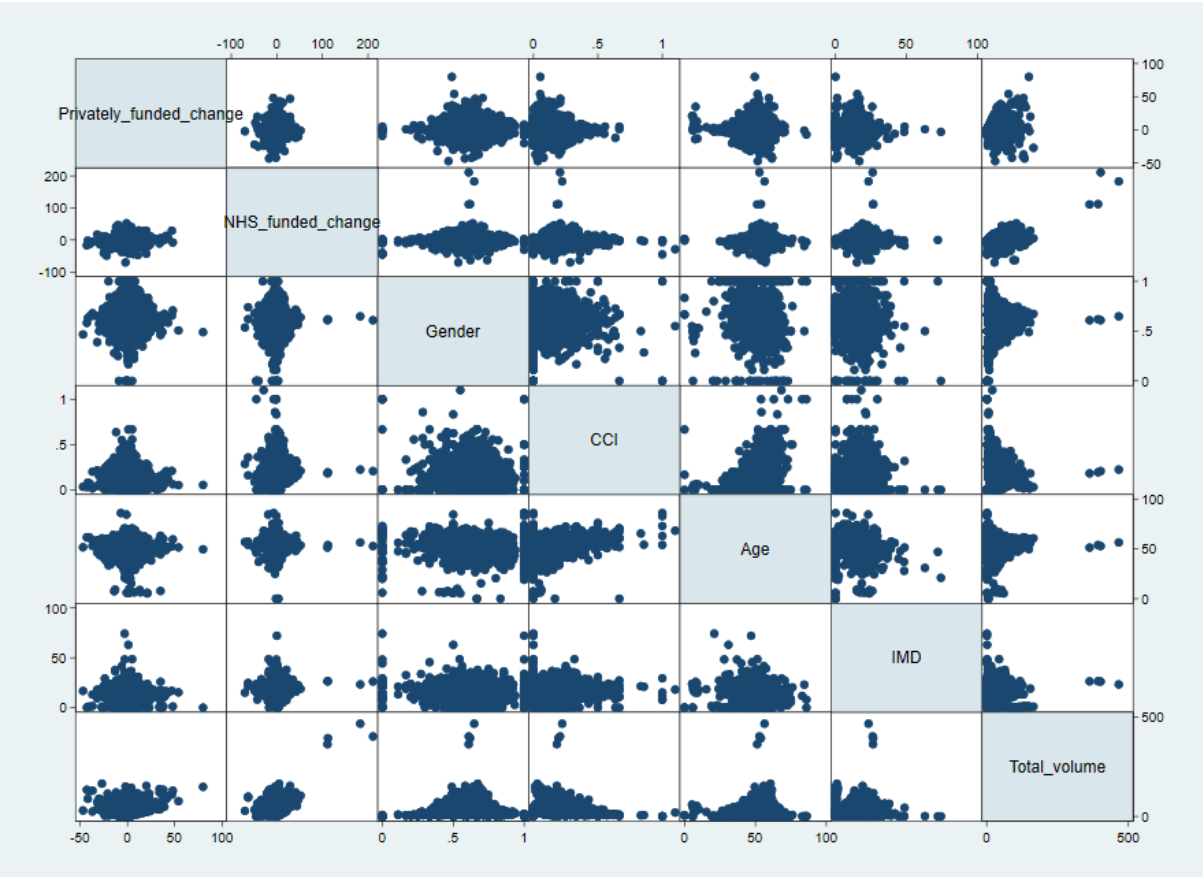
Table 5: Model specification tests for association between NHS and privately funded monthly volume change for Evidence-Based Interventions (EBI) procedures

	(Total) Private Hospital	(Category 1) Private Hospital	(Category 2) Private Hospital	(Total) Local healthcare market	(Category 1) Local healthcare market	(Category 2) Local healthcare market
Hausman test for fixed versus random effects[a]	186.75 p = 0.000	51.50 P=0.000	159.72 P=0.000	479.95 P=0.000	296.85 P=0.000	322.73 P=0.000

CCI: Charlson Comorbidty Index, IMD: Index of Multiple Deprivation

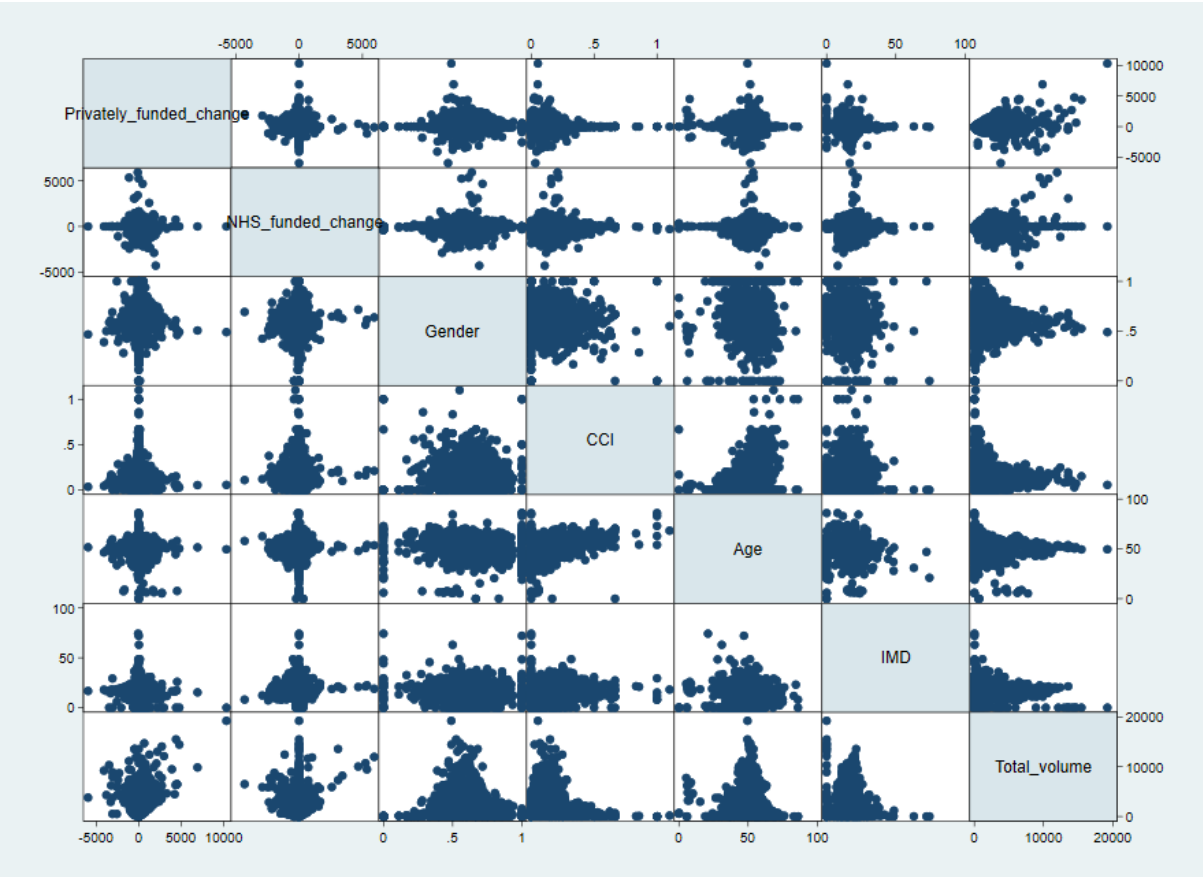
[a] The Hausman test establishes whether fixed rather than random effects is the correct model specification for individual-level effects. A significant p value implies that fixed effects is the correct model specification.
Further information is available here:
Hausman, J. A. 1978. Specification tests in econometrics. Econometrica 46: 1251–1271.(Hausman, 1978)

Figure 1: Scatter plot graph of observations for dependent and independent variables (Hospital analysis)



CCI: Charlson Comorbidty Index, IMD: Index of Multiple Deprivation

Figure 2: Scatter plot graph of observations for dependent and independent variables (Local healthcare market analysis)



CCI: Charlson Comorbidty Index, IMD: Index of Multiple Deprivation

Table 6: Volumes of procedures in private hospitals in England by region funding mechanism 2017/18 to 2019/20

	2017/18		2018/19		2019/20	
Region	Privately Funded	NHS Funded	Privately Funded	NHS Funded	Privately Funded	NHS Funded
East Midlands	1,916	4,942	1,543	3,969	1,823	2,698
East of England	6,372	3,524	5,858	3,285	6,081	2,912
London	7,901	2,613	7,883	2,206	8,662	1,965
North East	7,64	1,339	662	1,278	719	1,292
North West	3,371	6,281	2,831	5,867	3,239	6,239
South East	8,323	7,199	8,519	6,663	9,395	6,104
South West	3,645	5,923	3,217	5,382	3,527	5,030
West Midlands	2,907	3,886	2,508	3,185	2,695	2,823
Yorkshire and The Humber	2,258	5,791	2,339	5,495	2,418	4,635
Total	37,457	41,497	35,360	37,331	38,559	33,699

Table 7: Volumes of NHS, insured, and self-pay funded Evidence-Based Interventions (EBI) procedures in private hospitals in England 2017/18 to 2019/20 [a]

	2017/18			2018/19			2019/20		
Procedure	Insured	Self Pay	NHS Funded	Insured	Self Pay	NHS Funded	Insured	Self Pay	NHS Funded
Category 1 Procedures									
Intervention for snoring (not OSA)	27	20	56	20	15	51	29	12	40
Dilatation & curettage for heavy menstrual bleeding	52	8	88	47	8	40	59	*	52
Knee arthroscopy with osteoarthritis	188	32	1,349	281	54	871	325	63	763
Injection for nonspecific low back pain without sciatica	6,763	1,881	7,860	6,560	1,853	7,470	6,525	2,095	6,546
Total	7030	1941	9353	6908	1930	8432	6938	2177	7401
Category 2 Procedures									
Breast reduction	461	2,168	*	407	2,281	9	442	2,365	*
Grommets	265	90	221	237	90	230	280	85	227
Tonsillectomy	3,373	677	1,750	3,064	779	1,688	2,711	833	1,264
Haemorrhoid surgery	1,186	212	1,680	1,092	227	1,655	989	207	1,611
Hysterectomy for heavy bleeding	2,387	523	1,793	2,287	506	1,728	2,242	552	1,693
Chalazia removal	103	31	205	99	36	188	161	39	187
Shoulder decompression	2,598	269	5,309	2,164	242	3,795	2,259	218	2,613
Carpal tunnel syndrome release	2,219	741	11,384	2,159	792	10,307	2,667	1,058	9,968
Dupuytren's contracture release	707	162	3,625	858	191	3,710	943	227	3,583
Ganglion excision	542	81	1,926	623	93	1,537	722	85	1,522
Trigger finger release	571	99	2,323	679	115	2,248	701	137	2,061
Varicose vein surgery	4,522	4,495	1,922	4,508	2,517	1,804	4,711	2,719	1,563
Total	18,934	9,548	32,144	18,177	7,869	28,899	18828	8525	26,298

*PHIN applies a policy of small number suppression for any activities levels <8, OSA=Obstructive sleep apnoea. [a] There are slight discrepancies between total volumes of privately funded care in Table 2 of the main manuscript and this table as coding for patients accessing care through self-pay or insured mechanisms was only available for 94.58% of patients in 2019/20, 98.65% of patients in 2018/19, and 99.99% in 2017/18. March has been removed from the above data for all financial years to account for the influence of the emergence of the COVID-19 pandemic.

Table 8: Association between NHS and Private monthly volume change between 2019/20 and 2017/18 [a]

	(Total) Private Hospital	(Category 1) Private Hospital	(Category 2) Private Hospital	(Total) Local healthcare market	(Category 1) Local healthcare market	(Category 2) Local healthcare market
Δ NHS volume	-0.15*** (0.21, -0.09)	-0.07* (-0.13, -0.00)	-0.17*** (-0.22, -0.11)	-0.29*** (-0.42, -0.15)	-0.43* (-0.84, -0.02)	-0.28*** (-0.38, -0.19)
Gender	-2.75 (-5.74, 0.24)	0.60 (-2.02, 3.22)	-0.37 (-2.94, 2.21)	12.81 (-55.35, 80.97)	10.33 (-46.08, 66.74)	40.88 (-31.94, 113.70)
CCI	-3.10 (-6.56, 0.36)	-3.71** (-6.06, -1.37)	-2.23 (-5.12, 0.65)	-32.12 (-163.85, 99.82)	-15.55 (-79.75, 48.65)	-75.70* (-150.08, -1.31)
Age	-0.05 (-0.14, 0.03)	-0.03 (-0.14, 0.08)	-0.08* (-0.15, -0.00)	-1.65 (-5.51, 2.20)	-0.70 (-2.63, 1.24)	-2.82* (-5.47, -0.17)
IMD	-0.06 (-0.16, 0.05)	-0.11* (-0.21, -0.01)	-0.06 (-0.15, 0.04)	1.19 (-1.88, 4.26)	-0.03 (-1.65, 1.58)	-0.33 (-3.75, 3.09)
Total volume	0.50*** (0.42, 0.58)	0.46*** (0.34, 0.58)	0.51*** (0.43, 0.58)	0.68*** (0.53, 0.83)	0.89*** (0.55, 1.22)	0.67*** (0.52, 0.83)
Constant	-12.41*** (-18.54, -6.29)	-5.39 (-12.47, 1.70)	-9.06*** (-13.99, -4.14)	-739.48*** (-937.79, -541.17)	-473.43*** (-669.08, -277.79)	-457.65*** (-670.52, -244.77)
Observations	1352	349	1305	1895	994	1873
Adjusted R^2	0.282	0.241	0.292	0.304	0.265	0.367
Number of unit of observations	141	64	139	209	158	205

95% Confidence intervals in parentheses, CCI: Charlson Comorbidty Index, IMD: Index of Multiple Deprivation

*** p<0.001, ** p<0.01, * p<0.05 [a] March has been removed from the above data for all financial years to account for the influence of the emergence of the COVID-19 pandemic.

Table 9: Association between NHS and privately funded monthly volume change between 2019/20 and 2018/19 (Insurance analysis) [a]

	(Total) Private Hospital	(Category 1) Private Hospital	(Category 2) Private Hospital	(Total) Local healthcare market	(Category 1) Local healthcare market	(Category 2) Local healthcare market
Δ NHS volume	-0.13*** (-0.19, -0.07)	-0.16** (-0.27, -0.05)	-0.15*** (-0.21, -0.09)	-0.25** (-0.41, -0.10)	-0.09 (-0.26, 0.07)	-0.20*** (-0.28, -0.12)
Gender	1.72 (-1.01, 4.46)	-1.37 (-4.17, 1.42)	1.94 (-0.41, 4.30)	-15.58 (-91.79, 60.64)	-2.34 (-36.10, 31.41)	-27.63 (-104.67, 49.40)
CCI	-0.05 (-3.52, 3.41)	-4.34** (-7.20, -1.48)	-0.61 (-3.20, 1.97)	-34.09 (-105.91, 37.73)	-35.18** (-60.74, -9.62)	-33.50 (-97.62, 30.61)
Age	-0.06 (-0.15, 0.02)	-0.06 (-0.14, 0.02)	-0.08* (0.15, -0.01)	-2.34* (-4.20, -0.48)	-0.21 (-1.63, 1.20)	-2.29** (-3.99, -0.59)
IMD	-0.17* (-0.30, -0.04)	-0.06 (-0.17, 0.05)	-0.08 (-0.18, 0.02)	-2.79 (-6.02, 0.44)	-0.45 (-1.76, 0.86)	-1.49 (-4.26, 1.27)
Total volume	0.38*** (0.32, 0.45)	0.47*** (0.33, 0.62)	0.41*** (0.35, 0.46)	0.66*** (0.34, 0.99)	0.81** (0.21, 1.40)	0.53*** (0.43, 0.64)
Constant	-7.38* (-13.32, -1.44)	-2.58 (-7.90, 2.74)	-5.71* (-10.76, -0.67)	-456.95** (-793.35, -120.55)	-352.95** (-617.60, -88.29)	-213.66** (-360.93, -66.39)
Observations	1279	315	1227	1979	1043	1956
Adjusted R^2	0.161	0.251	0.159	0.383	0.482	0.236
No. of hospitals	140	63	138	198	154	196

95% Confidence intervals in parentheses, CCI: Charlson Comorbidty Index, IMD: Index of Multiple Deprivation

*** p<0.001, ** p<0.01, * p<0.05 [a] March has been removed from the above data for all financial years to account for the influence of the emergence of the COVID-19 pandemic.

Table 10: Association between NHS and privately funded monthly volume change between 2019/20 and 2018/19 (Self-pay analysis) [a]

	(Total) Private Hospital	(Category 1) Private Hospital	(Category 2) Private Hospital	(Total) Local healthcare market	(Category 1) Local healthcare market	(Category 2) Local healthcare market
Δ NHS volume	-0.09*** (-0.14,-0.05)	-0.17*** (-0.27,-0.08)	-0.11*** (-0.16, -0.06)	-0.10** (-0.18, -0.03)	-0.02 (-0.06, 0.03)	-0.15*** (-0.21, -0.09)
Gender	3.08** (1.21, 4.96)	-2.40* (-4.47, -0.34)	3.39*** (1.65, 5.14)	20.28 (-18.12, 58.68)	-16.27 (-35.54, 2.99)	11.22 (-24.18, 46.61)
CCI	-2.09* (-3.87, -0.30)	-1.89 (-4.19, 0.42)	-1.26 (-2.71, 0.19)	-6.52 (-44.21, 31.17)	-7.03 (-17.97, 3.92)	-6.33 (-34.51, 21.85)
Age	0.02 (-0.03, 0.08)	0.07* (0.00, 0.13)	-0.01 (-0.06, 0.04)	-0.01 (-0.92, 0.91)	0.38 (-0.06, 0.83)	-0.28 (-0.92, 0.37)
IMD	-0.06 (-0.14, 0.01)	-0.04 (-0.14, 0.05)	-0.06* (-0.12, -0.00)	-1.18 (-3.52, 0.89)	-0.06 (-0.52, 0.41)	-2.07 (-4.25, 0.11)
Total volume	0.24*** (0.17, 0.32)	0.36*** (0.25, 0.48)	0.28*** (0.20, 0.35)	0.23* (0.05, 0.40)	0.12 (-0.05, 0.30)	0.30*** (0.17, 0.43)
Constant	-8.08*** (-12.45, -3.70)	-6.28* (-11.03, -1.52)	-6.16** (-10.09, 2.22)	-128.64* (-235.92, -21.36)	-32.55 (-94.02, 28.91)	-110.04** (-176.22, -43.87)
Observations	1125	203	1074	1992	874	1956
Adjusted R^2	0.127	0.255	0.147	0.117	0.081	0.124
No. of hospitals	139	48	135	208	141	203

95% Confidence intervals in parentheses, CCI: Charlson Comorbidty Index, IMD: Index of Multiple Deprivation

*** p<0.001, ** p<0.01, * p<0.05 [a] March has been removed from the above data for all financial years to account for the influence of the emergence of the COVID-19 pandemic.

Table 11: Association between NHS and privately funded monthly volume change between 2019/20 and 2017/18 (Insurance analysis) [a]

	(Total) Private Hospital	(Category 1) Private Hospital	(Category 2) Private Hospital	(Total) Local healthcare market	(Category 1) Local healthcare market	(Category 2) Local healthcare market
Δ NHS volume	-0.12*** (-0.17, -0.06)	-0.09** (-0.16, -0.02)	-0.13*** (-0.18, -0.08)	-0.24*** (-0.36, -0.13)	-0.35* (-0.69, -0.02)	-0.26 (-0.35,0.17)
Gender	-1.40 (-3.80, 1.00)	0.19 (-1.75, 2.13)	-0.34 (-2.36, 1.67)	2.61 (-67.80, 73.03)	21.02 (-15.97, 58.00)	28.49 (-42.47, 99.45)
CCI	-3.09* (-5.80, -0.38)	-2.63 (-5.40, 0.14)	-2.19 (-4.61, 0.23)	-68.88 (-145.20, 7.44)	-16.39 (-47.42, 14.63)	-73.81* (-143.29, -4.33)
Age	-0.07 (-0.14, 0.01)	-0.05 (-0.15, 0.05)	-0.08** (-0.13, -0.02)	-0.94 (-3.14, 1.27)	-0.87 (-1.92, 0.21)	-0.98 (-2.98, 1.02)
IMD	-0.08 (-0.19, 0.03)	-0.09 (-0.19, 0.01)	-0.03 (-0.12, 0.06)	-1.61 (-4.42, 1.21)	-1.02 (-2.17, 0.13)	-0.74 (-4.15, 2.67)
Total volume	0.40*** (0.33, 0.48)	0.44*** (0.33, 0.56)	0.41*** (0.35, 0.48)	0.60*** (0.44, 0.76)	0.72*** (0.36, 1.08)	0.61*** (0.47, 0.76)
Constant	-7.22* (-12.74, -1.71)	-3.42 (-9.45, 2.61)	-5.53** (-9.38, -1.68)	-497.23*** (-654.22, -340.24)	264.72*** (-428.26, -101.18)	-401.42*** (-540.07, -262.77)
Observations	1301	316	1244	1788	913	1762
Adjusted R^2	0.218	0.225	0.233	0.322	0.351	0.325
No. of hospitals	137	58	134	199	154	197

95% Confidence intervals in parentheses, CCI: Charlson Comorbidty Index, IMD: Index of Multiple Deprivation

*** p<0.001, ** p<0.01, * p<0.05 [a] March has been removed from the above data for all financial years to account for the influence of the emergence of the COVID-19 pandemic.

Table 12: Association between NHS and privately funded monthly volume change between 2019/20 and 2017/18 (Self-pay analysis) [a]

	(Total) Private Hospital	(Category 1) Private Hospital	(Category 2) Private Hospital	(Total) Local healthcare market	(Category 1) Local healthcare market	(Category 2) Local healthcare market
Δ NHS volume	-0.10*** (-0.14, -0.07)	-0.03 (-0.10, 0.04)	-0.11*** (-0.14, -0.07)	-0.12*** (-0.17, 0.06)	-0.06 (-0.22, 0.09)	-0.12*** (-0.17, -0.06)
Gender	0.25 (-1.52, 2.01)	-0.35 (-2.50, 1.79)	1.14 (-0.59, 2.88)	-0.76 (-27.51, 26.00)	-17.45 (-33.87, -1.03)	3.87 (-22.71, 30.45)
CCI	-0.86 (-2.73, 1.02)	-0.36 (-2.27, 1.54)	-0.58 (-2.36, 1.20)	-11.12 (-45.32, 23.08)	-2.67 (-20.20, 14.85)	11.28 (-23.14, 45.71)
Age	0.01 (-0.04, 0.06)	0.02 (-0.04, 0.08)	0.01 (-0.04, 0.05)	0.36 (-0.56, 1.29)	-0.30 (-0.90, 0.29)	-0.23 (-1.01, 0.56)
IMD	-0.04 (-0.10, 0.01)	-0.03 (-0.10, 0.03)	-0.09*** (-0.13, -0.04)	-0.63 (-1.78, 0.52)	-0.23 (-0.84, 0.37)	-1.52* (-2.85, -0.18)
Total volume	0.27*** (0.21, 0.33)	0.25** (0.09, 0.41)	0.28*** (0.21, 0.35)	0.25*** (0.13, 0.38)	0.16 (-0.07, 0.38)	0.26*** (0.13, 0.39)
Constant	-6.79*** (-10.47, -3.12)	-3.23 (-8.16, 1.70)	-5.30** (-8.47, -2.14)	-152.71** (-254.36, -51.06)	2.86 (-77.61, 83.33)	-92.77* (-172.68, -12.87)
Observations	1062	200	1019	1792	791	1756
Adjusted R^2	0.157	0.137	0.166	0.176	0.084	0.159
No. of hospitals	133	44	56	208	139	185

95% Confidence intervals in parentheses, CCI: Charlson Comorbidty Index, IMD: Index of Multiple Deprivation

*** p<0.001, ** p<0.01, * p<0.05 [a] March has been removed from the above data for all financial years to account for the influence of the emergence of the COVID-19 pandemic.

Table 13: Association between NHS and privately funded monthly volume change between 2019/20 and 2018/19 for individual Evidence-Based Interventions (EBI) procedures by Region (Insured) [a]

	(Total) Private Hospital	(Category 1) Private Hospital	(Category 2) Private Hospital	(Total) Local healthcare market	(Category 1) Local healthcare market	(Category 2) Local healthcare market
East Midlands	-0.04 (-0.19,0.11)	-0.25 (-0.60,0.10)	-0.11 (-0.45,0.23)	-0.11* (-0.21,-0.00)	-0.10 (-0.30, 0.11)	-0.09 (-0.22,0.04)
East of England	-0.06 (-0.21,0.08)	-0.06 (-0.28,0.16)	-0.24** (-0.37,-0.11)	-0.09*** (-0.11,-0.08)	0.01 (-0.02,0.03)	0.01 (-0.18,0.21)
London	-0.25** (-0.43,-0.08)	-0.29*** (-0.29,-0.29)	-0.18 (-0.37,0.00)	-0.43*** (-0.64,-0.21)	-0.63*** (-0.94,-0.33)	-0.25*** (-0.41,-0.08)
North East	-0.00 (-0.39,0.39)	- -	-0.00 (-0.39,0.39)	0.05 (-0.24,0.33)	-0.07 (-0.09,-0.05)	-0.03 (-0.14,0.21)
North West	-0.11* (-0.19,-0.03	-0.19 (-0.43,0.06)	-0.04 (-0.13,0.05)	-0.07 (-0.18,0.04)	-0.18 (-0.47,0.12)	-0.03 (-0.09,0.03)
South East	-0.14 (-0.35,0.07)	-0.16 (-0.43,0.12)	-0.22* (-0.39,-0.06)	-0.36*** (-0.31,0.26)	-0.27*** (-0.39,-0.15)	-0.38*** (-0.51,-0.25)
South West	-0.30* (-0.57,-0.04)	-0.11 (-0.26,0.04)	-0.31** (-0.51,-0.11)	-0.18 (-0.43, 0.08)	-0.21 (-0.46,0.03)	-0.13 (-0.29, 0.04)
West Midlands	-0.24* (-0.42,-0.06)	-0.44* (-0.86,-0.02)	-0.19* (-0.35,-0.03)	-0.14* (-0.27,-0.01)	-0.60*** (-0.85,-0.34)	-0.03 (-0.19,0.13)
Yorkshire and the Humber	-0.01 (-0.19,0.17)	-0.07 (-0.20,0.07)	-0.01 (-0.12,0.10)	-0.01 (-0.13,0.11)	-0.02 (-0.22,0.18)	-0.02 (-0.10,0.05)

95% Confidence intervals in parentheses, *** p<0.001, ** p<0.01, * p<0.05. – observations in changes in volume for this procedure or financial mechanism were not sufficient to produce coefficient estimates. [a]March has been removed from the above data for all financial years to account for the influence of the emergence of the COVID-19 pandemic.

Table 14: Association between NHS and privately funded monthly volume change between 2019/20 and 2018/19 for individual Evidence-Based Interventions (EBI) procedures by Region (Self-Pay) [a]

	(Total) Private Hospital	(Category 1) Private Hospital	(Category 2) Private Hospital	(Total) Local healthcare market	(Category 1) Local healthcare market	(Category 2) Local healthcare market
East Midlands	-0.14* (-0.25,-0.04)	-	-0.17* (-0.32,-0.01)	-0.07 (-0.16,0.02)	-0.03 (-0.09,0.03)	-0.08 (-0.19,0.03)
East of England	-0.08* (-0.16,-0.01)	-0.05 (-0.22,0.12)	-0.23*** (-0.30,-0.15)	-0.06*** (-0.08,-0.04)	-0.00 (-0.01,0.00)	-0.19*** (-0.24,-0.15)
London	-0.12* (-0.23,-0.02)	- -	-0.13* (-0.23,-0.02)	-0.21*** (-0.31,-0.10)	-0.20** (-0.34,-0.06)	-0.18** (-0.30,-0.07)
North East	0.04 (-0.14,0.21)	- -	-0.04 (-0.28,0.21)	0.03 (-0.17,0.23)	- -	-0.05 (-0.24,0.15)
North West	-0.03 (-0.11,0.04)	-0.05 (-0.24,0.14)	-0.03 (-0.12,0.06)	-0.04 (-0.08,0.01)	-0.04 (-0.10,0.03)	-0.03 (-0.06,0.00)
South East	-0.19* (-0.34,-0.04)	-0.25* (-0.49,-0.02)	0.17* (-0.30,-0.03)	-0.19*** (-0.25,-0.13)	-0.18*** (-0.26,-0.10)	-0.10 (-0.22,0.02)
South West	-0.17 (-0.35,0.01)	-0.96 (-3.57,5.49)	-0.19 (-0.41,0.03)	-0.13*** (-0.18,-0.08)	-0.10 (-0.31,0.11)	-0.12*** (-0.16, -0.08)
West Midlands	-0.14 (-0.29,0.02)	-0.24 (-0.56,0.09)	-0.12 (-0.29,0.06)	-0.16*** (-0.22,-0.09)	-0.11 (-0.33,0.11)	-0.21*** (-0.28,-0.14)
Yorkshire and the Humber	0.01 (-0.09,0.11)	-0.23*** (-0.29,-0.18)	-0.02 (0.06,0.10)	0.02 (-0.06,0.10)	0.00 (-0.06,0.06)	-0.01 (-0.08,0.07)

95% Confidence intervals in parentheses, *** p<0.001, ** p<0.01, * p<0.05. – observations in changes in volume for this procedure or financial mechanism were not sufficient to produce coefficient estimates. [a]March has been removed from the above data for all financial years to account for the influence of the emergence of the COVID-19 pandemic.

10.Appendix D: Supplementary Material to Chapter 3

Table 1: Hip primary OPCS procedure codes and descriptions

Item	Operation OPCS codes	Description
H1.1	W371	Primary total prosthetic replacement of hip joint using cement
H1.2	W381	Primary Total Prosthetic Replacement not using cement
H1.3	W391	Primary total prosthetic replacement of hip joint NEC
H1.4	W431, Z843	Primary total prosthetic replacement of joint using cement NEC | Hip Joint
H1.5	W441, Z843	Primary total prosthetic replacement of joint not using cement NEC | Hip Joint
H1.6	W451, Z843	Primary total prosthetic replacement of joint NEC | Hip Joint
H1.7	W460, W372	Conversion from previous cemented prosthetic replacement of head of femur |Conversion to total prosthetic replacement of hip joint using cement
H1.8	W460, W382	Conversion from previous cemented prosthetic replacement of head of femur | Conversion to total prosthetic replacement of hip joint not using cement
H1.9	W460, W392	Conversion from previous cemented prosthetic replacement of head of femur |Conversion to total prosthetic replacement of hip joint NEC
H1.10	W470, W372	Conversion from previous uncemented prosthetic replacement of head of femur | Conversion to total prosthetic replacement of hip joint using cement
H1.11	W470, W382	Conversion from previous uncemented prosthetic replacement of head of femur| Conversion to total prosthetic replacement of hip joint not using cement
H1.12	W470, W392	Conversion from previous uncemented prosthetic replacement of head of femur | Conversion to total prosthetic replacement of hip joint NEC
H1.13	W521, Z843	Primary prosthetic replacement of articulation of bone using cement NEC | Hip Joint
H1.14	W521, Z756, Z761	Primary prosthetic replacement of articulation of bone using cement NEC | Acetabulum | Head of Femur
H1.15	W531, Z843	Primary prosthetic replacement of articulation of bone not using cement NEC | Hip Joint
H1.16	W531, Z756, Z761	Primary prosthetic replacement of articulation of bone not using cement NEC | Acetabulum | Head of Femur
H1.17	W541, Z843	Primary prosthetic replacement of articulation of bone NEC | Hip Joint
H1.18	W541, Z756, Z761	Primary prosthetic replacement of articulation of bone NEC | Acetabulum | Head of Femur
H1.19	W581, Z843	Primary resurfacing arthroplasty of joint | Hip joint
H1.20	W581, Z902	Primary resurfacing arthroplasty of joint | Hip NEC
H1.21	W581, Z756, Z761	Primary resurfacing arthroplasty of joint | Acetabulum | Head of femur
H1.22	W581, W378	Primary resurfacing arthroplasty of joint | Other specified total

		prosthetic replacement of hip joint using cement
H1.23	W581, W388	Primary resurfacing arthroplasty of joint | Other specified total prosthetic replacement of hip joint not using cement
H1.24	W581, W391	Primary resurfacing arthroplasty of joint | Primary total prosthetic replacement of hip joint NEC
H1.25	W581, W398	Primary resurfacing arthroplasty of joint | Other specified other total prosthetic replacement of hip joint
H1.26	W581, W461, Z756	Primary resurfacing arthroplasty of joint | Primary prosthetic replacement of head of femur using cement | Acetabulum
H1.27	W581, W471, Z756	Primary resurfacing arthroplasty of joint | Primary prosthetic replacement of head of femur not using cement | Acetabulum
H1.28	W581, W481, Z756	Primary resurfacing arthroplasty of joint | Primary prosthetic replacement of head of femur NEC | Acetabulum
H1.29	W931	Primary hybrid prosthetic replacement of hip joint using cemented acetabular component
H1.30	W941	Primary hybrid prosthetic replacement of hip joint using cemented femoral component
H1.31	W951	Primary hybrid prosthetic replacement of hip joint using cement NEC
H1.22	W581, W378	Primary resurfacing arthroplasty of joint | Other specified total prosthetic replacement of hip joint using cement

Source: NJR https://www.njrcentre.org.uk/wp-content/uploads/OPCS-Procedure-codes-relevant-to-NJRv8-njrcentre-Healthcare-providers-Entering-data-Manual-and-training.pdf

Table 2: Knee primary OPCS procedure codes and descriptions

Item	Operation OPCS codes	Description
K1.1	O181	Primary hybrid prosthetic replacement of knee joint using cement
K1.2	W401	Primary total prosthetic replacement of knee joint using cement
K1.3	W411	Primary total prosthetic replacement of knee joint not using cement
K1.4	W421	Primary total prosthetic replacement of knee joint NEC
K1.5	W431, Z844	Primary total prosthetic replacement of joint using cement NEC | Patellofemoral joint
K1.6	W431, Z845	Primary total prosthetic replacement of joint using cement NEC | Tibiofemoral joint
K1.7	W431, Z846	Primary total prosthetic replacement of joint using cement NEC | Knee joint
K1.8	W441, Z844	Primary total prosthetic replacement of joint not using cement NEC | Patellofemoral joint
K1.9	W441, Z845	Primary total prosthetic replacement of joint not using cement NEC | Tibiofemoral joint
K1.10	W441, Z846	Primary total prosthetic replacement of joint not using cement NEC | Knee joint
K1.11	W451, Z844	Primary total prosthetic replacement of joint NEC | Patellofemoral joint
K1.12	W451, Z845	Primary total prosthetic replacement of joint NEC | Tibiofemoral joint
K1.13	W451, Z846	Primary total prosthetic replacement of joint NEC | Knee joint
K1.14	W521, Z844	Primary prosthetic replacement of articulation of bone using cement NEC | Patellofemoral joint
K1.15	W521, Z845	Primary prosthetic replacement of articulation of bone using cement NEC | Tibiofemoral joint
K1.16	W521, Z846	Primary prosthetic replacement of articulation of bone using cement NEC | Knee joint
K1.17	W531, Z844	Primary prosthetic replacement of articulation of bone not using cement NEC | Patellofemoral joint
K1.18	W531, Z845	Primary prosthetic replacement of articulation of bone not using cement NEC | Tibiofemoral joint
K1.19	W531, Z846	Primary prosthetic replacement of articulation of bone not using cement NEC | Knee joint
K1.20	W541, Z844	Primary prosthetic replacement of articulation of bone NEC | Patellofemoral joint
K1.21	W541, Z845	Primary prosthetic replacement of articulation of bone NEC | Tibiofemoral joint
K1.22	W541, Z846	Primary prosthetic replacement of articulation of bone NEC | Knee joint
K1.23	W581, Z844	Primary resurfacing arthroplasty of joint | Patellofemoral joint
K1.24	W581, Z845	Primary resurfacing arthroplasty of joint | Tibiofemoral joint
K1.25	W581, Z846	Primary resurfacing arthroplasty of joint | Knee joint

Source: NJR https://www.njrcentre.org.uk/wp-content/uploads/OPCS-Procedure-codes-relevant-to-NJRv8-njrcentre-Healthcare-providers-Entering-data-Manual-and-training.pdf

Table 3: ICD-10 codes used for identification of adverse events

Adverse Event	ICD-10 codes	Exclusions
Adverse drug reaction	Y400-Y599 Y601-Y603 Y621-Y623 Y630-Y639 Y640-Y649 Y650 Y651 T881 T886 T887	
Infection	T814 T793 T826-T827 T835 T836 T845-T847 T857 T802 T880 Y95 N390 J120-J189 J200-J22 A400-A419 R578 T811	Primary diagnosis=T793, T826-T827,T835-T836, T845-T847, T857, T802,T880, Y9, A40-A41,R578, T81 Length of stay <4
Pressure ulcer	L89	Primary diagnosis=L8 G81, G82, Q05, G931 Length of stay <5
Venous Thromboembolism	I260 I269 I801 I802 I803 I808 I809 I828 I829	Primary diagnosis= I260, I269, I801, I802, I803, I808, I809, I828, I829 Primary operation code=L791, L792, L798

Source: Friebel et al 2021, Romano et al 2009

Table 4: Hospital Type and Volume by funding mechanism between 2016-2019[6]

	Total publicly funded volume	Mean publicly funded volume per site	Total privately funded volume	Mean privately funded volume per site	Mean combined volume per site	IQ range average combined volume per site
NHS hospitals (250)	363,917	1,456	-	-	1,456	1,495-3,150
-NHS Acute Hospitals (244)	348,411	1,428	-	-	1,428	1,481-3,080
-NHS Treatment Centre (6)	15,506 41,946	2,584	-	-	2,584	3,150-9,801
-Greater London (32)	37,402	1,169	-	-	1,169	457-1,870
-Outside London (218)	326,515	1,495	-	-	1,495	459-2,062
Private hospital (165)	168,893	1,024	78,175	474	1497	1,442-2,909
-Private Hospital (exc ISTC) (138)	125,403	908	70,709	512	1421	1,427-2,774
-ISTC (27)	43,490	1,611	7,466	277	1887	1,593-3,478
-Private hospital for-profit (133)	136,139	1,024	54,877	412	1436	1,589-3,464
-Private hospital not-for-profit (32)	32,754	1,024	23,298	728	1752	1,428-2,909
-Greater London (16)	5,573	342	5, 002	312	655	333-975
-Outside London (149)	163,320	1,097	73, 173	491	1,588	850-2,037
All hospitals (415)	532,810	1,284	78,175	474	1,473	540-2,007

[6] *These volumes combined data from NHS Digital Hospital Episode Statistics and the Private Healthcare Information Network. We do not have data for privately funded episodes in NHS hospitals, although this is understood to be a very small aspect of elective care activity in England

Table 5: HRGs for Private and NHS hospitals

HRG4 Code	Name	NHS Hospital	%	Private Hospital	%	Total
HA11	Major Hip Procedures Category 2 for Trauma	70	98.59%	1	1.41%	71
HA12	Major Hip Procedures Category 1 for Trauma	98	98.99%	1	1.01%	99
HA21	Major Knee Procedures Category 2	19	76.00%	6	24.00%	25
HA22	Major Knee Procedures Category 1 for Trauma	0	0.00%	1	100.00%	1
HB11	Major Hip Procedures for non-trauma	17,514	70.71%	7,255	29.29%	24,769
HB12	Major Hip Procedures for non-trauma	45,039	68.75%	20,468	31.25%	65,507
HB21	Major Knee Procedures for Non-Trauma, Category 2	58,688	73.61%	21,036	26.39%	79,724
HB22	Major Knee Procedures for Non-Trauma, Category 1	92	83.64%	18	16.36%	110
HB23	Intermediate Knee Procedures for non-trauma	292	87.69%	41	12.31%	333
HB99	Other Procedures for non-trauma	7	100.00%	0	0.00%	7
HD24	Non-Inflammatory, Bone or Joint Disorder	9	100.00%	0	0.00%	9
HN12	Very Major Hip Procedures for non-trauma	98,285	67.65%	47,010	32.35%	145,295
HN13	Major Hip Procedures for non-trauma	1	100.00%	0	0.00%	1
HN14	Intermediate Hip Procedures for non-trauma	1	100.00%	0	0.00%	1
HN22	Very Major Knee Procedures for Non-Trauma	116,318	67.23%	56,691	32.77%	173,009
HN23	Major Knee Procedures for Non-Trauma	978	77.87%	278	22.13%	1,256
HN24	Intermediate Knee Procedures for non-trauma	32	84.21%	6	15.79%	38
HN25	Minor Knee Procedures for non-trauma	3	100.00%	0	0.00%	3
HN80	Very Complex, Hip or Knee Procedures for non-trauma	384	92.75%	30	7.25%	414
HN81	Complex, Hip or Knee Procedures for non-trauma	5,880	87.09%	872	12.91%	6,752
HR01	Reconstruction Procedures Category 6	140	100.00%	0	0.00%	140
HR03	Reconstruction Procedures Category 4	15	100.00%	0	0.00%	15
HR04	Reconstruction Procedures Category 3	548	87.12%	81	12.88%	629
HR05	Reconstruction Procedures Category 2	19,129	56.25%	14,878	43.75%	34,007
HR06	Reconstruction Procedures Category 1	2	100.00%	0	0.00%	2
HT12	Very Major Hip Procedures for Trauma	124	99.20%	1	0.80%	125
HT22	Very Major Knee Procedures for Trauma	30	90.91%	3	9.09%	33
HT23	Major Knee Procedures for Trauma	2	100.00%	0	0.00%	2

HT81	Complex, Hip or Knee Procedures for Trauma	45	100.00%	0	0.00%	45
UZ01	Data Invalid for Grouping	102	32.80%	209	67.20%	311
VA10	Multiple Trauma with No Interventions	3	100.00%	0	0.00%	3
VA12	Multiple Trauma with Intervention score < 30	6	100.00%	0	0.00%	6
VA13	Multiple Trauma with Intervention Score 19-30	2	100.00%	0	0.00%	2
VA14	Multiple Trauma with Intervention Score 30-44	2	100.00%	0	0.00%	2
VA15	Multiple Trauma with Intervention Score >45	1	100.00%	0	0.00%	1
Total		363,861	68.30%	168,886	31.70%	532,747

Table 6: Outcomes, adverse events, efficiency measures for different reimbursement groups

	Very Major Knee Procedures for Non-Trauma (HN22)		Very Major Hip Procedures for non-trauma (HN12)		Major Hip Procedures for non-trauma (HB11, HB12)	
	NHS	Private	NHS	Private	NHS	Private
Adverse Events						
HAI (%)	0.77%	0.04%	0.71%	0.04%	0.61%	0.03%
Adverse Drug Reaction (%)	0.64%	0.23%	0.73%	0.21%	0.69%	0.23%
Pressure Ulcer (%)	0.15%	0.04%	0.25%	0.08%	0.28%	0.07%
Venous thromboembolism (%)	0.46%	0.16%	0.28%	0.10%	0.26%	0.05%
Outcomes						
In-hospital mortality (%)	0.04%	0.00%	0.06%	0.01%	0.06%	0.00%
Readmissions (%)	7.55%	5.15%	7.13%	4.98%	7.11%	4.70%
Hospital transfers (%)	0.79%	0.16%	0.83%	0.16%	0.89%	0.24%
Efficiency						
Pre-operative length of stay (days)	0.03	0.01	0.04	0.02	0.05	0.38
Post-operative length of stay (days)	4.03	2.88	3.97	2.86	4.32	2.69
Patient characteristics						
Sex (=1 Male) (%)	42.57%	44.52%	40.14%	39.64%	40.19%	39.52%
Age (mean)	69.19	68.62	68.50	67.95	68.29	67.98
IMD (mean)	3.09	3.32	3.16	3.40	3.18	3.42
CCI (mean)	0.68	0.49	0.65	0.44	0.60	0.34
Weekdays discharge (%)	74.85%	68.77%	74.84%	68.31%	75.79%	70.13%
Winter discharge (%)	30.59%	33.82%	30.48%	33.37%	37.53%	39.62%
PROMs						
Participation (%)	63.61%	61.42%	64.54%	62.13%	66.99%	68.96%
Hip/Knee Score (mean)	17.91	20.26	17.98	20.60	16.48	18.71

Table 7: Outcomes, adverse events, efficiency measures for different reimbursement groups

	Major Knee Procedures for Non-Trauma (HB21, HN23)		Reconstruction Procedures (HR05)		Complex, Hip or Knee Procedures for non-trauma (HN81)	
	NHS	Private	NHS	Private	NHS	Private
Adverse Events						
HAI (%)	0.62%	0.06%	0.67%	0.04%	1.41%	0.23%
Adverse Drug Reaction (%)	0.56%	0.19%	0.75%	0.20%	0.87%	0.23%
Pressure Ulcer (%)	0.15%	0.04%	0.27%	0.07%	0.58%	0.34%
Venous thromboembolism (%)	0.45%	0.10%	0.35%	0.18%	0.66%	0.34%
Outcomes						
In-hospital mortality (%)	0.05%	0.00%	0.07%	0.00%	0.08%	0.00%
Readmissions (%)	7.43%	5.18%	7.51%	5.36%	10.42%	7.62%
Hospital transfers (%)	0.81%	0.17%	0.76%	0.26%	1.41%	0.23%
Efficiency						
Pre-operative length of stay (days)	0.04	0.38	0.06	0.38	0.20	0.02
Post-operative length of stay (days)	4.24	2.58	4.74	2.88	5.93	3.45
Patient characteristics						
Sex (=1 Male) (%)	43.49%	47.45%	39.03%	41.93%	45.14%	44.89%
Age (mean)	68.96	68.10	69.12	69.16	67.01	66.58
IMD (mean)	3.09	3.30	3.10	3.31	3.15	3.35
CCI (mean)	0.63	0.39	0.68	0.42	1.07	0.69
Weekdays discharge (%)	75.74%	69.60%	75.74%	71.29%	76.24%	68.58%
Winter discharge (%)	37.44%	41.27%	38.82%	40.03%	32.77%	33.72%
PROMs						
Participation (%)	58.94%	53.14%	63.41%	67.98%	41.40%	50.00%
Hip/Knee Score (mean)	17.67	20.11	16.15	18.58	16.80	19.34

Table 8: Patient characteristics for NHS non-treatment centre hospitals and NHS treatment centres

	NHS non-treatment Hospitals	**NHS Treatment Centre**	**P value**
	348,411 (95.74%)	**15,506 (4.26%)**	
Adverse Events			
HAI (%)	0.76% (0.73%, 0.79%)	0.28% (0.19%, 0.36%)	0.000
Adverse Drug Reaction (%)	0.63% (0.61%, 0.66%)	1.73% (1.52%, 1.93%)	0.000
Pressure Ulcer (%)	0.22% (0.21%, 0.24%)	0.23% (0.15%, 0.30%)	0.546
Venous thromboembolism (%)	0.38% (0.36%, 0.40%)	0.29% (0.21%,0.37%)	0.037
Outcomes			
In-hospital mortality (%)	0.06% (0.05% ,0.07%)	0.00% (0.00%, 0.00%)	0.043
Readmissions (%)	7.48% (7.40%, 7.57%)	6.53%(6.14%, 6.92%)	0.000
Hospital transfers (%)	0.86% (0.83%, 0.89%)	0.48% (0.37%, 0.59%)	0.000
Length of stay			
Pre-operative length of stay	0.05 (0.04 0.05)	0.01 (0.01, 0.02)	0.000
Post-operative length of stay	4.20 (4.19, 4.21)	4.34 (4.30, 4.39)	0.000
Patient characteristics			
Sex (=1 Male) (%)	41.65% (41.49%, 41.81%)	39.17% (38.40%, 39.94%)	0.000
Age (mean)	68.75 (68.71, 68.78)	69.03 (68.87, 69.20)	0.001
IMD (mean)	3.11 (3.11, 3.12)	3.41 (3.39, 3.43)	0.000
CCI (mean)	0.66 (0.65, 0.66)	0.72 (0.70, 0.74)	0.000
Weekdays discharge (%)	75.34% (75.20%, 75.49%)	73.37% (72.68%, 74.07%)	0.000
Winter discharge (%)	33.27% (33.11%, 33.42%)	35.55% (35.47%, 36.16%)	0.000
PROMs			
Participation (%)	62.43% (62.23%, 62.62%)	77.14% (76.35%, 77.94%)	0.000
Hip/Knee Score (mean)	17.09 (17.05, 17.13)	19.24 (19.06, 19.42)	0.000
IMD = Index of Multiple Deprivation. Quintile 1 = Most Deprived, Quintile 5 = Least Deprived			

Table 9: Patient characteristics for Private non-treatment centre hospitals and Private treatment centres

	Private Hospitals- Non Treatment Centre	**Private Hospitals- Treatment Centre**	**P value**
	125,403 (74.75%)	**43, 490 (25.75%)**	
Adverse Events			
HAI (%)	0.04% (0.03%, 0.05%)	0.04% (0.02%, 0.06%)	0.668
Adverse Drug Reaction (%)	0.20% (0.17%, 0.22%)	0.26% (0.21%, 0.31%)	0.068
Pressure Ulcer (%)	0.05% (0.04%, 0.07%)	0.07% (0.04%, 0.09%)	0.865
Venous thromboembolism (%)	0.14% (0.12%, 0.16%)	0.06% (0.04%,0.08%)	0.000
Outcomes			
In-hospital mortality (%)	0.00% (0.00% ,0.00%)	0.00% (0.00%, 0.00%)	0.120
Readmissions (%)	4.98% (4.86%, 5.10%)	5.27% (5.06%, 5.48%)	0.099
Hospital transfers (%)	0.21% (0.18%, 0.23%)	0.10% (0.07%, 0.13%)	0.000
Length of stay			
Pre-operative length of stay	0.20 (0.20 0.21)	0.00 (0.00, 0.01)	0.000
Post-operative length of stay	2.70 (2.70, 2.71)	3.07 (3.05, 3.08)	0.000
Patient characteristics			
Sex (=1 Male) (%)	42.49% (42.22%, 42.77%)	42.50% (42.03%, 42.96%)	0.507
Age (mean)	68.26 (68.20, 68.31)	68.43 (68.34 ,68.52)	0.999
IMD (mean)	3.37 (3.36, 3.38)	3.32 (3.31, 3.33)	0.000
CCI (mean)	0.40 (0.40, 0.41)	0.51 (0.50, 0.52)	0.000
Weekdays discharge (%)	68.90% (68.65%, 69.17%)	70.01% (69.58%, 70.44%)	0.000
Winter discharge (%)	36.29% (36.02%, 36.56%)	35.78% (35.33%, 36.23%)	0.283
PROMs			
Participation (%)	58.52% (58.19%, 58.85%)	74.24% (73.75%, 74.73%)	0.000
Hip/Knee Score (mean)	19.95 (19.88, 20.02)	19.11 (19.01, 19.21)	0.000
IMD = Index of Multiple Deprivation. Quintile 1 = Most Deprived, Quintile 5 = Least Deprived			

Table 10: Patient characteristics for Private Not-for-Proft and For-Profit Hospitals

	Private Hospitals- Not-For-Profit	**Private Hospitals- For-Profit**	**P value**
	32,754 (19.39%)	**136,139 (80.61%)**	
Adverse Events			
HAI (%)	0.02% (0.01%, 0.04%)	0.04% (0.03%, 0.05%)	0.435
Adverse Drug Reaction (%)	0.08% (0.05%, 0.11%)	0.25% (0.22%, 0.27%)	0.000
Pressure Ulcer (%)	0.02% (0.00%, 0.04%)	0.07% (0.05%, 0.08%)	0.025
Venous thromboembolism (%)	0.10% (0.07%, 0.14%)	0.12% (0.11%,0.14%)	0.871
Outcomes			
In-hospital mortality (%)	0.00% (0.00% ,0.00%)	0.00% (0.00%,0.00%)	0.837
Readmissions (%)	4.79% (4.56%, 5.02%)	5.12%(5.00%, 5.24%)	0.071
Hospital transfers (%)	0.63% (0.55%, 0.72%)	0.07% (0.06%, 0.09%)	0.000
Length of stay			
Pre-operative length of stay	0.04 (0.03 0.06)	0.19 (0.18, 0.19)	0.000
Post-operative length of stay	2.89 (2.88, 2.91)	2.78 (2.77, 2.78)	0.000
Patient characteristics			
Sex (=1 Male) (%)	43.53% (43.00%, 44.07%)	42.25% (41.98%, 42.51%)	0.000
Age (mean)	68.54 (68.44, 68.64)	68.24 (68.19 ,68.29)	0.000
IMD (mean)	3.40 (3.38, 3.41)	3.34 (3.34, 3.35)	0.000
CCI (mean)	0.34 (0.33, 0.35)	0.45 (0.45, 0.46)	0.000
Weekdays discharge (%)	69.80% (69.30%, 70.30%)	69.04% (68.80%, 69.29%)	0.004
Winter discharge (%)	36.54% (36.01%, 37.06%)	36.07% (35.81%, 36.32%)	0.057
PROMs			
Participation (%)	73.63% (73.05%, 74.21%)	59.98% (59.67%, 60.29%)	0.000
Hip/Knee Score (mean)	19.93 (19.81, 20.05)	19.62 (19.56, 19.69)	0.000
IMD = Index of Multiple Deprivation. Quintile 1 = Most Deprived, Quintile 5 = Least Deprived			

Table 11: Patient characteristics for hip replacement from January 2016 to March 2018

	Hip Replacement		
	NHS Hospitals	**Private Hospitals**	**P value**
	50,845 (67.84%)	**24, 107 (32.16%)**	
Adverse Events			
HAI (%)	0.75% (0.67%, 0.82%)	0.03% (0.01%, 0.06%)	0.000
Adverse Drug Reaction (%)	0.72% (0.64%, 0.80%)	0.22% (0.16%, 0.27%)	0.000
Pressure Ulcer (%)	0.28% (0.24%, 0.33%)	0.07% (0.04%, 0.10%)	0.000
Venous thromboembolism (%)	0.32% (0.27%, 0.37%)	0.11% (0.07%,0.15%)	0.000
Outcomes			
In-hospital mortality (%)	0.06% (0.03% ,0.08%)	0.00% (0.00%, 0.00%)	0.001
Readmissions (%)	7.26% (7.04%, 7.49%)	5.03% (4.75%, 5.30%)	0.000
Hospital transfers (%)	0.89% (0.81%, 0.97%)	0.14% (0.10%, 0.19%)	0.000
Length of stay			
Pre-operative length of stay	0.04 (0.04, 005)	0.01 (0.01, 0.01)	0.000
Post-operative length of stay	3.90 (3.86, 3.93)	2.78 (2.76, 2.79)	0.000
Patient characteristics			
Sex (=1 Male) (%)	40.27% (39.85%, 40.70%)	39.56% (38.95%, 40.70%)	0.064
Age (mean)	68.55 (68.45, 68.65)	67.94 (67.81 ,68.07)	0.000
IMD (mean)	3.17 (3.15, 3.18)	3.39 (3.37, 3.41)	0.000
CCI (mean)	0.68 (0.67, 0.69)	0.45 (0.44, 0.46)	0.000
Weekdays discharge (%)	74.93% (74.55%, 75.31%)	67.88% (67.29%, 68.47%)	0.000
Winter discharge (%)	31.73% (31.32%, 32.13%)	33.76% (33.16%, 34.35%)	0.000
PROMs			
Participation (%)	65.50 (65.22, 65.77)	65.90 (65.49, 66.32)	0.945
Hip/knee score (mean)	16.49 (16.43, 16.55)	19.01 (18.92, 19.10)	0.000
IMD = Index of Multiple Deprivation. Quintile 1 = Most Deprived, Quintile 5 = Least Deprived			

Table 12: Patient characteristics for knee replacement from January 2016 to March 2018

	Knee replacement		
	NHS Hospitals	**Private Hospitals**	**P value**
	61,735 (67.87%)	**29, 220 (32.13%)**	
Adverse Events			
HAI (%)	0.76% (0.69%, 0.83%)	0.03% (0.01%, 0.05%)	0.000
Adverse Drug Reaction (%)	0.68% (0.60%, 0.73%)	0.21% (0.16%, 0.26%)	0.000
Pressure Ulcer (%)	0.15% (0.11%, 0.18%)	0.02% (0.01%, 0.04%)	0.000
Venous thromboembolism (%)	0.45% (0.39%, 0.50%)	0.18% (0.13%,0.23%)	0.000
Outcomes			
In-hospital mortality (%)	0.04% (0.03% ,0.06%)	0.00% (0.00%, 0.00%)	0.001
Readmissions (%)	7.78% (7.56%, 7.98%)	5.18% (4.93%, 5.44%)	0.000
Hospital transfers (%)	0.86% (0.79%, 0.93%)	0.16% (0.11%, 0.21%)	0.000
Length of stay			
Pre-operative length of stay	0.04 (0.03, 0.05)	0.01 (0.01, 0.01)	0.000
Post-operative length of stay	4.00 (3.97, 4.02)	2.81 (2.80, 2.82)	0.000
Patient characteristics			
Sex (=1 Male) (%)	42.65% (42.26%, 43.04%)	44.72% (44.17%, 45.31%)	0.000
Age (mean)	69.22 (69.14, 69.29)	68.66 (68.56 ,68.78)	0.000
IMD (mean)	3.09 (3.07, 3.10)	3.32 (3.30, 3.34)	0.000
CCI (mean)	0.70 (0.69, 0.71)	0.49 (0.48, 0.50)	0.000
Weekdays discharge (%)	74.74% (74.40%, 75.08%)	68.59% (68.05%, 69.12%)	0.000
Winter discharge (%)	32.08% (31.71%, 32.45%)	34.69% (34.14%, 35.23%)	0.000
PROMs			
Participation (%)	60.85 (60.60, 61.11)	60.26 (59.88, 60.64)	0.058
Hip/knee score (mean)	17.76 (17.73, 17.84)	20.27 (20.19, 20.34)	0.000
IMD = Index of Multiple Deprivation. Quintile 1 = Most Deprived, Quintile 5 = Least Deprived			

Table 13: Results of Probit and Poisson regression[§]

	Probit/Poisson (1)	Probit/Poisson with case mix (2)	$D_{NHS} - D_{private}$ IV (3)
Mortality R^2:	-0.002 (-0.005, 0.000) 0.921	-0.001*** (-0.001, -0.001) 0.593	-0.001 (-0.001, 0.000) 0.317
Readmission R^2:	-0.037*** (-0.041,-0.034) 0.736	-0.026*** (-0.029, -0.023) 0.224	-0.002 (-0.012,0.009) 0.024
Hospital Transfer R^2:	-0.013*** (-0.019,-0.008) 0.851	-0.010*** (-0.014, -0.016) 0.493	0.002 (-0.002,0.006) 0.004
Pre-op LOS R^2:	3.589*** (1.562, 8.248) 0.474	3.838*** (1.667, 8.837) 0.465	2.292*** (1.544, 3.403) 0.122
Post-op LOS R^2:	0.679*** (0.639, 0.721) 0.821	0.709*** (0.668, 0.752) 0.494	1.374*** (1.315, 1.437) 0.165
Hospital-associated infection R^2	-0.029*** (-0.042, -0.016) 0.917	-0.024*** (-0.034, -0.014) 0.772	-0.005 (-0.010, 0.000) 0.415
Adverse drug reaction R^2	-0.006*** (-0.007, -0.005) 0.926	-0.005*** (-0.006, -0.005) 0.674	0.002 (-0.002, 0.005) 0.025
Pressure Ulcer R^2	-0.005** (-0.008, -0.002) 0.653	-0.004** (-0.006, -0.002) 0.336	-0.001 (-0.002, 0.001) 0.101
Venous thrombo-embolism R^2	-0.005*** (-0.007, -0.003) 0.796	-0.004*** (-0.005,-0.002) 0.627	-0.000 (-0.002, 0.002) 0.046
Observations:	532,810	526,294	526,266

*** p<0.001, ** p<0.01, * p<0.05. [§] All models are run using Probit regression, with the exception of pre-operative and post-operative length of stay which was run using Poisson regression. The Probit regression co-efficients have been converted to average marginal effects (AME), whereas the Poisson regression co-efficients are incidence rate ratios (IRRs).

Table 14: Results of OLS and IV models for all NHS and private hospitals when including PROMs as covariate and London analysis

	Including PROMs as covariate		London Subanalysis	
	OLS with case mix	$D_{NHS} - D_{Private}$ IV	OLS with case mix	$D_{NHS} - D_{Private}$ IV
Mortality	-0.000***	0.000	-0.000	-0.003
	(-0.001,-0.000)	(-0.001, 0.001)	(-0.001,-0.000)	(-0.003,0.008)
R^2:	0.003	0.002	0.003	0.002
Endog test p value:		0.5511		0.8044
Readmission	-0.014***	0.012***	-0.027***	0.008
	(-0.016,-0.012)	(0.008, 0.016)	(-0.034,-0.021)	(-0.078,0.094)
R^2:	0.014	0.010	0.011	0.011
Endog test p value:		0.0009		0.4944
Hospital Transfer	-0.003***	0.009	-0.009***	0.020
	(-0.004,-0.003)	(-0.002, 0.017)	(-0.011,-0.007)	(-0.028,0.067)
R^2:	0.009	0.006	0.006	0.004
Endog test p value:		0.0000		0.7067
Pre-op LOS	0.196*	0.446**	0.407	0.783
	(0.031,0.361)	(0.116, 0.776)	(-0.160,0.974)	(-0.146,1.712)
R^2:	0.038	0.037	0.035	0.025
Endog test p value:		0.0000		0.0000
Post-op LOS	-1.133***	0.938*	-1.575***	-1.615
	(-1.350,-0.915)	(0.223, 1.654)	(-2.365,-0.785)	(-3.655,0.426)
R^2:	0.137	0.094	0.093	0.085
Endog test p value:		0.0000		0.0000
Hospital-associated infection	-0.005***	0.004	-0.006***	-0.001
	(-0.006, -0.004)	(-0.001, 0.017)	(-0.007, -0.057)	(-0.026, 0.024)
R^2	0.005	0.005	0.005	0.005
Endog test p value:		0.0001		0.0196
Adverse drug reaction	-0.004***	0.003**	-0.005***	-0.003
	(-0.005, -0.003)	(0.001, 0.006)	(-0.007, -0.003)	(-0.017, 0.012)
R^2	0.003	0.002	0.004	0.003
Endog test p value:		0.0014		0.8337
Pressure Ulcer	-0.001***	0.001	-0.002***	0.016**
	(-0.001, -0.001)	(-0.001, 0.003)	(-0.002, -0.001)	(0.004, 0.027)
R^2	0.004	0.004	0.002	0.013
Endog test p value:		0.1030		0.3228
Venous thrombo-embolism	-0.002***	0.001	-0.004***	-0.017
	(-0.003, -0.001)	(-0.003, 0.004)	(-0.006, -0.003)	(-0.046, 0.013)
R^2	0.001	0.001	0.002	0.002
Endog test p value:		0.0889		0.3228
1st stage F stat:		118.205		290.96
Observations:	228,980	228,980	42517	42517

*** p<0.001, ** p<0.01, * p<0.05. The endogeneity tests for the London analysis were run without clustering at the HRG level, as there were too few clusters to run this test.

Table 15: Results of OLS and IV models for NHS treatment centres versus Independent Sector Treatment Centres (ISTCs), and NHS Acute Hospital versus Private Hospitals (excluding ISTCs)

	ISTC versus NHS Treatment Centre		Private Hospital (excluding ISTC) versus NHS Acute Hospital	
	OLS with case mix	$D_{NHS} - D_{Private}$ IV	OLS with case mix	$D_{NHS} - D_{Private}$ IV
Mortality	-0.000***	-0.000*	-0.000***	0.000
	(-0.001,-0.000)	(-0.001,-0.000)	(-0.001, 0.000)	(-0.000,0.001)
R^2:	0.001	0.001	0.002	0.002
Endog test p value:		0.7174		0.1354
Readmission	-0.012***	0.006	-0.019***	0.004
	(-0.021,-0.003)	(-0.006,0.018)	(-0.020, -0.017)	(-0.001,0.009)
R^2:	0.009	0.008	0.013	0.010
Endog test p value:		0.0000		0.0178
Hospital Transfer	-0.004***	-0.005***	-0.005***	0.001
	(-0.007,-0.001)	(-0.008,-0.002)	(-0.005, -0.004)	(-0.004,0.005)
R^2:	0.004	0.003	0.008	0.004
Endog test p value:		0.2047		0.0810
Pre-op LOS	-0.011**	-0.012**	0.162	0.274
	(-0.019,-0.004)	(-0.021,-0.004)	(-0.041, 0.364)	(-0.041,0.589)
R^2:	0.002	0.002	0.016	0.016
Endog test p value:		0.8396		0.0829
Post-op LOS	-1.281***	-1.173***	-1.223***	0.157
	(-1.468,-1.094)	(-1.358,-0.987)	(-1.503,-0.942)	(-0.326,0.639)
R^2:	0.151	0.151	0.105	0.023
Endog test p value:		0.0000		0.0408
Hospital-associated infection	-0.003***	-0.003***	-0.006***	0.002
	(-0.003, -0.002)	(-0.003, -0.002)	(-0.006, -0.005)	(-0.001,0.004)
R^2	0.001	0.001	0.006	0.001
Endog test p value:		0.7121		0.0727
Adverse drug reaction	-0.015***	-0.014***	-0.004***	0.001
	(-0.018, -0.012)	(-0.017, -0.009)	(-0.004, 0.003)	(-0.002,0.004)
R^2	0.008	0.008	0.002	0.001
Endog test p value:		0.2868		0.0864
Pressure Ulcer	-0.001**	-0.002***	-0.001***	-0.003***
	(-0.002, -0.001)	(-0.003, -0.001)	(-0.001, -0.001)	(-0.004,-0.002)
R^2	0.002	0.002	0.003	0.002
Endog test p value:		0.7389		0.0909
Venous thrombo-embolism	-0.002***	-0.003***	-0.002***	0.001
	(-0.003, -0.001)	(-0.004, -0.002)	(-0.002, -0.001)	(-0.001,0.003)
R^2	0.001	0.000	0.001	0.000
Endog test p value:		0.0979		0.1215
1st stage F stat:		1302.085		450.449
Observations:	59,086	59,083	467,145	467,140

*** p<0.001, ** p<0.01, * p<0.05. The endogeneity tests were run without clustering at the HRG level, as there were too few clusters to run this test.

Table 16: Results of OLS and IV Models for NHS hospitals versus For-Profit Private Hospitals and Not-For-Profit Private Hospitals

	For-Profit Private Hospitals versus NHS hospital		Not-for-profit Private Hospitals versus NHS hospitals	
	OLS with case mix	$D_{NHS} - D_{Private}$ IV	OLS with case mix	$D_{NHS} - D_{Private}$ IV
Mortality	-0.000***	-0.000	-0.000***	-0.000
	(-0.001,-0.000)	(-0.001,0.000)	(-0.000, 0.000)	(-0.001,0.000)
R^2:	0.002	0.002	0.002	0.002
Endog test p value:		0.3673		0.7521
Readmission	-0.018***	0.008	-0.018***	-0.019***
	(-0.019,-0.016)	(-0.001,0.016)	(-0.021, -0.016)	(-0.034,-0.003)
R^2:	0.012	0.012	0.012	0.012
Endog test p value:		0.0239		0.9819
Hospital Transfer	-0.006***	0.004	0.000	0.010*
	(-0.006,-0.006)	(-0.001,0.009)	(-0.001, 0.001)	(0.001,0.019)
R^2:	0.008	0.004	0.008	0.007
Endog test p value:		0.0620		0.0496
Pre-op LOS	0.144	0.260	-0.030***	-0.132***
	(-0.038,0.327)	(-0.036,0.557)	(-0.034, -0.026)	(-0.172,-0.092)
R^2:	0.015	0.012	0.001	0.000
Endog test p value:		0.0690		0.0895
Post-op LOS	-1.185***	0.852**	-0.978***	-0.663***
	(-1.446,-0.923)	(0.333,1.371)	(-1.044,-0.942)	(-0.818,-0.508)
R^2:	0.104	0.008	0.087	0.086
Endog test p value:		0.0443		0.0622
Hospital-associated infection	-0.006***	0.001	-0.005***	-0.006**
	(-0.006, -0.005)	(-0.002, 0.004)	(-0.006, -0.005)	(-0.010,-0.002)
R^2	0.005	0.001	0.005	0.005
Endog test p value:		0.0902		0.7424
Adverse drug reaction	-0.004***	0.002	-0.005***	-0.010***
	(-0.005, -0.004)	(-0.001, 0.004)	(-0.006, 0.004)	(-0.014,-0.005)
R^2	0.002	0.001	0.002	0.002
Endog test p value:		0.0788		0.1465
Pressure Ulcer	-0.001***	0.001	-0.001***	-0.004***
	(-0.001, -0.001)	(-0.001, 0.002)	(-0.002, -0.001)	(-0.006,-0.002)
R^2	0.003	0.003	0.003	0.002
Endog test p value:		0.1384		0.0253
Venous thrombo-embolism	-0.002***	-0.000	-0.002***	0.001
	(-0.003, -0.002)	(-0.002, 0.002)	(-0.003, -0.002)	(-0.001,0.003)
R^2	0.001	0.001	0.001	0.001
Endog test p value:		0.1676		0.1840
1st stage F stat:		360.526		216.089
Observations:	493575	493570	390413	390409

*** p<0.001, ** p<0.01, * p<0.05.

Table 17: Results of nearest neighbour propensity score matching comparing adverse events, outcome and efficiency measures between private and NHS hospitals[7]

	Model 1: Basic Specification		Model 2: PROMs		Model 3: HRG	
	Hip	Knee	Oxford Hip Score	Oxford Knee Score	Hip	Knee
ATT on Mortality	-0.063* (-0.121,-0.004)	-0.079* (-0.144,-0.014)	-0.021 (-0.042,0.000)	-0.021 (-0.055,0.014)	-0.029 (-0.077,0.018)	-0.044** (-0.077,-0.011)
ATT on Readmissions	-2.616** (-3.827,-1.405)	-2.849 *** (-3.984,-1.714)	-1.504*** (-2.070,-0.937)	-1.575 *** (-2.012,-1.137)	-2.114 *** (-2.843,-1.384)	-2.031*** (-2.957,-1.104)
ATT on Transfers	-0.691*** (-0.947,-0.434)	-0.508*** (-0.783,-0.234)	-0.368*** (-0.502,-0.234)	-0.302*** (-0.410,-0.194)	-0.747*** (-1.010,-0.485)	-0.455*** (-0.618,-0.293)
ATT on Pre-op LOS	0.069*** (0.055,0.082)	0.024** (0.006,0.042)	0.201*** (0.188,0.215)	0.202*** (0.191,0.213)	0.076*** (0.061,0.091)	0.070*** (0.060,0.081)
ATT on Post-op LOS	-1.257 *** (-1.363,-1.151)	-1.363*** (-1.487,-1.240)	-1.057*** (-1.096,-1.017)	-1.153*** (-1.207,-1.098)	-1.151*** (-1.208,-1.095)	-1.371*** (-1.448,-1.293)
ATT on Adverse Events	-1.146*** (-1.637,-0.655)	-1.066** (-1.486,-0.647)	-1.055*** (-1.272,-0.838)	-1.185*** (-1.356,-1.014)	-1.143*** (-1.444,-0.847)	-1.189*** (-1.523,-0.855)
ATT on Infections	-0.756*** (-0.989,-0.523)	-0.481*** (-0.654,-0.309)	-0.437 *** (-0.538,-0.335)	-0.542 *** (-0.641,-0.444)	-0.689 *** (-0.896,-0.481)	-0.551*** (-0.770,-0.332)
ATT on Adv. Drug Reactions	-0.301* (-0.596, -0.005)	-0.218 (-0.472,-0.037)	-0.383*** (-0.527,-0.238)	-0.400 *** (-0.522,-0.278)	-0.389 * (-0.722,-0.056)	-0.355 *** (-0.510,-0.199)
ATT on Pres Ulcer	-0.068 (-0.242,0.106)	-0.108 (-0.251,0.036)	-0.155*** (-0.233,-0.077)	-0.083 * (-0.149,-0.016)	-0.023 (-0.168,0.123)	-0.130* (-0.216,-0.044)
ATT on VTE	-0.075 (-0.245,0.095)	-0.299* (-0.597,-0.001)	-0.182*** (-0.245,-0.120)	-0.302*** (-0.409,-0.195)	-0.092 (-0.226,0.041)	-0.216* (-0.409,-0.023)

[7] Columns report the Average Treatment Effect on the Treated (ATT) and the 95% confidence intervals. VTE = Venous Thromboembolism. Significance: *** p<0.01, ** p<0.05, * p<0.1. PSM on age, gender, and, charlson index . Balance test fulfilled for all models

Figure 1: Covariate balancing between private and NHS hospitals before and after nearest neighbour matching for hip replacement (basic specification)

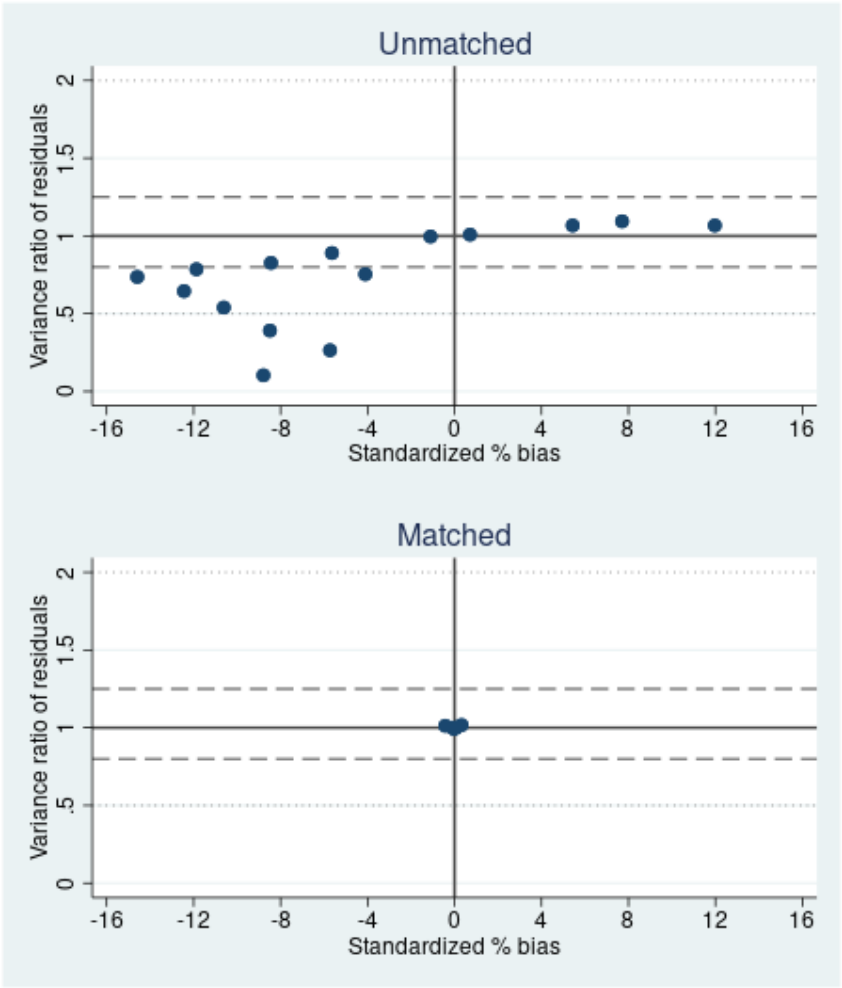


Figure 2: Covariate balancing between private and NHS hospitals before and after nearest neighbour matching for knee replacement (basic specification)

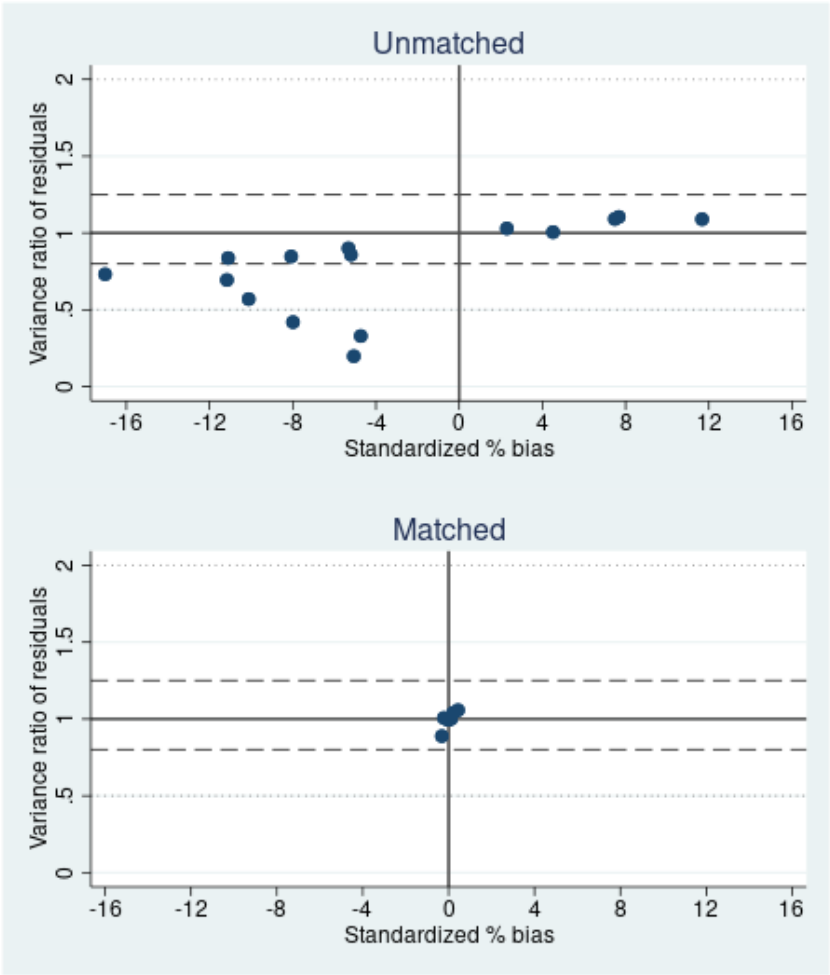


Figure 3: Covariate balancing between private and NHS hospitals before and after nearest neighbour matching for hip replacement (PROMs specification)

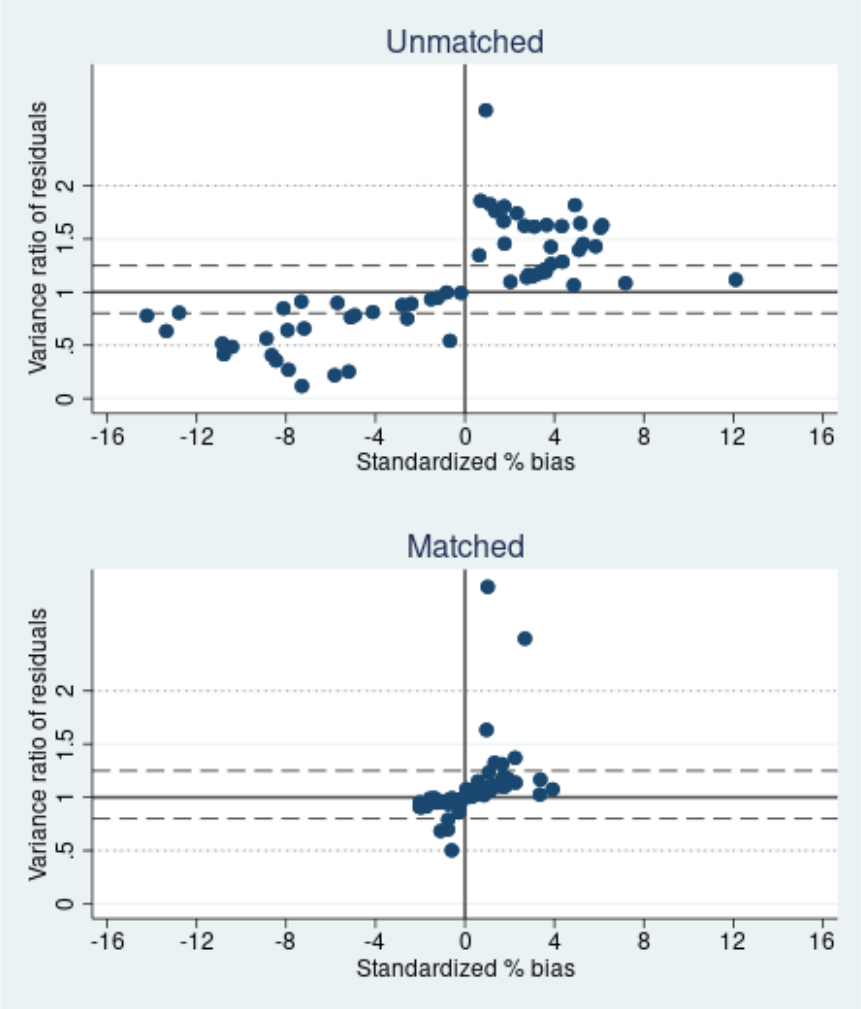


Figure 4: Covariate balancing between private and NHS hospitals before and after nearest neighbour matching for knee replacement (PROMs specification)

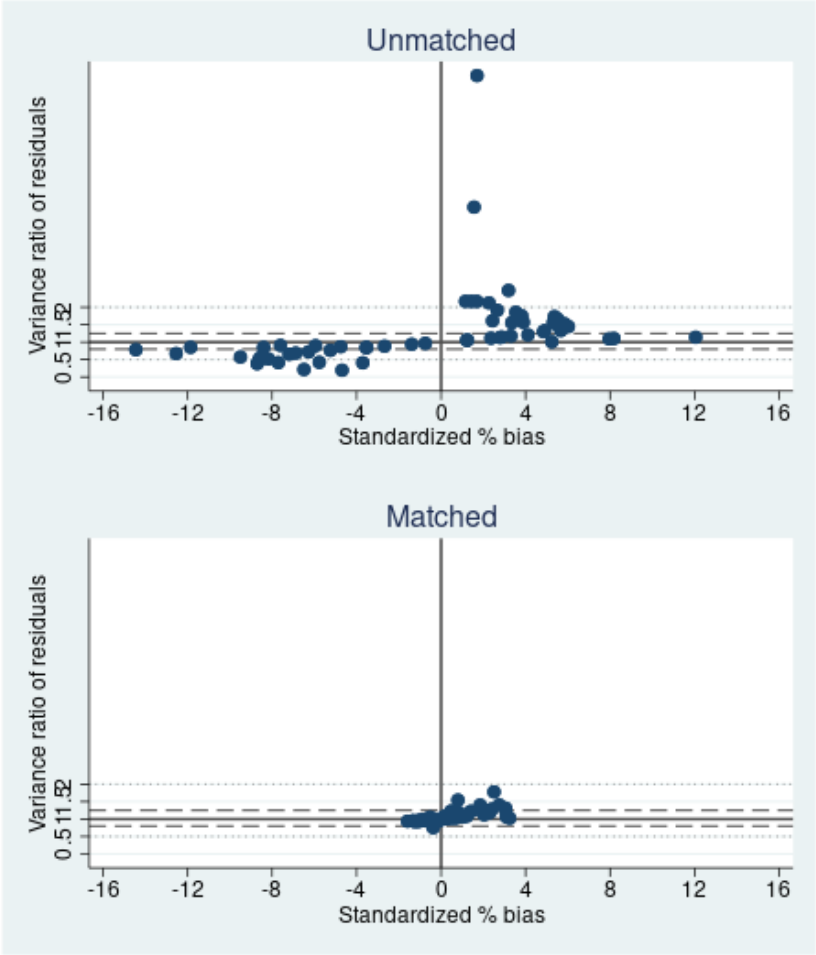


Figure 5: Covariate balancing between private and NHS hospitals before and after nearest neighbour matching for hip replacement (HRG specification)

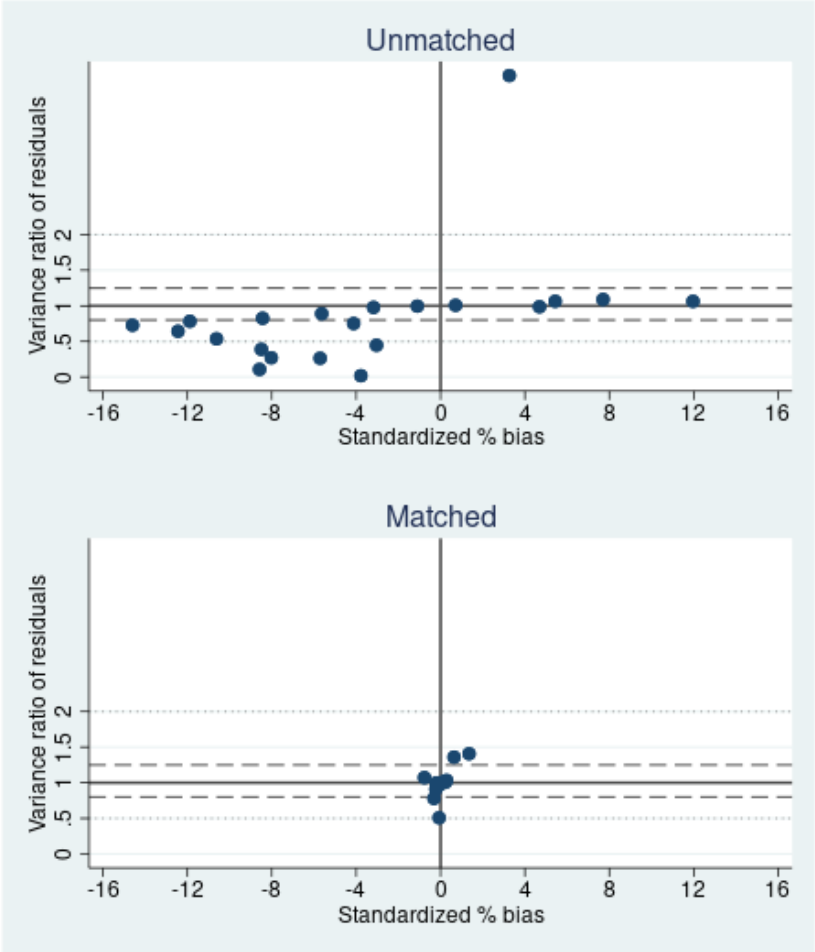


Figure 6: Covariate balancing between private and NHS hospitals before and after nearest neighbour matching for knee replacement (HRG specification)

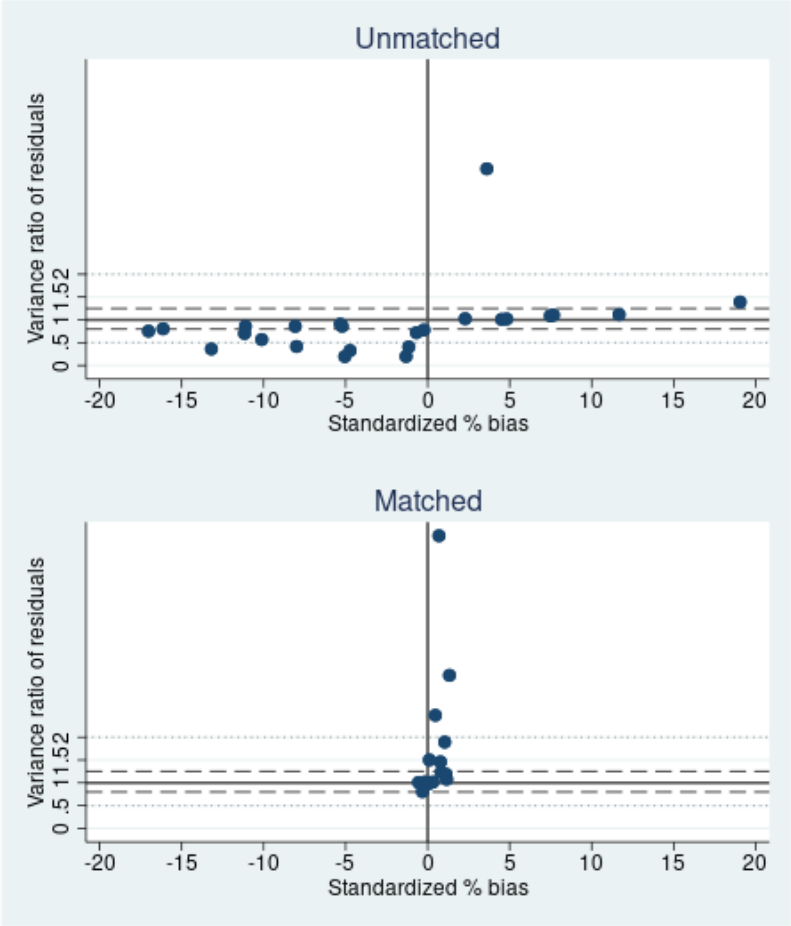


Figure 7: Covariate balancing between patients with and without hospital associated infections before and after nearest neighbour matching (NHS hospitals)

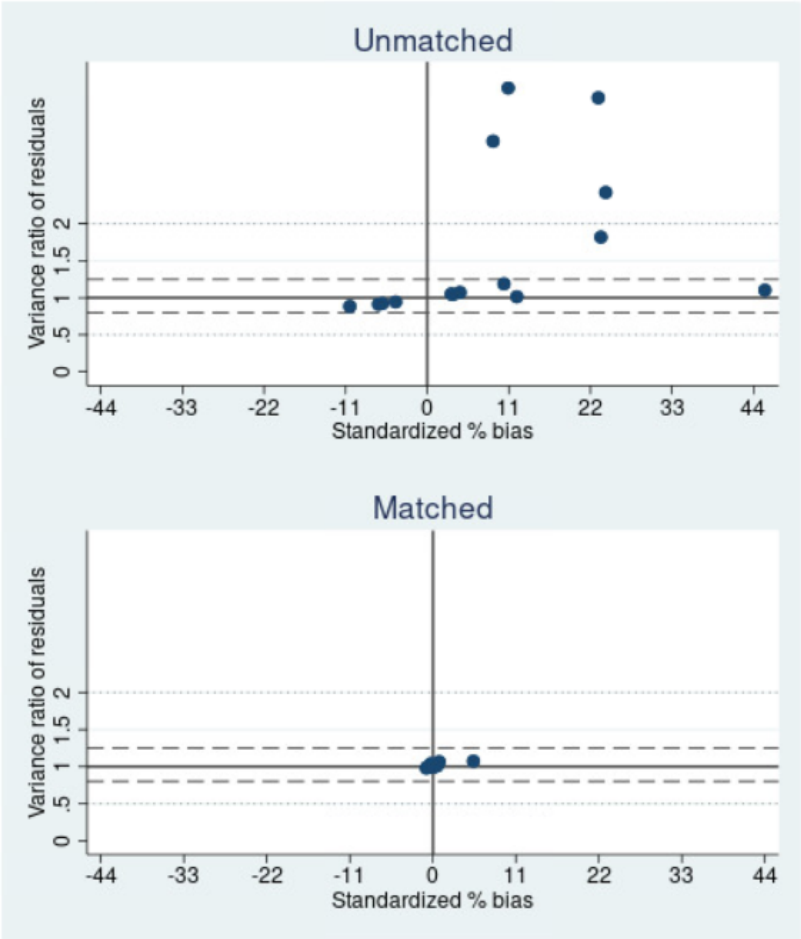


Figure 8: Covariate balancing between patients with and without hospital associated infections before and after nearest neighbour matching (Private hospitals)

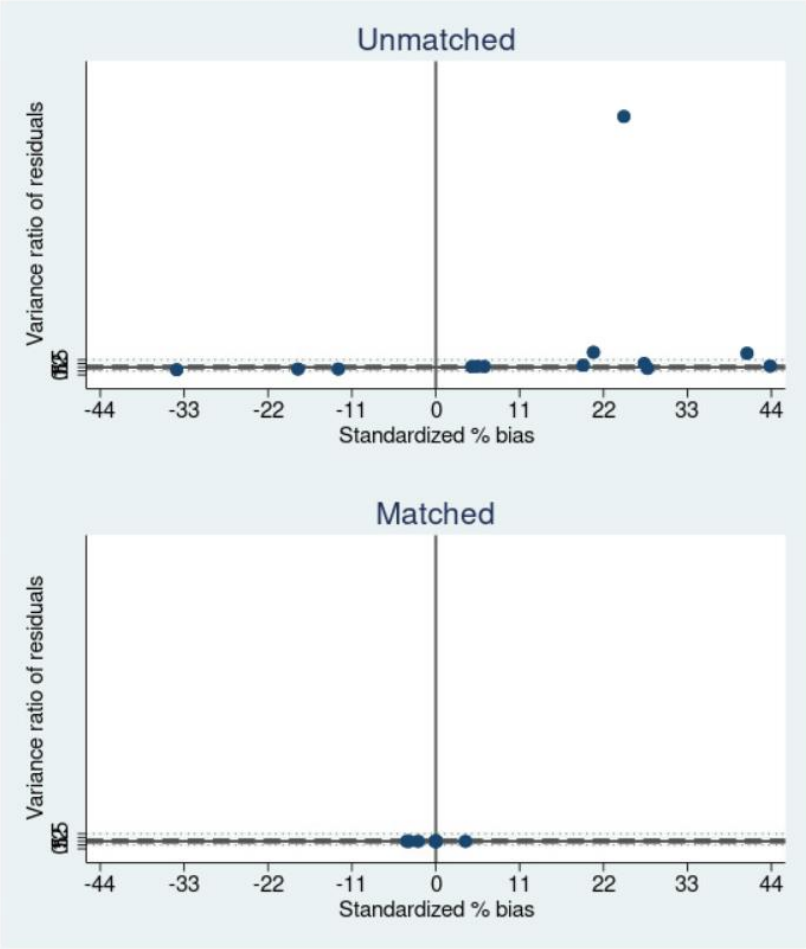


Figure 9: Covariate balancing between patients with and without adverse drug reaction before and after nearest neighbour matching (NHS hospitals)

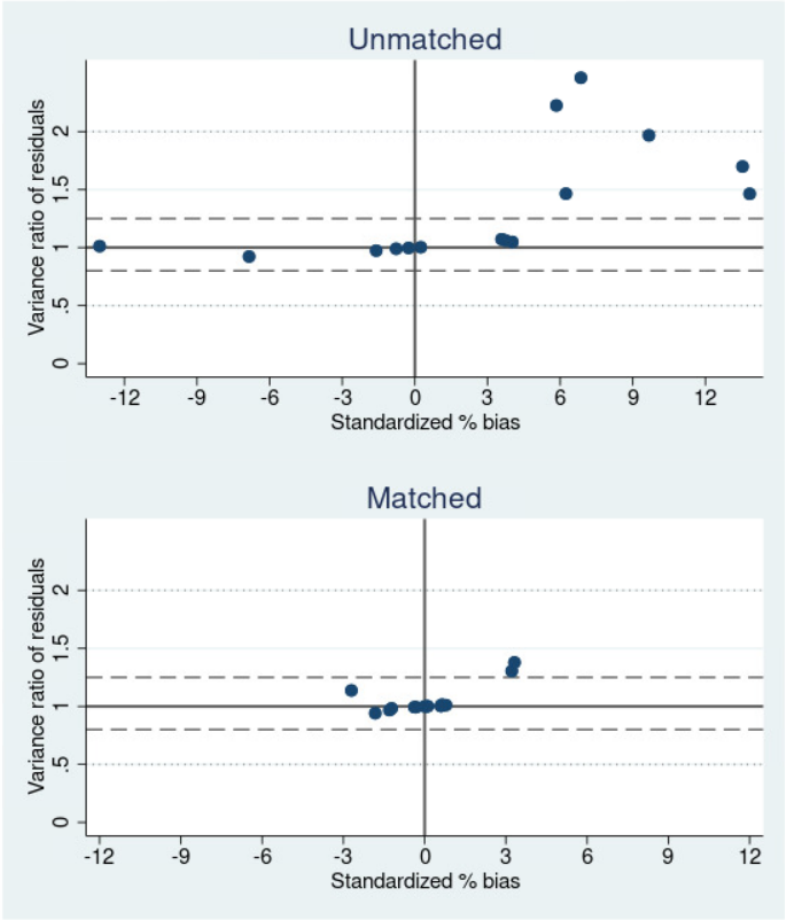


Figure 10: Covariate balancing between patients with and without adverse drug reaction before and after nearest neighbour matching (Private hospitals)

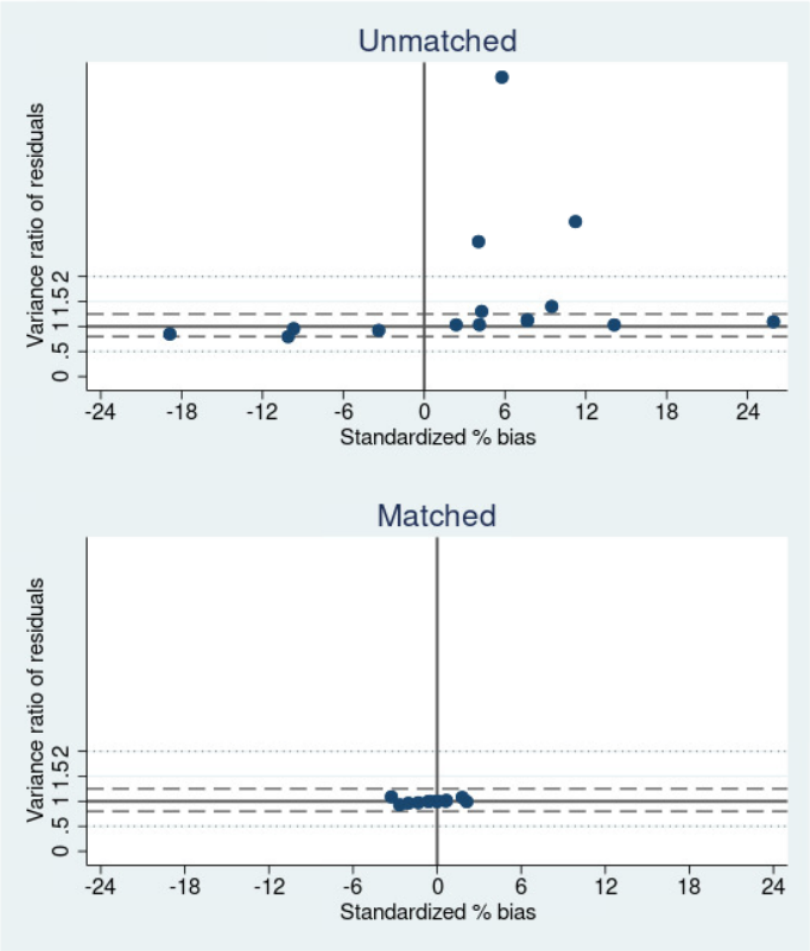


Figure 11: Covariate balancing between patients with and without pressure ulcer before and after nearest neighbour matching (NHS hospitals)

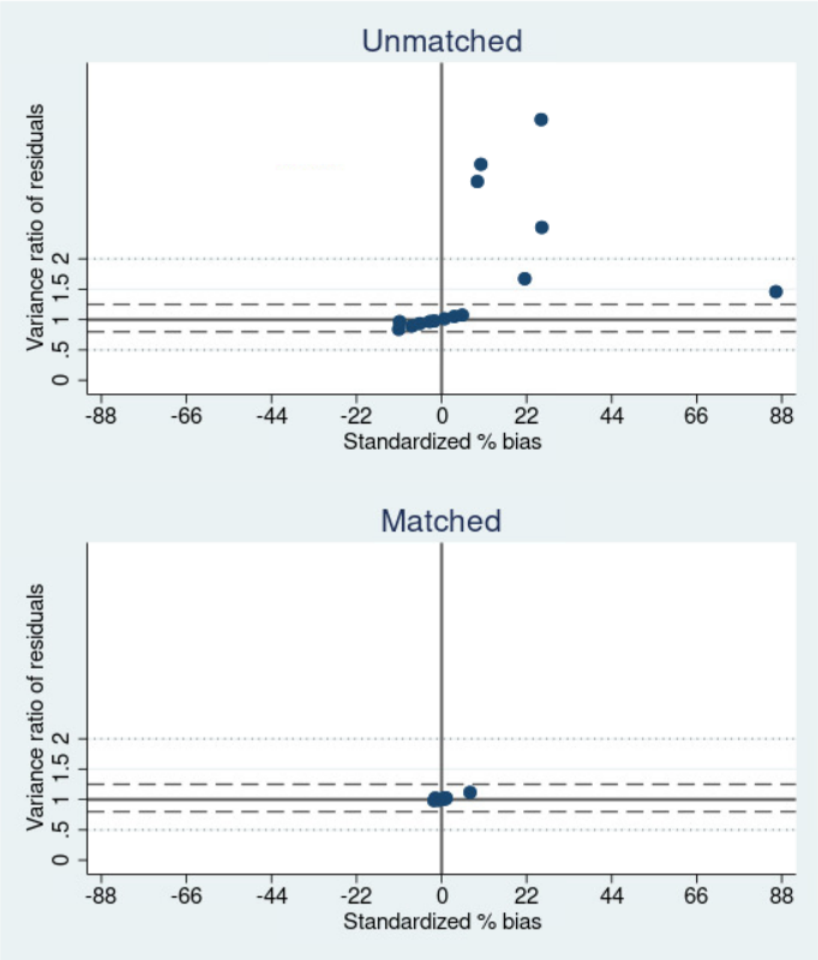


Figure 12: Covariate balancing between patients with and without pressure ulcer before and after nearest neighbour matching (Private hospitals)

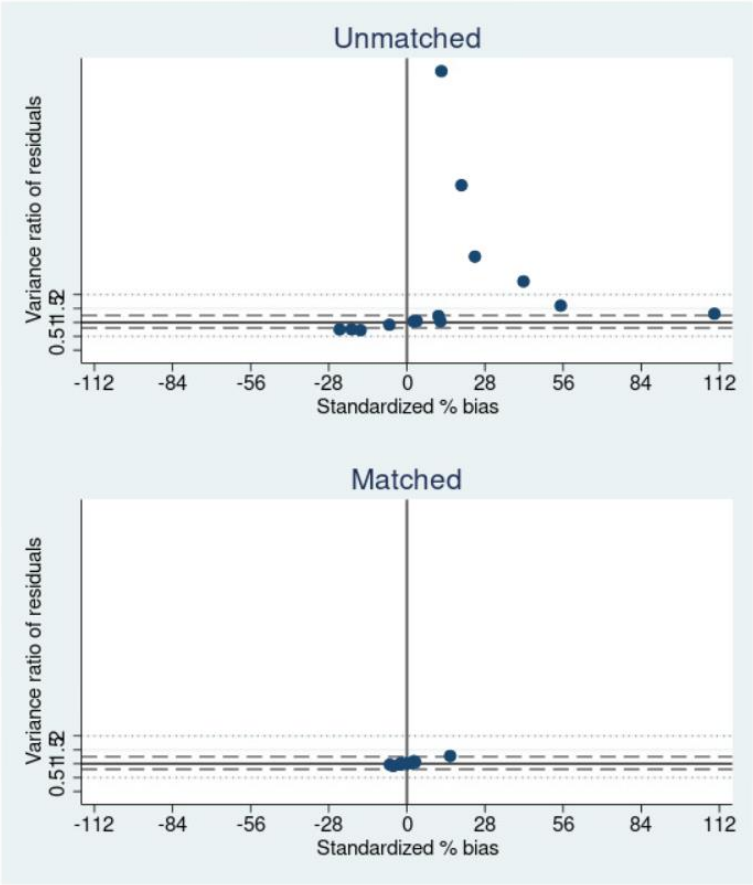


Figure 13: Covariate balancing between patients with and without venous thromboembolism before and after nearest neighbour matching (NHS hospitals)

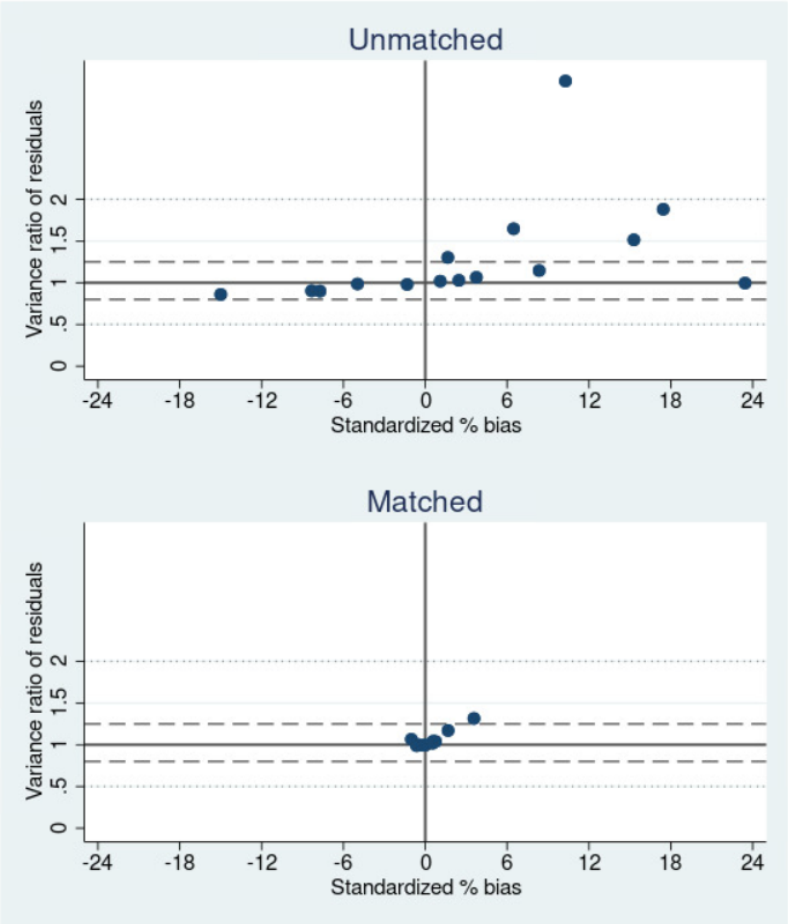


Figure 14: Covariate balancing between patients with and without venous thromboembolism before and after nearest neighbour matching (Private hospitals)

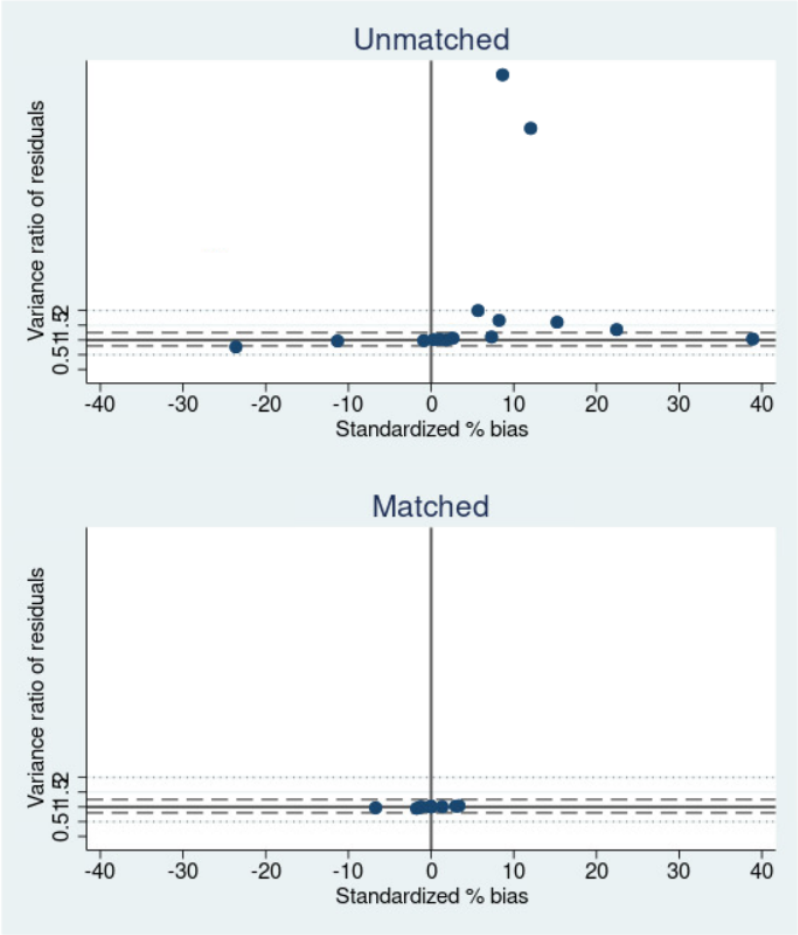


Table 18: Average treatment effect of experiencing adverse events on outcome and efficiency measures in NHS and private hospitals (Model 2: Nearest Neighbour Matching)

	Hospital-Associated Infections		Adverse Drug reactions		Pressure Ulcer		Venous Thromboembolism	
	NHS	Private	NHS	Private	NHS	Private	NHS	Private
ATT on Mortality	1.85*** (1.33, 2.36)	1.43 (-1.38, 4.24)	0.26* (-0.02, 0.53)	-	1.54*** (0.63, 2.45)	-	0.98*** (0.36, 1.60)	-
ATT on Readmission	7.35*** (5.25, 9.45)	8.57 (-3.67, 20.82)	4.30*** (2.31, 6.30)	3.10 (-1.76, 7.95)	8.74*** (4.06, 13.43)	9.47 (-2.09, 21.03)	8.89*** (5.83, 11.94)	24.10*** (16.39, 31.81)
ATT on Hospital transfer	2.58*** (1.63, 3.53)	-	0.89*** (0.14, 1.65)	0.93 (-0.49, 2.35)	3.86*** (1.87, 5.84)	-	2.18*** (0.91, 3.46)	7.18*** (2.62, 11.74)
ATT on Pre-op LoS	-0.03 (-0.09, 0.03)	0.36 (-0.25, 0.97)	0.02 (-0.04, 0.08)	-0.05 (-0.18,0.09)	0.25 (-0.13, 0.63)	-0.13* (-0.29, 0.04)	0.10** (0.03, 0.18)	-0.09 (-0.27, 0.08)
ATT on Post-op LoS	7.46*** (6.92, 8.00)	2.11*** (1.03, 3.20)	2.54*** (2.19, 2.90)	0.83*** (0.50, 1.16)	8.42*** (7.34, 9.50)	5.64*** (3.98, 7.31)	5.32*** (4.79, 5.85)	2.32*** (1.79, 2.85)

Average treatment effect (ATT), Length of stay (LOS), Pre-operative (Pre-op), Post-operative (Post-op)-, means there were not sufficient observations to allow the calculation of ATT. 95% CI in parentheses. *** p<0.01, ** p<0.05, * p<0.1