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Marco Mello
University of Aberdeen

Giuseppe Moscelli
University of Surrey and IZA

Ioannis Laliotis
University of Patras and University of London

Melisa Sayli
University of Surrey

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Work Pay, Contractual Changes and Employee Attrition: Evidence from NHS Trainee Doctors*

Retention of skilled workers is critical for the delivery of public services in high-stakes environments such as hospital care. We study how contractual pay terms affect the retention of trainee doctors in the English NHS and the relationship between trainee doctors' attrition and hospital quality. Our setting is a nationwide reform that reduced unsocial working hours pay rates. Using a longitudinal sample and a novel linkage of administrative datasets, our quasi difference-in-difference strategy leverages the pre-reform exposure of each trainee doctor to unsocial working hours and suggests that the implementation of the new pay terms led to a 6.7% increase in the annual number of trainee doctors leaving the English NHS. As plausible mechanism, we show that the reform was detrimental to pay satisfaction and increased trainee doctors intentions to change job outside healthcare. By exploiting the effect of the reform, we also document a positive association between trainee doctors' attrition and hospital mortality.

JEL Classification: I11, J22, J41, J45, J81, C23

Keywords: job contracts, employee attrition, pay satisfaction, on-the-job training, doctors, hospitals, patient mortality

Corresponding author:
Giuseppe Moscelli
School of Economics
University of Surrey
Surrey, GU2 7XH
United Kingdom
E-mail: g.moscelli@surrey.ac.uk

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1 Introduction

Workers' compensation in critical public sector domains, like health care in countries adopting a Beveridge-like system, is a contentious issue for governments and policymakers, especially during economic downturn times, as it triggers complicated financial trade-offs related to the extension of salary increases to a large labour force. In the absence of either tax hikes or spending cuts, generous pay rises to public sector workers can in fact lead to budget deficits. At the same time, adequate or competitive pay is essential to minimize the attrition of employees to better-rewarding outside options, as a high turnover – especially of high-quality workers – can impair the smooth delivery and quality of public services (Propper and Van Reenen, 2010). In this work, we seek to bring new evidence on the way contractual conditions – including basic and overtime pay terms – affect the employee attrition and job satisfaction, by evaluating the effects of on a nationwide reform in 2016 that restructured the contractual pay terms of trainee doctors in English public hospitals. In August 2016 the UK government imposed a new national contract for English NHS trainee doctors; on the pros, the 2016 contract increased trainee doctors' basic salary by 10.5%; however, and quite controversially, the new contract also reduced the pay for unsocial work hours, i.e. shifts at night times and during weekends. For instance, the maximum supplement pay granted to trainee doctors for work during weekends was reduced from 50% under the 2002 contract to 15% under the new contract. We exploit this reform to investigate how the extensive margin of trainee doctors' labour supply responds to changes in the remuneration for unsocial working hours, what are the mechanisms at play and whether there are implications for the quality of hospital services provided.

Over the last decades, the shortage of healthcare workers has been posing a threat to the provision of hospital care in developed OECD countries like the UK (White, 2012; Alderson and Alladi, 2014; Iacobucci, 2018), the US, Italy, France, Canada and Switzerland (Scheffler and Arnold, 2019; Gong et al., 2019; Zhang et al., 2020). Within the English National Health Service (NHS), the mounting loss of trainee doctors (also known as *junior doctors*) – medical graduates undergoing postgraduate in-hospital training – is of particular relevance as they represent the future of the NHS medical workforce. For instance, the share of NHS trainee doctors who immediately took up a specialty post after their general training programme decreased from 71.3% in 2011 to 37.7% in 2018 (Rimmer, 2019). The growing attrition of trainee doctors is frequently linked to unfavorable working conditions in the NHS, such as a stretched work-life balance, inadequate pay for the amount of work provided, unappealing training and job opportunities (Smith et al., 2018; Lambert et al., 2018; Moss et al., 2004; Rizan et al., 2019); and doctors' attrition is of further concern, as it may have adverse effects

on hospital quality and patient outcomes by lowering staffing levels below safety thresholds (Lin, 2014; Akosa Antwi and Bowblis, 2018; Stoye and Warner, 2023).

Trainee doctors' attrition is important to study for several reasons. First, they are an interesting subgroup of medical staff as the trainee status places them onto the steep part of the age-earnings profile: whilst their remuneration may be still relatively low, their opportunity cost in terms of missed human capital accumulation and viable outside options (e.g. leaving to practice in another organization or country) are relatively high.[1] It follows that an improvement (deterioration) of working conditions is likely to increase (decrease) their retention rates. Second, the retention of medical workers (which is the opposite of their attrition) is indicative of an effective personnel policy, and it is of paramount importance in developing and preserving an organization's culture and its human capital stock. Third, the English NHS has been experiencing workforce shortages and it substantially relies on attracting healthcare employees from other countries; a process that has become harder after Brexit.[2] Hence, reduced retention among trainee doctors is expected to shift the overall workload towards the remaining doctors. Fourth, low retention of trainee doctors is expected to affect hospital quality and the delivery of healthcare services negatively, because in the English NHS they act both as first assessors of the severity of patients when they are admitted to hospitals and as aids to the services provided by tenured doctors. Moreover, the recent struggle of NHS hospitals to cope with the surge in the demand for care, due to and following the COVID-19 pandemic shock, has made it clear that improving healthcare workers' retention is crucial to ensure the effectiveness of healthcare delivery.

The 2016 contractual reform provides a well-suited quasi-experiment to evaluate how pay conditions affect healthcare workers' retention, as it has introduced new terms of pay for all trainee doctors in English NHS hospitals. Specifically, it restructured trainees' compensation scheme by lowering the relative value of unsocial working hours pay in their total remuneration system. Such changes are known to affect both labor supply decisions and performance of workers (Lazear and Shaw, 2007). However, the main challenge in evaluating such horizontal, nationwide interventions is the absence of individuals that remained unaffected by the policy and therefore that can be used as a control group. To identify the causal effect of interest, we follow previous literature (e.g. Propper et al. 2008; Cooper et al. 2011; Gaynor et al. 2013) and rely on the varying intensity of exposure to the introduction of the new

[1] OECD statistics show that the total number of the UK-trained doctors in Australia rose from 3,949 in 2013 to 6,621 in 2021; see `https://stats.oecd.org/Index.aspx?DataSetCode=HEALTH_WFMI`.

[2] As of March 2021, official statistics indicate that at least 30% of the approximately 124,000 doctors in the English NHS are non-UK nationals (`https://commonslibrary.parliament.uk/research-briefings/cbp-7783/`). Moreover, 4.8% of planned full-time equivalent (FTE) medical workforce levels were estimated to be vacant (see `https://digital.nhs.uk/data-and-information/publications/statistical/nhs-vacancies-survey/april-2015---march-2021`).

policy, which was more detrimental for particular groups of trainee doctors.

We construct a predetermined, continuous measure of treatment intensity, based on the supplement pay that trainee doctors received on top of their basic salary during their first two years of training as a compensation for their unsocial work hours. The higher this supplement pay component was, relative to their basic salary, which is the same for all trainee doctors due to the centrally regulated NHS pay policy, the more exposed trainee doctors were to unsocial working conditions. Hence, the trainees working more unsocial hours before the reform were the ones who felt most penalized by the introduction of the new national contract. Indeed, unsocial working hours - such as nights and weekend shifts - are the ones most unpleasant to provide one's labour supply, either due to the higher disutility of working during these times instead of engaging in other leisure activities like sleeping or socializing, or for the higher opportunity-costs of unsocial hours due, for example, to childcare or elderly care duties. It follows that decreasing the pay reward associated with unsocial hours may create an outrage effect in the workers, leading to decreased job satisfaction and ultimately decreasing their retention within an organization, even if their total compensation remains the same.

This study leverages the original linkage of several administrative high-quality datasets. We create a panel of doctor employment spells across acute and mental health care NHS hospitals by extracting data from the Electronic Staff Records (ESR), an administrative monthly payroll dataset containing the universe of NHS hospital workers records; the panel allows us to investigate the effects of the 2016 contract adoption on the attrition of NHS trainee doctors. We link our panel to NHS doctors' survey responses about their pay satisfaction and intentions to quit, in order to investigate the main mechanisms driving our findings. Finally, we link the employment spell records to the universe of NHS acute hospital admission records comprised in the Hospital Episode Statistics Admitted Patient Care data (HES APC) linked to Office for National Statistics (ONS) Civil Registration Deaths certificates, to investigate the association between trainee doctors' attrition from the NHS and hospital inpatient mortality. The main sample includes only trainee doctors who joined the NHS under the pre-2016 contractual terms, i.e. those who were exposed to the changes brought by the reform: we track trainees' employment within the NHS up to December 2018, and distinguish between those who permanently left the NHS from those who took a temporary break from the medical training.

Our main finding shows that the introduction of the 2016 contract had a negative effect on retention: we estimate a 6.7% yearly increase in the number of English NHS trainee doctors leaving the English NHS. Importantly, our main results are corroborated by the fact we also find negative effects of the 2016 contract on the trainee doctors' satisfaction with their pay, and a positive effect on the trainees' intentions to quit the healthcare sector.

The aforementioned results on both pay satisfaction and intentions to leave the hospital organization or the NHS are robust to falsification tests in which we evaluate the effects of the 2016 contract either by backdating the starting date of the new trainee doctors' contract, or by using categories of doctors whose contractual terms did not change. Finally, we exploit the reform-driven increase in the trainee doctors' quits to provide suggestive evidence that trainee doctors' attrition is positively associated with the mortality risk of hospital patients admitted for an emergency condition.

Overall, these findings provide novel evidence about the interplay between working conditions and medical workers' retention, confirming that hospital medical personnel is responsive to pay structure; they suggests the need for adopting contractual (pay) schemes that do not indirectly benefit or disadvantage specific segments of an organization's workforce; last, but not least, they suggest that trainee doctors' retention is important to preserve hospital service quality.

The remainder of this paper is structured as follows. Section 2 illustrates the key features of the English National Health Service (NHS), the training pathway to become a qualified doctor in the UK, the contractual changes introduced in 2016 by the new junior doctors' contract and the data used for the analysis. Section 3 introduces the empirical strategy used in this paper to assess how the introduction of the 2016 contract affected the retention of junior doctors within the English NHS. Section 4 reports the baseline results, tests their robustness, and discusses the implications for hospital quality. Section 5 investigates the mechanisms behind the main findings of the paper. Section 6 investigates the association between the trainee doctors' attrition and hospital mortality rates. Section 7 concludes.

2 Background

2.1 Related literature

Our paper is related to several areas of research. Estimating the impact of compensation structure and working conditions on employee retention, their decision to quit and their performance is challenging due to the scarcity of appropriate sources of exogenous variation (Lazear and Oyer, 2019; Glaser and Rahman, 2023). Hence, evidence remains both mixed and limited. Lazear and Rosen (1981) argue that employers should maintain substantial pay differences across grades to improve retention and exert the appropriate effort from their employees, whereas Gibbons and Murphy (1992) suggest that the existence of future promotion opportunities may act as a motivational factors for younger workers even in the absence of current financial incentives. Berg et al. (2017) argue that highly specialized training also

improves employee retention, because job separations imply significant losses in terms of organization-specific human capital. As we show in subsection 2.3, all the features above, i.e. uncertainty in outcomes, large pay differentials across grades, promotion opportunities, and specialized training are pertinent to the labour supply decisions of trainee doctors employed by English NHS secondary healthcare providers.

In private, non-healthcare sector settings, there is evidence that adverse working conditions increase the intention and probability to quit (Böckerman and Ilmakunnas, 2009); that increasing wages can be effectively used to reduce workforce turnover (Dale-Olsen, 2006; Gielen and van Ours, 2006); and that relative pay terms affect employee willingness to enter employment, or quit, at a given remuneration level (Breza et al., 2018). According to Lazear and Shaw (2007), the interaction of workers' preferences and firms' pay schemes would determine how the latter attract and retain their workforce. Compensation levels do not always come first, as workers place value even on other job attributes such as working conditions, working hours and the recognition their effort receives from their managers. Moreover, employees enjoying a specific attribute or amenity in their current job tend to value that amenity or attribute more highly than peers who do not have it (Maestas et al., 2023). Hence, changing the relative value of such attributes in the total compensation package, as in the case of the new 2016 contract for NHS trainee doctors (see subsection 2.4), may influence a worker's decision to quit their job. Compensation schemes also affect workers' productivity, with higher (lower) productivity associated with piece-rate (fixed salary) payments (Fernie and Metcalf, 1999; Shearer, 2004; Freeman and Kleiner, 2005). When restructuring compensation terms compresses firms' pay relative to their output, high-ability workers may choose to quit their jobs, leaving their former employers with a pool of lower-ability employees. This instance typically occurs when workers place a relatively high value on extrinsic rewards: for a given motivation level, some employees develop a higher disutility for a working environment where unpleasant job attributes are paid relatively less (Lazear and Shaw, 2007).

As most of the evidence focuses on private sector employers, less is known for large public sector organizations, like the English NHS, where pay conditions and career progression are heavily regulated, and incentives are different from those in profit-maximizing settings. The existing evidence about the impact of working conditions on the retention in the public sector is mixed; previous studies have found either positive (Duflo et al., 2012) or null (Fryer, 2013) effects of financial incentives for education workers on students' learning outcomes, and positive effects on teachers' absenteeism; and despite improved pay increased the retention of British naval officers, career progression matters more than money (Glaser and Rahman, 2023).

Furthermore, the evidence on how working and remuneration conditions affect the physician labor supply decisions remains contentious and widely debated (Lee et al., 2019). In the medical literature, this evidence is limited to mere correlations or based on surveys prone to non-random response biases (Kmietowicz, 2015; Cleland et al., 2016; Spooner et al., 2017; Scanlan et al., 2018). The health economics literature on physician labour supply reviewed by Lee et al. (2019) suggests that the doctors' labour supply curve is quite inelastic, partly due to the highly specialized nature of their job, which limits their outside options. Using US data, Rizzo and Blumenthal (1994) found evidence that the short-run labour supply is rather inelastic to wages, but less inelastic for female physicians. This evidence is confirmed also by the small short-run physician labour supply wage-elasticities found by Andreassen et al. (2013) in Norway, a country with a healthcare setting more similar to the English NHS than the US one.

While in the short run wage changes do not seem to considerably affect the labour supply of senior physicians, who are on the higher end of the age-earnings profile schedule, reforms that change (the composition of) payments for the work supplied might affect more the labour supply of trainee physicians, who are on the steeper part of the age-earnings profile curve. Indeed, financial incentives are relevant for the location decisions of early-career physicians (Agarwal, 2017; Chatterji et al., 2018), but there is a lack of robust causal evidence on the factors affecting the decisions to quit of physicians during their on-the-job training period: this is exactly the focus of our research, as we investigate the effect of the introduction of the 2016 contract on the quitting decisions of NHS hospital trainee doctors and the implications of trainee doctors' attrition on hospital patient mortality. As such, our contribution is different from Stoye and Warner (2023), who investigate how daily mass-absences due to NHS trainee doctors' participation to strikes against the new 2016 contractual terms affected quality of hospital care in the pre-contract period, finding no effect on patient mortality, but higher readmission rates for black emergency patients.

2.2 The English NHS and its physician workforce

In England, most of the healthcare provision is state-provided by the National Health Service (NHS), which is funded by taxation and free at the point of use. While primary care physicians, called General Practitioners (or GPs), are private and subcontracted by the NHS, secondary care doctors are directly employed by the NHS and work in healthcare organizations called hospital Trusts, which manage one or more hospital sites. According to publicly available NHS Workforce Statistics (June 2021), the total NHS Hospital and Community Health Service (HCHS) medical workforce headcount is nearly 120 thousands,

with about 63,300 fully qualified doctors, i.e. senior doctors, and 60,400 trainee doctors.[3] Between 2009 and 2019, the overall number of doctors employed by NHS organizations has grown by around 29.5%. The remuneration and working conditions of the NHS clinical staff are centrally regulated. The Review Body on Doctors' and Dentists' Remuneration (DDRB) provides advice to the UK government on the remuneration of doctors (and dentists) employed by, or providing their services to, the NHS. Any governmental decision on pay and work contract terms is then set at the national level through NHS Employers, which represents the workforce leaders from all NHS organizations.

2.3 Organization of medical training in the English NHS

After graduating from medical schools, NHS trainee doctors undertake in-hospital training to become fully qualified doctors. To enroll in the training program, medical graduates have to participate in a national application process that operates on a preference-based system. During this process, they are required to rank all 18 Foundation Schools in the UK, 15 of which are located in England, according to their personal preferences.[4] While making their selections, candidates must carefully weigh factors such as their desired training location and the level of competition they may encounter from other applicants. Provided that there are sufficient training posts available, medical graduates secure their placement in primary preference. Otherwise, they get allocated into their next highest ranked Foundation School with still available open posts.[5]

Since the introduction of the 2005 Modernising Medical Careers (MMC) programme, the training consists of two stages. The initial stage encompasses a two-year Foundation Programme, where trainees develop fundamental skills and knowledge essential for practicing medicine. This Foundation training is succeeded by Specialty training, which spans from five to eight years, depending on the chosen medical specialty following the successful completion of the Foundation programme.[6] An important exception is the general practitioner track, which requires only three years of Specialty training. Overall, it can take up to ten years for a trainee doctor to successfully qualify as a senior doctor in English NHS hospitals.

[3] `https://digital.nhs.uk/data-and-information/publications/statistical/nhs-workforce-statistics/june-2021`.

[4] Foundation Schools, also known as NHS deaneries before 2013 or Local Education and Training Board from 2013 onwards, are the organizational structures responsible for postgraduate medical and dental training at local regional level, and they comprise several hospital Trusts.

[5] In 2015, 68% of medical graduates were allocated to their first Foundation School choice (Cartwright, 2015).

[6] For some specialty areas (e.g. Anaesthetics, Emergency Medicine, Psychiatry), the Specialty training is split into two further stages: Core training and higher Specialty training. The core training lasts up to three years, after which trainee doctors need to reapply for higher Specialty training. The remaining specialty areas instead involve a run-through Specialty training and only one application process.

During Foundation Years 1 and 2 (FY1 and FY2, respectively), trainee doctors undergo rotations across various hospitals and medical specialties. This enables them to gain essential experience by being exposed to diverse work environments and performing a range of medical tasks. Rotations take place every three to six months; however, the most important rotation date is the first Wednesday in August, when newly graduated medical students commence their own in-hospital training. Trainee doctors typically rotate across hospital organizations within the same Foundation School where they were admitted for their Foundation training. The assignment of rotations is determined by the local Health Education England (HEE) offices. Thus, trainee doctors have no influence over their placements across hospitals and medical specialties, once they are admitted to the regional program they originally applied for.[7]

Even specialty trainees (often referred to as Specialty Registrars; SR hereafter) rotate across hospitals, although at a lower frequency than Foundation doctors. At the successful conclusion of their Specialty training, trainee doctors are awarded the Certificate of Completion of Training (CCT). The possession of a CCT renders doctors eligible for inclusion in the Specialty Register, enabling them to apply for senior doctor job positions in English NHS hospitals.

2.4 The 2016 Trainee Doctor Contract (2016 TDC)

The working conditions of trainee doctors in English hospitals are governed by national agreements, typically negotiated and amended by three key parties: the Department of Health and Social Care (DHSC), NHS Employers, and the British Medical Association (BMA), which is the largest doctors' union in the UK. In 2016, a new contract brought substantial changes compared to the existing 2002 contractual pay terms. The agreement on the new contract was finalized in May, following a compromise reached after an extensive series of negotiations that led to months of industrial actions by trainee doctors.[8] Nevertheless, the new contract was implemented only from August 2016.

One of the stated objectives was to ensure a consistent provision of healthcare services in terms of quantity and quality throughout the entire week.[9] At the same time, to ensure

[7] See for instance: `https://www.bma.org.uk/news-and-opinion/junior-doctors-backed-in-call-for-humane-rotations`.

[8] On January 12, 2016, trainee doctors initiated their first strike within the NHS in 40 years. The industrial action persisted in the subsequent months, with trainee doctors abstaining from work on February 10th, March 9th-10th, and April 26th-27th. During this last instance, they not only withdrew from routine care, as in previous strikes, but also from emergency services. The magnitude of these protests is illustrated in Figure A.1, plotting the timeline of trainee doctors' absences from the workplace.

[9] A main concern of the government was to address the higher mortality risk faced by patients admitted to NHS hospitals during weekends (Aylin et al., 2010; Freemantle et al., 2012, 2015; Han et al., 2018).

the financial sustainability of hospital services, the new contract substantially reduced the cost for NHS organizations to roster trainee doctors during nights and weekends, as shown in Table 1. According to the new contractual terms, NHS trainee doctors received a 10.5% basic salary pay rise, but also substantial cuts to their unsocial working hours pay. Under the 2016 contract, the trainee doctors' monthly pay for working on weekends was capped at a 15% pay rate premium over their basic pay. In contrast, the supplement pay under the 2002 contract was, theoretically capped at 100% of a trainee doctor's basic salary and effectively quantified between 20% and 50% of their hourly basic salary, as shown in Table 2 and further discussed in subsection 3.2.

Table 1. Comparison of 2002 and 2016 NHS trainee doctor contractual terms

Pay components	**2002 contractual terms**	**2016 contractual terms**
Changes with respect to 2002 contract Basic Salary	-	10%-11% Basic Salary increase, but down from initially promised 13.5% increase
Allowance for weekend work	maximum of 2.0 × basic monthly pay for overall work (i.e. normal shifts plus unsocial hours shifts)	maximum of 1.15 × basic pay rate for 1 shift each 2 weekends
Allowance for night shifts (11pm - 6 am)	1.5 × basic pay rate	1.37 × basic pay rate
Allowance for *additional hours*	1.2 × basic pay rate	1.0 × basic pay rate

Notes. In the NHS, *unsocial hours* are defined as work shifts during weekend days (Saturday and Sunday) or nights (11pm - 6 am), whereas *additional hours* are the number of hours worked in addition to a 40-hour week and that are neither weekend nor night shifts (see also `https://www.bmj.com/careers/article/the-complete-guide-to-nhs-pay-for-doctors`).

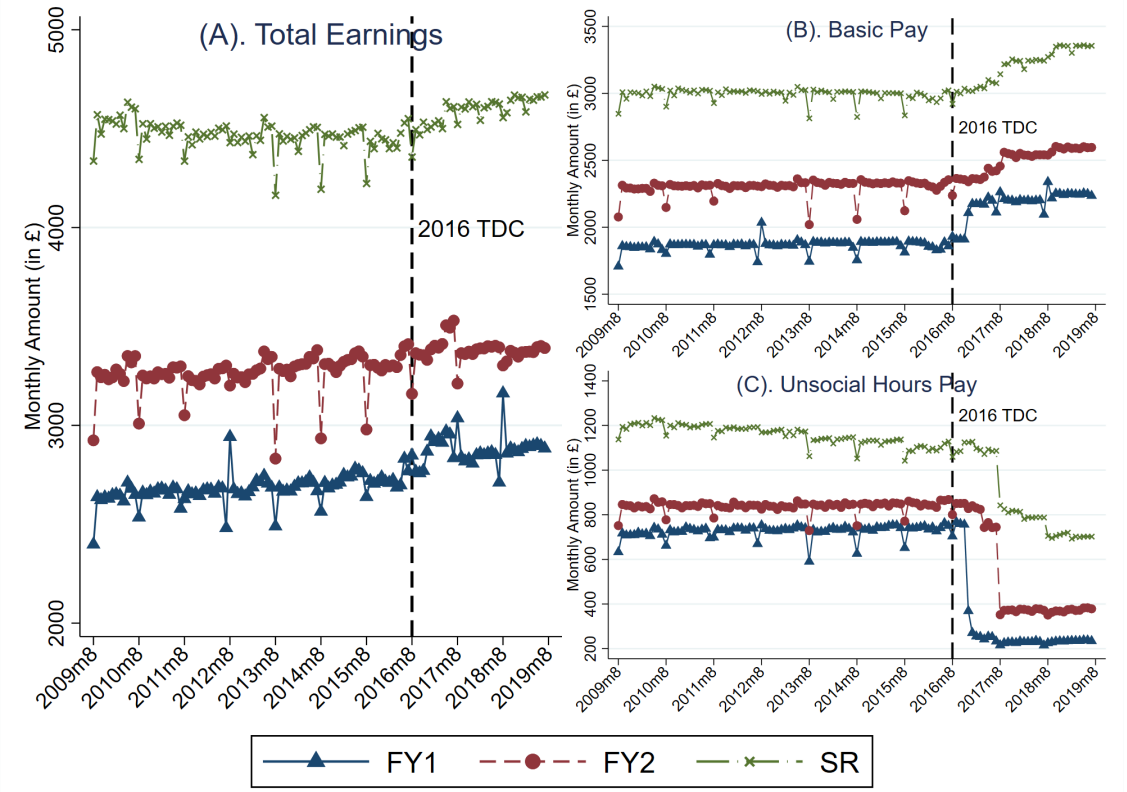
The 2016 contract also reduced the compensation for other types of unsocial work. Indeed, it decreased the pay premium for night shifts, from 1.5 to 1.37 times the basic hourly pay, as well as that for additional hours worked beyond the maximum of 40 hours per week, from 1.2 to 1.0 times the basic hourly pay.[10]

The aforementioned pay changes introduced by the new contract are shown in Figure 1, which plots the monthly average total earnings (Panel A), basic pay (Panel B) and unsocial hours supplement earnings (Panel C) over time and by trainee seniority. On average, while

However, subsequent studies have shown that the implementation of the new contract might not have reduced weekend hospital mortality (Meacock and Sutton, 2018; Underwood et al., 2019).

[10]The terms of the 2016 TDC alongside its amendments are available at: `https://www.bma.org.uk/pay-and-contracts/contracts/junior-doctor-contract/junior-doctor-contract-in-england`.

Figure 1. Monthly trainee doctors' total earnings, basic pay and unsocial hours pay



Notes. Authors' calculation from the Electronic Staff Records (ESR), using data for all NHS trainee doctors between August 2009 and July 2018. 2016 TDC = official starting implementation date of the 2016 Trainee Doctor Contract. FY1 = Foundation Year 1; FY2 = Foundation Year 2; SR = Specialty Registrar.

the total monthly earnings were not significantly impacted by the new terms (Panel A), and the overall number of hours worked remained stable (see Appendix Figure A.3), the new contract substantially restructured the composition of trainee doctors' pay. This change involved a significant decrease in the proportion of pay attributed to the unsocial hours pay supplement (Panel C).

Assuming that unsocial hours are an unpleasant job attribute that trainee doctors must accept during their training period as NHS workers, a cut to the unsocial hours pay relative to the total salary package might generate a disincentive to remain employed in English NHS hospitals, despite the compensating increase in basic pay. Due to the rotations across different hospital organizations and medical specialties, medical trainees are in fact exposed to different unsocial working hours patterns. As these unsocial working hours patterns are relatively persistent during NHS trainee doctors' career even after the Foundation Training period (we show so in Appendix Table A.7, subsection 4.2), our hypothesis is that the 2016 TDC could have caused unintended distributional consequences in the trainees' extensive

rewards that were outside the control of the individual doctor, with some trainees being more penalized than others in both their pay for the labour provided during less likable, unsocial working hours, and in different domains of their job satisfaction.

As stated by the BMA union, the 10-11% increase in basic pay might have been "misleading due to the changes to pay for unsocial hours" (The Guardian 2016a). Furthermore, the basic pay increase was deemed unsatisfactory by trainee doctors, as it fell short of the initially promised 13.5% salary increase, which had been retracted by the UK government (The Guardian 2016b). As shown in Appendix Figure A.2, the 10.5% basic pay rise was barely sufficient to keep the real terms take-home salary of trainee doctors stable and approximately at a 22% lower level than their 2008/09 pay (BMA 2022). Hence, it was likely discounted in trainee doctors' pay expectations more like a late compensation for the lost purchasing power rather than as a salary improvement.

3 Data and Methods

3.1 Electronic Staff Records (ESR) and other data sources

Our analysis is mainly based on the Electronic Staff Records (ESR), an administrative dataset collected by DHSC and containing monthly individual-level payroll information on all healthcare workers of the English NHS. We focus on an ESR extract including trainee doctors (TDs hereafter) who joined the NHS under the 2002 agreement, and thus who were exposed to the change in their contractual terms brought by the introduction of the 2016 TDC.

We restrict the attention to trainee doctors who entered the NHS medical training starting from August 2009 and as Foundation Year 1 (FY1). These trainees went through the standard pathway of the NHS medical training and - for this reason - were subject to a series of comparable hospital rotations, which provide the source of variation in unsocial work exploited by the analysis. We discard from the analysis all trainee doctors who had ever been classified under a non-doctor title (391) or who always lacked a General Medical Council (GMC) number (3,252).[11] We also exclude the Specialty training spells (i.e. records after FY2) of trainee doctors entering a Specialty training in General Practice (GP track). Indeed, most GP trainees disappears from the NHS payroll right after the completion of

[11] This information is retrieved by linking the ESR records with an extract of the 2013-2019 HERMES dataset. We also drop from the sample 8,681 dental trainees, who undergo a slightly different training than trainee doctors, which for instance involves only one Foundation year. Finally, we discard both trainee doctors with just one-month training spells and those whose training grade cannot be harmonized with the standard medical training pathway.

their training programme, when they either open or are employed by a GP practice, thus preventing us from assessing precisely if and when they interrupt their medical training.

Our estimation sample goes from January 2010 to December 2018, which provides us with a long enough post-contract period to assess whether trainee doctors permanently left the NHS or took only a temporary training break (see Section 3 for more details). In the reminder of the paper, we split specialty trainees in two groups, based on the first three years and the subsequent years of Specialty training. To distinguish between different stages of the Specialty training over time, we compute the cumulative full-time equivalent spent actively into Specialty training.

The final sample consists of 40,954 trainee doctors followed over 8 years, i.e. 1,761,537 observations in total. Summary statistics for the main variables of interest are provided in Table A.1. They are calculated for the period between January 2010 and July 2016, i.e. the "pre-contract period", and separately for each trainee doctor training stage. The first two rows of Table A.1 confirm how - under the 2002 contractual terms - the average trainee doctor used to earn approximately 40% of the basic salary as additional compensation for unsocial work. The average monthly probability of leaving the NHS (defined in Section 3.3 and denoted by Leave) was about 2% during the pre-contract period. Moreover, it was relatively low (high) for Foundation Year 1 (Foundation Year 2) doctors. Not surprisingly, the vast majority of medical trainees is British, followed by overseas and European trainees. Finally, females account for the majority of trainee doctors (58% on average), aged around 27 years old.

Appendix Figure A.4 illustrates the other data sources that we use in this work, and how they are linked to our employment spell panel. The HERMES dataset, collected by Health Education England (HEE) and reporting an annual snapshot of the English NHS hospital workforce, is used to refine the sample of trainee doctors and to attach a Foundation School record to each trainee hospital doctor. Trainee doctors' responses about their satisfaction with pay and intentions to quit are extracted from the worker-level NHS Staff Survey (NSS), the largest survey of healthcare workers' satisfaction in the world, and used as additional dependent variables to explore the mechanisms of our main findings. Finally, risk-adjusted hospital quality measures (30-day mortality rates) for all emergency and planned patients admitted to NHS hospital in each month are computed from the Hospital Episode Statistics Admitted Patient Care (HES APC) dataset. Our risk-adjusted mortality indicators capture patient mortality both inside and outside the hospital, thanks to the linkage between HES APC and the Office for National Statistics (ONS) Civil Registration Deaths dataset.

3.2 Measuring the exposure to unsocial work

The ESR does not record the amount of unsocial working hours. In order to estimate the effect of the 2016 TDC on trainee doctors' retention, we therefore construct a measure of treatment exposure based on the pre-contract pay granted to Foundation doctors as a compensation for the amount of unsocial work hours done. Specifically, until August 2016, trainee doctors were paid a monthly pay supplement on top of their basic salary that depended on (i) the average number of weekly hours worked, and (ii) the number of hours worked during unsocial shifts.[12]

Table 2 summarizes the 7 bands that were applicable to a trainee doctor post under the 2002 contractual terms, together with the associated pay supplement as percentage of the basic salary. The last column confirms that the supplement pay for unsocial work granted by the 2002 contract was significantly higher than that associated with the 2016 contract (see Table 1). For instance, working 48-56 hours per week implied a pay supplement of either 50% or 80% of the basic salary, depending on whether trainee doctors worked more or less than 1 weekend in 3. However, in practice trainee doctors cannot work more than 48 hours a week, unless they opt out from the regulation embedded by the European Working Time Directive. For this reason, our treatment intensity variable is exclusively based on unsocial supplement earnings, which in our period of study mostly varied by the amount of work done during unsocial hours, rather than by the intensity of the working schedule.[13]

Table 2. Unsocial Hours Pay Supplement as a % of Basic Salary (2002 contract)

Band	Hours Worked	Unsocial Degree	Pay Supplement as % of Basic Salary
Band 3	$>$ 56 hours a week		100%
Band 2a	48-56 hours a week	1 weekend in 3	80%
Band 2b	48-56 hours a week	less than 1 weekend in 3	50%
Band 1a	41-47 hours a week	1 weekend in 4	50%
Band 1b	41-47 hours a week	less than 1 weekend in 4	40%
Band 1c	41-47 hours a week	low frequency non-resident on call	20%
No band	$<$ 41 hours a week		0%

We construct a measure of individual exposure to unsocial work in three steps. First, we compute the unsocial earnings share as the ratio between trainee doctors' unsocial supplement pay and their basic salary, in each hospital organization h and calendar month t, i.e.

[12]The terms of the 2002 TDC, along with its amendments, are available at: `https://www.nhsemployers.org/articles/old-terms-and-conditions-service-medical-and-dental-staff`.

[13]Still, subsection 4.2 explores the sensitivity of our results to the role played by a potential confounding factor like the intensity of the working schedule.

$\frac{UnsocialPay_{i,h,t}}{BasicSalary_{i,h,t}}$. Second, for each hospital organization h and month t, we take the median of these ratios among Foundation doctors only, $\overline{UNS}^{FY}_{h,t} = \text{med}(\frac{UnsocialPay^{FY}_{i,h,t}}{BasicSalary^{FY}_{i,h,t}})$. Higher values of this ratio indicate a more unsocial working environment for the hospital trainee doctors in a given month. Third, in order to introduce individual-level variation, we attribute $\overline{UNS}^{FY}_{h,t}$ to each trainee doctor employed at hospital organization h in month t, and then take the average across all the pre-contract monthly observations for each trainee doctor i, which gives:

$$UNS_i = \frac{\sum_1^{\overline{T}} (\overline{UNS}^{FY}_{h,t} * I_i(t))}{\sum_1^{\overline{T}} I_i(t)}, \tag{1}$$

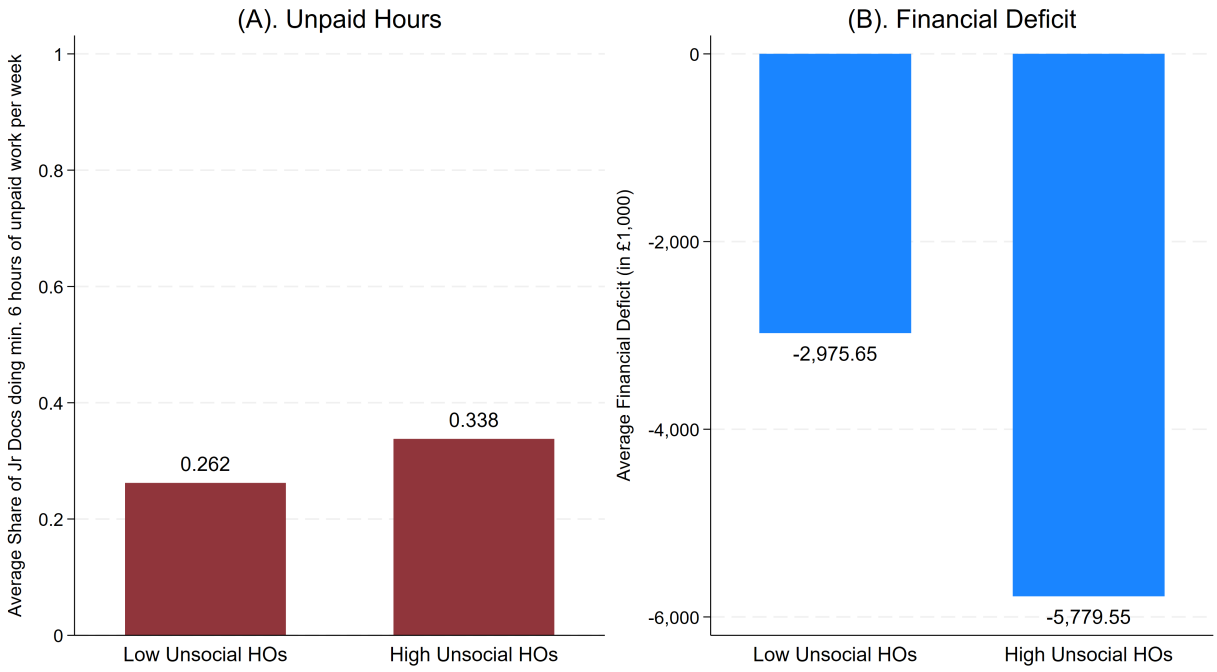
with $I_i(t)$ being an indicator for observing trainee doctor i at time t, $t \in \{1, ..., \overline{T}\}$ and 1 ($\overline{T}$) denoting the first (last) available observation of i before August 2016.

Thus, UNS_i is a measure of exposure to unsocial work in hospital organizations before the introduction of the 2016 TDC. Generally, unsocial work correlates with other working conditions and arrangements that are undesirable from a worker's perspective. For instance, Figure 2 shows that NHS hospital organisations where unsocial work is more common are characterised by a higher share of unpaid work and by larger financial deficits. Hence, more exposed trainee doctors not only had a more demanding schedule in terms of working hours, but they were also less likely to be remunerated for this appropriately.

Our main analysis uses only Foundation doctors to quantify the unsocial work pattern of NHS organizations because, during their Foundation years, trainee doctors are subject to rotas across hospital organizations over which they can exert a very limited choice, if any (see Section 2.3). This approach protects our analysis from the self-selection bias that would arise if it was possible to choose the medical specialty and the hospital organization for the Foundation years rotations freely, as the amount of unsocial work required is heavily determined by the specialty departments which trainees get assigned to (see for instance Figure A.5). This fact is corroborated by Table A.2, which presents balance tests for demographic characteristics between two subgroups of trainee doctors, allocated depending on whether their treatment exposure level lies below or above the median sample value (i.e. 0.418).

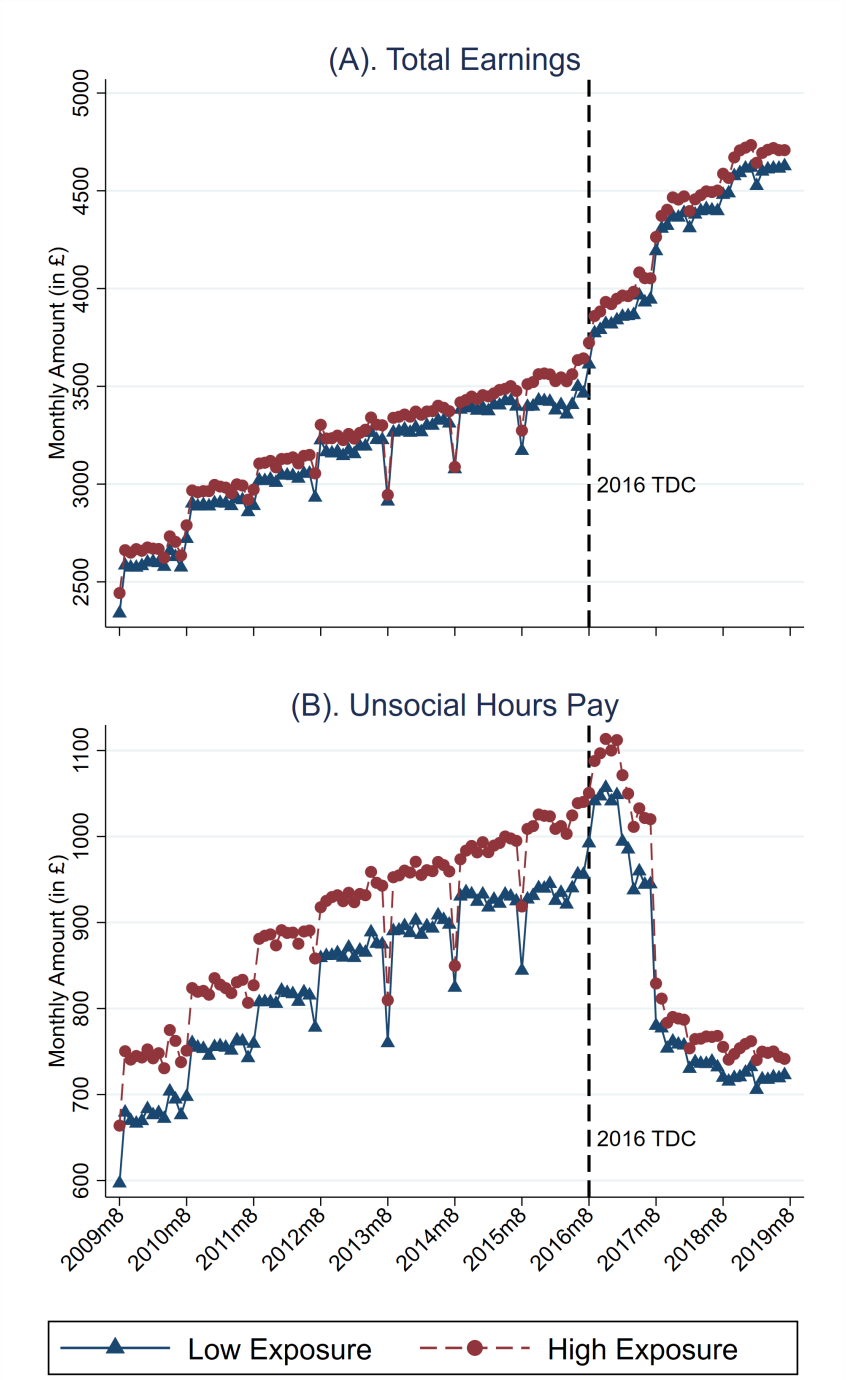
Figure 3 shows that, following the phased implementation of the 2016 TDC completed in August 2017 only, trainees with an unsocial work exposure above the median level experienced a more pronounced reduction in the remuneration for unsocial work (Panel B), although their total monthly earnings continued to be higher than the lower exposed group (Panel A). The pre-reform earnings gap between more and less exposed trainees highlighted by Figure 3 likely represents just a lower bound, because HOs with a high TDs' unsocial

Figure 2. Hospital Organization characteristics by levels of unsocial work



Notes: Low Unsocial HOs are hospital Trusts with a yearly level of unsocial work below the yearly sample median; High Unsocial HOs are hospital Trusts with a yearly level of unsocial work above the yearly sample median. The amount of unsocial work supplied at each HO is defined as the median share of unsocial work earnings among Foundation doctors in a given year. The graphs are produced using data during the period the years 2010-2015, respectively from: the Electronic Staff Records, to classify hospital organisations based on their yearly unsocial work levels; the NHS Staff Survey, to compute the share of trainee doctors doing at least 6 unpaid hours per week; the yearly consolidated NHS Trusts financial accounts, with regards to NHS HOs financial deficit. The final figures reported in the two sub-panels were computed as the grand averages of these yearly variable values, separately for low and high unsocial HOs.

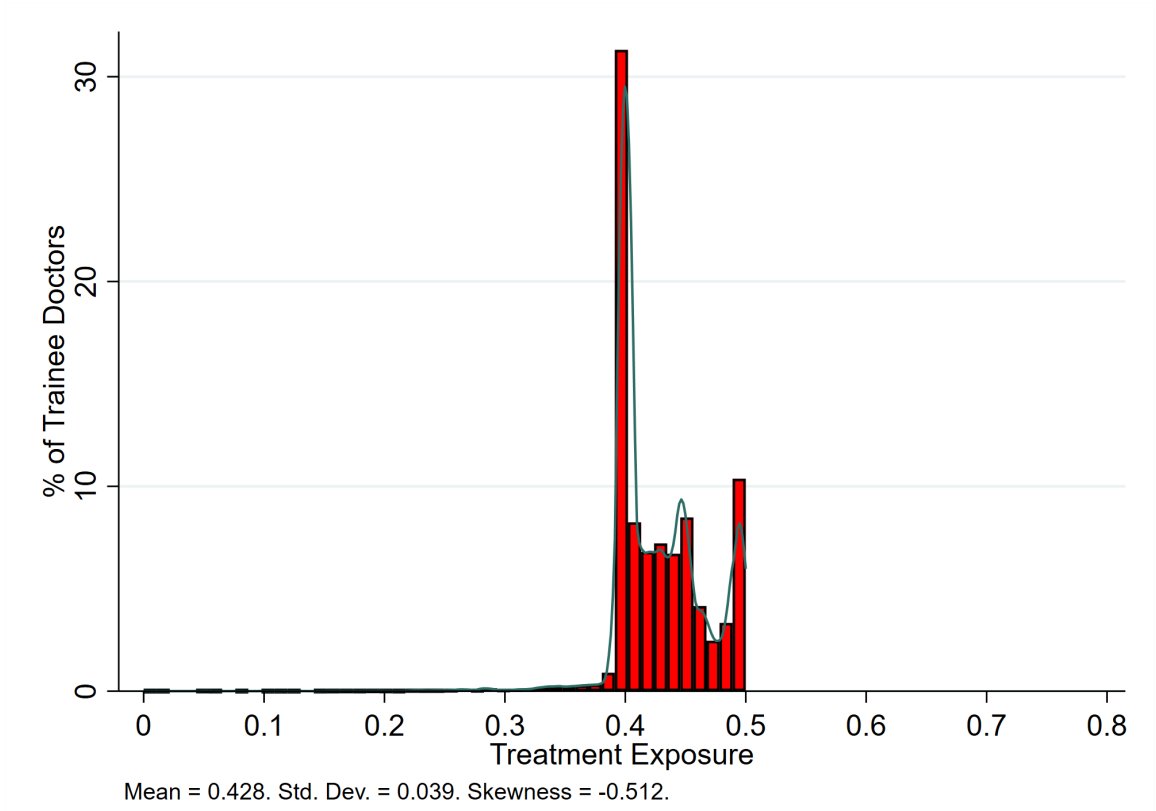
Figure 3. Income penalization by treatment (unsocial work) exposure level



Notes: *Low Exposure*: trainee doctors with a level of treatment (unsocial work) exposure below the median; *High Exposure*: trainee doctors with a level of treatment (unsocial work) exposure above the median. The graphs are produced using only in-sample trainee doctors, namely trainee doctors who entered the NHS as Foundation Year 1 (FY1) and who were already in training prior to the introduction of the 2016 national contract. The trainee doctors' training progression explains the increasing earnings trend displayed by the plot.

work level are also characterized by a higher share of TDs' unpaid work, as documented in Figure 2. Moreover, given that more exposed individuals were enjoying a higher supplement pay for their larger amount of unsocial work, it is reasonable to assume that they valued more this extra reward relative to less exposed peers (Maestas et al., 2023). Hence, despite the increase in basic pay that was common to everyone, we expect that trainee doctors responded regarding their decision to quit heterogeneously. Finally, Figure 4 plots the entire distribution of the treatment exposure variable. Its average value is 0.428, i.e. 42.8% of the basic salary, with a 0.039 standard deviation. The vast majority of trainee doctors records a treatment exposure value between 40% and 50% of the basic salary, respectively corresponding to Bands 1b and 1a in Table 2.

Figure 4. Treatment (unsocial work) exposure distribution



3.3 Empirical Strategy

To study whether the pre-TDC exposure to unsocial work is associated with a post-contract increase in the trainee doctors' leaving rate, we estimate the following linear prob-

ability model (LPM)[14]:

$$L_{iht} = \theta_1 C_t + \theta_2 (C_t * UNS_i) + \beta X_{it} + \alpha_i + \pi_{ht} + \epsilon_{iht}. \quad (2)$$

L_{iht} is an indicator variable equals to 1 if trainee doctor i leaves hospital organization h in month t (for reasons other than death or maternity) and does not reappear in the ESR in the subsequent 6 months. C_t is a dummy for the post-contract period, taking the value of 1 from August 2016 onward. UNS_i is the continuous treatment intensity variable defined in Section 3.2. In this quasi DiD setting, the coefficient of interest, θ_2, measures the effect of the pre-contract exposure to unsocial work on the probability of leaving the NHS after the introduction of the 2016 TDC, provided that the parallel trends assumption holds across all different levels of UNS_i. We also separately investigate whether the 2016 TDC affected the decision to leave the NHS medical training permanently or temporarily.[15]

The set of covariates, X_{it}, includes several controls for potential confounding, which might correlate with both trainees' attrition and the exposure to unsocial working hours. It contains: a polynomial of degree two in age; binary variables controlling for the period when trainee doctors went on strike against the new contract (from January to April 2016). Furthermore, X_{it} includes the interactions between binary variables controlling for the trainees' medical area of specialization in a given month and indicators for the four different grades of the trainee doctor training: Foundation Year 1, Foundation Year 2, Specialty Registrar (first to third year) and Specialty Registrar (fourth to eight year); these interactions allow us to control for the compound, nonlinear effects of training in certain medical specialties on the decision to quit the NHS. X_{it} also includes the interactions between the aforementioned four trainee medical grade categories and binary indicators for the twelve calendar months of the year, in order to capture the different seasonal attrition patterns at various stages of the trainee doctors' training (see Appendix Figure A.6).[16]

Equation 2 includes individual fixed effects, α_i, controlling for unobserved time-invariant trainee-level factors that may correlate with the decisions to leave the NHS. Their inclusion reduces the risk of omitted variable bias in the estimates of interest due to time-invariant

[14]The large sample size, coupled with the presence of high-dimensional fixed effects, does not allow the model to be estimated with nonlinear models for binary outcomes such as logit or probit.

[15]The permanent leave indicator, PL_{iht}, takes the value of one if trainee doctors disappear from the ESR for more than 13 months. On the contrary, we define a training break dummy, TB_{iht}, whenever a trainee doctor disappears from the ESR registry for a period ranging from 7 to 13 months, in order to accommodate the large number of trainee doctors that take a sabbatical before moving into Specialty training (Rimmer, 2017; Torjesen, 2018; Rimmer, 2019).

[16]Appendix Figure A.6 shows that an increasing number of trainee doctors decides to quit the NHS or take a training break after terminating their Foundation Programme. For instance, the share of FY2 doctors that left the NHS for at least 7 months in July 2018 was around 40%.

unobserved heterogeneity. However, we also experiment with the exclusion of α_i from the various model specifications. Instead, π_{ht} are binary variables for the hospital organization h in which trainee doctor i is employed at time t; these dummies serve to account for unobserved labour supply and demand factors that might correlate with the trainee doctors' attrition at the hospital organization level and over the course of trainee doctors' employment in the NHS. Finally, ϵ_{iht} is the error term, assumed to be correlated among trainee doctors that are part of the same training programme. For this reason, Equation 2 is estimated using OLS and with standard errors clustered according to the first NHS hospital organization joined by each trainee doctor.

Identification. The identification of the coefficient of interest, θ_2, stems from the variation in the amount of unsocial work related to trainee doctors' rotations across hospital organizations and medical specialties over time. As explained in subsection 2.3, trainees may express preferences over which medical specialties to rotate - apart from the compulsory rotations in General Medicine and Surgery - but they cannot exert a choice about which hospital organization (within their Foundation School network) they will undergo a given specialty rotation.[17] Thus, two trainee doctors in the same Foundation School might rotate in the same combination of medical specialties during their Foundation Training, but in two different hospital organizations and at different times. The variation over time in terms of resources, staff employed and healthcare demand from patients across different hospital organizations eventually determine the amount of unsocial working hours demanded from trainees. Hence, regardless of the inclusion of trainee fixed-effects α_i, Equation 2 identifies the change in the effect of unsocial working hours measure UNS_i in the post-2016 contract period, based on the rotations of trainee i across a series of hospitals $h = 1, .., H$ and conditional on the included interactions between trainee grades and specialties, and trainee grades and calendar months of the year.

[17] Even when trainees actively choose some of the specialties where they rotate, this self-selection does not affect our results: our sample of trainees includes only those who were admitted to Foundation School up to the year 2015 intake, we measure UNS_i only in the period before the new contractual terms were applied, and before January 2016 the new TDC terms penalizing unsocial hours pay were not known. Hence, trainees could not have self-selected into specialties based on expected gains from the new contractual terms. Moreover, the inclusion of trainee fixed-effects α_i in our preferred specification removes any source of trainee-specific confounding due to unobservable and time-invariant 'taste for unsocial medical specialties' that is systematically correlated with the propensity to leave the NHS.

4 Results

4.1 The effect of the 2016 contract on trainee doctors' attrition

Table 3 reports the estimates of coefficient of interest, θ_2, from the quasi DiD Equation (2), first without (columns 1-3) and then with (columns 4-6) the inclusion of trainee doctor fixed effects α_i.[18] The estimates of θ_2 indicate that higher exposure to unsocial work in the pre-contract period was associated with an increase in the monthly probability of leaving the NHS after the 2016 contractual terms were introduced. The magnitude of $\hat{\theta}_2$ increases by about one third (0.027 versus 0.019) and the fit of the model also improves when individual fixed effects are included.

Table 3. Effect of the 2016 contract on trainee doctors' attrition from the NHS

	(1)	(2)	(3)	(4)	(5)	(6)
	L	PL	TB	L	PL	TB
2016 Contract	-0.009***	-0.007***	-0.002	-0.010***	-0.010***	0.000
	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)
2016 Contract * Unsocial Work Exposure	0.019***	0.013**	0.005	0.027***	0.020***	0.007
	(0.006)	(0.006)	(0.004)	(0.008)	(0.007)	(0.005)
N		40,954			40,954	
N * T		1,761,537			1,761,537	
Individual FE	✗	✗	✗	✓	✓	✓
R-squared	0.187	0.107	0.082	0.216	0.140	0.108

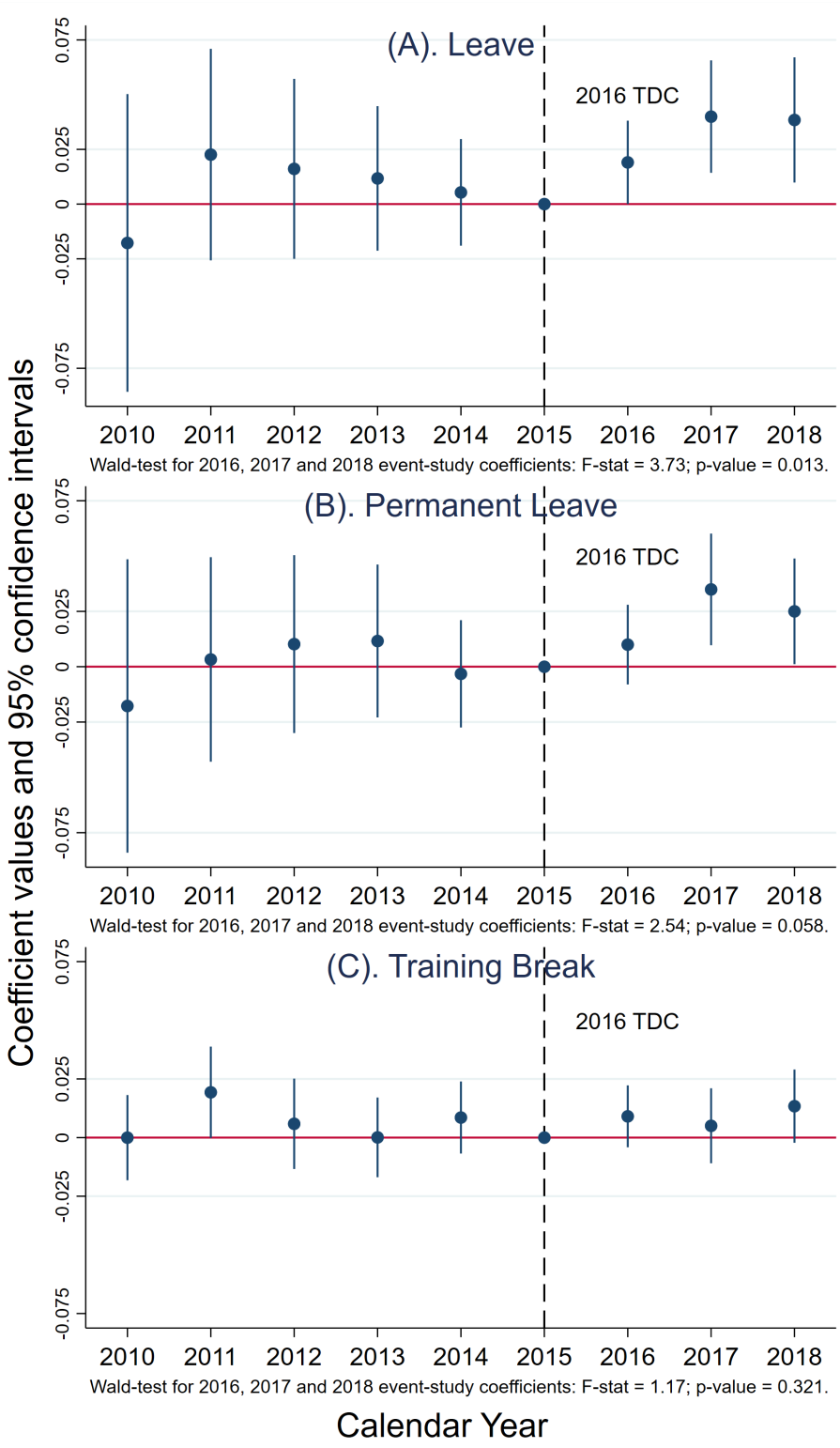
Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 13 months. TB = Leave the ESR for a period ranging between 7 and 13 months. The sample goes from January 2010 to December 2018 and is made of only trainee doctors joining the NHS as Foundation Year 1 under the 2002 contractual terms (i.e. Cohorts 2009-2015). All specifications include: hospital organization fixed effects; interactions of trainee grade categories and calendar month fixed effects; interactions of trainee grade categories and medical specialty fixed effects; a binary variable valued one between January and June 2016 (i.e. trainee doctors' strikes); a polynomial of degree two in trainee doctors' age. The specifications without individual fixed effects (columns 1-3) also include a series of dummy variables controlling for: the first NHS hospital organization entered by trainee doctors; gender; nationality; ethnicity; NHS cohort of entry. N denotes the number of trainee doctors used in the estimation. $N * T$ is the overall number of monthly trainee doctors' records used in the estimation. Standard errors clustered by the first NHS hospital organization joined by trainee doctors are reported in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

Considering that from August 2015 to July 2016 the average monthly trainee doctors' headcount in our sample is 23,835, the estimate at the mean translates into an additional loss of about 275 trainee doctors (=0.428*0.027*23,835) from the English NHS, corresponding to a 6% increase with respect to the 2015 number of quitting trainees (4,549 leavers).

The remaining columns of Table 3 indicate that the 2016 TDC primarily increased the decision to quit permanently the NHS, rather than increasing the instances of temporary breaks from the medical training: the impact of the contract is of 204 (=0.428*0.020*23,835) TDs

[18] In the specification without individual fixed effects, we control for individual-level heterogeneity by including the following time-invariant control variables: dummies for the first NHS hospital organization of employment; gender; nationality; ethnicity; cohort of entry into the NHS.

Figure 5. The effect of the 2016 contract: event-study estimates



lost, or equivalently a 6.7% increase in the number of TDs permanently leaving the NHS in the 12 months prior to the introduction of the contract (3,025 permanent leavers). Although striking, these figures are lower than the trainee doctors' intentions to quit documented by NHS survey data before the approval of the 2016 contract (Kmietowicz, 2015).

We also estimate a dynamic version of Equation 2 using an event-study design, by replacing the post-contract indicator with a set of calendar year dummies. This alternative specification allows us to examine how the introduction of the 2016 contract affected trainee doctors' retention in each year around its implementation date. Moreover, it allows us to control more flexibly for a large set of common shocks that might have affected the retention of all trainee doctors included in our analysis sample, such as the unexpected result of the Brexit referendum held in June 2016, namely a few months prior to the introduction of our policy reform of interest. The estimated coefficients are shown by Figure 5, whereas the point estimates are reported in Table A.3. In all years following the introduction of the 2016 contract, higher exposure to unsocial work is associated with an increase in the likelihood of leaving the NHS. This effect appears to peak in 2017, when the new 2016 contractual terms were fully in place and its transitory phase had expired. Furthermore, the interaction terms over the pre-2016 period are statistically indistinguishable from zero, providing support to the plausibility of the parallel trend assumption.

4.2 Falsifications tests and other robustness checks

Falsification tests. To validate the main findings discussed in subsection 4.1, we perform a series of falsification tests using four alternative estimation samples. First, we verify whether our measure of exposure to unsocial work explains the post-contract probability of leaving the NHS of a group of senior doctors with an age profile similar or close to trainee doctors, but not subject to the 2016 change in their national contractual terms. We construct both a monthly panel of 7,133 senior doctors with up to 5 years of experience in a hospital consultant grade and a separate panel of 5,654 associate specialist and specialty (SAS) doctors. Both these hospital physician categories represent the natural professional progression of a NHS trainee doctor.

The senior doctors' monthly ESR records are matched with the median share of unsocial supplement pay among Foundation doctors in the same hospital organization where senior doctors are employed. We then compute the pre-reform exposure UNS_i as the average of these monthly median values for each senior doctor in each of the aforementioned two categories. We then estimate our baseline specification, Equation 2, using these alternative samples. The results, reported in Panel A of Table 4, show that the pre-contract exposure to

unsocial work did not affect the likelihood of leaving the NHS for either group of early-career senior hospital doctors. Moreover, most of the θ_2 estimates are negatively signed.

Table 4. Falsification tests for the 2016 contract effects on TDs' NHS leaving decision

	Consultants			SAS		
	(1)	(2)	(3)	(4)	(5)	(6)
	L	PL	TB	L	PL	TB
Panel A: Senior doctors						
2016 Contract	0.003	0.001	0.001	0.003	0.003	0.000
	(0.003)	(0.003)	(0.001)	(0.004)	(0.004)	(0.001)
2016 Contract * Unsocial Work Exposure	-0.005	-0.003	-0.003	-0.005	-0.006	0.001
	(0.007)	(0.007)	(0.002)	(0.010)	(0.009)	(0.003)
N		7,133			5,654	
N * T		288,388			173,501	
R-squared	0.107	0.108	0.069	0.102	0.104	0.085
	2012 Contract			2013 Contract		
Panel B: Contract date						
Placebo Contract	0.005	0.006	-0.001	-0.001	0.002	-0.003
	(0.005)	(0.005)	(0.003)	(0.005)	(0.005)	(0.002)
Placebo Contract * Unsocial Work Exposure	-0.007	-0.001	-0.006	0.005	0.001	0.004
	(0.012)	(0.011)	(0.006)	(0.012)	(0.012)	(0.006)
N		17,452			22,717	
N * T		713,896			874,773	
R-squared	0.198	0.131	0.099	0.208	0.136	0.105

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 13 months. TB = Leave the ESR for a period ranging between 7 and 13 months. All specifications include: hospital organization fixed effects; interactions of trainee grade categories and calendar month fixed effects; medical specialty fixed effects; a polynomial of degree two in doctors' age. Panel A specifications included a binary variable valued one between January and June 2016 (i.e. trainee doctors' strikes). The specifications in columns 1-3 of Panel A are estimated using a sample of senior doctors who entered a consultant post no longer than 5 years before. The specifications in columns 4-6 of Panel A are estimated using a sample of associate specialist and specialty (SAS) doctors. The specifications in Panel B are estimated using trainee doctors' ESR records from August 2009 to July 2014, using the period from August 2012 to July 2014 (columns 1-3) or from August 2013 to July 2014 (columns 4-6) as placebo post-contract period. N denotes the number of doctors used in the estimation. $N * T$ is the overall number of monthly doctors' records used in the estimation. Standard errors reported in parenthesis are clustered by current NHS hospital organization (Panel A) or first NHS hospital organization joined by trainee doctors (Panel B). Significance levels: * 0.1; ** 0.05 *** 0.01.

Panel B of Table 4 provides the results for another set of falsification tests, in which we backdate the trainee doctors' contract change date: we estimate Equation 2 on a sample of trainee doctors from August 2009 to July 2014, with the post-contract period spanning from either August 2012 to July 2014 (columns 1-3) or from August 2013 to July 2014 (columns 4-6). For consistency, the treatment exposure variable of these specifications is respectively defined on the two alternative placebo pre-contract periods (i.e. from January 2010 to July 2012 and from January 2010 to July 2013). Once again, we find no significant effect of the 2016 TDC on NHS trainees' attrition. These falsification exercises confirm that our baseline

analysis identifies the effect of the 2016 contract on trainee doctors' retention, rather than that of unsocial work exposure per se.

Hours worked. We also check whether our results could be explained by the different intensity of the workload that trainee doctors were exposed to before August 2016, rather than its unsocial degree. As mentioned in Section 3.2, the amount of unsocial income earned up to August 2016 was related not only to unsocial work shifts, but also to the number of additional hours worked (see Table 1 and Table 2). To assess this potential confounding effect, we define the variable $Hours_i$ by following the same approach described in Section 3.2 for defining UNS_i. Thus, $Hours_i$ measures the pre-contract work intensity that trainee doctors experienced until August 2016, by using the amount of hours worked by hospital organization peers at the Foundation training stage. Then, the interaction between this continuous variable and the 2016 contract dummy is included in Equation 2 as an additional control, to capture the effect of work intensity on trainee doctors' leaving rate.

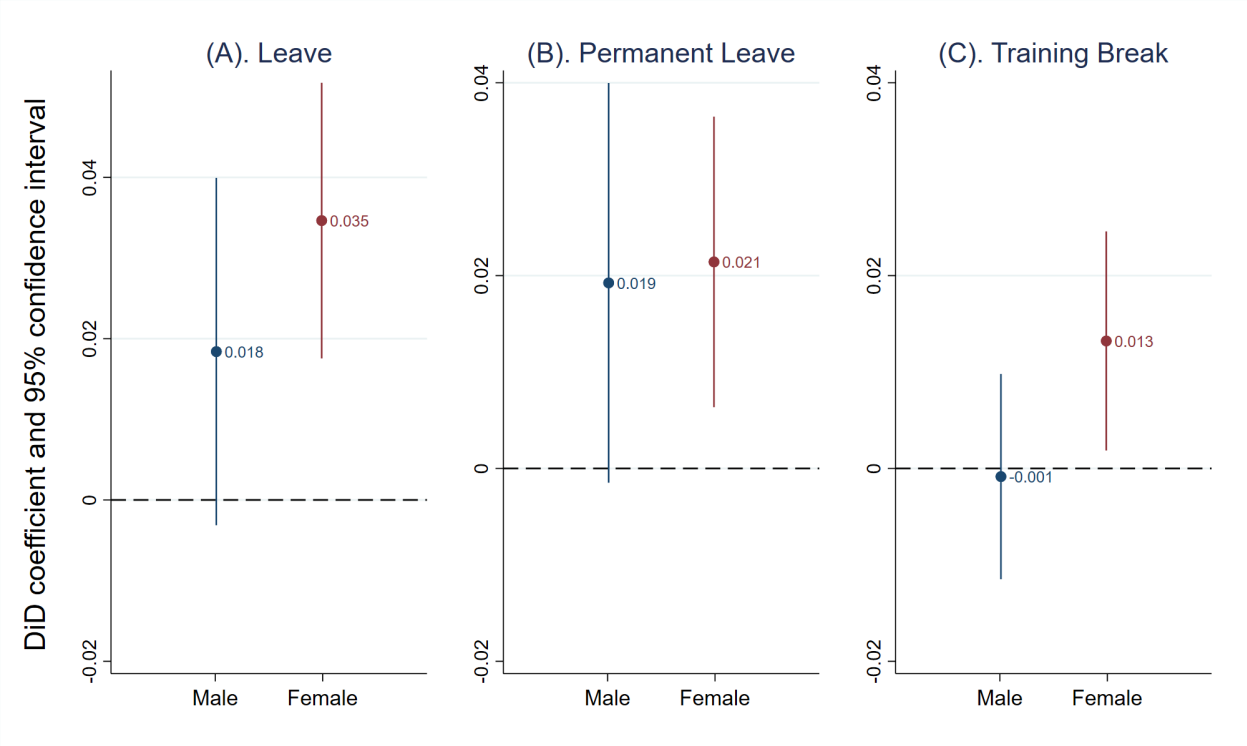
The results of this specification are provided in Table A.5. The coefficients for the added work intensity proxy are statistically significant across all columns, but negative. This might be explained by a higher attachment to work (thus fewer NHS leavers) in hospital organizations characterized by high intensity of work. The fact that the coefficient of interest θ_2 remains statistically significant and in line with the main estimates in Table 3 reassures that the effect of interest on trainees' attrition from the NHS is not driven by the intensity of their working schedule.

Gender heterogeneity. By reducing the pay for unsocial working hours, the 2016 Trainee Doctor Contract had been criticized prior to its approval for the possibility to disproportionately affect female trainees (Harries et al., 2015; Rimmer, 2015, 2016). The provision of work during unsocial hours has evident opportunity costs with respect to caring duties, for either children or the elderly, which are more frequently performed by women (Foley et al., 2023). To test this hypothesis, we estimate Equation 2 separately for male and female trainee doctors.

The key findings, summarized by Figure 6, suggest that female trainee doctors were indeed more likely to leave the NHS when exposed to more pre-reform unsocial work, after the introduction of the 2016 contract: the θ_2 point estimate is 0.035 for female trainees and 0.018 for male ones (see panel A of Figure 6).[19] This difference, however, appears primarily driven by the decision to take a break from the NHS medical training (panel C of Figure 6). A Wald test between the male and female DiD interactions in a fully-interacted model by

[19]The point estimates are provided in Panel A of Table A.4.

Figure 6. Gendered effects of the 2016 contract on trainees' attrition from the NHS



gender of our baseline specifications rejects the null of equal effects on the likelihood of a career break, whereas we do not find any statistically meaningful difference in terms of the probability of a permanent quit.

In Panel B of Table A.4 we further analyze these gendered effects by interacting the effect of interest with a dummy for part-time employment, which takes value one if the mode of trainee doctors' appointment in the pre-contract period was a part-time position; the results do not document notable differences between full-time and part-time trainee doctors, as the coefficient of interest interacted with the part-time dummy is not significant.[20]

Additional analyses. The identification strategy outlined in sub-section 4.1 relies on two main assumptions. First, it requires parallel trends to hold across the distribution of UNS_i during the entire pre-contract period. Intuitively, this condition imposes that exposure to unsocial work should not be correlated with trends in trainees' NHS attrition. Second, it assumes that trainee doctors highly exposed to unsocial work prior to the 2016 reform were more penalized by the new contractual terms. This section provides further evidence in support of these assumptions, by reporting the results of two specifications that use only pre-treatment employment records.

[20]The part-time sample excludes trainee doctors on parental leave, recorded by the ESR as part-time trainees.

Table A.6 displays the estimates of a linear specification in which the individual exposure to unsocial work is interacted with either a monthly (Panel A) or a yearly (Panel B) time trend. None of the interactions terms is statistically significant. This finding shows that exposure to unsocial work during the pre-contract period was not correlated with trends in NHS attrition rate, thus providing evidence in support of the parallel trend assumption on top of Figure 5.

Table A.7 reports estimates of a linear specification testing the association between the amount of unsocial earnings as a share of basic pay during the Foundation training years and the same pay measure during the first year of Specialty training. Columns 1 and 3 show a significant association in the pay for unsocial work across different stages of the trainee doctor training. An even stronger association is documented for hours worked across these two periods (Columns 2 and 4). These findings are suggestive of the persistence in working patterns from the Foundation training period to the medical specialization period. Indeed, it is likely that a substantial share of trainee doctors originally assigned to specialties with more unsocial work continue their training in such specialties even after the Foundation years, or they would otherwise risk losing (or, at the very least, not putting to fruition) the human capital related to the specific on-the-job training that they acquired. Consequently, trainee doctors who were particularly exposed to unsocial work under the 2002 trainee contract might have been more penalized, or might have reasonably felt to be more penalized in the near future, by the introduction of the 2016 contractual terms, which would explain the existence of a scarring or outrage effect that increased trainee doctors' attrition from the NHS.

5 Mechanisms: pay satisfaction and intentions to quit

To understand the behavioural mechanism explaining the post-2016 contract increase in the trainee doctors' leaving rate, we exploit data from the annual NHS Staff Survey (NSS), the largest repeated healthcare workforce survey in the world, which is carried out each year, from September to November, across all NHS HOs. The NSS allows us to test whether and to what extent the introduction of the 2016 pay terms were satisfactory for trainee doctors employed by hospital organisations with different unsocial work demands. As the yearly responses to the NSS are pseudonymized, we cannot directly link them to the trainee doctors' employment spells from the ESR. However, by using worker-level NSS data, we are able to measure trainee doctors' pay satisfaction in each hospital-year pair, which is impossible to do with the publicly available NSS data because the responses for trainee and senior doctors are reported altogether in this reporting format.

We extract all trainee doctors' NSS records from 2009 to 2019 and, based on the trainee doctors' hospital organization of employment in each year, we match the survey responses with the Foundation doctors' median share of unsocial work earnings between August 2015 and July 2016. For those hospital organisations that did not have any Foundation doctor over the 12-month window prior to the introduction of the 2016 contract, we compute the median share of unsocial work earnings of the specialty doctor trainees employed there. The item of interest in the NSS questionnaire about pay satisfaction is expressed on a Likert scale from 1 (very unsatisfied) to 5 (very satisfied), therefore we estimate an ordinal logit model (including hospital organization fixed effects) with the interaction between the proxy for the hospital-level amount of unsocial work described above and a post-reform dummy (valued one from 2016 onwards), as the main covariate of interest.[21]

The results of this exercise are reported in Column 1 of Table 5. The coefficient associated with the DiD interaction term is negative and statistically significant. Hence, trainee doctors' satisfaction with pay significantly decreased after the introduction of the 2016 contract in hospital organisations with more unsocial work. This finding is further supported by the remaining estimates reported in Table 5, which - similarly to the results discussed in subsection 4.2 - consists of a series of falsification tests. In Column 2, the pay satisfaction outcome is measured from the universe of senior doctors who responded to the NSS. Instead, Columns 3 and 4 provide results on the effects of the 2016 contract on trainee doctors' pay satisfaction using two alternative placebo contract change dates; this analysis uses a sample of NSS records from 2009 to 2015, i.e. the pre-contract period: the post-contract period is defined as the years from 2012 to 2015 in the model reported in Column 3, and as the years from 2013 to 2015 in the analysis summarised in Column 4. The value of the hospital organization exposure thus changes accordingly, as it always gets computed in the 12 months prior to the placebo treatment date (i.e. from August 2011 to July 2012 in Column 3 and from August 2012 to July 2013 in Column 4). None of these three falsification checks results in statistically significant effects on pay satisfaction. The findings summarised in Table 5 are therefore consistent with the our hypothesis that NHS TDs attributed a high value to the work provided during unsocial hours or its opportunity-costs (Maestas et al., 2023), and suffered a disutility from the devaluation in their unsocial hours pay brought by the 2016 TD contract (Lazear and Shaw, 2007).

Since 2018, the NSS data include also detailed information on NHS hospital workers' intention to quit either the NHS or the HO where they are employed, which allows us

[21] The model also controls for trainee doctors' gender and age, respectively using a female dummy and 3 age group dummies for being younger than 31, aged 31-40 and older than 40; the estimation sample excludes trainees with missing information on gender and age, resulting in a loss of 1,776 observations (3.8% of the total).

Table 5. Effect of the 2016 contract on trainee doctors' satisfaction with pay

	Outcome: Pay satisfaction			
		Falsification tests		
	Junior Doctors	Senior Doctors	Placebo Contract Date 1	Placebo Contract Date 2
	(1)	(2)	(3)	(4)
2016 Contract * HO Unsocial Work	-0.551***	0.026	0.074	-0.411
	(0.208)	(0.105)	(0.428)	(0.434)
N * T	44,633	151,103	16,097	15,936

Notes. Ordinal logit individual-level model estimates for satisfaction with the level of pay. Unsocial work is computed as the hospital organisation's median share of unsocial work earnings among Foundation doctors (if present, otherwise among specialty trainees) over the 12 months prior to the 2016 contract reform. The sample used for the placebo contract date falsification tests goes from 2009 to 2015 included. The placebo contract date change is 2012 in Column 3 and 2013 in Column 4. Controls included but omitted from the table: an indicator variable for female trainees and three age indicator variables (younger than 30, aged 31-40, older than 40). The age controls for the senior doctors' model are the following three indicators: younger than 40, aged 41-50, older than 50. Standard errors are clustered at the hospital organisation level. Significance levels: * 0.1; ** 0.05 *** 0.01.

to study how the introduction of the 2016 contract affected TDs' intentions to quit their jobs. For this sake, we use the 2018 cross-sectional NSS data at individual doctor level to investigate how the intention to quit the current employment correlates with both pay satisfaction and the amount of unsocial work that was typically carried out at the hospital prior to the 2016 reform. Column 1 of Table 6 reports a significantly negative association between the TDs' intention to look for a job in a new organisation in the next year and a binary variable equal to one when a TD is satisfied with the level of pay. As shown by the coefficient reported in Column 2 of Table 6, the intention to look for a new job over the next 12 months is positively associated (significant at 10%) with the amount of unsocial work provided to the HO in the 12 months prior to the introduction of the 2016 contract. Furthermore, Column 3 shows that the positive association between unsocial work and the intention to look for a new job is stronger in magnitude and more precise for TDs who were consecutively employed by the same HO for longer than one year.[22]

Finally, the last three columns of Table 6 provide the results of a multinomial logit regression investigating the desired employment destinations for the TDs who considered leaving their current job, as a function of the amount of unsocial work provided at each HO before the introduction of the 2016 contract. The estimates are reported in three different

[22]By splitting the 2018 trainee doctors based on the length of their tenure we are able to identify a subgroup of TDs who, during the transition to the new national contract – between August 2016 and August 2017– were likely still employed by the same HO for which their pre-reform exposure to the 2016 contractual terms is measured, as opposed to a subgroup of TDs who joined the employer HO in 2018, following a scheduled training rotation.

Table 6. Unsocial work, pay satisfaction and intentions to quit

	Ordinal Logit: "I will probably look for a job at a new organisation in the next 12 months"			Multinomial Logit: "If you are considering leaving your current job, what would be your most likely destination?"		
	All Junior Doctors	All Junior Doctors	All Junior Doctors by tenure	Career Break	Leavers outside healthcare	Leavers towards non-NHS organisation
	(1)	(2)	(3)	(4a)	(4b)	(4c)
Pay Satisfaction	-0.783***					
	(0.041)					
Unsocial Work		0.694*				
		(0.386)				
Unsocial Work * Employed by HO for less than 1 year			0.563	-0.197	1.047	-0.977
			(0.407)	(0.911)	(1.015)	(0.652)
Unsocial Work * Employed by HO for longer than 1 year			0.836**	1.019	2.187**	-0.173
			(0.392)	(0.944)	(0.966)	(0.646)
N * T	7,066	7,107	6,938		6,060	

Notes. Ordinal logit model estimates for trainee doctors' intention to look for a new job and multinomial logit estimates for trainee doctors' likely destination if considering quitting job. All models use trainee-level data for 2018 only, when NSS questionnaire items about intentions to quit become available for the first time. Unsocial work is computed as the hospital organisation's median share of unsocial work earnings among Foundation doctors (if present, otherwise among specialty trainees) over the 12 months prior to the 2016 contract reform. Controls included but omitted from the table: an indicator variable for female trainees and three age indicator variables (younger than 30, aged 31-40, older than 40). Standard errors are clustered at the hospital level. Significance levels: * 0.1; ** 0.05 *** 0.01.

columns (4a-4c), but they are produced from the same multinomial logit regression having the group of trainees who did not consider leave the NHS hospital sector in 2018 as the reference outcome category.[23] According to the estimates, more unsocial work prior to the 2016 reform means higher intention to quit the current job and to leave the healthcare sector completely, especially among those trainees that in 2018 were employed by the same HO for longer than one year (Column 4b). For the same subgroup of trainees, unsocial work is positively associated also with the intention to take a career break, although this effect is not statistically significant (Column 4a). Overall, the analyses provided in this section suggest that the 2016 contractual terms for NHS TDs reduced pay satisfaction in HOs where unsocial work was more common; in turn, it is likely that the decreased pay satisfaction increased TDs' intention to quit their current employment and to look for a job outside healthcare.

6 Trainee doctors' attrition and hospital quality

Evidence from the US suggests that increased staffing levels and lower nurse turnover improve patient outcomes and reduce hospital mortality (Lin, 2014; Akosa Antwi and Bowblis, 2018). Our results in Sections 4 and 5 show that the 2016 TDC reform has increased trainee doctors' attrition rate; a natural and related research question is whether such attrition af-

[23]The reference category of the multinomial logit regression reported in Columns 4a-4c of Table 6 is made by TDs who either do not consider leaving their job at all or who consider leaving their job for a new job either in the same or in a different NHS hospital organisation.

fects hospital quality, and how. To this end, we link the ESR employment spell records with the HERMES dataset and Hospital Episodes Statistics (HES), in order to assess whether TDs' attrition is associated with lower quality of patient care. We carry out this analysis by employing the quasi-DiD regression Equation 2 as a first stage, in the same spirit of Duflo (2001) but using a two-step control function (CF) approach (Terza et al. 2008) instead of an instrumental variable approach, given the need to account for the non-negativity of the hospital mortality outcome variable by using a non-linear regression model.[24] The empirical research question that we can and seek to answer here is not whether the changes in trainee attrition driven by the 2016 TDC led to changes in hospital mortality, but whether what is the unbiased association between TDs' attrition and hospital mortality, after employing the CF strategy to control for the endogeneity bias of leaving due to reverse causality – i.e. TDs leaving the NHS due to high mortality in the HOs where they rotated. Trainee doctors' attrition rate is potentially endogenous, as it may be driven by hospital mortality or by time-varying unobservable factors that are correlated with hospital mortality. By including the unexplained, idiosyncratic part of TDs' attrition rate, and exploiting the exogenous variation induced by the the 2016 TDC, we obtain a correlation measure between hospital mortality rates and NHS trainee doctors' attrition that is plausibly purged of confounding factors and that exclusively relates to the systematic component of the TDs' attrition rate, i.e. the part of the attrition that is largely predictable by healthcare commissioners and hospital managers. Thus, we operate the following procedure.

Initially, we predict the error residuals, $\hat{\epsilon}_{iht}$, from the baseline model estimates of Equation 2. For each calendar month of our sample, this term absorbs any unobserved determinant of TDs' NHS attrition rate. Next, we aggregate these residuals and the observed monthly trainee doctors' NHS leaving rate according to the NHS Foundation School that each hospital belongs to, because TDs primarily rotate across hospital organizations within the same Foundation School.[25] This estimation step provides us with the average level of TDs' attrition rates and the average unexplained or idiosyncratic attrition rates (captured by Equation 2 regression residuals), both measured at the Foundation School level.

Then we compute 30-day risk-adjusted hospital mortality rates for three categories of patients (all-cause of admission; emergency admissions only; planned admissions only) in

[24]The 2016 TDC had an effect not only on the TDs' labour supply extensive margins (i.e. their NHS attrition rate), but also on trainees' pay satisfaction, which is measured by survey responses from the TDs who did not quit. If TDs' labour supply has had both direct and indirect effects on hospital quality, we cannot employ either instrumental variables or difference in differences strategies, as both the exclusion restriction and Stable Unit Treatment Value assumptions respectively would be violated.

[25]Due to rotations, TDs' attrition in month $t-1$ can affect any hospital within a given Foundation School group, depending on whether the trainee is scheduled to remain in the same hospital of rotation or they are due to move to a different HO in month t.

each NHS acute care HO and month.[26] Effectively, this outcome variable counts the number of deaths recorded by a hospital every 100 monthly inpatient admissions, accounting for the idiosyncratic mortality risk of each admitted patient as of predicted by a series of observable characteristics. We then match these risk-adjusted hospital quality indicators with the corresponding lagged trainee doctors' NHS attrition rates at the Foundation School level.

Finally, given the non-negative nature of the mortality rate outcome variable, we estimate the following fixed-effects Poisson regression:

$$\mathbb{E}(MORT^{j}_{h,t}|X_{h,t}) = exp\Big\{\zeta_1 L_{d,t-1} + \zeta_2 \hat{\epsilon}_{d,t-1} + \pi_d + year_t + month_t\Big\}, \tag{3}$$

where: $MORT_{h,t}$ indicates the mortality rate (ranging from 0 to 1) j at hospital h in month t, where $j = \{\text{Any Cause, Emergency, Planned}\}$; $L_{d,t-1}$ is the average trainee doctors' leaving rate (ranging from 0 to 1) for Foundation School d in month $t-1$; $\hat{\epsilon}_{d,t-1}$ are the average estimated NHS leaving rate residuals (ranging from 0 to 1) for Foundation School d in month $t-1$; π_d are hospital fixed effects, whereas $year_t$ and $month_t$ are year and month effects, respectively. The model is estimated via Quasi-Maximum Likelihood (QMLE), with standard errors that are clustered at the hospital level and obtained via 1,000 boostrap replications.

Table 7 displays the Poisson semi-elasticity estimates from Equation 3: the mortality rates for both all and emergency patients are positively associated with the lagged observed trainee doctor leaving rates, regardless of whether we include the estimated first-step residuals as a control covariate in the model (Columns 4-6) or not (Columns 1-3). However, these positive associations are stronger in magnitude and become statistically significant only after the inclusion of the TDs' attrition residuals. This finding confirms the initial suspicion that the naïve association between the observed trainee leaving rate and hospital mortality rates might be downward biased and substantially underestimate the magnitude of the association of interest. Column 5 suggests that a percentage point increase in the trainee doctors' leaving rate is associated with 1.5 additional deaths every 100 emergency patients ($e^{0.405}/100$) on average. Instead, we do not find any significant association between planned patients'

[26] We compute 30-day risk-adjusted hospital mortality rates following a very similar methodology to the one used by NHS Digital (NHS Digital, 2023). Differently from NHS Digital method, we produce monthly (not yearly) risk-adjusted hospital mortality rates, after estimating separate logistic regression for each financial year of the sample, and then generating monthly risk-adjusted HO mortality predictions for the different months in the same financial year. In the logistic regression, the binary outcome is patient mortality, in or outside the hospital, within 30 days from hospital admission; the mortality predictors used in the risk-adjustments are patient gender, age. Charlson co-morbidity index and month of admission. The monthly risk-adjusted HO mortality rate is computed as the ratio between the number of observed and predicted deaths, rescaled by the average mortality rate across all HOs in a given calendar month of the same financial year.

Table 7. Association between trainee doctors' attrition and hospital risk-adjusted mortality

	30-day Risk-Adjusted Mortality					
	Any Cause (1)	Emergency (2)	Planned (3)	Any Cause (4)	Emergency (5)	Planned (6)
Lagged NHS Leaving Rate	0.086	0.086	0.214	0.245**	0.405***	0.597
	(0.053)	(0.064)	(0.224)	(0.097)	(0.128)	(0.402)
Lagged Residuals				-0.288**	-0.587***	-0.701
				(0.136)	(0.180)	(0.590)
Average mortality	0.026	0.041	0.004	0.026	0.041	0.004
Average NHS Leaving Rate	0.015	0.015	0.015	0.015	0.015	0.015
N	166	166	166	166	166	166
N * T	16,054	16,015	15,982	16,054	16,015	15,982

Notes. Poisson semi-elasticities measuring the association between hospital risk-adjusted mortality rates at time t and the average trainee doctors' attrition (at the Foundation School level) at time $t-1$. The lagged residuals term corresponds to the average (at the Foundation School level) residuals ϵ_{iht} estimated from our baseline trainee-level linear probability model for leaving the NHS, Equation 2. Standard errors are clustered at the hospital level and obtained via 1,000 bootstrap replications. Significance levels: * 0.1; ** 0.05 *** 0.01.

mortality and trainee doctors' attrition. Hence, the analysis summarised in Table 7 provides suggestive evidence that higher trainee doctor attrition might be detrimental, at least for the quality of care provided to hospital patients admitted with an emergency condition, who indeed may be the class of patients whose health status is more responsive to a decrease in hospital staff levels.

7 Conclusions

Setting an optimal pay structure is critical for the smooth delivery of quality public healthcare services. Organizations need to decide about the compensation package they should offer to their employees, while both securing their effort and meeting their participation constraints (Dixit, 2002). Hence, the evaluation of employee responsiveness to pay conditions using organization-specific quasi-natural experiments or sources of plausible exogenous variation, as suggested by Lazear and Shaw (2007), is crucial to inform whether the chosen pay structure is successful or not, and what are the implications for employee retention and the delivery of services.

In this paper we exploit a reform that restructured the remuneration scheme of trainee doctors working in English NHS hospitals. The new national contract implemented in August 2016 severely reduced their pay for work provided during unsocial shifts, which are frequent and a necessary work commitment for physicians choosing to pursue a career within hospital care. We provide the first evidence of the impact of this reform on the attrition of trainee doctors from the NHS and their pay satisfaction, and then we exploit the exogenous variation

in the trainee doctors' leaving rate to analyze the relationship between trainee doctors' attrition and hospital quality.

Pay terms that lower the relative compensation for unappealing job aspects, such as unsocial work shifts, are known to affect both the decision to quit and the performance of workers (Lazear and Shaw, 2007). Quite consistently, our estimates suggest that the introduction of the new contract caused a significant increase in the probability to quit the NHS, i.e. a 6% increase with respect to the figures in the year before the reform, which translates into an additional loss of 275 trainee doctors – 204 of whom permanently quit the NHS. These results are robust to various model specifications and falsification tests. Moreover, we show that this attrition effect most likely stems from a significant reduction in the pay satisfaction of NHS trainee doctors, induced by the 2016 contractual terms, which ultimately also increased NHS trainee doctors intentions to quit their current job and switch to alternative occupations outside healthcare. With regards to hospital quality, our results also suggest the attrition rate of hospital trainee doctors is positively associated with the mortality rates of emergency patients, and that this relationship is considerably understated if the endogeneity of trainees' attrition is not accounted for.

Given the ongoing shortage of healthcare workers in the English NHS and the stated objective of the reform to make the delivery of care smoother, our findings on the detrimental effects of the 2016 trainee doctors' contract have significant policy implications. On a general level, when designing contractual changes for key groups of employees in the public service, policy-makers should take into account a set of high-level considerations, possibly not limited to or driven exclusively by cost-effectiveness motives. Working conditions and pay contractual terms do matter for the retention of public sector workers, such as hospital doctors, and must be fine-tuned in jobs that entail critical issues with respect to important aspects such as work-life balance, work stress, low pay for the amount of work provided and long training periods to accumulate human capital. Distributional changes in extrinsic rewards may affect labour supply if workers experience negative changes in the job attributes to which they attach a higher value or opportunity cost; in fact, we find evidence of negative effects on trainee doctors' retention within the NHS and also their pay satisfaction.

With specific regards to healthcare workers, policy-makers should carefully consider how to maintain, develop and attract an adequate stock of human capital within the national healthcare system. This aspect is even more important in healthcare settings like the English NHS, where pay is centrally regulated and healthcare professionals have become less mobile because of tighter immigration policies, including Brexit. As our findings show, it is likely that the retention of any clinical worker matters for preserving an adequate level of hospital quality: hospital patient mortality is positively associated with the attrition of trainee

doctors, even though these physicians do not carry the direct responsibility for patients' care, which is ultimately tasked to senior hospital doctors. Therefore it is desirable that, in the design of contractual arrangements concerning healthcare workers, policy-makers device terms and incentives apt to improve the job satisfaction and retention of the clinical workforce, including trainee doctors: both the quality and the sustainability of public healthcare systems may crucially depend on this.

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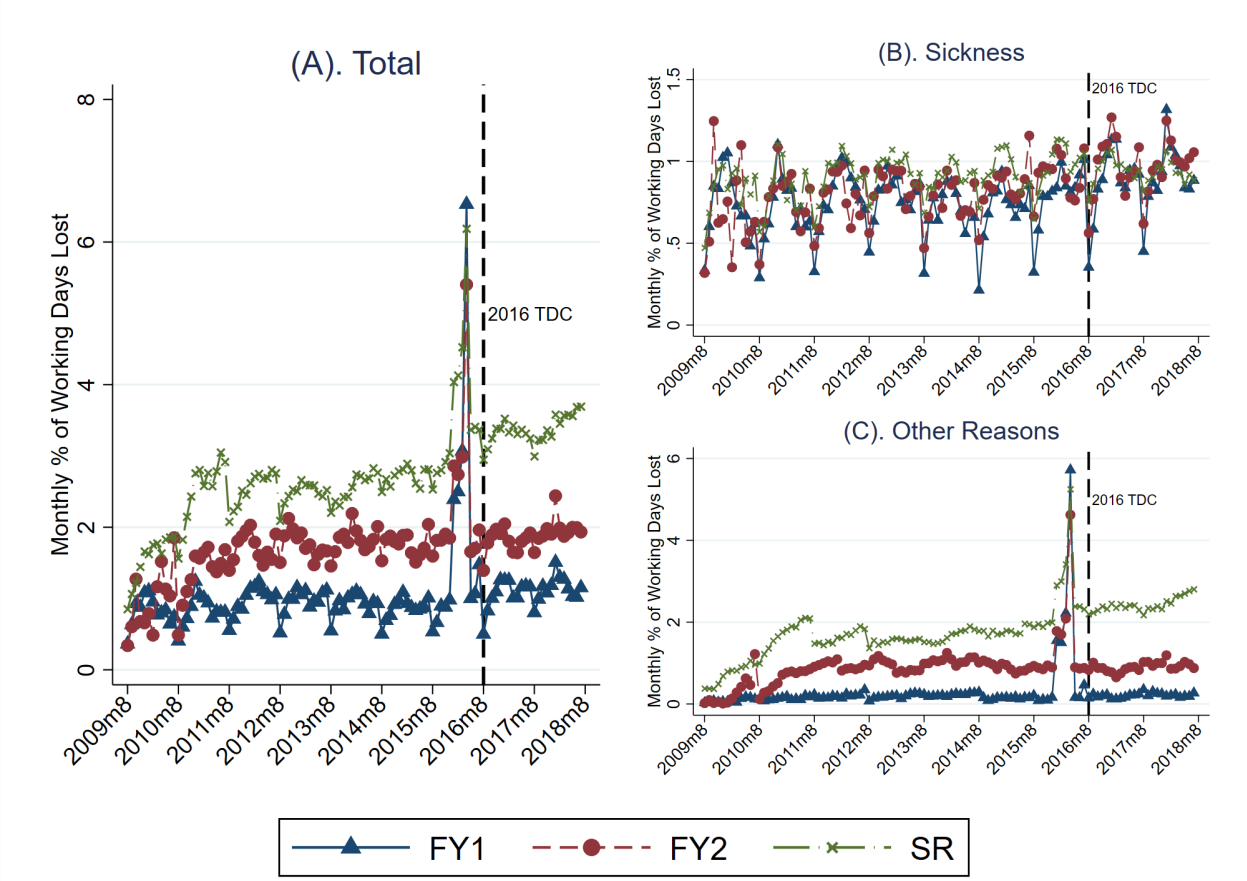
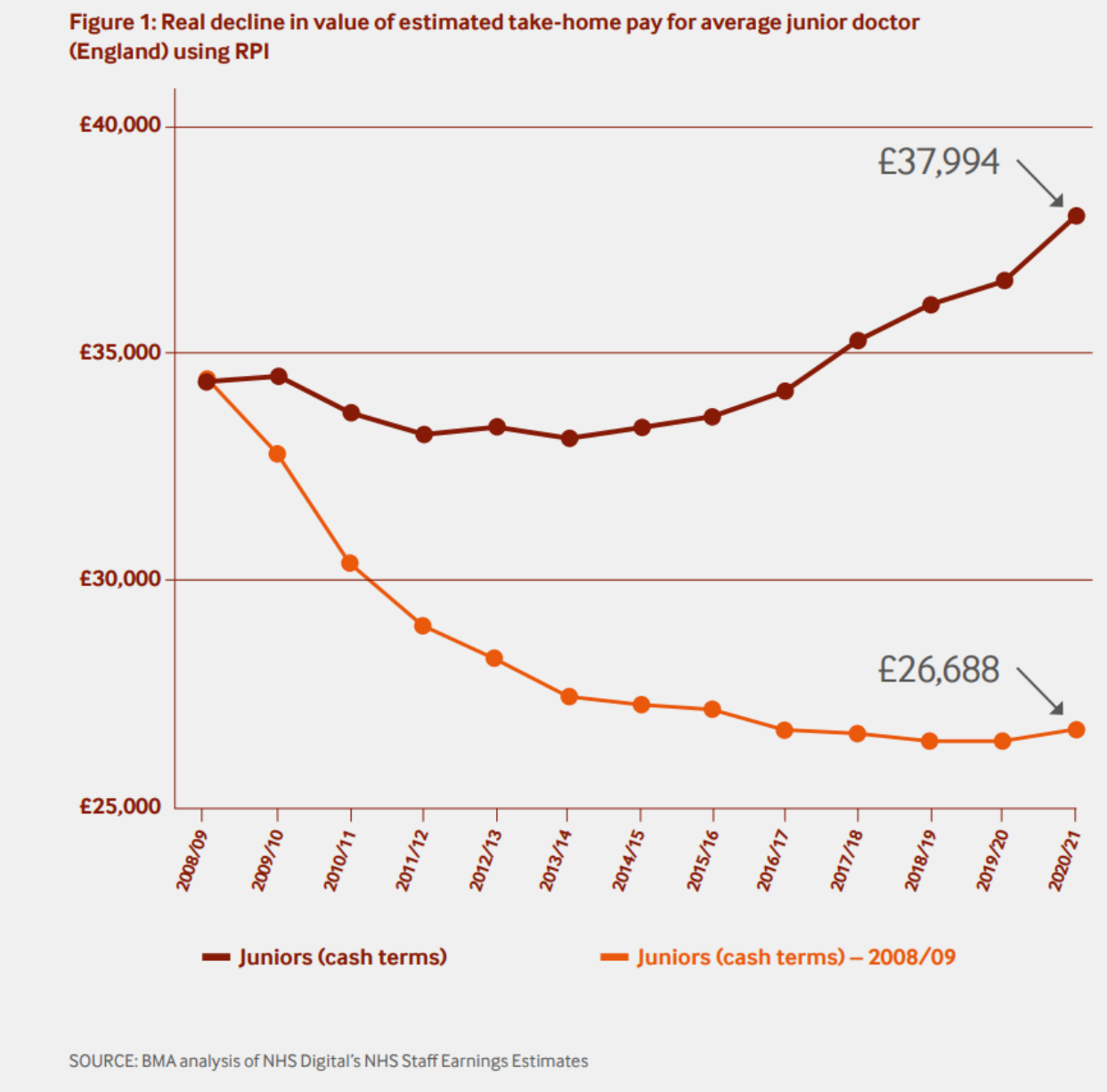
A Appendix

Figure A.1. Trainee doctors' monthly absence rates



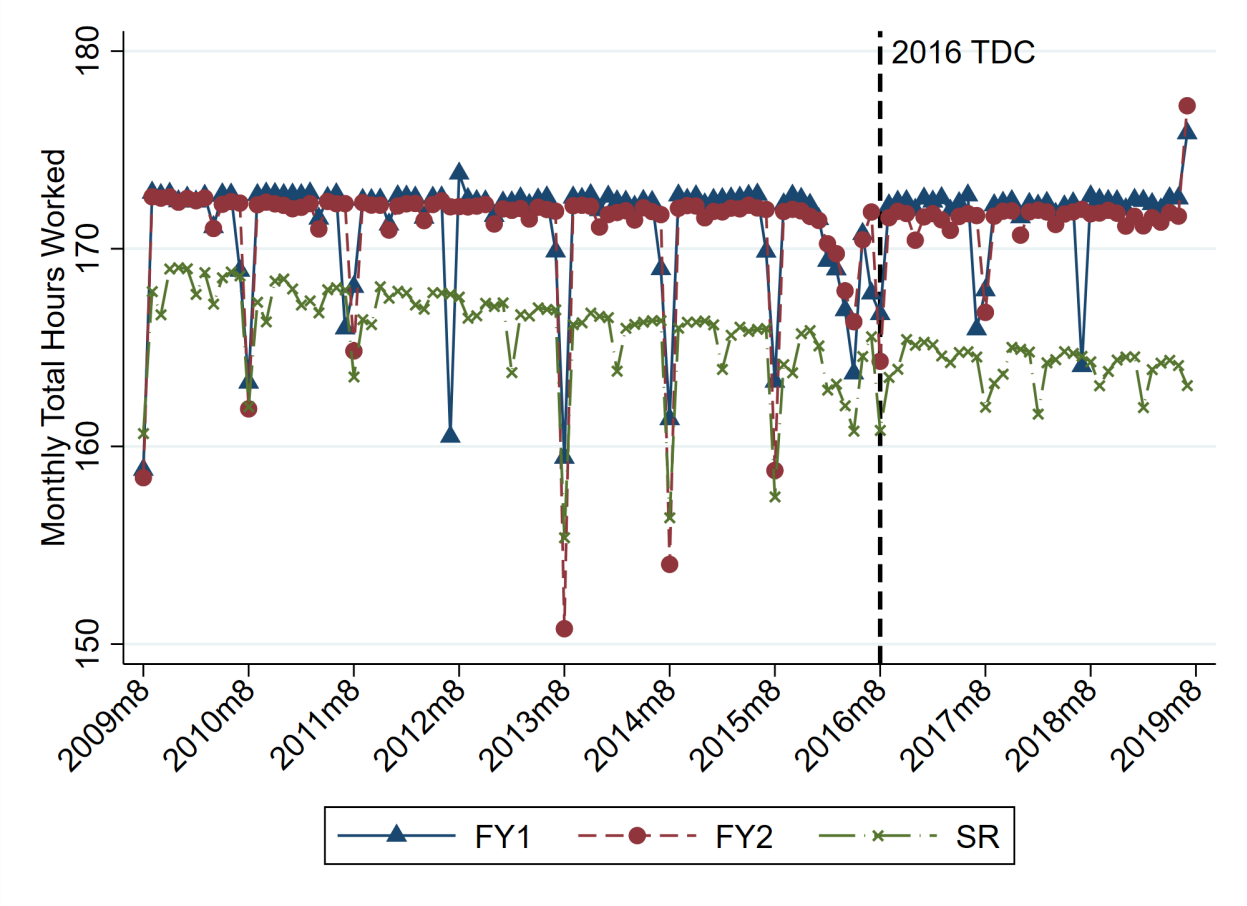
Notes. Authors' calculation from the Electronic Staff Records (ESR), using data for all NHS trainee doctors between August 2009 and July 2018. 2016 TDC = official starting implementation date of the 2016 Trainee Doctor Contract. FY1 = Foundation Year 1; FY2 = Foundation Year 2; SR = Specialty Registrar.

Figure A.2. Trainee doctors' real terms annual earnings, 2008-2021



Notes. Source: BMA computations (`https://www.bma.org.uk/media/5093/junior-doctor-pay-briefing-feb-2022-v1.pdf`).

Figure A.3. Monthly Hours Worked



Notes. Authors' calculation from the Electronic Staff Records (ESR), using data for all NHS trainee doctors between August 2009 and July 2018. 2016 TDC = official starting implementation date of the 2016 Trainee Doctor Contract. FY1 = Foundation Year 1; FY2 = Foundation Year 2; SR = Specialty Registrar.

Figure A.4. Data sources and linkages

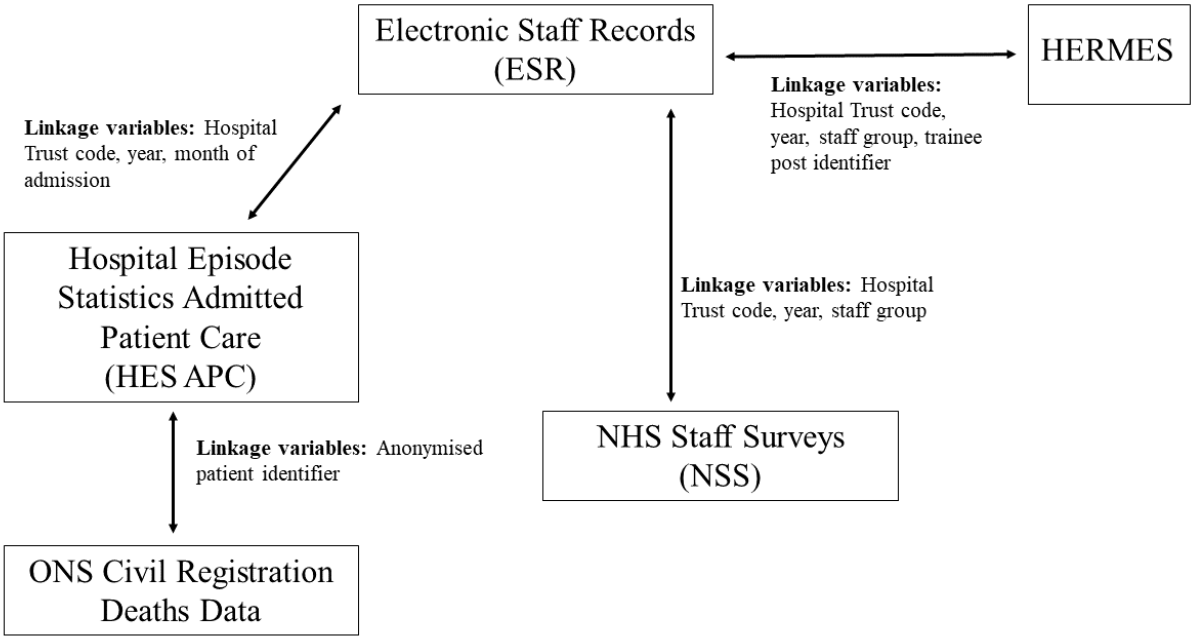
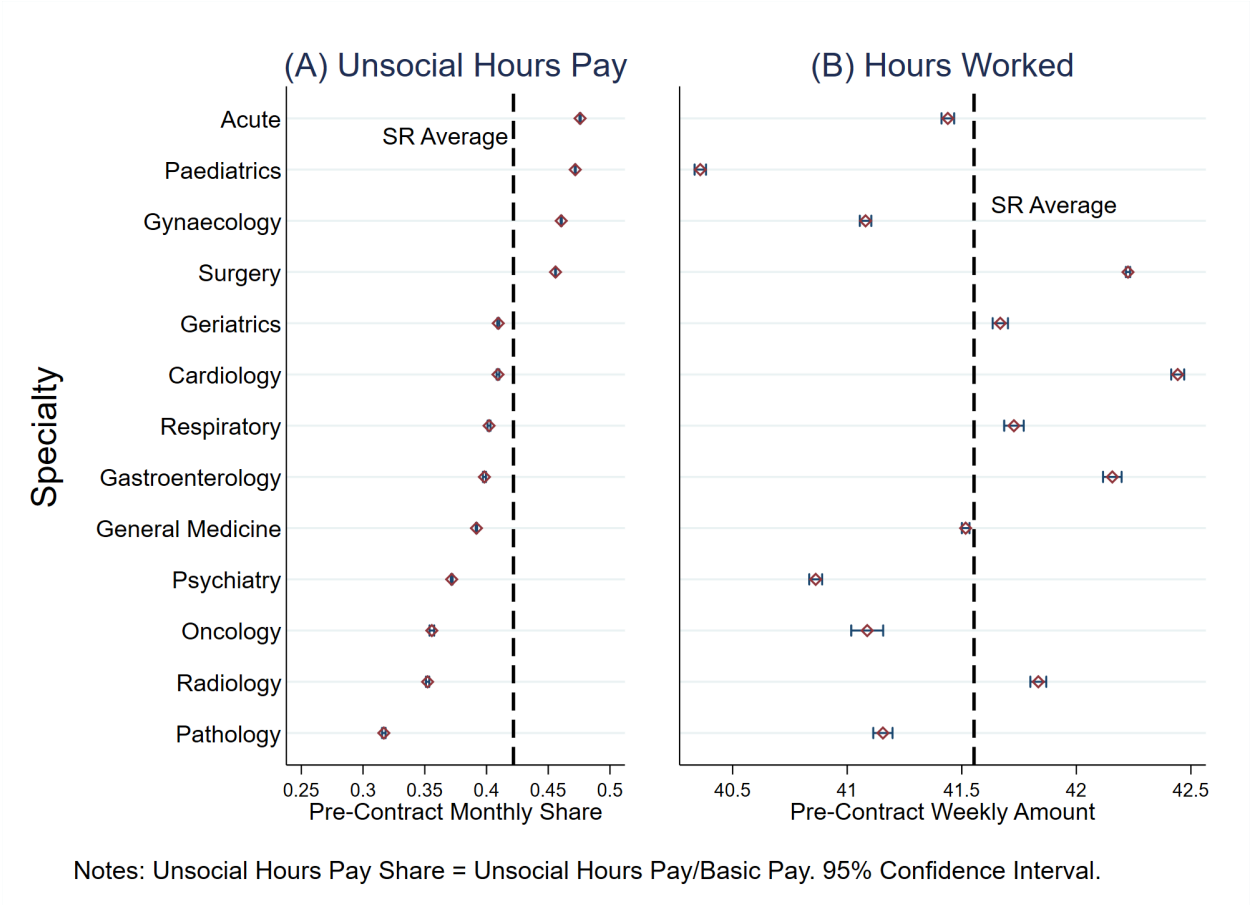
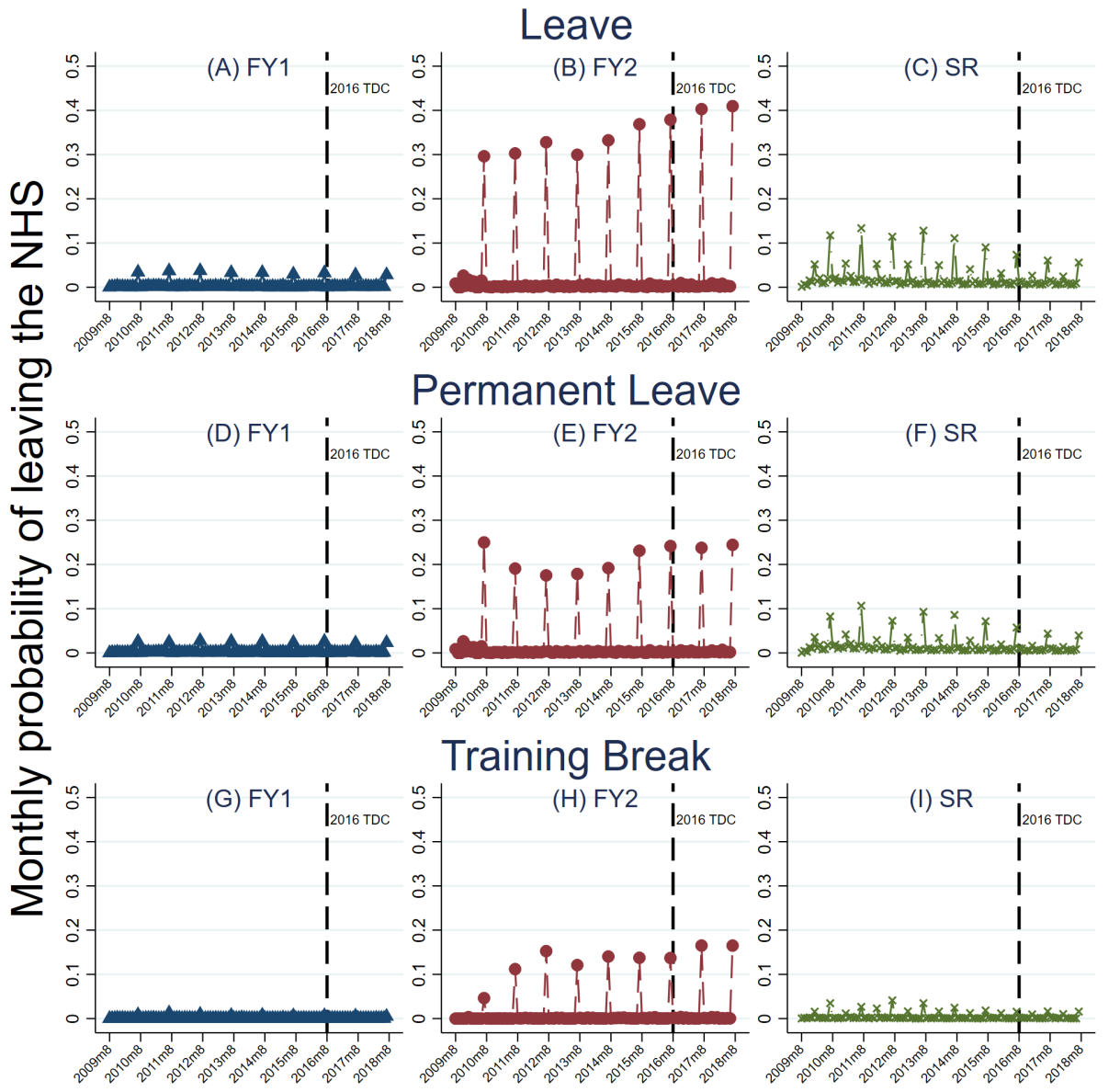


Figure A.5. Share of unsocial working hours and total hours worked, by specialty



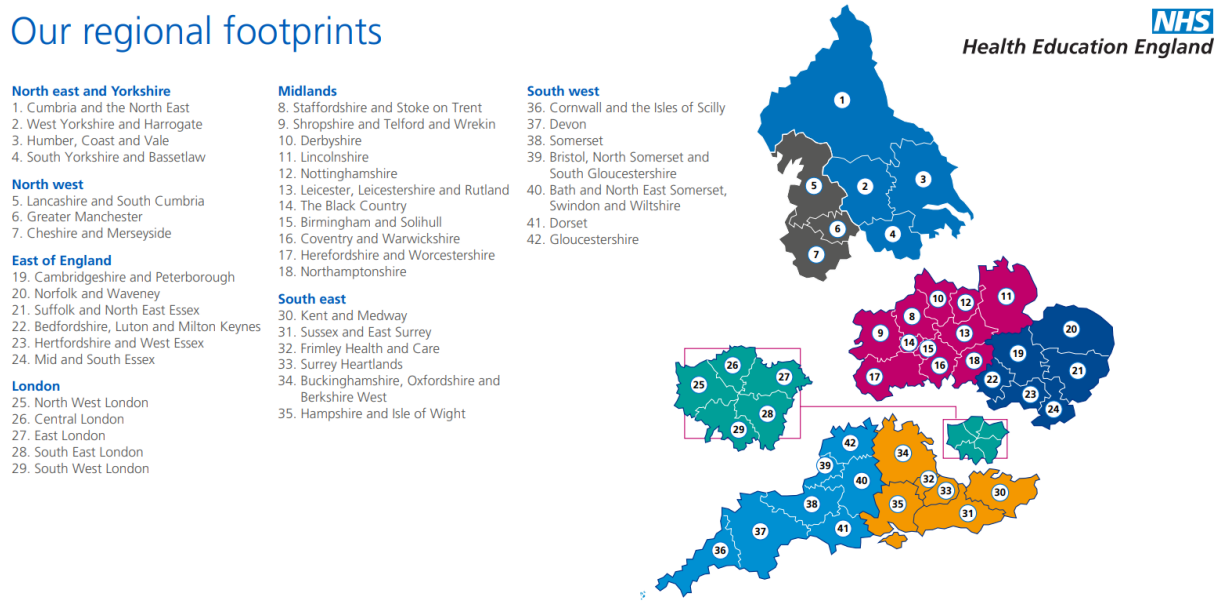
Notes. Authors' calculation from the Electronic Staff Records (ESR), using data for NHS specialty trainee doctors between August 2009 and July 2016. SR = Specialty Registrar.

Figure A.6. Monthly Leaving Rates



Notes. Authors' calculation from the Electronic Staff Records (ESR), using data for all NHS trainee doctors between August 2009 and July 2018. 2016 TDC = official starting implementation date of the 2016 Trainee Doctor Contract. FY1 = Foundation Year 1; FY2 = Foundation Year 2; SR = Specialty Registrar.

Figure A.7. HEE regions and subregions



Notes. Source: Health Education England, at `https://www.hee.nhs.uk/`.

Table A.1. Summary statistics: Trainee Doctors' sample in the pre-reform period

	All	FY1	FY2	ST1-ST3	ST4-ST8
Basic Pay (in £)	2,250.29	1,858.27	2,299.58	2,574.60	2,957.63
	(389.35)	(169.65)	(166.68)	(278.48)	(301.00)
Unsocial Hours Supplement Pay (in £)	906.54	729.83	852.12	1,121.77	1,300.71
	(404.28)	(275.61)	(455.39)	(345.80)	(374.87)
Total Earnings (in £)	3,256.52	2,669.57	3,251.87	3,813.91	4,412.37
	(744.18)	(423.48)	(588.48)	(584.88)	(635.87)
Weekly Hours Worked	42.65	42.77	42.79	42.41	42.30
	(3.49)	(3.52)	(3.02)	(3.80)	(3.91)
Share of Leaving NHS (L)	0.02	0.00	0.03	0.02	0.01
	(0.13)	(0.07)	(0.17)	(0.13)	(0.12)
Share of Permanently Leaving NHS (PL)	0.01	0.00	0.02	0.01	0.01
	(0.10)	(0.06)	(0.13)	(0.11)	(0.10)
Share of Training Break (TB)	0.01	0.00	0.01	0.01	0.00
	(0.08)	(0.03)	(0.11)	(0.08)	(0.07)
Age	27.29	25.94	26.91	28.75	30.97
	(3.64)	(3.42)	(3.39)	(3.34)	(3.16)
Share of Female	0.58	0.58	0.59	0.57	0.54
	(0.49)	(0.49)	(0.49)	(0.50)	(0.50)
Share of BAME	0.29	0.29	0.29	0.28	0.27
	(0.45)	(0.45)	(0.45)	(0.45)	(0.45)
Share of British	0.85	0.83	0.85	0.86	0.86
	(0.36)	(0.38)	(0.36)	(0.35)	(0.34)
Share of European	0.05	0.05	0.05	0.05	0.05
	(0.22)	(0.22)	(0.21)	(0.22)	(0.22)
Share of Overseas (non-UK, non-EU)	0.07	0.08	0.07	0.07	0.07
	(0.26)	(0.27)	(0.26)	(0.26)	(0.26)
Trainees	40,954	40,947	32,994	16,514	4,625
Observations	1,320,263	464,692	402,792	401,315	51,464

Notes. Standard deviation in parenthesis. Leave (L) = Leave the ESR for more than 6 months. Permanent Leave (PL) = Leave the ESR for more than 13 months. Training Break (TB) = Leave the ESR for a period ranging between 7 and 13 months. BAME = Black, Asian or other ethnic minorities. FY1 = Foundation Year 1; FY1 = Foundation Year 2; SR1-SR3 = Specialty Registrar (1-3 years); SR4-SR8 = Specialty Registrar (4-8 years). All variables are expressed on a monthly basis if not specified otherwise.

Table A.2. Balance Table

	Below median exposure (1)	Above median exposure (2)	t-test (1)-(2)
Hours (1^{st} year of training)	42.655	42.879	-0.223
	(0.148)	(0.081)	
Earnings (1^{st} year of training)	2,622.794	2,709.865	-87.071***
	(16.150)	(12.282)	
Hours (August 2017-July 2018)	41.208	41.258	-0.050
	(0.092)	(0.138)	
Earnings (August 2017-July 2018)	4,329.583	4,421.019	-91.436***
	(23.416)	(18.186)	
Age	25.436	25.423	0.013
	(0.062)	(0.057)	
Female	0.587	0.580	0.006
	(0.006)	(0.005)	
BAME	0.294	0.285	0.009
	(0.014)	(0.012)	
British	0.826	0.812	0.015
	(0.011)	(0.017)	
European	0.051	0.052	-0.002
	(0.002)	(0.003)	
Overseas	0.085	0.077	0.009*
	(0.006)	(0.004)	
Cohort 2009	0.136	0.135	0.001
	(0.006)	(0.005)	
Cohort 2010	0.141	0.144	-0.003
	(0.006)	(0.005)	
Cohort 2011	0.149	0.148	0.001
	(0.007)	(0.005)	
Cohort 2012	0.125	0.133	-0.008
	(0.006)	(0.005)	
Cohort 2013	0.147	0.150	-0.003
	(0.005)	(0.004)	
Cohort 2014	0.135	0.156	-0.021*
	(0.007)	(0.007)	
Cohort 2015	0.167	0.134	0.032
	(0.011)	(0.011)	

Notes: Summary statistics and balance tests comparing low exposed (below median) and high exposed (above median) trainee doctors to unsocial work. BAME = Black, Asian or other ethnic minorities. Standard errors are clustered by the first NHS hospital organization entered by trainee doctors. Significance levels: * 0.1; ** 0.05 *** 0.01.

Table A.3. Event-study estimates of the 2016 TDC effect on trainee doctors' attrition from the NHS

	(1)	(2)	(3)	(4)	(5)	(6)
	L	PL	TB	L	PL	TB
Year 2010 * Unsocial Work Exposure	-0.011	-0.012	0.001	-0.018	-0.018	-0.000
	(0.011)	(0.010)	(0.003)	(0.034)	(0.034)	(0.009)
Year 2011 * Unsocial Work Exposure	0.015	-0.000	0.015***	0.023	0.003	0.019*
	(0.012)	(0.011)	(0.006)	(0.024)	(0.023)	(0.010)
Year 2012 * Unsocial Work Exposure	0.009	0.006	0.003	0.016	0.010	0.006
	(0.011)	(0.009)	(0.007)	(0.021)	(0.020)	(0.010)
Year 2013 * Unsocial Work Exposure	0.010	0.010	-0.001	0.012	0.012	0.000
	(0.011)	(0.011)	(0.005)	(0.017)	(0.017)	(0.009)
Year 2014 * Unsocial Work Exposure	0.006	-0.003	0.008*	0.005	-0.003	0.009
	(0.010)	(0.009)	(0.005)	(0.012)	(0.012)	(0.008)
Year 2016 * Unsocial Work Exposure	0.012	0.007	0.005	0.019**	0.010	0.009
	(0.008)	(0.007)	(0.004)	(0.010)	(0.009)	(0.007)
Year 2017 * Unsocial Work Exposure	0.029**	0.028***	0.001	0.040***	0.035***	0.005
	(0.012)	(0.010)	(0.007)	(0.013)	(0.013)	(0.008)
Year 2018 * Unsocial Work Exposure	0.019*	0.012*	0.006	0.038***	0.025**	0.013*
	(0.010)	(0.007)	(0.006)	(0.014)	(0.012)	(0.008)
N		40,954			40,954	
N * T		1,761,537			1,761,537	
Individual FE	✗	✗	✗	✓	✓	✓
R-squared	0.187	0.107	0.082	0.216	0.140	0.108

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 13 months. TB = Leave the ESR for a period ranging between 7 and 13 months. The sample goes from January 2010 to December 2018 and is made of only trainee doctors joining the NHS as Foundation Year 1 under the 2002 contractual terms (i.e. Cohorts 2009-2015). All models include: year fixed effects; hospital organization fixed effects; grade-specific calendar month fixed effects; grade-specific specialty fixed effects; a dummy taking value one between January and June 2016 (i.e. trainee doctors' strikes); a polynomial of degree two in trainee doctors' age. The specifications without individual fixed effects (columns 1-3) also include a series of dummy variables controlling for: the first NHS hospital organization entered by trainee doctors; gender; nationality; ethnicity; NHS cohort of entry. N denotes the number of trainee doctors used in the estimation. $N * T$ denotes the overall number of monthly trainee doctors' records used in the estimation. Standard errors clustered by the first NHS hospital organization joined by trainee doctors are reported in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

Table A.4. Heterogeneous effects by gender and type of appointment

	Male			Female		
	(1)	(2)	(3)	(4)	(5)	(6)
	L	PL	TB	L	PL	TB
Panel A: Gender						
2016 Contract	-0.005	-0.009*	0.004*	-0.013***	-0.011***	-0.002
	(0.005)	(0.005)	(0.002)	(0.004)	(0.003)	(0.002)
2016 Contract * Unsocial Work Exposure	0.018*	0.019*	-0.001	0.035***	0.021***	0.013**
	(0.011)	(0.010)	(0.005)	(0.009)	(0.008)	(0.006)
N		17,049			23,905	
N * T		749,078			1,012,459	
R-squared	0.229	0.153	0.109	0.207	0.132	0.108
Panel B: Gender and Type of Appointment						
2016 Contract (Full-Time)	-0.005	-0.009*	0.004*	-0.014***	-0.011***	-0.002
	(0.005)	(0.005)	(0.002)	(0.004)	(0.003)	(0.002)
2016 Contract * Part-Time	0.124	0.177	-0.053	0.010	0.000	0.010
	(0.177)	(0.155)	(0.081)	(0.031)	(0.029)	(0.019)
2016 Contract * Unsocial Work Exposure	0.019*	0.020*	-0.001	0.035***	0.021***	0.013**
	(0.011)	(0.010)	(0.005)	(0.009)	(0.008)	(0.006)
2016 Contract * Unsocial Work Exposure * Part-Time	-0.285	-0.433	0.148	-0.013	0.013	-0.025
	(0.442)	(0.376)	(0.208)	(0.073)	(0.067)	(0.045)
N		17,045			23,881	
N * T		748,888			1,011,288	
R-squared	0.230	0.153	0.109	0.207	0.132	0.108

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 13 months. TB = Leave the ESR for a period ranging between 7 and 13 months. Part-time trainee doctors are identifies based on the mode in the trainee doctors' type of appointment during the pre-contract period. The specifications include: individual fixed effects; hospital organization fixed effects; grade-specific calendar month fixed effects; grade-specific specialty fixed effects; a dummy taking value one between January and June 2016 (i.e. trainee doctors' strikes); a polynomial of degree two in trainee doctors' age. N denotes the number of trainee doctors used in the estimation. $N * T$ denotes the overall number of monthly trainee doctors' records used in the estimation. Standard errors clustered by the first NHS hospital organization joined by trainee doctors are reported in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

Table A.5. Effect on trainee doctors' attrition from the NHS, controlling for work intensity

	(1)	(2)	(3)
	L	PL	TB
2016 Contract	0.226***	0.139**	0.087**
	(0.066)	(0.057)	(0.034)
2016 Contract * Unsocial Work Exposure	0.031***	0.022***	0.008*
	(0.008)	(0.007)	(0.005)
2016 Contract * Working Hours Exposure	-0.005***	-0.003***	-0.002**
	(0.002)	(0.001)	(0.001)
N		40,954	
N * T		1,761,537	
R-squared	0.216	0.140	0.108

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 13 months. TB = Leave the ESR for a period ranging between 7 and 13 months. $Hours$ is defined following the approach described in subsection 3.2 to define UNS. The specifications include: individual fixed effects; hospital organization fixed effects; grade-specific calendar month fixed effects; grade-specific specialty fixed effects; a dummy taking value one between January and June 2016 (i.e. trainee doctors' strikes); a polynomial of degree two in trainee doctors' age. N denotes the number of trainee doctors used in the estimation. $N * T$ denotes the overall number of monthly trainee doctors' records used in the estimation. Standard errors clustered by the first NHS hospital organization joined by trainee doctors are reported in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

Table A.6. Test for parallel pre-trends

	(1)	(2)	(3)
	L	PL	TB
Panel A			
Monthly Trend	-0.000	0.000	-0.000***
	(0.000)	(0.000)	(0.000)
Monthly Trend * Unsocial Work Exposure	0.001	0.001	-0.000
	(0.001)	(0.001)	(0.000)
Panel B			
Yearly Trend	-0.001	0.002	-0.003***
	(0.003)	(0.003)	(0.001)
Yearly Trend * Unsocial Work Exposure	0.005	0.006	-0.001
	(0.007)	(0.007)	(0.002)
N		40,954	
N * T		1,320,263	
R-squared	0.229	0.150	0.114
Individual FE	✓	✓	✓
Trust FE	✓	✓	✓
Month FE	✓	✓	✓
Specialty FE	✓	✓	✓

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 13 months. TB = Leave the ESR for a period ranging between 7 and 13 months. The specifications include: individual fixed effects; hospital organization fixed effects; grade-specific calendar month fixed effects; grade-specific specialty fixed effects; a dummy taking value one between January and June 2016 (i.e. trainee doctors' strikes); a polynomial of degree two in trainee doctors' age. The sample goes from January 2010 to July 2016 (i.e. pre-contract period) and is made of only trainee doctors joining the NHS as Foundation Year 1 under the 2002 terms (i.e. Cohorts 2009-2015). N denotes the number of trainee doctors used in the estimation. $N * T$ denotes the overall number of monthly trainee doctors' records used in the estimation. Standard errors clustered by the first NHS hospital organization joined by trainee doctors are reported in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

Table A.7. Persistence of training working patterns

	(1)	(2)	(3)	(4)
	Unsocial Work Pay (SR)	Hours Worked (SR)	Unsocial Work Pay (SR)	Hours Worked (SR)
Unsocial Work Pay (FY)	0.127***		0.088***	
	(0.020)		(0.016)	
Hours Worked (FY)		0.532***		0.530***
		(0.079)		(0.080)
N	16,308		16,301	
R-squared	0.029	0.355	0.130	0.207
Current Trust FE	✗	✗	✓	✓
Specialty FE	✗	✗	✓	✓

Notes: OLS estimates of a cross-sectional model relating the average value of unsocial work supplement earnings as percentage of basic salary (columns 1 and 3) and hours worked (columns 2 and 4) in the first 12 months of Specialty training with the corresponding averages during the Foundation Programme. Only trainee doctors who underwent (at least part of) both the Foundation and the Specialty training before August 2016 are used for the analysis. Specialty dummies (included in columns 3 and 4 only) refer to the medical area of work recorded by trainee doctors at the beginning of their Specialty training. All models also control for demographic (gender, age, ethnicity, nationality), NHS cohort, medical training (i.e. first hospital organization entered by trainee doctors) and year dummies. N denotes the number of trainee doctors (observations) used in the estimation. Standard errors clustered by the first NHS hospital organization entered by trainee doctors are reported in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.