The impact of the 2016 Junior Doctor Contract on the retention of trainee doctors within the English NHS

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Abstract

In August 2016 the UK government imposed a new national contract on NHS Junior Doctors, involving an increase in the basic salary but also more weekend working paid at the standard weekday rate. This paper studies how the introduction of the 2016 Junior Doctor Contract (JDC) affected the retention of Junior Doctors within the English NHS, by implementing a Difference-in-Difference (DiD) analysis with heterogeneous treatment intensity. We construct a predetermined and continuous measure of individual exposure to treatment, based on the remuneration for unsocial work earned by Trust-level Foundation Doctors. This approach identifies Junior Doctors that rotated across Trusts where unsocial work was more common and that reasonably were more penalized by the new contractual terms. We find that a one-standard-deviation

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increase in the ratio between unsocial supplement pay and basic salary was associated with a 0.1% increase in the monthly probability of leaving the NHS, which translates into approximately 5% of all medical trainees leaving the NHS over a year. Furthermore, we show that specialties in which weekend working is more frequent (e.g. A&E) experienced a greater loss of trainees compared to those in which much of the work takes place over a 5-day week (e.g. Psychiatry). These findings highlight the importance of working conditions for the progression in the medical career and the retention of healthcare workers.

Keywords: Junior Doctors, contract reform, working conditions, workforce retention, English NHS

1 Introduction

The exodus of healthcare workers has been posing a serious threat to the provision of hospital care in the English NHS during the last decade. Of particular importance is the mounting loss of Junior Doctors, as they are the future of the NHS medical workforce. For instance, Rimmer (2019) shows that the share of Junior Doctors who immediately took up a specialty post after their foundation programme decreased from 71.3% in 2011 to 37.7% in 2018 (see also Goldacre et al. (2010), Rimmer (2017) and Torjesen (2018)). However, the reasons for these worrisome trends are still not yet fully understood (e.g. Smith et al. (2018), Lambert et al. (2018)).

Several analyses agree at least on the fact that working conditions are among the main factors behind the interruption of a medical training in the UK (Moss et al., 2004; Rizan et al., 2019). Indeed, NHS Junior Doctors' adverse working conditions have frequently been in the public eye (Dudley, 1990; Quine, 2002; Jackson and Moreton, 2013; Gander et al., 2007) and subject to a few policy interventions over the years. Since August 2009, the maximum number of Junior Doctors' working hours has been reduced from 58 to 48 a week (Pickersgill, 2001; McIntyre et al., 2010; Datta and Davies, 2014), in compliance with the European Working Time Directive (EWTD). From August 2016, the UK government instead imposed a new national contract (2016 JDC) on NHS Junior Doctors, which has led to an increase in the basic salary but also more weekend working time paid at the standard weekday rate.

Up to now, however, there is no clear-cut causal evidence on how working conditions, and in particular those related to pay, can influence the retention of trainee doctors, within the English NHS as well as abroad. Much of the previous research has reported associations or survey-based insights (see for instance Kmietowicz (2015), Cleland et al. (2016), Spooner et al. (2017), and Scanlan et al. (2018)), which are likely to suffer from self-selectivity bias and so are not enough to understand if the recent and current work policies are well-placed

to provide a sustainable physician workforce in the medium-to-long run. In this paper, we aim to fill this gap in the literature and we study the effect of the introduction of the aforementioned 2016 JDC on the retention of NHS Junior Doctors. Most of the studies on physicians' labour supply responsiveness to wage changes have concluded that physicians' labour supply is relatively inelastic to pay changes, although physicians do change the way they operate their services in relation to how they are paid (see Lee et al. (2019) for an extensive review of the related literature). The aforementioned studies, however, focus on the entire age-distribution of the physicians workforce, and not on medical trainees. Junior doctors are an interesting sub-population of study as their trainee status places them in the steep part of the age-earnings profile schedule, so that, whilst their wage may be still low, their opportunity-costs in terms of missed human capital accumulation and viable outside options (i.e. leaving to practice in another organization or country) are likely relatively high. In turn, this implies that positive (negative) changes in the working conditions will likely affect positively (negatively) junior doctors' labour supply extensive margins, rather than the intensive ones. Hence, we focus our investigation on the effects of pay on junior doctors' retention, for two main reasons: retention within the medical workforce or a given health-care organization is a measure of the labour supply extensive margins; and lack of retention of doctors in training has severe implications for a publicly-funded NHS like the English one, which already experiences a shortage of medical workforce and relies substantially on migrant healthcare workers from abroad.[1]

The 2016 JDC provides a unique opportunity to study whether contractual conditions, in particular those related to pay, really matter for the retention of healthcare workers[2], as it has introduced new contractual terms that were significantly more detrimental for specific

[1]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`).

[2]Most studies have focused on the effects of working conditions on the retention of education workers only. See for instance Fuller et al. (2015); Geiger and Pivovarova (2018); Harrell et al. (2019).

subgroups of Junior Doctors. The main challenge in evaluating national-level interventions is in fact the absence of non-affected parties by the policy that can be used as adequate control units for the analysis. In these cases, researchers have often to rely on different levels of exposure to the treatment under study to identify the effect of interest (e.g. Propper et al. (2008); Cooper et al. (2011); Gaynor et al. (2013)). We construct a predetermined, continuous and Trust-level measure of treatment intensity that is corresponded to junior doctors (but not to tenured doctors, known as senior doctors or consultants) on top of the basic salary as a compensation for the workload and the amount of unsocial work done, and that is based on the pay scale of junior doctors in their first two years of training (Foundation doctors). We expect Junior Doctors particularly exposed to unsocial working conditions to be the most penalized by the new contract, at least in terms of remuneration. The idea of using Foundation doctors' banding pay to identify more unsocial NHS Trusts is motivated by the fact that Foundation doctors are subject to frequent rotations across Trusts: these rotations are imposed by their contract and decided by their local Health Education England (HEE) office, so that there is no scope for Junior Doctors to exert an an endogenous choice about which NHS Trust they are assigned to.[3] Thus, our approach eliminates bias related to Junior Doctors' self-selection into NHS Trusts according to their working conditions.

Our results suggest that the introduction of the 2016 JDC significantly affected the retention of Junior Doctors within the English NHS. We find that a one-standard deviation increase in our treatment intensity variable increased the monthly probability of leaving the NHS by 0.1%. This result translates into approximately 5% of all medical trainees leaving the English NHS over a year. Moreover, a heterogeneity analysis shows that the loss of trainees was greater for specialties typically associated with more unsocial working conditions, e.g. A&E. Our findings highlight the importance of favourable working conditions in (attracting) and retaining Junior Doctors.

[3]On the contrary, specialty trainees can manipulate to some extent the amount of unsocial working hours, by simply choosing or shifting to medicine areas of specialty that require less unsocial work.

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 JDC and the data used for the analysis. Section 3 introduces the approach used in this paper to assess how the introduction of the 2016 JDC affected the retention of Junior Doctors within the English NHS. Section 4 reports the main results. Section 5 tests the robustness of the findings. Section 6 concludes.

2 Institutional Background

2.1 The English NHS and its physician workforce.

In England most of the healthcare provision is provided by the state National Health Service (NHS), funded by taxation and free at the point of use. While primary care physicians, called General Practitioners (GPs), are private doctors that are subcontracted to work for the NHS, secondary care doctors are directly employed by the NHS and work in healthcare organizations called hospital Trusts that manage one or more hospital sites. The total NHS Hospital and Community Health Service (HCHS) workforce headcount of professionally qualified clinical staff, i.e. doctors, nurses and midwives, ambulance staff etc., was nearly 700 thousand, with about 63,300 senior doctors and 60,400 junior doctors, based on publicly available NHS Workforce Statistics (June 2021).[4] Over the last 10 years, the overall number of doctors employed in NHS Trusts has grown by 29.3%, i.e. 2.93% each year.

The remuneration and working conditions of the NHS clinical staff are heavily and 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. DDRB receives evidence by relevant organisations

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

and stakeholders, such as the British Medical Association, and then provides independent advice regarding pay and working conditions to the government for further action. Any Government decisions is then set at the national level through NHS Employers, which represents the workforce leaders from all NHS organizations. As such, there is a very limited room for local NHS employers to apply different terms and conditions for their medical staff. This centralised system limits the scope of NHS employers to offer more attractive conditions to new hires, promote their existing staff faster, and adjust rapidly to staff shortages (Propper and Van Reenen, 2010).

2.2 Junior Doctor Training

After graduating from medical schools, Junior Doctors undergo in-hospital training to become fully qualified doctors in the English NHS. Since 2005[5], their training has consisted of: (i) a two-year foundation programme during which trainees are supposed to acquire the general skills and knowledge to perform the medical profession; (ii) plus a specialty training whose duration generally varies from 5 to 8 years, according to the specialty accessed upon successful completion of the foundation programme.[6] [7] A shorter track is however granted for aspiring general practitioners, who enter a specialty training in general practice that is only three years long. Another exception is the career as Specialty and Associate Specialist (SAS) doctor, which requires at least four years of full-time specialty training, two of which in their relevant specialty. Overall, it may take up to 10 years for a Junior Doctor to qualify as a consultant in the English NHS.

During the foundation years (hereinafter denoted by FY1 and FY2, respectively), Ju-

[5]The medical training pathway outlined in this section was introduced by the Modernising Medical Careers (MMC) programme, which significantly modified the previously existing traditional system.

[6]At the end of the two foundation years Junior Doctors are awarded with the Foundation Programme Certificate of Completion (FPCC). They can then apply for the preferred specialty training, the entrance of which depends on the competences and results achieved during the foundation programme.

[7]For some medicine areas (e.g. Anaesthetics, Emergency Medicine, Psychiatry), the specialty training is split into two further stages: core training (denoted by CT) and higher specialty training (denoted by ST). The core training lasts up to 3 years, after which Junior Doctors need to reapply for higher specialty training. The remaining specialty areas instead involve a run-through specialty training and only one application process.

nior Doctors are subject to rotations across hospital Trusts and specialty areas, which allow them to gain basic experience by being exposed to different work environments and tasks. Generally, rotations take place every 3 to 6 months[8] and only within the Health Education England (HEE) region in which Junior Doctors applied for foundation training.[9] Moreover, they are borne by local HEE offices, therefore Foundation doctors cannot exert much influence on where to be allocated to.[10] Even specialty trainees (hereinafter denoted by SR, standing for specialty registrar) often move across hospital Trusts, although the frequency of these rotations varies by specialty area and local need of specific medical skills.

The Certificate of Completion of Training (CCT) is granted to Junior Doctors at the end of the specialty training, conditional on passing an exit exam and on satisfactory Record of In-Training Assessments (RITA). The CCT makes doctors eligible to be listed in the Specialty register, which in turn allows them to apply for jobs as consultants (i.e. tenured/senior doctor) in the English NHS.

2.3 The 2016 Junior Doctor Contract (2016 JDC)

The working conditions of Junior Doctors within the English NHS are regulated by national agreements. These are struck and frequently amended by three main parties: NHS Employers, the British Medical Association (BMA), which is the main UK Doctors' union, and the Department of Health and Social Care (DHSC). Our work focuses on how Junior Doctors' retention was affected by the introduction of the new national contract imposed in 2016, which marked a profound change from the previously existing terms, agreed by a large extent in 2002.

The 2016 compromise was reached in May, after a long series of negotiations resulted in

[8]However, the most important rotation date is the first Wednesday in August (also known as "August rotation" or "changeover period"), when also newly graduated medical students start their training as a Junior Doctor.

[9]There are 7 HEE regions in England: East of England, London, Midlands, North East and Yorkshire, North West, South East and South West.

[10]This feature of the UK medical training pathway is a key part of the identification strategy implemented in this paper

months of strikes by Junior Doctors.[11] However, the new contract started to be imposed only from August 2016, according to a phased timeline. The main aim of the contract was to provide the same amount and quality of healthcare services over the entire week.[12] To pursue this goal, the 2016 JDC was primarily based on making cheaper for hospitals to hire Junior Doctors on weekends, by paying a larger number of Saturday and Sunday shifts at the standard weekly rate.

Specifically, under the 2016 contractual terms Junior Doctors can receive from a minimum 3% to a maximum 10% pay rise for working at least seven full weekends a year.[13] This system is considerably more convenient for NHS Trusts, which pre-2016 granted a premium rate (i.e. band supplement) usually between 20% and 50% of Junior Doctors' basic salary, according (but not limited) to the amount of working hours done over the weekend (see subsection 3.1 for more details). Similarly, the 2016 JDC has made night working less remunerative, by providing a 37% pay increase for any 8-hour (or more) shift between 8pm and 10am, rather than the previously in place 50% enhancement.[14]

The overall cut in unsocial hours income was compensated by an increase in the Junior Doctors' basic salary of about 10-11%.[15] These changes made by the 2016 Junior Doctor Contract can be seen from Figure 1, which plots the monthly average basic pay (Panel A)

[11] On 12 January 2016, Junior Doctors called the first strike across the NHS in 40 years. The industrial action continued in the following months, as Junior Doctors withdrew their labour even on February 10th and April 26th, this latter time walking out not only from routine care as in the previous two cases, but also from emergency services. The significance of such protests can be appreciated from Figure A.1, which plots the number of Junior Doctors' absences from the workplace over time. Furnivall et al. (2018) estimated that these strikes led to 9,1% fewer admissions, 6,8% fewer A&E attendances, 6% fewer outpatient appointments and 52% more appointments cancellation. No effect on mortality was instead detected.

[12] This government plan was meant to fix or at least improve a well known issue in the English NHS, namely that death risk is higher when patients are admitted at weekends (Aylin et al., 2010; Freemantle et al., 2012, 2015; Han et al., 2018). However, studies have shown how the 2016 JDC might not have succeeded in reducing weekend mortality (see for instance Meacock and Sutton (2018); Underwood et al. (2019)). Higher mortality rates over weekends have been documented even in other health systems than the UK one (Marco et al., 2010; Sharp et al., 2013; Goldstein et al., 2014; Isogai et al., 2015; Behrendt et al., 2019).

[13] The maximum weekend allowance was equal to 10% of the basic pay and was granted upon working every other weekend in a year.

[14] A summary of the changes brought by the 2016 JDC can be found at: `https://www.theguardian.com/society/2016/may/18/junior-doctors-contract-deal-what-was-agreed`. The full and updated terms of the 2016 JDC are instead available at: `https://www.bma.org.uk/pay-and-contracts/contracts/junior-doctor-contract/junior-doctor-contract-in-england`.

[15] Junior Doctors also receive an 8% uplift for doing on-call work and a 22% bonus for doing locum shifts.

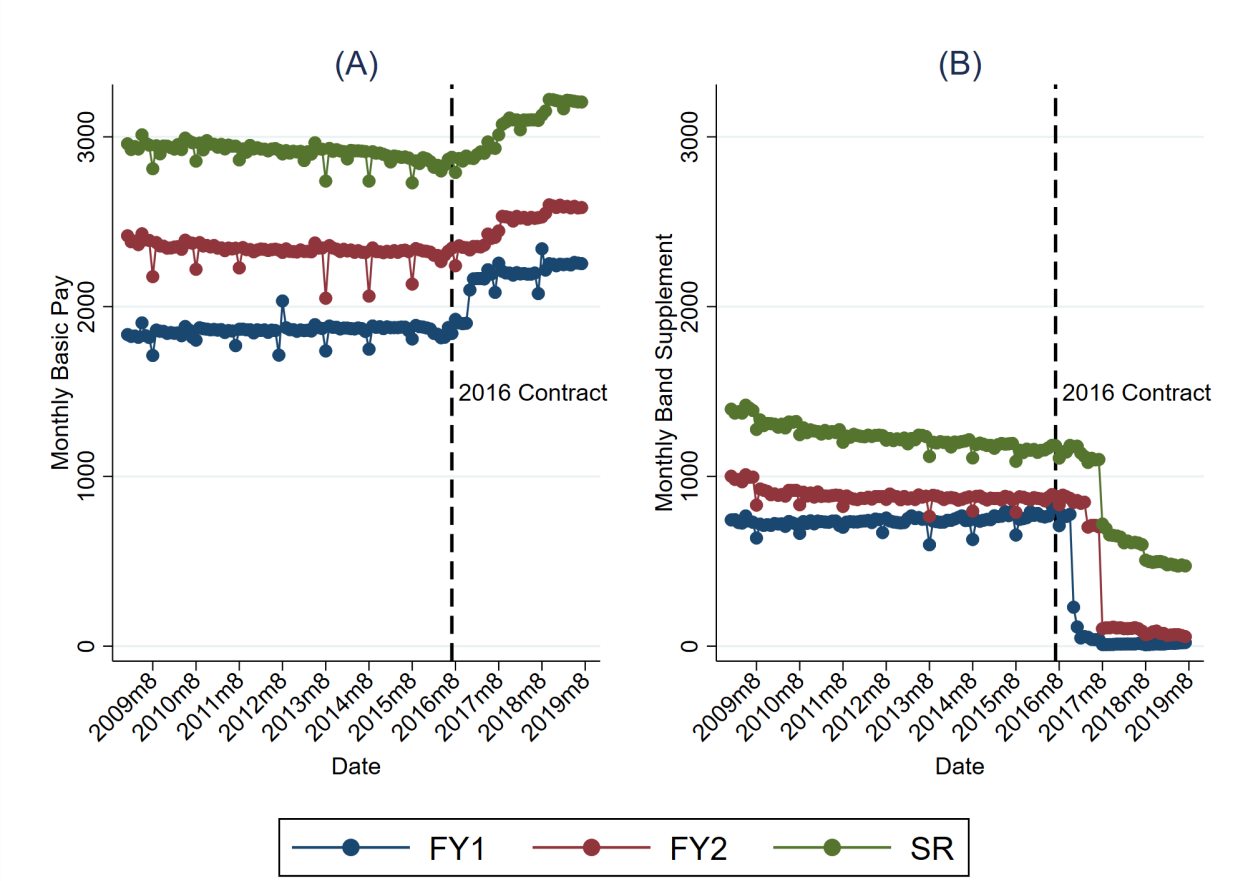

Figure 1: Monthly Junior Doctors' Basic Pay and Band Supplement Pay

and band supplement (Panel B) by different Junior Doctor title (i.e. Foundation Year 1, Foundation Year 2 and Specialty Registrar) over time.[16] Overall, the 2016 JDC has not resulted in a substantial change in total monthly earnings (see Figure A.2), and also the total amount of paid hours worked has remained constant, as shown by Figure A.3. [17] [18]

[16] Figure 1 is the result of a elaboration of the authors, which uses ESR data on all cohorts of Junior Doctors between 2009 and 2018, contrarily to the smaller sample used for the analysis (see subsection 2.4)

[17] Instead, there seems to have been an increase in shift working payments and additional standard time payments since August 2016 (see Figure A.4 and Figure A.5). This does not change the fact that the overall amount of income earned by Junior Doctors for unsocial and overtime work has significantly reduced under the 2016 contractual terms (Figure A.6).

[18] Other relevant changes occurred with the 2016 JDC have been: the introduction of a guardian of safe working, aimed at preventing overwork; and the creation of accelerated learning programmes targeted to Junior Doctors returning from some time off (e.g. maternity or paternity leave), in order to help them catching up with the training.

2.4 Electronic Staff Records (ESR)

The Electronic Staff Records (ESR) is administrative dataset commissioned from the Department of Health and Social Care (DHSC) and which contains monthly individual-level payroll information on all healthcare workers of the English NHS, together with supplementary records about the number of absences from the workplace and the decision to leave the NHS organization(s) in which they are employed. In this work, we use an extract from the ESR that includes Junior Doctors cohorts between 2009 and 2015, namely only doctors in training that joined the NHS between August 2009 and July 2016 under the 2002 agreement, and that were potentially exposed to a change in their contractual terms as a result of the 2016 JDC.[19]

We collapse multiple monthly records per employee ID into one, by adding up all monthly pay components and assuming as the main employment post the one associated with the highest number of monthly hours worked. Importantly, we discarded from the analysis all Junior Doctors for whom an unexpected career progression was observed in the records (e.g. from Specialty to Foundation training, from Senior to Junior Doctor), which clearly reflect some data imputation error typical of large administrative datasets. Similarly, we discarded individuals who have ever been classified under a job role that does not correspond to a doctor title or who ever lacked a General Medical Council (GMC) number, which we retrieved by matching our ESR extract with a an extract of the 2013-2019 HERMES dataset, which is collected by Health Education England (HEE) and reports an annual snapshot of the records of the healthcare workforce for the English NHS. We also truncate Junior Doctor spells that are longer than 10 years, or longer than 5 years in the case of GP trainees and exclude observations in which Junior Doctors are older than 55 years.[20] We follow Junior Doctors up to July 2018 (i.e. before the August 2018 changeover period), which provides us with

[19]To sharply identify NHS medical trainees in the data, we exploit the ESR variables Staff Group and Job Role, which group ESR records according to the title associated with each employment post. We recoded these variables to account for the fact that Junior Doctor titles differed over time, for instance Foundation Doctors were known as House Officers.

[20]We identify GP trainees according to the procedure described in subsection 4.2.

enough observations on their career history to assess when Junior Doctors leave the NHS for good or only take a temporarily career break (see section 3 for more details).

Table 1: Summary Statistics

	All		FY1		FY2		SR (1 to 3 years)		SR (4 to 8 years)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Basic Pay	2,446.30	2,864.84	1,858.42	1,702.41	2,312.47	2,327.90	2,731.41	2,868.02	3,011.11	3,094.04
	(723.33)	(895.48)	(200.61)	(916.21)	(415.60)	(510.11)	(747.24)	(784.07)	(971.55)	(1055.37)
Band Supplement	978.07	830.05	739.78	431.64	874.18	772.70	1,111.29	696.30	1,255.07	1,051.15
	(608.40)	(824.61)	(354.16)	(611.93)	(534.41)	(609.90)	(655.37)	(781.42)	(801.44)	(913.16)
Total Earnings	3,610.46	4,251.55	2,677.38	2,485.59	3,323.31	3,401.12	4,080.81	4,194.62	4,627.61	4,703.66
	(1198.85)	(1369.61)	(479.85)	(1227.66)	(802.38)	(937.67)	(1192.48)	(1203.47)	(1532.25)	(1541.38)
Weekly Hours Worked	42.02	40.74	43.00	33.54	42.45	41.99	41.71	41.58	39.50	39.05
	(8.98)	(12.43)	(5.74)	(17.89)	(7.90)	(10.50)	(10.00)	(11.81)	(12.58)	(13.72)
Leave (L)	0.02	0.02	0.00	0.02	0.03	0.04	0.02	0.02	0.01	0.01
	(0.14)	(0.13)	(0.06)	(0.15)	(0.18)	(0.19)	(0.15)	(0.13)	(0.11)	(0.10)
Permanent Leave (PL)	0.01	0.01	0.00	0.02	0.02	0.02	0.02	0.01	0.01	0.01
	(0.12)	(0.11)	(0.05)	(0.14)	(0.14)	(0.14)	(0.13)	(0.11)	(0.10)	(0.09)
Career Break (CB)	0.01	0.01	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00
	(0.07)	(0.07)	(0.03)	(0.06)	(0.11)	(0.13)	(0.07)	(0.07)	(0.05)	(0.04)
Age	29.31	30.98	25.89	29.93	27.59	27.44	31.16	30.19	34.25	33.60
	(5.20)	(4.82)	(3.38)	(5.19)	(4.20)	(3.98)	(5.03)	(4.30)	(4.89)	(4.48)
Female	0.56	0.56	0.58	0.65	0.58	0.58	0.54	0.56	0.52	0.55
	(0.50)	(0.50)	(0.49)	(0.48)	(0.49)	(0.49)	(0.50)	(0.50)	(0.50)	(0.50)
BAME	0.32	0.33	0.28	0.33	0.31	0.29	0.34	0.35	0.38	0.33
	(0.47)	(0.47)	(0.45)	(0.47)	(0.46)	(0.45)	(0.47)	(0.48)	(0.49)	(0.47)
British	0.74	0.73	0.87	0.77	0.81	0.84	0.66	0.72	0.65	0.70
	(0.44)	(0.44)	(0.34)	(0.42)	(0.40)	(0.37)	(0.48)	(0.45)	(0.48)	(0.46)
European	0.10	0.10	0.05	0.12	0.07	0.07	0.14	0.10	0.12	0.11
	(0.30)	(0.30)	(0.23)	(0.32)	(0.26)	(0.25)	(0.35)	(0.30)	(0.32)	(0.31)
Overseas	0.15	0.17	0.07	0.11	0.12	0.09	0.20	0.18	0.23	0.18
	(0.36)	(0.37)	(0.26)	(0.31)	(0.33)	(0.29)	(0.40)	(0.38)	(0.42)	(0.39)
GP Trainee	0.19	0.18	0.24	0.18	0.22	0.25	0.16	0.27	0.05	0.04
	(0.39)	(0.39)	(0.42)	(0.39)	(0.42)	(0.44)	(0.37)	(0.44)	(0.22)	(0.19)
Trainees (N)	56627	27333	34464	211	32745	6225	37177	17106	7885	10854
Observations (N*T)	1734488	518958	414854	1577	409206	75217	770747	261579	139681	180585

Notes: Pre = From August 2009 to July 2016. Post = From August 2016 to July 2018. FY1 = Foundation Year 1. FY2 = Foundation Year 2. SR = Specialty Registrar. L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 18 months. CB = Leave the ESR for a period ranging between 7 and 18 months. All variables are expressed on a monthly basis if not specified otherwise.

The final sample consists of 56,627 Junior Doctors over 7 years, for a total of 2,253,446 observations. Summary statistics for the key variables used in this paper are provided in Table 1, separately for the period going from August 2009 to July 2016 (hereinafter referred as the "pre-contract period") and that going from August 2016 to July 2018 (hereinafter referred as the "post-contract period"). Note how the share of observations associated with specialty training passes from 52% in the pre-contract period (=(770,747+139,681)/1,734,488) to 85% (=(261,579+180,585)/518,958) in the post-contract period. This fact naturally follows from the training progression of foundation doctors, who are required to have joined the NHS before the introduction of the 2016 JDC in order to be retained for the analysis. The

average monthly probability of leaving the NHS (i.e. defined in Section 3.2 and denoted by Leave) is 2% both in the pre-contract and post-contract period. Moreover, it is particularly low in Foundation Year 1 and high in Foundation Year 2. Not surprisingly, most Junior Doctors are British, followed by Overseas and European trainees. Similarly, women account for the majority of medical trainees (56% on average), who on average are aged 29.

3 Methods

3.1 Unsocial working exposure

Our analysis exploits the heterogeneity in the individual exposure to the contract changes outlined in Section 2.3 in order to estimate the effects of the 2016 JDC on the retention of NHS Junior Doctors.[21] In absence of data on unsocial working hours, we construct a proxy for treatment exposure that is based on the pre-contract pay supplement granted to foundation doctors as a compensation for the intensity of the work done and its unsocial degree. Specifically, until August 2016 Junior Doctors were paid a band supplement (besides their basic salary) that depended on the average number of weekly hours worked and on how many of these hours occurred during unsocial shifts, i.e. shifts on nights and weekends.

Table 2 summarizes the 7 bands that were applicable to a Junior Doctor post, together with the associated pay supplement as percentage of the basic salary. For instance, working between 48 and 56 hours a week implied a pay supplement of either 50% or 80% of the Junior Doctor's basic salary, depending on whether the work shifts consisted primarily of less or more unsocial hours.

Our baseline treatment intensity variable is based on the total amount of band supplement earnings, which in our sample timespan mostly vary by the amount of work done during unsocial hours, rather than by the intensity of the weekly working schedule.

[21] Since the seminal work by Card (1992), a large number of analyses has used treatment intensity variations for policy evaluation. See for instance Propper et al. (2008), Cooper et al. (2011), Gaynor et al. (2013) and Cooper et al. (2018).

Table 2: Pay Banding under the 2002 JDC

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	most unsocially	80%
Band 2b	48-56 hours a week	least unsocially	50%
Band 1a	40-48 hours a week	most unsocially	50%
Band 1b	40-48 hours a week	moderately unsocially	40%
Band 1c	40-48 hours a week	least unsocially	20%
No band	$<$ 41 hours a week		0%

Firstly, we define the band supplement pay as percentage of basic salary provided to the median Foundation Doctor in a given Trust h and month t (i.e. $\bar{B}^{FY}_{h,t} = \text{med}(\frac{Band^{FY}_{h,t}}{BasicSalary^{FY}_{h,t}})$). Higher values of this ratio indicate a more demanding working environment for Junior Doctors in that month. Then, we average this variable across all i's pre-2016 JDC observations, according to the Trust h in which Junior Doctor i was employed at each t. Formally:

$$B_i = \frac{\sum_1^{\bar{T}} (\bar{B}^{FY}_{h,t} * I_i(t))}{\sum_1^{\bar{T}} I_i(t)}, \tag{1}$$

where $I_i(t)$ is an indicator for observing Junior Doctor i at time t, with $t \in \{1, ..., T\}$ and 1 ($\bar{T}$) denoting the first (last) available observation for individual i since July 2009 (before August 2016).

The above is a measure of exposure to specialties and medical departments with a more intense shift routine before the introduction of the 2016 JDC. We use only Foundation Junior Doctors to construct this treatment exposure variable because, especially during their Foundation years, doctors in training are subject to rotas across hospital Trusts and specialty areas on which they can exert a very limited choice, if any (see Section 2.2). This approach prevents our analysis from being affected by the self-selection bias that would arise if it was possible to freely choose the specialty departments (and the Trust) for the Foundation years rotations, as the amount of unsocial work required is heavily determined by the medical

specialties to which trainees are assigned to (see Section 4.3).

It is very likely that a large share of junior doctors originally assigned to these "high-intensity" specialties will continue their training in such specialties even after the Foundation years, as they would have acquired specific on-the-job training that would be otherwise lost working in other specialties. This stickiness in work patterns and tasks is documented by Table 3, which reports estimates of a positive and strongly significant correlation between the average value of individual work-related measures (i.e. band supplement, total earnings and hours worked) in the first 12 months of specialty training and the corresponding average value recorded by Junior Doctors during their foundation programme.[22] For instance, one additional pound of band supplement earnings during the foundation years is associated with more than 0.21 pence of band supplement earnings at the beginning of the specialty training (Column 1 and 4). As such, we should expect trainees who rotated across NHS organizations and deaneries where unsocial work was more frequent to be the most penalized by the new 2016 contractual terms, as they would work longer unsocial hours than their peers and incur into a pay decrease for the unsocial hours shifts with respect to what they would have received according to the JDC in force up to 2016. This fact is also hinted by Figure 2, which compares the evolution in time of the aforementioned work-related variables (together with Basic Pay) for Junior Doctors that belong to the top quartile of the treatment intensity distribution (i.e. values of B_i greater than 0.47) and for the remaining group of trainees. It shows how, on average, highly-exposed Junior Doctors experienced a more pronounced drop in supplement earnings coming from unsocial, overtime and shift work (Panel C), which was compensated by an increase in the amount of labour supplied (Panel B) such that total earnings stayed in the wake of those associated with less-exposed Junior Doctors (Panel A).

Figure 3 plots the distribution of our treatment exposure variable.[23] Its average value is

[22] The analysis in Table 3 uses only observations up to July 2016, both to avoid compositional effects, i.e. stickyness in working habits being affected by the 2016 JDC, and also because the 2016 JDC dependent variables were not yet affected by the introduction of the 2016 JDC.

[23] Importantly, we dropped individuals that present unlikely values of B_i that are smaller than 0 or greater than 1.

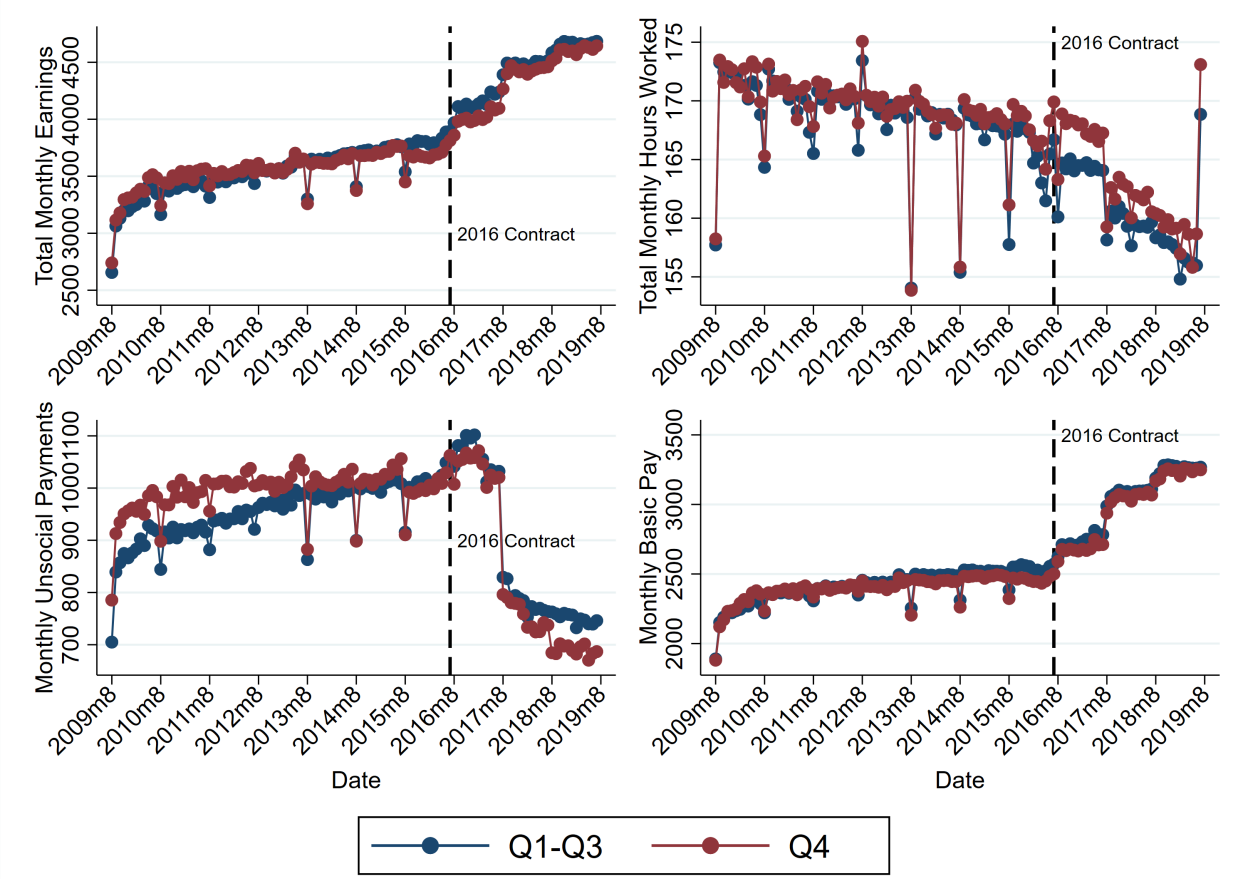

Figure 2: Key Working Variables Over Time and by Treatment Exposure Quartiles

0.423, while the standard deviation is 0.055. The vast majority of Junior Doctors reports a value between 40% and 50% of the basic salary, which is consistent with pay supplements of Band 1. Moreover, the distribution of B_i presents two modes around 0.40 and 0.50, which are likely to reflect the different unsocial degree of similar amounts of working hours (i.e. Band 1b vs Band 1a, respectively). The next section presents the model that uses such cross-sectional variation to assess the effect of the 2016 JDC on the retention of NHS Junior Doctors.

Table 3: Stickiness in Working metrics after Foundation Programme

	(1) Band	(2) Total Earnings	(3) Hours Worked	(4) Band	(5) Total Earnings	(6) Hours Worked
Band (FY)	0.259***			0.215***		
	(0.025)			(0.022)		
Total Earnings (FY)		0.483***			0.445***	
		(0.020)			(0.020)	
Total Hour Worked (FY)			0.284***			0.278***
			(0.054)			(0.053)
N	19985	19985	19985	19985	19985	19985
R-sq	0.039	0.164	0.041	0.314	0.286	0.110
Trust FE	No	No	No	Yes	Yes	Yes
Specialty FE	No	No	No	Yes	Yes	Yes

Notes: The models correlate the average value of Band Supplement Pay, Total Earnings and Hours Worked in the first 12 months of specialty training with the corresponding averages during the foundation programme. Only Junior Doctors that underwent (at least part of) both the foundation and the specialty training before August 2016 are used for the analysis. Trusts and Specialty dummies refer to the NHS Trust and the medical area of work recorded by Junior Doctors at the beginning of their specialty training. Standard errors clustered at the NHS Trust level in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

3.2 Quasi-DiD model: effect of the 2016 JDC on the probability of leaving the NHS

We estimate the following baseline linear probability model (LPM) for the (monthly) probability of leaving the NHS:

$$L_{iht} = \theta_1 C_t + \theta_2 (C_t * B_i) + \theta_3 (C_t * GP_i) + \theta_4 (C_t * B_i * GP_i) + \beta X_{it} + \alpha_i + \pi_h + \mu_t + \epsilon_{iht}. \quad (2)$$

L_{iht} is an indicator variable that takes value one if Junior Doctor i leaves (for reasons other than death or maternity) hospital Trust h in month t and does not reappear in the ESR for more than 6 consecutive months. C_t is instead a dummy for the post-contract period, namely from 2016 August onwards. B_i is the continuous treatment intensity variable defined in Section 3.1. Thus, the DiD coefficient of interest, θ_2, measures the effect of pre-contract experience in working during unsocial hours (as measured by B_i) on the probability of leaving the NHS after the introduction of the 2016 JDC, provided that pre-contract leaving rates show parallel trends across the entire distribution of B_i (which we test in subsection 4.1).

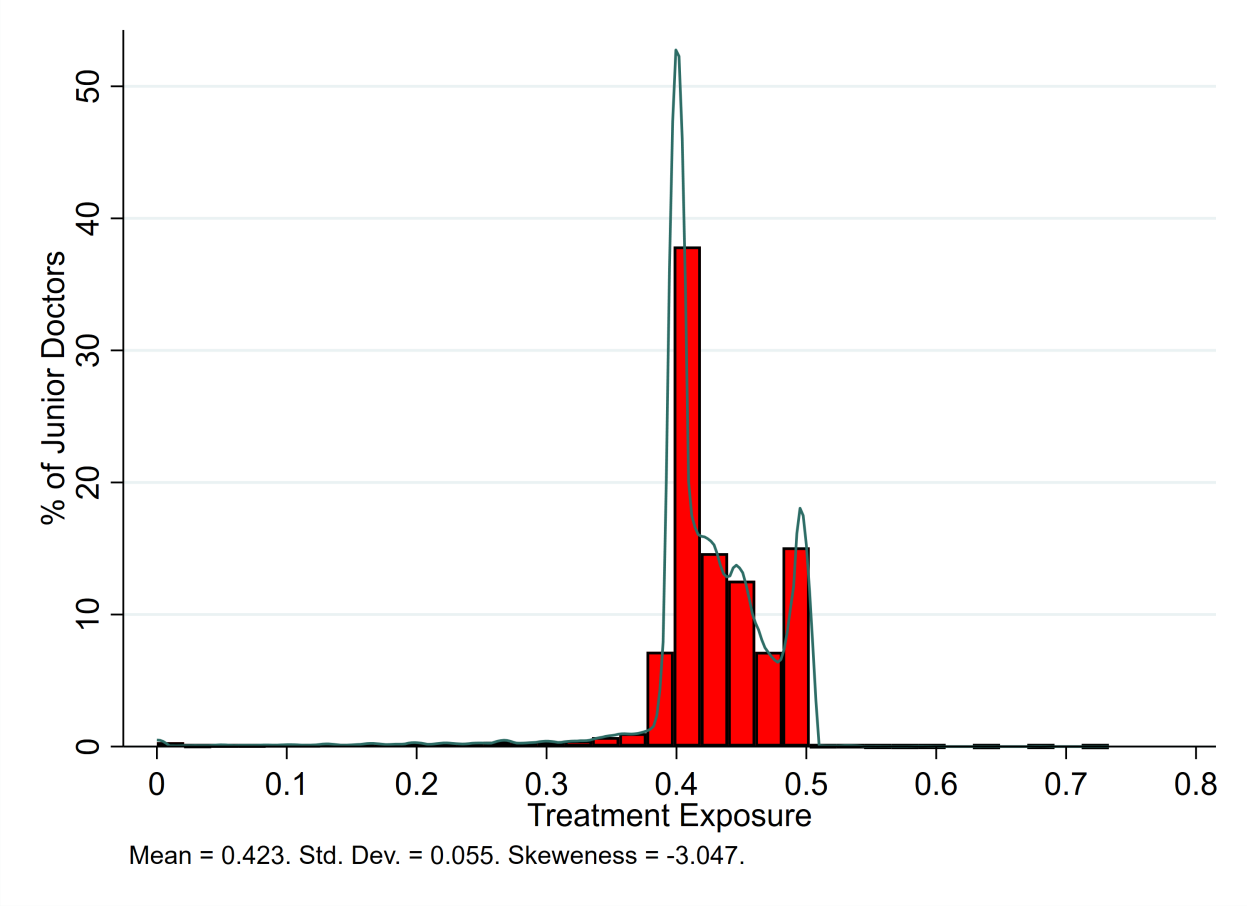

Figure 3: Treatment Exposure Distribution

GP_i is an indicator variable that takes value one if Junior Doctor i has ever been a Registrar specializing in general practice. By interacting it with our post-contract covariates (i.e. C_t and $C_t * B_i$), we are able to distinguish between the effects that the introduction of the 2016 JDC had on the retention of Junior Doctors with different on-the-job training programmes, in terms of duration as well as career prospects (see Section 2.2).

X_{it} is a vector of control variables. Specifically, we control for: whether Junior Doctor i in month t is older than 34; a dummy taking value one for strikes in the period going from January to April 2016 (i.e. when Junior Doctors' went on strike against the new contract); for the current Junior Doctors' medical area of specialization. Importantly, we interact the specialty area with indicators for the following four different grades of the Junior Doctor Career: Foundation Year 1, Foundation Year 2, Specialty Registrar (1 to 3 years)

and Specialty Registrar (4 to 8 years). This vector allows us to disentangle the effects that specializing in one specific area of medicine has on the decision to quit the NHS for different subgroups of Junior Doctors, who decide in which area(s) to specialize only at the end of the Foundation programme.

α_i are individual fixed effects controlling for unobserved employee-level factors that can be correlated with the decisions to leave the NHS for a certain period of time. Similarly, π_h are Trust-level fixed effects that control for time-invariant features of hospital Trust h that can affect the likelihood of quitting the NHS. μ_t includes four vectors of Junior Doctor grade-specific monthly dummies, which capture the different seasonal retention patterns of Junior Doctors at various training stages (see Figure A.7).[24] . Finally, ϵ_{iht} is the error term, which is assumed to be correlated across observations of the same individual. For this reason, the model is estimated through OLS and with standard errors that are clustered at the employee level.

Although L_{iht} is our main outcome of interest, we provide results even for models with alternative dependent variables. We investigate whether and to what extent the 2016 JDC affected both the decision to quit the NHS for good and that of taking a temporarily break from the medical training. In the first case, L_{iht} is replaced by an indicator variable (PL_{iht}) taking value one if Junior Doctor i leaves hospital Trust h in month t and does not reappear in the ESR for more than 18 months, which we consider as a long enough period of absence to classify this as a permanent leave.[25] On the contrary, we define a career break (denoted by CB_{iht}) whenever Junior Doctors leave the ESR for a period ranging between 6 and 18 months, which is a reasonable time frame to encompass the growing number of trainees taking a sabbatical before moving into specialty training (Rimmer (2017), Torjesen (2018)

[24] Figure A.7 shows that an increasing number of Junior Doctors decide to quit the NHS or to take a career break after terminating their Foundation programme. The share of Foundation Year 2 doctors that left the NHS for at least 6 months in July 2017 was 40%.

[25] With a finite sample of data overtime is in fact impossible to ascertain whether Junior Doctors left the NHS forever without running the risk of introducing misclassification bias. Indeed, Junior Doctors disappearing from the data at the beginning of the sample would have certainly more chances to be classified as "temporarily leavers" than those who left the ESR afterwards, for a simple fact of data horizon availability.

and Rimmer (2019)).

4 Results

4.1 Testing for pre-trends

The baseline model presented in the previous section relies on the assumption that the trend in the probability of leaving the NHS between August 2009 and July 2016 is not a function of our treatment exposure variable B_i. Here, Table 4 provides some evidence in support of this assumption, by reporting OLS coefficients for models using only pre-treatment observations (i.e. from August 2009 to July 2016). These auxiliary models indicate that the pre-treatment trend in leaving rates for non-GP trainees, our hospital Junior Doctors group of interest, did not depend on our treatment-intensity variable. On the contrary, GP trainees present a pre-contract leaving trend that decreases with respect to B_i, which highlights the importance to keep separate these two groups of different Junior Doctors in the analysis.[26]

However, we also provide results for an alternative specification to Equation 2, which requires a weaker assumption on leaving rate trends. Specifically, we compare the post-contract change in leaving rate of doctors in training exposed to highly unsocial working environments with that of all remaining Junior Doctors. In this case, B_i is going to be replaced by an indicator for belonging to the top quartile (i.e. values of B_i greater than 0.47) of the distribution of B_i (i.e. $Q4_i$). Thus, the parallel trend assumption only involves the leaving rates for these two groups of trainees to be along the same path until August 2016. Figure A.10 shows how this requirement is likely to hold in our sample, since the pre-contract annual probability of leaving the NHS was comparable in the top quartile and the remaining three quartiles of B_i.[27]

[26] In section 5, we also provide a sensitivity analysis that excludes GP trainees from the sample.

[27] Figure A.10 is based on the annual probability of leaving the NHS to remove seasonality of monthly Junior Doctors leaving rates (see Figure A.7). In order to compute their annual counterpart, we retain only the first individual observation between August and December of each year, and we look at whether each Junior Doctor disappeared from the ESR for at least 6 consecutive months at any point in time within

Table 4: Test for parallel pre-trends

	(1) L	(2) PL	(3) CB
Panel A: Monthly Trend			
Monthly Trend (No GP Track)	0.00073***	0.00096***	-0.00023***
	(0.00007)	(0.00006)	(0.00003)
Monthly Trend (GP Track)	0.00146***	0.00138***	0.00008
	(0.00024)	(0.00022)	(0.00012)
Monthly Trend * Band (No GP Track)	0.00000	-0.00002	0.00002
	(0.00015)	(0.00014)	(0.00007)
Monthly Trend * Band (GP Track)	-0.00170***	-0.00126**	-0.00043
	(0.00056)	(0.00051)	(0.00027)
R-sq	0.184	0.142	0.093
Panel B: Yearly Trend			
Yearly Trend (No GP Track)	0.00912***	0.01189***	-0.00277***
	(0.00075)	(0.00070)	(0.00036)
Yearly Trend (GP Track)	0.01791***	0.01647***	0.00145
	(0.00272)	(0.00239)	(0.00135)
Yearly Trend * Band (No GP Track)	-0.00096	-0.00120	0.00023
	(0.00174)	(0.00162)	(0.00082)
Yearly Trend * Band (GP Track)	-0.02107***	-0.01476***	-0.00631**
	(0.00629)	(0.00551)	(0.00311)
N	1734488	1734488	1734488
R-sq	0.184	0.142	0.093
Observations	Aug2009-Jul2016	Aug2009-Jul2016	Aug2009-Jul2016

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 18 months. CB = Leave the ESR for a period ranging between 7 and 18 months. The models include: individual fixed effects; Trust fixed effects; grade-specific monthly fixed effects. The sample goes from August 2009 to July 2016 (i.e. pre-contract period) and is made of only Junior Doctors joining the NHS under the 2002 terms (i.e. Cohorts 2009-2015). Standard errors clustered at the individual level in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

4.2 Main results

Table 5 reports the DiD estimates based on the continuous and the binary definition of our treatment intensity variable, in columns 1-3 and 4-6, respectively. The results indicate

12 months from the retained observation. Note that the "jumps" displayed by Figure A.10 in 2010, 2016 and 2017 are due to compositional effects: in 2009, our sample is over-represented by Junior Doctors who just started their training as Foundation Year 1; in 2016 the share of FY1 drastically decreases as most first-year trainees joining in 2015 were already promoted to Foundation Year 2 doctors, who instead almost disappear in 2017 when the vast majority of the sample is finally comprised of Specialty Registrar. Our model accounts for all these compositional effects thanks to the inclusion of μ_t, which for each period in our sample measure the grade-specific average probability of leaving the NHS.

that higher exposure to unsocial work was associated with an increase in the monthly probability of leaving the NHS after the 2016 contractual terms were introduced. Specifically, the coefficient reported in Column 1 suggests that a one-standard deviation (=0.055) increase in our treatment intensity variable determined approximately a 0.1% (=0.055*0.0212) increase in the monthly probability of leaving the NHS for non-GP trainees. Since in the last 12 months before the introduction of the 2016 JDC (i.e. from August 2015 to July 2016) the average monthly headcount of non-GP trainees in our analysis sample was 25,231, this estimate translates into an yearly loss of approximately 353 Junior Doctors from the English NHS (=0.055*0.0212*12*25,231). Because the average value of our treatment exposure variable is 0.423, we can also conclude that the introduction of the 2016 JDC implied an overall exodus of at least 2,715 Junior Doctors over a year (=0.423*0.0212*12*25,231), which corresponds to approximately 5% of the 2015 number of NHS Junior Doctors according to our administrative records before any sample restriction is imposed to perform the analysis.[28] Although striking, these numbers are lower than what predicted by survey evidence (see Kmietowicz (2015)).

Similar insights can be drawn from the plain DiD displayed in Columns 4-6 of Table 5. The coefficients signal an additional 0.3% monthly probability of leaving the NHS for those non-GP trainees who belonged to the top quartile of our treatment exposure distribution. On the contrary, we do not find any significant effect for GP trainees in none of the specifications.

The remaining columns of Table 5 indicates that the 2016 JDC affected both the decision to quit permanently the NHS and that of taking a break from the medical training. In the former case, we document a 0.07% increase in the probability to leave the NHS for good given a standard-deviation increase in B_i. In the latter, a 0.055 increase in the share between band supplement and basic pay was instead associated with an increased leaving likelihood of 0.04%.

[28]This figure is also in line with official NHS statistics, according to which there were around 53,000 Junior Doctors in 2015.

Table 5: Baseline results

	Continuous			Binary		
	(1)	(2)	(3)	(4)	(5)	(6)
	L	PL	CB	L	PL	CB
2016 Contract (No GP Track)	-0.00193	0.0000278	-0.00196*	0.00623***	0.00497***	0.00126***
	(0.00208)	(0.00187)	(0.00104)	(0.000334)	(0.000286)	(0.000188)
2016 Contract (GP Track)	0.0111*	0.00773	0.00339	0.0131***	0.00534***	0.00771***
	(0.00663)	(0.00540)	(0.00445)	(0.000773)	(0.000628)	(0.000534)
2016 Contract * Band (No GP Track)	0.0212***	0.0133***	0.00799***			
	(0.00485)	(0.00437)	(0.00245)			
2016 Contract * Band (GP Track)	0.00487	-0.00573	0.0106			
	(0.0152)	(0.0124)	(0.0102)			
2016 Contract * Band Q4 (No GP Track)				0.00329***	0.00262***	0.000670**
				(0.000569)	(0.000485)	(0.000323)
2016 Contract * Band Q4 (GP Track)				0.000618	-0.000292	0.000911
				(0.00126)	(0.00104)	(0.000823)
N	56,627	56,627	56,627	56,627	56,627	56,627
N * T	2,253,446	2,253,446	2,253,446	2,253,446	2,253,446	2,253,446
R-sq	0.174	0.129	0.091	0.174	0.129	0.091

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 18 months. CB = Leave the ESR for a period ranging between 7 and 18 months. The models include: individual fixed effects; Trust fixed effects; grade-specific monthly fixed effects; grade-specific specialty fixed effects; a dummy taking value one between January and June 2016 (i.e. Junior Doctors' strikes); a dummy taking value one if older than 34. The sample goes from August 2009 to July 2018 and is made of only Junior Doctors joining the NHS under the 2002 terms (i.e. Cohorts 2009-2015). Standard errors clustered at the individual level in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

4.3 Heterogeneous analysis by specialty area

In this section, we investigate the retention effects of the 2016 JDC by exploiting the heterogeneous amount of unsocial work required by different specialty areas. In certain medical areas doctors are always available on-call (e.g. A&E, Gynaecology), while in other specialties much of the work takes place over the normal 5-day week (e.g. Psychiatry). This feature of medical specialties clearly emerges from Figure 4, which plots the pre-contract average share of band supplement earned by specialty registrars in the following 7 primary areas of work: Acute[29], Gynaecology, General Medicine[30], Oncology, Pathology, Psychiatry and Surgery. For instance, trainees in Acute Medicine received almost an additional 50% of their basic pay as a salary limited to unsocial work. This ratio is significantly lower

[29] Acute Medicine includes Accident and Emergency, Intensive Care and General Acute.

[30] The most common specialties within the General Medicine area (besides General Medicine itself) are: Elderly Care, Paediatrics, Cardiology and Respiratory Medicine.

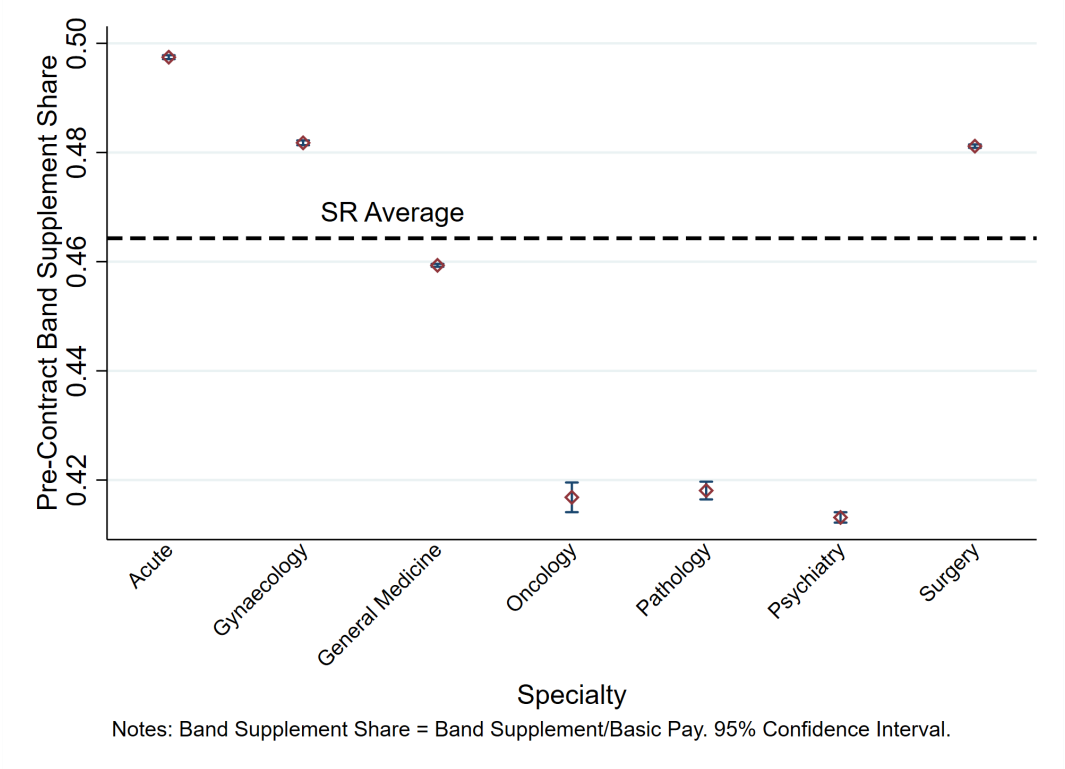

Figure 4: Band Supplement as share of Basic Pay by Specialty Area

(approximately 42%) for Junior Doctors specializing in Psychiatry, Pathology or Oncology.[31]

We provide an alternative model to Equation 2 in which we compare specialty registrars' leaving rates for each of these specialty areas, by using Psychiatry (i.e. the one with the lowest share of band supplement on average) as reference category.[32] Based on what argued so far, we should expect those specialty areas in which unsocial work is more common to have experienced the greatest loss of trainees as a consequence of the contractual terms introduced in 2016. Because registrars may decide to switch specialty as a result of the imposition of the 2016 JDC, we truncate training spells before any specialty change. Similarly to the binary DiD model provided in Columns 4-6 of Table 5, the parallel trend assumption only requires the pre-treatment leaving rates of these 7 subgroups of registrars to show the same trend, which is a condition by and large supported by Figure 5. The results of this analysis are

[31]Note that we deliberately excluded GP trainees from this alternative analysis, since their specialty training significantly differs from that of the other specialties. The model provided in this section does not use even few registrars for whom it was not possible to recover the specialty area from the ESR.

[32]Specifically, we simply replace B_i in Equation 2 with specialty area indicators.

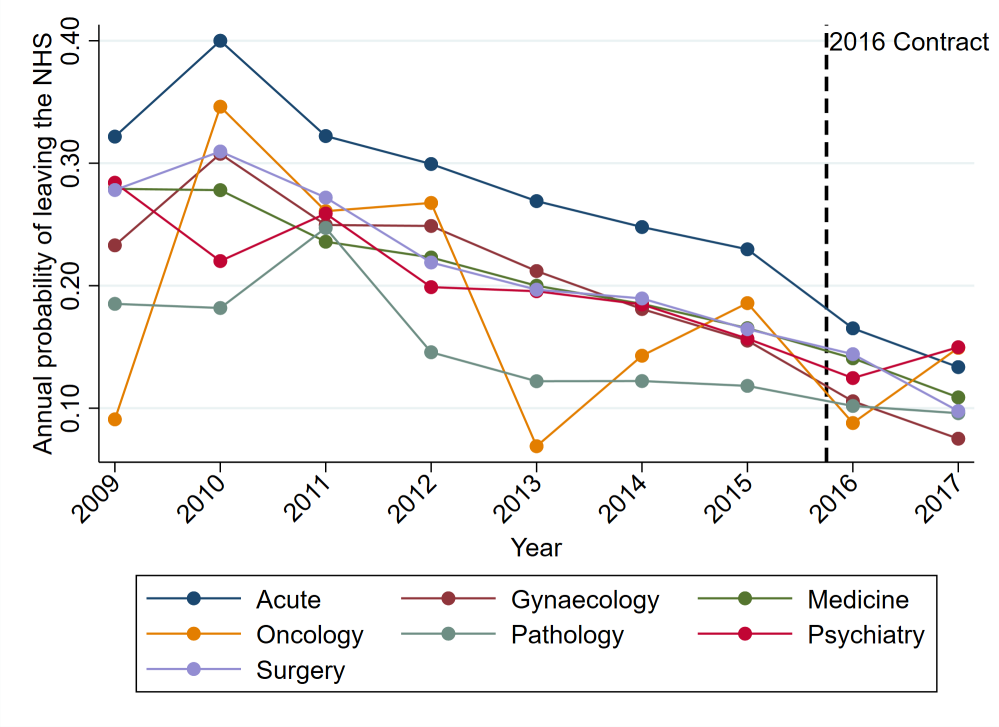

Figure 5: Leaving Rate Trends across Specialty Areas

reported in Table 6 and confirm the pattern emerging from Section 4.2.

Column 1 suggests that the monthly probability of leaving the NHS has increased in all specialty areas since 2016. For instance, the monthly probability of leaving the NHS for Psychiatry trainees has risen by 0.5%. This increase is statistically indistinguishable to that recorded in Oncology and Pathology, the two other specialty areas generally characterized by lower amounts of unsocial work. Instead, the four specialties with a significantly higher share of band supplement present a more pronounced effect. The interaction between the post-2016 dummy and General Acute is positive and highly significant, indicating how registrars in Acute Medicine were on average 1.1% more likely to leave the NHS for at least 6 months after August 2016 than trainees in Psychiatry. Similar increases, although lower in magnitude, are documented for General Medicine, Gynaecology and Surgery. Overall, the results reported in this section provide additional evidence in support of our baseline findings: the 2016 JDC affected the retention of Junior Doctors, especially those who had been exposed to highly unsocial work before the introduction of the new contract.

Table 6: Analysis by Registrars' specialty area

	(1)	(2)	(3)
	L	PL	CB
2016 Contract (Psychiatry)	0.00595***	0.00449***	0.00146*
	(0.00156)	(0.00136)	(0.000849)
2016 Contract * Acute	0.0110***	0.00893***	0.00205*
	(0.00259)	(0.00233)	(0.00117)
2016 Contract * Gynaecology	0.00405**	0.00382**	0.000226
	(0.00194)	(0.00172)	(0.000979)
2016 Contract * General Medicine	0.00760***	0.00601***	0.00160*
	(0.00167)	(0.00146)	(0.000898)
2016 Contract * Oncology	0.00187	0.00366	-0.00179
	(0.00448)	(0.00428)	(0.00139)
2016 Contract * Pathology	0.00328	0.00307	0.000210
	(0.00247)	(0.00225)	(0.00112)
2016 Contract * Surgery	0.00805***	0.00678***	0.00127
	(0.00169)	(0.00147)	(0.000902)
N	29,168	29,168	29,168
N * T	930,471	930,471	930,471
R-sq	0.116	0.112	0.057

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 18 months. CB = Leave the ESR for a period ranging between 7 and 18 months. The models include: individual fixed effects; Trust fixed effects; grade-specific monthly fixed effects; grade-specific specialty fixed effects; a dummy taking value one between January and June 2016 (i.e. Junior Doctors' strikes); a dummy taking value one if older than 34. The sample is made of only Specialty Registrars. The Specialty Area assigned to each Registrar is the one recorded in the last observation before the introduction of the 2016 JDC in August 2016. Employment spells are truncated at the occurrence of any specialty change after August 2016. Standard errors clustered at the individual level in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

4.4 Controlling for the confounding of the Brexit referendum

A concern related to the results presented so far is whether they are confounded by the effects of the June 2016 Brexit referendum, which was held between the approval of the 2016 JDC and the beginning of its implementation. In this section, we present checks for this potential confounding factor.

Table 7: Heterogeneous effects by local level of Brexit support

	Overall			By Nationality		
	(1)	(2)	(3)	(4)	(5)	(6)
	L	PL	CB	L	PL	CB
2016 Contract * Brexit Support Q1	0.00171	0.00347	-0.00176			
	(0.00326)	(0.00290)	(0.00155)			
2016 Contract * Brexit Support Q2	-0.00627	-0.00474	-0.00153			
	(0.00433)	(0.00396)	(0.00196)			
2016 Contract * Brexit Support Q3	-0.00851**	-0.00767**	-0.000844			
	(0.00390)	(0.00346)	(0.00220)			
2016 Contract * Brexit Support Q4	-0.000218	0.00313	-0.00335			
	(0.00450)	(0.00403)	(0.00247)			
2016 Contract * Brexit Support Q1 * Band	0.0153**	0.00819	0.00712*			
	(0.00778)	(0.00690)	(0.00377)			
2016 Contract * Brexit Support Q2 * Band	0.0303***	0.0214**	0.00886*			
	(0.0101)	(0.00927)	(0.00460)			
2016 Contract * Brexit Support Q3 * Band	0.0339***	0.0294***	0.00450			
	(0.00907)	(0.00806)	(0.00515)			
2016 Contract * Brexit Support Q4 * Band	0.0154	0.00344	0.0119**			
	(0.0104)	(0.00930)	(0.00576)			
2016 Contract (UK and Brexit Support Q1) * Band				0.0190**	0.00535	0.0136***
				(0.00895)	(0.00779)	(0.00481)
2016 Contract (UK and Brexit Support Q2) * Band				0.0228*	0.0100	0.0127**
				(0.0122)	(0.0111)	(0.00613)
2016 Contract (UK and Brexit Support Q3) * Band				0.0337***	0.0324***	0.00123
				(0.0108)	(0.00919)	(0.00710)
2016 Contract (UK and Brexit Support Q4) * Band				0.00872	-0.00976	0.0185***
				(0.0135)	(0.0125)	(0.00708)
2016 Contract (EU-EEA and Brexit Support Q1) * Band				0.0216	0.0272*	-0.00558
				(0.0177)	(0.0155)	(0.00896)
2016 Contract (EU-EEA and Brexit Support Q2) * Band				0.000675	-0.00408	0.00476
				(0.0328)	(0.0316)	(0.00841)
2016 Contract (EU-EEA and Brexit Support Q3) * Band				0.0274	0.00213	0.0253**
				(0.0437)	(0.0411)	(0.0126)
2016 Contract (EU-EEA and Brexit Support Q4) * Band				0.0263	0.0125	0.0138
				(0.0361)	(0.0228)	(0.0270)
2016 Contract (Overseas and Brexit Support Q1) * Band				0.0310	0.0247	0.00634
				(0.0204)	(0.0189)	(0.00580)
2016 Contract (Overseas and Brexit Support Q2) * Band				0.0749***	0.0783***	-0.00345
				(0.0177)	(0.0157)	(0.00843)
2016 Contract (Overseas and Brexit Support Q3) * Band				0.0335**	0.0270*	0.00648
				(0.0156)	(0.0145)	(0.00683)
2016 Contract (Overseas and Brexit Support Q4) * Band				0.0262	0.0295*	-0.00330
				(0.0159)	(0.0154)	(0.00620)
N	56,627	56,627	56,627	56,411	56,411	56,411
N * T	2,253,446	2,253,446	2,253,446	2,250,012	2,250,012	2,250,012
R-sq	0.174	0.129	0.091	0.174	0.129	0.091

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 18 months. CB = Leave the ESR for a period ranging between 7 and 18 months. The models include: individual fixed effects; Trust fixed effects; grade-specific monthly fixed effects; grade-specific specialty fixed effects; a dummy taking value one between January and June 2016 (i.e. Junior Doctors' strikes); a dummy taking value one if older than 34. Brexit support is measured as the 2016 referendum share of votes for leaving the EU in the last area where Junior Doctors were employed before the introduction of the 2016 JDC. All coefficients refer to non-GP trainees. Standard errors clustered at the individual level in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

We exploit data on the Brexit referendum outcome at the constituency-area level, and use the postcode location of each NHS hospital organization in our sample to match the local support for Brexit to our Junior Doctor sample. Specifically, we define a variable measuring the support for Brexit (i.e. the share of votes for leaving the EU) in the area where each Junior Doctor was employed right before the referendum (i.e. the area of the last NHS Trust in which Junior Doctors were employed before June 2016). We then estimate a variant of Equation 2 where the DiD variables are interacted with four indicator variables identifying the quartile of the Brexit support distribution that each Junior Doctor belongs to. The results of this alternative specification are provided in Columns 1-3 of Table 7.

Column 1 shows a positive coefficient for the interaction between our treatment intensity variable and the post-2016 JDC indicator across all Brexit support quartiles. However, this effect is not statistically significant at the top fourth quartile. Overall, the findings reported in Column 1 of Table 7 do not seem to present any pattern with respect to the Brexit referendum outcome. Even the coefficients in Columns 2 and 3 of suggest an increase in the probability to leave the NHS (both permanently and temporarily) regardless of the Brexit support in the local area.

In Columns 4-6 of Table 7, we refine further this analysis and investigate whether our main effect of interest differed not only with respect to the local Brexit support, but also to Junior Doctors' nationality. If anything, it is reasonable to expect the Brexit referendum outcome to be more relevant for EU doctors to stay or leave the NHS. Thus, the analysis provided in Columns 1-3 of Table 7 may mask substantial heterogeneity across different nationality groups.

The results provided in Table 7 by Brexit support quartile and Junior Doctor's nationality indicate that the previous findings are mostly driven by British and Overseas doctors. The increase in the probability of quitting the NHS for EU Junior Doctors, following the introduction of the 2016 JDC and a higher exposure to unsocial work, is not statistically significant irrespective of the Brexit support quantile. Based on the results provided in this

section, we can conclude that the Brexit referendum does not pose an issue for our findings.

4.5 Heterogeneous effects by gender and type of appointment

By making weekend working less remunerative, the 2016 JDC was also believed to affect disproportionately Junior Doctors working part-time or taking paternity leave (see Harries et al. (2015), Rimmer (2015) and Rimmer (2016)). In Table 8, we test this hypothesis by providing heterogeneous effects by gender and type of appointment.[33]

The analysis shows how women and part-time Junior Doctors were indeed more likely to leave the NHS for a given increase in the exposure to unsocial working shifts, after the 2016 JDC was imposed. Specifically, columns 1 and 2 indicate that our baseline results are mostly driven by female Junior Doctors, since males were only more likely to take a temporary break from the training as a result of the 2016 JDC (Column 3).

Similarly, the results provided in columns 4-6 suggest that Junior Doctors training part-time were around three times more likely than full-time trainees to leave the NHS given the same increase in our treatment exposure variable. These findings confirm the concerns related to the consequences of the 2016 JDC for particularly affected groups of Junior Doctors.

5 Robustness checks

The first robustness check is aimed at verifying whether the results are due to the different workload that Junior Doctors might be exposed to before August 2016, rather than its unsocial degree. As mentioned in Section 3.1, the band supplement consisted of a remuneration not only for unsocial shifts, but also for the number of hours worked. To assess this potential confounder effect, we defined the variable $Hours_i$ by following the same approach described in Section 3.1. Thus, $Hours_i$ measures the pre-contract work intensity that Junior

[33] Table A.1 instead reports results by age and ethnicity. It shows how older Junior Doctors have been more affected by the 2016 JDC, while we do not find any striking difference between white and ethnic minorities (i.e. black and Asian).

Table 8: Heterogeneous effects by gender and type of appointment

	Gender			Appointment Type		
	(1)	(2)	(3)	(4)	(5)	(6)
	L	PL	CB	L	PL	CB
2016 Contract (Male)	0.00687**	0.00890***	-0.00203			
	(0.00340)	(0.00314)	(0.00154)			
2016 Contract (Female)	-0.00707***	-0.00519**	-0.00189			
	(0.00247)	(0.00218)	(0.00131)			
2016 Contract * Band Supplement (Male)	0.00474	-0.00386	0.00860**			
	(0.00790)	(0.00727)	(0.00360)			
2016 Contract * Band Supplement (Female)	0.0298***	0.0224***	0.00743**			
	(0.00582)	(0.00513)	(0.00310)			
2016 Contract (Full-Time)				0.000110	0.00148	-0.00137
				(0.00223)	(0.00200)	(0.00111)
2016 Contract (Part-Time)				-0.0122***	-0.00718*	-0.00497**
				(0.00436)	(0.00398)	(0.00218)
2016 Contract * Band Supplement (Full-Time)				0.0168***	0.0101**	0.00666**
				(0.00519)	(0.00466)	(0.00261)
2016 Contract * Band Supplement (Part-Time)				0.0428***	0.0280***	0.0148***
				(0.0106)	(0.00955)	(0.00538)
N	56,627	56,627	56,627	56,627	56,627	56,627
N * T	2,253,446	2,253,446	2,253,446	2,253,446	2,253,446	2,253,446
R-sq	0.174	0.129	0.091	0.174	0.129	0.091

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 18 months. CB = Leave the ESR for a period ranging between 7 and 18 months. The models include: individual fixed effects; Trust fixed effects; grade-specific monthly fixed effects; grade-specific specialty fixed effects; a dummy taking value one between January and June 2016 (i.e. Junior Doctors' strikes); a dummy taking value one if older than 34. All coefficients refer to non-GP trainees. Standard errors clustered at the individual level in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

Doctors have been exposed to by using the amount of hours worked by foundation doctors until August 2016. Then, the interaction(s) between this new continuous variable and the 2016 contract dummy has been included in Equation 2, in order to capture the potential effect of work intensity on the leaving rate of Junior Doctors.

The results of this model are provided in Table 9. The coefficients for the added work intensity proxy are not statistically significant in any of the columns. Our effect of interest in Column 1 turns out to be only marginally lower in magnitude than the baseline one provided in Table 5. This is due to a weaker statistical relationship between our treatment intensity variable and the probability of taking a break from the NHS (Column 3), which in Table 9 is not statistically significant anymore. Overall, we can conclude that our treatment intensity variable mostly captures the exposure of Junior Doctors to unsocial work and its effect on leaving rates after the introduction of the 2016 JDC.

Second, Table A.2 presents results for our baseline models but using only monthly ESR

Table 9: Robustness check for work intensity

	(1)	(2)	(3)
	L	PL	CB
2016 Contract (No GP Track)	-0.00297	0.0000880	-0.00306*
	(0.00324)	(0.00287)	(0.00168)
2016 Contract (GP Track)	0.00991	-0.000998	0.0109
	(0.0142)	(0.0108)	(0.00944)
2016 Contract * Band (No GP Track)	0.0191***	0.0133**	0.00575
	(0.00713)	(0.00628)	(0.00371)
2016 Contract * Band (GP Track)	0.00431	-0.00922	0.0135
	(0.0157)	(0.0126)	(0.0106)
2016 Contract * Hours (No GP Track)	0.0000459	-0.00000238	0.0000482
	(0.000110)	(0.0000962)	(0.0000588)
2016 Contract * Hours (GP Track)	0.0000337	0.000238	-0.000204
	(0.000334)	(0.000247)	(0.000224)
N	56,627	56,627	56,627
N * T	2,253,446	2,253,446	2,253,446
R-sq	0.174	0.129	0.091

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 18 months. CB = Leave the ESR for a period ranging between 7 and 18 months. The models include: individual fixed effects; Trust fixed effects; grade-specific monthly fixed effects; grade-specific specialty fixed effects; a dummy taking value one between January and June 2016 (i.e. Junior Doctors' strikes); a dummy taking value one if older than 34. *Hours* is defined following the approach described in subsection 3.1 to define *Band*. Standard errors clustered at the individual level in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

records between August 2013 and July 2018, which represent a sample where the parallel trend assumption seems to hold even more strongly between high levels and low-medium levels of exposure to unsocial work (see Figure A.10). Again, the results are consistent with the rest of the paper and provide further reassurance about the conclusions of this study.

Finally, Table A.3 tests the robustness of our findings to the exclusion of GP trainees from the analysis, who may be a problematic group of Junior Doctors for two main reasons: (i) they are characterized by a significantly shorter training track which can shape retention behaviour; (ii) they display pre-contract leaving trends that depend on our treatment exposure variable (see Table 4). The results hold and are very similar to those reported in

Table 5.

6 Conclusions

Using detailed employee-level data, this paper shows how the retention of medical trainees in the English NHS was affected by the introduction of the national 2016 Junior Doctor Contract (JDC), which has made unsocial hours work (i.e. night shifts and weekend working) less remunerative for doctors in training in England. We have implemented a DiD strategy with continuous treatment intensity to exploit the heterogeneous exposure of Junior Doctors to the 2016 contract changes. Specifically, it uses the pre-contract monetary compensation for unsocial work earned by Junior Doctors at the foundation stage to identify the most unsocial working environments, and therefore the trainees that felt reasonably more penalized by the new contractual terms.

Our analysis shows that the imposition of the 2016 JDC increased the Junior Doctors' probability of leaving the NHS, especially for those who were used to unsocial work. The baseline results indicate that one-within-standard-deviation increase in our treatment intensity variable was associated with a 0.1% increase in the monthly probability of quitting the NHS. This effect corresponds to a loss of approximately 353 Junior Doctors over a year and translates into an overall yearly exodus of about 2,715 trainees (approximately 5% of all NHS medical trainees in 2015) from the English NHS.

Results from an alternative DiD model shows that the seriousness of the trainees drain varied across specialty areas, which involve considerably different levels of unsocial work depending on the tasks that they require. For instance, we find that specialties in which unsocial shifts are common like A&E and Gynaecology experienced a greater loss of specialty trainees than Psychiatry, where much of the work takes place over the standard 5-day week. Moreover, we show that female and part-time Junior Doctors have been disproportionately affected by the contractual terms introduced in 2016. A heterogeneous analysis by local

support for the Brexit Referendum vote rules out any potential confounding effects related to the 2016 Brexit referendum.

Overall, the findings demonstrate how working conditions can affect the progression in the medical career and the retention of healthcare workers. They are also important for designing future policy interventions and contractual agreements aimed at improving the retention of human capital in hospital care systems, especially those similar to the English NHS. Understanding whether the 2016 contractual terms imposed on Junior Doctors have also affected the quality of healthcare provision, especially during weekends, is an empirical issue that we leave for future investigation.

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A Appendix

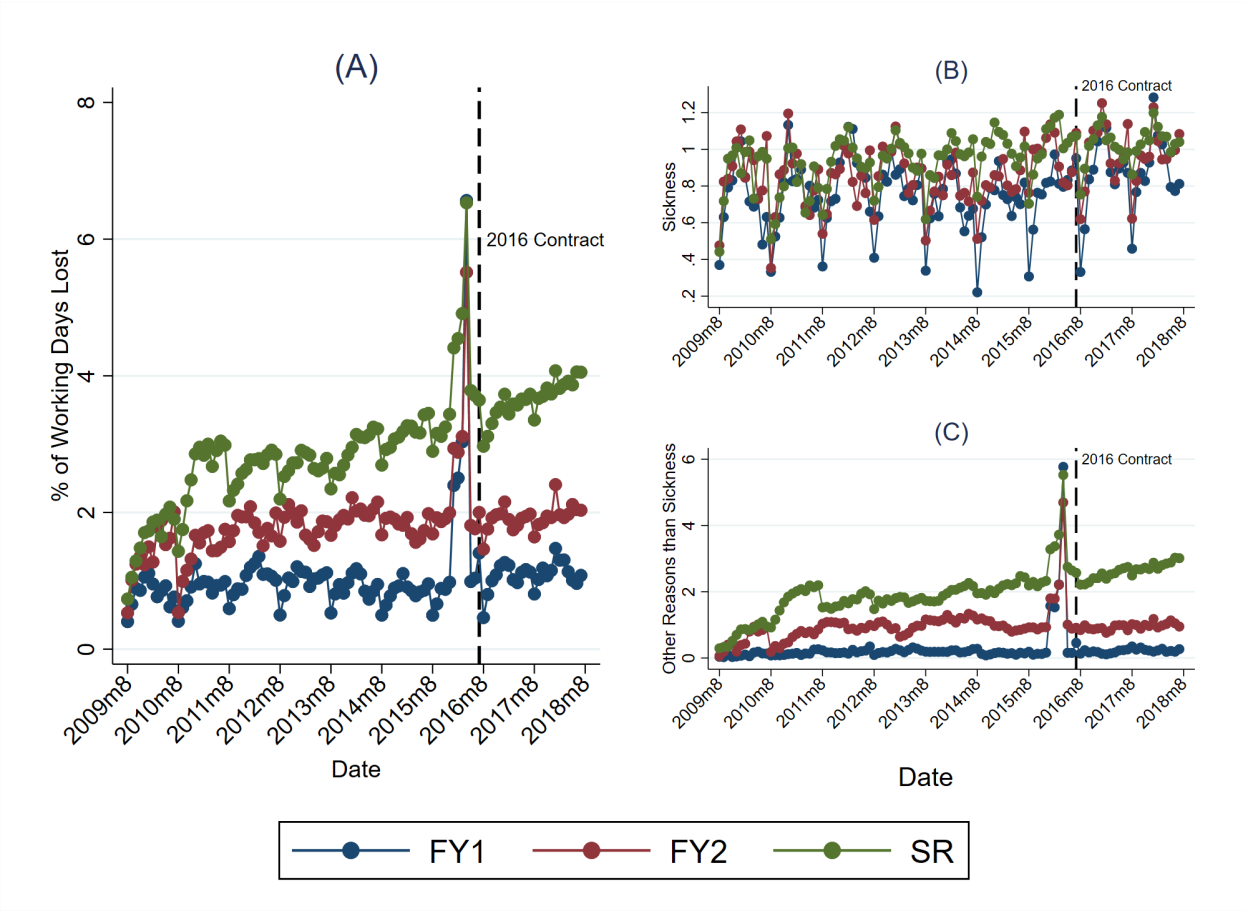

Figure A.1: Monthly Absences Rates

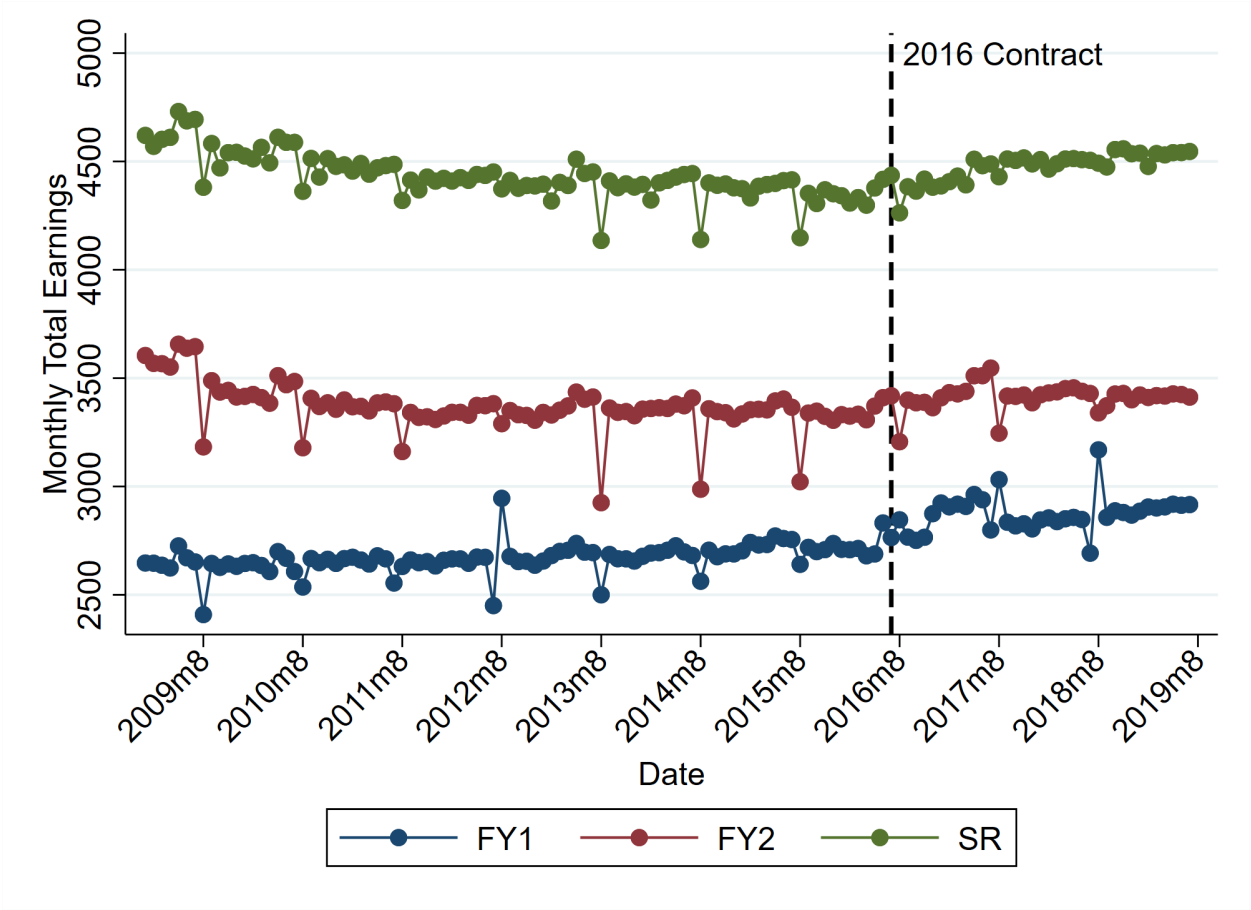

Figure A.2: Monthly Total Earnings

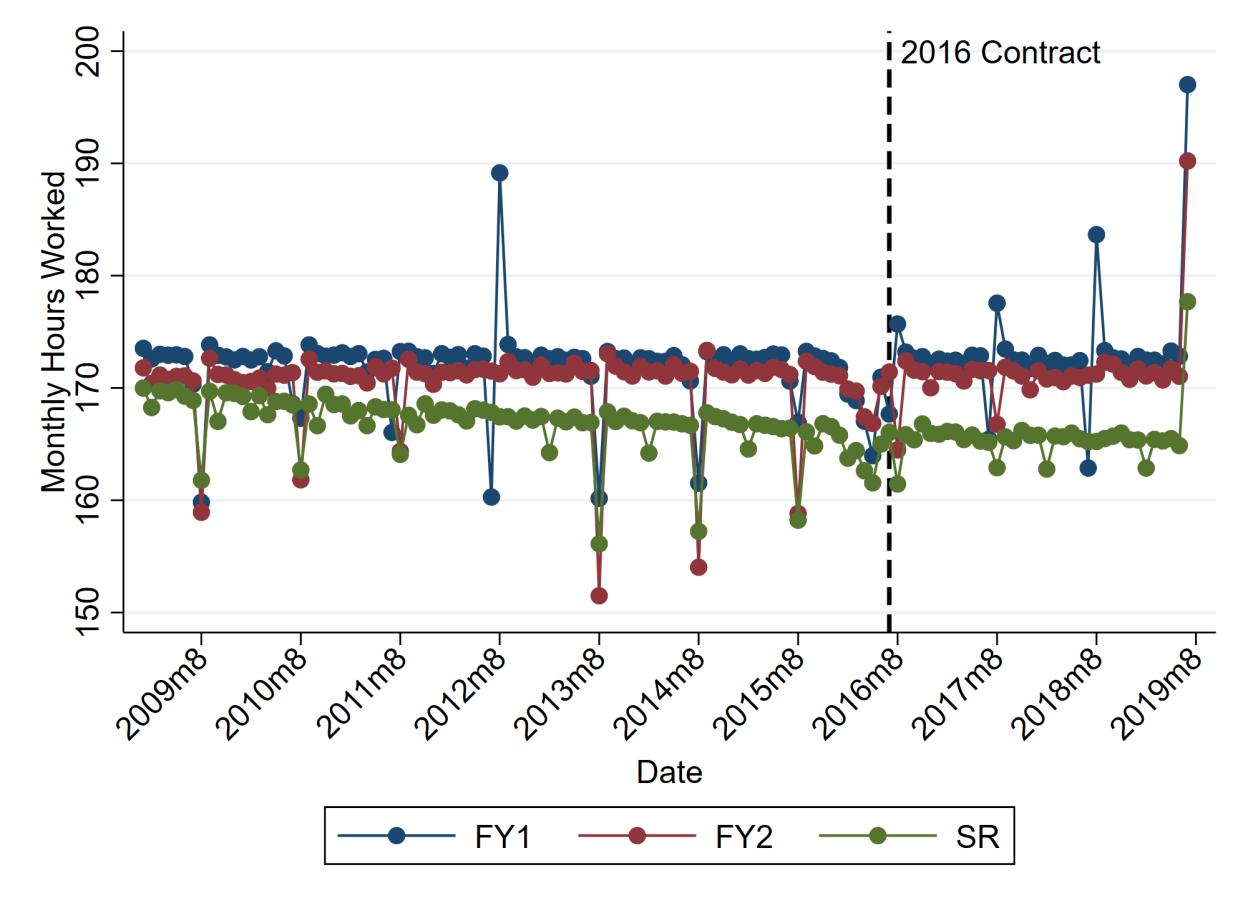

Figure A.3: Monthly Hours Worked

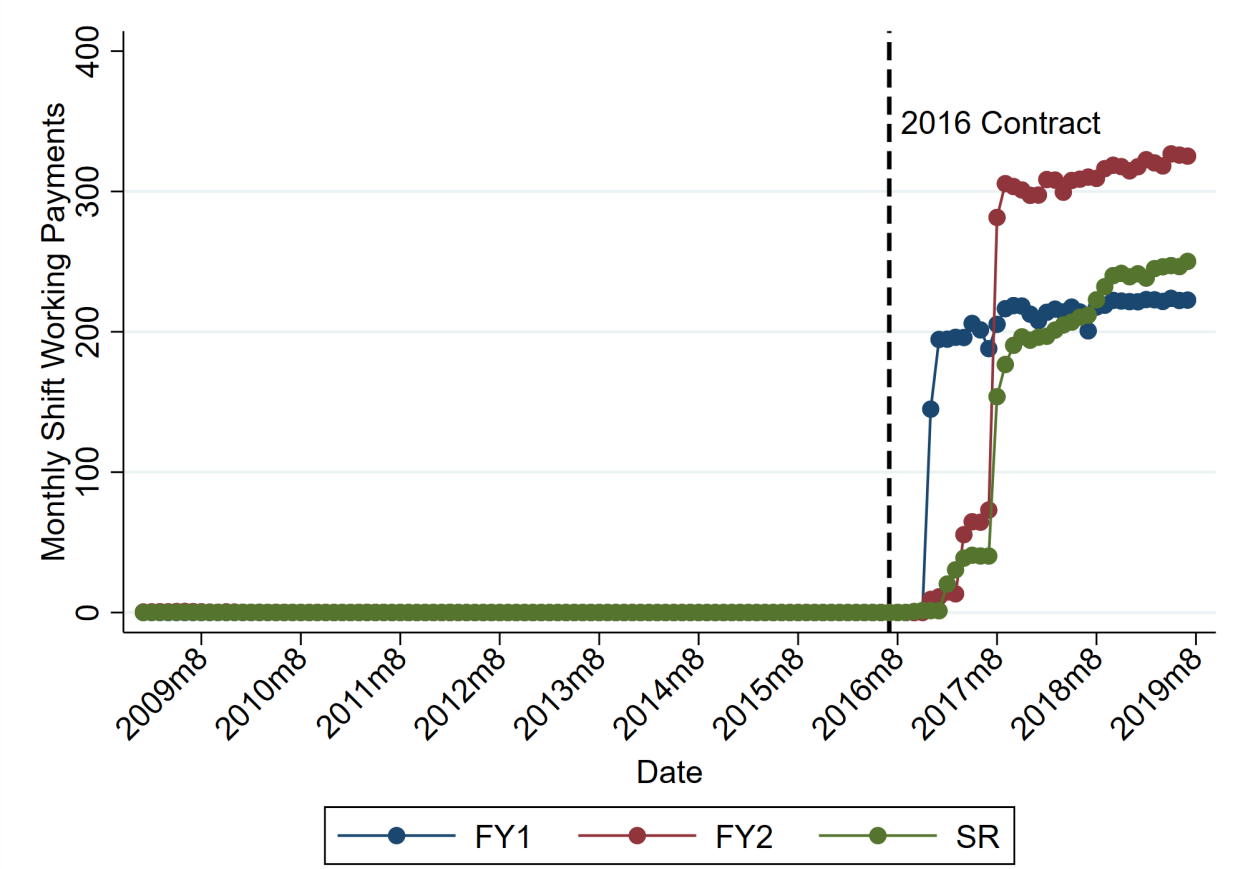

Figure A.4: Monthly Shift Working Pay

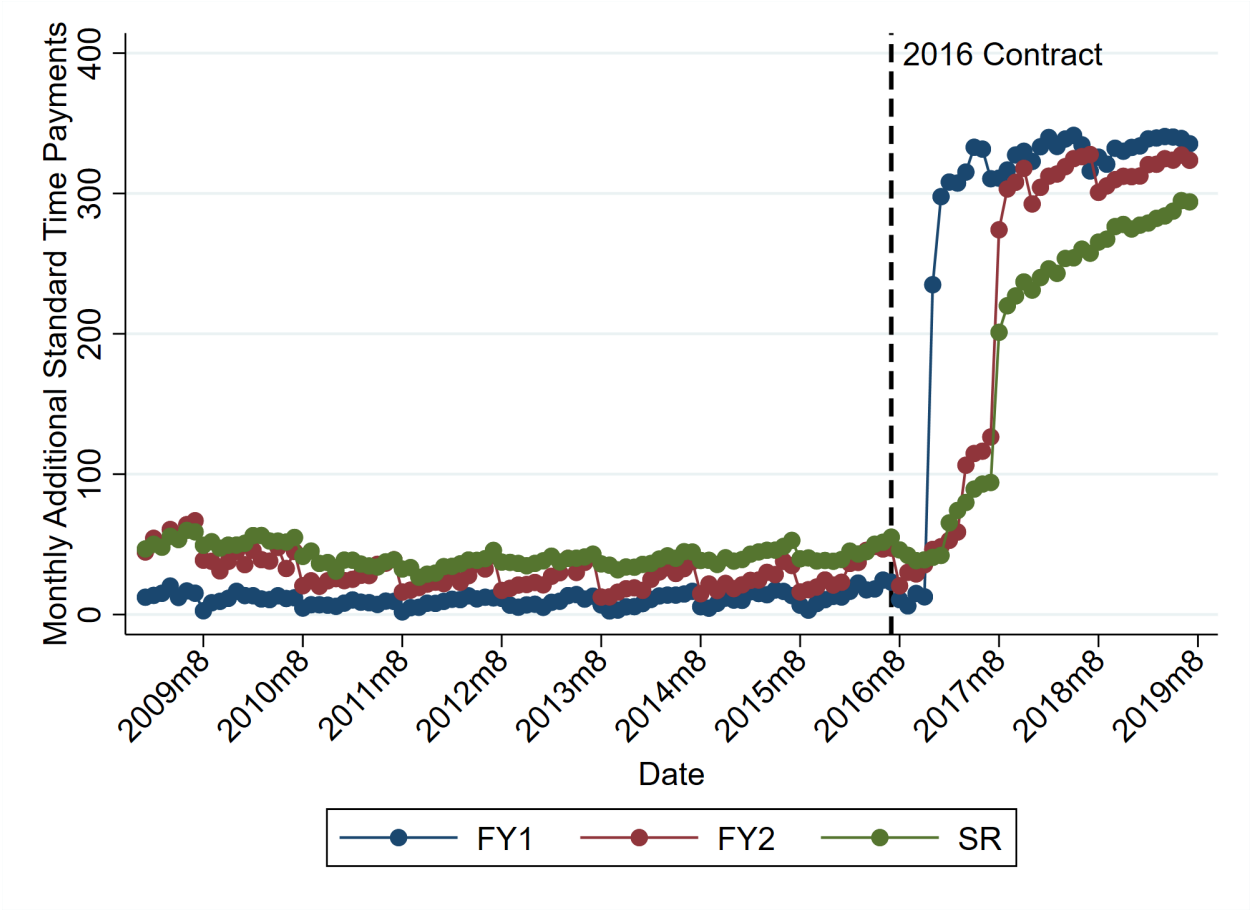

Figure A.5: Monthly Additional Standard Time Pay

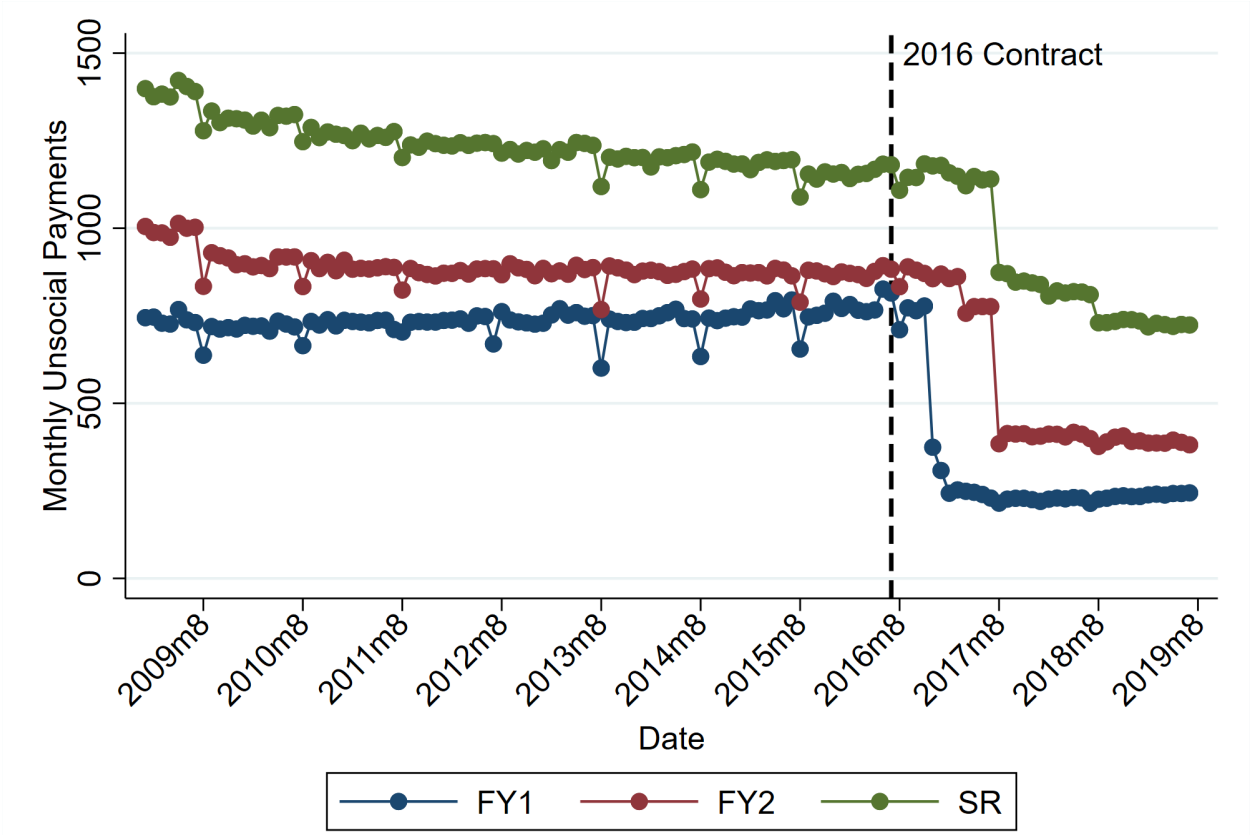

Figure A.6: Monthly Unsocial Pay

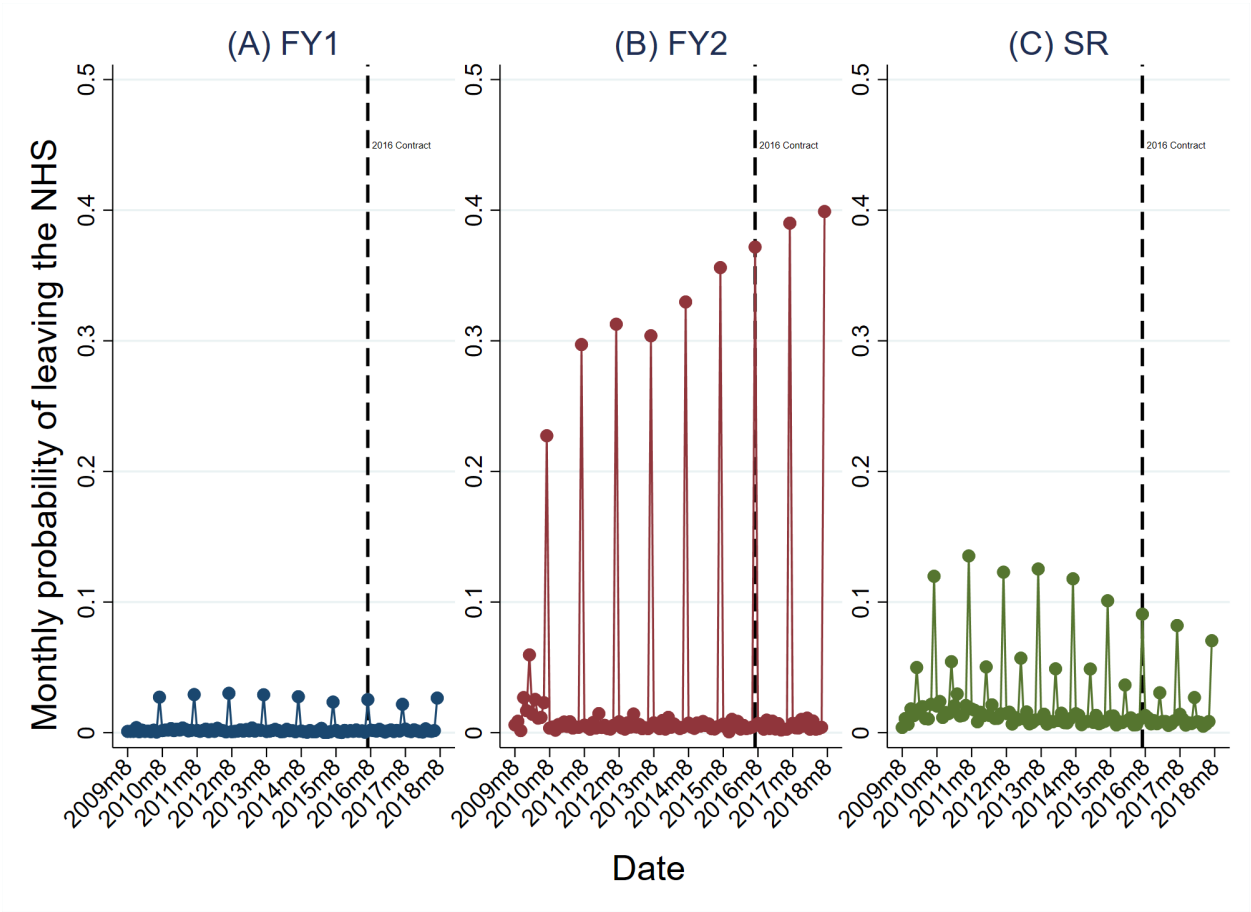

Figure A.7: Monthly Leaving Rates

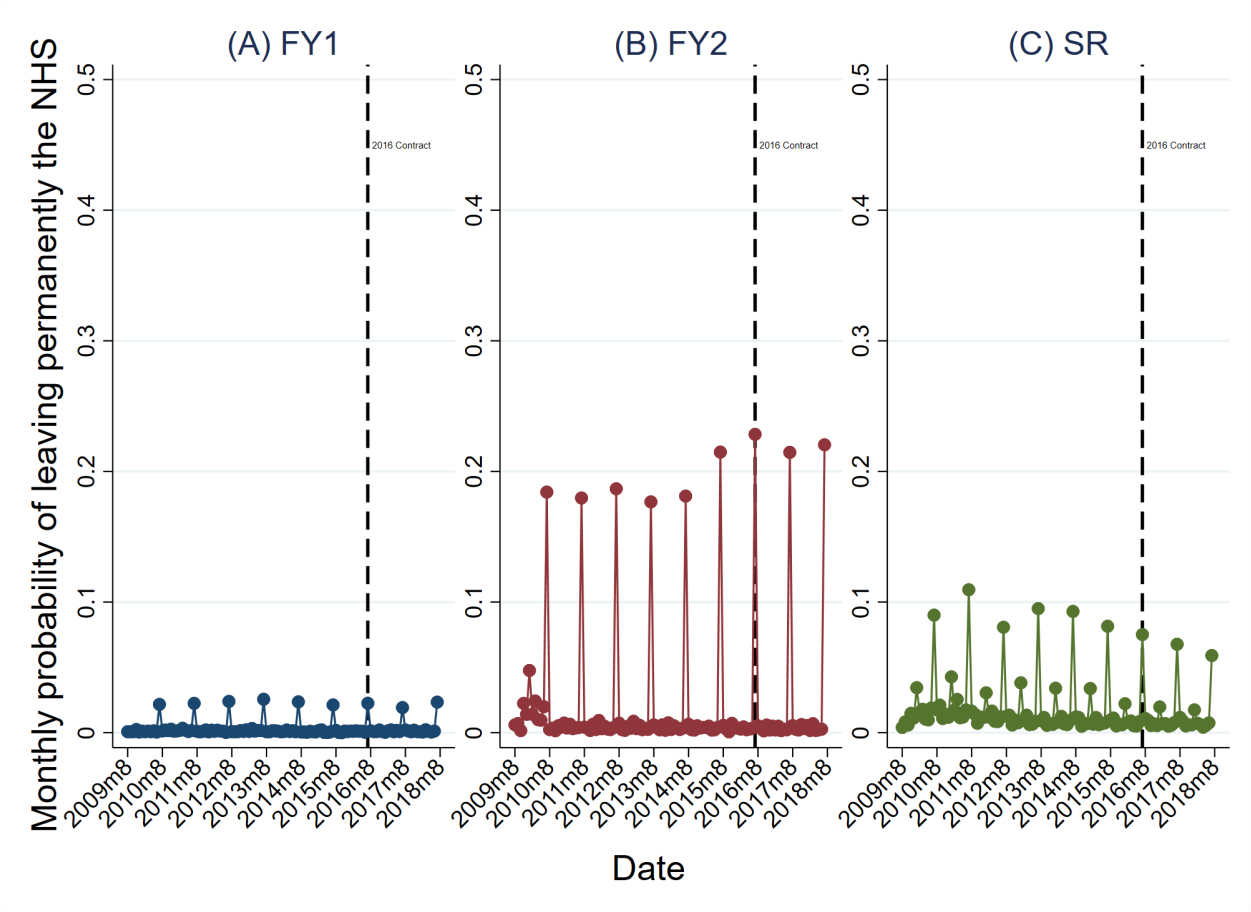

Figure A.8: Monthly Permanent Leaving Rates

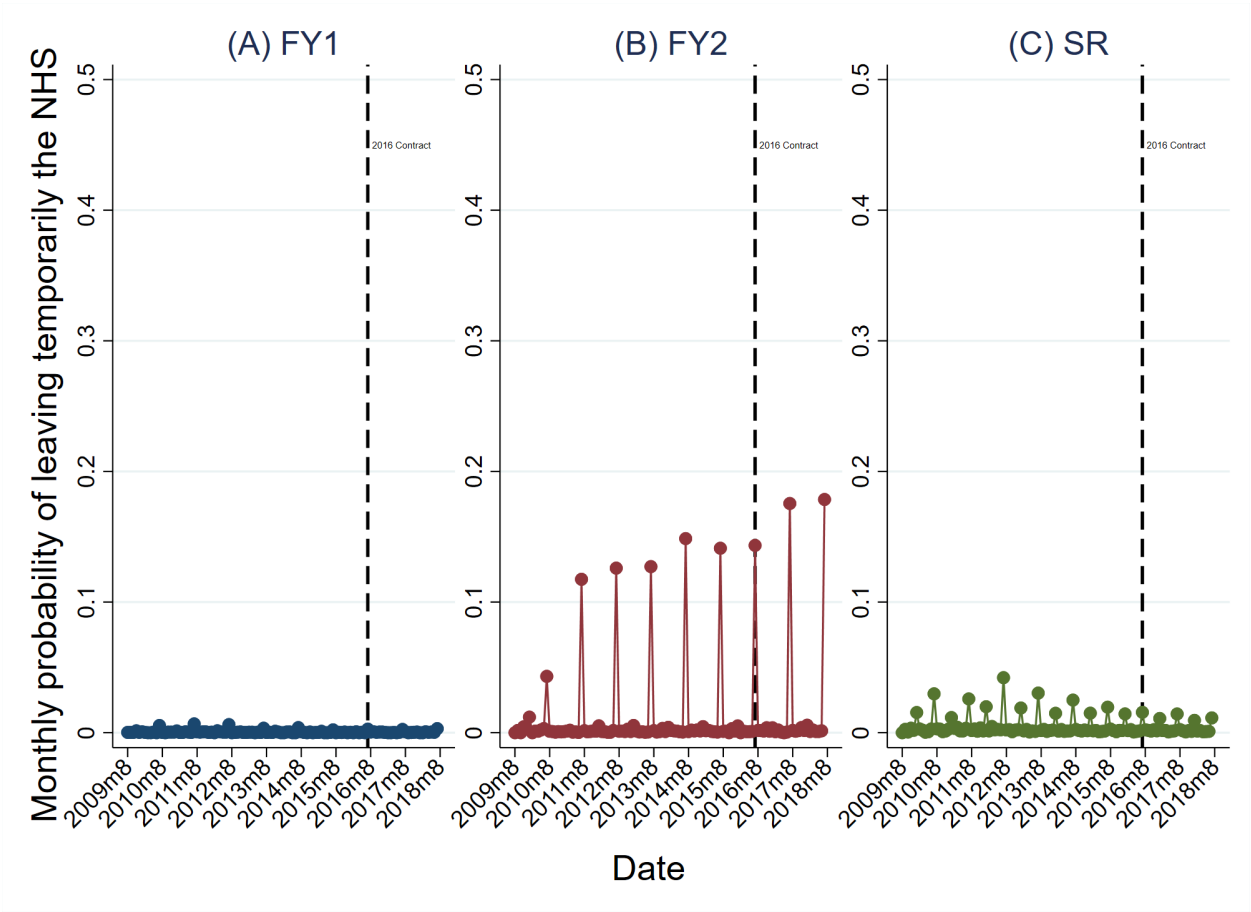

Figure A.9: Monthly Temporary Leaving Rates

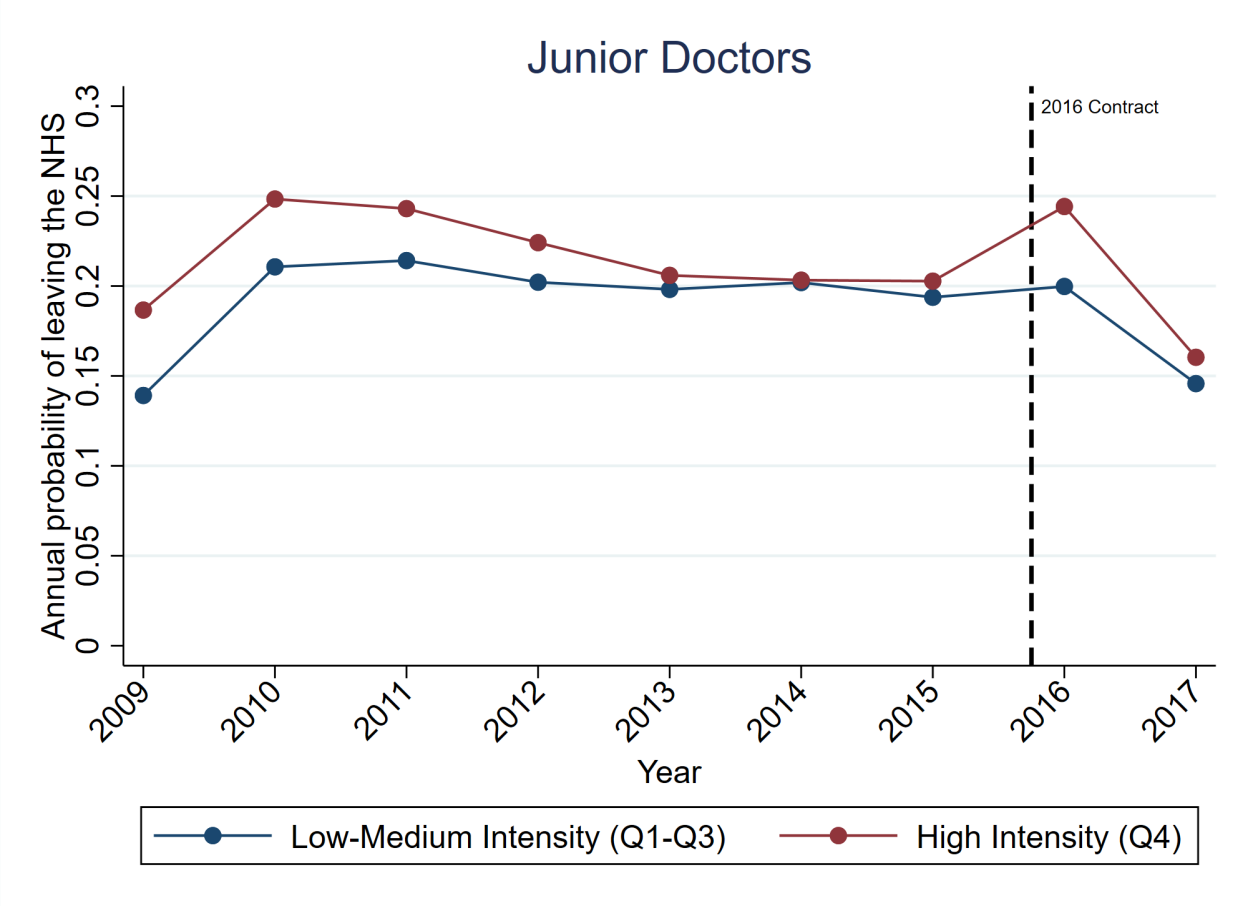

Figure A.10: Leaving trends across the treatment exposure distribution

Table A.1: Heterogeneous effects by age and ethnicity

	Age			Ethnicity		
	(1)	(2)	(3)	(4)	(5)	(6)
	L	PL	CB	L	PL	CB
2016 Contract (Younger than 35)	-0.000178	0.00153	-0.00171			
	(0.00250)	(0.00222)	(0.00136)			
2016 Contract (Older than 34))	-0.00517	-0.00280	-0.00237*			
	(0.00325)	(0.00300)	(0.00136)			
2016 Contract * Band (Younger than 35)	0.0158***	0.00829	0.00747**			
	(0.00582)	(0.00515)	(0.00318)			
2016 Contract * Band (Older than 34)	0.0346***	0.0259***	0.00872***			
	(0.00775)	(0.00716)	(0.00324)			
2016 Contract (White)				-0.00442*	-0.00115	-0.00327**
				(0.00267)	(0.00242)	(0.00135)
2016 Contract (BAME)				0.000201	0.000532	-0.000331
				(0.00319)	(0.00281)	(0.00165)
2016 Contract * Band (White)				0.0250***	0.0143**	0.0107***
				(0.00624)	(0.00564)	(0.00317)
2016 Contract * Band (BAME)				0.0172**	0.0123*	0.00483
				(0.00747)	(0.00655)	(0.00389)
N	56,627	56,627	56,627	56,627	56,627	56,627
N * T	2,253,446	2,253,446	2,253,446	2,253,446	2,253,446	2,253,446
R-sq	0.174	0.129	0.091	0.174	0.128	0.092

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 18 months. CB = Leave the ESR for a period ranging between 7 and 18 months. The models include: individual fixed effects; Trust fixed effects; grade-specific monthly fixed effects; grade-specific specialty fixed effects; a dummy taking value one between January and June 2016 (i.e. Junior Doctors' strikes); a dummy taking value one if older than 34. All coefficients refer to non-GP trainees. Standard errors clustered at the individual level in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

Table A.2: Sample Robustness check

	Continuous			Binary		
	(1)	(2)	(3)	(4)	(5)	(6)
	L	PL	CB	L	PL	CB
2016 Contract (No GP Track)	0.00625***	0.00765***	-0.00140	0.0117***	0.0110***	0.000710***
	(0.00214)	(0.00189)	(0.00112)	(0.000376)	(0.000323)	(0.000212)
2016 Contract (GP Track)	0.0175***	0.0138***	0.00377	0.0182***	0.0113***	0.00689***
	(0.00670)	(0.00529)	(0.00468)	(0.000815)	(0.000652)	(0.000580)
2016 Contract * Band (No GP Track)	0.0145***	0.00940**	0.00512*			
	(0.00500)	(0.00443)	(0.00263)			
2016 Contract * Band (GP Track)	0.00154	-0.00608	0.00762			
	(0.0153)	(0.0121)	(0.0107)			
2016 Contract * Band Q4 (No GP Track)				0.00273***	0.00249***	0.000245
				(0.000597)	(0.000506)	(0.000351)
2016 Contract * Band Q4 (GP Track)				0.0000376	-0.000560	0.000597
				(0.00127)	(0.00102)	(0.000869)
N	46,831	46,831	46,831	46,831	46,831	46,831
N * T	1,550,201	1,550,201	1,550,201	1,550,201	1,550,201	1,550,201
R-sq	0.188	0.144	0.103	0.188	0.144	0.103
Observations	Aug2013-July2018	Aug2013-July2018	Aug2013-July2018	Aug2013-July2018	Aug2013-July2018	Aug2013-July2018

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 18 months. CB = Leave the ESR for a period ranging between 7 and 18 months. The models include: individual fixed effects; Trust fixed effects; grade-specific monthly fixed effects; grade-specific specialty fixed effects; a dummy taking value one between January and June 2016 (i.e. Junior Doctors' strikes); a dummy taking value one if older than 34. The sample includes only observations from August 2013 to July 2018. Standard errors clustered at the individual level in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.

Table A.3: Baseline models without GP trainees

	(1)	(2)	(3)	(4)	(5)	(6)
	L	PL	CB	L	PL	CB
2016 Contract	-0.00160	0.000271	-0.00187*	0.00605***	0.00430***	0.00175***
	(0.00209)	(0.00189)	(0.00104)	(0.000340)	(0.000293)	(0.000188)
2016 Contract * Band	0.0200***	0.0110**	0.00897***			
	(0.00488)	(0.00440)	(0.00244)			
2016 Contract * Band Q4				0.00318***	0.00246***	0.000715**
				(0.000570)	(0.000486)	(0.000324)
N	46,941	46,941	46,941	46,941	46,941	46,941
N * T	1,835,678	1,835,678	1,835,678	1,835,678	1,835,678	1,835,678
R-sq	0.171	0.135	0.079	0.171	0.135	0.079
GP Trainees	No	No	No	No	No	No

Notes: L = Leave the ESR for more than 6 months. PL = Leave the ESR for more than 18 months. CB = Leave the ESR for a period ranging between 7 and 18 months. The models include: individual fixed effects; Trust fixed effects; grade-specific monthly fixed effects; grade-specific specialty fixed effects; a dummy taking value one between January and June 2016 (i.e. Junior Doctors' strikes); a dummy taking value one if older than 34. The sample includes only non-GP trainees. Standard errors clustered at the individual level in parenthesis. Significance levels: * 0.1; ** 0.05 *** 0.01.