Staff engagement, coworkers' complementarity and employee retention: Evidence from English NHS hospitals

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Abstract

Retention of skilled workers is essential for labour-intensive organisations like hospitals, where an excessive turnover of doctors and nurses can reduce the quality and quantity of services to patients. In the public sector, where salaries are often not negotiable at individual level, workers increasingly care about the non-pecuniary aspects of their jobs. We empirically investigate the role played by two such aspects, staff engagement and the retention of complementary coworkers, in affecting employee retention within the public hospital sector. We exploit a unique and rich panel dataset based on employee-level payroll and staff survey records from the universe of English NHS hospitals, and estimate dynamic panel data models to deal with the bias due to reverse causality. We find that nurses' retention is positively associated with their engagement, whereas doctors' retention is positively associated with nurses' retention. This heterogeneous response of employee retention can be explained by the hierarchy of workers' professional roles within the organisation.

Keywords: employee retention, staff engagement, job complementarities, coworkers, hospitals, endogeneity. **JEL Codes:** C33, C36, I11, J22, J28, J63

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1 Introduction

"Health systems can only function with health workers" (WHO, 2016a), because health care remains a labour-intensive sector, where new medical technologies complement human labour without fully replacing it. Over the last decade, the shortages of healthcare professionals have been a growing concern for the governments of several countries (Barriball et al., 2015; Cosgrave et al., 2019) and international organisations (Magnusson, 2017; WHO, 2018). Already in 2016, the World Health organisation (WHO) estimated a projected shortfall of 18 million health workers by 2030 (WHO, 2016a). Unlike low-income, developing countries, usually struggling with the recruitment and formation of healthcare workers, the issue in wealthy, developed countries is mostly related to increasing workforce burnout (Hall et al., 2016; Johnson et al., 2018; De Hert, 2020) and insufficient retention of skilled professionals (Buchan and Aiken, 2008; Buerhaus, 2008; Manzano-García and Ayala-Calvo, 2014). The main drivers of these trends are known: on the demand-side, population ageing and the consequent rise in the demand for health care; on the supply-side, pay and hiring freezes of healthcare professionals operated by governments after the 2008 Great Recession, coupled with an increased mobility of healthcare workers in a competitive labour market (WHO, 2016b).

Outside the healthcare sector, excessive personnel turnover has been found detrimental for firms' performance indicators such as profits, revenues, customer service, scrap rates and training costs (Siebert and Zubanov, 2009; Hausknecht and Trevor, 2011; Allen et al., 2010; Detert et al., 2007; Staw, 1980; Michele Kacmar et al., 2006). An additional, common concern within health care, particularly in time-sensitive areas of hospital care, is that excessive personnel turnover may generate pressure on the remaining workers leading to lower quality of patient care (e.g., see Needleman et al. (2002) and McHugh et al. (2021) for the negative relationship between nurses' shortages and hospital quality indicators). In countries like the US and the UK, the COVID-19 pandemic has also triggered a wave of voluntary employee

resignations, the so called "Great Resignation" (The Economist, 2021a); this phenomenon has affected even the English National Health Service (NHS) with a record-high historical level of about 2% quits of its entire workforce (iNews, 2022). As high staff turnover issues are likely to persist in the near future (The Economist, 2021b), both in health care and other sectors, the sustainability of large organisations, such as public and private healthcare systems, hinges crucially on a better understanding of the mechanisms governing the economics of workforce *retention* (Sheather and Slattery, 2021).

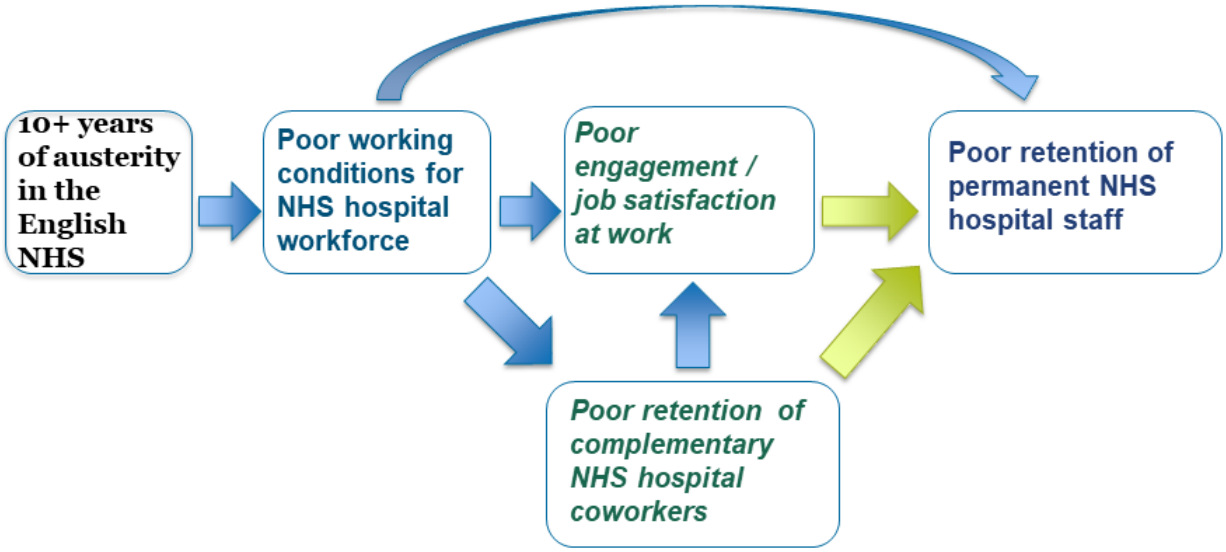
Employee retention is defined as the decision to keep on working for the organisation where one is employed, i.e. the opposite of workers' turnover or attrition. This work contributes to the literature on this topic by focusing on the nexus between workers' retention and two key non-pecuniary, yet management-related, job aspects: staff engagement and the retention of complementary workers. To this extent, we analyse the dynamics of the retention of hospital nurses and doctors, using administrative workforce records from the universe of public hospitals in the English National Health Service (NHS).

Staff engagement is a construct introduced by the psychology and management literature (Kahn, 1990; Harter et al., 2002; Schaufeli et al., 2002). It is defined "as a blend of three existing concepts: job satisfaction, commitment to the organisation and extra-role behaviour, i.e. the discretionary effort to go beyond the job description"(Schaufeli, 2013). The concept of staff engagement seems relevant for employees working in the public sector and healthcare workers in particular, given the altruistic or intrinsic motivation that is associated with choosing these kinds of jobs (Ellis and McGuire, 1986). Staff engagement has been monitored across NHS care providers and within the NHS it is regarded as an organisational characteristic arising from a top-down managerial effort to keep workers motivated in their jobs; for this reason, it is not equivalent to job satisfaction. Moreover, labour-intensive organisations employ workers with varied and complementary skill-sets and competences to produce their outputs (Neffke, 2019). Hospital care is the prototypical example of a multi-input production

function setting, where nurses and doctors are predominantly employed as complementary labour inputs to deliver patient care. The complementarity between these two groups of hospital workers is likely reflected also in their choices about where to work: for example, a large number of nurses resigning from a hospital may trigger a wave of doctors' resignations due to worse working conditions and excessive demand pressure on the remaining workers.

We cover the following research questions. First, we analyse how working conditions and other managerial inputs are associated with staff engagement. Second, and our main objective, we investigate the association between hospital workers' retention, their engagement and the retention of complementary workers, both at the mean and along the retention distribution.[1] Third, we also examine whether hospital workers' labour supply intensive margins, proxied by hours worked and absences from work, are responsive to changes in staff engagement and complementary workers' intensive margins.

Figure 1: Data generating process and relationships of interest (in yellow)



The English NHS is an ideal setting to conduct this study for a number of reasons. It is the world's fifth biggest employer (as of 2019), providing us with high-quality employee payroll data and large sample sizes for both hospitals and their clinical workers. The pay of

[1]Figure 1 shows a scheme of the Data Generating Process we hypothesise, with the two relationships of in interest that we aim to test empirically in yellow.

doctors and nurses working in NHS hospitals is regulated at the national level, thus reducing the risk of confounding due to individually-contracted monetary incentives in our analysis. The minimum quality standards of the NHS healthcare services are subject to national regulation and monitored by an independent regulator (Care Quality Commission), yet there is wide variation in the quality performance of NHS hospital organisations (Appleby et al., 2011; NHS Improvement, 2018; Public Health England, 2015) and in their employee retention rates (Propper et al., 2021). The NHS has been struggling with employee retention issues for the latest decade, well before the COVID pandemic (Buchan et al., 2019). Lastly, we can exploit the high-quality data from the NHS Staff Survey (NSS), the largest survey in the world on healthcare staff behaviour, which has been collected and used by the NHS to support a sustainable workforce planning.

In the empirical analysis, we build a panel of hospital data over ten years from rich employee-level hospital payroll records, including about 320,000 (50,000) nurses (tenured doctors) per year, and measure the retention of NHS hospital nurses and doctors through two indicators: the *stability index rate*, an official retention metrics used by the NHS, and the *NHS leaving rate*. We use two-way fixed effects, system-GMM and unconditional quantile regressions (à la Firpo et al. (2009)) to evaluate the association of our variables of interest with the retention outcomes of nurses and doctors, by estimating separate regressions for each of the two occupational groups. We address the potential reverse causality of staff engagement and complementary workers' retention with employee retention, i.e. the instance when poor staff engagement arises in hospitals with a high turnover of many clinical workers, by employing system-GMM estimators à la Arellano and Bover (1995) and Blundell and Bond (1998). Up to our knowledge, we are the first to investigate the relationship between retention, staff engagement and workers' complementarities in such a fashion.

We find that a within-standard-deviation increase in nurses' engagement is associated with a 16% (15%) within-standard-deviation increase (decrease) in nurses' stability index

(rate of leaving the NHS hospital sector). Also, a within-standard-deviation increase in nurses' stability index (rate of leaving the NHS hospital sector) is associated with a 11% (11.5%) within-standard-deviation increase in senior doctors' stability index (rate of leaving the NHS hospital sector).

The unconditional quantile regressions (UQR) confirm the above results, with larger estimates documented for low-retention hospitals. We also find that nurses' retention is not associated with the complementary retention of doctors employed in the same hospital, and doctors' retention is unaffected by their own engagement at work. With respect to labour supply intensive margins, the only significant association that we document is a negative relationship between nurses' engagement and their sickness absence rate, while no significant association is found for senior doctors. Overall, our analysis provides evidence of a dynamic mechanism of hospital workforce retention driven primarily by the engagement and retention of nurses. It also suggests that the employee retention response to non-monetary job aspects is heterogeneous, and that this heterogeneity may be related to the hierarchical position and roles of different occupational groups within an organisation.

The rest of the paper is organised as follows. Section 2 provides a review of the related literature, the institutional background and a description of the data used in this study. Section 3 presents the empirical strategy. Section 4 illustrates the results and robustness checks. Section 5 concludes.

2 Background, Institutional Setting and Data

2.1 Related Literature

Our study is closely related to the research on job satisfaction and well-being at work. The empirical literature has shown that there exists a relationship between income and job

satisfaction[2], and that job satisfaction is a significant predictor of turnover and turnover intentions (Clark, 2001; Shields and Ward, 2001; Lévy-Garboua et al., 2007). For nurses working in the English NHS, Shields and Ward (2001) find that higher job dissatisfaction is associated with a higher likelihood of quitting the NHS, especially if such dissatisfaction is due to lack of promotion and training opportunities rather than dissatisfaction with pay. Staff engagement can be considered as an alternative, broader metric of well-being at work, which relates to non-pecuniary aspects of employment. Our work contributes to this strand of literature by showing that nurses' and doctors' engagement scores are positively associated with their job satisfaction; and also that nurses' retention is positively associated with their engagement at work, but not with their job satisfaction.

Other related studies have investigated the link between staff engagement and hospital performance in terms of quality of patient care and workforce metrics. For instance, using mostly cross-sectional data, West et al. (2011) and Topakas et al. (2011) show that higher engagement score is associated with higher patient satisfaction and better quality of care. Panel data evidence from Badgett et al. (2020) also reports a negative association between standardised hospital mortality and employee motivation. Moreover, West and Dawson (2017) show that staff engagement is negatively associated with absenteeism and agency staff spending. Unlike our analysis, these studies do not properly account for unobserved hospital heterogeneity and do not address any reverse causality concern.

An emerging literature has recently stressed the role of positive spillovers from coworkers in explaining the labour market outcomes of peers. Using data from the US, Herkenhoff et al. (2018) show that coworkers matter for the human capital accumulation of an individual; similarly, Nix (2020) and Jarosch et al. (2021), respectively using data from Sweden and Germany, report a positive influence on worker's earnings from an increase in coworkers' education and wages. Our analysis adds to this literature, as we are among the first to investigate the role played by complementary coworkers in influencing hospital staff retention.

[2]For instance, there is evidence that workers' job satisfaction is only weakly associated with income (Clark and Oswald, 1996), but positively affected by the income of peer coworker (Clark et al., 2009).

More broadly, our study can be linked to the literature on the effect of managerial quality on hospital performance (Bloom et al., 2015; Tsai et al., 2015; Janke et al., 2019; Bloom et al., 2020). Indeed, fostering staff engagement and managing the labour supply of groups of workers with complementary occupational roles fall under the remit of an organisations' executive team and are human resources strategies that, we show, may contribute to improving employee retention.[3] Two studies related to ours are Hoffman and Tadelis (2021) and Friebel et al. (2022) who, using either instrumental variables (IV) or a randomized controlled trial, respectively show the positive impact on reducing employee turnover of better managerial skills and of a goal-setting intervention to reduce employee quit rates; aside from the methods, our work distinguishes from theirs as we analyse employee data from an entire sector, not just one firm, for a longer period of time (ten years). One similarity is that our system-GMM strategy, based on lagged variables as internal instruments, resembles one of the IV strategies implemented by Hoffman and Tadelis (2021), using a managers' past score as the instrument for the current score. Finally, our work is in line with an increasing number of studies exploiting tailored surveys to capture and characterise agents' heterogeneous behaviour and choices in a richer way than using administrative data only (see e.g. Bloom et al., 2015; Alesina et al., 2018; Alsan et al., 2020; Adams-Prassl et al., 2020).

2.2 The English NHS and its clinical workforce

The English NHS is a publicly-funded healthcare system based on taxation and free at the point of use for the patients. Since its establishment in 1948, the NHS has been the main provider of health care in England; the share of the population who has also a private health insurance policy, as an add-on to NHS services, is just about 7% (The King's Fund, 2014). The delivery of NHS hospital care to acute and mental health patients is operated by hospital organisations known as Trust, with about 164 Acute care Trusts and 48 Mental

[3]As an example of the managerial input aimed at improving staff engagement within the English NHS, in Figure 5 we report the business cases of NHS organisations as reported by NHS Employers, which is the organisation negotiating contracts with healthcare staff on behalf of the UK government.

Health (MH) Trusts in 2019. Acute care Trusts are organisations that include on average 6 hospital sites and are reimbursed for patient treatments according to fixed-priced tariffs, set at national level and adjusted for differences in local area costs; whereas the reimbursement of MH patients' treatments to MH hospital Trusts is based either on capitation or on episodic payments according to nationally-set tariffs.[4]

The NHS clinical hospital workforce is mainly made of nurses, midwives and specialist doctors also called hospital *consultants* or *senior doctors*.[5] Each Trust is tasked with the recruitment of the clinical workers it needs to deliver healthcare services. Doctors and nurses employed by NHS Trusts are paid according to pay scales regulated by national contracts, which are reviewed annually by the Review Body on Doctors' and Dentists' Remuneration (DDRB) and the NHS Pay Review Body (NHSPRB); the regulated pay scale, and so the salary received, depends on the worker's training and tenure. Based on the location of the Trust where they work, nurses receive also a fixed high-cost area supplement, which is higher in the London area; apart from this, the monthly pay for both nurses and doctors can be considered as fixed, with little to no variation within England.

2.3 The annual NHS Staff Survey

Since 2003, the staff working in NHS organisations is asked to complete the annual nation-wide NHS Staff Survey (NSS), one of the largest workforce surveys in the world.[6] The results from the survey guide the official NHS monitoring bodies, NHS England and NHS Improvement, to improve staff experience both locally and nationally, and support national

[4]NHS hospital care services are reimbursed and commissioned to NHS Trusts by the local Clinical Commissioning Groups (CCGs), which are responsible for assessing needs, planning and prioritising, purchasing and monitoring health services for patients residing within their local area. NHS services are organised and commissioned on a local, regional and national basis by the CCGs alongside the two NHS monitoring bodies, NHS England (NHSE) and NHS Improvement (NHSI), which are responsible for regulating the performance, outcomes and use of resources respectively of CCGs and Trusts.

[5]In the remainder of this work, we use the term *senior doctors* for tenured hospital doctors, as opposed to trainee doctors, who are frequently called *junior doctors* in the UK. We also do not use the term *physician* to avoid confusion, as in the English NHS setting this term may apply either to hospital doctors or to primary care doctors (also referred to as GPs, or *General Practitioners*).

[6]`https://www.nhsstaffsurveys.com/about-the-survey/`.

assessments and research commissioned by the Department of Health (West et al., 2011; West and Dawson, 2017). The survey is carried out from late September to early December each year and paints a picture of NHS staff's experiences at work.[7] The NSS is completed by a large representative sample of NHS employees, with a 46.73% response rate in 2018.[8] NHS workers' engagement is measured through the NSS, as further discussed in Section 2.4.1. The NSS data show that, in 2018, 24.64% of senior doctors and 29.78% of registered nurses have often considered leaving their organisation. Moreover, staff engagement for senior doctors and nurses who considered leaving their hospital Trust was, on average, lower by 2.30 and 1.76 points respectively than those who did not consider leaving.

2.4 Data

We construct a panel of NHS hospital Trusts in England by collating information from multiple micro-level data sources from 2009/10 to 2019/2020 financial years. Our data sources include the monthly Electronic Staff Records (ESR) 2009-2019, the annual employee-level NHS Staff Surveys (NSS) 2009-2018, the UK Office for National Statistics postcode data, and the Annual Survey of Hours and Earnings (ASHE).

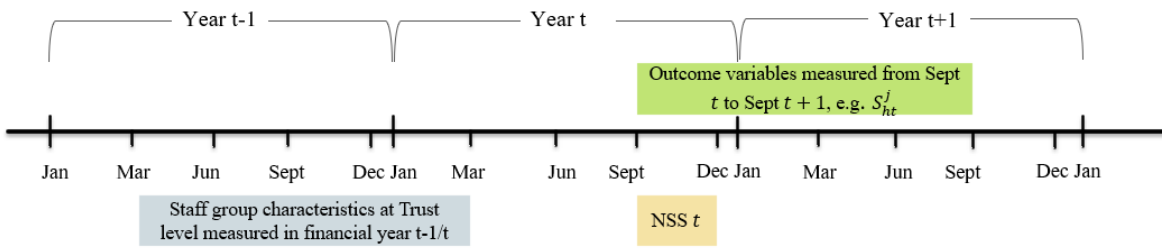
Our outcome variables of interest are retention measures of nurses and senior doctors employed in acute and MH care NHS hospitals.[9] We exclude hospital Trusts that did not have nurses or senior doctors on active assignment during the sample period; and Trusts that are observed for less than 9 consecutive years in the panel. We also exclude NHS trainee doctors (junior doctors) from the main analysis, due to the temporary nature of their posts and their planned rotations across specialties and Trusts every few months. Thus, trainee doctors' employment within an NHS Trust is not a good indicator of hospital workforce retention.

[7]The survey contains questions about job experiences, health, workplace culture and wellbeing at work, along with some demographic information.

[8]For example, around 1.07 million NHS employees were invited to take part in the NSS 2018.

[9]For our analyses we have access only to ESR records of NHS hospital doctors and nurses, not of administrative, ancillary and clerical NHS hospital workers, a large part of whom is outsourced from the private sector (HSJ, 2013).

Figure 2: Data setup



Notes: Outcomes include stability index, NHS leaving rates, absences and hours worked. t refers to the base year. The NSS refers to the period for the fieldwork of the NHS Staff Survey, which take place every year in autumn. The NSS runs on average for the 8 weeks from late September to early December. Staff working in Trusts in 1st September are eligible to respond to the NSS.

The final sample consists of 190 NHS Hospital Trusts in England.[10] Figure 2 illustrates the structure of the data and the time frame for the measurement of the relevant variables, which we discuss further in the following sections.

2.4.1 *Staff engagement, its components and other work environment variables*

To construct the staff engagement scores, we use individual-level information from the NHS staff survey (NSS) for the period between 2009 and 2018.[11] By using individual-level NSS data, we are able to aggregate the NSS variables (i.e. the engagement score, its components and other work environment variables used in Section 3.1) at Trust-level, separately for nurses and senior doctors.[12]

The NSS contains a battery of questions capturing the engagement components as *motivation*, *inclusion* and *advocacy*. The motivation component refers to the work engagement elements of "vigour, dedication and absorption", as described in Schaufeli et al. (2002). The measure encompasses how staff feels about their job and while they work. Advocacy is related to staff's view about the organisation as a place to work and to receive health care. The inclusion domain entails staff's views on their role in decision making in the organisa-

[10] 97.4% of the Trusts are observed during the whole panel, i.e. for 10 years.
[11] These data have been accessed under a data sharing agreement with NHS England.
[12] On the contrary, publicly available NSS data report only aggregated data for nurses and midwives together, or junior and senior doctors together. This feature of our analysis helps limiting issues of measurement error, which might arise for example from using the combined engagement score of nurses and midwives.

tion, and the extent of their influence in making changes happen. The overall engagement score is computed following the official methodology used by the NHS and developed by the NSS Survey Coordination Centre. Each engagement component is an average of three questionnaire items (see Table 8). The overall engagement of an employee is the mean score of motivation, advocacy and inclusion components. [13] Employee-level NSS data are then aggregated to obtain the engagement score, E^j_{ht}, for staff groups j at Trust h in survey year t. The overall engagement score ranges from 0 to 10, with a higher score indicating higher levels of staff engagement.

2.4.2 *Measures of workforce retention*

We employ two of the official indicators adopted by the NHS Workforce Statistics unit to measure employee retention outputs by staff group at Trust level: the stability index and the NHS leaving rate. Both measures capture the retention of existing human capital over a specified time span, one within the hospital organisation and the other within the whole NHS hospital sector. We calculate the stability indices from the employee-level ESR, which is an administrative payroll record containing monthly information on the universe of NHS employees in England, and which we were granted access to by the Department for Health and Social Care.

The stability index of staff group j in Trust h in the period $[t, t+\tau]$, $S^j_{ht\tau}$, is the percentage of the same staff who remained actively employed in the same Trust and staff group at times t and $t+\tau$:

$$S^j_{ht\tau} = \left(\frac{\sum_i \mathbb{I}_i(\text{individual } i \text{ in staff group } j \text{ actively employed in Trust } h \text{ at } t+\tau | \text{employed at } t)}{\sum_i \mathbb{I}_i(\text{individual } i \text{ in staff group } j \text{ actively employed in Trust } h \text{ at } t)} \right) \times 100$$

where $j = \{\text{nurses}(N), \text{senior doctors}(SD)\}$ and τ is a certain number of months.[14]

[13] The NSS technical documents give further details on engagement score computation at `https://www.nhsstaffsurveys.com/results/results-archive/`.

[14] We track the organisational changes and staff transfers within the NHS hospital care system over the sample period. Unless taken into account, staff transfers create sudden and consistent drops in the stability index, introducing bias to the measurement of Trust level workforce retention outcomes. We use information on

The stability indices $S^{j}_{ht\tau}$ are computed by tracking employees over time and across organisations: for example, if Trust A had 100 active nurses in September 2013 and 90 of the same nurses were still in their active posts in Trust A in September 2014, then nurses' stability index for Trust A in September 2013, $S^{\mathrm{N}}_{A,\text{Sept 2013},12months}$, is 90%.

To identify NHS leavers, we track the employees who left their NHS Trust by $t+\tau$ until $t+(\tau+0.5)$, i.e. within the six months following the termination of an employment spells in the ESR data. During this time, if employees do not reappear in any NHS hospital organisation covered by the ESR, we assume that they have left the NHS hospital sector.[15] In the rest of the paper, we set $\tau = 12$ months, and drop τ from the notation.

We compute stability indices and NHS leaving rates from September of year t to September $t+1$, as staff engagement, one of our key independent variables of interest, is measured yearly from September to December of a given calendar year, as shown in Figure 2.[16]

staff transfers from the Data Quality Annex 2020, published by NHS Digital, to adjust the stability indices for staff transfers by excluding from the group of leavers who switched from a given NHS organisation due to an externally imposed staff transfer. This adjustment can be done only for NHS organisations with employee records in the ESR. Instead, for staff transfers documented in the NHS Digital Data Quality Annex 2020 but between NHS organisations and other healthcare organisations without records in the ESR, the stability index was imputed as an average between the two endpoints of the stability indices that were unaffected by the staff transfer.

[15] Exits from the ESR mean that workers can take new jobs in any part of the economy outside the NHS hospital sector, e.g. also in other parts of the NHS such as GP practices, primary mental health care, or parts of community care not captured by the ESR. In this work we are primarily concerned with the retention of workers within the NHS hospital sector, as outflows of specialised employees such as nurses and doctors imply a loss in human capital that is costly to replenish. Therefore, for brevity, we refer to "NHS leaving rates" instead of "NHS hospital (sector) leaving rates".

[16] The staff eligible to respond to the NSS is drawn from staff lists on 1st of September, so measuring the retention outcome variables in any month prior to September might lead to selection bias due to a discrepancy between the set of workers eligible for the NSS and those used to calculate stability indices and NHS leaving rates.

3 Methods

3.1 The determinants of staff engagement: work environment conditions and managerial inputs

In this section we investigate the determinants of staff engagement at hospital Trust level. This research question is preliminary to our main contribution and allows us to show that staff engagement is related to managerial inputs and work environment conditions that arise at hospital organisational level. We follow Bailey et al. (2017), who systematically reviewed 155 studies and grouped the set of factors determining engagement into five categories: individual psychological states, aspects of job design, perceived leadership and management, perceptions of organisation and organisational interventions. We proxy these determinants with variables included in the NSS data but not used to compute the staff engagement score. We estimate, separately for nurses and senior doctors, linear regressions of the following specification

$$\begin{aligned} E^j_{ht} = \beta_1 X^j_{ht} + \beta_2 JOB^j_{ht} + \beta_3 W_{ht} + \beta_4 SAT^j_{ht} + \beta_5 LEAD^j_{ht} + \beta_6 ATTR^j_{ht} \\ + \beta_7 RES^j_{ht} + \beta_8 SR_{ht} + \lambda_t + \mu_h + \varepsilon_{ht} \end{aligned} \tag{1}$$

where the outcome variable E^j_{ht} is the engagement specific by staff group and Trust, λ_t and μ_h are time and hospital Trust fixed effects, and all covariates are measured at the hospital organisation level.

The vector X includes demographic composition of staff group j in Trust h such as share of staff by age brackets[17], gender and ethnic minority status. The vector JOB contains the share of staff by job experience measured as the time spent in their current role, and the share of full-time workers contracted for more than 30 hours per week. The vector W contains

[17]There are almost no nurses under the age of 21 and no senior doctors under the age of 31, the shares of whom are therefore not included among the covariates.

a number of workplace characteristics such as the shares of employees who experienced bullying or were discriminated against in the last 12 months. To capture potential burn-out, we control for the share of staff who: experienced work-related stress in the last 12 months; came to work despite feeling unwell in the last 3 months (presenteeism); felt supported by co-workers; believed that the Trust has a fair career progression. The vector SAT contains staff's satisfaction with job aspects like pay, recognition of work, work responsibilities, and opportunities to use their skills at work. $LEAD$ is the share of staff who agrees that senior management tries to involve employees in important decisions, which is our proxy variable for perceived leadership. We include the share of workers pleased with the standards of their work, $ATTR$, as a proxy for the hospital employees' psychological state. Resources at work are also found to be positively associated with staff engagement (Bakker et al., 2007); the variable RES captures this by measuring workers' satisfaction with having adequate materials and enough staff at Trust to do their job. We also include the hospital response rate to the NSS, SR, to test whether the response rate has a significant association with engagement levels in hospital organisations.

3.2 Conceptual framework and baseline empirical strategy

We restrict our attention to nurses and senior doctors, because these are the two employee groups with complementary skill-sets who provide care to patients and constitute the majority of the hospital clinical workforce, in the NHS as well as other healthcare systems. We also assume that there is limited scope for nurses and senior doctors to be substitutes in their daily tasks. The aggregate retention of workers employed in job role j at the hospital organisation h, R_h^j, can thus be characterised as

$$R_h^j = f\left(\underset{+}{M_h^j}; \underset{+}{E_h^j}; \underset{+}{R_h^{-j}}; \underset{\pm}{Z_h^j}\right), \tag{2}$$

i.e. a function of: monetary factors, M_h^j, such as basic salary and performance-related pay;

non-monetary factors, such as job engagement, E_h^j; the retention of complementary workers $-j$, R_h^{-j}; some of the work environment characteristics examined in Section 3.1 and related to the organisational and managerial culture, Z_h^j, e.g. support to employees and colleagues, discrimination or unfair treatment, presenteism and managerial effort to coordinate effectively with the clinicians treating the patients. We expect workers' retention to be non-decreasing in their own group's engagement and in the retention of complementary workers. The latter is potentially an important factor for the retention of nurses and senior doctors, since a fall in the retention of experienced and trusted coworkers generate work stress and increase pressure on the remaining employees.

In our English NHS setting and using panel data, Equation 2 can be represented by the following linear specification with year and hospital Trust fixed effects

$$R_{ht}^j = \beta_1 E_{ht}^j + \beta_2 R_{ht}^{-j} + \beta_3 SR_{ht} + \theta_1 X_{ht}^j + \theta_2 Z_{ht}^j + \lambda_t + \mu_h + \varepsilon_{ht}, \tag{3}$$

where t is time in years, and senior doctors is the complementary group of nurses, and vice versa. The workforce retention outcomes, R_{ht}^j, are the stability index and the NHS leaving rate. In Equation 3, we also include the hospital NSS response rate, SR_{ht}, as this term controls for the possible selectivity in the NSS responses to engagement and other NSS items.[18] Instead, we omit any term related to monetary factors M_h^j, as nurses' and doctors' pay is regulated at the national level. Thus, pay variations are simply captured by Trust fixed effects μ and time fixed effects λ. The vector X_{ht} includes staff demographics by employee group, like average age, the share of female, European, overseas and ethnic minority staff, as these workers' characteristics can vary in time across Trusts and affect the retention of clinical workers. Z_{ht}^j is a vector of time-varying hospital work characteristics, including lagged confounders from the previous financial year that can be correlated with

[18] We recognise and deal with the potentially endogenous nature of SR_{ht} in the system-GMM estimation; see below. This variable is available only at hospital organisation level, and not for nurses and doctors separately.

either the engagement or the retention of group j: the average hours worked; a gender wage gap proxy[19]; the share of staff who experienced discrimination; the share of staff who did at least 11 hours unpaid work per week; and the number of competitor hospitals within 30 km radius. ε_{ht} is the error term.

3.3 Reverse causality and system-GMM estimation

The main methodological challenge in our study is to produce unbiased estimates of the parameters of interest β_1 and β_2. If there are only time-invariant unobservable factors affecting both hospital-level engagement and retention, Equation 3 will difference these out through the hospital and time fixed effects, and the estimated coefficients $\hat{\beta}_1$ and $\hat{\beta}_2$ will not be biased.

However, the aggregate employee retention choices may also be thought as a form of human capital, knowledge and expertise accumulation within a hospital organisation. As such, stability and NHS leaving rates may be governed by dynamic, time-varying processes. In this case, the concern is that both E^j_{ht} and R^{-j}_{ht} are potentially endogeneous regressors, respectively due to reverse causality, i.e. lower engagement stemming from higher staff turnover, or simultaneity between the retention of the two groups. For staff engagement, the severity of this issue is likely attenuated because, as shown in Figure 2, the measure of engagement used in our analysis is retrospective, i.e. it is measured in t but related to the 12 months before t, while the retention outcomes are prospective with respect to the engagement score, i.e. they are related to the 12 months from September in year t. Nevertheless, both hospital staff engagement and workforce retention are persistent variables, so the concerns of reverse causality and simultaneity biases may not be entirely removed by our data setup. For this reason, we turn to our preferred model,

$$R^j_{ht} = \beta_0 R^j_{ht-1} + \beta_1 E^j_{ht} + \beta_2 R^{-j}_{ht} + \beta_3 SR_{ht} + \theta_1 X^j_{ht} + \theta_2 Z^j_{ht} + \lambda_t + \mu_h + \varepsilon_{ht} \tag{4}$$

[19]This is defined as the ratio of male to female workers' non-negative total earnings in staff group j who have full-time permanent position in Trust h.

to investigate our relationship of interest.

The estimation of Equation 4 is more complicated than Equation 3 due to the inclusion of the lagged dependent variable as a control. A naive OLS estimation by first or mean differencing would lead to bias in the estimated coefficient of the lagged outcome, $\hat{\beta}_0$, and thus possibly also lead to biased estimates of the two coefficients of interest, $\hat{\beta}_1$ and $\hat{\beta}_2$.[20] Additionally, some of the explanatory variables included in Equation 4 are possibly not strictly exogenous, but only predetermined.

To overcome these issues, we employ a system-GMM model approach (Arellano and Bover, 1995; Blundell and Bond, 1998) and use lagged differences and levels of the variables of interest as internal instruments to estimate Equation 4. More specifically, we treat R^j_{ht-1}, E^j_{ht}, R^{-j}_{ht} and SR_{ht} as endogenous, the Z_{ht} variables as predetermined, and the hospital demographic characteristics X_{ht} (from previous financial year) and time effects as exogenous. We estimate system-GMM using forward orthogonal deviations (FOD), i.e. subtracting the forward mean, to eliminate the hospital organisation fixed effects, instead of the first-differences transformation.[21] We use backward orthogonal deviations, i.e. replacing instruments with their deviations from past means, as instruments for the FOD transformed equation (Hayakawa et al., 2009), and the lagged differences as instruments for the level equation, exploiting a two-step approach.[22] We employ the first three lags of the engagement score, the lagged retention outcomes, the complementary workers' retention input and the NSS response rate as lagged internal instruments. Finally, we adjust the standard errors using the Windmeijer (2005) finite-sample correction.

The system-GMM estimation of Equation 4 is appealing in our setting, for a number of

[20] As explained by (Nickell, 1981), this issue arises because of the residual correlation between the demeaned lagged dependent variable and the demeaned error term, which is the more problematic the shorter the length of the panel; in our case, a bias equal to $\frac{1}{10}$, which is not huge.

[21] The advantage of using FOD is that it uses more information than first differencing, which is important to prevent introducing missingness in the differenced variables in unbalanced panels like ours.

[22] The system-GMM was estimated using the user-contributed **xtabond2** (version 03.07.00) command by Roodman (2009) in Stata 16.1. We also check the consistency of our results with **xtdpdgmm** (version 2.3.9) by Kripfganz (2019); the estimates are substantially equal to the third decimal place for nurses and second decimal place for doctors.

reasons. First of all, we do not have available a set of time-varying external instruments to use as sources of exogenous variation, since worker's retention, staff engagement and retention of complementary workers are all variables that are potentially exposed to the same hospital environment and shocks. Thus, to address the time-varying endogeneity problem that possibly affects our setting, we rely on a system-GMM approach with internal instruments as done by many other dynamic panel applications in the economics literature (e.g., see Griffith et al. (2006) and Levine et al. (2000)). Second, given the stationary and persistent nature of staff engagement and retention from one year to the next, lagged values of our endogeneous variables are likely strong predictors of their present realisations. Moreover, provided that a sufficient time lag is allowed for, past values of staff engagement and retention should be largely unrelated to current realisation of the shock ε_{ht}, therefore representing appropriate internal instruments; to ascertain this, we perform an autocorrelation test of the regression errors (Angrist and Pischke, 2008). Using lagged values as IVs in the system-GMM is also closely related to the IV strategy inspired by Ashenfelter and Krueger (1994) and used by Hoffman and Tadelis (2021), who employ a managers' past score as the instrument for the current score and comment that doing so greatly reduces the bias from contemporaneous measurement error; in our context, this argument applies to both measurement error and reverse causality. Finally, the system-GMM approach has better finite sample properties than difference-GMM estimates (Blundell and Bond, 1998; Cameron and Trivedi, 2005). Under the assumption that the system-GMM approach controls for reverse causality and other sources of endogeneity, the estimates of β_1 and β_2 provide us with the unbiased associations between retention and engagement, and between retention rates of complementary workers.[23]

[23] We have two main reasons to estimate models at hospital level, and not at individual worker level. First, we can access NSS data at the worker level, but due to anonymised nature of the survey it is not possible to link NSS collected variables, including the engagement score, to individual NHS hospital workers. This means that any individual level regression of retention on staff engagement could be estimated only by using the average engagement at hospital level as a regressor. Similarly, for the retention of complementary workers, the main concern for our analysis is the retention rate of workers from one year to another within the same organisation. Within a given hospital organisation, hospital staff and nurses in particular can be allocated to rotas across department and sites of the same hospital organisation depending on the

3.4 Unconditional quantile regressions with hospital fixed effects

We also investigate the effects of staff engagement and job complementarities beyond the mean and over the distribution of retention. We estimate Unconditional Quantile Regressions (UQR) as proposed by Firpo et al. (2009). We prefer UQR to the conditional quantile regression (CQR) (Koenker and Bassett Jr, 1978), as UQR is more adapt to the inclusion of fixed effects and UQR estimates have a direct policy interpretation compared to CQR.[24]

The UQR model specification is:

$$R_\tau(R^j_{ht}) = \beta_{1\tau}E^j_{ht} + \beta_{2\tau}R^{-j}_{ht} + \theta_{1\tau}X^j_{ht} + \theta_{2\tau}Z^j_{ht} + \lambda_t + \mu_h + \varepsilon_{ht}, \tag{5}$$

where $R_\tau(R^j_{ht})$ is the Recentered Influence Function (RIF) for the τ-unconditonal quantile, q_τ, of the retention measure R for staff group j.[25] Thus, $\beta_{1\tau}$ ($\beta_{2\tau}$) identifies the association of staff group j's engagement (staff group $-j$'s retention) with retention of staff group j at the τ^{th}-unconditonal quantile, where $\tau = 10, 25, 50, 90$. We calculate bootstrapped standard errors with 1,000 replications clustered at Trust level. By comparing hospital organisations with similar retention rates along the retention distribution, the UQR strategy is also likely to attenuate some of the reverse causality issues affecting naive OLS estimates obtained using the full sample. Thus, we provide UQR as an alternative estimation method to validate the qualitative findings from the system-GMM.

contingency of staff shortages and patient demand pressures. Therefore, what matters for our purposes is their aggregated retention of complementary workers at the firm level. Second, the estimation of nonlinear dynamic panel data models using binary retention outcomes of individual workers is complicated by issues of bias for panels with $T < 30$ (Judson and Owen, 1999) and lack of consistency when including fixed effects (Pesaran and Smith, 1995), and it would also prevent the estimation of UQRs models that we use to validate the system-GMM findings.

[24] In panel data framework, CQR requires additional strong assumptions such as unit fixed effects remaining constant across quantiles (see Canay (2011)).

[25] RIF is a linear approximation of the influence an observation with retention R^j_h has on the unconditional quantiles q_τ (Firpo et al., 2009; Rios-Avila and Maroto, 2022). It is computed as $R_\tau(R^j_{ht}) = q_\tau + (\tau - 1[R^j_{ht} \leq q_\tau])/f_R(q_\tau)$, where $f_R(q_\tau)$ is the density function at q_τ estimated under the Gaussian kernel distribution and by using a bandwidth that minimises the mean integrated squared error.

4 Results

4.1 Descriptive Statistics

The summary statistics of the main variables used in the analysis are shown in Table 1, including the between (across hospital organisations) and within (same hospitals over time) standard deviations. Panel (a) of Figure 3 shows the evolution of the stability index and NHS leaving rates of nurses and senior doctors, from 2009/10 to 2018/19: on average, 86.57% of nurses and 87.67% of senior doctors remain in their hospital organisation each year.[26]

Nurses' retention decreased in the first half of our sample period, but there was a significant increase in nurses' stability index from 2017 onward. The retention of senior doctors was relatively stable between 2009/10 and 2018/19, although the variance in their stability indices across Trusts was higher than that of nurses (see in Figure 7).

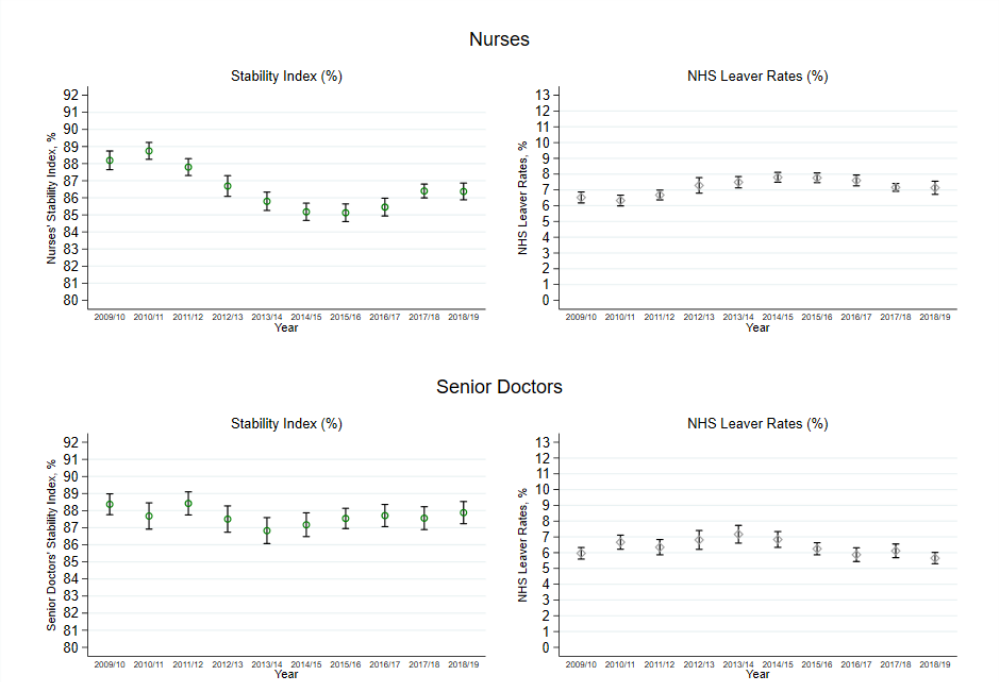
Between 2009 and 2018, the average engagement of nurses (senior doctors) stood at 7 (6.93) out of 10. The levels of engagement for both staff groups have increased over time, as shown in panel (b) of Figure 3. Nurses' engagement increased significantly from 6.63 points in 2009 to 7.21 points in 2018, while the variation of nurses' engagement across Trusts reduced over time (see panel (a) Figure 7). Compared to nurses, senior doctors had higher between-variance in engagement (see panel (b) in Figure 7), although this may reflect the smaller sample size of senior doctors in the NSS.[27] Both nurses' and senior doctors' motivation has been higher than advocacy and inclusion components of engagement, with a gradual increase

[26] Leaving the NHS includes any reason such as voluntary quits, redundancies and retirement. As rate of retirement across years remained relatively flat, we do not exclude leavers due to retirement from our analyses. The share of clinical workers who are laid off by NHS hospitals is very small: in 2010 (2018) only 0.328% (0.271%) and 0.212% (0.165%) respectively of the active nursing and senior doctors staffs were dismissed or made redundant by their employers, based on ESR data.

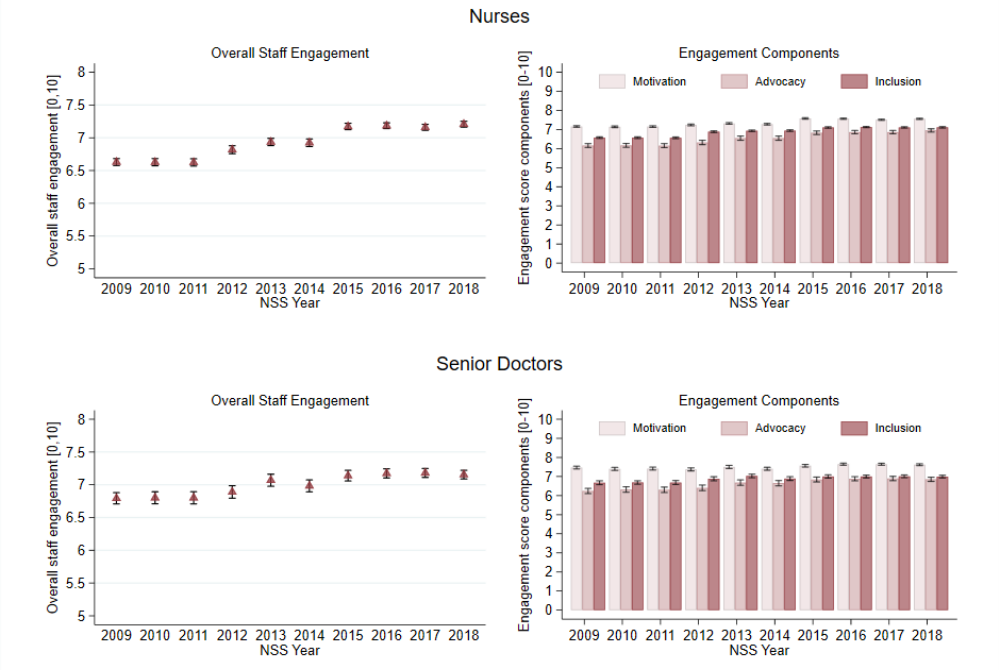
[27] The distribution of the engagement score has slightly changed over time, as shown in panel (b) of Figures 8 and 9. This can be due also to changes in the NSS sampling method, as the number of NHS staff sampled and invited to complete the NSS questionnaire increased over time. Hospital Trusts were required to invite either all employees (census) or a random sample of their workforce to complete the survey. Until 2015, Trusts with more than 600 employees could draw a random sample of 600, which was increased to 1,250 in 2016 (Badgett et al., 2020). Table 9 reports the NSS base samples and response rates from 2009 to 2018.

Figure 3: Retention and engagement of nurses and senior doctors, by year

(a) Stability an NHS leaving rates



(b) Engagement and its components



Notes: Authors' calculation from the Electronic Staff Records 2009-2020 using stability and NHS leaving rates in September (panel (a)) and from the NHS Staff Surveys (NSS) 2009-2018 (panel (b)) with 95% confidence bands around the mean.

Table 1: Summary Statistics of selected variables, 2010-2018

	Nurses				Senior Doctors			
	Mean	Standard deviation			Mean	Standard deviation		
		Overall	Between	Within		Overall	Between	Within
Outcome variables								
Stability index (rate), %	86.397	3.730	2.842	2.425	87.602	4.839	3.248	3.607
NHS leaving rate, %	7.249	2.502	1.839	1.702	6.407	3.317	2.190	2.502
Sickness absence rate, %	4.495	0.849	0.760	0.384	1.499	0.853	0.667	0.534
Other lost days absence rate, %	2.521	0.925	0.758	0.532	0.930	0.646	0.473	0.440
Monthly hours worked	163.091	1.418	0.916	1.084	152.252	2.125	1.512	1.493
Engagement and components by staff group								
Overall engagement score	6.961	0.426	0.302	0.302	7.021	0.602	0.425	0.428
Component: motivation score	7.373	0.315	0.196	0.247	7.507	0.495	0.293	0.400
Component: advocacy score	6.584	0.754	0.612	0.444	6.646	0.939	0.725	0.599
Component: inclusion score	6.930	0.345	0.186	0.291	6.909	0.633	0.400	0.492
NSS response rate	47.729	8.965	5.889	6.771	47.723	8.964	5.885	6.769
NHS Trust-staff group characteristics								
Share of female (%)	87.899	8.095	7.943	1.617	35.815	9.602	9.178	2.990
Average age	42.476	2.202	2.140	0.537	47.462	1.359	1.166	0.712
Share of British staff (%)	84.812	11.612	11.404	2.373	73.119	9.872	9.537	2.624
Share of European staff (%)	4.692	4.614	3.958	2.384	8.292	3.749	3.410	1.568
Share of Overseas staff (%)	10.081	8.235	8.106	1.604	18.051	9.159	8.956	1.994
Ethnic minority (BAME) staff (%)	19.674	16.824	16.801	1.528	37.863	14.789	14.525	2.967
Average hours worked (hours > 0)	162.911	1.349	0.729	1.136	152.129	3.319	2.018	2.639
Gender Pay Gap (male to female ratio)	1.043	0.052	0.031	0.042	1.150	0.086	0.073	0.046
Discriminated by managers or colleagues (%)	8.403	3.634	2.599	2.546	7.346	6.202	3.031	5.412
Worked at least 11 hours unpaid hours (%)	4.454	2.451	1.565	1.891	10.734	8.124	4.673	6.648
Number of other Trusts in 30km	20.425	19.577	19.485	2.358	20.455	19.581	19.484	2.360

Notes: Authors' calculations from ESR and NHS Staff Surveys. Summary statistics come from the estimation samples for nurses and senior doctors with 1,704 and 1,701 hospital Trust-year observations from 190 NHS Trusts.

in nurses' advocacy levels from early 2010s to 2018. Figure 6 and Table 10 respectively show that the missing values for engagement score at employee level are very low both for nurses and senior doctors, and that the engagement score missingness is mostly related to a serial item non-response of the worker.[28]

We also compute yearly pairwise correlations at hospital organisation level between nurses' and doctors' retention outcomes, which are reported in Table 2. These correlations are not particularly large: on average about 0.19 for the stability index and 0.27 for

[28]Table 10 displays estimates of the association between the share of missing engagement scores and demographic or contractual characteristics of workers controlling for year and hospital fixed effects.

the NHS leaving rate.

Table 2: Yearly pairwise correlations of workforce retention outcomes at NHS Trust level

Years	2010	2011	2012	2013	2014	2015	2016	2017	2018
	Stability Index (Nurses)								
Stability Index (Doctors)	0.16**	0.19**	0.20***	0.15**	0.29***	0.32***	0.23***	0.16**	0.03
NHS Leaving Rate (Nurses)	-0.72***	-0.72***	-0.84***	-0.74***	-0.75***	-0.73***	-0.77***	-0.71***	-0.78***
NHS Leaving Rate (Doctors)	-0.13*	-0.05	-0.19***	-0.09	-0.16**	-0.11	-0.20***	-0.08	-0.02
	Stability Index (Doctors)								
NHS Leaving Rate (Nurses)	-0.24***	-0.32***	-0.24***	-0.25***	-0.37***	-0.27***	-0.22***	-0.20***	-0.06
NHS Leaving Rate (Doctors)	-0.56***	-0.78***	-0.83***	-0.85***	-0.79***	-0.69***	-0.75***	-0.78***	-0.64***
	NHS Leaving Rate (Nurses)								
NHS Leaving Rate (Doctors)	0.30***	0.27***	0.29***	0.26***	0.32***	0.23***	0.37***	0.25***	0.14*

Notes: Based on a sample of 190 NHS Trusts. *p<0.1; **p<0.05; ***p<0.01.

4.2 Work environment conditions and managerial inputs as determinants of staff engagement

Table 3 presents the determinants of nurses' and senior doctors' engagement.[29] We find that workplace culture, leadership and resources have all a positive association with engagement. One of the key predictors of engagement for both groups is the perception that managers involve employees in important decisions. Self-realisation at work, measured by the share of staff with opportunities to use their skills, has also a significant positive association with engagement. As expected, both nurses' and senior doctors' engagement is lower in hospitals where bullying, discrimination and work stress are more frequent. These findings suggest that clinical workers' engagement can be fostered by improving on culture and leadership at the workplace.

The analysis provided in this section highlights also some heterogeneity in the determinants of nurses' and senior doctors' engagement. For instance, we find that having a full-time job matters for nurses' engagement and not for senior doctors' engagement. Likewise, while pay satisfaction plays a role in explaining nurses' engagement, the same cannot be concluded for

[29]The mean and standard deviation of the variables used in this analysis are reported in Table 11.

senior doctors. (see column 6 of Table 3).

The results also show that senior doctors' engagement is positively associated with the perception of having enough coworkers to work with, whereas we do not find a statistically significant relationship for nurses. Finally, the estimates reported in Table 3 reassure us about the fact that the share of NSS respondents does not affect the levels of engagement score recorded. Indeed, the relationship between staff engagement and the NSS response rate is not statistically significant in our richest model specification (columns 3 and 6).

Table 3: Determinants of clinical staff engagement

	Nurses			**Senior Doctors**		
	NI	**NII**	**NIII**	**DI**	**DII**	**DIII**
Share of contracted 30+ hours	0.409***	0.327***	0.287***	0.300	0.103	0.064
	(0.127)	(0.098)	(0.101)	(0.183)	(0.148)	(0.145)
Bullied by managers/colleagues (last 12 months)	-0.576***	-0.332***	-0.274***	-0.750***	-0.463***	-0.249**
	(0.156)	(0.115)	(0.104)	(0.156)	(0.129)	(0.111)
Discriminated by manager/colleague (last 12 months)	-0.513**	-0.176	-0.265*	-0.659***	-0.501***	-0.664***
	(0.212)	(0.176)	(0.151)	(0.227)	(0.178)	(0.148)
Felt unwell due to work stress (last 12 months)	-1.266***	-0.706***	-0.341***	-0.895***	-0.496***	-0.399***
	(0.097)	(0.093)	(0.088)	(0.101)	(0.090)	(0.079)
Came to work despite not feeling well (last 3 months)	-0.458***	-0.291***	-0.162**	-0.305***	-0.129	0.001
	(0.101)	(0.084)	(0.081)	(0.104)	(0.084)	(0.074)
Agree Trust acts fairly w.r.t. career progression & promotion	1.466***	0.902***	0.622***	1.202***	0.623***	0.383***
	(0.114)	(0.112)	(0.103)	(0.112)	(0.111)	(0.100)
Share of staff satisfied/very sat. with: Support from colleagues	0.931***	0.122	-0.022	0.723***	0.109	0.157
	(0.142)	(0.122)	(0.116)	(0.130)	(0.123)	(0.120)
Share of staff satisfied/very sat. with: Level of pay		0.419***	0.192**		0.212**	0.052
		(0.101)	(0.086)		(0.084)	(0.074)
Share of staff satisfied/very sat. with: Recognition for good work		1.283***	0.714***		1.172***	0.656***
		(0.100)	(0.088)		(0.107)	(0.122)
Share of staff satisfied/very sat. with: Responsibility given		0.313**	0.111		0.345**	0.215
		(0.147)	(0.133)		(0.157)	(0.134)
Share of staff satisfied/very sat. with: Opportunities to use skills		0.867***	0.686***		1.133***	0.817***
		(0.132)	(0.120)		(0.127)	(0.121)
Share of staff agree or strongly agree						
Sr. managers try involve staff in important decisions			0.952***			0.986***
			(0.092)			(0.096)
Able to do my job to a standard I am personally pleased with			0.781***			0.587***
			(0.103)			(0.087)
Have adequate materials, supplies, equipment to do work			0.359***			0.349***
			(0.081)			(0.076)
Enough staff at this Trust for me to do my job			0.142			0.228**
			(0.087)			(0.103)
NSS Response rate (%)	0.001	0.001	0.001	0.003*	0.003**	0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Constant	4.700***	3.947***	3.604***	5.613***	4.481***	4.303***
	(0.346)	(0.273)	(0.259)	(0.330)	(0.309)	(0.268)
R^2	0.880	0.913	0.932	0.708	0.792	0.839

Notes: There are 190 Trusts, and 1,894 Trust-year observations for nurses and 1,892 Trust-year observations for senior doctors. The models also control for the share of staff by age groups, gender, ethnic minority, and tenure at the Trust. All specifications also include Trust and year fixed effects. The age categories start at 31-40 year-old for nurses and 41-50 for senior doctors. Standard errors are clustered at Trust level. *p<0.1; **p<0.05; ***p<0.01.

4.3 Main results

The first panel of Table 4 reports OLS coefficients of Equation 3, with and without hospital Trust fixed effects, estimated separately for nurses (columns 1-4) and senior doctors (columns 5-8). Nurses' engagement is positively associated with the stability index and negatively associated with the NHS leaving rate. Instead, the OLS estimates do not show a significant association between senior doctor's engagement and their retention. The pooled and fixed-effects OLS estimates reported in Table 4 also show that senior doctors' retention is positively associated with nurses' retention (see columns 5-8, second row of panel (a)), and that this association works to a certain extent also the opposite way around (from columns 1-4, second row of panel (a)).

However, as discussed in Section 3.3, the OLS estimates reported in panel (a) of Table 4 may be biased due to several reasons: reverse causality between retention and engagement; simultaneity of the retention of nurses and senior doctors; employee self-selection in responding to the NHS Staff Survey, which in turn may be driven by staff retention and affect the measurement of the engagement score. For this reason, we estimate Equation 4 via system-GMM, with coefficients reported in panel (b) of Table 4 for nurses (columns 1-2) and senior doctors (columns 3-4).

We document persistence in employee retention: the lagged stability index is positive and significant at 1% level in both columns (1) and (3). However, this persistence is weaker for the NHS leaving rate. The Arellano–Bond test for first- and second-order autocorrelation in the first-differenced errors cannot reject the null of zero autocorrelation at the second lag. Similarly, the Hansen overidentification test cannot reject the null hypothesis that the overidentifying restrictions are valid.

An even clearer pattern of results emerges here compared to panel (a) of Table 4: engagement is a predictor of nurses' retention, while nurses' retention is a predictor of senior doctors' retention. The relationship between nurses' engagement and the stability index

Table 4: OLS and system-GMM estimates on employee retention outcomes.

	Panel a. OLS estimates							
	Nurses				**Senior Doctors**			
	Stability rate		**NHS Leaving rate**		**Stability rate**		**NHS Leaving rate**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Own group engagement	-0.640	1.118***	0.543	-0.689***	0.644**	0.388*	-0.279	-0.100
	(0.473)	(0.312)	(0.541)	(0.235)	(0.285)	(0.219)	(0.185)	(0.149)
Complementary coworkers retention	0.106***	0.053**	0.106***	0.089**	0.296***	0.152***	0.306***	0.191***
	(0.029)	(0.027)	(0.025)	(0.040)	(0.052)	(0.053)	(0.049)	(0.057)
NSS response rate	-0.021	0.006	0.005	-0.009	-0.004	-0.004	0.004	0.001
	(0.013)	(0.011)	(0.007)	(0.007)	(0.016)	(0.018)	(0.010)	(0.012)
Constant	-21.706	-27.062	49.803***	84.457***	-27.886	-27.830	48.970***	40.247**
	(24.561)	(38.502)	(14.560)	(30.963)	(18.224)	(20.273)	(14.230)	(15.788)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trust Fixed Effecs	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.401	0.267	0.350	0.157	0.200	0.103	0.218	0.079

	Panel b. System-GMM estimates			
	Nurses		**Senior Doctors**	
	Stability rate	**NHS Leaving rate**	**Stability rate**	**NHS Leaving rate**
	(1)	(2)	(3)	(4)
Own group engagement	1.284**	-0.829**	0.227	-0.053
	(0.498)	(0.340)	(0.298)	(0.224)
Complementary coworkers retention	0.015	0.030	0.160**	0.169***
	(0.027)	(0.028)	(0.078)	(0.051)
NSS response rate	-0.004	-0.007	-0.012	0.008
	(0.016)	(0.011)	(0.025)	(0.013)
Own group lagged retention	0.199***	0.110*	0.191***	0.044
	(0.059)	(0.063)	(0.057)	(0.043)
AR(1) p-value	0.000	0.003	0.000	0.000
AR(2) p-value	0.307	0.608	0.435	0.898
Hansen test degrees of freedom	43	43	43	43
Hansen over-id. test p-value	0.566	0.451	0.277	0.803

Notes: Sample size: 190 Trusts; 1,704 (1,701) Trust-year observations for nurses (senior doctors). All standard errors clustered at Trust level. System-GMM standard errors using Windmeijer (2005) small sample adjustment. *p<0.1; **p<0.05; ***p<0.01.

(NHS leaving rate) is positive (negative), significant at 5% level and larger in absolute value, 1.284 (-0.689), than the corresponding OLS estimate, 1.118 (-0.829). Similarly, the association between nurses' stability index (NHS leaving rate) and senior doctors' stability index (NHS leaving rate) is positive, significant at 5% (1%) level and larger (smaller) in absolute value, 0.160 (0.169), than the corresponding OLS term, 0.152 (0.191).[30] The size of these effects is not small: one within-standard-deviation increase in nurses' engagement is associated with a 15.99% (-14.71%) within-standard-deviation increase (decrease) in nurses' stability index (NHS leaving rate); one within-standard-deviation increase in nurses' stability index

[30]Similar results, available from the authors upon request, are obtained when the vectors of control covariates X^j_{ht} and Z^j_{ht} are omitted from the specification of Equation 4.

(NHS leaving rate) is associated with a 10.76% (11.50%) within-standard-deviation increase in senior doctors' stability index (NHS leaving rate). [31]

We also investigate whether the items that make up the engagement score have heterogeneous effects on hospital workforce retention, by replacing the overall engagement scores with motivation, advocacy and inclusion scores in our system-GMM estimation of Equation 4. Both nurses and senior doctors present a positive relationship between the advocacy score and the stability index (see column 2 in Table 12). Although senior doctors' engagement does not seem to affect retention, a high level of senior doctors' advocacy for their hospital organisation (i.e. holding a high regard for the quality of patient care and as a workplace) is associated with higher retention. Furthermore, the effects of motivation (for nurses) and inclusion (for senior doctors) on retention outcomes are not significant when estimated via system-GMM, differently from the OLS estimates reported in Table 12.

4.4 Effects along the retention distribution

Table 5 reports results for Equation 5, which investigates the heterogeneity of our relationships of interest along the unconditional distribution of staff retention. The top panel indicates that the correlation between nurses' engagement and retention is more pronounced at the bottom (top) half of the stability index (NHS leaving rate) distribution. In particular, the engagement coefficient at the 25^{th} quintile is equal to 1.79, which is about 30% larger than the system-GMM coefficient at the mean (1.284). In addition, the association between nurses' engagement and NHS leaving rate is particularly pronounced at the top decile of the

[31] The corresponding elasticities are reported in Appendix Table 13 and computed consistently with the specifications in Equations 3, 4 and 5, by estimating the elasticity, $\frac{d(log(\hat{R})}{dlog(X)}$, as $\frac{X}{\hat{R}}\frac{d(\hat{R}}{d(X)}$ where $X = \{E, R^{-j}\}$. In particular, a 10% increase in nurses' engagement leads to a 1% increase in their stability index, but to a -8.5% decrease in nurses' NHS leaving rate; and a 10% increase (decrease) in nurses' stability index (NHS leaving rate) leads to a 1.6% increase (2% increase) in senior doctors' stability index (NHS leaving rate). Despite the elasticity estimates from fixed effects and GMM models being relatively inelastic with respect to engagement and nurses' retention, they are still larger in magnitude than the 0.07 wage elasticity of NHS nurses' labour supply estimated by Crawford et al. (2015).

leaving rate distribution (-1.96, compared to the -0.83 system-GMM coefficient).

In line with the OLS and system-GMM estimates, we do not find a significant relationship between senior doctors' engagement and retention along the entire distribution. However, the complementary relationship between nurses' and doctors' retention is more evident in hospital Trusts with low (high) stability (leaving) rates, with coefficients significant at least at 5% level for the 25^{th} and 50^{th} quintiles of the stability index distribution and for the 50^{th}, 75^{th} and 90^{th} quintiles of the NHS leaving rate distribution. Overall, the unconditional quantile regression estimates provide additional evidence in support of the findings obtained with the system-GMM.

Table 5: UQR estimates on employee retention outcomes.

	Nurses									
	Stability rate					**NHS Leaving rate**				
	Q10	**Q25**	**Q50**	**Q75**	**Q90**	**Q10**	**Q25**	**Q50**	**Q75**	**Q90**
Own group engagement	0.838	1.788***	1.416***	1.010**	0.196	-0.358	-0.165	-1.059***	-0.683**	-1.957***
	(0.845)	(0.573)	(0.451)	(0.418)	(0.485)	(0.228)	(0.244)	(0.277)	(0.338)	(0.621)
Complementary coworkers retention	0.084	0.052	0.035	-0.001	0.011	-0.012	0.010	0.020	0.062**	0.153*
	(0.055)	(0.036)	(0.029)	(0.020)	(0.024)	(0.016)	(0.016)	(0.021)	(0.031)	(0.081)
NSS response rate	0.018	0.008	0.028*	0.015	-0.007	0.004	-0.010	-0.009	-0.015	-0.007
	(0.028)	(0.020)	(0.016)	(0.013)	(0.015)	(0.008)	(0.008)	(0.009)	(0.011)	(0.023)
Within R^2	0.0481	0.1177	0.1704	0.2059	0.2318	0.0994	0.1130	0.1058	0.0739	0.0478
RIF mean	81.488	84.316	86.895	89.116	90.516	4.825	5.645	6.821	8.388	9.998
RIF mean stand. error	0.188	0.140	0.116	0.093	0.094	0.052	0.053	0.064	0.081	0.131
	Senior Doctors									
	Stability rate					**Leaving the NHS rate**				
	Q10	**Q25**	**Q50**	**Q75**	**Q90**	**Q10**	**Q25**	**Q50**	**Q75**	**Q90**
Own group engagement	0.580	0.547	0.207	0.012	0.038	-0.003	-0.081	0.087	-0.215	-0.162
	(0.797)	(0.380)	(0.212)	(0.248)	(0.248)	(0.175)	(0.142)	(0.166)	(0.228)	(0.484)
Complementary coworkers retention	0.166	0.271***	0.133***	0.056	0.033	0.063	0.039	0.108***	0.247***	0.343**
	(0.176)	(0.070)	(0.049)	(0.046)	(0.058)	(0.071)	(0.043)	(0.035)	(0.064)	(0.139)
NSS response rate	-0.011	0.010	0.005	0.020	0.007	0.004	0.005	-0.014	-0.016	-0.013
	(0.055)	(0.027)	(0.017)	(0.014)	(0.016)	(0.012)	(0.009)	(0.011)	(0.015)	(0.032)
Within R^2	0.0569	0.0578	0.0304	0.0270	0.0149	0.0193	0.0256	0.0434	0.0566	0.0476
RIF mean	82.013	85.717	88.516	90.649	92.315	3.460	4.493	5.749	7.483	9.850
RIF mean stand. error	0.287	0.160	0.112	0.102	0.106	0.067	0.058	0.070	0.101	0.191

Notes: Sample size: 190 Trusts; 1,704 (1,701) Trust-year observations for nurses (senior doctors). Bootstrapped (1,000 replications) standard errors clustered at Trust level. *p<0.1; **p<0.05; ***p<0.01.

4.5 Effects on labour supply intensive margins

This section examines the relationship between hospital staff engagement, retention and labour supply intensive margin as proxied either by staff absences from the workplace or by

the total amount of hours worked.[32]

The effects on absences are reported in Table 14. Nurses' engagement has a negative and significant impact on sick leave (columns 1-3 of Table 14), while we do not find any significant effect on nurses' absences due to other reasons. A one-within-standard-deviation increase in nurses' engagement is associated with a 13.17% within-standard-deviation reduction in nurses' sickness absence. Similar to the specifications modelling retention outcomes, senior doctors' engagement does not seem to matter for any type of absences. We do not find complementarities in the absence rates of nurses and senior doctors when we account for reverse causality by using system-GMM. These results are by and large confirmed by the UQRs estimates displayed in Table 15.

The system-GMM estimates of the relationships between hours worked, engagement score and hours worked by complementary workers are not statically significant at 5% level, either for nurses or doctors (column 2 of Table 16). Using UQRs, we find a significant association only for nurses working in Trusts above the 75^{th} percentile of the hours worked distribution. We conclude that staff engagement is only relevant for nurses' absences, and that coworkers complementarities do not affect labour supply intensive margins proxied by hours worked.

4.6 Mechanisms and robustness checks

4.6.1 Staff engagement defined as a pychometric-based factor measure

A potential concern related to the NSS engagement score is that it assigns equal weights to each component and it is therefore not valid in psychometric terms. In this section, we test the robustness of the results to an alternative measure of engagement, which is computed as a single factor and valid on a psychometric scale. More specifically, we use NSS individual level data and compute polychoric correlations between the nine sub-component items

[32]Employee monthly absence rates are collected in the ESR; we first aggregate absence rates by staff group and Trust for each month, then they are averaged over the 12-month window going from September of year t to August of year $t+1$. Instead, to define the amount of hours worked by staff group in a given hospital Trust and year (again from September of year t to August of year $t+1$), we use ESR records with positive monthly hours and associated with full-time nurses and senior doctors on a permanent contract.

underlying the overall engagement score (see Table 8). We then take the first factor from the polychoric correlation analysis and define it as the psychometrically-robust engagement index at individual worker level.[33] Finally, we average this alternative engagement index for each hospital organisation in every year of our sample, i.e. from 2009 to 2018.

Table 6: Estimates using a psychometrically-robust engagement index

	Panel a. Nurses			
	Stability rate		**NHS Leaving rate**	
	FE	**GMM**	**FE**	**GMM**
Own group engagement factor	2.121***	2.088**	-1.403***	-1.443**
	(0.586)	(0.933)	(0.412)	(0.597)
Complementary coworkers retention	0.053**	0.016	0.089**	0.029
	(0.026)	(0.027)	(0.040)	(0.028)
NSS response rate	0.006	-0.004	-0.008	-0.007
	(0.011)	(0.016)	(0.007)	(0.011)
Own group lagged retention		0.201***		0.108*
		(0.059)		(0.063)
AR(1) p-value		0.000		0.002
AR(2) p-value		0.309		0.603
Hansen over-id test p-value		0.515		0.482
	Panel b. Senior Doctors			
	Stability rate		**NHS Leaving rate**	
	FE	**GMM**	**FE**	**GMM**
Own group engagement factor	1.097*	0.492	-0.011	0.114
	(0.569)	(0.426)	(0.282)	(0.431)
Complementary coworkers retention	0.153***	0.161**	0.192***	0.168***
	(0.053)	(0.078)	(0.057)	(0.051)
NSS response rate	-0.004	-0.011	0.000	0.009
	(0.018)	(0.025)	(0.012)	(0.013)
Own group lagged retention		0.191***		0.046
		(0.058)		(0.043)
AR(1) p-value		0.000		0.000
AR(2) p-value		0.424		0.922
Hansen over-id test p-value		0.226		0.808

Notes: Sample size and standard errors as in Table 4. *p<0.1; **p<0.05; ***p<0.01.

[33]On average, the first polychoric factor explains 80% (83%) of the variance for nurses (senior doctors).

Table 6 reports estimates of this alternative specification, for both retention outcomes of nurses and senior doctors. The results are very much in line with the rest of the paper. We conclude that using the NSS-defined staff engagement score does not represent an issue for the conclusions of this study.

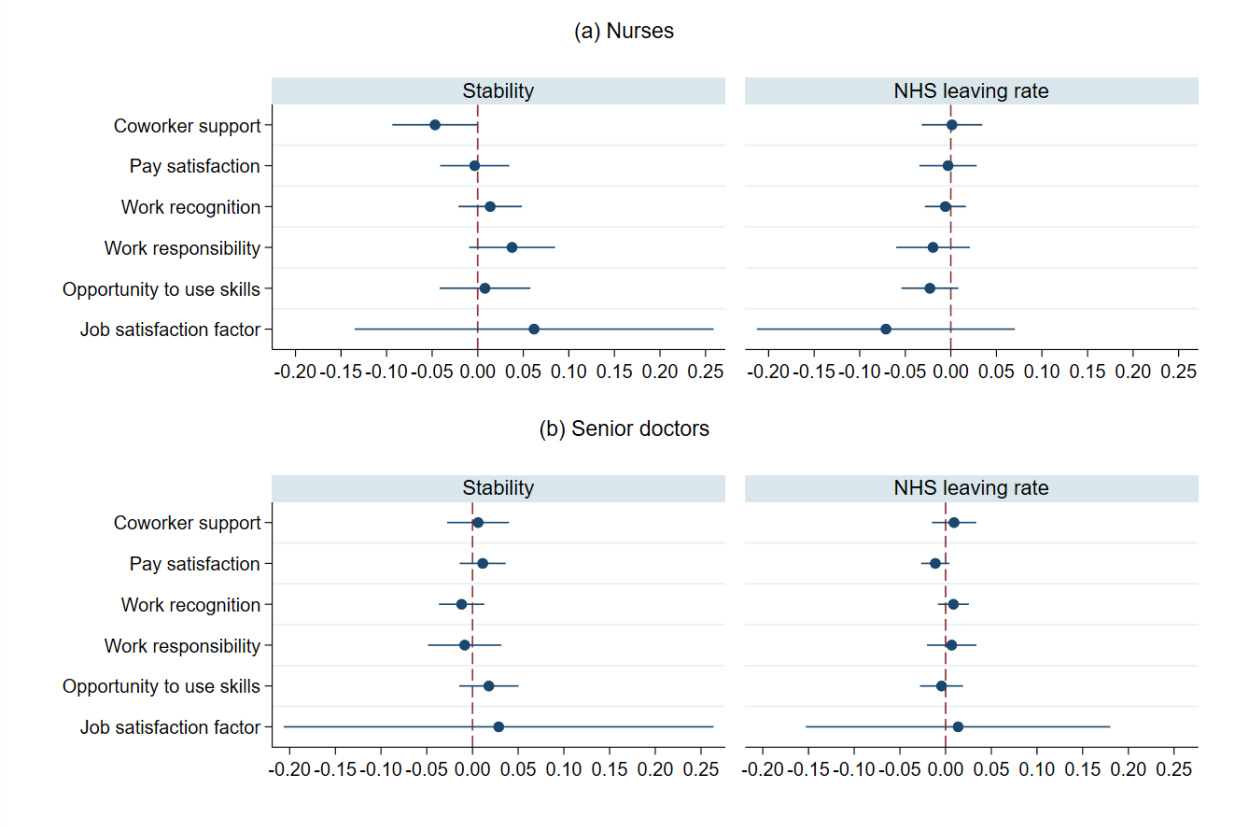
4.6.2 Staff engagement or job satisfaction?

Another concern related to the engagement score is whether it really measures staff engagement or some other work-related constructs correlated with engagement, e.g. job satisfaction. This issue is plausible, since we know from the work psychology literature that engagement is a composite measure encompassing, but not limited to, job satisfaction (Schaufeli, 2013). Moreover, the analysis reported in Table 3 shows that, in our sample, job satisfaction indicators are positively associated with the engagement scores of both nurses and senior doctors.

Here, we estimate system-GMM models where we replace the engagement score of nurses and senior doctors with the five job satisfaction indicators (support from colleagues; pay satisfaction; recognition for good work; responsibility given; opportunity to use job skills) used in 3, or with an additional job satisfaction proxy computed as the first principal component of these five job satisfaction variables.[34] The estimates for the job satisfaction items, summarised by Figure 4 and reported in detail in Table 17, are never statistically significant at 5% level, although they often show the expected sign. This finding corroborates the results of our analysis, which likely identifies a genuine association between clinical staff engagement and retention.

[34]The first principal component explains 54.7% (50.4%) of the variance for nurses' (doctors') job satisfaction indicators.

Figure 4: Replacing staff engagement with job satisfaction metrics (system-GMM estimates)



4.6.3 Complementarities in retention between senior doctors and experienced nurses

In this section, we test further the complementarity hypothesis between senior doctors' and nurses' retention by estimating models in which we split nurses in two groups: by age, or by their job grade according to their pay band levels.[35] Both age and job grade are proxy for nurses' experience, which might play an important role in complementing senior doctors' day-to-day activities. We assume less experienced nurses to be defined by AfC Bands 1-5 (or age at most 40 years old), and more experienced nurses to be those in AfC Bands 6-9 (or age 41 and above).

Table 7 reports the system-GMM estimates of our coefficients of interest, respectively

[35] Nurses' pay band levels are defined nationally by the Agenda for Change (AfC) contract for NHS employees. The AfC pay scales for 2017/18 are available at `https://www.rcn.org.uk/employment-and-pay/NHS-pay-scales-2017-18`.

for stability indices (panel a) and NHS leaving rates (panel b). Our findings support the complementarity hypothesis; we document a significant and positive association between senior doctors' retention (within the NHS Trust) and the retention of older (0.18) or more senior (0.17) nurses, but no significant association with junior nurses; we also find a positive and significant association between senior doctors' retention within the NHS and older nurses' NHS leaving rate (0.23).

Table 7: Coworkers complementarities in retention outcomes, by age or job seniority

	Pay Band	**Age**
Panel (a): Stability rate		
Nurses' stability (Band 1-5, age < 41)	-0.043	0.001
	(0.054)	(0.049)
Nurses' stability (Band 6-9, age ≥ 41)	0.170**	0.178**
	(0.074)	(0.074)
Senior doctors' engagement	0.255	0.279
	(0.357)	(0.346)
AR(1) p-value	0.000	0.000
AR(2) p-value	0.461	0.299
Hansen over-id. test p-value	0.442	0.241
Panel (b): NHS Leaving rate		
Nurses' NHS Leaving rates (Band 1-5, age < 41)	-0.028	-0.026
	(0.042)	(0.033)
Nurses' NHS Leaving rates (Band 6-9,age ≥ 41)	0.039	0.226***
	(0.053)	(0.059)
Senior doctors' engagement	0.034	-0.173
	(0.182)	(0.206)
AR(1) p-value	0.000	0.000
AR(2) p-value	0.859	0.866
Hansen over-id. test p-value	0.986	0.893

Notes: Estimations based on system GMM with the same specifications as in main analyses.Based on a sample of 189 NHS Trusts (1,692 Trust-year observations) for Band and 190 NHS Trusts (1,701 Trust-year observations) for Age. Degrees of freedom for the Hansen over-identification test is 69 for all models. Standard errors clustered at hospital Trust level in parentheses. *p<0.1; **p<0.05; ***p<0.01.

4.6.4 Confounding due to quit rates of NHS trainee doctors

So far, we have only considered nurses as complements in the retention function of senior doctors. Trainee hospital doctors (also known as *junior doctors* in the UK) constitute a large part of the medical workforce in English NHS hospitals, since they act in roles supporting or acting on behalf of senior doctors. For this reason, even the retention of these two groups of medical workers might be positively associated at hospital level. However, junior hospital doctors are also subject to periodic compulsory rotations across different NHS Trusts during their training. Thus, a meaningful association in the retention of these two occupational groups can be likely retrieved only by analysing the association between the NHS leaving rates of senior and junior doctors, and not between their stability indices.

Table 18 presents GMM estimates for a specification where the outcome is the NHS leaving rate of senior doctors, and which includes the NHS leaving rate of junior doctors as an additional control variable of interest, alongside the engagement of senior doctors and the retention of nurses. Column 3 of Table 18 assumes that junior doctors' NHS leaving rate is predetermined, while column 4 assumes it is endogenous (analogously to nurses' NHS leaving rate). The results are very similar to the baseline estimates reported in Table 4, and the relationship between nurses' and senior doctors' retention holds. Also, there is no significant association between the NHS leaving rate of senior and junior hospital doctors.

4.6.5 Confounding due to outside wages and local cost of living

Although NHS salaries are regulated at the national level, heterogeneity in health workers' wages (and nurses in particular) can still arise from variations in the outside wages across local labour markets (Propper and Van Reenen, 2010). As such, outside wages represent a possible omitted factor affecting the turnover rates of hospital workers with a low pay, i.e. nurses in our case. For this reason, we estimate fixed effects and system-GMM specifications including the log transformation of nurses' outside wage, computed in a similar fashion to

Propper and Van Reenen (2010), as a control variable.[36]

Furthermore, we replace outside wages with a proxy for local cost of living, the median (terraced) house price in the travel-to-work area[37], which has been shown to be another determinant of nurses' retention decisions (Propper et al., 2021). These specifications are computed only for nurses, as higher salaries and a longer specialisation training likely make outside wages and cost of living secondary-order factors for the retention of NHS senior hospital doctors.[38]

As shown in Table 19, the order of magnitude and the statistical significance of the regression estimates are comparable to the baseline results displayed in Table 4. The system-GMM models suggest that the effect of the outside wage on nurses' stability index (NHS leaving rate) is negative (positive), significant at 1% level and thus in line with the Propper and Van Reenen (2010) predictions. The models reported in columns 5-8 provide qualitatively similar results. An increase in local cost of living is associated with a significant reduction in nurses' retention, at least when estimated via system-GMM. We conclude that our findings on the effect of nurses' engagement on their retention are robust to variations in these additional confounders. Moreover, in light of the aforementioned contributions, we claim that the estimates from our system-GMM models are superior to the OLS with fixed effects, as the effects of outside wages and house prices on retention are significant at or above 5% level only when using system-GMM.

[36] We use data from the Annual Survey of Hours and Earnings (ASHE) between 2009 and 2019 to compute the outside wage of nurses working in a given NHS hospital organisation. We define the outside wage as the mean yearly wage received by non-manual female workers employed in the 60-km radius around the hospital Trust headquarters.

[37] We use terraced house price data from the HPSSA dataset provided by Office for National Statistics (ONS).

[38] NHS hospital doctors' basic salary ranged from £75k to £100k (£78k to £105k) in 2009/10 (2018/19), compared to registered nurses' basic salary, which instead ranged from £21k to £40.1k (£22.5k to £43k) in 2009/10 (2018/19). Moreover, NHS hospital specialist doctors undergo a five to ten years-long human capital investment in specialty training to get accredited to the medical profession, leading to very high opportunity-costs for them to switch to similarly high paid jobs (e.g. senior doctors, bankers and solicitors).

4.6.6 Confounding due to simultaneity bias

The estimation of Equation 4, including both engagement and complementary workers' retention as variables of interest, produces associations that are meaningful both statistically and economically (see Table 4). However, the simultaneity between the retention of complementary occupational groups may raise possible concerns about these estimates. In particular, the system-GMM estimates may be biased if the lagged differences and levels of nurses' and senior doctors' retention were highly correlated or collinear between each other, resulting either in weak or not valid internal instruments. To address these concerns, we estimate a modified version of Equation 4 in which we include our variables of interest one at a time.

The results, shown in Table 20, indicate that our main results are quite stable and not statistically different from those reported in Table 4 (panel (b)). These findings are also supported by the yearly pairwise correlations of the retention outcomes, reported in Table 2, which are not large and show that the retention choices of NHS nurses and senior doctors employed by the same hospital organisation are not contemporaneous but displaced across different periods. Overall, this evidence of imperfect collinearity amongst the retention of the two clinical staff groups reassures about the reliability of our system-GMM estimates.

4.6.7 Controlling for local support to Brexit

Finally, our sample includes years after the June 2016 Brexit referendum, when 52% of UK voters cast a ballot to leave the European Union. A possible concern is that our estimates are affected by EU-born hospital workers that have chosen to quit their hospital Trust or the NHS after the referendum, especially if located in areas where the support for Brexit was particularly strong.

To ascertain this, we augment our system-GMM specification with an interaction term between a binary post-Brexit dummy and the local share of votes in support of leaving the

EU recorded at the 2016 Brexit referendum.[39] The resulting estimates, displayed in Table 21, indicate that the post-Brexit interaction term is never statistically significant and that our main estimates of interest are similar to those reported in Table 4.

5 Conclusions

Healthcare systems face a historical workforce challenge, and so it is important to understand the mechanisms governing the dynamics and determinants of hospital workforce turnover (Sheather and Slattery, 2021). In this work, we have investigated the relationship between hospital workers' retention and two of its possible key drivers: staff engagement and the retention of complementary workers.

We document a number of novel findings. First of all, higher staff engagement is associated with higher retention of hospital nurses, but not of senior doctors: one within-standard-deviation increase in nurses' engagement is associated with a 15.99% within-standard-deviation increase in nurses' stability index. Moreover, we show that nurses' retention is positively associated with their engagement and not their job satisfaction, which indirectly highlights how these are related but different constructs. Staff engagement exhibits also a negative association with nurses' sickness absence rates, but not with their hours worked, or any association with doctors' absences and hours worked. We also find that nurses' retention has a positive impact on the retention of senior doctors employed in the same hospital organisation, as one within-standard-deviation increase in nurses' stability is associated with a 10.76% within-standard-deviation increase in senior doctors' stability index. Our estimates are consistent not only across different robustness checks and using two different estimation methods, system-GMM and unconditional quantile regressions, but also externally with

[39] We use data on local electoral results at the 2016 Brexit referendum from the UK Electoral Commission independent body (`https://www.electoralcommission.org.uk/who-we-are-and-what-we-do/elections-and-referendums/past-elections-and-referendums/eu-referendum/results-and-turnout-eu-referendum`). These data are merged to our panel of English hospitals based on the local authority codes of their headquarters, which we retrieved by combining ESR data with geography information from the National Statistics Postcode Lookup produced by the ONS.

the findings of other related studies (Propper and Van Reenen, 2010; Propper et al., 2021). In particular, if we assume that a higher staff engagement (and, eventually, also a higher retention of complementary coworkers) is the product of better people management skills and not simply a mechanical byproduct of a more efficient organisational environment, our findings complement those reported by Hoffman and Tadelis (2021) and contribute towards the understanding of the mechanisms that drive employee retention.

A key to interpret these results is that hospital workers' retention is likely heterogenous depending on the profession of the hospital employee. NHS hospital nurses complement senior doctors' labour inputs by aiding the latter and caring for patients (Baraniak (2002)). Yet, their wage is roughly half of senior doctors' wage. Moreover, nurses lack structured career development opportunities after obtaining their professional qualification (see Kleinknecht and Hefferin (1982) and Donner and Wheeler (2001) for a discussion). As workers providing their labour and acting under the guidance of senior doctors, nurses tend to rank lower than senior doctors in the hospital organisation hierarchy and they cannot delegate their work duties to other agents. Therefore, a factor that possibly helps to retain them within their employer organisation is job motivation (Huyghebaert et al., 2019; Shields and Ward, 2001), which can be stimulated by hospital managers through the enhancement of staff engagement policies at work.

On the contrary, NHS hospital doctors are well-paid, at the top of the hospital organisation hierarchy and have plenty of training and development opportunities[40], which are embedded in the progression of their medical career profile also through dedicated time and budgets for training and research. As such, the engagement at work of senior doctors is likely an innate feature related to their daily mansions, and this could be one reason why their retention outcomes appear rather unresponsive to engagement. Thus, one factor helping retaining senior hospital doctors in their job is the retention of enough coworker nurses to

[40]See for instance: `https://wessex.hee.nhs.uk/wider-workforce/sas-doctors/development-opportunities/`.

support them in their activities and tasks. A fall in nurses' retention, instead, may force senior doctors to perform tasks that they usually delegate to nurses (Laurant et al., 2005), resulting in increased workloads and reduced time for patients. This conjecture is supported by the fact that we find senior doctors' engagement to be positively associated with having enough hospital staff to perform their job, and the increase in senior doctors' retention being driven by more experienced nurses, who intuitively serve doctors as better complements.

Overall, the evidence we gathered suggests that staff engagement and retention of complementary workers are promising leverages to attenuate employee attrition, especially in organisations with higher than average turnover. In the English NHS, in particular, healthcare policy-makers should focus on improving engagement and the retention of nurses in the first place, as an increase in engagement not only directly benefits nurses' retention, but it also has indirect positive spillover effects on senior doctors' retention.

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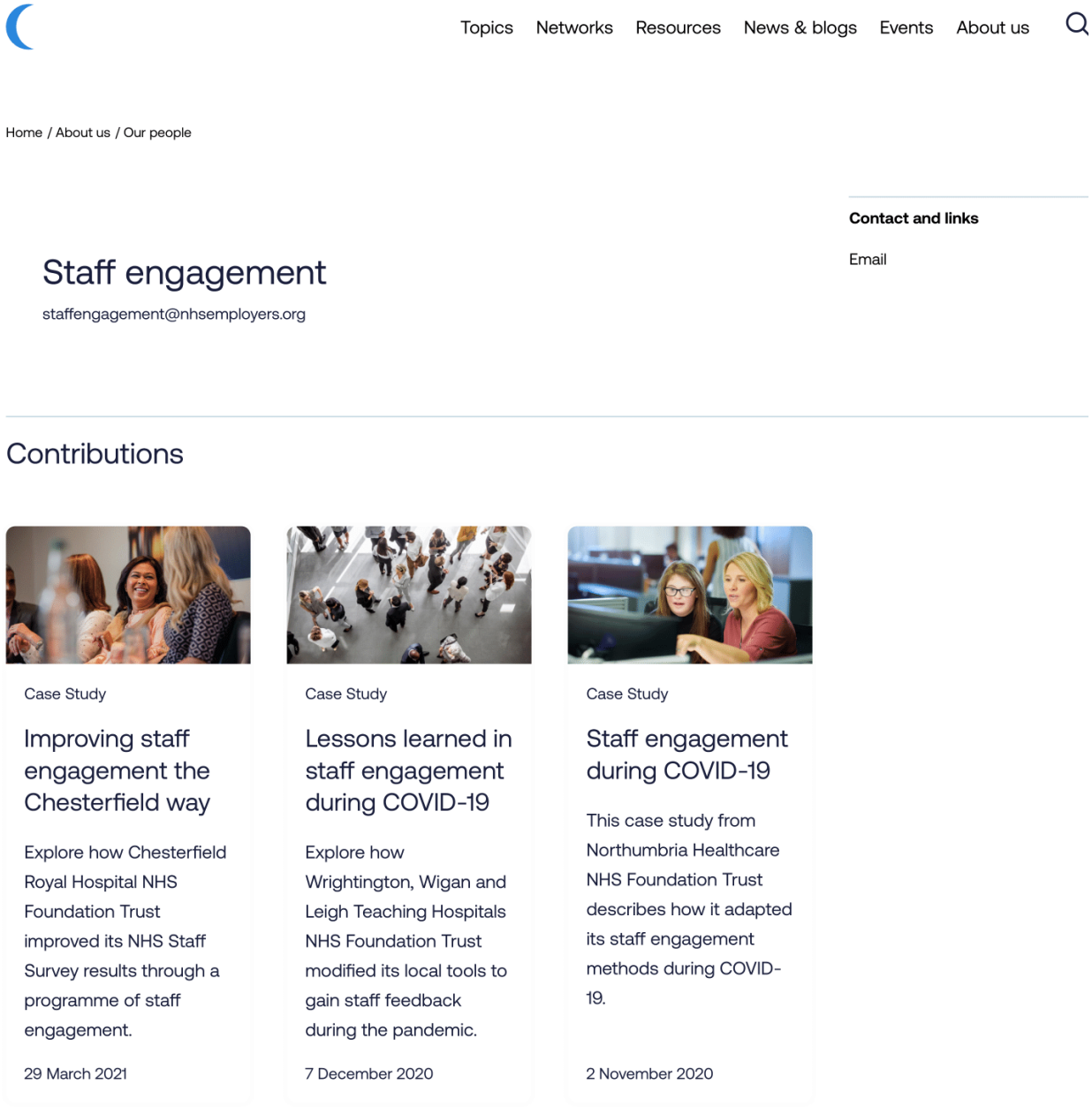
Online Appendix

Figure 5: Business cases on staff engagement improvement by NHS Employers



Notes: Screenshot from the NHS Employers website, accessed on July 27th, 2022. `https://www.nhsemployers.org/~/media/Employers/Documents/SiteCollectionDocuments/staff-engagement-toolkit.pdf`

Figure 6: Distribution of missing engagement scores over NSS years

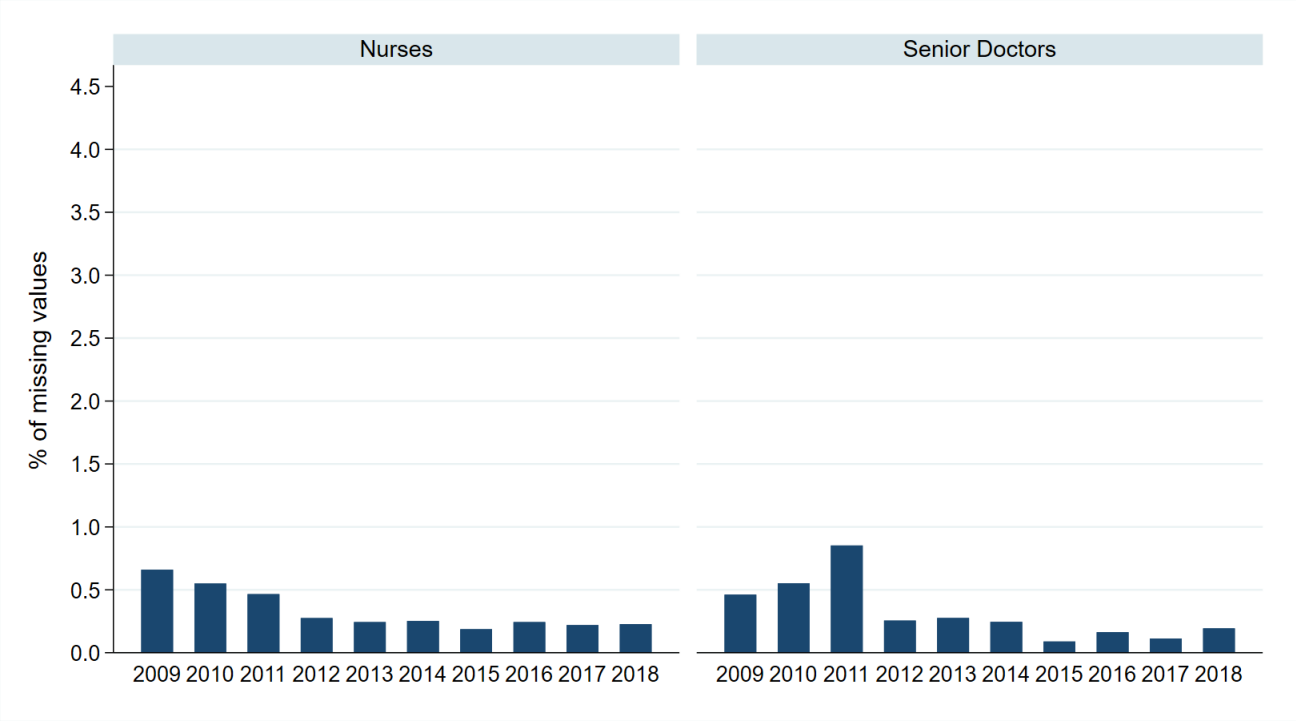
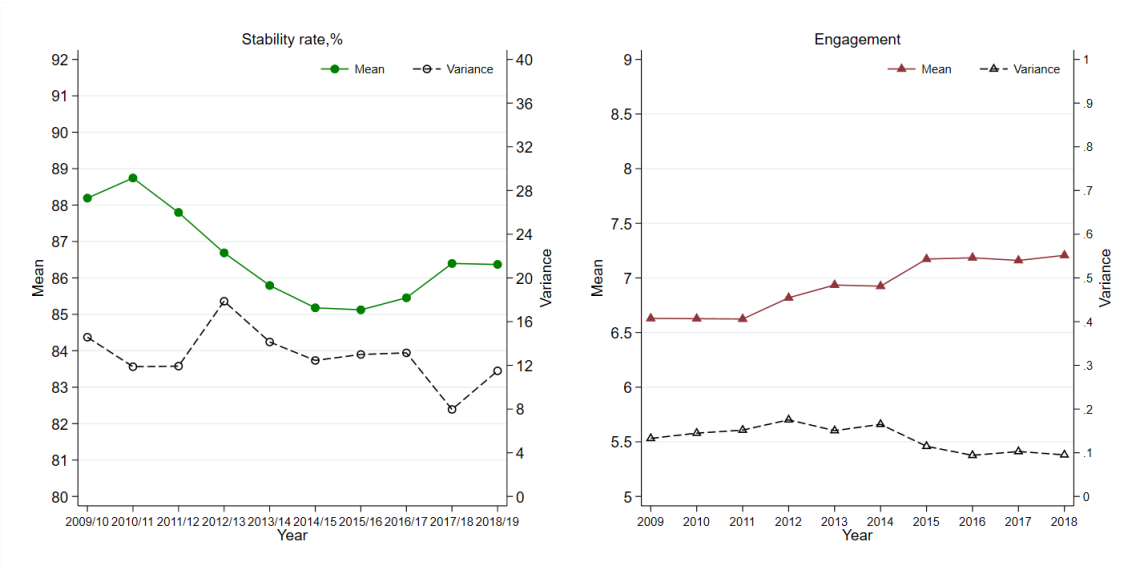
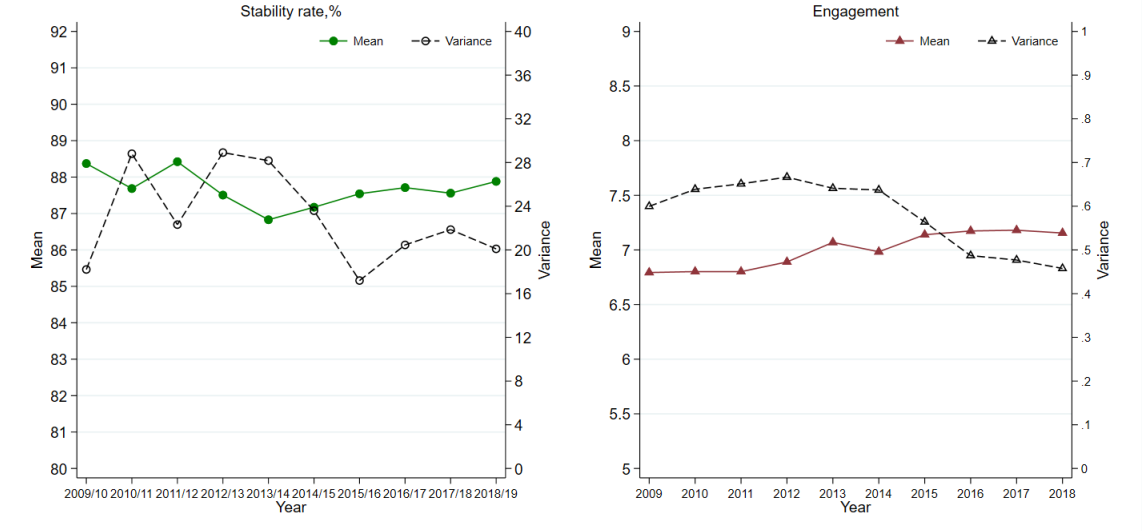


Figure 7: Changes in the mean and variance of stability and engagement over time



(a) Nurses



(b) Senior Doctors

Figure 8: Distribution of Nurses' Retention and Overall Engagement

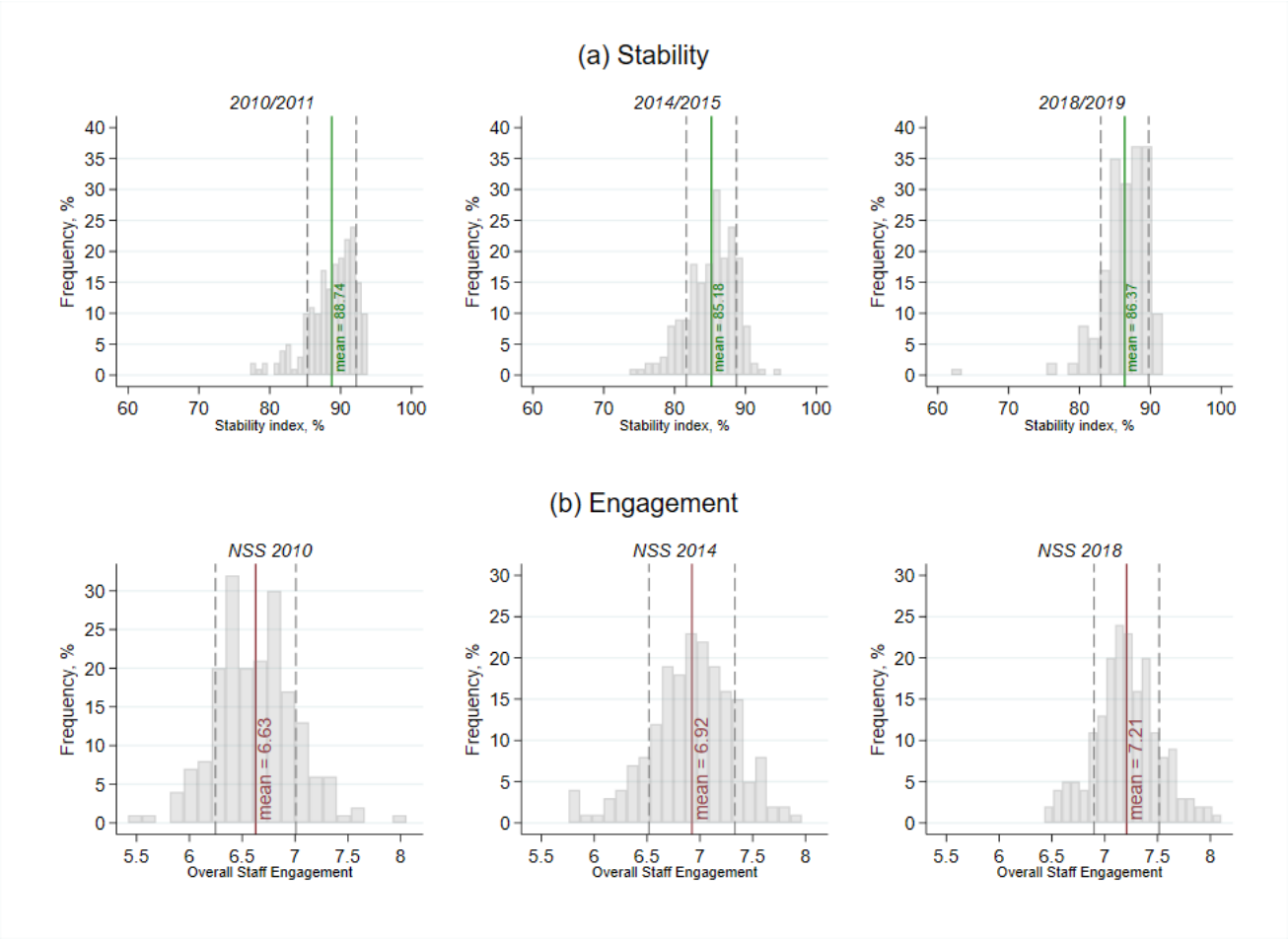


Figure 9: Distribution of Senior Doctors' Retention and Overall Engagement

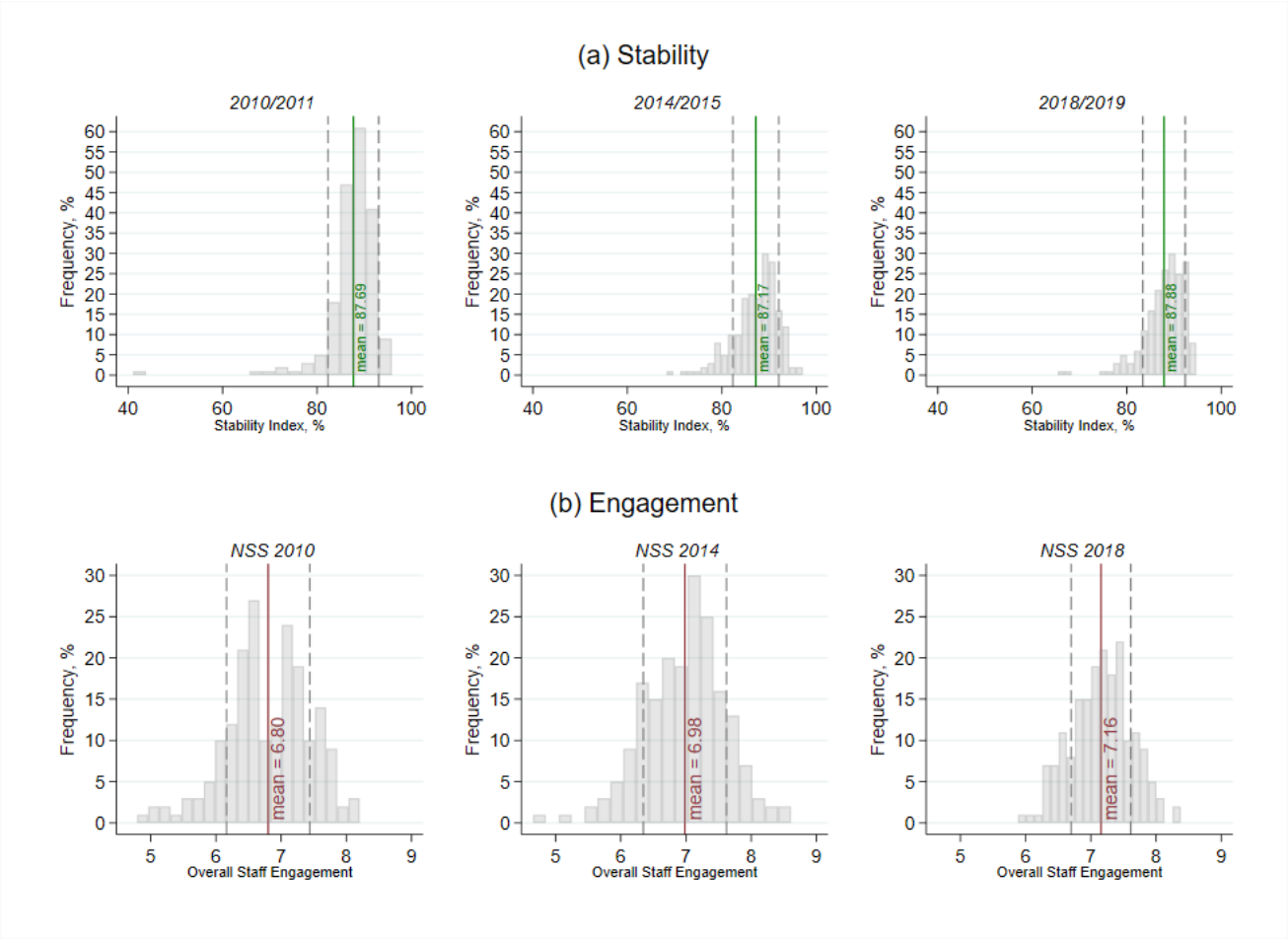


Table 8: Components of overall staff engagement in NHS Staff Surveys (NSS)

Motivation
For each of the statements below, how often do you feel this way about your job?
a. I look forward to going to work.
b. I am enthusiastic about my job.
c. Time passes quickly when I am working.
Advocacy
To what extent do these statements reflect your view of your organisation as a whole?
a. Care of patients/service-users is my organisation's top priority.
b. I would recommend my organisation as a place to work.
c. If a friend or relative needed treatment I would be happy with the standard of care provided by this organisation.
Inclusion
To what extent do you agree or disagree with the following statements about your work?
a. There are frequent opportunities for me to show initiative in my role.
b. I am able to make suggestions to improve the work of my team/department.
c. I am able to make improvements happen in my are of work.

Notes: Motivation items are measured in a frequency scale ranging from 1 (never) to 5 (always), advocacy and inclusion are measured with Likert scale 1 (strongly disagree) to 5 (strongly agree). The items are converted to scales ranging fron 0 to 10. Each component of overall staff engagement is an equally weighted average of the items.

Table 9: Sample Sizes and Response Rates, NSS 2009-2018

	Base sample size				Response Rates (in %)				
	Mean	Std dev	Min	Max	Mean	Std dev	Min	Max	N
2009	792.83	59.89	467	850	51.71	6.81	32.62	65.48	189
2010	794.83	77.12	480	1484	52.24	7.90	32.62	70.34	190
2011	810.24	70.10	465	1412	53.16	7.27	33.97	75.19	190
2012	807.63	56.12	464	850	50.19	7.39	29.82	71.17	190
2013	1749.96	1757.62	504	7943	50.33	8.34	30.27	77.90	190
2014	2571.18	2313.78	535	11223	43.99	9.11	23.16	81.55	190
2015	3123.52	2685.73	560	14946	42.83	9.00	18.82	78.26	189
2016	4156.37	2881.60	556	15657	44.85	8.10	28.80	76.58	190
2017	4704.29	3026.86	619	16910	45.84	8.24	27.28	72.90	190
2018	4854.58	3331.82	643	19310	46.20	8.73	24.59	71.64	186
2009-18	2431.94	2635.44	464	19310	48.14	8.86	18.82	81.55	1894

Notes: Authors' calculations from individual level NSS data from 2009 to 2018.

Table 10: Share of missing engagement score and worker characteristics

	Nurses				**Senior Doctors**			
	Engagement	Motivation	Advocacy	Inclusion	Engagement	Motivation	Advocacy	Inclusion
Gender (ref: male)								
female	0.995	1.007	0.992	0.991	1.000	1.004	1.003	0.998
	(0.006)	(0.009)	(0.008)	(0.008)	(0.003)	(0.006)	(0.005)	(0.005)
other	1.093	1.065	1.044	1.140*	0.998	1.054	0.859**	1.004
	(0.066)	(0.122)	(0.191)	(0.082)	(0.039)	(0.229)	(0.053)	(0.042)
missing	0.998	1.024**	0.986	0.996	1.003	0.991	0.986	0.995
	(0.007)	(0.011)	(0.013)	(0.010)	(0.007)	(0.009)	(0.011)	(0.009)
Age (ref: 31-40)								
16 - 20 ”	1.042	1.117	1.082	0.932	0.971	1.093	0.912	0.961
	(0.148)	(0.244)	(0.215)	(0.147)	(0.060)	(0.177)	(0.064)	(0.056)
21 - 30	0.999	1.016	1.013	0.998	1.047	0.982	1.063	1.021
	(0.007)	(0.010)	(0.019)	(0.008)	(0.064)	(0.066)	(0.078)	(0.069)
41 - 50	0.999	1.010	0.996	0.995	0.995	0.987	1.002	0.993
	(0.006)	(0.008)	(0.008)	(0.007)	(0.004)	(0.008)	(0.007)	(0.006)
51 - 65	1.001	1.008	1.005	1.001	1.000	0.993	1.004	0.999
	(0.006)	(0.009)	(0.007)	(0.007)	(0.004)	(0.010)	(0.007)	(0.007)
66+	1.013	1.002	1.040**	1.014	0.985	0.983	1.027	0.989
	(0.012)	(0.014)	(0.019)	(0.014)	(0.009)	(0.014)	(0.017)	(0.014)
missing age	1.114***	1.147***	1.108**	1.115**	1.050***	1.038	1.056**	1.041**
	(0.043)	(0.045)	(0.053)	(0.047)	(0.019)	(0.026)	(0.024)	(0.020)
Ethnicity (ref: White)								
mixed	0.983	1.037	1.023	0.979	1.010	1.006	1.003	1.008
	(0.020)	(0.039)	(0.041)	(0.022)	(0.012)	(0.019)	(0.017)	(0.015)
Asian/Asian British	1.002	1.009	0.996	1.004	1.010	1.003	1.014	1.008
	(0.007)	(0.011)	(0.020)	(0.008)	(0.006)	(0.009)	(0.009)	(0.008)
Black/Black British	1.005	1.014	1.038**	1.003	1.009	0.993	1.009	1.009
	(0.009)	(0.013)	(0.016)	(0.010)	(0.010)	(0.013)	(0.011)	(0.015)
Chinese/Chinese British	1.009	0.933	1.052	0.964	1.023	1.040	1.036	1.026
	(0.034)	(0.053)	(0.050)	(0.036)	(0.022)	(0.028)	(0.030)	(0.023)
Other	1.002	1.073***	0.958	0.990	0.996	1.002	0.988	1.009
	(0.018)	(0.029)	(0.039)	(0.017)	(0.010)	(0.017)	(0.016)	(0.015)
missing	1.069**	1.017	1.036	1.068**	1.012	1.018	1.034	1.018
	(0.029)	(0.027)	(0.026)	(0.032)	(0.012)	(0.018)	(0.021)	(0.017)
Disability (ref:yes)								
no disability	1.000	0.988	1.006	1.006	1.003	0.999	1.000	1.006
	(0.005)	(0.008)	(0.009)	(0.008)	(0.005)	(0.008)	(0.007)	(0.006)
missing	0.952*	0.970	1.035***	0.961	1.014	1.034	1.031	1.039
	(0.025)	(0.029)	(0.014)	(0.025)	(0.015)	(0.027)	(0.022)	(0.024)
Tenure at organisation (ref: 3-5 years)								
Less than 1 year ”	0.997	0.998	0.993	0.993	1.004	0.981*	1.007	0.999
	(0.008)	(0.011)	(0.015)	(0.009)	(0.007)	(0.010)	(0.011)	(0.009)
1 - 2 years ”	0.985*	0.978*	0.999	0.989	1.002	1.003	1.011	0.994
	(0.008)	(0.011)	(0.009)	(0.010)	(0.006)	(0.010)	(0.010)	(0.009)
6 - 10 years ”	0.991	0.975**	1.012	0.990	1.005	1.005	1.010	0.998
	(0.010)	(0.010)	(0.013)	(0.010)	(0.006)	(0.007)	(0.009)	(0.009)
11 - 15 years ”	0.999	1.000	1.022**	1.005	1.001	1.011	1.003	1.001
	(0.008)	(0.009)	(0.009)	(0.010)	(0.005)	(0.008)	(0.008)	(0.005)
More than 15 years ”	0.997	0.993	1.012	1.002	1.001	1.004	1.000	0.999
	(0.007)	(0.009)	(0.009)	(0.011)	(0.006)	(0.007)	(0.008)	(0.007)
missing ”	0.993	1.057***	1.014	0.999	1.016	1.014	1.010	1.017
	(0.013)	(0.019)	(0.013)	(0.016)	(0.011)	(0.015)	(0.016)	(0.013)
Contract (ref: part-time)								
Full-time	1.000	0.987**	0.989	1.002	0.992	1.005	0.998	0.991
	(0.004)	(0.006)	(0.010)	(0.006)	(0.005)	(0.009)	(0.008)	(0.007)
mssing	1.055*	1.002	0.951	1.055*	0.994	0.993	0.986	0.996
	(0.031)	(0.029)	(0.030)	(0.031)	(0.010)	(0.015)	(0.017)	(0.012)
R^2	0.351	0.468	0.227	0.311	0.169	0.153	0.152	0.157

Notes: All covariates are shares at Trust level aggregated from individual-level NSS 2009-2018. The models also control for year and Trust fixed effects. There are 1,894 Trust-year observations for nurses and 1,893 Trust-year observations for senior doctors. Standard errors are clustered at Trust level. *p<0.1; **p<0.05; ***p<0.01.

Table 11: Summary statistics from NHS Staff Survey 2009-2018

	Nurses				Senior Doctors			
	Mean	Standard deviation			Mean	Standard deviation		
		Overall	Between	Within		Overall	Between	Within
Demographic characteristics								
Age 31 - 40	0.215	0.061	0.038	0.048				
Age 41 - 50	0.323	0.061	0.031	0.053	0.416	0.112	0.050	0.100
Age 51 - 65	0.324	0.088	0.061	0.063	0.366	0.116	0.061	0.099
Age 66+	0.017	0.021	0.008	0.020	0.023	0.039	0.016	0.036
Female	0.838	0.098	0.086	0.047	0.346	0.131	0.096	0.090
Other (incld missing)	0.043	0.045	0.020	0.040	0.044	0.058	0.022	0.054
Ethnic minority (BAME)	0.169	0.151	0.148	0.035	0.318	0.167	0.136	0.096
Experience in hospital Trust								
Less than 1 year	0.057	0.033	0.019	0.026	0.057	0.058	0.021	0.054
3 - 5 years	0.143	0.047	0.029	0.038	0.179	0.091	0.035	0.084
6 - 10 years	0.198	0.061	0.024	0.056	0.233	0.098	0.041	0.089
11 - 15 years	0.167	0.046	0.018	0.042	0.178	0.092	0.037	0.084
More than 15 years	0.332	0.097	0.084	0.048	0.248	0.107	0.058	0.091
Full-time (Contracted 30+ hrs)	0.818	0.077	0.065	0.041	0.904	0.084	0.058	0.061
Bullied at work from manager/coworkers in the last 12 months	0.241	0.070	0.041	0.057	0.218	0.111	0.054	0.098
Discrimination at work from manager/coworkers in the last 12 months	0.084	0.037	0.026	0.026	0.072	0.063	0.030	0.055
Felt unwell due work stress in the last 12 months)	0.391	0.077	0.047	0.061	0.307	0.119	0.055	0.106
Come to work despite not feeling well in the last 12 months	0.652	0.081	0.036	0.072	0.482	0.145	0.060	0.132
Organization acts fairly with respect to career progression/promotion	0.612	0.072	0.053	0.049	0.660	0.125	0.068	0.105
Job aspects, satisfied or very satisfied								
Support from colleagues	0.817	0.055	0.030	0.047	0.831	0.092	0.042	0.082
Level of pay	0.353	0.075	0.051	0.055	0.624	0.127	0.071	0.106
Recognition for good work	0.497	0.089	0.046	0.077	0.506	0.137	0.072	0.117
Responsibility given	0.760	0.054	0.031	0.044	0.838	0.092	0.048	0.079
Opportunities to use skills	0.763	0.060	0.037	0.047	0.801	0.101	0.053	0.086
Agree or strongly agree								
Senior managers try involve staff in important decisions	0.309	0.087	0.059	0.064	0.376	0.150	0.091	0.120
I am able to do my job to a standard I am personally pleased with	0.694	0.122	0.053	0.109	0.709	0.143	0.065	0.127
I have adequate materials, supplies, equipment to do my work	0.540	0.083	0.062	0.055	0.485	0.145	0.096	0.109
There is enough staff at this organisation for me to do my job	0.265	0.082	0.060	0.056	0.278	0.129	0.083	0.099

Notes: Summary statistics are calculated using the samples of columns 3 and 6 in Table 3 based on 190 NHS Trusts and 1,894 Trust-year observations for nurses and 1,892 for senior doctors.

Table 12: OLS and system-GMM estimates using engagement components

	OLS with two-way fixed effects					
	Stability rate			NHS Leaving rate		
	Motivation	Advocacy	Inclusion	Motivation	Advocacy	Inclusion
	Panel (a) Nurses					
Own group engagement component	0.803**	0.796***	0.568	-0.389	-0.495***	-0.446
	(0.342)	(0.198)	(0.369)	(0.266)	(0.146)	(0.279)
Complementary coworkers retention	0.055**	0.051*	0.054**	0.090**	0.087**	0.090**
	(0.027)	(0.026)	(0.027)	(0.040)	(0.040)	(0.040)
NSS response rate	0.009	0.004	0.010	-0.011	-0.007	-0.011
	(0.011)	(0.011)	(0.011)	(0.007)	(0.007)	(0.007)
Constant	-26.954	-20.041	-25.521	83.372***	80.271**	84.407***
	(37.933)	(38.302)	(37.913)	(30.127)	(30.946)	(30.507)
R^2	0.262	0.270	0.261	0.153	0.160	0.154
	Panel (b) Senior Doctors					
Own group engagement component	-0.313	0.435**	0.459**	0.225	-0.150	-0.185
	(0.229)	(0.178)	(0.198)	(0.169)	(0.109)	(0.114)
Complementary coworkers retention	0.156***	0.148***	0.152***	0.194***	0.188***	0.191***
	(0.053)	(0.053)	(0.053)	(0.057)	(0.057)	(0.058)
NSS response rate	-0.002	-0.005	-0.004	-0.000	0.001	0.001
	(0.018)	(0.018)	(0.018)	(0.012)	(0.012)	(0.012)
Constant	-23.033	-27.844	-27.562	37.671**	40.650**	40.499**
	(20.061)	(20.255)	(20.356)	(15.960)	(15.770)	(15.905)
R^2	0.103	0.106	0.105	0.080	0.079	0.080
	System GMM					
	Stability rate			NHS Leaving rate		
	Motivation	Advocacy	Inclusion	Motivation	Advocacy	Inclusion
	Panel (a) Nurses					
Own group engagement component	0.409	0.993***	0.724	-0.448	-0.653***	-0.526
	(0.496)	(0.333)	(0.481)	(0.330)	(0.216)	(0.352)
Complementary coworkers retention	0.013	0.011	0.017	0.031	0.031	0.028
	(0.028)	(0.028)	(0.027)	(0.028)	(0.030)	(0.029)
NSS response rate	-0.002	-0.009	-0.002	-0.008	-0.005	-0.008
	(0.016)	(0.016)	(0.015)	(0.011)	(0.011)	(0.011)
Own group lagged retention	0.211***	0.184***	0.216***	0.117*	0.099	0.117*
	(0.058)	(0.060)	(0.056)	(0.064)	(0.061)	(0.062)
AR(1) p-value	0.000	0.000	0.000	0.003	0.003	0.003
AR(2) p-value	0.312	0.296	0.311	0.585	0.609	0.604
Hansen test degrees of freedom	43	43	43	43	43	43
Hansen over-id. test p-value	0.477	0.565	0.583	0.539	0.403	0.572
	Panel (b) Senior Doctors					
Own group engagement component	-0.491	0.501**	0.327	0.349	-0.105	-0.182
	(0.345)	(0.237)	(0.239)	(0.243)	(0.169)	(0.165)
Complementary coworkers retention	0.158**	0.145*	0.168**	0.170***	0.170***	0.169***
	(0.074)	(0.080)	(0.077)	(0.051)	(0.052)	(0.050)
NSS response rate	-0.001	-0.018	-0.009	0.005	0.008	0.012
	(0.025)	(0.024)	(0.025)	(0.013)	(0.013)	(0.013)
Own group lagged retention	0.188***	0.179***	0.195***	0.044	0.043	0.043
	(0.058)	(0.057)	(0.057)	(0.042)	(0.042)	(0.041)
AR(1) p-value	0.000	0.000	0.000	0.000	0.000	0.000
AR(2) p-value	0.388	0.493	0.427	0.933	0.881	0.902
Hansen test degrees of freedom	43	43	43	43	43	43
Hansen over-id. test p-value	0.225	0.325	0.267	0.740	0.769	0.781

Notes: There are 190 Trusts and 1,704 (1,701) Trust-year observations for nurses (senior doctors). All standard errors clustered at Trust level. System-GMM standard errors using Windmeijer (2005) small sample adjustment. *p<0.1; **p<0.05; ***p<0.01.

Table 13: Elasticities of retention to engagement and complementary workers' retention

	FE	GMM	Unconditional Quantile Regression				
			Q10	Q25	Q50	Q75	Q90
(a) Nurses' Stability Rate							
Own group engagement	0.090***	0.103***	0.072	0.148***	0.114***	0.079**	0.015
	(0.025)	(0.040)	(0.072)	(0.048)	(0.036)	(0.033)	(0.037)
Complementary coworkers stability	0.054**	0.015	0.091	0.054	0.036	-0.000	0.011
	(0.027)	(0.028)	(0.059)	(0.038)	(0.029)	(0.019)	(0.023)
(b) Nurses' NHS leaving Rate							
Own group engagement	-0.724***	-0.847**	-0.465	-0.216	-1.174***	-0.576**	-1.432***
	(0.271)	(0.350)	(0.362)	(0.321)	(0.358)	(0.284)	(0.498)
Complementary coworkers NHS leaving rate	0.081*	0.027	-0.014	0.011	0.019	0.048**	0.100*
	(0.043)	(0.026)	(0.022)	(0.019)	(0.021)	(0.023)	(0.052)
(c) Senior Doctors' Stability Rate							
Own group engagement	0.031*	0.018	0.050	0.045	0.016	0.001	0.003
	(0.018)	(0.024)	(0.068)	(0.031)	(0.017)	(0.019)	(0.019)
Complementary coworkers stability	0.150***	0.157**	0.176	0.273***	0.129***	0.054	0.031
	(0.052)	(0.076)	(0.186)	(0.071)	(0.047)	(0.044)	(0.054)
(d) Senior Doctors' NHS leaving Rate							
Own group engagement	-0.119	-0.063	-0.011	-0.133	0.115	-0.208	-0.124
	(0.177)	(0.267)	(0.370)	(0.228)	(0.219)	(0.222)	(0.370)
Complementary coworkers NHS leaving rate	0.227***	0.201***	0.133	0.064	0.144***	0.238***	0.259**
	(0.066)	(0.059)	(0.153)	(0.071)	(0.044)	(0.060)	(0.104)

Notes: Sample size: 190 Trusts; 1,704 (1,701) Trust-year observations for nurses (senior doctors). Standard errors clustered at Trust level and computed with the delta method. *p<0.1; **p<0.05; ***p<0.01. For Nurses' NHS Leavers rate at 10^{th} quantile only, the specification exclude the control for the share of female nurses. For Senior Doctors' NHS Leavers rate at 10^{th} and 25^{th} quantile only, the specification exclude the control for the number of rival hospitals.

Table 14: Estimates with absences from the workplace as dependent variable

	Sickness absence rate			**Other lost days absence rate**		
	Pooled	**FE**	**GMM**	**Pooled**	**FE**	**GMM**
			Nurses			
Own group engagement	-0.493***	-0.182***	-0.232***	0.076	-0.013	0.031
	(0.117)	(0.056)	(0.073)	(0.094)	(0.075)	(0.120)
Complementary coworkers absence rate	0.135***	0.035*	0.035	0.319***	0.073**	0.062
	(0.037)	(0.020)	(0.024)	(0.054)	(0.032)	(0.058)
NSS response rate	-0.010***	-0.005**	-0.005*	-0.002	0.001	-0.002
	(0.003)	(0.002)	(0.003)	(0.006)	(0.003)	(0.003)
Own group lagged absence rate			0.391***			0.450***
			(0.053)			(0.124)
AR(1) p-value			0.000			0.000
AR(2) p-value			0.244			0.949
Hansen test degrees of freedom			43			43
Hansen over-id. test p-value			0.279			0.016
R^2	0.524	0.069		0.240	0.139	
			Senior doctors			
Own group engagement	-0.059	0.010	0.055	-0.005	0.009	-0.006
	(0.039)	(0.035)	(0.054)	(0.051)	(0.038)	(0.046)
Complementary coworkers absence rate	0.397***	0.067*	0.073	0.171***	0.048*	0.038
	(0.038)	(0.038)	(0.057)	(0.039)	(0.027)	(0.032)
NSS response rate	0.008***	0.001	0.001	0.002	-0.002	-0.000
	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
Own group lagged absence rate			0.198***			0.237***
			(0.055)			(0.070)
AR(1) p-value			0.000			0.000
AR(2) p-value			0.202			0.540
Hansen test degrees of freedom			43			43
Hansen over-id. test p-value			0.837			0.571
R^2	0.376	0.042		0.153	0.045	

Notes: There are 190 Trusts and 1,704 (1,701) Trust-year observations for nurses (senior doctors). All standard errors clustered at Trust level. System-GMM standard errors using Windmeijer (2005) small sample adjustment. *p<0.1; **p<0.05; ***p<0.01.

Table 15: UQR estimates with absences from the workplace as dependent variable

	Nurses									
	Sickness absence rate					**Other lost days absence rate**				
	Q10	**Q25**	**Q50**	**Q75**	**Q90**	**Q10**	**Q25**	**Q50**	**Q75**	**Q90**
Own group engagement	0.105	-0.214*	-0.311***	-0.305**	-0.131	0.087	-0.020	-0.061	-0.151	-0.107
	(0.135)	(0.110)	(0.105)	(0.139)	(0.157)	(0.146)	(0.101)	(0.098)	(0.142)	(0.200)
Complementary coworkers absence rate	0.028	0.007	0.013	0.080	0.022	0.051	0.0515	0.085*	0.074	0.035
	(0.027)	(0.025)	(0.028)	(0.057)	(0.073)	(0.072)	(0.045)	(0.048)	(0.069)	(0.094)
NSS response rate	-0.004	-0.000	-0.004	-0.009**	-0.013***	0.001	-0.001	-0.003	-0.007	0.006
	(0.007)	(0.004)	(0.003)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)	(0.009)
Within R^2	0.0299	0.0372	0.0405	0.0359	0.0193	0.0799	0.0861	0.0750	0.0753	0.0462
RIF mean	3.422	3.896	4.467	5.093	5.575	1.512	1.951	2.401	3.000	3.656
se(RIF mean)	0.030	0.027	0.027	0.030	0.033	0.029	0.023	0.023	0.034	0.044
	Senior Doctors									
	Sickness absence rate					**Other lost days absence rate**				
	Q10	**Q25**	**Q50**	**Q75**	**Q90**	**Q10**	**Q25**	**Q50**	**Q75**	**Q90**
Own group engagement	-0.039	0.005	-0.0625	-0.0212	-0.0174	0.025	-0.052	0.006	0.023	-0.041
	(0.038)	(0.038)	(0.0444)	(0.0728)	(0.1599)	(0.038)	(0.037)	(0.046)	(0.063)	(0.089)
Complementary coworkers absence rate	0.031	0.001	0.0297	0.0426	0.1803	0.068	0.026	0.044	0.069	0.046
	(0.043)	(0.035)	(0.0448)	(0.0744)	(0.1714)	(0.049)	(0.041)	(0.039)	(0.052)	(0.060)
NSS response rate	-0.000	-0.002	0.0013	0.0091*	0.0053	-0.001	-0.002	-0.004	0.003	-0.000
	(0.003)	(0.003)	(0.0028)	(0.0049)	(0.0092)	(0.003)	(0.003)	(0.003)	(0.004)	(0.006)
Within R^2	0.0253	0.0220	0.0224	0.0359	0.0355	0.0231	0.0255	0.0241	0.0336	0.0147
RIF mean	0.656	0.937	1.308	1.854	2.595	0.215	0.472	0.820	1.244	1.808
se(RIF mean)	0.019	0.017	0.020	0.033	0.057	0.016	0.016	0.017	0.025	0.037

Notes: There are 190 Trusts; 1,704 (1,701) Trust-year observations for nurses (senior doctors). All standard errors clustered at Trust level. UQR standard errors bootstrapped (1,000 replications). *p<0.1; **p<0.05; ***p<0.01.

Table 16: Estimates with hours worked as dependent variable

	Nurses						
	FE	**GMM**	**Q10**	**Q25**	**Q50**	**Q75**	**Q90**
Own group engagement	0.393**	0.051	0.167	0.115	0.103	0.972***	1.062*
	(0.174)	(0.103)	(0.109)	(0.097)	(0.120)	(0.321)	(0.639)
Complementary coworkers hours	-0.005	-0.047	0.008	-0.008	0.000	-0.012	-0.018
	(0.017)	(0.043)	(0.013)	(0.013)	(0.017)	(0.044)	(0.062)
Own group lagged hours		0.862***					
		(0.026)					
AR(1) p-value		0.001					
AR(2) p-value		0.423					
Hansen test degrees of freedom		41					
Hansen over-id test, p-value		0.214					
RIF mean			161.882	162.171	162.547	163.693	165.044
se(RIF mean)			0.019	0.019	0.025	0.073	0.103
R-squared	0.455		0.0792	0.1858	0.4363	0.3628	0.1729
	Senior Doctors						
	FE	**GMM**	**Q10**	**Q25**	**Q50**	**Q75**	**Q90**
Own group engagement	0.005	0.023	0.082	-0.009	-0.018	-0.060	-0.359
	(0.122)	(0.117)	(0.201)	(0.064)	(0.053)	(0.087)	(0.317)
Complementary coworkers hours	-0.028	-0.001	-0.017	-0.035	-0.041*	-0.028	-0.187
	(0.053)	(0.026)	(0.091)	(0.033)	(0.023)	(0.043)	(0.136)
Own group lagged hours		0.602***					
		(0.144)					
AR(1) p-value		0.004					
AR(2) p-value		0.076					
Hansen test degrees of freedom		41					
Hansen over-id test, p-value		0.404					
RIF mean			150.903	151.723	152.142	152.711	153.646
se(RIF mean)			0.073	0.024	0.021	0.035	0.114
R-squared	0.034		0.0246	0.0419	0.1087	0.1029	0.0333

Notes: There are 190 Trusts; 1,704 (1,701) Trust-year observations for nurses (senior doctors). All standard errors clustered at Trust level. System-GMM standard errors using Windmeijer (2005) small sample adjustment. UQR standard errors bootstrapped (1,000 replications). *p<0.1; **p<0.05; ***p<0.01.

Table 17: System-GMM estimates replacing engagement score with job satisfaction items

	Nurses											
	Stability rate						NHS Leaving rate					
Own group lagged retention	0.209***	0.210***	0.203***	0.215***	0.211***	0.220***	0.115*	0.112*	0.116*	0.117**	0.108*	0.118**
	(0.058)	(0.060)	(0.058)	(0.061)	(0.061)	(0.061)	(0.063)	(0.062)	(0.062)	(0.059)	(0.060)	(0.059)
Complementary coworkers retention	0.010	0.013	0.013	0.014	0.015	0.014	0.024	0.030	0.030	0.028	0.031	0.030
	(0.026)	(0.027)	(0.027)	(0.025)	(0.026)	(0.026)	(0.029)	(0.030)	(0.029)	(0.029)	(0.029)	(0.029)
Support from colleagues	-0.047*						0.001					
	(0.024)						(0.017)					
Pay satisfaction		-0.003						-0.003				
		(0.019)						(0.016)				
Recognition for good work			0.014						-0.006			
			(0.018)						(0.011)			
Responsibility given				0.038						-0.020		
				(0.024)						(0.021)		
Opportunity to use skills					0.008						-0.023	
					(0.025)						(0.016)	
Principal component						0.062						-0.071
						(0.100)						(0.072)
AR(1) p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.002	0.001	0.002	0.002
AR(2) p-value	0.298	0.304	0.306	0.315	0.306	0.314	0.573	0.594	0.601	0.596	0.595	0.597
Hanse over-id. test p-value	0.583	0.679	0.634	0.574	0.522	0.558	0.406	0.475	0.528	0.451	0.414	0.404
	Senior Doctors											
	Stability rate						NHS Leaving rate					
Own group lagged retention	0.190***	0.195***	0.189***	0.189***	0.202***	0.189***	0.043	0.051	0.038	0.040	0.044	0.038
	(0.054)	(0.057)	(0.059)	(0.057)	(0.051)	(0.054)	(0.045)	(0.042)	(0.043)	(0.042)	(0.042)	(0.043)
Complementary coworkers retention	0.160**	0.172**	0.159**	0.164**	0.162**	0.161**	0.170***	0.171***	0.167***	0.168***	0.165***	0.166***
	(0.076)	(0.077)	(0.076)	(0.075)	(0.078)	(0.076)	(0.052)	(0.054)	(0.050)	(0.051)	(0.050)	(0.051)
Support from colleagues	0.006						0.009					
	(0.017)						(0.012)					
Pay satisfaction		0.011						-0.011				
		(0.013)						(0.008)				
Recognition for good work			-0.012						0.009			
			(0.013)						(0.009)			
Responsibility given				-0.009						0.007		
				(0.020)						(0.014)		
Opportunity to use skills					0.018						-0.004	
					(0.016)						(0.012)	
Principal component						0.029						0.014
						(0.119)						(0.084)
AR(1) p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR(2) p-value	0.456	0.458	0.419	0.453	0.455	0.471	0.873	0.898	0.867	0.905	0.862	0.845
Hanse over-id. test p-value	0.260	0.246	0.234	0.229	0.287	0.297	0.437	0.774	0.606	0.755	0.726	0.644

Notes: Sample size: 190 Trusts; 1,704 (1,701) Trust-year observations for nurses (senior doctors). All standard errors clustered at Trust level. System-GMM standard errors are adjusted for small sample using Windmeijer (2005). *p<0.1; **p<0.05; ***p<0.01.

Table 18: Estimates including junior doctors' NHS leaving rate

	FE	**GMM (I)**	**GMM (II)**
Own group engagement	-0.125	-0.154	0.026
	(0.150)	(0.213)	(0.211)
Nurses' retention	0.193***	0.167***	0.196***
	(0.057)	(0.052)	(0.054)
Junior doctors' NHS Leaver rate	1.002	-0.902	-1.225
	(1.736)	(2.630)	(1.575)
NSS response rate	0.002	0.008	0.020
	(0.011)	(0.013)	(0.013)
Own group lagged retention		0.028	0.057
		(0.042)	(0.044)
AR(1) p-value		0.000	0.000
AR(2) p-value		0.887	0.855
Hansen degrees of freedom		45	69
Hansen over-id test p-value		0.832	0.592

Notes: Sample size: 190 Trusts; 1,704 (1,701) Trust-year observations for nurses (senior doctors). All standard errors clustered at Trust level. System-GMM standard errors are adjusted for small sample using Windmeijer (2005). *p<0.1; **p<0.05; ***p<0.01.

Table 19: OLS and system-GMM estimates controlling for outside wages and house prices

	Nurses							
	Stability rate		NHS Leaving rate		Stability rate		NHS Leaving rate	
	FE	GMM	FE	GMM	FE	GMM	FE	GMM
Own group overall engagement score	1.115***	1.283***	-0.692***	-0.783**	1.158***	1.189**	-0.699***	-0.762**
	(0.311)	(0.477)	(0.233)	(0.332)	(0.314)	(0.470)	(0.236)	(0.324)
Complementary coworkers retention	0.053**	0.022	0.089**	0.033	0.052*	0.021	0.089**	0.025
	(0.027)	(0.026)	(0.040)	(0.027)	(0.027)	(0.025)	(0.041)	(0.023)
Own group lagged retention		0.197***		0.103		0.197***		0.113*
		(0.056)		(0.064)		(0.056)		(0.064)
log(Outside Wage)	0.560	-6.657***	0.497	4.461***				
	(4.100)	(1.935)	(2.740)	(1.519)				
log(House Prices)					2.333*	-2.419***	-0.596	1.667***
					(1.380)	(0.517)	(0.949)	(0.450)
AR(1) p-value		0.000		0.002		0.000		0.002
AR(2) p-value		0.295		0.580		0.295		0.600
Hansen test degrees of freedom		43		43		43		43
Hansen over-id. test p-value		0.495		0.361		0.519		0.541
R^2	0.267		0.157		0.269		0.157	

Notes: There are 190 Trusts and 1,704 (1,701) Trust-year observations for nurses (senior doctors). All standard errors clustered at Trust level. System-GMM standard errors using Windmeijer (2005) small sample adjustment. *p<0.1; **p<0.05; ***p<0.01.

Table 20: System-GMM estimates including one key variable at a time

	Nurses			Senior Doctors		
	(1) Main model	(2) Engagement only	(3) Stability only	(4) Main model	(5) Engagement only	(6) Stability only
Own group overall engagement score	1.284**	1.079**		0.227	0.328	
	(0.498)	(0.544)		(0.298)	(0.348)	
Complementary coworkers stability	0.015		0.014	0.160**		0.163**
	(0.027)		(0.027)	(0.078)		(0.077)
Own group lagged stability index	0.199***	0.181***	0.208***	0.191***	0.125***	0.191***
	(0.059)	(0.063)	(0.057)	(0.057)	(0.043)	(0.058)
Constant	2.638	9.622	5.890	-13.452	-9.177	-14.736
	(28.169)	(28.172)	(26.766)	(32.526)	(30.737)	(33.248)
AR(1) p-value	0.000	0.000	0.000	0.000	0.000	0.000
AR(2) p-value	0.307	0.273	0.304	0.435	0.840	0.442
AHansen test degrees of freedom	43.000	17.000	40.000	43.000	17.000	40.000
Hansen over-id. test p-value	0.566	0.363	0.589	0.277	0.809	0.187
	Nurses			**Senior Doctors**		
	(1) Main model	(2) Engagement only	(3) NHS leaving rate only	(4) Main model	(5) Engagement only	(6) NHS leaving rate only
Own group overall engagement score	-0.829**	-0.884**		-0.053	-0.114	
	(0.340)	(0.362)		(0.224)	(0.270)	
Complementary coworkers NHS leaving rate	0.030		0.029	0.169***		0.168***
	(0.028)		(0.030)	(0.051)		(0.051)
Own group lagged NHS leaving rate	0.110*	0.090*	0.114*	0.044	-0.003	0.043
	(0.063)	(0.052)	(0.062)	(0.043)	(0.045)	(0.042)
Constant	44.911**	46.725**	39.298**	27.902	38.085*	25.436
	(17.382)	(19.913)	(16.585)	(18.395)	(21.491)	(19.417)
AR(1) p-value	0.003	0.002	0.002	0.000	0.000	0.000
AR(2) p-value	0.608	0.550	0.582	0.898	0.319	0.901
Hansen test degrees of freedom	43.000	17.000	40.000	43.000	17.000	40.000
Hansen over-id. test p-value	0.451	0.081	0.521	0.803	0.787	0.712

Notes: There are 190 Trusts and 1,704 (1,701) Trust-year observations for nurses (senior doctors). System-GMM standard errors using Windmeijer (2005) small sample adjustment. *p<0.1; **p<0.05; ***p<0.01.

Table 21: Robustness check to local support for Brexit

	Nurses		Senior Doctors	
	Stability	NHS Leaving rate	Stability	NHS Leaving rate
Own group lagged retention	0.201***	0.111*	0.190***	0.044
	(0.060)	(0.065)	(0.057)	(0.042)
Own group engagement score	1.308**	-0.844**	0.229	-0.045
	(0.509)	(0.351)	(0.302)	(0.225)
Complementary coworkers retention	0.011	0.025	0.157**	0.169***
	(0.027)	(0.028)	(0.078)	(0.051)
Post Brexit * Share of votes to leave the EU	0.014	-0.011	-0.016	-0.003
	(0.014)	(0.011)	(0.020)	(0.012)
Constant	3.332	44.872**	-15.230	28.492
	(28.417)	(18.013)	(32.296)	(18.501)
AR(1) p-value	0.000	0.003	0.000	0.000
AR(2) p-value	0.307	0.610	0.452	0.893
Hansen test degrees of freedom	43	43	43	43
Hansen over-id. test p-value	0.479	0.406	0.282	0.799

Notes: There are 190 Trusts and 1,704 (1,701) Trust-year observations for nurses (senior doctors). All standard errors clustered at Trust level. System-GMM standard errors using Windmeijer (2005) small sample adjustment. *p<0.1; **p<0.05; ***p<0.01.