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ABSTRACT

Staff Engagement, Job Complementarity and Labour Supply: Evidence from the English NHS Hospital Workforce*

We investigate the relationship among staff engagement, job complementarities and labour supply in the hospital sector, where excessive turnover of the clinical staff (doctors and nurses) can be detrimental for quality of care. We exploit a unique and rich panel dataset constructed by combining employee-level payroll and survey records from the universe of English NHS hospitals. System-GMM estimates remove the endogeneity bias due to reverse causality, revealing nurses' elasticities of retention with respect to engagement of 0.1 and 0.85, and doctors' elasticities of retention with respect to nurses' retention of 0.16 and 0.2, respectively within the hospital and the NHS. Estimates of unconditional quantile regressions confirm these findings, with nurses' engagement-elasticities as large as 1.4 for providers with low retention. Higher engagement is also beneficial to reduce staff absences. Our work is informative on the role played by staff engagement and labour supply complementarities in the workforce planning and management of large organizations.

JEL Classification: C33, C36, I11, J22, J28, J63

Keywords: labour supply, workforce retention, staff engagement, job complementarities, healthcare organization, endogeneity

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1 Introduction

"Health systems can only function with health workers" (WHO, 2016a), and this is because health care remains a labour-intensive sector, in which new medical technologies complement human labour without fully replacing it. Over the last decade, the long-term planning for the recruitment, formation and retention of healthcare professionals has been an ongoing concern for the governments of several countries (Barriball et al., 2015; Cosgrave et al., 2019)[1] and international organizations (Magnusson, 2017; WHO, 2018). Already in 2016 the World Health Organization (WHO) estimated a projected shortfall of 18 million health workers by 2030, and highlighted that "countries at all levels of socioeconomic development face, to varying degrees, difficulties in the education, employment, deployment, retention, and performance of their workforce."[2] What originally was an endemic issue of low-income, developing countries, usually struggling with the recruitment and formation of healthcare workers, has now become a problem also in wealthy, developed countries, which instead face increasing issues of workforce burnout (Hall et al., 2016; Johnson et al., 2018; De Hert, 2020) and retention (Buchan and Aiken, 2008; Buerhaus, 2008; Manzano-García and Ayala-Calvo, 2014). Population ageing and the consequent rise in the demand for healthcare services and treatments are the main demand-side factors responsible for this situation, coupled with supply-side factors like welfare and public services cuts (e.g. those enforced by governments after the 2008 Great Recession and resulting in pay and hiring freezes in publicly-funded healthcare systems) as well as the mobility of healthcare professional in a globalised and competitive labour market (WHO, 2016b).

For years, the decreased retention of nurses and doctors within primary care and hospital organizations has been an ongoing issue in countries like the US, the UK and Australia, where preserving adequate staffing level of healthcare professionals in periods of high de-

[1] See also the case of Oregon at `https://www.oregon.gov/oha/HPA/HP-PCO/Pages/Workforce-Retention.aspx`.

[2] `https://www.who.int/health-topics/health-workforce`.

mand is often problematic, e.g. during Winter pressures in the English National Health Service (NHS). The excessive turnover of healthcare workers, especially in time-sensitive areas of hospital care, may generate excessive pressure on the remaining workers ("stayers", as opposed to the "leavers"), leading to lower quality of patient care. Even before the onset of the COVID-19 pandemic, adequate levels of hospital nursing staff were correlated with smaller odds of adverse patient outcomes like urinary tracts infections, upper gastrointestinal bleeding, hospital-acquired pneumonia and cardiac arrest (Needleman et al., 2002), as well as mortality, unplanned readmissions and long length of in-hospital stay (McHugh et al., 2021). With the COVID-19 outbreak, maintaining adequate nurses and consultants staffing levels has attained a greater salience, as the survival of hospitalized COVID patients has been leaning heavily on labour-intensive treatments operated by hospital doctors and nurses.

The already precarious workforce retention situation has been further aggravated by the COVID-19 pandemic, triggering a wave of voluntary resignations (the so called "Great Resignation") in countries like the US and the UK[3] and reaching record-high historical levels of about 2% of entire workforce also in the English NHS[4]. Issues due to high staff turnover are likely to persist in the near future[5], both in health care as in other sectors. Therefore, a better understanding of the mechanisms governing labour supply, and in particular the economics of workforce retention (Sheather and Slattery, 2021), becomes paramount for the sustainability of large organizations like public and private healthcare systems.

Through this work we aim to add to the existing knowledge about the economics of labour supply and retention, by focusing on the nexus between labour supply and two key variables: staff engagement and the retention (labour supply) of complementary workers. To investigate the relationships among these variables, we exploit the setting provided by

[3] https://www-economist-com.surrey.idm.oclc.org/finance-and-economics/evidence-for-the-great-resignation-is-thin-on-the-ground/21806659

[4] https://inews.co.uk/news/health/nhs-staff-quit-record-numbers-ptsd-covid-pandemic-trauma-1387115

[5] https://www-economist-com.surrey.idm.oclc.org/business/2021/11/27/how-to-manage-the-great-resignation

hospital services, where high levels of both engagement and teamwork by professionals with complementary skill-sets are the key for an efficient and high-quality provision of care to patients, and we analyse the labour supply dynamics of the hospital clinical workforce, i.e. nurses and doctors.

Our empirical study uses administrative workforce records from the universe of the acute care and mental health hospitals in the English NHS. The English NHS provides an ideal setting for this study for a number of reasons: it is the world's fifth biggest employer (as of 2019), providing us with large sample sizes for both hospitals and their employees; the pay of doctors and nurses working in NHS hospitals is centrally regulated at the national level, thus preventing the confounding due to mobility and self-selection linked to individually-contracted work pay incentives; 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 performance of NHS hospital organizations (Appleby et al., 2011; Improvement, 2018)[6] and in their workforce retention rates (Propper et al., 2021); the NHS workforce has been struggling with retention issues for the latest decade, well before the COVID pandemic (Buchan et al., 2019).

The concept of workforce retention is very close to that of labour supply at extensive margins, with the caveat that retention refers to the decision to stay in or leave the organization where the worker is currently employed and not whether they participate in the labour market or not. Given the loss of human capital and the disruption to services stemming from high turnover, the workforce retention performances of NHS providers are strictly monitored by NHS leaders and policy-makers.[7] Staff engagement, instead, rose to popularity in the psychology and management literature over the last thirty years (Kahn, 1990; Harter et al., 2002; Schaufeli et al., 2002), and it is defined "as a blend of three existing concepts: job satisfaction, commitment to the organization, and extra-role behavior, i.e. the discretionary effort to go beyond the job description"(Schaufeli, 2013). As such, it is potentially important

[6]See also `https://fingertips.phe.org.uk/documents/atlas_2015%20compendium.pdf`
[7]`https://www.england.nhs.uk/looking-after-our-people/`

for employees working in the public sector, and particularly for healthcare workers, whose vocation and task are to preserve and restore patients' health and who are usually considered altruistic or intrinsically motivated in doing their jobs (Ellis and McGuire, 1986). Exactly for this reason, staff engagement has been monitored and used by NHS organizations to design and develop sustainable workforce strategies since 2009[8], and it is a likely driver of workforce retention in the hospital sector. Lastly, complementarities in labour supply and workforce retention are at the core of the production function of complex labour-intensive organizations like hospitals, where the joint use of different skills and competences is needed to reach the common goal of providing effective patient care. Hospital care can be conceived as a multi-input production function setting, where nurses and doctors are predominantly employed as labour input complements (and sometimes, yet rarely, substitutes) for the provision of clinical diagnostics and care to patients. The complementarities of these two occupational groups of hospital workers likely also imply complementarities in their labour supply choices with respect to the hospital organization where they work: for example, a large number of nurses resigning from a hospital during a given year may trigger the resignation of doctors due to worse working conditions and excessive demand pressure on the stayer workers; or vice versa, if the resignations started mainly from the doctors' side.

We cover the following research questions. First, we show how labour supply factors, working conditions and other managerial inputs are related to staff engagement. Second, we investigate whether staff engagement and labour supply complementarities are related to the labour supply extensive margins of nurses and doctors, both at the mean and along the distribution of workforce retention. Third, we analyze whether staff engagement and labour supply complementarities are related to measures of labour supply intensive margins, i.e. hours worked and absences from work. By doing so, we contribute to the economics literature on labour supply (Blundell and MaCurdy, 1999), health care organization (Propper

[8] `https://www.nhsemployers.org/people/staff-engagement`

and Van Reenen, 2010; Propper et al., 2010; Cooper et al., 2011; Gaynor et al., 2013), health care management (Bloom et al., 2015; Tsai et al., 2015; Janke et al., 2019; Bloom et al., 2020), and job satisfaction (Clark and Oswald, 1996; Oswald, 1997).

We measure the retention of NHS hospital nurses and doctors through two variables, the stability index and NHS leaving rates, which are official retention metrics used by the NHS Workforce Statistics to measure the share of hospital workers retained within NHS Trust organizations and the whole NHS.[9] We build a panel of hospital data over ten years and make use of two-way fixed effects, system-GMM and unconditional quantile regressions to evaluate the association of our variables of interest with the labour supply outcomes of nurses and doctors, by running separate regressions for each of the two occupational groups. The potential endogeneity of staff engagement and complementary workers' labour supply with workforce retention, i.e. the instance when poor staff engagement arises in hospitals with a high turnover of many clinical workers, is addressed by employing system-GMM estimators à la Arellano and Bover (1995) and Blundell and Bond (1998). These estimators have been successfully used in the economic literature to remove the endogeneity bias in panel data settings similar to ours, e.g. Griffith et al. (2006) and Levine et al. (2000), especially in cases where external instruments are not obviously available to the researcher. Up to our knowledge, this is the first study in economics to model as we do the relationship among labour supply, staff engagement and labour supply complementarities among workers with different specializations and accounting for the endogeneity due to reverse causality.

System-GMM estimates remove the endogeneity bias due to reverse causality, revealing nurses' engagement-elasticities of retention equal to 0.1 within the hospital and 0.85 within the NHS, but also doctors' elasticities of retention to nurses' retention equal to 0.16 and 0.2, respectively within the hospital and the NHS. Estimates from unconditional quantile regressions (UQR) models à la Firpo et al. (2009) confirm the above findings, with nurses' engagement-elasticities of retention within the NHS as large as 1.4 for providers with low

[9]See e.g. `https://digital.nhs.uk/data-and-information/publications/statistical/nhs-workforce-statistics/october-2021`, accessed 23/02/2022.

retention. Higher engagement is also beneficial to reduce staff absences. We find that engagement and labour supply complementarities work differently for nurses and doctors: nurses retention is not associated with the complementary retention of doctors employed in the same hospital, and doctors' retention is unaffected by their engagement at work. Overall, the system-GMM and UQR estimates provide evidence about a dynamic mechanism of hospital workforce retention that is driven primarily by the engagement and retention of nurses; whereas, with respect to labour supply intensive margins, staff engagement has only an effect on nurses' sickness absence rate (but not on hours worked), and no effect is found for senior doctors' outcomes.

Our findings are informative for economists, policy-makers and healthcare managers active in the design of workforce policies and organizational models focused on increasing job satisfaction, preventing or reducing labour supply shortages, and ultimately improving the efficiency and the sustainability of healthcare systems.

The rest of the paper is organised as follows. Section 2 provides the background to the study, with a review of the related literature and the institutional setting of the English NHS. Section 3, Methods, describes the data and the empirical strategy. Section 4 and 5 present respectively the results and the robustness checks. Section 6 concludes.

2 Background and Institutional Settings

2.1 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 Kings Fund, 2014). The delivery of NHS hospital care to acute and mental health patients is operated

by hospital organizations known as Trust, with about 164 Acute care Trusts and 48 Mental Health (MH) Trusts in 2019. Acute care Trusts are organizations 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. 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 organized 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.[10]

The NHS clinical hospital workforce is mainly made by nurses and midwives, and specialist doctors, also called hospital consultants or senior doctors (as opposed to trainees, who are frequently called junior doctors). Each Trust is tasked with the recruitment of the clinical workers needed to run their healthcare services. Doctors and nurses employed by NHS Trusts are paid according to pay scales defined in a national-level, regulated 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 level. 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.

[10]NHSE and NHSI merged into a single organization in April 2019.

2.2 The annual NHS Staff Survey

Since 2003, staff working in NHS organizations are invited to complete the annual nationwide NHS Staff Survey (NSS), which is one of the largest workforce surveys in the world.[11] The results from the survey guide the monitoring bodies, NHSE and NHSI, to improve staff experience both locally and nationally, and support national assessments and research commissioned by the Department of Health (West et al., 2011; West and Dawson, 2017). The NHS Employers Staff Engagement toolkit defines staff engagement as: "Engaged staff think and act in a positive way about the work they do, the people they work with and the organization that they work in.".[12] This definition of staff engagement is closely related to the one described in occupational psychology literature as a state of mind at and about work where employees show "vigour, dedication and absorption" (Schaufeli et al., 2002; Schaufeli and Bakker, 2004). Staff engagement in the NHS is measured through the NHS Staff Surveys and further discussed in Section 2.3.1. The survey is carried out from late September to early December each year since 2003, and paints a picture of NHS staff's experiences at their job and work lives.[13] The NSS is completed by a large representative sample of NHS employees, with a 46.73% response rate in 2018.[14] The NSS data shows that, in 2018, 24.64% of consultants and 29.78% of registered nurses have often considered leaving their organization, and also that the engagement levels of consultants and nurses who considered leaving their hospital Trust were, on average, lower by 2.30 and 1.76 points respectively than those who did not consider leaving.

[11] See https://www.nhsstaffsurveys.com/about-the-survey/

[12] See https://www.nhsemployers.org/~/media/Employers/Documents/SiteCollectionDocuments/staff-engagement-toolkit.pdf accessed on July 6, 2021.

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

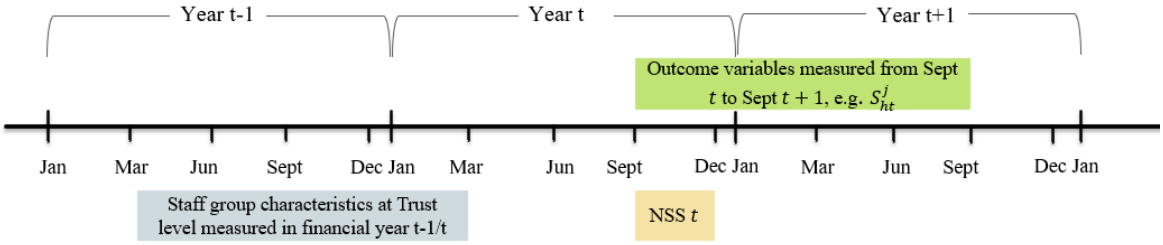
[14] Around 1.07 million NHS employees were invited to take part in the NSS 2018. Table A2 reports statistics of the NSS base sample sizes and response rates at Trust level for the duration of our sample period.

2.3 Data

We construct a panel of NHS Trusts (NHS hospital) in England by collating information from multiple micro-level data sources covering years, September to September, from 2009/10 to 2019/2020. 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 measures of labour supply, and in particular retention, of clinical workers, i.e. nurses and consultants (senior doctors), employed in acute and MH care NHS hospitals.[15] We exclude hospital Trusts that did not have nurses and/or consultants on active assignment during the sample period, and were observed for less than 9 consecutive years in the panel. We also exclude NHS trainee doctors (junior doctors) from the analysis, since in the first years of their training they are rostered at least twice a year to specialties across different NHS organizations.[16]

Figure 1: Data setup



Notes: Outcomes include stability index, NHS leavers 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 since 2003. 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.[17] Figure 1 illustrates

[15] Our access to ESR data on NHS hospital Trusts is limited to nurses and doctors only, and does not include records on administrative and clerical staff such as receptionist and cleaners.

[16] NHS Junior doctors are contractually required to rotate during their training, and also their employment within NHS organizations is temporary and rather erratic until they become consultants (i.e. senior doctors); therefore, their employment spell within a NHS Trust would be a lousy indicator of hospital workforce retention.

[17] 97.4% of the Trusts are observed during the whole panel, i.e. for 10 years.

the structure of the data and the time frames for relevant variables, which we discuss in the following sections.

2.3.1 *Staff engagement, engagement components and work environment variables*

The information to construct the staff engagement scores come from the individual-level NHS staff surveys (NSS) from 2009 to 2018, which we accessed under a license provided by NHSE. The use of the individual-level NSS data helps us preventing measurement error bias in our analysis, as it allows us to aggregate the NSS variables (i.e. the engagement score, the engagement score components and other work environment variables that are associated with engagement and used in Section 3.1) at Trust-level exactly for the two workers groups of interest, i.e. nurses and senior doctors.[18]

To compute the engagement score, we follow the official methodology used by the NHS and developed by the NSS Survey Coordination centre.[19] 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 how they feel while they work. Advocacy is related to staff's view about their organization as a place to work, to receive healthcare, and about the quality of care provided to patients. The inclusion domain of engagement entails staff's views on their role in decision making in their organization, and the extent of their influence in making changes happen. Each component is measured by three separate questionnaire items (see Table A1), and the weighted average of these items yields the score for an engagement component. The overall staff engagement of an employee is the weighted average of these three component scores. We aggregate individual-level NSS data to obtain the overall engagement score, E^j_{ht},

[18] Publicly available NSS data report only aggregated data for nurses and midwives together, and junior and senior doctors together.

[19] The technical documents that outline the engagement score computations for 2017 and 2018 NSS can be found online at `https://www.nhsstaffsurveys.com/results/results-archive/`.

for staff groups j at Trust h in survey year t. The overall engagement scores range from 0 to 10, with a higher score indicating higher levels of staff engagement.

2.3.2 *Measures of workforce retention*

We employ two of the official measures adopted by the NHS Workforce Statistics unit to describe workforce retention outputs by staff group, nurses and senior doctors, at Trust level: the stability index (rate) and the rate of leaving the NHS. Both measures capture the retention of existing human capital within the organization, as well as within the whole NHS, over a specified time span. We calculate the stability indices from the employee-level ESR, which is an administrative payroll data 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[20] 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.[21] Our computation of the stability indices $S^j_{ht\tau}$ is made by tracking employee at individual level: for example, if Trust A had 100 active nurses in September 2013 and 90 of the same nurses

[20] We define an employment spell as "active" in any of the following cases: Active Assignments, Maternity, Internal Secondment and Acting Up (i.e. a worker moved into a higher pay band to fill a post on a temporary basis).

[21] We track the organizational 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 the information on staff transfers from Data Quality Annex 2020, published by NHS Digital, to adjust the stability indices for staff transfers by excluding from the stability index calculation the staff who switched from a given NHS organization due to an externally imposed staff transfer. This adjustment can be done only for NHS organizations with employee records in the ESR. Instead, for staff transfers documented in the NHS Digital Data Quality Annex 2020 but between NHS organizations and other healthcare organizations without records in the ESR, the stability index was imputed as an average between the two endpoint stability index rates that were unaffected by the staff transfer.

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%.

An alternative way to measure retention is the turnover rate, which is the share of staff group j actively employed in Trust h at time t who left the active post or switched to another staff group between t and $t+1$, i.e. $TU^j_{ht\tau} = 100 - S^j_{ht\tau}$. By looking into turnover, we can distinguish between those who leave their organization but remain within the NHS hospital sector, "churns" ($CH^j_{ht\tau}$), and those who leave the NHS, "NHS leavers" ($L^j_{ht\tau}$), and $TU^j_{ht\tau} = CH^j_{ht\tau} + L^j_{ht\tau}$. To define churns and NHS-leavers, we track the employees who left their NHS Trust by $t+1$ until $t+(1+0.5)$, i.e. for the six months following the termination of an employment spells in the ESR data. If they reappear in any NHS hospital organization covered by the ESR, we classify them as churns; if not, we assume they have left the NHS hospital sector.[22]

We compute stability indices and rates of leaving the NHS hospital sector from September of year t to September of year $t+1$ as one of our key independent variables of interest, staff engagement, is measured on a yearly basis from September to December of the same calendar year, as shown in Figure 1.[23] For the rest of the paper we set $\tau = 12$ months, unless stated otherwise, thus we drop τ from the notation.

2.3.3 *Absences and hours of work*

Stability and leavers rates are measures of the medium term labour supply extensive margins at Trust level. But hospital workers can vary their short-term labour supply also by increasing their absences or reducing hours worked. Already in 2019, before the COVID

[22]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 workers outflows imply a loss in human capital that it is costly to replenish, therefore for brevity's sake we refer to "NHS leaving rates" instead of "NHS hospitals leaving rates".

[23]The staff eligible to respond to the NSS is drawn from staff lists on 1st of September, so measuring the labour supply 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 rates of leaving the NHS.

pandemic, the NHS was characterized by a 4.1% sickness absence rate[24], which is higher than the average 2% sickness absence rate in other sectors of the UK economy economy[25]. Most worryingly, the year-on-year sickness absence rate has been trending upward since 2011, while trending downwards for the overall UK economy. The predominant reason for sick leave in the NHS is related to mental health issues like anxiety, stress and depression[26], which is not difficult to relate to work pressures. High absence rates may be negative signals of organizational health and wellbeing. The labour economics literature has also shown that peers absence affect individual absenteeism behaviour (Ichino and Maggi, 2000; Hesselius et al., 2009), and higher absence rate is associated with negative employment outcomes (Chadi and Goerke, 2018). Higher absence rates also increase the workload on the non-sick staff, who need to shoulder the responsibilities of absent colleagues, increasing the likelihood of burnout and turnover. While sickness absence would naturally be present due to illness, particularly in healthcare settings, absences due to other reasons may be mitigated by better organizational management and through increased staff engagement. For this reason, we also analyse the associations of staff engagement and occupational complementarities with work absences related to sickness and other causes, as a way to proxy the response of short term staff labour supply to our main variables of interest.

We use individual-level ESR data to construct absence rates by occupation at Trust level, and restrict our attention to staff on active assignment.[27] The absence rates for each staff group in each Trust are aggregated by month, and the average absence rates by staff and Trust are defined over the 12 months from September t to August $t+1$.

The sickness rate, IL_{ht}^{j}, is the average percentage days lost due to sickness in Trust h by staff group j in a year t from September to September, while the rate of days lost, LA_{ht}^{j}, are absences due to reasons other than sickness which may include parental leaves, special

[24] https://www.kingsfund.org.uk/blog/2019/10/nhs-sickness-absence

[25] https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/labourproductivity/articles/sicknessabsenceinthelabourmarket/2020

[26] https://www.kingsfund.org.uk/blog/2019/10/nhs-sickness-absence

[27] The ESR records absences as work-time equivalent (WTE), which we convert into calendar days.

leave, annual leave and study leave.

The information on the monthly total hours of paid work also comes from the individual-level ESR data. We use positive monthly work hours for nurses and senior doctors who are on a permanent contract and work full-time at a hospital organization. We calculate the average monthly hours, H_{ht}^{j} worked between September t to August $t+1$ (inclusive) for each staff group j working at Trust h at time t.

2.3.4 *Outside wages for nurses and doctors*

We use data at small area level from the Annual Survey of Hours and Earnings (ASHE) from 2009 to 2019 compute the outside wage for a given NHS hospital organization, with a similar methodology to that described in Propper and Van Reenen (2010). The outside wage is defined as the mean yearly wage received by non-manual workers working in the same catchment area of 60 kilometres around the hospital Trust headquarters, for each of the two occupational groups (i.e. nurses and senior doctors).[28]

2.3.5 *Other controls*

We also control for aggregated demographic and job characteristics of staff groups to account for the differences in workforce compositions across hospital Trusts. The average characteristics aggregated by staff group, Trust and financial year come from the monthly ESR 2009-2019.[29] The demographic controls for staff group j, include percentage of female staff, mean age, percentage of British, European and Overseas staff, and the percentage of ethnic minority staff defined as belonging to any ethnic background except white.

The job characteristics used as controls in the main analysis include: the average non-zero hours worked by full-time staff and gender pay gap, proxied by the ratio of full-time male to female pay, from the ESR; and also two proxies for the work environment from

[28] The outside wage of nurses is computed only using female workers, as in Propper and Van Reenen (2010), since 89% of nurses in the English NHS were female, as of 2018; see `https://digital.nhs.uk/news/2018/narrowing-of-nhs-gender-divide-but-men-still-the-majority-in-senior-roles`

[29] As shown in Figure 1, $t-1$ refers to the previous financial year.

individual-level NSS 2009-2018: the percentages of staff working at least 11 unpaid hours in a week and who experienced discrimination in the last 12 months. These variables have been chosen as confounders as they are a minimal set of plausible factors that could affect both labour supply and engagement of hospital workers.

As a supply-side factor, we use the number of competitor hospitals within a 30 kilometres radius, which is computed from straight line distances across NHS Trusts, non-NHS organizations and independent service providers using the historical NHS Organization Data Service archives and ONS postcode look-up[30], matched to the NHS organizations in the ESR.

3 Methods

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

In the first instance, before the main analysis, we investigate the determinants of staff engagement at hospital Trust level, separately for nurses and senior doctors. This allows us to establish how much engagement is related to managerial inputs and work environment conditions. The set of factors that determine engagement is grouped by Bailey et al. (2017) into five categories, based on a systematic review of 155 studies: individual psychological states, aspects of job design, perceived leadership and management, perceptions of organization and organizational interventions. We proxy these determinants using variables included in the NSS data but excluded from the items used to compute the engagement score. We estimate, separately for nurses and senior doctors, fixed-effects linear regressions of the following equation

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

[30] https://digital.nhs.uk/services/organisation-data-service/file-downloads

where λ_t and μ_h are time and hospital Trust fixed effects, the outcome variable E^j_{ht} is the engagement specific by staff group and Trust, and all covariates are measured at the hospital organization level. X includes demographic composition of staff group j in Trust h such as share of staff by age categories[31], gender and ethnic minority status. JOB contains the share of staff by job experience measured by the time spent in their current role, and the share of full-time workers contracted for more than 30 hours per week. W contains workplace characteristics such as the share of employees who have experienced bullying and share of those 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; believe that the Trust has a fair career progression. 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 staff in important decisions, which is our proxy variable for perceived leadership.

We include the share of staff pleased with 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), and the variable RES captures this as the worker's satisfaction with having adequate materials and enough staff at Trust to do their job. We also include the NSS response rates from each Trust, RR, to test whether the response rates have significant associations with engagement levels in hospital organizations.

3.2 Baseline empirical strategy

Without any loss of generality, we restrict our attention to nurses and senior doctors, the two occupational groups constituting the majority of the hospital clinical workforce, in the NHS and other healthcare systems, and providing care to patients. We assume the possible

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

existence of complementarities in the labour supplied by these two groups of workers to run hospital services, and that there is limited scope for nurses and senior doctors to substitutes in their daily tasks.[32] The aggregate labour supply of workers employed in job role j at the hospital organization h, LS_h^j, can thus be characterized as

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

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, and the labour supply of complementary workers $-j$, LS_h^{-j}; and some of the work environment characteristics examined in Section 3.1 and related to the organizational and managerial culture, Z_h^j,, e.g. support to employees and colleagues, discrimination or unfair treatment, presenteeism and managerial effort to coordinate effectively with the clinicians treating the patients.

The definition of LS_h^j in Equation 2 is kept general to encompass both labour supply at extensive and intensive margins. Our prior expectation is for both types of margins to be non-decreasing in the own group engagement and the labour supply of complementary workers. The latter is potentially a more important factor for the retention of nurses and senior doctors within a hospital Trust or the NHS (extensive margins), rather than their work hours or absences (intensive margins), since a fall in the retention of experienced and trusted co-workers may decrease productivity and generate work stress and pressure for the stayers in the medium term.

In a panel data setting applied to the English NHS, the empirical counterpart of Equation 2 is represented by the following linear specification with year and hospital Trust fixed effects

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

[32] We rule out perfect substitutability, as it is unrealistic to describe the heterogeneous types of hospital workers (e.g. doctors, nurses, receptionists, cleaners) as substitutes.

where t is time, and for nurses, senior doctors are the complementary group, and vice versa.

The labour supply measures that we use for workforce retention are the stability index and the rate of leavers from the NHS. We also use short term labour supply measures such as sickness absences and non-sickness days of leave; and finally we use total monthly hours worked as a measure of labour supply at intensive margin. In the specification of Equation 3 we omit any term related to monetary factors M_h^j, as nurses' and doctors' pay is regulated at the national level, thus with little to no scope for variation across hospitals, and its organization-level value will be captured by the Trust fixed effects. On the other hand, we include a vector X_{ht} of staff demographics, 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 labour supply of clinical workers. The time-varying labour supply characteristics at Trust level from the previous financial year, Z_{ht}^j, include confounders that can be correlated with either the engagement or the labour supply of group j: the average hours worked[33]; a gender wage gap proxy (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); 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. μ_h and λ_t are Trust and time fixed effects respectively, and ε_{ht} being the error term.

The main methodological challenge is to produce reliable estimates of the association of the labour supply outcome with the staff engagement of the same group of workers and the labour supply input of the complementary group of workers, as there may be some hospital-level unobserved factors affecting both workforce engagement and retention. If such unobservable confounding factors are time-invariant, Equation 3 will control for these through μ_h and λ_t , and the parameters β_1 and β_2 will not be biased.

However, hospital workers' labour supply may also depend on past realisations and

[33]This control variable is excluded from models where the outcome measure is total monthly hours of work.

shocks, which may be governed by a dynamic, time-varying process. This is particularly true for workforce retention outcomes, i.e. stability and NHS leaving rate, as they can also be thought as forms of human capital, knowledge and expertise accumulation within a hospital organization (Trust). In this case, the concern is that both E^j_{ht} and LS^{-j}_{ht} might be endogenous for the outcome LS^j_{ht} due to reverse causality, e.g. lower nurse engagement stemming from higher nursing staff turnover. The severity of this issue in our analysis is likely attenuated because, as shown in Figure 1, the measure of staff engagement is retrospective, i.e. it is measured in t but related to the 12 months before t, while the labour supply measures we use as 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 staff engagement and hospital workforce retention are persistent variables, so residual concerns of reverse causality might still occur despite our data setup. For this reason, we turn to our preferred model,

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

to investigate our relationship of interest.

The estimation of Equation 4 is more complicated than Equation 3 due to the inclusion of both lagged dependent variable and (Trust) fixed effects. A naive OLS estimation by first or mean differencing would lead to bias in the coefficient of the lagged outcome, and thus possibly also lead to biased estimates of the two coefficients of interest, engagement and complementary labour supply (Nickell, 1981).[34] Additionally, some of the explanatory variables of the specification are most likely not strictly exogenous but only predetermined, thus correlated with future error terms but uncorrelated with past and current error terms.

To overcome the time-varying endogeneity bias, we employ a system-GMM model approach (Arellano and Bover, 1995; Blundell and Bond, 1998) and use lagged differences

[34]This is because of the residual correlation between the demeaned lagged dependent variable and the demeaned error term, which is more problematic the shorter the length of the panel (in our case, a bias equal to $\frac{1}{10}$, which is not huge).

and levels of the variables of interest as internal instruments to estimate Equation 4. In particular, we treat S^j_{ht-1}, E^j_{ht} and S^{-j}_{ht} as endogenous, the X_{ht} variables related to hospital labour supply as predetermined, and the hospital demographic characteristics (from previous financial year) and time effects as exogenous.

Arellano-Bover/Blundell-Bond System GMM estimation of Equation 4 is appealing in our setting for a number of reasons. First of all, lagged values of the engagement score and labour supply variables are likely to be strongly correlated with current values, as these variables are rather stationary and persistent from one year to the next, thus making them strong instruments for the variables in levels that can be used in a system GMM.

Second, provided that a sufficient time lag is allowed for, the lagged values of the engagement and labour supply variables are likely plausibly exogenous instrumental variables for their current values. This is mostly due to the fact that the engagement and labour supply variables that we use are derived from the aggregation at hospital level of individual workers' labour supply choices and engagement assessment. It can be easily argued that the labour supply and the engagement of a single hospital worker is more elastic to a time-varying random shock, while the aggregate labour supply and engagement of the workers employed by a given hospital organization is less sensitive to such idiosyncratic shocks, unless these time-varying shocks are driven by a common cause (e.g. an epidemic event like COVID-19).[35]

Our setting also differs from the case of regressions with earnings as a dependent variable, where unexpected past earnings of individual workers conflate in the error term: labour supply variables *at hospital level* are persistent, but their unexpected components are unlikely to be as correlated over time as they are at the worker's level, as these unexpected components result from the aggregation of positive and negative labour supply shocks of all hospital workers. It follows that sufficiently deep lags, from $t-2$ onwards, should make valid

[35] Our analysis focuses on the financial years 2009/10-2018/19, a period when huge time-varying shocks like the COVID-19 pandemic were absent. It also exploits a sample of NHS Trusts in England that did not close or open due to mergers and acquisitions processes, making it more unlikely that common shocks can affect hospital workers' labour supply and engagement. In our sample only 8 Trusts, out of 190, acquired another organization.

instruments for our purpose. To ascertain this, in line with current practice (Angrist and Pischke, 2008), we perform a serial autocorrelation test of the regression errors.

Moreover, the system-GMM approach has better finite sample properties than difference-GMM estimates (Blundell and Bond, 1998; Cameron and Trivedi, 2005). Finally, under the strong assumption that the internal instruments removed *all* the time-varying endogeneity bias in the estimates of coefficients β_0, β_1 and β_2, we could interpret the associations of labour supply with engagement and the complementary labour supply input as causal estimates.[36]

We estimate system GMM using forward orthogonal deviations (FOD), i.e. subtracting the forward mean, to eliminate the hospital organization fixed effects, instead of the first-differences transformation. The advantage of using FOD is that it uses more information than first differencing, which may be important for unbalanced panels like ours.[37] We use backward orthogonal deviations as instruments, i.e. replacing instruments with their deviations from past means, for the FOD transformed equation (Hayakawa et al., 2009). And we use the lagged differences as instruments for the level equation, which creates the system GMM, exploiting a two-step approach.[38] Both for the levels and the differences equations, we employ the first three lags of the engagement score, the lagged labour supply outcomes and the complementary workers; labour supply input as instruments and other control variables instrument themselves. Finally, we adjust the standard errors using the Windmeijer (2005) finite-sample correction.

[36] Ideally we would estimate the system GMM including also external instruments as additional sources of exogenous variation. However, given the inter-relatedness of the variables at play in our setting, it is quite unlikely to find variables that are both time-varying and plausible as exogenous shifters for the own group engagement and the labour supply of the complementary workers.

[37] With balanced panel FOD and first-differencing transformations are identical depending on the weighting matrix and all available GMM instruments used (Arellano and Bover, 1995).

[38] The system-GMM esitmation was done 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.

3.3 Fixed-effects unconditional quantile regressions

We also investigate the effects of staff engagement and job complementarities on labour supply along the labour supply distribution. To do so, we estimate Unconditional Quantile Regressions (UQR) as proposed by Firpo et al. (2009), which is preferable to a conditional quantile approach (Koenker and Bassett Jr, 1978) as UQR estimates of the parameters of interest have a direct policy interpretation.[39] Indeed, the inclusion of covariates may significantly reshape the distribution of our labour supply measures LS (Borah and Basu 2013). Moreover, by splitting the outcomes of interest according to unconditional quantiles, the UQR estimates are likely more robust than fixed-effects linear regressions to the aforementioned reverse causality bias issues, and so they provide an alternative method to validate the system-GMM estimates. The UQR model specification therefore is:

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

where $R_\tau(LS^j_{ht})$ is the Recentered Influence Function (RIF) for the τ-unconditonal quantile (denoted by q_τ) of the labour supply measure LS for staff group j. It is computed as $R_\tau(LS^j_{ht}) = q_\tau + (\tau - 1[LS^j_{ht} \leq q_\tau])/f_{LS}(q_\tau)$, where $f_{LS}(q_\tau)$ 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. $\beta_{1\tau}$ ($\beta_{2\tau}$) identifies the association of staff j engagement (staff $-j$ retention) with staff j retention at the τ-unconditonal quantile, where τ can be the 10^{th}, 25^{th}, 50^{th}, 75^{th} or the 90^{th} unconditional quantile. The clustered standard errors are at hospital organization level, and computed via bootstrapping with 1,000 replications.

[39] Conditional quantile regressions also involve additional strong assumptions in panel frameworks, with fixed effects that must remain constant across quantiles (see Canay (2011)).

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 organizations) and within (same hospitals over time) standard deviations.

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

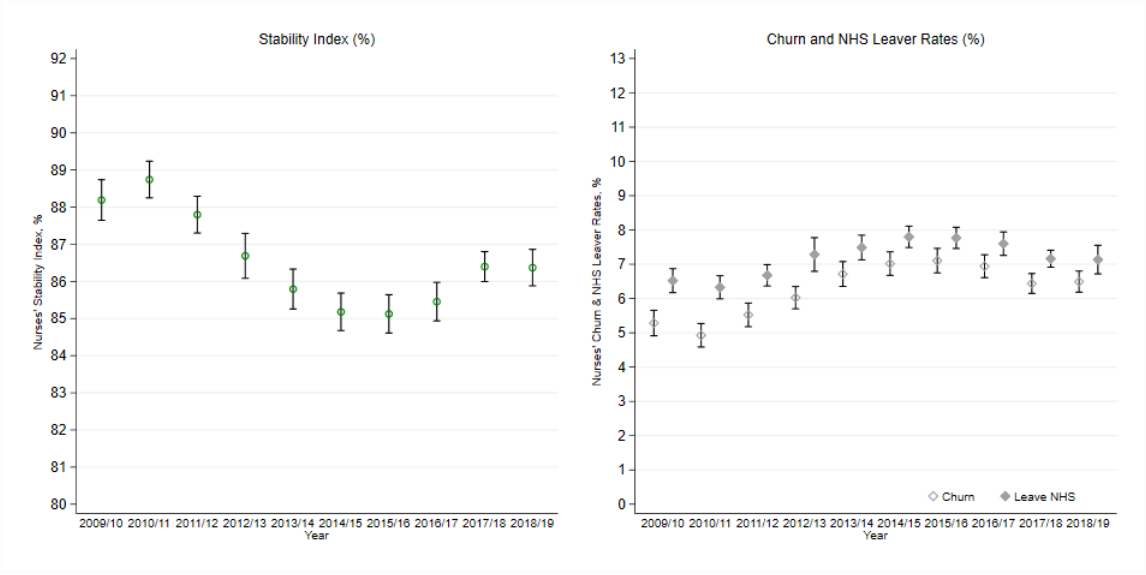
	Nurses				Senior Doctors			
	Mean	Standard deviation			Mean	Standard deviation		
		Overall	Between	Within		Overall	Between	Within
Outcome variables								
Stability index (rate), %	86.397	3.730	2.842	2.425	87.602	4.839	3.248	3.607
Leaving the NHS rate, %	7.249	2.502	1.839	1.702	6.407	3.317	2.190	2.502
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 providers within 30 km	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.

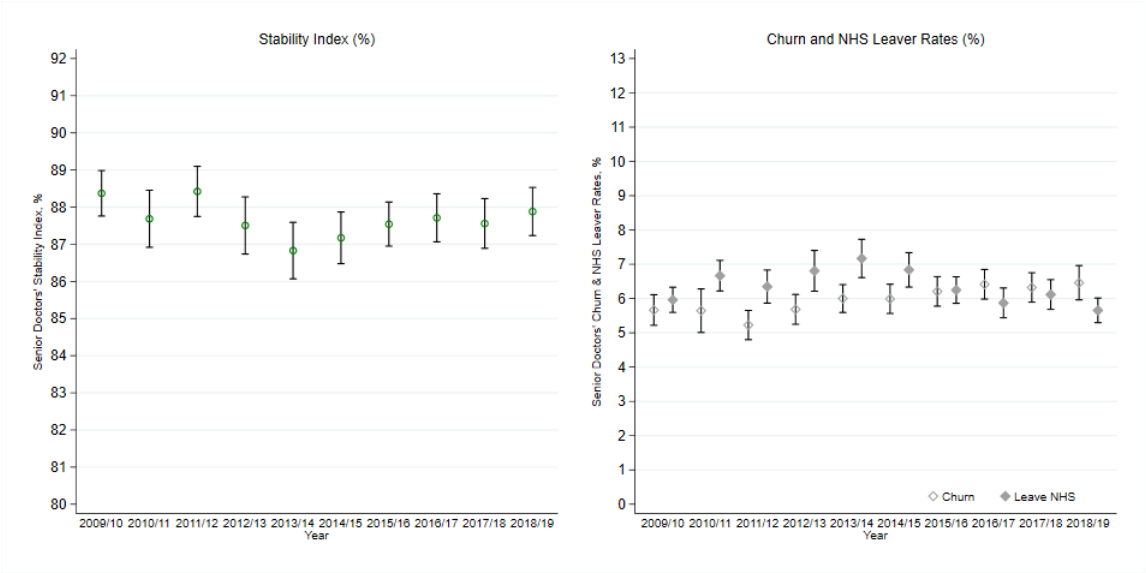
Figure 2 shows the evolution of the stability and turnover (i.e. churn plus NHS leaving rates) rates of nurses and senior doctors from 2009/10 to 2018/19: on average 86.57% of

nurses and 87.67% of senior doctors remain in their hospital organization each year.[40]

Figure 2: Stability, churn and leaving rates, by year



(a) Nurses



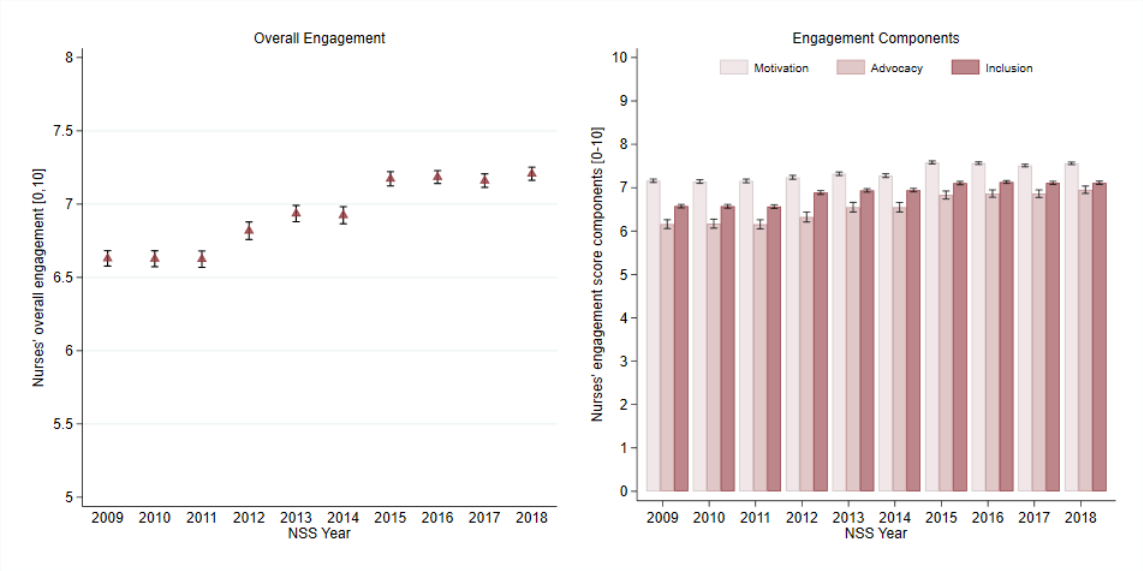
(b) Senior Doctors

Notes: Authors' computations using the Electronic Staff Records (ESR) with 95% confidence bands around the mean.

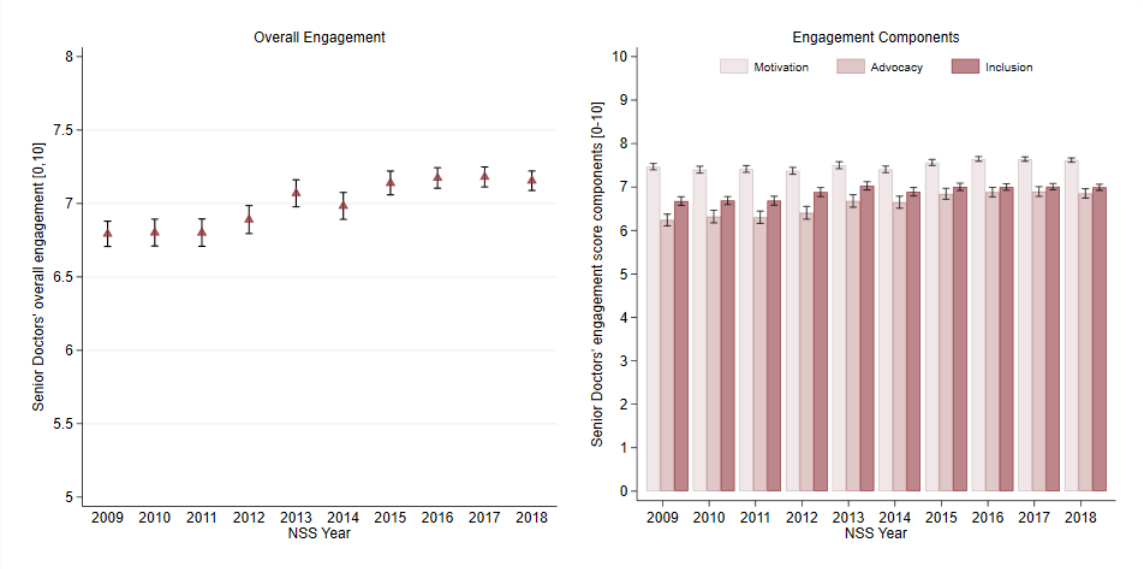
Nurses' retention decreased in the first half of our sample period, but there was a signifi-

[40]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.

Figure 3: Overall engagement and engagement components over time



(a) Nurses



(b) Senior Doctors

Notes: Authors' computations using the NHS Staff Surveys (NSS) 2009-2018 with 95% confidence bands around the mean.

cant increase in nurses' stability index from 2017 onward and a drop in the variance of nurses stability index across Trusts (see panel (a) Figure A1). The turnover at the beginning of the decade was mostly driven by nurses' leaving the NHS rather than their churn across NHS Trusts. 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 panel (b) in Figure A1). The pattern of senior doctors' turnover has also changed over time, with more senior doctors moving across Trusts than leaving the NHS.

Between 2009 and 2018, the average engagement of nurses stood at 7, and at 6.93 out of 10 for senior doctors. The levels of engagement for both staff groups has increased over time as shown in panels (a) and (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 A1). Compared to nurses, senior doctors had higher between variance in engagement (see panel (b) in Figure A1), but this may reflect the smaller sample size of senior doctors in NSS.[41] Both nurses' and senior doctors' motivation has been higher than advocacy and inclusion components of engagement, with a gradual increase in nurses' advocacy levels from early 2010s to 2018.

Finally, Figure A2 presents the patterns in the work absences rates and monthly hours worked. Nurses' absence rate is higher than doctors' ones, not only because of sickness (4.5% on average, almost three times senior doctors' sickness rate, 1.5%), but also for absences unrelated to sickness. Most nurses are female, and these patterns are consistent with gender differences in absenteeism (Bridges and Mumford, 2001) and work-related pressures, e.g. in the NSS 2018 sample, 57.7% of nurses and 40.3% of senior doctors working in the NHS declared that they went to work despite feeling unwell. With respect to paid hours worked, nurses work for 10 to 12 hours longer than hospital consultants, for an average of 163 monthly hours.

[41] The distribution of the engagement score also changes over time, as shown in panel (b) of Figures A3 and A4. The decrease in the variation of engagement in both staff groups from 2015 onward can also be due to changes in the NSS sampling method. 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). As staff numbers sampled and invited to fill the NSS questionnaire increased, this has likely reduced response variation, especially from smaller hospital organizations. Table A2 reports the NSS base samples and response rates from 2009 to 2018.

4.2 Associations of work environment conditions and managerial inputs with staff engagement

Table 2 presents the determinants of overall engagement for nurses and senior doctors.[42]

We find that positive workplace culture, leadership and resources are positively associated with engagement. One of the key predictors of engagement for both groups is the perception of positive leadership that involves staff into important decisions. Self-realisation at work, measured by the share of staff who have opportunities to use their skills has also significant positive associations with engagement. As expected, overall engagement of both staff groups are lower in Trusts where the share of staff who were exposed to negative workplace environment such as bullying, discrimination and work stress. Even after controlling for other factors, both bullying and discrimination both have a negative association with senior doctors' engagement, whereas the relationship between nurses' engagement and discrimination weakens when we control for other job aspects. When resources are controlled for, the negative association of presenteeism drops both for nurses and senior doctors, and presenteeism is no longer statistically significant as a determinant for senior doctors' engagement. These findings suggest that the workplace culture and the leadership play important roles in determining engagement levels of clinical workforce, and can foster engagement by improving on these factors.

Our analysis suggests that the same work environment factors present heterogeneous associations with the overall staff engagement of nurses' and senior doctors'. For example, while a higher share of full-time nursing staff is associated with higher nursing engagement at Trust level, we do not find the same association for senior doctors. Likewise, while the share of nurses who are satisfied with their pay plays a role in their engagement, we do not find statistically significant associations with senior doctors' pay satisfaction and engagement (see Table 2 column (DIII)).

[42]The mean and standard deviation of the variables used in this analysis are reported in Table A3.

Table 2: Working conditions, managerial inputs and staff engagement: fixed-effects regressions estimates

	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.

Most importantly, the results from this analysis on the determinants of staff engagement also support indirectly the main results on the effects on workforce retention outcomes, as we see that senior doctors' engagements is positively associated with the perception of having enough co-workers to do their job, whereas we do not find a statistically significant association between this variable and nurses' overall staff engagement. Finally, these estimates also reassure us that engagement scores are not driven by NSS response rates, as the associations are never statistically significant in the full model (columns 3 and 6).

4.3 Estimates on labour supply extensive margins

Table 3 reports OLS and FE estimates of Equation 3, separately for nurses (columns 1-4) and senior doctors (columns 5-8).

Nurses' engagement is positively associated with both retention outcomes, i.e. stability and leaving the NHS rates. On average, a unit increase in nurses' engagement score is associated with a 1.12 percentage-points (pp) increase in their stability index (column 2 in Table 3). The engagement score is measured on a scale between 0 and 10, so a unit increase in engagement is quite large and perhaps not attainable in the short-run, while a standard deviation increase is more likely. A one-within-standard-deviation (0.302) increase in nurses' engagement score corresponds to an increase in their stability index by 0.34 pp. Similarly, a one-within-standard-deviation increase in nurses' engagement score corresponds to a 0.2 pp reduction in their NHS-leavers' rate. Table 3 also shows that Nurses' retention is influenced by the retention of their complementary staff group, i.e. senior doctors. On average, a 5-percentage-point increase in senior doctors' stability rate[43] is associated with 0.19pp increase in nurses' retention measured in terms of stability. Senior doctors have even stronger impact on nurses' NHS-leaving rate (column 4 in Table 3). A one-within-standard-deviation (2.5pp) increase in senior doctors' leaving rate increases nurses' NHS-leavers' rates by 0.22pp, on average.

[43] A 5pp increase in senior doctors' stability rate is around 1.5 times of a within-standard-deviation (3.607).

Table 3: Association of workforce retention with staff engagement and job complementarities: OLS and FE estimates.

	Nurses				**Senior Doctors**			
	Stability rate		**Leaving the NHS rate**		**Stability rate**		**Leaving the NHS rate**	
	OLS	FE	OLS	FE	OLS	FE	OLS	FE
Own group overall engagement score	-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 group 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)
Trust-staff group characteristics								
Share of female (%)	0.040	0.132	-0.103***	-0.176	-0.109***	-0.090**	0.080***	0.041
	(0.025)	(0.118)	(0.021)	(0.127)	(0.026)	(0.045)	(0.015)	(0.044)
Average age	-0.089	0.162	0.213***	-0.123	0.768***	1.250***	-0.117	-0.121
	(0.083)	(0.183)	(0.049)	(0.163)	(0.282)	(0.325)	(0.222)	(0.203)
Share of British staff (%)	0.464**	0.753***	-0.298***	-0.508**	0.665***	0.485***	-0.440***	-0.323***
	(0.190)	(0.279)	(0.107)	(0.221)	(0.139)	(0.144)	(0.089)	(0.120)
Share of European staff (%)	0.263	0.880***	-0.180	-0.567**	0.598***	0.542***	-0.445***	-0.405***
	(0.196)	(0.297)	(0.109)	(0.240)	(0.137)	(0.161)	(0.088)	(0.129)
Share of Overseas staff (%)	0.474**	0.844**	-0.316***	-0.500*	0.637***	0.258	-0.429***	-0.244*
	(0.203)	(0.326)	(0.114)	(0.263)	(0.142)	(0.164)	(0.093)	(0.136)
Share of ethnic minority (BAME) staff (%)	0.001	0.093	-0.032	-0.104*	-0.084***	0.075	0.035**	-0.090**
	(0.029)	(0.065)	(0.027)	(0.054)	(0.021)	(0.059)	(0.015)	(0.041)
Average hours worked (for hours > 0)	0.374***	0.008	-0.098*	0.026	-0.064*	-0.033	0.025	0.030
	(0.084)	(0.066)	(0.059)	(0.039)	(0.036)	(0.031)	(0.028)	(0.023)
Gender Pay Gap (male to female ratio)	2.177	5.597***	-3.290***	-5.194***	-0.525	0.730	-0.458	0.511
	(1.962)	(1.770)	(0.939)	(1.408)	(2.186)	(2.127)	(1.869)	(1.763)
Share of staff discriminated by managers or colleagues (%)	-0.073*	-0.019	0.097*	0.048	0.011	0.029	-0.013	-0.012
	(0.040)	(0.025)	(0.058)	(0.038)	(0.020)	(0.019)	(0.013)	(0.012)
Share of staff worked at least 11 hours unpaid hours (%)	-0.152***	0.036	0.099***	-0.017	0.012	-0.012	-0.007	-0.001
	(0.044)	(0.028)	(0.028)	(0.024)	(0.015)	(0.016)	(0.010)	(0.011)
Number of other providers within 30 km	-0.037***	-0.002	0.015	0.015	0.037***	0.030	-0.036***	-0.026
	(0.014)	(0.027)	(0.012)	(0.017)	(0.012)	(0.043)	(0.006)	(0.030)
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

Notes: There are 190 Trusts, and 1,704 Trust-year observations for nurses and 1,701 Trust-year observations for senior doctors. Standard errors are clustered at Trust level. *p<0.1; **p<0.05; ***p<0.01.

We do not find a significant relationship between senior doctor's engagement and their retention. Yet, there is a strong association between senior doctors' and nurses' retention. This job-complementary relationship is larger for senior doctors than for nurses (row 2 in Table 3); a 5 percentage points increase in nurses' stability (NHS leaving) rate is associated with a 0.76pp (0.96pp) increase in senior doctors' stability (NHS leaving) rate.

As discussed in Section 3.2, we estimate system-GMM models to limit the potential endogeneity bias in the estimates of interest due to: the reverse causality between retention and engagement; the simultaneity of the workforce retention of nurses and doctors; the time-varying selectivity in the measurement of the engagement score, if the variation in the NSS response rate is driven by the relationship between staff engagement and retention. Table 4 reports results from the system-GMM estimates of Equation 4 for nurses (columns 1-2) and senior doctors (columns 3-4).

Table 4: Association of staff engagement and labour supply complementarities on workforce retention: system GMM estimates.

	Nurses		**Senior Doctors**	
	Stability rate	**Leaving the NHS rate**	**Stability rate**	**Leaving the NHS rate**
Own group overall engagement score	1.284**	-0.829**	0.227	-0.053
	(0.498)	(0.340)	(0.298)	(0.224)
Complementary group 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: There are 190 Trusts, and 1,704 Trust-year observations for nurses and 1,701 Trust-year observations for senior doctors. The model specifications are the same as in Table 3 with an addition of the lagged retention measure. Standard errors are clustered at Trust level with Windmeijer (2005) small sample adjustment. *p<0.1; **p<0.05; ***p<0.01.

We document a persistence in clinical workforce's retention; the lagged stability index is positive and significant at 1% level in both columns (1) and (3). However, such persistence is weaker for nurses' leaving rate, and not significantly different from zero for senior doctors. The autocorrelation tests suggest that the second lags of our endogenous variables, i.e. lagged retention, engagement and contemporaneous complementary staff group's retention, are appropriate instruments; and the Hansen overidentification test cannot reject the null.

The coefficient of engagement remains positive and significant for nurses, with the estimated impact that is very similar to the FE models presented in Table 3. The system-GMM

coefficient of nurses' retention on senior doctors' retention becomes instead non-statistically significant (cfr. columns 1 and 2 with columns 2 and 4 of Table 3). However, we confirm a strong and significant association of nurses' retention with senior doctors' stability and NHS leaving rates.[44]

We also investigate whether the engagement score components have heterogeneous impacts on workforce retention by replacing the overall engagement scores with motivation, advocacy and inclusion scores and re-estimating the system-GMM model from Equation 4.

Table 5: Association of staff engagement components and staff complementarities on retention: system GMM.

	Stability rate			**Leaving the NHS 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 group 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 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)
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 group 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)
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 Trust-year observations for nurses and 1,701 Trust-year observations for senior doctors. Standard errors are clustered at Trust level with Windmeijer (2005) small sample adjustment. The model specifications are the same as in Table 4 except for engagement components. *p<0.1; **p<0.05; ***p<0.01.

Both nurses and senior doctors present a positive relationship between advocacy and the

[44]Similar results, available from the authors upon request, are obtained when the vectors of control covariates X_{ht}^{j} and Z_{ht}^{j} are omitted from the specification of Equation 4.

stability index (see column 2 in Table 5). Although senior doctors' engagement does not affect retention, a high level of senior doctors' advocacy (i.e. holding a high regard for the quality of patient care and as a workplace) for their hospital organization improves their retention. Furthermore, the system-GMM estimates of the association of motivation (for nurses) and inclusion (for senior doctors) with their retention outcomes are not significant, differently from the OLS fixed-effects estimates in Table A4.

Table 6 reports results for Equation 5, which investigates the heterogeneity of the associations of interest along the unconditional distribution of staff retention. Panel (a) indicates that the correlation of nurses' engagement and retention is more pronounced at the bottom (top) half of the stability index (leaving the NHS) distribution. In particular, the engagement coefficient at the 25^{th} quintile is 1.79, which is about 30% larger than the analogous system-GMM coefficient (1.284). Also, the largest estimate of the association between nurses' engagement and their NHS leaving rate is at the top decile of the distribution of NHS leaving rate across Trust (-1.96, compared to the -0.83 system-GMM coefficient). The distribution of nurses' retention seems also rather unaffected by the retention of senior doctors, with the only exception at the 75^{th} quintile of the NHS leaving rate distribution.

In line with the OLS and system-GMM estimates, we do not find significant associations of the engagement score with senior doctors' retention outcomes along the entire distributions. However, the complementary labour supply 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 and the 50^{th}, 75^{th} and 90^{th} quintiles of the NHS leaving rate.

Overall, the unconditional quantile regression estimates are more in line with the findings from the system-GMM than the model with Trust fixed effects shown in Table 3.

Table 6: Unconditional quantile regression estimates on labour supply extensive margins

	Stability rate					Leaving the NHS rate				
	Q10	**Q25**	**Q50**	**Q75**	**Q90**	**Q10**	**Q25**	**Q50**	**Q75**	**Q90**
	Panel (a) Nurses									
Own group engagement	0.8379	1.7876***	1.4155***	1.0102**	0.1962	-0.3579	-0.1652	-1.0589***	-0.6829**	-1.9574***
	(0.8449)	(0.5729)	(0.4514)	(0.4184)	(0.4854)	(0.2282)	(0.2442)	(0.2767)	(0.3382)	(0.6208)
Complementary group retention	0.0844	0.0517	0.0353	-0.0005	0.0114	-0.0116	0.0095	0.0196	0.0620**	0.1533*
	(0.0553)	(0.0361)	(0.0287)	(0.0197)	(0.0236)	(0.0157)	(0.0164)	(0.0214)	(0.0306)	(0.0809)
NSS response rate	0.0177	0.0082	0.0281*	0.0147	-0.0068	0.0036	-0.0100	-0.0085	-0.0146	-0.0065
	(0.0277)	(0.0195)	(0.0163)	(0.0125)	(0.0149)	(0.0077)	(0.0079)	(0.0093)	(0.0114)	(0.0225)
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
	Panel (b) Senior Doctors									
Own group engagement	0.5804	0.5470	0.2069	0.0116	0.0383	-0.0028	-0.0808	0.0874	-0.2148	-0.1622
	(0.7965)	(0.3804)	(0.2120)	(0.2482)	(0.2477)	(0.1747)	(0.1419)	(0.1663)	(0.2282)	(0.4837)
Complementary group retention	0.1660	0.2710***	0.1325***	0.0564	0.0333	0.0626	0.0393	0.1082***	0.2467***	0.3426**
	(0.1756)	(0.0702)	(0.0486)	(0.0457)	(0.0575)	(0.0713)	(0.0430)	(0.0351)	(0.0639)	(0.1388)
NSS response rate	-0.0106	0.0104	0.0049	0.0199	0.0067	0.0040	0.0051	-0.0139	-0.0155	-0.0133
	(0.0554)	(0.0267)	(0.0172)	(0.0138)	(0.0160)	(0.0116)	(0.0094)	(0.0108)	(0.0153)	(0.0315)
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: There are 190 Trusts, and 1,704 Trust-year observations for nurses and 1,701 Trust-year observations for senior doctors. Standard errors are bootstrapped (1,000 replications) and clustered at Trust level. *p<0.1; **p<0.05; ***p<0.01.

We also compute the elasticities of labour supply retention with respect to the two main variables of interest, engagement and complementary workers' labour supply, from the system-GMM and UQR estimates. The results are shown in Table 7. The sign and the statistical significance of these estimates are consistent with the coefficient shown in Table 3, Table 4 and Table 6. Despite the elasticity estimates from fixed effects and GMM models reveal a relatively inelastic response to engagement (nurses) and nurses' retention (senior doctors), they are all larger in magnitude than the 0.07 wage elasticity of labour supply for NHS nurses estimated by Crawford et al. (2015). In particular: a 10% increase in nurses' engagement leads to a 1% increase in their stability index rate, but especially to a -8.5% decrease in nurses' NHS leaving rate; and a 10% increase (decrease) in nurses' stability rate (NHS leaving rate) leads to a 1.6% increase (2% increase) in senior doctors' stability ((NHS leaving) rate. Remarkably, nurses' retention within the NHS can also be quite elastic to engagement, as the engagement elasticities at the median (-1.17) and the 90^{th} quantile (-1.43) show.

Table 7: Elasticities of labour supply 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 group 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 leavers 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 group NHS leavers' 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 group 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 leavers 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 group NHS leavers' 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: There are 190 Trusts, and 1,704 Trust-year observations for nurses and 1,701 Trust-year observations for senior doctors. Standard errors are 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.

4.4 Estimates on labour supply intensive margins

Table 8 presents the estimates for the association of the variables of interest with absences from work due to sickness and other reasons. Nurses' engagement has a negative and significant impact on sick leave (columns 1-3), but we do not find any impact on absences due to other reasons. Specifically, a one-within-standard-deviation increase in nurses' engagement decreases the amount of absences from the workplace due to sickness by at least 0.05pp (column 2 of Table 8). Similar to the findings on retention outcomes, senior doctors' engagement does not matter for any type of absences. Any effect of staff complementarities on absences fades of statistical significance when we take into account potential time-varying endogeneity.

We also examine whether staff engagement affects the number of working hours supplied by NHS nurses and senior doctors, with estimates presented in Table 9. We do not find

Table 8: Associations with absences from the workplace (FE and GMM estimates)

	Sickness absence rate			**Other lost days absence rate**		
	OLS	**FE**	**GMM**	**OLS**	**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 group abence 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 group absence	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 Trust-year observations for nurses and 1,701 Trust-year observations for senior doctors. Standard errors are clustered at Trust level. *p<0.1; **p<0.05; ***p<0.01.

Table 9: Associations with hours worked (FE, GMM and UQR estimates)

			Unconditional Quantile Regression				
	FE	**GMM**	**Q10**	**Q25**	**Q50**	**Q75**	**Q90**
			Nurses				
Own group engagement	0.393**	0.051	0.1665	0.1148	0.1033	0.9718***	1.0616*
	(0.174)	(0.103)	(0.1093)	(0.0968)	(0.1202)	(0.3210)	(0.6390)
Complementary group hours	-0.005	-0.047	0.0075	-0.0081	0.0002	-0.0120	-0.0175
	(0.017)	(0.043)	(0.0130)	(0.0128)	(0.0171)	(0.0442)	(0.0618)
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^2	0.455		0.0792	0.1858	0.4363	0.3628	0.1729
			Senior Doctors				
Own group engagement	0.005	0.023	0.0816	-0.0086	-0.0181	-0.0600	-0.3593
	(0.122)	(0.117)	(0.2005)	(0.0639)	(0.0528)	(0.0867)	(0.3169)
Complementary group hours	-0.028	-0.001	-0.0169	-0.0353	-0.0406*	-0.0283	-0.1867
	(0.053)	(0.026)	(0.0909)	(0.0333)	(0.0233)	(0.0433)	(0.1361)
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^2	0.034		0.0246	0.0419	0.1087	0.1029	0.0333

Notes: There are 190 Trusts, and 1,704 Trust-year observations for nurses and 1,701 Trust-year observations for senior doctors. Standard errors are clustered at Trust level. *p<0.1; **p<0.05; ***p<0.01.

any strongly significant relationship between the engagement score and the number of hours worked. If anything, only more engaged nurses are likely to supply more labour, at least according to the FE model displayed in column 1 of Table 9. This effect seems to be driven by the top of the unconditional distribution for hours worked (columns 6 and 7), namely by those NHS Trusts where the amount of labour supplied is already high. Table 9 also does not document any complementarity between nurses' and senior doctors' labour supply intensive margins.

4.5 Robustness checks

Complementarity between Senior Doctors' and Nurses' retention.

In our main analysis, we find that nurses retention directly impacts senior doctors' retention outcomes. We further test the complementarity hypothesis between senior doctors' and nurses' retention by estimating models in which we split the nurses' retention in two groups, depending on either their age or their job grade, reflected by their Agenda for Change (AfC) pay bands. Both age and job grade are proxy for nurses' experience, which might play a big 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 A6 reports the elasticities from the GMM estimates for stability rates (panel a) and NHS leaving rates (panel b). Our findings support the complementarity hypothesis; we find significant positive elasticities of senior doctors' retention within the NHS Trust with respect to retention of older (0.17) and more senior (0.18) nurses, but no significant relationship with junior nurses; we also find a positive and significant elasticity of senior doctors' retention within the NHS as a function of older nurses' NHS leaving rates (0.32).

Controlling for outside wages in the local labour market.

Since NHS workers' salaries are regulated at the national level, heterogeneity of outside wages

across local labour markets is a possible confounding factor that may affect the turnover rates of hospital workers with a low pay level, e.g. nurses (Propper and Van Reenen, 2010). For this reason, we estimate fixed effects and system-GMM models including outside wages for both nurses and senior doctors. Just as Propper and Van Reenen (2010), in our specifications we include the natural logarithm of the outside wages for the occupational group whose labour supply function we are modelling. Our results are robust to the inclusion of outside wages. As shown in Table A7, for both nurses and senior doctors, the order of magnitude and the statistical significance of estimates are comparable to ones from the system-GMM (in Table 4). For nurses, the system-GMM (but noticeably not the fixed effects models) produce estimates of the effects of outside wages on the nurses' stability index (NHS leaving rate) that are negative (positive), significant at 1% level and thus in line with the Propper and Van Reenen (2010) predictions. However, for senior doctors the estimates from the system-GMM model with outside wages on the labour supply extensive margins exhibit a counterintuitive sign (positive for stability and negative for NHS leaving rates). We speculate that the inclusion of outside wages for senior doctors generates these rather surprising results because NHS hospital consultants (i.e. senior doctors) are among the top earners in the UK, with annual gross basic salaries that are on average more than twice nurses' salaries and the median earner's salary.[45] For such reason, and also due to the longer human capital investment to specialize and being formally accredited to the medical profession, the concept of outside wage does not fully apply to senior doctors as it does for nurses, probably because of a higher opportunity-cost for senior doctors to switch to similarly high paid jobs (e.g. consultants, bankers and solicitors).

Confounding due to simultaneity bias.

Although the estimation of the Equation 4 specification, including both engagement and

[45]NHS hospital consultants basic salary ranged from £75k to £100k (£78k to £105k) in 2009/10 (2018/19), compared to registered nurses' basic salary, which ranged from £21k to £40.1k (£22.5k to £43k) in 2009/10 (2018/19). The median income in the UK was £25.9k (£29.6k) in in 2009/10 (2018/19).

complementary workers' labour supply as variables of interest, produces associations that are meaningful both statistically and economically (see Table 4), the simultaneity between the labour supply dependent variable and the labour supply of the complementary occupational group may raise possible concerns about bias in coefficients of interest. In particular, there might be a problem with the system-GMM estimation if the lagged differences and levels of the labour supply measures of nurses and senior doctors were highly correlated or collinear, as this might make the lagged values both weaker and less valid as instruments. To address these concerns and check the robustness of our results, we estimate a modified version of Equation 4 in which we include the variables of interest one at a time. The results, shown in Table A8, indicate that our main results are quite stable and not statistically different from those reported in Table 4. These results are also supported by the fact that the yearly pairwise correlations at hospital organization level between nurses' and doctors' labour supply retention outcomes, reported in Table A9, are not very large: on average about 0.19 for the stability indices and 0.27 for NHS leaving rates. Overall, this suggests that there is enough within variation at NHS Trust level to obtain reliable estimates of the coefficients of interest from the system-GMM, using the lagged values as instruments.

5 Conclusions

Healthcare systems that have been facing workforce retention challenges for a long time, like the English NHS, are subject to detrimental effects on the morale and wellbeing of their healthcare workforce, which in turn may have repercussions on the provision and quality of patient care. In the absence of systemic policy interventions fostering a massive intake of new recruits or a generalized reduction in hospital staff turnover, it is important to understand the mechanisms governing hospital workforce retention rates, such as having an engaged workforce. In this work, we have first shown that staff engagement is indeed positively related to favourable working conditions and better managerial inputs, and then we have

investigated the relationship linking hospital workers' labour supply to two of its possible key drivers: staff engagement and the labour supply of complementary workers.

High levels of engagement are associated with lower turnover (West et al., 2011), yet there is limited evidence on the causal link between engagement and clinical workforce labour supply. We document a number of novel findings, which may have direct and policy-relevant implications in the development of workforce strategies, plans and interventions to improve the retention of healthcare workers and stabilize turnover rates.

First of all, staff engagement is correlated with labour supply at extensive margins, in particular for nurses. Nurses' stability index, an official NHS workforce statistic measuring the proportion of staff retained in a given hospital organization over 12 months, increases by 0.34 percentage points for a one standard deviation increase in nurses' engagement. On the contrary, doctors' engagement does not affect significantly their retention. A possible explanation for this selective role played by staff engagement on hospital nurses, but not senior doctors, lies in the fact that, in the English NHS, nurses lack proper career pathways and structured development opportunities after their professional qualification, while specialist hospital doctors are given plenty of such training and development opportunities, which are embedded in the progression of their medical career profile also through dedicated time and budgets to do further training and research. Furthermore, staff advocacy is found to be the key engagement component affecting positively staff retention, and in this case this is true for both nurses and senior doctors.

We also find that the retention of nurses has a positive impact on the retention of senior doctors in the same hospital organization, as a 5pp increase in nurses' stability index contributes to a 0.76pp increase in doctors' stability index. This finding is indirectly supported by the fact that the engagement of senior doctors is positively associated with having enough hospital staff to be able to perform their job, and suggests a clear one-sided complementar-

ity in workforce retention mechanisms where senior doctors are dependent on nurses, but not vice versa. A simple explanation for this is related to labour demand: in the English NHS, nurses and midwives represent the largest share of the clinical workforce (with a 3:1 ratio of nurses to doctors) and their wages are substantially lower than doctors' wages; also, nurses' labour supply within the NHS hospital care sector is more elastic than doctors', because nurses' training qualification is shorter and this implies lower opportunity-costs in terms of lost economies of experience if nurses decide to switch jobs, leaving NHS hospitals for other employment opportunities in or outside health care. Altogether, these facts show that the retention of the nursing workforce is essential as a labour demand input to run hospital services, especially for medical co-workers like doctors who employ nurses' skills and labour to care for patients. These findings, which emerge clearly from the system-GMM estimations, are also confirmed by estimates of unconditional quantile regressions over the workforce retention distribution.

Staff engagement exhibits also a (negative) relationship at the mean with nurses' labour supply intensive margins proxied by their sickness absence rates, but it has no impact on other nurses' absences, any type of doctors' absences and also with hours worked. Also, staff complementarities do not seem to play any effect on nurses and doctors' absences and hours worked. This is not unreasonable, as labour supply intensive margins are short-term work outcomes that might be less responsive to our two variables of interest. Engagement and job complementarities are likely factors that have an impact on working conditions more in the medium and long term, affecting human capital accumulation, job satisfaction, work-related stress and therefore also hospital workforce retention outcomes. Nevertheless, we find that nurses' labour intensity is responsive to their engagement, which is probably due to the fact that throughout our period of study the English NHS hospital nursing staff has been particularly under pressure, poorly paid and with a lack of career development prospects. In fact, we find that the increase in pay satisfaction is positively associated with nurses' overall engagement, but not with doctors' engagement.

The robustness of our findings to different models and specifications, their internal consistency and the positive feedback received by expert NHS nurses and consultants indicate that the associations we find are the closest we can get to the estimation of causal effects for the variables of interest, without a valid source of exogenous variation. Overall, the evidence we gathered suggests that healthcare policy-makers should focus on improving engagement and retention of nurses in the first place, both in the English NHS and in other healthcare systems where nurses constitute the backbone of the hospital clinical workforce. The increase in engagement directly benefits nurses' retention, while nurses' retention has indirect positive spillover effects on senior doctors' retention. This strategy would not only favour the accumulation of human capital within a given hospital organization (proxied by the stability index rate), but it would also help reducing the overall exodus of health workers from the hospital sector (proxied by the NHS leavers rate). The positive effects from the adoption of such workforce strategies seem particularly likely and valuable for hospital organizations characterized by the highest clinical workforce turnover.

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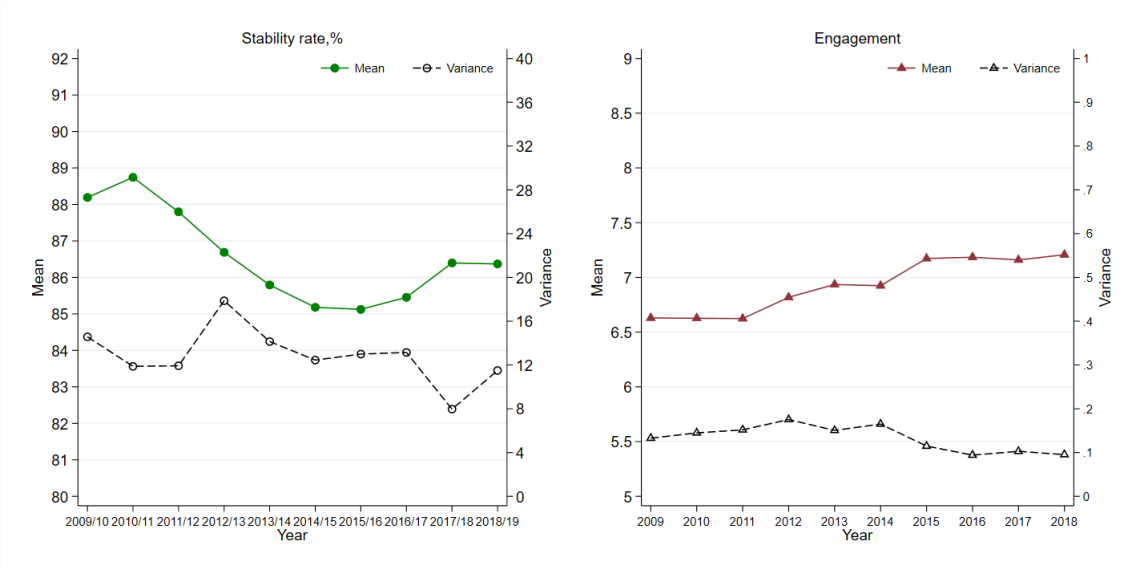
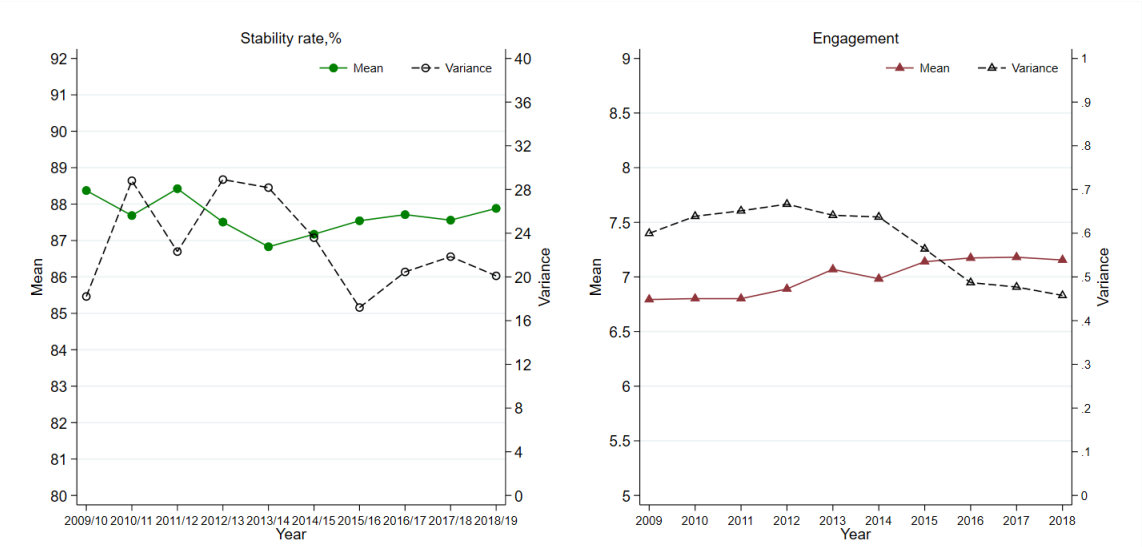
A Appendix

Figure A1: Changes in the mean and variance of stability and engagement over time

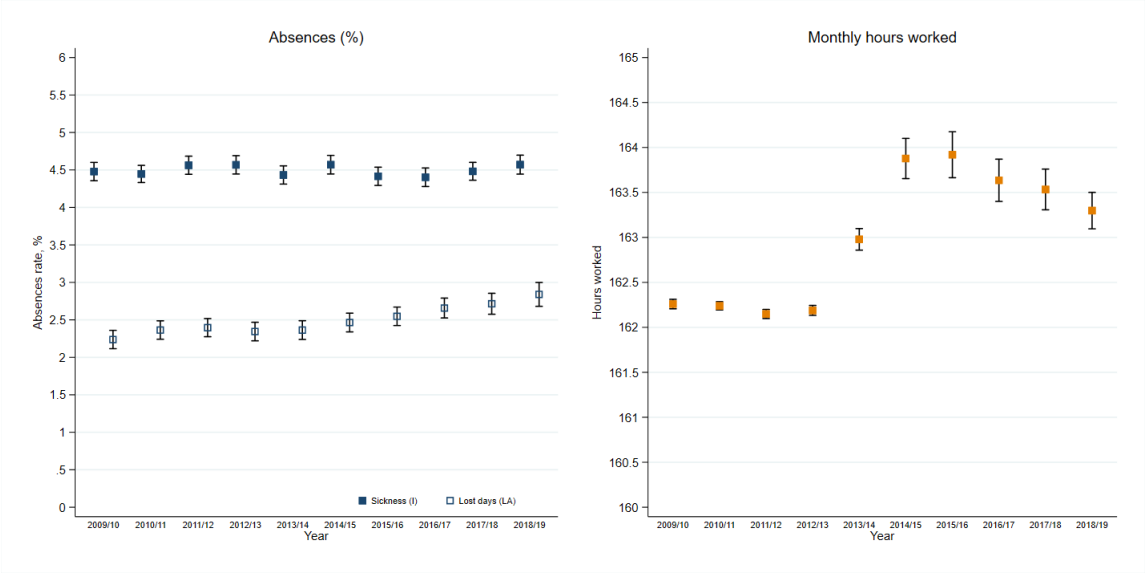


(a) Nurses

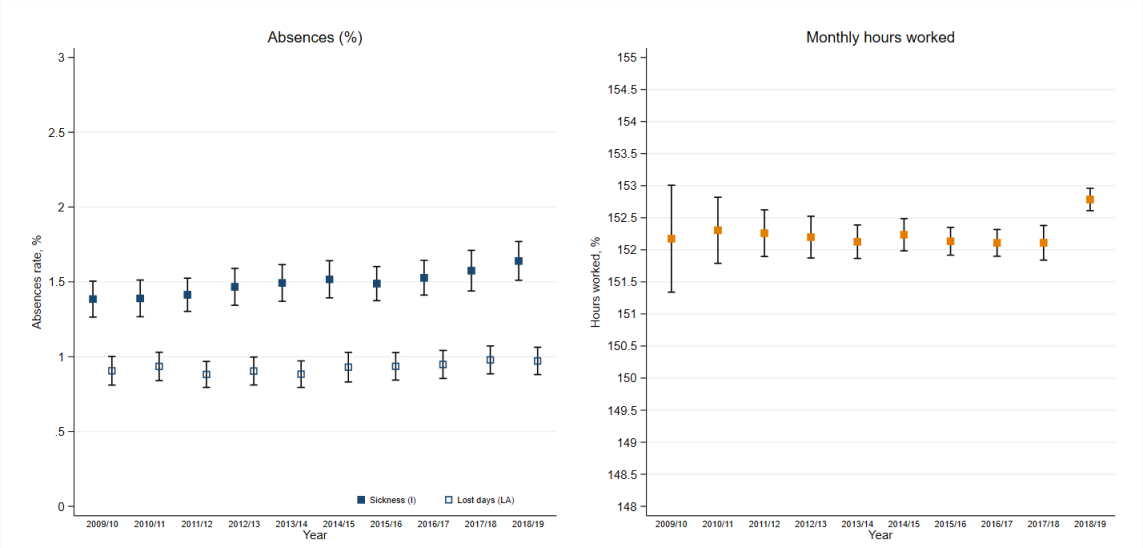


(b) Senior Doctors

Figure A2: Absences and hours worked over time



(a) Nurses



(b) Senior Doctors

Notes: Authors' computations using the ESR with 95% confidence bands around the mean.

Figure A3: Distribution of Nurses' Retention and Overall Engagement

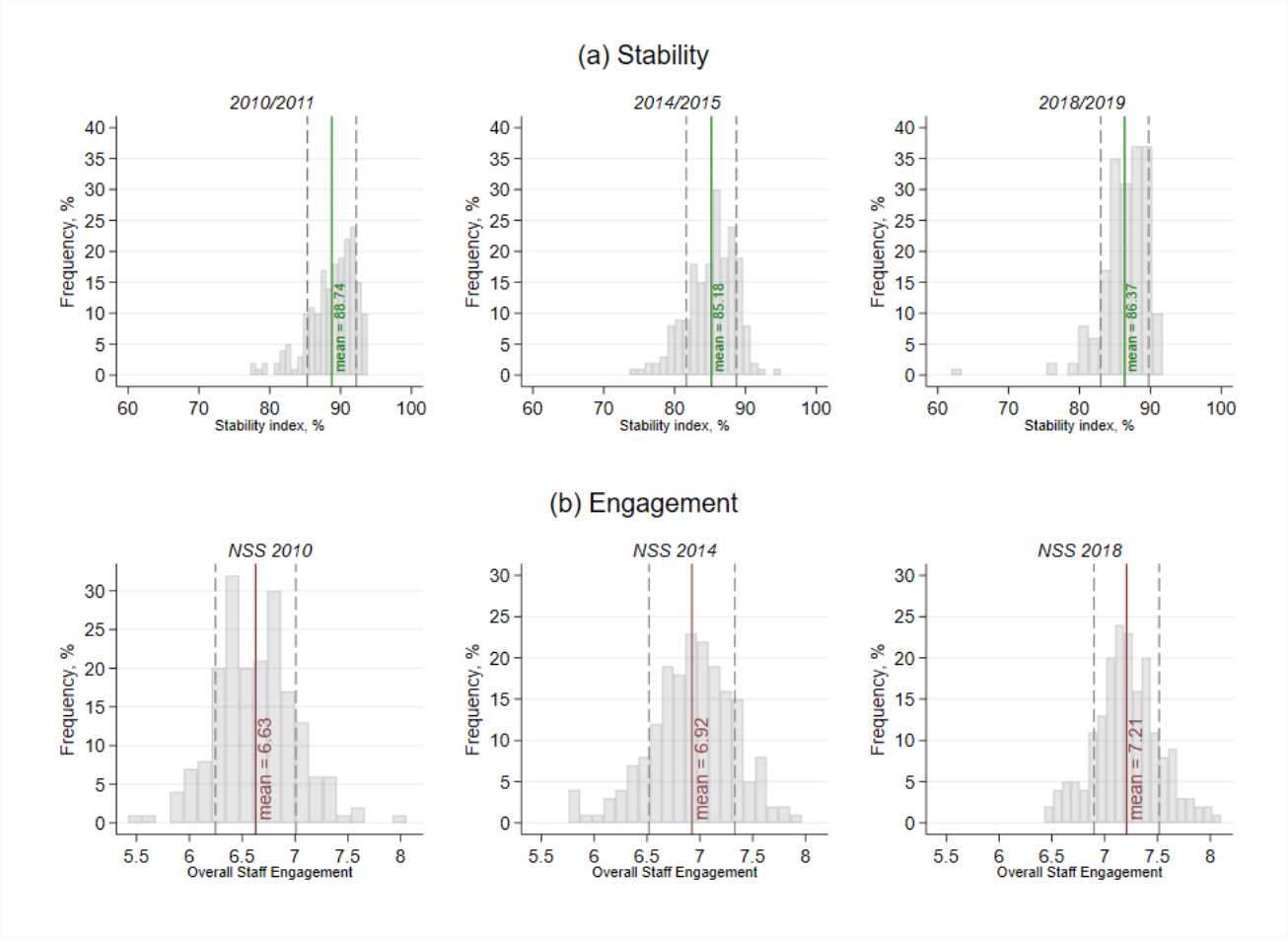


Figure A4: Distribution of Senior Doctors' Retention and Overall Engagement

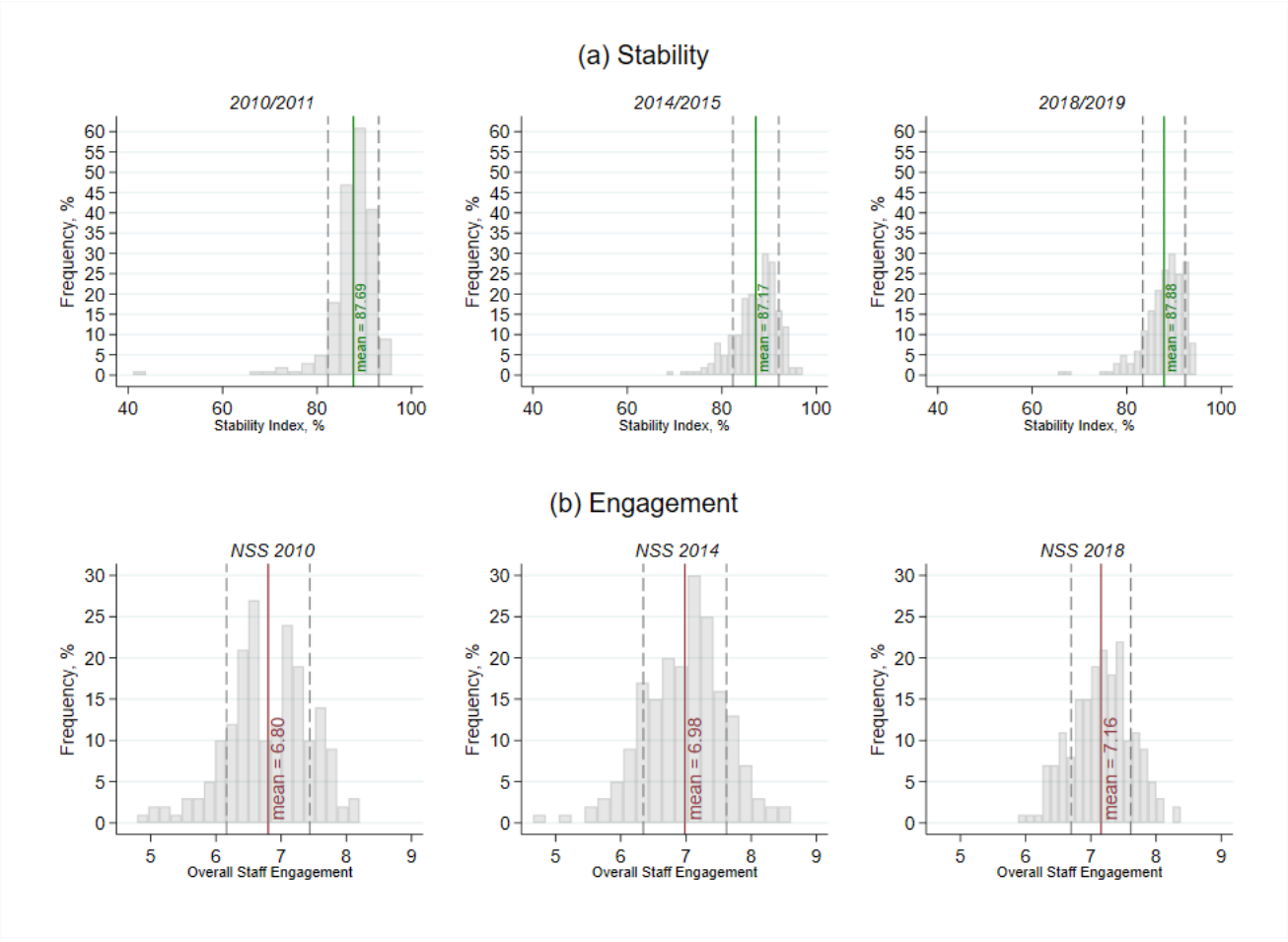


Table A1: Components of overall staff engagement in NHS Staff Surveys (NSS)

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 A2: Sample Sizes and Response Rates, NSS 2009-2018

	NSS base samples by NHS Trust				Response Rates by NHS Trust (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

Table A3: Summary statistics from NSS 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 2 based on 190 NHS Trusts and 1,894 Trust-year observations for nurses and 1,892 for senior doctors.

Table A4: Associations with retention, by engagement components: Trust FEs model.

	Stability rate			Leaving the NHS 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 group 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 group 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

Notes: There are 190 Trusts, and 1,704 Trust-year observations for nurses and 1,701 Trust-year observations for senior doctors. Standard errors are clustered at Trust level. *p<0.1; **p<0.05; ***p<0.01.

Table A5: Effects on absences, UQRs

	Sickness absence rate					Other lost days absence rate				
	Q10	**Q25**	**Q50**	**Q75**	**Q90**	**Q10**	**Q25**	**Q50**	**Q75**	**Q90**
	Panel (a) Nurses									
Own group engagement	0.1054	-0.2140*	-0.3109***	-0.3052**	-0.1310	0.0873	-0.0199	-0.0609	-0.1513	-0.1065
	(0.1347)	(0.1099)	(0.1047)	(0.1394)	(0.1567)	(0.1460)	(0.1009)	(0.0981)	(0.1417)	(0.2002)
Complementary group absence rate	0.0280	0.0071	0.0130	0.0802	0.0223	0.0507	0.0515	0.0853*	0.0740	0.0354
	(0.0273)	(0.0254)	(0.0276)	(0.0569)	(0.0727)	(0.0715)	(0.0449)	(0.0475)	(0.0691)	(0.0940)
NSS response rate	-0.0037	-0.0003	-0.0039	-0.0089**	-0.0128***	0.0010	-0.0007	-0.0028	-0.0074	0.0063
	(0.0065)	(0.0036)	(0.0034)	(0.0039)	(0.0048)	(0.0042)	(0.0038)	(0.0037)	(0.0049)	(0.0085)
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
Within R^2	0.0299	0.0372	0.0405	0.0359	0.0193	0.0799	0.0861	0.0750	0.0753	0.0462
	Panel (b) Senior Doctors									
Own group engagement	-0.0389	0.0053	-0.0625	-0.0212	-0.0174	0.0246	-0.0515	0.0058	0.0228	-0.0413
	(0.0381)	(0.0378)	(0.0444)	(0.0728)	(0.1599)	(0.0384)	(0.0367)	(0.0464)	(0.0627)	(0.0893)
Complementary group absence rate	0.0307	0.0010	0.0297	0.0426	0.1803	0.0682	0.0264	0.0439	0.0691	0.0458
	(0.0427)	(0.0352)	(0.0448)	(0.0744)	(0.1714)	(0.0493)	(0.0405)	(0.0391)	(0.0517)	(0.0595)
NSS response rate	-0.0001	-0.0015	0.0013	0.0091*	0.0053	-0.0008	-0.0019	-0.0041	0.0028	-0.0003
	(0.0031)	(0.0027)	(0.0028)	(0.0049)	(0.0092)	(0.0030)	(0.0026)	(0.0026)	(0.0043)	(0.0064)
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
Within R^2	0.0253	0.0220	0.0224	0.0359	0.0355	0.0231	0.0255	0.0241	0.0336	0.0147

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

Table A6: Elasticities of senior doctors' retention with respect to retention of nurses by different grade and age

	Band	**Age**
Panel (a): Stability rates		
Nurses' stability (Band 1-5, age < 41)	-0.042	0.001
	(0.052)	(0.047)
Nurses' stability (Band 6-9, age ≥ 41)	0.172**	0.179**
	(0.075)	(0.074)
Senior doctors' engagement	0.020	0.022
	(0.028)	(0.028)
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): Leaving the NHS rates		
Nurses' NHS-leaver rates (Band 1-5, age < 41)	-0.036	-0.033
	(0.055)	(0.040)
Nurses' NHS-leaver rates (Band 6-9, age ≥ 41))	0.041	0.319***
	(0.054)	(0.069)
Senior doctors' engagement	0.041	-0.183
	(0.220)	(0.262)
AR(1) p-value	0.000	0.000
AR(2) p-value	0.859	0.812
Hansen over-id. test p-value	0.986	0.861

Notes: Estimations based on system GMM with the same specifications as in main analyses, except the second column in panel(b) does not include the share of female senior doctors' as a covariate. 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 are clustered at Trust level and are in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table A7: FE and GMM estimates on labour supply extensive margins, including outside wages

	Nurses				Senior Doctors			
	Stability rate		Leaving the NHS rate		Stability rate		Leaving the NHS rate	
	FE	GMM	FE	GMM	FE	GMM	FE	GMM
Own group overall engagement score	1.115***	1.212**	-0.692***	-0.756**	0.374*	0.227	-0.101	-0.051
	(0.311)	(0.488)	(0.233)	(0.346)	(0.221)	(0.307)	(0.149)	(0.226)
Complementary group retention	0.053**	0.021	0.089**	0.137**	0.152***	0.155**	0.191***	0.172***
	(0.027)	(0.027)	(0.040)	(0.063)	(0.053)	(0.076)	(0.057)	(0.051)
Own group lagged retention		0.242***		0.137**		0.186***		0.045
		(0.057)		(0.063)		(0.055)		(0.043)
log(Outside Wage)	0.560	-5.974***	0.497	4.153***	2.768	2.569*	0.265	-2.865***
	(4.100)	(1.862)	(2.740)	(1.571)	(5.523)	(1.549)	(3.931)	(0.923)
Constant	-32.888	63.214**	79.278*	2.199	-56.631	-35.625	37.485	59.204***
	(61.435)	(31.229)	(43.444)	(21.085)	(61.135)	(33.399)	(41.772)	(20.456)
AR(1) p-value		0.000		0.002		0.000		0.000
AR(2) p-value		0.329		0.701		0.431		0.878
Hansen test degrees of freedom		44		440		43		43
Hansen over-id. test p-value		0.233		0.197		0.316		0.715
R^2	0.267		0.157		0.103		0.079	

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

Table A8: GMM estimates on labour supply extensive margins, including one key variable at a time

	Nurses			Senior Doctors		
	(1) Main model	(2) Engagement only	(3) Stability Index only	(4) Main model	(5) Engagement only	(6) Stability Index only
Own group overall engagement score	1.284**	1.079**		0.227	0.328	
	(0.498)	(0.544)		(0.298)	(0.348)	
Complementary group stability index	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 group 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 Trust-year observations for nurses and 1,701 Trust-year observations for senior doctors. Standard errors are clustered at Trust level. *p<0.1; **p<0.05; ***p<0.01.

Table A9: 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.