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IZA DP No. 15480

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ABSTRACT

Do Non-monetary Interventions Improve Staff Retention? Evidence from English NHS Hospitals*

Excessive turnover reduces the stock of an organization's human capital. In the public sector, where wage increases are often constrained, managers need to leverage non-monetary working conditions to retain their workers. We investigate whether workers are responsive to improvements in non-wage aspects of their job by evaluating the impact on nurse retention of a programme that encouraged public hospitals to increase staff retention through data monitoring and improving the non-pecuniary aspects of nursing jobs. Employing rich employee-level administrative data from the universe of English NHS hospitals, and a staggered difference-in-difference design, we find that the programme has improved nursing retention within hospitals and decreased exits from the public hospital sector. Our results indicate that a light-touch intervention can shift management behavior and improve hospital workforce turnover. These findings are important in sectors affected by labor supply shortages, and they are especially policy-relevant in the health care context, where such shortages have potentially negative effects on patient outcomes.

JEL Classification: J32, J38, J45, J63, I11, C22

Keywords: labor supply, workforce retention, non-monetary incentives, hospital care, staggered difference-in-differences

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1 Introduction

Work is the engine of society, and understanding how individuals are incentivized to work is a central concern among social scientists. In the last two decades, research has widened its scope from the estimation of wage elasticities to investigate how a broader range of factors influence whether, how long and how hard employees work. The responsiveness of labor supply to the non-financial aspects of job quality is especially pertinent in public sector occupations, where large workforces combined with budget constraints limit the potential for wage increases. In addition, workers with mission-driven preferences may value the different facets of jobs differently compared to those in the private sector (Besley and Ghatak, 2005; Ellingsen and Johannesson, 2008; Brekke and Nyborg, 2010; Lee et al., 2019). With this study, we evaluate the effectiveness of changing the non-pecuniary aspects of public-sector jobs on a large scale, by exploiting a labor market policy aimed at decreasing the turnover of nurses working in all public hospitals in England. We offer causal evidence that changing management practices can improve employee retention, and also deliver insights about which non-monetary incentives can be exploited to stimulate labor supply. We show that a low-powered incentive to monitor retention and improve job quality led to significant reductions in turnover among public sector workers.

Limiting excessive workforce turnover is important for the efficient functioning of healthcare organizations. Health care is a labor intensive sector and nurses are a vital part of its workforce, constituting about one third of the healthcare workers in both the United States and the United Kingdom. Nurse vacancy rates are high across OECD countries: although the numbers of nurses have been increasing, the supply of nurses is failing to keep up with rising demand. In the UK, even before the COVID-19 pandemic, there was a 50,000 nurse staffing gap (Buchan et al., 2020), and vacancy rates for registered nurses increased from 6% to 11% between 2013 and 2016 (Helm and Bungeroth, 2017). In the US about 1.1 million new registered nurses are needed by 2030 (Bureau of Labor Statistics, U.S. De-

partment of Labor, 2021). Moreover, nurse shortages have been linked to lower quality of health care provided, for example higher patient mortality (Rafferty et al., 2007; Ball et al., 2018; Griffiths et al., 2019), higher likelihood of missed care (Ball et al., 2014; Griffiths et al., 2018), and increased length of hospital stay (Duffield et al., 2011). Therefore, policy makers are seeking sustainable, cost-effective ways to reduce nurse shortages and high turnover rates.

Compared to training new nurses, which takes 3 to 4 years, improving retention is a time and cost-efficient solution to staff shortages (Shields, 2004), with the additional benefit of retaining specific human capital within the employing organization. A possible strategy to improve retention is to increase wages. However, as reviewed in Lee et al. (2019), the empirical literature supports a limited role for wages to increase labor supply among nurses. Even if nurse retention was highly responsive to wages, a conspicuous pay rise across a sector as large as UK public healthcare[1] is expensive.[2] An alternative approach to reducing turnover rates is to improve the non-financial elements of employment valued by workers. An emerging literature discusses the importance of the non-pecuniary aspects of jobs for employee well-being, job satisfaction, labor supply and effort. In particular, Cassar and Meier (2018) emphasize the importance of mission, autonomy, competence and relatedness which come together to create 'meaningful' work. For example, employees have been shown to value aspects of autonomy such as being involved in decision making processes (Böckerman et al., 2012); flexibility (Mas and Pallais, 2017); and the value of competence is illustrated by employees' responses to being recognized for their efforts and having opportunities to learn on the job (Gallus, 2017). A small emerging literature looks specifically at the impact of non-pecuniary occupational aspects on workforce retention, and demonstrates that interventions with varying degrees of intensity can reduce quit-rates (Shields and Ward, 2001; Moscelli et al., 2022). Alan et al. (2021) shows that an extremely specific intervention to im-

[1]The National Health Service, studied here, was the fifth largest employer in the world in 2015 (Forbes, 2015)

[2]In April 2022, the UK Government had to increase general taxation specifically to fund a raise in NHS spending that included a pay rise for NHS workers (BBC News, 2022; The Times, 2021).

prove company culture reduced voluntary quits among white-collar workers in Turkey while Friebel et al. (2022) shows smaller but still substantial effects of simply asking managers to 'do what they can' to reduce turnover among retail workers in Eastern Europe. Hoffman and Tadelis (2021) demonstrates that positive human resource management practices, including career support, clear expectations, coaching, consultation, a positive attitude and trust has a substantial effect on staff retention in a large high-tech firm. Many of these factors are key features of the policy evaluated here.

Our work contributes to the labor, organization management and health economics literature in several ways. First, we test the hypothesis of whether a low-cost non-wage intervention improves retention within a given (healthcare) organization, and also within the whole (public hospital care) sector. At present, there have been no studies on the influence of non-wage element of jobs on retention in the public sector. Specifically, we evaluate the effects of the Retention Direct Support Programme (henceforth, *RDSP* or 'the *Programme*'), which was launched in July 2017 by NHS Improvement (NHSI), the monitoring body of English National Health Service (NHS) hospital organizations. The explicit purpose of this intervention was to reduce turnover rates among nurses working in NHS hospitals. There was no specific direction issued about how the NHS hospital organizations should achieve this goal, so this programme has something in common with the "do what you can" intervention discussed in Friebel et al. (2022), although managers were prompted by NHSI if no activity was observed. Hospital providers were tasked to build their own retention strategies: NHSI provided tailored retention data to identify areas for improvement as well as liaison officers to help develop and execute action plans. The areas of intervention considered in these plans included many of aforementioned factors that positively influence job satisfaction, in particular improving career progression, professional development, work-culture and job flexibility. The provision and analysis of retention data is an especially important feature of this intervention because NHS hospital providers "do not collect data on retention in a consistent and robust way and so any national drive to improve nurse retention would have to address

this" (Marangozov et al., 2016). Gosnell et al. (2020) show that simply providing workers with data on their performance has a substantial impact on their performance.

Second, we provide a causal identification of the impact of the Programme, based on the differential timing of the RDSP across cohorts and exploiting the new methodological advances in difference-in-difference (DiD) estimation with staggered treatment adoption, specifically the DiD estimator proposed by Callaway and Sant'Anna (2021). The RDSP was implemented in a staggered fashion: hospital organizations, called Trusts in the English NHS, were split into five cohorts, with each cohort starting the Programme at different times. Our evaluation makes use of a unique dataset, consisting of a monthly panel of English NHS hospitals, which we constructed by combining different sources of micro-level administrative data (Electronic Staff Records 2015-2019 and NHS Staff Surveys 2013-2018) with organization-level data from NHSI (timing, cohorts and themes of the RSDP intervention). Overall, we find that the RDSP has improved nursing retention by 0.78 percentage points (ppt) leading to the retention, on average, of 1,697 nurses and midwives who would have left their Trust otherwise. This is around a quarter to a half of the standard deviation of the retention rate across Trusts in the pre-period. Our results hold when we use alternative estimators, such as interaction-weighted estimator of Sun and Abraham (2021), to capture the dynamic treatment effects of interest.

Third, we investigate possible spillover effects on patient outcomes and hospital productivity. The intervention was designed to improve workforce retention at the hospital organization level, but it is possible that patient outcomes such as mortality would also improve as vacancies and staff turnover reduce. Moreover, if the intervention led to a general improvement in management and productivity, we might expect participation to improve patient outcomes directly. An alternative hypothesis is that the specific focus on retention could distract hospital managers and senior clinicians from activities with more direct benefit for patients, in line with the classical principle of equal compensation in incentives (Holmstrom and Mil-

grom, 1991), such that agents reallocate their efforts to those activities boosting performance close to standards; this chimes with results from Friebel et al. (2022), which find a positive impact on retention but no effect on store-level profits. We find no statistically significant evidence of either positive or negative effects on patient outcomes (standardized mortality and unplanned readmission rates) or productivity (proxied by the number of admissions) in the treated organizations.

Fourth, we try to unpack the "black box" of the RDSP by exploiting information about the Programme areas of intervention used by each hospital organization. Although it is not possible to establish precise causal links between individual activities and outcomes, our results provide suggestive evidence that the success of the intervention was heterogeneous according to the baseline hospital retention rates and the different areas of intervention chosen. In particular, improving career progression, development and engagement and stimulating a compassionate work culture contributed to the largest retention gains for the hospitals characterized by the worse average retention before the intervention; while improvements in staff engagement, support to new staff, selection of new joiners and the inclusion of retention in the organization strategy worked best in treated providers with the highest baseline retention.

This work is related to several literatures. With respect to the literature on optimal targets and incentives, Friebel et al. (2022) shows that goal-setting alone is sufficient to encourage managers to act to improve retention in the private sector. The literature also shows that targets and incentives can influence performance in the NHS (Propper et al., 2010; Cooper et al., 2011; Gaynor et al., 2013; Bloom et al., 2015) and other public services (Burgess et al., 2017; Verbeeten, 2008). However, strong incentives can be counter-productive when agents are pro-socially motivated (Ellingsen and Johannesson, 2008; Bowles and Polania-Reyes, 2012), raising the question of the optimal strength of incentives in the public sector. We show that weak incentives are sufficient to motivate NHS managers to make changes to working conditions that influence workers' retention. Our study also speaks to the litera-

ture on effective management (Bloom and Van Reenen, 2007; Hoffman and Tadelis, 2021; Alan et al., 2021). Data, monitoring and people management are emphasized as strongly associated with good management and performance in public sector organizations (Bloom et al., 2014; McNally et al., 2022). The intervention assessed here is best characterized as a provision of information and a "nudge" towards adopting best practice in human resource management. Finally, we also contribute to the literature about the features of meaningful work (Kahn, 1990; Chalofsky, 2003; Bailey et al., 2019). Our results demonstrate that the changes brought about by the policy are applicable in the public sector and affect the decision to quit, an important margin in understaffed public services.

The paper proceeds as follows. Section 2 presents the institutional settings of the English NHS, its nursing workforce and the RDSP policy. In Section 3 we describe the data and the empirical strategy, while Section 4 reports the results of the analysis. Section 5 concludes.

2 Institutional Background

2.1 The English NHS and its nursing workforce

The NHS is publicly funded through general taxation and provides free comprehensive primary, secondary and tertiary healthcare services to over 56 million people in England[3] and a further 11 million in the other devolved nations of the UK (Scotland, Wales and Northern Ireland). The NHS budget for England in 2017 was approximately £110bn. Public hospitals providing secondary care are run by organizations called NHS hospital Trusts, or simply NHS Trusts.

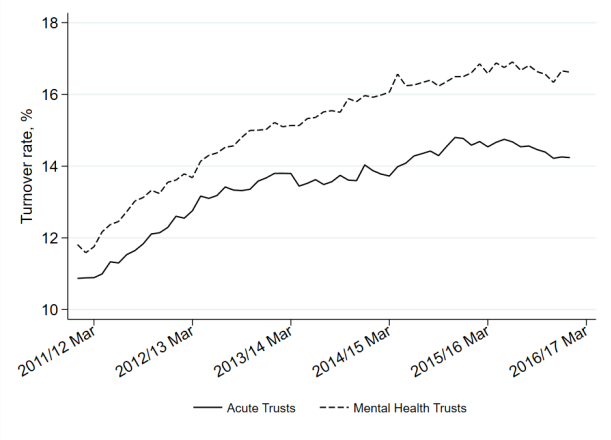
In March 2020 about 564,000 nurses, midwives and nursing associates living in England were registered with the Nursing and Midwifery Council (NMC) (NMC, 2020).[4] The English NHS

[3]Recent estimates suggest that only around 10.5% of the UK population hold voluntary private health insurance (Tikkanen et al., 2020)

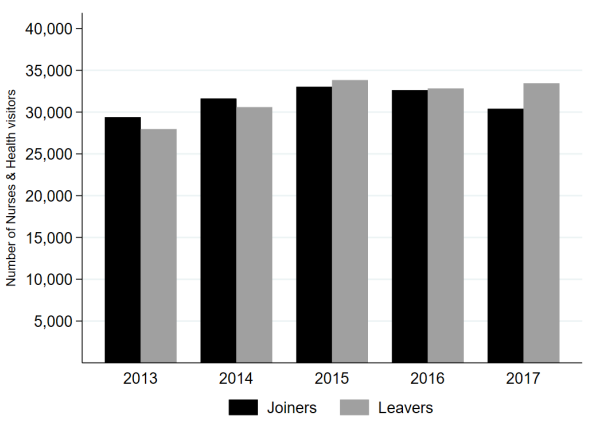
[4]The NMC is the professional body for nurses and midwives in the UK. To practice their profession, nurses and midwives need to register with the NMC and qualify to the NMC's standards.

Figure 1: Trends in NHS Nursing Workforce

(a) Turnover



(b) Joiners to and leavers from the NHS



Notes: Panel (a): Authors' calculation from the Electronic Staff Records 2009-2020. Turnover is measured for each month from one year to the following. The Figure produced using the ESR might differ from the official Workforce Statistics released by the NHS Digital. Panel (b): Headcounts of Nurses and Health Visitors in NHS Hospital and Community Health Services. Each period runs from September to the following September. Data is from NHS Digital, NHS Hospital & Community Health Service workforce statistics (NHS Digital, 2018; National Audit Office, 2020).

employs around 330,000 of these registered nurses and midwives[5], who make almost half of the professionally qualified clinical staff.[6]

The nursing workforce has been under significant pressure from growing demand for health-care combined with high turnover rates, and have reported high levels of work-related stress that have increased together with staff turnover rates (Perreira et al., 2018). National Audit Office (2020) notes that the increase in the full-time equivalent nursing numbers between 2010/11 and 2018/17 was not enough to meet NHS needs. Figure 1(a) and Figure 1(b) show that turnover rates have increased in recent years and that in 2017 more nurses left the NHS than joined. Consequently vacancy rates are high, standing at 38,000 full-time equivalent open posts in the first quarter of 2017/18 (June 2017) (NHS Digital, 2021) or 10.9%. Because of the high number of nursing vacancies, the NHS relies significantly also on temporary and agency staff, which cost NHS Trusts approximately £1.46 billion per year (The Open University, 2018); an improvement in workforce retention is expected to reduce

[5]For brevity, in this work the terms "nursing staff" and "nurses" are referred to both nurses and midwives.
[6]Clinical staff includes Hospital and Community Health Service (HCHS) doctors, qualified nurses and health visitors, midwives, qualified scientific, therapeutic and technical staff and qualified ambulance staff.

these labor costs as well as preventing losses in human capital.

2.2 Retention Direct Support Programme

The Retention Direct Support Programme (RDSP) was designed by NHS Improvement to tackle the nursing supply challenge. The aim of the RDSP was to improve nursing retention in public acute care Trusts and retention across the clinical workforce (i.e. nurses and doctors) in mental health Trusts in England (NHS England, 2019).

The Programme was clinically-led, involving at least one member of the nursing team from the Trust, and focused on factors that are under Trusts' control (NHS Improvement, 2017). The RDSP implementation consisted in a common organizational structure of the Programme and performance monitoring process for all Trusts, alongside the development of retention improvement plans tailored to address each Trust's retention needs (see details below).

The Programme was rolled out in a staggered fashion over 5 cohorts from 2017 until 2020. NHSI, the hospital monitoring body, allocated Trusts into cohorts over time, starting with Trusts that had above-average leaver rates.[7] The RDSP's first cohort was launched in June 2017; other cohorts started at later dates and respectively in October 2017 (Cohort 2), April 2018 (Cohort 3), November 2018 (Cohort 4). By the end of 2018, 146 secondary care Trusts had been enrolled in the Programme. In September 2019 the RDSP was extended to the other 62 Acute and Mental health Trusts (Cohort 5) and all the Ambulance Trusts in England, until the Programme's *de facto* end in Spring 2020 due to the start of the COVID-19 pandemic.

Structure of the RDSP interventions

In the weeks following the first contact from NHSI, clinical and workforce leads from the Trusts were invited to participate in a "Retention Masterclass workshop", scheduled around

[7]The selection was based on several factors, but more weight was given to Trust's turnover rates and trends in the five years preceding the RDSP. Trusts did not know which Cohort they were allocated to, until only a few weeks before they were contacted to join the Programme.

six weeks in advance. These Trusts received data packs from the NHSI a few days before the workshop, which contained Trust-specific retention measures with regional benchmarks (NHS Improvement, 2017) to help Trusts understand their retention profile and potential for improvement. The Retention Masterclass workshop was the official launch event of the RDSP; it introduced the Programme to the Trusts' team, and functioned as an interactive platform to review and discuss the barriers to retention in their organizations. During the workshop, NHSI also presented the domains that Trusts might focus on to reduce their leaver rates, showcased best practices and demonstrated how data can be used to inform decision making. Trusts were also given guidelines on ways to develop action plans.[8]

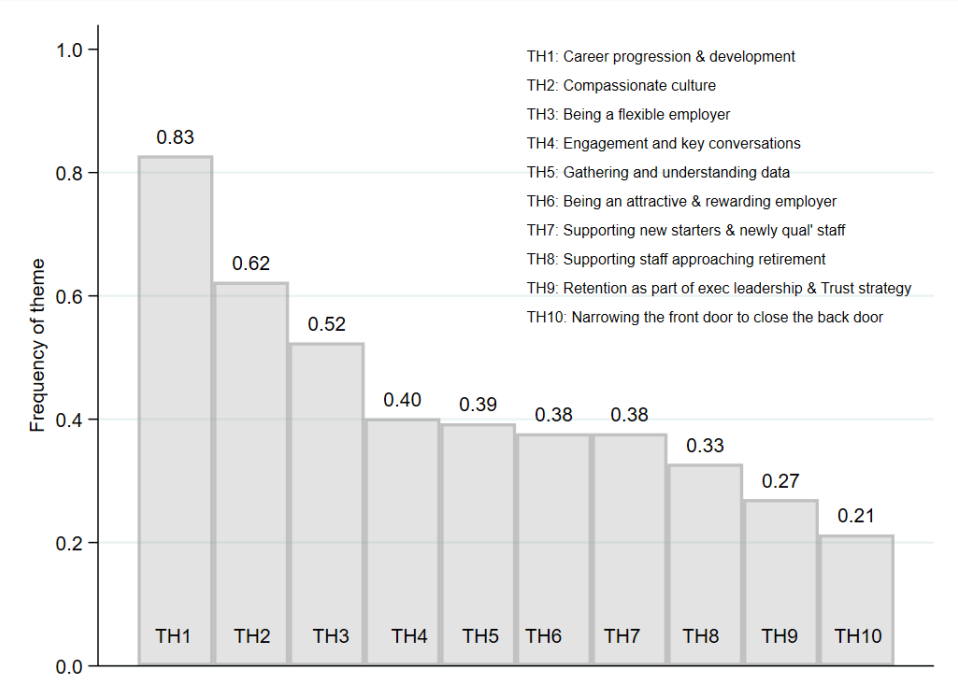
Each Trust was matched with an NHSI officer acting as lead and collaborating with the Trust for the whole duration of the RDSP. Trusts were given 90 days to develop and submit a Retention Improvement Action Plan, and expected to use this period to review their data, identify areas of improvement and set clear and measurable actions to reduce turnover rates. In the 12 months following the launch of the RDSP in cohorts, NHSI officers monitored the progress of the Trusts, provided quarterly data packs and supported Trusts that lagged behind their agreed targets.

Retention Improvement Action Plans

An important difference setting the RDSP apart from other nation-wide NHS policies, such as the 18-week waiting time target for planned surgery or the 4-hour waiting time target for urgent emergency hospital care, was that the Programme did not set any specific turnover rate targets for Trusts to achieve. NHSI's expectation was to see an *improvement in turnover rates* in the 12 months following the start of the Programme. Moreover, rather than a one-fits-all approach, RDSP encouraged Trusts to focus on retention challenges endemic to their workforce, and to set their turnover goals accordingly. In this way, the Programme also enabled Trusts to incorporate existing and planned workforce governance initiatives into their action plans.

[8]For more details on the workshop, the presentation for Cohort 1 is available at `https://www.networks.nhs.uk/nhs-networks/nhsi-retention-support-cohort-1/documents/14-july-workshop-slides`.

Figure 2: Frequency of Themes in Retention Improvement Action Plans



Notes: Authors' calculations from NHSI thematic coding matrix from Cohorts 1 to 4. The themes are categorised by NHSI using action plans submitted by 122 Trusts.

NHSI identified 10 recurring themes from the submitted Action Plans. Figure 2 shows the frequency of recurring themes in all Action Plans. At least three quarters of the Trusts in the first four cohorts focused on career progression and development (TH1) of their nursing workforce, included strategies to develop clear and attainable career paths, re-design appraisal processes, and career coaching.[9]

The second most frequent theme arising from the action plans was establishing a compassionate culture (TH2). This theme covered action points and initiatives on different aspects of nurses and midwives' experiences at their organization, ranging from focusing on mental health and wellbeing needs to managing workloads and preventing burn-out. The emphasis on these aspects is in line with the high levels of stress identified in the NHS Staff Survey. Some Trusts also mentioned their aim to work on recognition of good work and valuing

[9]This is explained by the fact that NHS nurses perceive a lack of continuous learning and development opportunities offered in their roles (House of Commons Health Committee, 2018; NHS, 2019), also due to the cuts to Continuing Professional Development (CPD) from the Health Education England's budget. The workforce development budget is mostly used for nurses' training and it suffered a 60% cut from 2015/16 to 2017/18 (Bungeroth et al., 2018).

staff, as well as strategies to reduce negative workplace experiences such as bullying and harassment.

Slightly more than half of the Trusts in the first four cohorts identified strategies to improve flexibility at work, another aspect emphasized by House of Commons Health Committee (2018) and the 2019 NHS Long-term Plan (NHS, 2019) as necessary for improved retention. The "Being a flexible employer" theme contained strategies offering flexibility in rotations, improving online shift-scheduling, and facilitating transfer schemes.

While pay is a contentious topic among nurses and midwives (Mirror, 2020; The Guardian, 2021; The New Statesman, 2021), it was not a recurring theme in retention improvement plans. Only 13 of 122 action plans mentioned pay and it was classified under the promotion of "rewards and pay" sub-theme of Theme 6, "Being an attractive employer". This is perhaps not surprising, as NHS nurses and midwives' wages are negotiated and determined at national level, with no scope for individual bargaining.

3 Data and Methods

To understand the impact of the RDSP on nursing retention in English secondary care, we construct a monthly panel of NHS Trusts in England using various micro-level datasets.

We construct measures of retention from the monthly Electronic Staff Records (ESR) 2009-2020. The ESR is an administrative dataset that contains monthly payroll information, along with basic demographic characteristics (e.g. age, gender and ethnicity) of all employees working in the NHS in England. The information on the RDSP comes from NHS Improvement (NHSI), which was the NHS monitoring body responsible for the development and implementation of the intervention.[10] These data contain information about the timing of the Programme's roll-out.

We complement our panel with the information on nurses' attitudes toward work and perceptions of their workplace using individual-level data from the NHS Staff Survey (NSS)

[10]NHSI works with the Department of Health and Social Care, and, together with NHS England, it monitors, oversees and provides support to NHS Trusts to improve the provision of healthcare services to patients.

2014-2018, which we re-aggregate at Trust level. The NSS are annual staff surveys commissioned by the NHS to collect information on NHS employees' experiences and wellbeing at work (NHS England, 2022). The NSS data is a valuable resource to understand the differences in nursing staff's beliefs and perceptions about their workplace, which can be correlated with the ability of a given Trust to retain its nursing workforce. In the regression analysis we exploit Trust-level variables from the NSS data before the RDSP was launched as baseline covariates to enforce one of our main robustness checks, i.e. the difference-in-differences under *conditional* parallel trend assumption. Figure A1 illustrates the structure of our data and its setup.

Finally, to investigate the potential impact of the RDSP on hospital quality and productivity, we construct a monthly Trust-level panel using the Hospital Episode Statistics (HES) data from 2009/10 to 2019/20, which provide information on admissions to acute care English NHS hospitals. For patient outcomes, we use HES Admitted Patient Care data linked to Office of National Statistics (ONS) mortality data at patient level to calculate 30-day monthly standardized hospital mortality indicators (SHMI) and emergency re-admission rates for planned admissions, and to measure the hospital-level productivity as the number of emergency and planned admissions to acute care hospitals.

3.1 Measures of retention

We measure nursing retention in two ways: with the stability rate and with the NHS leaver rate, both are computed for each month on a year-on-year basis by hospital Trust. More specifically, we define the stability rate for nurses and midwives' in Trust h at calendar time measured in month t, S_{ht}, as

$$S_{ht} = \left(\frac{\sum_h \mathbb{I}_i(\text{ employed in Trust } h \text{ at } t | \text{ employed at } t-12)}{\sum_h \mathbb{I}_i(\text{employed in Trust } h \text{ at } t-12)} \right) \times 100$$

The stability rate indicates the percentage of the nurses and midwives who were actively employed in Trust h at $t-12$ and were still employed in the same Trust at t.In other words,

we measure how many nurses and midwives are retained in a Trust on a year-on-year basis for each month, which accounts for seasonality by comparing the same month a year apart.[11] By definition, the stability rate in calendar time t, S_{ht}, reflects the leaving decisions that occurred between $t-12$ and t; this may have implications for the impact evaluation of the Programme, as we further discuss in Section 4.

The complement to the stability rate is the turnover rate, $100-S_{ht}$, which we split into churn, i.e. the rate of nurses and midwives' movements between NHS Trusts, and the NHS leaver rate (or leaver rate in short), which is the rate of nurses and midwives who leave the NHS. While the RDSP did not directly aim to reduce the number of nurses and midwives who leave the NHS, some organizational changes instigated by the RDSP may also discourage nurses from leaving the NHS. Thus, we also evaluate the impact of the RDSP on the NHS leaver rates.

We calculate the NHS leaver rate, L_{ht}, as the percentage of nurses and midwives who left their organizations at t and have not reappeared in the NHS payroll within the following six months, $t+6$, i.e.

$$L_{ht} = \left(\frac{\sum_h \mathbb{I}_i(\text{ left Trust } h \text{ between } t-12 \text{ and } t | \text{not in ESR until } t+6)}{\sum_h \mathbb{I}_i(\text{employed in Trust } h \text{ at } t-12)} \right) \times 100$$

We limit the sample for NHS leaver rates to nurses and midwives below the age of 65, which is the standard retirement age for nursing staff. Nevertheless, our measure still captures nursing staff who retire early, which is an important (and possibly preventable) source of exits from the NHS.

3.2 Empirical Strategy

We employ a difference-in-differences (DiD) strategy to assess how effective the RDSP has been in improving nursing retention in acute and mental health Trusts in the English NHS. A naive estimation of the impact of the RDSP on retention, S_{ht}, and on leaver rates, L_{ht},

[11] For example, if hospital Trust had 100 nurses and midwives in April 2017 and of those nurses and midwives 85 of them remained in the same Trust in April 2018, the stability index in April 2018, $S_{\text{April 2018}}$, is 85%.

can be achieved with the following (static) two-way fixed effects (TWFE) baseline model:

$$Y_{ht} = \mu_h + \lambda_t + \beta^{TWFE} D_{ht} + \varepsilon_{ht} \quad , \tag{1}$$

where $Y_{ht} = \{S_{ht}, L_{ht}\}$ are the retention outcomes in Trust h at calendar time t. D_{ht} is the treatment indicator, and takes the value 1 for all periods when Trusts launched the RDSP. μ_h and λ_t are Trust and calendar time fixed effects, respectively. The parameter of interest in this specification is β, which, under the parallel trends assumption, identifies the overall average treatment effect on the treated (ATT).

A common way to analyze the dynamics of treatment effects is through an event-study TWFE specification:

$$Y_{ht} = \mu_h + \lambda_t + \sum_{k=-T}^{-2} \delta_k D_h^k + \sum_{k=0}^{T} \delta_k D_h^k + \varepsilon_{ht} \quad , \tag{2}$$

where D_{ht}^k is the event-time indicator for the relative time (in months) to/from RDSP, k. The lag parameters, $\delta_{k\geq 0}$, are the estimates for the treatment effects at k, and $\delta_{k<-1}$ are pre-treatment estimates, which are conventionally used for testing the parallel trends assumption. As it is standard in the literature, we exclude the month before the RDSP launched, $k = -1$, as the reference period.[12]

Recent methodological advances in the DiD literature have shown that β in Eq. (1) and δ_s in Eq. (2) may be biased when there is a staggered treatment adoption with multiple periods and heterogenous treatment effects (Goodman-Bacon, 2021; Callaway and Sant'Anna, 2021; Sun and Abraham, 2021; de Chaisemartin and D'Haultfœuille, 2020; Borusyak et al., 2021). The bias in β^{TWFE} stems from the variance weighting of the OLS, and, more importantly, from using the early-treated units as controls for later-treated units, i.e. making "forbidden" comparisons (Goodman-Bacon, 2021; Baker et al., 2022). Compared to static TWFE, the

[12]It is also common practice to bin or trim the relative time periods that are too distant from the treatment. In our estimation of equation (2), we bin the periods before and after 12 months to/from the RDSP.

differential treatment timing becomes less concerning in event-study TWFE approach as the length of exposure to treatment (start of the RDSP in our context) is taken into account explicitly. Yet, the lead and lag estimates might still be biased due to treatment effect heterogeneity, and due to treatment effects from other relative time periods (Sun and Abraham, 2021). To avoid the bad comparisons of the TWFE, the alternative heterogeneity-robust DiD estimators either provide flexible specifications by adding interaction terms for cohorts (e.g. Sun and Abraham, 2021; Wooldridge, 2021) or by transforming the comparisons into a conventional two groups - two periods setting (i.e treatment and control, before and after) and aggregating treatment effects (Callaway and Sant'Anna, 2021).[13]

In our analysis, we evaluate the RDSP's impact on nursing retention outcomes using the methodology proposed by Callaway and Sant'Anna (2021) (CSA) and exploit the variation in the timing of the RDSP across different groups of NHS Trusts for identification.[14] We also present estimation results from the traditional TWFE regressions, and check the robustness of our results using Sun and Abraham (2021)'s (SA) interaction weighted approach.[15]

Callaway and Sant'Anna (2021) heterogeneity-robust estimator

The staggered-DiD approach by Callaway and Sant'Anna (2021) is based on a series of average treatment effect at time t for the cohort first treated at time c, $ATT(c,t)$s. In the context of our study, the cohort-time ATTs are the average treatment effects at calendar time t for hospital Trusts that started RDSP at time c. Borrowing notation from Roth et al. (2022), under parallel trends and no anticipation, the average treatment effects in

[13]For a review of TWFE and recent DiD estimation methods see Roth et al. (2022) and de Chaisemartin and D'Haultfœuille (2022).

[14]We use did package version 2.0.0 (Callaway and Sant'Anna, 2020) and csdid package (Rios-Avila et al., 2021) to estimate CSA models in R and Stata 16, respectively.

[15]SA interact relative time periods with cohort indicators, excluding indicators for never-treated group (or last treated cohort) in a linear TWFE framework. We use eventstudyinteract command in Stata 16 for estimation (Sun, 2021). The CSA and SA estimates are comparable when the control group consists of never-treated Trusts and without covariates. The inclusion of time-varying covariates (linearly) in TWFE framework requires additional assumptions (Sant'Anna and Zhao, 2020) as treatment may have different effects across subgroups of the treated Trusts (Baker et al., 2022; Roth et al., 2022).

post-treatment period when $c \leq t$:

$$ATT(c,t) = E[y_{ht} - y_{h,c-1}|C_h = c] - E[y_{ht} - y_{h,c-1}|C_h = NT] \quad ,$$

which is the difference in the retention between time t and $c-1$, i.e. the period the RDSP started in cohort c for treated Trusts in cohort c and the control group, NT. As we shall discuss, the control group can consists of Trusts that are either *never-treated* or *not-yet-treated* by t. Likewise the pre-treatment effects for the period when $c > t$ are

$$ATT(c,t) = E[y_{ht} - y_{h,t-1}|C_h = c] - E[y_{ht} - y_{h,t-1}|C_h = NT].$$

The reference period for comparison during pre-treatment periods is the preceding calendar month, $t-1$. These short-differences are in contrast to the universal reference period of dynamic TWFE or Sun and Abraham (2021) that use the last period before the treatment as the reference period for all differences.[16]

CSA also allows for parallel trends to hold after conditioning on covariates through a doubly robust estimation method.[17] As the cohort allocation of RDSP was not exactly random, imposing parallel trends conditional on past retention values and other covariates provides an additional robustness check.

Policy makers are often interested in an overall effect as well as how the effects evolve over time. An additional advantage of the CSA approach is the option to aggregate average treatment effects into a single policy effect. We can aggregate $ATT(c,t)$s to understand the overall impact of taking part in the RDSP, across cohorts and over time:

$$ATE = \sum_{c \in C} \sum_{t} \omega(c,t) \cdot ATT(c,t) \quad ,$$

[16]For a discussion on varying reference periods, see Callaway (2021).

[17]This method combines inverse probability weighting (matching) and outcome regression method to minimise mis-specification bias. The doubly-robust approach of Sant'Anna and Zhao (2020) is adapted to work under multi-period and multi-group settings in Callaway and Sant'Anna (2021).

where we choose relevant weights, $\omega(c,t)$, e.g. by different lengths of treatment exposure (event-study ATEs), or by the time each cohort spends under treatment (cohort-specific ATEs).

Trusts in Cohort 5 started the RDSP only in September 2019, which was shortly before the *de facto* end of the RDSP in January 2020 and also very close to the last period of our observation window. Thus, we consider Trusts allocated to the first four cohorts as treated, and Trusts in Cohort 5 as controls, i.e. *never-treated* Trusts.[18] One advantage of using Cohort 5 as the never-treated comparison group is that it allows us to estimate the RSDP's impact on every cohort for at least over a 12 month period. This particularly affects Cohort 4 Trusts, whose 12th month under the RDSP falls on November 2019. As such, we restrict our estimation period to end in November 2019, which coincides with the end of action plan submissions for Cohort 5. We also check the robustness of our results by changing the definition of the control group to be *not-yet-treated* Trusts, i.e. all the Trusts belonging to cohorts that have not yet started the intervention.

The setup of the RDSP as a staggered treatment fits well with the identifying assumptions of CSA's difference-in-differences approach: the RDSP was irreversible, and once the RDSP action plans were implemented by Trusts, the policies remained in place for the remainder of the sample period. There should be no anticipation effects of the treatment on treated organizations, as hospital Trusts were informed about their involvement in the RDSP only 6 weeks in advance, with only limited information about the scope and the extent of the Programme as this was delivered by the initial Retention Masterclass workshop. The short notice period minimizes the risk of potential anticipation for individual hospital Trusts. Another potential concern in this identification setting is the existence of potential spillover effects across Trusts from different cohorts. These could arise among Trusts that are geographically close to each other or have some sort of cooperation. We discount this possibility

[18]It is not possible to capture the impact of the Programme for Cohort 5 in such a limited time frame.

for a number of reasons. First, the customized nature of the retention strategies adopted by each Trust means that the strategy adopted by one may not be suitable elsewhere. Additionally, Trusts not included in the RDSP would not have access to the bespoke data and support from their supervising lead officer at NHSI. .

Sample restrictions

We restrict our attention to nursing and midwifery staff working in acute (including Community and Specialist care) and mental health care Trusts. We also exclude a small number of Trusts that have undergone organizational changes, e.g. mergers and acquisitions, from July 2016 onward, because in this case it is not possible to univocally assign a Trust to a certain cohort. We also exclude one Trust with very few nursing staff[19], one Trust that did not keep workforce information in ESR and one Trust which have started using the ESR towards the end of the sample period.

Our analysis sample includes 193 NHS Trusts observed from June 2016 to November 2019. This time window allows us to observe all Trusts in the treated group for at least 12 months before and after their enrollment into the RDSP assigned cohorts (Cohort 1 in July 2017 and Cohort 4 in November 2018).

3.3 Descriptive statistics

The RDSP included a similar number of Trusts in each cohort. Table 1 presents an overview of the NHS hospital Trusts in each RDSP cohort. The estimation sample is a balanced panel in terms of calendar time, but unbalanced with respect to the time into treatment, due to the staggered and irreversible nature of the RDSP (e.g. earlier cohorts have shorter pre-RDSP periods and longer post-RDSP periods compared to later cohorts).

In the five years before the start of the RDSP (2011/2 to 2015/16), the average monthly stability rate of nurses and midwives stood at 86.46% and the NHS leaving rate for nurses

[19]The Trust had on average only 20 nurses in each month, with the second smallest Trust having a nursing staff eight times larger.

Table 1: Overview of Cohorts in the RSDP

	Cohort 1	**Cohort 2**	**Cohort 3**	**Cohort 4**	**Control group**
RDSP launch (treatment start)	July 2017	October 2017	April 2018	November 2018	-
Number of pre-RDSP periods	13	16	22	29	41
Number of post-RDSP periods	28	25	19	12	
Number of Trusts	31	29	35	37	61
Trust-month observations	1302	1218	1470	1554	2562
Average monthly NHS-leaver rates over past 5 years, 2011/12-2015/16	8.45% (1.98)	7.79% (2.16)	7.50% (1.85)	6.68% (1.77)	6.28% (1.37)
Average monthly stability rates over past 5 years, 2011/12-2015/16	83.57% (2.69)	85.79% (2.91)	86.93% (2.43)	86.53% (3.27)	87.92% (2.35)
Distribution of past average monthly stability rates					
Bottom quartile	67.74%	27.59%	20.00%	18.92%	9.84%
Second quartile	19.35%	42.38%	22.86%	29.73%	18.03%
Third quartile	9.68%	10.34%	37.14%	24.32%	32.79%
Top quartile	3.23%	20.69%	20.00%	27.03%	39.34%

Notes: Control group consists of Trusts in Cohort 5 and two additional Trusts that were not included in the RDSP list. Past retention is the average monthly stability rates between 2011/12 - 2015/16, and the table shows the share of Trusts in each quartile within cohorts.

under the age of 65 was 7.15%. The first cohort of the RDSP had the lowest average stability rate over this period, with more than two-thirds of its Trusts in the bottom quartile of the pre-RDSP stability distribution. Compared to the first Cohort, only 27.59% of Trusts in Cohort 2 were in the bottom quartile in terms of stability (Table 1), and more than half of the Trusts in Cohorts 3 and 4 were from the top two quartiles. Nevertheless, Figure 3 shows that the distributions of pre-RDSP retention measures substantially overlap among the treated and the control group.

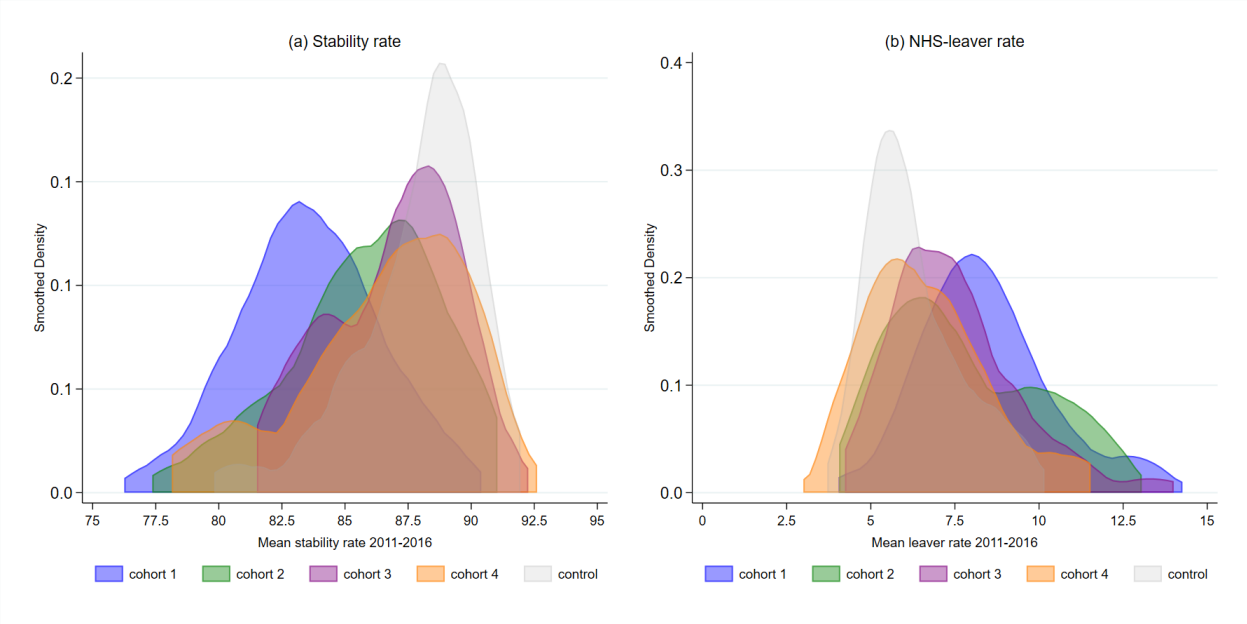
Despite differences in their retention levels, hospital Trusts across all treated cohorts experienced similar trends with decreasing (increasing) stability rates (NHS leaver rates) from early 2011/12 to 2016/17 until the RDSP was launched (see Figure A2 panels (a) and (b) in Appendix). Similarly, from a closer visual inspection of the pre-trends in Figure 4, we see that all treated cohorts exhibit retention trends similar to the control cohort in the months leading up to the RDSP.[20] This finding is not surprising, considering that the allocation of Trusts into RDSP cohorts was primarily based on the retention *levels* in the 5 years preceding the start of the Programme. As this is quite a long period, selection into the Programme

[20]In the next section, we show that parallel trends hold unconditionally under multiple hypothesis testing.

was not correlated with retention trends. In Table A1, we test the mean differences in retention outcomes between *treated* and *control* cohorts for the month before the RDSP launched (pre-RDSP) and at the end of the sample period: during the pre-RDSP period, all cohorts had significantly lower stability rates, and higher NHS leaver rates than the control group (except for Cohort 4).

Finally, Appendix Table A2 presents the summary statistics for selected characteristics from June 2017, i.e. the month before the RDSP was first launched.[21]

Figure 3: Distribution of average monthly retention measures between 2011/12 - 2015/6

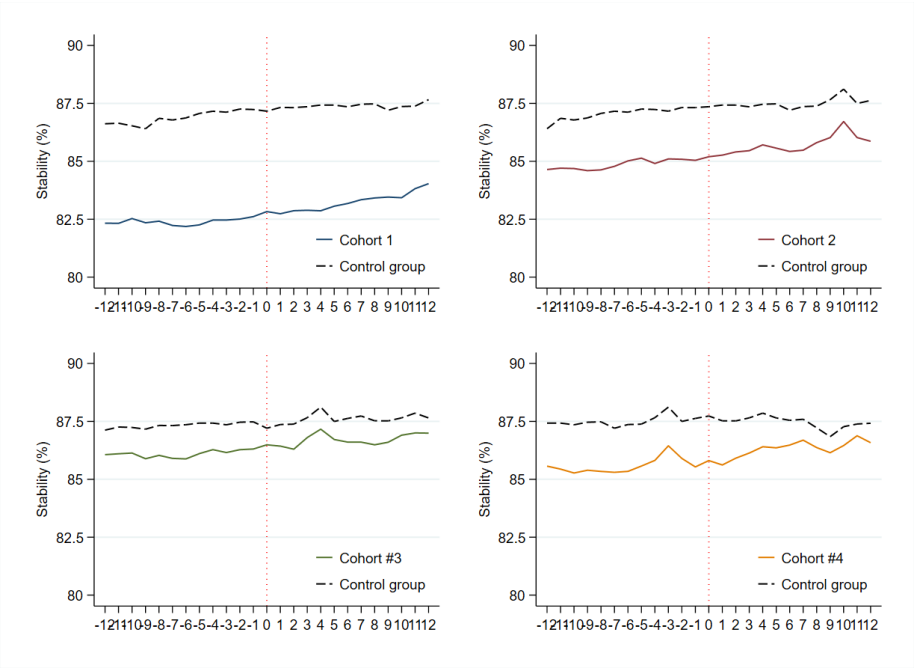


Notes: Smooth histograms are calculated using a kernel density smoother.

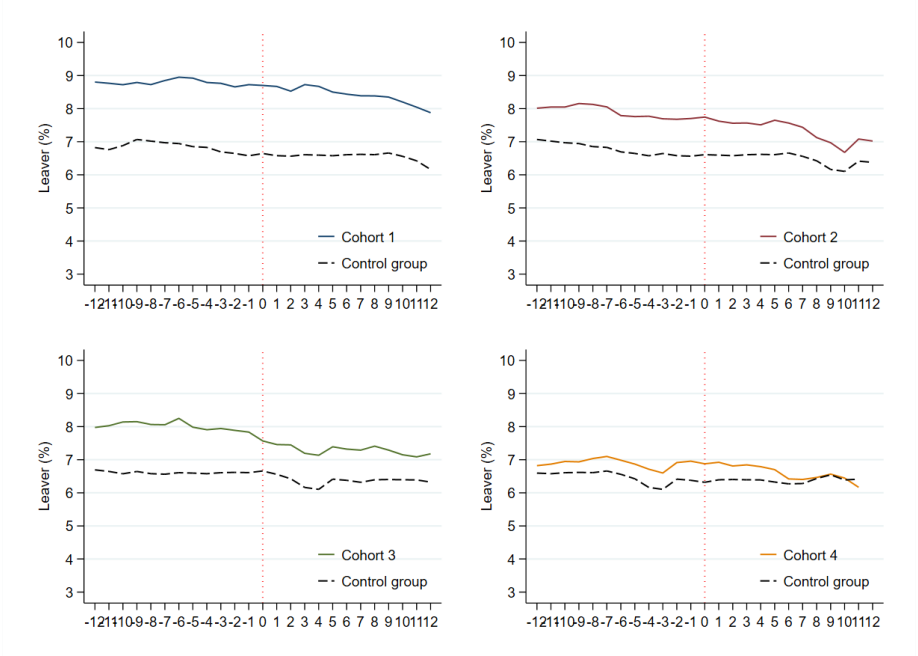
[21] The majority of nursing staff is female in all cohorts, and one-in-eight nursing staff is from overseas in the first two cohorts, whereas this rate reduces to 1 in 15 in the control cohort. There are slightly more nurses and midwives from an ethnic minority background in treated cohorts compared to in the control group. Many of these differences are likely to reflect regional labor market differences, which are not directly under the control of the Trusts.Retention also varies across regions, and this is partially reflected in the composition of the cohorts. More than a quarter of the Trusts in London and East of England were in Cohort 1, followed by one fifth of secondary care Trusts in South East. On the other hand, more than half of the Trusts in South West were in the control group. The average monthly stability rate of nurses and midwives between 2011/12 and 2015/16 ranged from 82.64% in London to 89.20% in North East and Yorkshire. Before the RDSP's roll-out, the overall nursing staff engagement stood on average at 7.15 on a scale of 0 (lowest) to 10 (highest), and only Cohort 3 had lower average engagement score than the control group in 2015 NSS.In all cohorts, more than half of the nursing staff agreed that they receive recognition for their good work. In terms of work organization, the nursing staff in control Trusts is less likely to work more than 11 additional unpaid hours than treated Trusts with around one in 16 nurses in the first cohorts working additional unpaid hours. The average monthly sickness rate is also similar across cohorts and control group in the month preceding the RDSP's first launch at around 4%.

Figure 4: Common trends between treated and control cohorts

(a) Stability rate



(b) NHS leaver rate



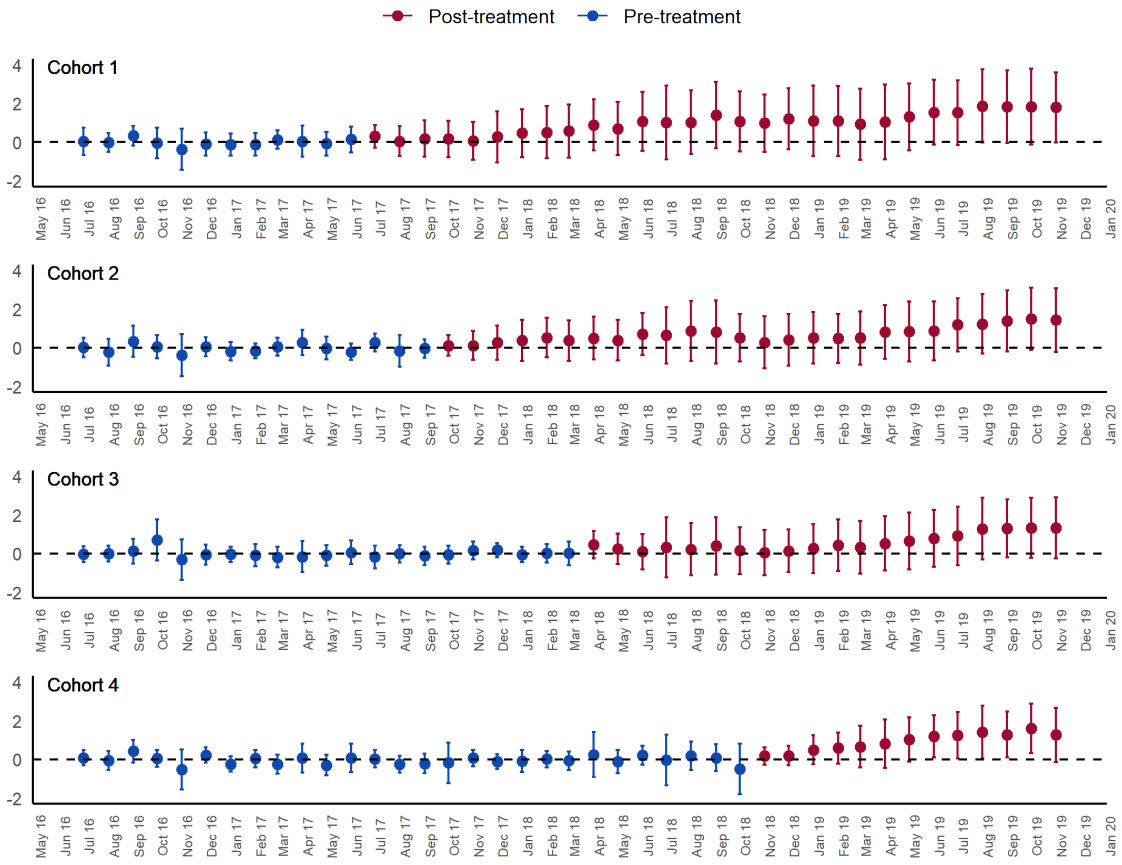
Notes: Figures are centered at the time RDSP was launched in Cohorts, Trusts, and are balanced for relative time periods. The vertical dashed line indicates the timing of the RDSP, and the figures show 12 months before and 12 months after the RDSP.

4 Results

4.1 Retention outcomes

We first discuss the RDSP's impact on stability rates. Figure 5 presents the $\widehat{ATT}(c,t)$s for each cohort and time period with 95% simultaneous confidence intervals under unconditional parallel trends. Using the augmented Wald-test proposed by CSA, we test whether the pre-treatment estimates for the 6 (12) months leading to the treatment are jointly equal to zero, which we fail to reject with a p-value for 0.273 (0.080). The Figure shows increasing treatment effects in the months after the RDSP was introduced.

Figure 5: RDSP cohort-time average treatment effects on stability rate



Notes: The effect of RDSP on nurses and midwives' stability rates under the unconditional parallel trends assumption. The point estimates are shown with simultaneous 95% confidence bands from bootstrapped standard errors allowing for clustering at Trust level.

Looking in more detail, the first group of Trusts (Cohort 1), which started the RDSP in July 2017, show positive effects from 7 months into the cohort's enrollment, with the effects

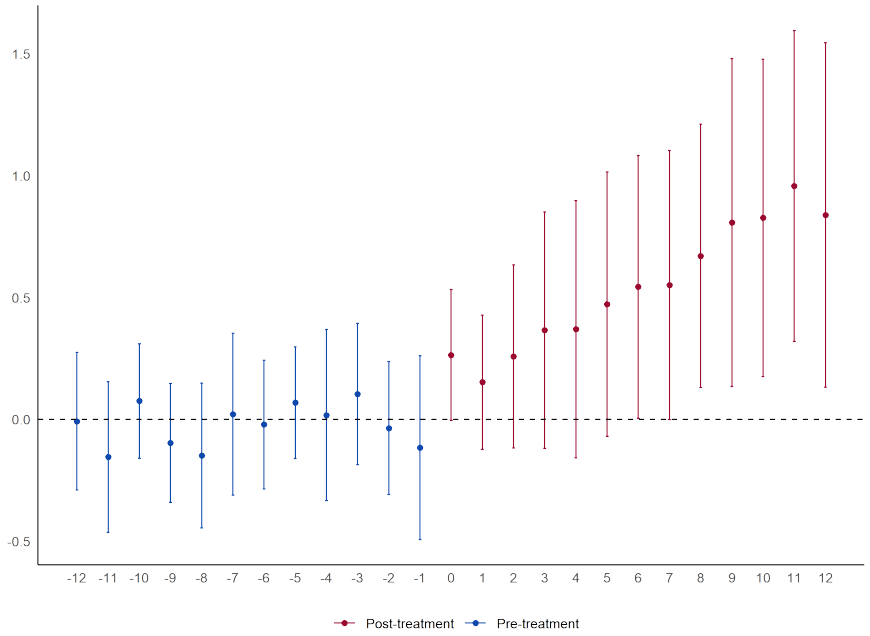
becoming statistically significant at the 5% level only towards the end of our sample period, i.e. after 24 months in the Programme. In contrast, as shown in the last panel of Figure 5, Cohort 4 Trusts experienced stronger effects after a shorter exposure to the RDSP compared to other cohorts. However, as our sample has a large number of pre- and post-treatment periods, the cohort-time ATTs are mostly imprecisely estimated. Thus, in the remainder of the paper, we focus our attention mostly on ATT estimates aggregated across the full set of Trusts or by Trusts in the same cohort, which are not only more precisely estimated, but also more policy relevant.

Figure 6 is an event-study plot of the average treatment effects for the first 12 months after the exposure to the RDSP. The average treatment effects come from a balanced sample in terms of treatment timing, i.e. all cohorts have at least 12 months post-treatment period. We find a stronger increasing impact of the RDSP over time when compared to cohort-time ATTs shown in Figure 5. On average, there is no significant impact of RDSP on stability rate in the first three months. This is likely because during this period Trusts worked on designing their Retention Improvement Action Plans, but had not implemented them yet.

We find similar results using both the dynamic TWFE and Sun and Abraham's (2020) interaction-weighted estimators. The comparison of event-study estimates is presented in Figure 7, under unconditional parallel trends. A potential explanation for the similarity between the dynamic TWFE estimates and the robust estimators is the relatively large number of *never-treated* Trusts compared to treated Trusts at each time period. The large size of the control group helps reducing the importance of negative weights at each length of exposure to treatment and minimizing the bias from using early-treated units as controls (Jakiela, 2021; Baker et al., 2022).

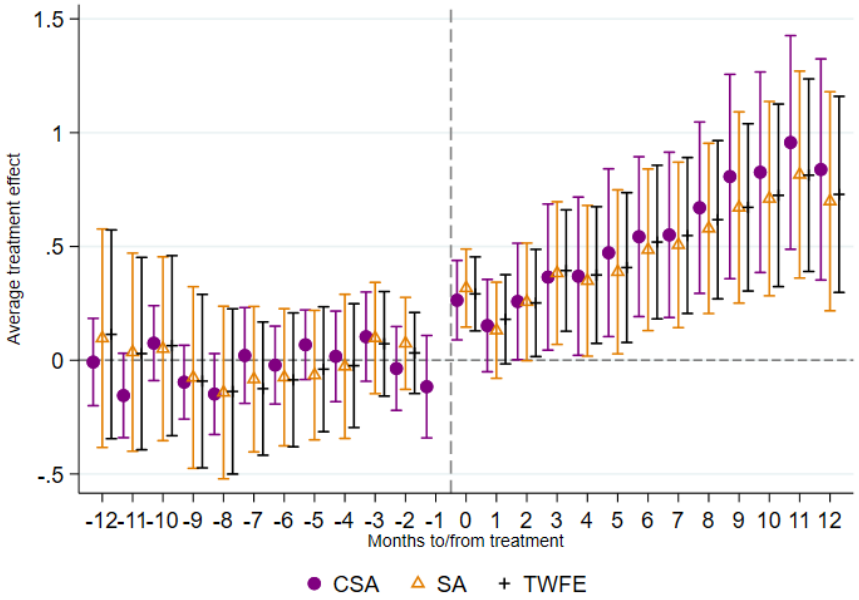
Table 2 reports the ATTs aggregated by cohort and across all cohorts (overall ATT). Under unconditional parallel trends (column 1), the highest average treatment effect is found for Cohort 1 Trusts, which on average corresponds to one-third of a standard deviation increase in nurses' stability rate. This is perhaps not surprising as these Trusts were the first to be

Figure 6: Dynamic treatment effects on stability rate



Notes: Event-study estimates under unconditional parallel trend assumption with uniform 95% confidence intervals and bootstrapped clustered standard errors allowing for clustering at Trust level using did package in R (Callaway and Sant'Anna, 2020). We use balanced cohorts with relative time periods spanning from 12 months pre- and post-treatment.

Figure 7: Dynamic treatment effects on stability rate, alternative estimators



Notes: Event-study estimates under unconditional parallel trend assumption. To facilitate comparisons across different estimators, the figure shows asymptotic standard errors clustered at Trust level with point-wise 95% confidence intervals. In Sun and Abraham (2021) and TWFE specifications, the month before the RDSP, $k = -1$, is omitted to avoid multicollinearity; and periods $k < -12$ and $k > 12$ are binned instead of trimming the sample.

Table 2: Average treatment effects of RDSP on retention outcomes

	Stability rate		**NHS-leaver rate**	
β^{TWFE}	0.472		-0.249	
	(0.170)***		(0.125)**	
Callaway and Sant'Anna (2021)				
Overall ATT	0.775	0.862	-0.408	-0.389
	(0.188)***	(0.199)***	(0.131)***	(0.137)***
	[0.196]§	[0.195]§	[0.128]§	[0.135]§
Cohort-specific ATTs				
Cohort 1	0.950	1.017	-0.498	-0.448
	(0.352)***	(0.366)***	(0.254)**	(0.261)*
	[0.360]§	[0.388]§	[0.233]	[0.278]
Cohort 2	0.677	0.616	-0.416	-0.377
	(0.303)**	(0.361)*	(0.202)**	(0.236)
	[0.309]	[0.348]	[0.209]	[0.231]
Cohort 3	0.557	0.843	-0.394	-0.386
	(0.336)*	(0.403)**	(0.248)	(0.253)
	[0.333]	[0.394]	[0.250]	[0.251]
Cohort 4	0.912	0.944	-0.341	-0.351
	(0.267)***	(0.265)***	(0.183)*	(0.183)*
	[0.269]§	[0.259]§	[0.181]	[0.183]
Conditional parallel trends (PTA)	no	yes	no	yes
PTA p-value (12 months)	0.080	0.689	0.135	0.214
PTA p-value (6 months)	0.273	0.656	0.623	0.646

Notes: Standard errors are clustered at Trust level. Asymptotic standard errors are in parentheses, and estimated using csdid package in Stata 16 (Rios-Avila et al., 2021), p-values *p<0.1; **p<0.05; ***p<0.01. Clustered bootstrapped standard errors are in brackets, and estimated using did package in R (Callaway and Sant'Anna, 2020)). § indicates that the 95% simultaneous confidence band does not cover 0. Estimation period ends in November 2019 for stability rate and October 2019 for leaving the NHS rate.

enrolled into RDSP, spending 28 months in the treatment. Despite spending less than half of the time Cohort 1 spent in RDSP, Trusts in Cohort 4 increased their retention on average by 0.91ppt in 12 months, which is equal to 28% of the standard deviation in the month before the RDSP was launched in Cohort 4. On average, the Programme had some positive, but imprecisely estimated effects on Trusts in Cohorts 2 and 3.

The cohort-specific effects provide the average treatment effect for each cohort, i.e. the

impact of being enrolled in the RDSP averaged across the time the cohort spends in the Programme. We then compute the overall impact of the Programme by taking a weighted average of the estimated cohort-specific ATTs. The overall impact of participating in the RDSP is on average a 0.78ppt increase in stability of nursing workforce in treated Trusts. The conventional counterpart of the overall ATT is DiD estimate from the TWFE, β^{TWFE}, which at 0.47ppt is almost half the size of the overall ATT under unconditional parallel trends.

We present the average treatment effects of the RDSP on the stability of nursing staff under conditional parallel trends in the second column of Table 2. Conditioning trends on observed covariates might be considered as a more credible approach compared to unconditional parallel trends assumption if retention trajectories depend on factors that would determine Trusts' allocation into cohorts. Given the nature of allocation into RDSP cohorts, this approach gives rise to an additional challenge of finding a set of covariates that provide a common support for the propensity score for Callaway and Sant'Anna (2021)'s doubly-robust estimator. As conditions, we use the difference between the average past retention of the Trust and its allocated cohort to capture variations in past retention. As shown in Figure 3, there was some variation in retention across Trusts in each cohort, providing common support for *treated* and *never-treated* Trusts. We also control for the age of creation of the Trust[22] and nurses and midwives' sickness absence rate, to capture organizational and workforce practices. In specifications using stability rates as outcomes, we also include items from the NHS Staff Surveys to characterize the workplace environment before the launch of the RDSP: the share of nurses and midwives among the NSS respondents of the Trust; and the shares of nurses and midwives who are satisfied with their recognition of good work, and with the support from their immediate managers and co-workers, which has been found to influence nursing retention (Marufu et al., 2021).[23] All these covariates are set to their pre-treatment

[22]Older Trust might have some established workforce retention practices.

[23]We also estimated alternative specifications including the share of nurses who felt unwell due to work stress, and the share of those who were bullied at work by their managers or co-workers in the last 12 months. The results are similar to the baseline model presented in Table 2, and are available upon request.

values, i.e. the month before the RDSP was launched in a cohort, and employed only to estimate the propensity score used to re-weight the effects, thus they do not influence the RDSP retention outcome directly. The doubly-robust ATTs estimates are of comparable magnitude to those estimated under unconditional parallel trends. We find that the RDSP helped increasing nurses and midwives' retention of treated NHS hospital Trusts on average by 0.86ppt. The cohort-specific ATTs are also similar, with a slight increase in magnitude particularly for Cohort 3.

Our second set of main results uses the NHS leaver rates of nurses and midwives as the retention outcome of interest, to investigate whether the RDSP reduced the loss of human capital to the NHS overall. We first estimate the impact of the RDSP on NHS leaver rates under unconditional parallel trends. The augmented Wald test on the pre-treatment estimates provides statistical evidence that the nurses and midwives' NHS leaver rates follow common trends in pre-treatment periods (see column 3 in Table 2). The RDSP had some positive impact in lowering the leaver rates in each cohort, but the cohort effects are less precisely estimated.[24]

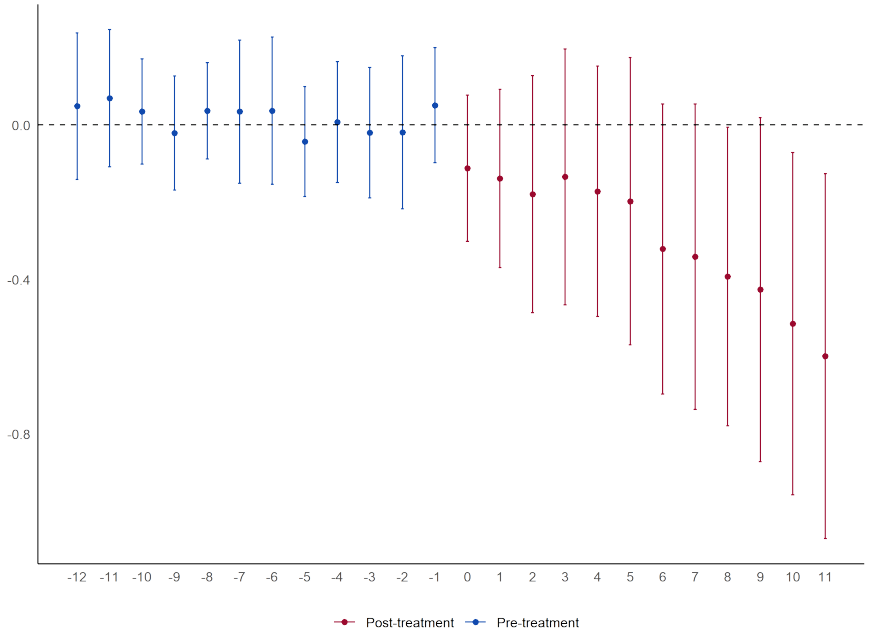
The RDSP had decreasing dynamic treatment effects on nursing staff NHS leaver rates in the first 11 months of RDSP as illustrated in Figure 8.[25] The average impact of the RDSP goes from 0.39ppt reduction in NHS leaver rate at 8 months to 0.60ppt decrease at the 11^{th} month of RDSP. As discussed above about the dynamic effects on the stability rate, another potential explanation for this decreasing pattern could be the timing of the measurement of NHS leaving rates; we return to this point in the robustness checks sub-section.

Similar to stability rates, alternative estimation methods provide similar estimates for the dynamic treatment effects (see Figure A4). When we aggregate the cohort-specific ATTs, we find that the RDSP reduced nurses and midwives' NHS leaver rates by 0.41ppt in treated

[24]Figure A3 presents the cohort-time ATTs.

[25]We focus on 11 months after the RDSP kicked off in Trusts because NHS leaver rates, as described in Section 3.1, are constructed by following up nurses and midwives in the ESR for $t + 5$ months to differentiate between churns and NHS leavers. Thus the last non-missing value for NHS leaver rates is the one for October 2019.

Figure 8: Dynamic treatment effects on leaving the NHS rate



Notes: Event-study estimates under unconditional parallel trend assumption with uniform 95% confidence intervals and bootstrapped clustered standard errors allowing for clustering at Trust level using did package in R (Callaway and Sant'Anna, 2020). We use balanced cohorts with relative time periods spanning from 12 months pre- and 11 months post-treatment.

Trusts. This amounts to one-fifth of a standard deviation decrease in the NHS leaver rates of nurses and midwives (where the SD is calculated for the month before Trusts' RDSP launch). The last column in Table 2 presents the results under conditional parallel trends[26], which are quite similar in magnitude to the ones obtained under unconditional parallel trends.

4.2 Robustness Checks

Partial treatment and the impact of the RDSP over time

As described in Section 3.1, the retention measures are calculated by computing (in each month and Trust) the share of nurses who were present 12 months before who are still in working at time t. This means that for the first twelve months after the Programme's introduction we can regard the Trusts as being only partially treated. The share of leaving

[26]Through the propensity score estimation, we indirectly control for the mean difference between the past 5 years' average NHS leaver rates of Trust and the allocated cohort, the Trust-level sickness absence rate of nurses and midwives and their pay satisfaction. These findings are robust to alternative specifications including work stress, bullying and fair career progression.

decisions taken pre-RDSP falls as we observe points closer to 12 months post-intervention, and from 12 months onwards all data comes from the post-RDSP period, allowing the full effect of the treatment to be observed. In order to check the implications of this, we compare the overall and cohort-specific ATTs in Table 2 with the censored ATTs, which we obtain by averaging the cohort-specific ATTs from 12^{th} to 19^{th} months into the Programme, and alternatively from 12^{th} months to the final observations of our sample. The censored ATT estimates are presented in Table 3.[27]

Table 3: Breakdown of RDSP impact over time

(a) Stability rates

	ATT [0,11]		**ATT [12,19]**		**ATT [12,τ]**	
Overall	0.519	[0.157]§	0.915	[0.275]§	1.096	[0.289]§
Cohort 1	0.427	[0.280]	1.104	[0.455]§	1.319	[0.425]§
Cohort 2	0.473	[0.277]	0.544	[0.407]	0.853	[0.414]§
Cohort 3	0.256	[0.327]	1.009	[0.454]§	1.009	[0.454]§
Cohort 4	0.884	[0.261]§	1.257	[0.412]§	1.257	[0.412]§

(b) NHS-leavers' rates

	ATT [0,11]		**ATT [12,18]**		**ATT [12,$\tau-1$]**	
Overall	-0.294	[0.106]§	-0.531	[0.215]§	-0.609	[0.229]§
Cohort 1	-0.270	[0.257]	-0.521	[0.308]	-0.669	[0.307]§
Cohort 2	-0.258	[0.188]	-0.507	[0.279]	-0.563	[0.312]
Cohort 3	-0.297	[0.233]	-0.560	[0.367]	-0.560	[0.367]
Cohort 4	-0.341	[0.183]				

Notes: Bootstrapped standard errors are clustered at Trust level.§ indicates that the 95% simultaneous confidence band does not cover 0. τ indicates the elapsed time of RDSP, which corresponds to November 2019 for stability rate and October 2019 for the NHS leaver rate. $\tau = 28$ for Cohort 1, $\tau = 25$ for Cohort 2, $\tau = 19$ for Cohort 3, and $\tau = 12$ for Cohort 4.

Although higher (lower) in magnitude, we find that the truncated impact of the RDSP, both overall and at cohort-specific level, on stability (NHS leaver rate) is not statistically different from the main effects reported in Table 2. The largest difference between ATT estimates is for Cohort 3, but the difference is not statistically significant (0.56 vs 1.01). From this

[27]The censored ATTs are obtained using the same unconditional PTA model, but instead of aggregating all post-treatment periods as presented in Table 2, we aggregate the ATTs only for a set of post-treatment periods on and after 12 months.

analysis we conclude that the ATTs in Table 2 are likely to be conservative point estimates of the Programme's impact, which might be even more effective in increasing nursing workforce retention. Despite this, we favor the uncensored results as they allow us to capture the impact of Programme from its point of introduction and allow the inclusion of Cohort 4, which is only observed for 12 months post-treatment.

Choice of the reference control group

In our main analyses, we use Trusts in Cohort 5 as the *never-treated* control group as they started the RDSP towards the end of the national retention Programme, and mainly consisted of Trusts that have below-average turnover rates. To this extent, we set the end of our sample period to November 2019. We do not expect any large bias to arise from this, given that the launch of RDSP for Cohort 5 occurred in September 2019 and the first 90 days since the Programme enrollment were devoted to developing and submitting the Retention Improvement Action Plan, thus without any active implementation happening before the formal agreement with the NHSI monitoring body.

To check whether our findings are sensitive to the definition of the comparison group, we re-estimate our models where our control group consists of the *not-yet-treated* Trusts, rather than the *never-treated* Cohort 5. This increases the number of Trusts in the control group for each time period, some of which might be more comparable to early treated Trusts, but comes with a disadvantage of shorter analysis period. In practice, this means that the post-treatment period spans only until August 2019, as Trusts in Cohort 5 were enrolled in the Programme from September 2019.

We present the estimation results in Table A3 for stability rates and leaving the NHS rates. Columns (II) show the results from the model using Cohort 5 Trusts as the *never-treated* control group and restricting the sample to end in August 2019 to match the sample period with the *not-yet treated* control group in columns (III). We find that the RDSP increased nursing retention on average by 0.68ppt, which is slightly, but not significantly, lower than our baseline estimates. The difference is mainly because the post-treatment period spans

only until September 2019, when the last Cohort was enrolled in the RDSP. As RDSP's impact increased over time, reducing the post-treatment period leads to a lower overall effect of RDSP on nursing retention; this occurrence may particularly affect Cohort 4, which ends prematurely at 9 months rather than 12 months and is therefore more subject to the partial treatment issue mentioned above. Our results hold for nurses and midwives' NHS leaver rates when we re-define our comparison group as not-yet treated Trusts: we find the RDSP has decreased the NHS leaver rates on average by 0.37ppt. Thus, our results are robust using Cohort 5 as the never-treated control group with the additional advantage of observing treatment effects in later periods by increasing the length of post-treatment period.

Heterogeneity analysis

Our main analysis is based on the whole population of nurses and midwives actively employed in English NHS hospital Trusts. Here we further assess whether the impact of the policy differed for particular groups of nurses and midwives. We recompute the retention measures for particular categories of nursing staff: i) those *not* on zero-hour, temporary contracts that are not shift-based (called "*Bank* staff" workers in the NHS); ii) those on permanent contracts (as opposed to workers on fixed-term contracts); iii) nurses employed by acute care Trusts (as opposed to nurses employed by mental health care Trusts); and finally, just for the stability rates, nursing staff below the legal retirement age of 65 years, i.e. the same group used for the computation of NHS leaver rates.

Table B1 presents the aggregated average treatment effects on retention outcomes for aforementioned different sub-samples, following the same CSA specifications under conditional parallel trends assumption in Section 4.1. The overall impact of the RDSP are very similar to the retention outcomes defined over a broader group of nursing staff in the baseline models. The cohort-level ATTs also exhibit similar patterns with the first and last cohorts gaining higher returns from the RDSP. The only exemption is for Cohort 3 Trusts, which significantly improved the stability of nursing staff who do not work only as Bank staff (column 2

in Table B1.[28]

4.3 RDSP effects on labor supply at the intensive margins

So far our analysis has considered nurses' and midwives' labor supply at the extensive margin as proxied by stability and NHS leaver rates, because the explicit aim of the RDSP was to reduce turnover rates and improve retention within and across Trusts. Nevertheless, some strategies outlined in action plans, such as e-Rostering[29], might have led to a re-allocation of working hours and encouraged nurses to work more.

We focus on the average monthly hours worked by nurses and midwives who work full-time.[30] In 2016, the average monthly working hours for a full time nursing staff was 166.8 hours, which is 4 hours more than the full-time contractual hours of 37.5 per week.[31] There was very little variation across full-time hours worked across cohorts in the last 3 years leading up to the RDSP (Figure A5 panel a). Yet, there were significantly fewer full-time nursing staff in the control group than there was in treated cohorts, particularly in the first two cohorts (Figure A5 panel b).

The RDSP did not have any impact on the average hours worked by full-time nurses and midwives in treated Trusts, as shown in Figure 9. This is not surprising, as the RDSP's primary target was to improve working conditions affecting staff retention, but the same conditions do not provide any strong incentive to work longer hours.

The Programme might have improved flexibility offers through additional Bank work. In 2016, the year before the RDSP was launched, the average Bank hours made up 1.5% of nurses and midwives monthly hours, and conditional on being registered as a Bank nurse or midwife the average increased to 12.3%. The share of Bank hours within nursing staff's

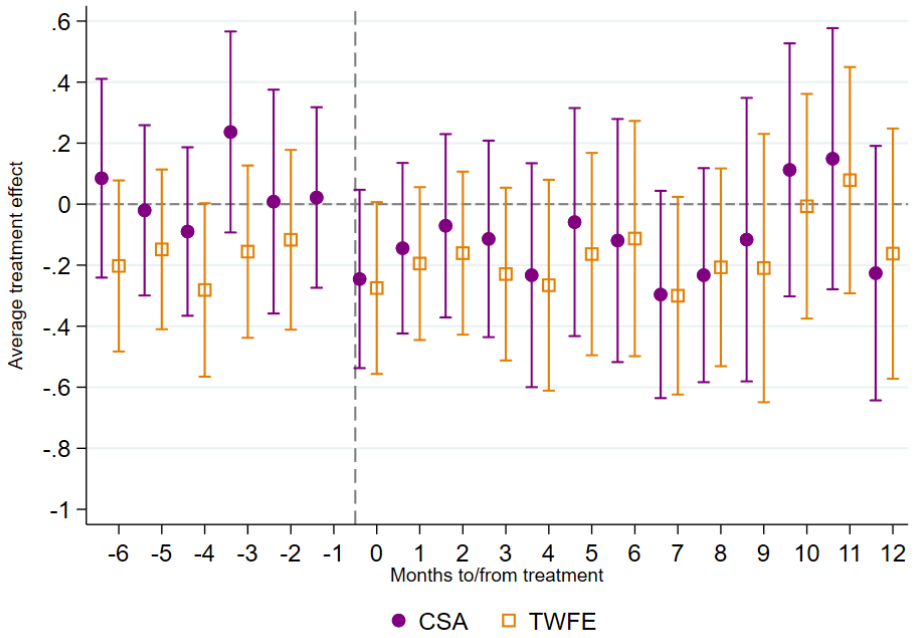
[28] The full set of results from the heterogeneity analysis are discussed in detail in Appendix B.

[29] E-Rostering is an electronic shift system that provides information on staffing levels to meet healthcare demands and also facilitate workforce flexibility.

[30] We exclude negative and zero hours from the sample, and define full-time job by the total monthly work-time equivalent (WTE) of at least 0.95. For instance, if a nurse has 2 part-time jobs in a Trust with 0.55 WTE and 0.40 WTE jobs, their total monthly WTE is 0.95, and they qualify as a full-time nurse even though they hold part-time jobs.

[31] The ESR is a payroll data, thus it does not have information on unpaid hours. Nurses and midwives are likely to work additional unpaid hours to cover shifts and provide quality patient care.

Figure 9: Dynamic average treatment effects on full-time hours worked



Notes: Hours worked is calculated using nurses and midwives who worked full-time with total WTE $\geq$ 0.95. Figure is from the model estimated under unconditional PTA, and shows estimates with 95% point-wise confidence intervals based on asymptotic standard errors clustered at Trust level. The p-value for the augmented Wald test for that CSA pre-treatment estimates in the 6 months leading up to the RDSP is 0.153. For dynamic TWFE, the periods more than 6 months before and 12 months after the RDSP are binned and not shown in the figure..

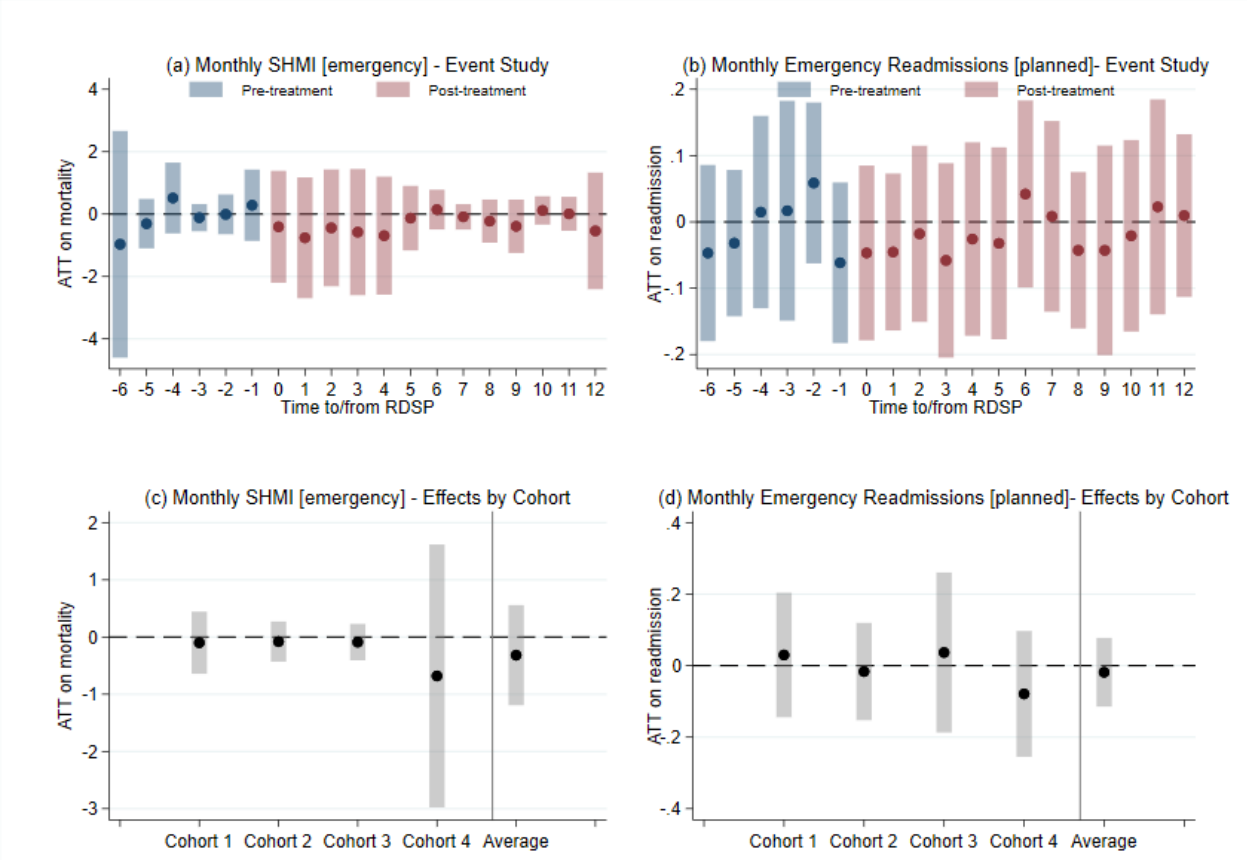
working hours converged across cohorts in 2017, and has been on an increasing trend since then (Figure A6). We do not find supporting evidence that the retention Programme had an impact on the share of Bank hours (see Figure A7).

4.4 RDSP impacts on health outcomes and hospital productivity

As mentioned in the Introduction, the impact of the RDSP on patient outcomes and hospital productivity is a priori ambiguous. For health outcomes, we compute the impact of the RDSP on two widely used indicators of hospital quality: standardized hospital mortality indicators (SHMI) for emergency patients admitted for treatment to acute care NHS hospitals and unplanned emergency re-admission rates for planned patients. The results are shown in 10, The RDSP effects on mortality are shown to be zero or negative for emergency patients in all cohorts (10 (c)), and the impact of RDSP is very close to zero for emergency re-

admission in every cohort. Neither the event-study estimates nor the cohort-level estimates are statistically significant at 5% level.

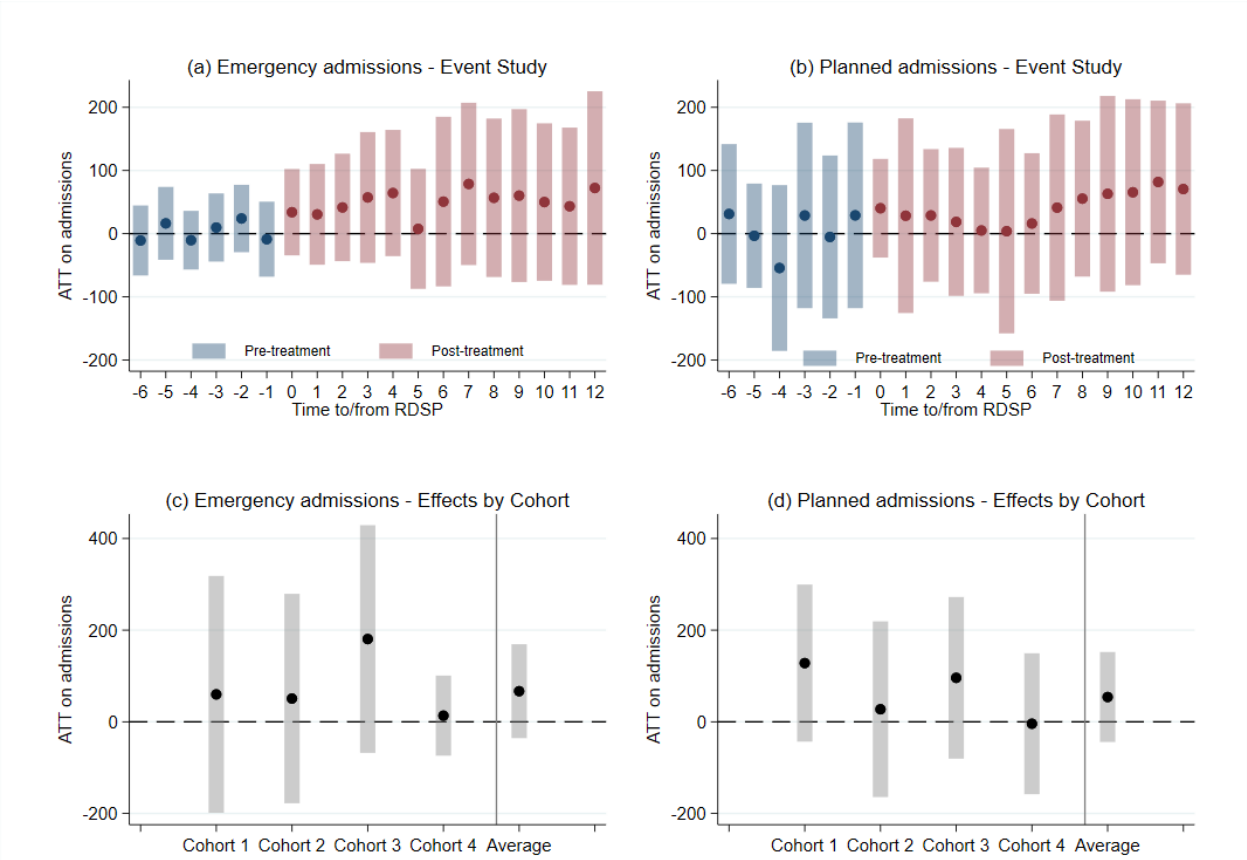
Figure 10: Effects of RDSP on risk-adjusted mortality and unplanned emergency re-admissions for patients in acute care hospitals



Notes: Average treatment effects are estimated using CSA (2020) under unconditional parallel trends assumption. The estimates are presented with uniform confidence intervals with bootstrapped standard errors clustered at hospital Trust level. The pre-treatment parallel trends hold for the 6 months preceding the RDSP with p-values 0.135 for SHMI for emergency patients and 0.088 for emergency re-admissions for planned patients.

Figure 11 reports the impact of the RDSP on the number of emergency and planned patients admitted for treatment to acute care NHS hospitals. The number of hospital admissions can be thought as a productivity indicator at organization level. The RDSP effects are shown to be positive, although never statistically significant at the 5% level, for both emergency and planned patients across all cohorts.

Figure 11: Effects of RDSP on level of admissions in acute care hospitals



Notes: Average treatment effects are estimated using CSA (2020) under unconditional parallel trends assumption. The estimates are presented with uniform confidence intervals with bootstrapped standard errors clustered at hospital Trust level. The pre-treatment parallel trends hold for the 6 months preceding the RDSP with p-values 0.159 for emergency admissions and 0.403 for planned admissions.

4.5 What works? Decomposition of cohort-specific effects on retention according to the RDSP themes

The RDSP policy has improved nurses' and midwives' retention overall. From a policy point of view we wish to understand which aspects of the policy and hospital strategies were most effective. To do so, we exploit the information that we have about the broad themes that appeared in the action plans for a large sub-sample of hospital organizations from Cohort 1 to 4 (112 Trusts out of 132 treated Trusts in our estimation sample). As discussed in Section 2.2, the categorization of the broad themes was done by the Programme's monitoring body, NHSI, and derived from an ex post grouping of the approved RDSP plans. We use this information to understand what strategies might have worked better to improve retention

across Trusts in different cohorts.

To gauge a measure of the association between specific areas of intervention and the impact on nurse retention, we focus on treated hospital organizations, and estimate the following constrained linear regression model

$$S_{ht} = \alpha + \sum_{c=1}^{4} \sum_{a=1}^{10} \beta_c^a I_{c,h} A_{a,h} D_t + \mu_h + \tau_t + \varepsilon_{ht} \quad , \tag{3}$$

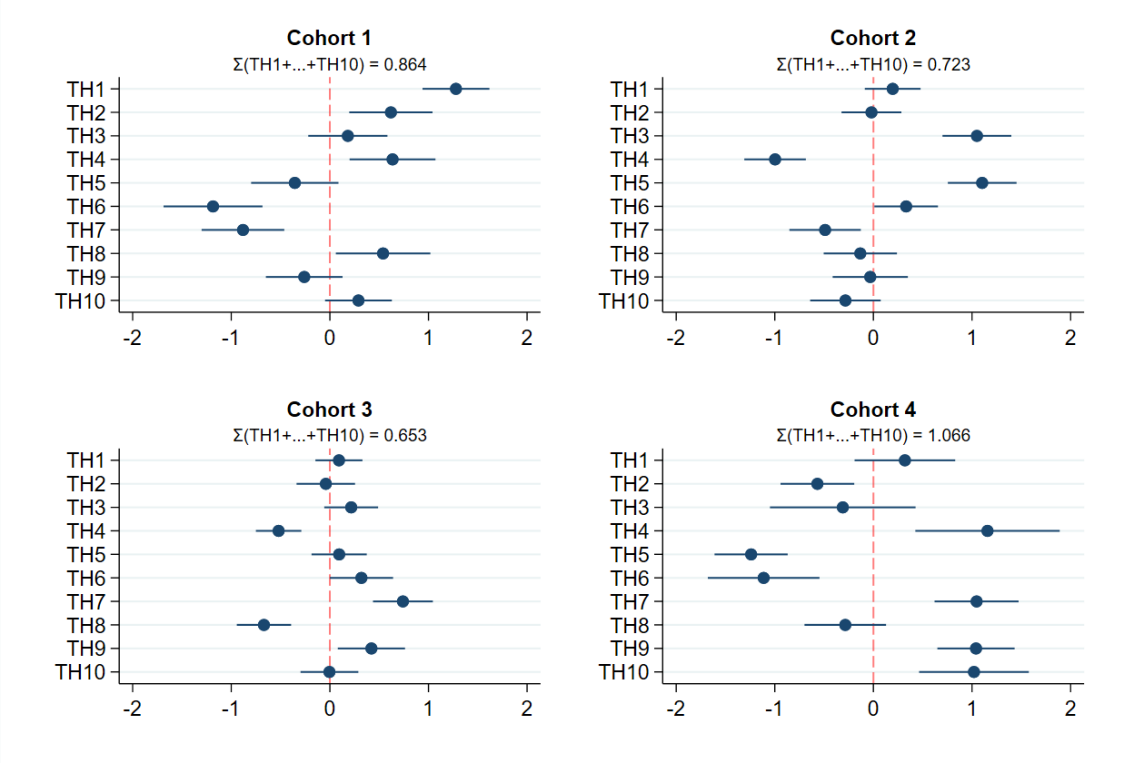
with time and hospital Trust fixed effects, and where $I_{c,h}$ is the cohort identifier for Trust h in cohort c, $A_{a,h}$ is a dummy variable for theme a adopted by Trust h during RDSP, and as before D_t takes the value one for the post-treatment period. We are interested in the parameter of the interaction term, β_c^a, which provides the difference in retention within cohorts for adopting a theme. The constraints are placed on the parameter of interests, β_c^as, where we set the sum of the estimated effects of the themes $\sum_{a=1}^{10} \beta_c^a$ for each treated cohort, $c = \{1, 2, 3, 4\}$, to be equal to the cohort-specific ATTs estimated under unconditional parallel trends assumption. The constrained regression in Eq. 3 decomposes the estimated ATTs of each cohort according to the themes chosen by the Trusts. To prevent sample selectivity issues related to the partial availability of action plans and related themes, we re-estimate the cohort-level ATTs on stability and NHS leaving rates on the sub-sample of 112 Trusts disclosing this information. The estimated ATTs are reported in Table A5 and are very similar to those in Table 2.[32] The results from this decomposition do not have a causal interpretation[33], but they can provide suggestive insights about which areas of the RDSP intervention were associated with larger gains in nursing workforce retention.

Figure 12 presents the estimated associations between action plan themes and Trusts' stability rates for each cohort.In all cohorts, we find between 3 and 5 themes with a positive and

[32]The estimated cohort-level ATTs imposed as constraints are unbiased as they depend just on the dynamic treatment assignment of RDSP cohorts. The imposition of these unbiased constraints is expected to reduce issues related to the endogeneity of the themes in our regression-based decomposition.

[33]The Action Plans (thus, also the related themes) were written by the Trusts' managers together with their respective NHSI lead officers, rather than exogenously determined.

Figure 12: Effects of RDSP themes on Stability rates for Cohorts 1-4



Notes: Results from estimating the constrained regression equation 3 using Trusts in Cohorts 1-4 with 95% confidence intervals from robust standard errors. The sum of theme parameters equals cohort-specific ATTs from a model estimated using the 112 treated Trusts that submitted an action plan with themes, and aggregated in the same fashion as in Table 2. For details on the themes within Cohorts, see Table A4.

significant impact on the stability of nurses and midwives. Retention gains are associated with different strategies (themes) in different cohorts. This is not unexpected, as the RDSP was not a prescriptive one-size-fits-all intervention, but one which allowed Trusts enough flexibility what to prioritize to improve workers' retention.

In Cohort 1, the highest positive associations are found with themes addressing the personal and professional needs of nursing staff, such as *career progression and development* (TH1), promoting *engagement and key conversations* (TH4), fostering *compassionate culture* (TH2) and *supporting staff approaching retirement* (TH8). Despite a positive but statistically insignificant impact of the RDSP on Cohorts 2 and 3 stability rates, we find some action points worked better than others in these Trusts: for Cohort 2 Trusts, the action points were centered around organizational matters such as being a*flexible* (TH3) and *an attractive*

& rewarding employer (TH6); in Cohort 3 Trusts, the retention gains are associated with *supporting new staff* (TH7) and having retention on the agenda of a Trust managers (TH9). Interestingly, the highest positive theme association on nursing stability for Cohort 2 Trusts were from the *gathering and understanding data* theme (TH5), which had been introduced as a step to identify and address barriers against retaining staff in the Trusts during RDSP retention workshops (see footnote 8). Trusts in the last treated cohort, Cohort 4, spent 12 months in RDSP until the end of our observation period. During this time, we find that a mix of staffing policies such as fostering engagement, and managerial strategies to improve retention are associated with gains in nursing stability.

Finally, the results from constrained linear regression for nursing NHS leaver rates from equation 3 are presented in Figure A8, and show patterns of associations between themes and drops in NHS leaver are very similar, although specular, to those with stability rates.

5 Conclusions

Staffing pressures are intense in the public sector as demand continues to grow while turnover rates increase. Public sector workers may be responsive to non-financial aspects of their jobs (Ashraf et al., 2014), although relatively little is known about how working conditions can be improved to increase employee retention. This paper is the first to examine the impact of a large scale, national-level intervention, the Retention Direct Support Programme (RDSP), which aimed to increase nurse retention in NHS hospital providers by improving nurses' non-financial conditions.

We find that the RDSP achieved its objective. Our most conservative estimates show that the Programme improved the stability rates of nurses and midwives by 0.78ppt on average, or almost a quarter of the between-Trust standard deviation in nursing retention. The RDSP led to the retention of 1,697 nurses and midwives who would have otherwise left their Trusts. There is a positive, but limited, impact of the Programme in reducing exits from the NHS

overall. These estimates are likely to be conservative due to the nature of our retention outcomes, computed over 12 months. When we focus our attention on the post-treatment period beginning 12 months after the RDSP enrollment, we find even larger proportionate retention gains in terms of Trust-specific stability rates and exits from the NHS.
While the RDSP succeeded in improving retention, it was insufficient to resolve the retention problem in NHS hospitals. Nevertheless, in interpreting these results it should be emphasized that we might be surprised that the policy had *any* measurable effect: this is a very light-touch intervention, which appears to have worked primarily by filling information gaps on the scale of the problem at the single hospital organization level, and by providing some examples of best practice about how it could be solved. Such an approach has the additional advantage of being relatively cheap and potentially complementary to other policies designed to alleviate workforce pressures.

A policy achieving its targets does not imply it is also cost effective. NHSI estimates that it costs £11,000 to replace a nurse (NHS Improvement, 2018), which implies the Programme saved £18,667,000 (i.e. $11,000 \times 1,697$ nurses who did not change Trust or leave the NHS) from the NHS budget. However, it is hard to compare this with the cost of the Programme: while no additional funding was made available to the treated NHS providers, it is clear that staff time was used, both in Trusts and at the NHSI monitoring body. We know little about the amount of staff time spent and even less about its opportunity cost, although we have indirect evidence that the opportunity cost was not too large - as it is not visible as reduced admissions numbers or higher mortality rates. Thus, it seems likely that the value of staff time spent per Trust was less than £141,500 per Trust on average (i.e. £18,667,000 divided by the 132 treated NHS Trusts), implying a probable cost-effectiveness of the RDSP.

The RDSP achieved its stated aim of improving staff retention, but did not benefit other hospital performance measures: we find no evidence that the Programme affected patient health outcomes or hospital productivity in either direction. However, a limit to gains in

hospital quality and productivity is largely to be expected, for several reasons. First, explicit gains beyond a reduced workforce turnover were outside the direct scope of the intervention, and they may have diverted activities away from other objectives (see Friebel et al. (2022) for a case of diversion of efforts in the private sector). Second, patient care quality and admissions are also influenced by constraints on other inputs, such as hospital doctors' capacity and the availability of hospital resources (e.g. operating theaters). The latter are respectively labor and capital inputs complementary to nurses' labor, but which were not enhanced by the RDSP intervention. Third, and related to the point above, the effects of a change in staff retention may be asymmetric, i.e. smaller when staff retention increases than when staff retention decreases, because NHS hospital wards work very close to capacity.

Finally, our results also add to the discussion of the trade-off between centralization and decentralization in the management of public organizations (Marschak, 1959; Sah and Stiglitz, 1991; Alonso et al., 2008). It appears that preserving a certain level of centralization, in terms of disseminating information and providing guidance on best practices, may help decentralized units to overcome information asymmetries. This contrasts with the paradigm that fully decentralized systems are usually more efficient (Alonso et al., 2008; Besley and Coate, 2003; Dewatripont and Maskin, 1995). Hence, our findings suggest that an effective configuration of service providers in the public sector may be achieved through an organizational structure in which centralized and decentralized decision-making units cooperate while retaining distinct functions. Such cooperation, based on a constant exchange of information flows, can be useful to monitor and evaluate the organizational performance of the decentralized branches, and, as demonstrated by the RDSP, may lead to widespread improvements in the targeted outcomes.

References

Alan, S., Corekcioglu, G. and Sutter, M. (2021), 'Improving workplace climate in large corporations: A clustered randomized intervention', *CEPR Discussion Paper No. DP16532* .

Alonso, R., Dessein, W. and Matouschek, N. (2008), 'When does coordination require centralization?', *American Economic Review* **98**(1), 145–79.

Ashraf, N., Bandiera, O. and Jack, B. K. (2014), 'No margin, no mission? a field experiment on incentives for public service delivery', *Journal of Public Economics* **120**, 1–17.

Bailey, C., Yeoman, R., Madden, A., Thompson, M. and Kerridge, G. (2019), 'A review of the empirical literature on meaningful work: Progress and research agenda', *Human Resource Development Review* **18**(1), 83–113.

Baker, A. C., Larcker, D. F. and Wang, C. C. (2022), 'How much should we trust staggered difference-in-differences estimates?', *Journal of Financial Economics* **144**(2), 370–395.

Ball, J. E., Bruyneel, L., Aiken, L. H., Sermeus, W., Sloane, D. M., Rafferty, A. M., Lindqvist, R., Tishelman, C. and Griffiths, P. (2018), 'Post-operative mortality, missed care and nurse staffing in nine countries: A cross-sectional study', *International Journal of Nursing Studies* **78**, 10–15. Special Issue: The Impact of Nursing.

Ball, J. E., Murrells, T., Rafferty, A. M., Morrow, E. and Griffiths, P. (2014), '"Care left undone" during nursing shifts: associations with workload and perceived quality of care', *BMJ Quality & Safety* **23**(2), 116–125.

BBC News (2022), 'National Insurance: Will tax changes save me money?', *BBC News* . By Reuben, Anthony and Eddington, Tom. Published online on April 6, 2022 at `https://www.bbc.co.uk/news/uk-politics-58436009`.

Besley, T. and Coate, S. (2003), 'Centralized versus decentralized provision of local public goods: a political economy approach', *Journal of public economics* **87**(12), 2611–2637.

Besley, T. and Ghatak, M. (2005), 'Competition and incentives with motivated agents', *American Economic Review* **95**(3), 616–636.

Bloom, N., Liang, J., Roberts, J. and Ying, Z. J. (2014), 'Does Working from Home Work? Evidence from a Chinese Experiment', *The Quarterly Journal of Economics* **130**(1), 165–218.

Bloom, N., Propper, C., Seiler, S. and Van Reenen, J. (2015), 'The impact of competition on management quality: evidence from public hospitals', *The Review of Economic Studies* **82**(2), 457–489.

Bloom, N. and Van Reenen, J. (2007), 'Measuring and explaining management practices across firms and countries', *The Quarterly Journal of Economics* **122**(4), 1351–1408.

Böckerman, P., Bryson, A. and Ilmakunnas, P. (2012), 'Does high involvement management improve worker wellbeing?', *Journal of Economic Behavior & Organization* **84**(2), 660–680.

Borusyak, K., Jaravel, X. and Spiess, J. (2021), 'Revisiting event study designs: Robust and efficient estimation'. arXiv preprint:2108.12419, available at `https://arxiv.org/abs/2108.12419`.

Bowles, S. and Polania-Reyes, S. (2012), 'Economic incentives and social preferences: substitutes or complements?', *Journal of Economic Literature* **50**(2), 368–425.

Brekke, K. A. and Nyborg, K. (2010), 'Selfish bakers, caring nurses? A model of work motivation', *Journal of Economic Behavior & Organization* **75**(3), 377–394.

Buchan, J. (2002), 'Nursing shortages and evidence-based interventions: a case study from Scotland', *International Nursing Review* **49**(4), 209–218.

Buchan, J., Ball, J., Shembavnekar, N. and Charlesworth, A. (2020), 'Building the NHS nursing workforce in England', *London: The Health Foundation* . https://doi.org/10.37829/HF-2020-RC14.

Buchan, J., Charlesworth, A., Gershlick, B. and Seccombe, I. (2019), 'A critical moment: NHS staffing trends, retention and attrition', *London: Health Foundation* . https://www.health.org.uk/publications/reports/a-critical-moment.

Bungeroth, L., Fennell, E. and S., A. (2018), 'Investing in a Safe and Effective Workforce: Continuing professional development for nurses in the UK'. Royal College of Nursing. Accessed on 2/11/2021 at https://www.rcn.org.uk/-/media/royal-college-of-nursing/documents/publications/2018/may/pdf-007028.pdf?la=en.

Bureau of Labor Statistics, U.S. Department of Labor (2021), 'Registered Nurses'. *Occupational Outlook Handbook*. https://www.bls.gov/ooh/healthcare/registered-nurses.htm.

Burgess, S., Propper, C., Ratto, M. and Tominey, E. (2017), 'Incentives in the public sector: evidence from a government agency', *The Economic Journal* **127**(605), F117–F141.

Callaway, B. (2021), 'Universal vs. varying base period in event studies'. November 20201. https://bcallaway11.github.io/posts/event-study-universal-v-varying-base-period.

Callaway, B. and Sant'Anna, P. H. (2020), 'did: Difference in differences'. R package version 2.0.0.

Callaway, B. and Sant'Anna, P. H. (2021), 'Difference-in-differences with multiple time periods', *Journal of Econometrics* **225**(2), 200–230. Themed Issue: Treatment Effect 1.

Cassar, L. and Meier, S. (2018), 'Nonmonetary incentives and the implications of work as a source of meaning', *Journal of Economic Perspectives* **32**(3), 215–38.

Chalofsky, N. (2003), 'An emerging construct for meaningful work', *Human Resource Development International* **6**(1), 69–83.

Cooper, Z., Gibbons, S., Jones, S. and McGuire, A. (2011), 'Does hospital competition save lives? Evidence from the English NHS patient choice reforms', *The Economic Journal* **121**(554), F228–F260.

de Chaisemartin, C. and D'Haultfœuille, X. (2020), 'Two-way fixed effects estimators with heterogeneous treatment effects', *American Economic Review* **110**(9), 2964–96.

de Chaisemartin, C. and D'Haultfœuille, X. (2022), 'Two-way fixed effects and differences-in-differences with heterogeneous treatment effects: A survey'. NBER Working Paper Series: 29691, available at http://www.nber.org/papers/w29691.

Dewatripont, M. and Maskin, E. (1995), 'Credit and efficiency in centralized and decentralized economies', *The Review of Economic Studies* **62**(4), 541–555.

Duffield, C., Diers, D., O'Brien-Pallas, L., Aisbett, C., Roche, M., King, M. and Aisbett, K. (2011), 'Nursing staffing, nursing workload, the work environment and patient outcomes', *Applied Nursing Research* **24**(4), 244–255.

Ellingsen, T. and Johannesson, M. (2008), 'Pride and prejudice: The human side of incentive theory', *American economic review* **98**(3), 990–1008.

Forbes (2015), 'The World's Biggest Employers [Infographic]', *Forbes* . By McCarthy, Niall. Published online on June 23, 2015 at https://www.forbes.com/sites/niallmccarthy/2015/06/23/the-worlds-biggest-employers-infographic/?sh=1a5b9711686b.

Friebel, G., Heinz, M. and Zubanov, N. (2022), 'Middle managers, personnel turnover, and performance: A long-term field experiment in a retail chain', *Management Science* **68**(1), 211–229.

Gallus, J. (2017), 'Fostering public good contributions with symbolic awards: A large-scale natural field experiment at Wikipedia', *Management Science* **63**(12), 3999–4015.

Gaynor, M., Moreno-Serra, R. and Propper, C. (2013), 'Death by market power: reform, competition, and patient outcomes in the National Health Service', *American Economic Journal: Economic Policy* **5**(4), 134–66.

Goodman-Bacon, A. (2021), 'Difference-in-differences with variation in treatment timing', *Journal of Econometrics* **225**(2), 254–277. Themed Issue: Treatment Effect 1.

Gosnell, G. K., List, J. A. and Metcalfe, R. D. (2020), 'The impact of management practices on employee productivity: A field experiment with airline captains', *Journal of Political Economy* **128**(4), 1195–1233.

Griffiths, P., Maruotti, A., Saucedo, A. R., Redfern, O. C., Ball, J. E., Briggs, J., Dall'Ora, C., Schmidt, P. E. and Smith, G. B. (2019), 'Nurse staffing, nursing assistants and hospital mortality: retrospective longitudinal cohort study', *BMJ Quality & Safety* **28**(8), 609–617.

Griffiths, P., Recio-Saucedo, A., Dall'Ora, C., Briggs, J., Maruotti, A., Meredith, P., Smith, G. B., Ball, J. and the Missed Care Study Group (2018), 'The association between nurse staffing and omissions in nursing care: A systematic review', *Journal of Advanced Nursing* **74**(7), 1474–1487.

Helm, C. and Bungeroth, L. (2017), 'Safe and effective staffing: the real picture'. Royal College of Nursing London. `https://www.rcn.org.uk/professional-development/publications/pub-006195`.

Hoffman, M. and Tadelis, S. (2021), 'People management skills, employee attrition, and manager rewards: An empirical analysis', *Journal of Political Economy* **129**(1), 243–285.

Holmstrom, B. and Milgrom, P. (1991), 'Multitask principal-agent analyses: Incentive contracts, asset ownership, and job design', *JL Econ. & Org.* **7**, 24.

House of Commons Health Committee (2018), The nursing workforce: Second Report of Session 2017-19, Technical report, House of Commons. `https://publications.parliament.uk/pa/cm201719/cmselect/cmhealth/353/353.pdf`.

Jakiela, P. (2021), 'Simple diagnostics for two-way fixed effects'. arXiv.2103.13229, available at `https://arxiv.org/abs/2103.13229`.

Kahn, W. A. (1990), 'Psychological conditions of personal engagement and disengagement at work', *Academy of management journal* **33**(4), 692–724.

Lee, T., Propper, C. and Stoye, G. (2019), 'Medical labour supply and the production of healthcare', *Fiscal Studies* **40**(4), 621–661.

Marangozov, R., Williams, M. and Buchan, J. (2016), 'The labour market for nurses in the UK and its relationship to the demand for, and supply of, international nurses in the NHS', *Brighton: Institute for Employment Studies* .

Marschak, T. (1959), 'Centralization and decentralization in economic organizations', *Econometrica: Journal of the Econometric Society* pp. 399–430.

Marufu, T. C., Collins, A., Vargas, L., Gillespie, L. and Almghairbi, D. (2021), 'Factors influencing retention among hospital nurses: systematic review', *British Journal of Nursing* **30**(5), 302–308.

Mas, A. and Pallais, A. (2017), 'Valuing alternative work arrangements', *American Economic Review* **107**(12), 3722–59.

McNally, S., Schmidt, L. and Valero, A. (2022), 'Do management practices matter in further education?'. Published on March 14th, 2002, available at `https://blogs.lse.ac.uk/businessreview/2022/03/14/do-management-practices-matter-in-further-education/`.

Mirror (2020), 'NHS faces fresh crisis as 250,000 nurses consider quitting because of low pay', *Mirror* . By Nelson, Nigel and McLaughlin, Chris. Published online on July 25, 2020 at https://www.mirror.co.uk/news/uk-news/nhs-faces-fresh-crisis-250000-22416470. Accessed on 19/05/2022.

Moscelli, G., Sayli, M. and Mello, M. (2022), Staff Engagement, Job Complementarity and Labour Supply: Evidence from the English NHS Hospital Workforce, IZA Discussion Papers 15126, Institute of Labor Economics (IZA).

National Audit Office (2020), 'The NHS nursing workforce', *HC 109 Session 2019-2021. Department of Health & Social Care* . https://www.nao.org.uk/report/nhs-nursing-workforce/.

NHS (2019), The NHS Long Term Plan, Technical report, NHS England and NHS Improvement. https://www.longtermplan.nhs.uk/publication/nhs-long-term-plan/.

NHS Digital (2018), 'Nurse and Health Visitor joiners and leavers from the NHS'. Accessed on 15/09/2021 at https://digital.nhs.uk/data-and-information/find-data-and-publications/supplementary-information/2018-supplementary-information-files/leavers-and-joiners/nurse-and-health-visitor-joiners-and-leavers-from-the-nhs.

NHS Digital (2021), 'NHS Vacancy Statistics England April 2015 – June 2021 Experimental Statistics'. Accessed on 14/09/2021 at https://digital.nhs.uk/data-and-information/publications/statistical/nhs-vacancies-survey/april-2015---june-2021-experimental-statistics.

NHS England (2019), 'Interim NHS People Plan'. Accessed on 14/06/2021 at https://www.longtermplan.nhs.uk/wp-content/uploads/2019/05/Interim-NHS-People-Plan_June2019.pdf.

NHS England (2022), 'NHS Staff Survey in England'. https://www.england.nhs.uk/statistics/statistical-work-areas/nhs-staff-survey-in-england/. Accessed on 14/02/2022.

NHS Improvement (2017), 'Retention Support Programme'. Accessed on 05/11/2020 at https://www.networks.nhs.uk/nhs-networks/nhsi-retention-support-cohort-1/documents/programme-outline.

NHS Improvement (2018), 'Treasuring the NHS's greatest asset - retaining our workforce'. Presented by Mark Radford, Director of Nursing, NHSI on 7th June 2018. Accessed on 16/06/2021 at https://www.hfma.org.uk/docs/default-source/educationandevents/national-events/brighter-together-2018/(2)-mark-radford.pdf?sfvrsn=2.

Perreira, T. A., Berta, W. and Herbert, M. (2018), 'The employee retention triad in health care: Exploring relationships amongst organisational justice, affective commitment and turnover intention', *Journal of Clinical Nursing* **27**(7-8), e1451–e1461.

Propper, C., Sutton, M., Whitnall, C. and Windmeijer, F. (2010), 'Incentives and targets in hospital care: evidence from a natural experiment', *Journal of Public Economics* **94**(3-4), 318–335.

Rafferty, A. M., Clarke, S. P., Coles, J., Ball, J., James, P., McKee, M. and Aiken, L. H. (2007), 'Outcomes of variation in hospital nurse staffing in English hospitals: cross-sectional analysis of survey data and discharge records', *International Journal of Nursing Studies* **44**(2), 175–182.

Rios-Avila, F., Sant'Anna, P. and Callaway, B. (2021), 'Csdid: Stata module for the estimation of difference-in-difference models with multiple time periods'. "https://EconPapers.repec.org/RePEc:boc:bocode:s458976".

Roth, J., Sant'Anna, P. H. C., Bilinski, A. and Poe, J. (2022), 'What's trending in difference-

in-differences? a synthesis of the recent econometrics literature'. Available at arXiv: https://arxiv.org/abs/2201.01194.

Sah, R. K. and Stiglitz, J. E. (1991), 'The quality of managers in centralized versus decentralized organizations', *The Quarterly Journal of Economics* **106**(1), 289–295.

Sant'Anna, P. H. and Zhao, J. (2020), 'Doubly robust difference-in-differences estimators', *Journal of Econometrics* **219**(1), 101–122.

Shields, M. A. (2004), 'Addressing nurse shortages: What can policy makers learn from the econometric evidence on nurse labour supply?', *The Economic Journal* **114**(499), F464–F498.

Shields, M. A. and Ward, M. (2001), 'Improving nurse retention in the National Health Service in England: the impact of job satisfaction on intentions to quit', *Journal of Health Economics* **20**(5), 677–701.

Sun, L. (2021), 'Eventstudyinteract: Stata module to implement the interaction weighted estimator for an event study'.

Sun, L. and Abraham, S. (2021), 'Estimating dynamic treatment effects in event studies with heterogeneous treatment effects', *Journal of Econometrics* **225**(2), 175–199. Themed Issue: Treatment Effect 1.

The Guardian (2021), 'Threat of nurses' strike over 3% pay award for NHS staff', *The Guardian* . By Campbell, Denis and Allegretti, Aubrey. Published online on July 21, 2021 at https://www.theguardian.com/society/2021/jul/21/government-offers-nhs-staff-in-england-3-pay-rise. Accessed on 19/05/2022.

The New Statesman (2021), 'Exclusive polling: Majority say NHS nurses and doctors are paid too little', *The New Statesman UK Edition* . By Chakelian, Anoosh. Published online on August 31, 2021 at https://www.newstatesman.com/politics/2021/08/exclusive-polling-majority-say-nhs-nurses-and-doctors-are-paid-too-little. Accessed on 19/05/2022.

The Open University (2018), Tackling the nursing shortage, Technical report, The Open University. https://cdn.ps.emap.com/wp-content/uploads/sites/3/2018/05/The_Open_University_Tackling_the_nursing_shortage_Report_2018.pdf.

The Times (2021), 'NHS staff's 3% pay rise 'likely to come out of social care tax'', *The Times* . By Swinford, Steven and Smyth, Chris and Dathan, Matt and Woolcock, Nicola. Published online on July 22, 2021 at https://www.thetimes.co.uk/article/nhs-staffs-3-pay-rise-likely-to-come-out-of-social-care-tax-0w226n8fw.

Tikkanen, R., Osborn, R., Mossialos, E., A, D. and GA, W. (2020), 'International health care system profiles'. Accessed on 22/10/2021 at https://www.commonwealthfund.org/international-health-policy-center/countries/england.

Verbeeten, F. H. (2008), 'Performance management practices in public sector organizations: Impact on performance', *Accounting, Auditing & Accountability Journal* .

Wooldridge, J. M. (2021), Two-way fixed effects, the two-way mundlak regression, and difference-in-differences estimators. (August 17, 2021). Available at SSRN:http://dx.doi.org/10.2139/ssrn.3906345.

Table A1: Average retention before and after the RDSP by cohort

	Stability rate		**NHS-leavers rate**	
	Pre-RDSP	**End of RDSP**	**Pre-RDSP**	**End of RDSP**
Cohort 1	82.613	84.580	8.725	7.363
	(2.838)	(2.758)	(1.805)	(1.876)
Control	87.238	87.419	6.576	6.415
	(2.770)	(3.105)	(1.569)	(1.754)
$\Delta(C1 - Control)$	-4.625***	-2.839***	2.149***	0.948**
	(0.616)	(0.660)	(0.364)	(0.396)
Cohort 2	85.042	86.569	7.702	6.72
	(3.204)	(2.662)	(1.905)	(1.554)
Control	87.319	87.419	6.564	6.415
	(2.811)	(3.105)	(1.776)	(1.754)
$\Delta(C2 - Control)$	-2.277***	-0.851	1.139***	0.306
	(0.664)	(0.670)	(0.410)	(0.382)
Cohort 3	86.307	87.562	7.836	6.791
	(3.210)	(2.286)	(2.303)	(1.823)
Control	87.481	87.419	6.611	6.415
	(2.711)	(3.105)	(1.904)	(1.754)
$\Delta(C3 - Control)$	-1.175*	0.142	1.226***	0.376
	(0.615)	(0.601)	(0.436)	(0.377)
Cohort 4	85.534	86.581	6.957	6.168
	(3.239)	(3.124)	(1.557)	(1.772)
Control	87.629	87.419	6.379	6.415
	(2.619)	(3.105)	(1.796)	(1.754)
$\Delta(C4 - Control)$	-2.095***	-0.838	0.579	-0.247
	(0.597)	(0.648)	(0.356)	(0.367)

Notes: Pre-RDSP averages are calculated for the month before the RDSP was launched in Trusts, i.e. the timings for each cohort are June 2017, September 2017, March 2018, and October 2018, respectively. The end of the RDSP statistics are based on the stability rates in November 2019, and on NHS leaver rates in October 2019. For cohorts, standard deviations are in parentheses, and for $\Delta(C - Control)$ standard errors are in parentheses with p-values *p<0.1; **p<0.05; ***p<0.01.

Table A2: Sample summary statistics by cohort, pre-RDSP (measured in June 2017)

	Cohort 1		Cohort 2		Cohort 3		Cohort 4		Control cohort	
	Mean	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**	**Mean**	**Std dev**
Nursing workforce composition in Trust										
Share of female nurses and midwives, %	87.339	6.296	84.909	9.629	85.913	8.244	91.691	4.663	92.538	2.906
Average age	42.705	2.372	43.648	2.280	43.410	2.166	42.217	2.504	42.676	2.114
Share from the EU, %	9.648	7.002	6.339	4.814	6.138	6.215	6.940	5.032	5.864	5.450
Share from Overseas, %	12.123	7.983	11.295	8.853	8.179	8.072	8.477	6.063	6.467	4.752
Share from ethnic minority background, %	27.635	18.570	25.035	20.766	14.914	14.280	21.275	17.283	12.624	10.050
Other Trust characteristics and outcomes										
All staff headcount (size of Trust)	4,801	2,993	4,914	2,710	5,063	2,598	5,331	3,530	5,280	2,864
Number of nurses and midwives	1,632	1,165	1,557	860	1,671	929	1,707	1,057	1,659	850
Trust age (years from foundation)	18.194	6.660	17.483	6.027	18.200	5.925	20.351	5.554	20.016	6.201
Sickness absence rate, %	4.037	1.137	4.241	0.805	4.357	0.935	4.269	1.019	4.204	0.787
Average hours worked (full-time, ¿=0)	166.631	4.524	166.341	4.831	167.430	3.475	166.374	3.928	166.824	2.814
Share of Bank hours in average hours worked, %	1.716	2.098	1.564	1.913	1.791	1.868	1.568	1.821	1.489	1.430
Monthly SHMI, emergency patients	2.722	1.320	2.876	0.506	2.963	0.695	2.579	1.201	2.753	0.782
Monthly emergency readmission rate, electives	1.167	0.656	0.882	0.330	1.046	0.298	1.249	1.202	0.989	0.533
Number of emergency admissions	2,780	2,046	3,305	1,803	3,272	1,757	2,691	2,038	2,814	1,648
Number of elective admissions	4,804	4,493	5,162	3,318	4,765	2,992	4,991	4,239	4,866	3,393
NSS 2015 items										
Overall engagement score	7.204	0.275	7.096	0.321	6.999	0.345	7.224	0.315	7.207	0.333
Share of nursing staff (%) who										
Worked at least 11 hours additional unpaid hours per week	6.984	3.001	6.411	2.708	5.200	2.452	5.115	2.325	4.433	1.985
Recognised for good work	53.307	4.284	54.042	5.230	52.962	6.802	51.788	7.268	52.647	7.168
Felt unwell due work stress in the last 12 months	41.076	5.685	42.248	6.357	43.216	7.021	40.234	5.077	39.668	6.414
Satisfied with the support from immediate manager	69.014	4.327	70.055	5.309	70.148	5.807	67.745	6.237	68.494	5.224
Satisfied with the support from colleagues	83.694	4.728	85.245	4.272	85.416	3.242	83.587	4.104	85.800	3.695
NHS regions										
East of England	0.194	0.402	0.172	0.384	0.114	0.323	0.000	0.000	0.098	0.300
London	0.290	0.461	0.276	0.455	0.057	0.236	0.216	0.417	0.082	0.277
Midlands	0.097	0.301	0.172	0.384	0.200	0.406	0.189	0.397	0.180	0.388
North East and Yorkshire	0.032	0.180	0.103	0.310	0.143	0.355	0.189	0.397	0.180	0.388
North West	0.129	0.341	0.103	0.310	0.114	0.323	0.216	0.417	0.180	0.388
South East	0.194	0.402	0.103	0.310	0.257	0.443	0.135	0.347	0.082	0.277
South West	0.065	0.250	0.069	0.258	0.114	0.323	0.054	0.229	0.197	0.401

Notes: Nursing workforce compositions are averages from previous financial year and calculated using the ESR. Staff headcounts come from NHS Workforce Statistics. NSS 2015 items are calculated from individual level data for nurses and midwives. † SHMI and admission numbers are calculated for acute care NHS Trusts only, thus the sample sizes for each cohort is smaller than for other summary statistics.

Table A3: Stability rates: never-treated vs. not-yet-treated comparison groups

	Stability rate			**Leaving the NHS rate**		
	(I)	**(II)**	**(III)**	**(I)**	**(II)**	**(III)**
Control group	Never-treated	Never-treated	Not-yet-treated	Never-treated	Never-treated	Not-yet-treated
Post-treatment until	November 2019	August 2019	August 2019	October 2019	August 2019	August 2019
overall ATT	0.775	0.656	0.677	-0.408	-0.361	-0.371
	(0.188)***	(0.180)***	(0.176)***	(0.131)***	(0.126)***	(0.125)***
	[0.196]§	[0.182]§	[0.174]§	[0.128]§	[0.125]§	[0.120]§
partially aggregated						
Cohort 1	0.950	0.851	0.971	-0.498	-0.454	-0.481
	(0.352)***	(0.340)**	(0.324)***	(0.254)**	(0.251)*	(0.244)**
	[0.360]§	[0.329]§	[0.349]§	[0.233]	[0.261]	[0.262]
Cohort 2	0.677	0.579	0.589	-0.416	-0.388	-0.394
	(0.303)**	(0.289)***	(0.278)**	(0.202)**	(0.196)**	(0.189)**
	[0.309]	[0.273]	[0.280]	[0.209]	[0.199]	[0.193]
Cohort 3	0.557	0.424	0.378	-0.394	-0.348	-0.358
	(0.336)*	(0.327)	(0.319)	-0.248	(0.242)	(0.234)
	[0.333]	[0.351]	[0.323]	[0.250]	[0.241]	[0.234]
Cohort 4	0.912	0.773	0.773	-0.341	-0.274	-0.274
	(0.267)***	(0.258)***	(0.258)***	(0.183)*	(0.169)	(0.169)
	[0.269]§	[0.255]§	[0.266]§	[0.181]	[0.166]	[0.166]
pre-trend Wald test (df = 48) p-value	0.080	0.080	0.236	0.135	0.135	0.083

Notes: Aggregated treatment effect parameters under the Unconditional DiD Assumption of CSA with never-treated Trusts as control group. Asymptotic standard errors are in parentheses, and estimated using csdid package in Stata (Rios-Avila et al., 2021), p-values *p<0.1; **p<0.05; ***p<0.01. Clustered bootstrapped standard errors are in brackets, and estimated using did package in R (Callaway and Sant'Anna, 2020). The cohort-specific effects take into account selective treatment timing. § indicates that the 95% simultaneous confidence band does not cover 0.

Table A4: RDSP Action Plans by cohorts, theme frequencies (%)

	Cohort 1	**Cohort 2**	**Cohort 3**	**Cohort 4**	**Total**
TH1: Career progression & development	81.48	88.89	76.47	83.33	82.14
TH2: Compassionate culture	66.67	66.67	64.71	58.33	64.29
TH3: Being a flexible employer	44.44	55.56	41.18	70.83	51.79
TH4: Engagement and key conversations	22.22	37.04	52.94	37.50	38.39
TH5: Gathering and understanding data	40.74	33.33	44.12	37.50	39.29
TH6: Being an attractive & rewarding employer	44.44	51.85	29.41	20.83	36.61
TH7: Supporting new starters & newly qualified staff	40.74	33.33	35.29	41.67	37.50
TH8: Supporting staff approaching retirement	29.63	25.93	26.47	50.00	32.14
TH9: Retention as part of executive leadership & Trust strategy	37.04	29.63	20.59	25.00	27.68
TH10: Narrowing the front door to close the back door	33.33	14.81	26.47	12.50	22.32
Number of action plans	27	27	34	24	112

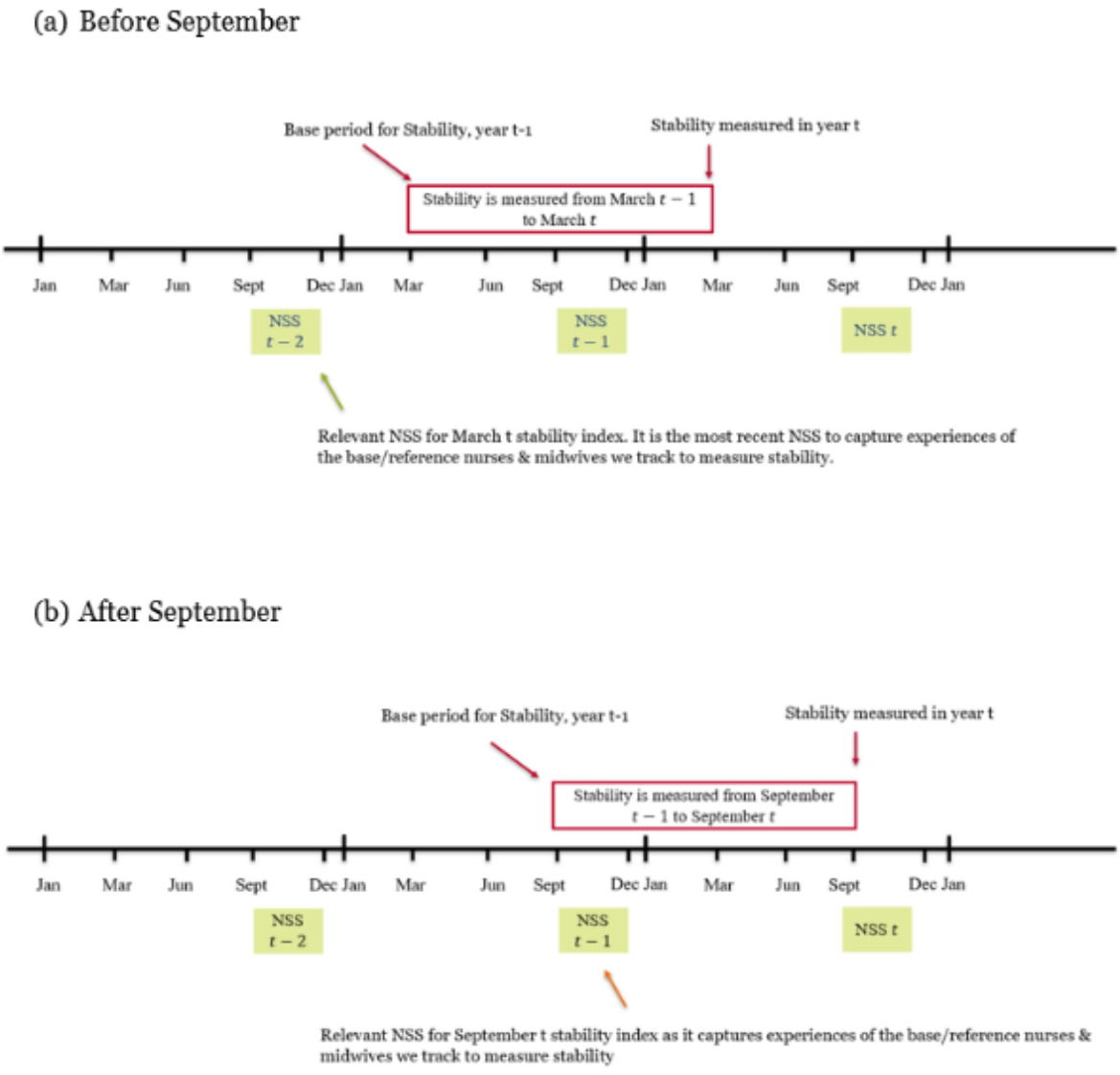
Notes: The statistics come from a sub-sample of Trusts from Cohorts 1 to 4 that submitted action plans, i.e. excludes 15 Trusts. The breakdown of excluded Trusts by cohort are: 4 Trusts in Cohort 1, 8 in Cohort 4 and one Trust each in Cohorts 2 and 3. Also, 6 Trusts were not recorded in NHSI's action plan data (83.3%) were in Cohort 4.

Table A5: Overall and cohort level impact of RDSP for Trusts that submitted Action Plans

	Stability rate		NHS-leaver rate	
Overall ATT	0.810	[0.196]§	-0.436	[0.148]§
Cohort-specific ATTs				
Cohort 1	0.864	[0.345]§	-0.489	[0.267]
Cohort 2	0.723	[0.334]	-0.471	[0.211]
Cohort 3	0.653	[0.326]	-0.420	[0.261]
Cohort 4	1.066	[0.294]§	-0.358	[0.180]
Pre-trend test p-value				
PTA p-value (6 month)	0.463		0.723	

Notes: Using only Trusts that submitted Action Plans as treated units. Aggregated treatment effect parameters under the unconditional parallel trends assumption of CSA with never-treated Trusts as control group. Clustered bootstrapped standard errors are in brackets. § indicates that the 95% simultaneous confidence band does not cover 0.

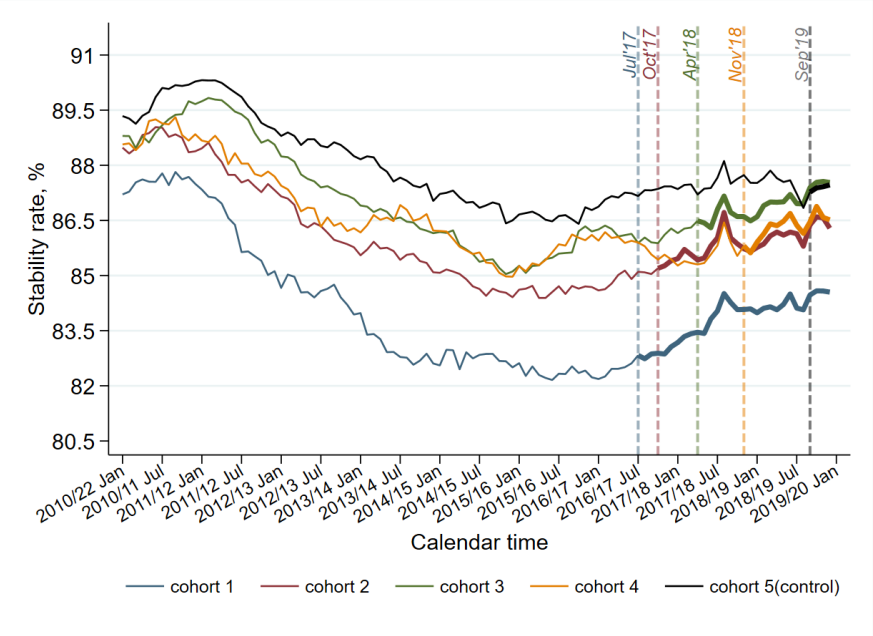
Figure A1: Data setup



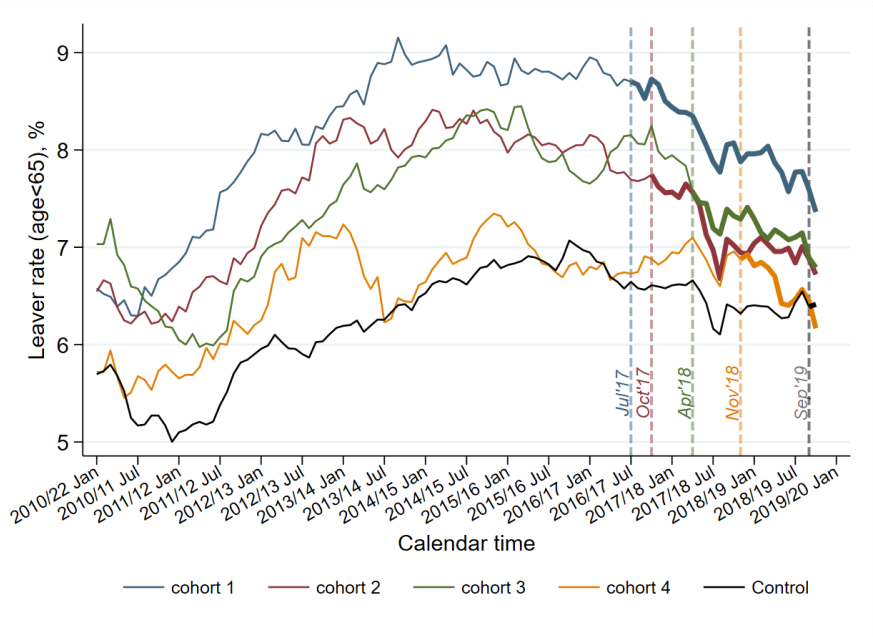
Notes: The same holds for NHS leaver rates. t refers to the analysis year, $t-1$ is the base year. NSS refers to the NHS Staff Survey which is conducted every year in autumn since 2003. Staff working in Trusts in 1st September are eligible to respond to the NSS. The NSS runs from the mid-September and remains open on average 8 weeks.

Figure A2: Each cohort's retention profile and RDSP launch dates

(a) Stability rates from 2010/11 to 2019/20

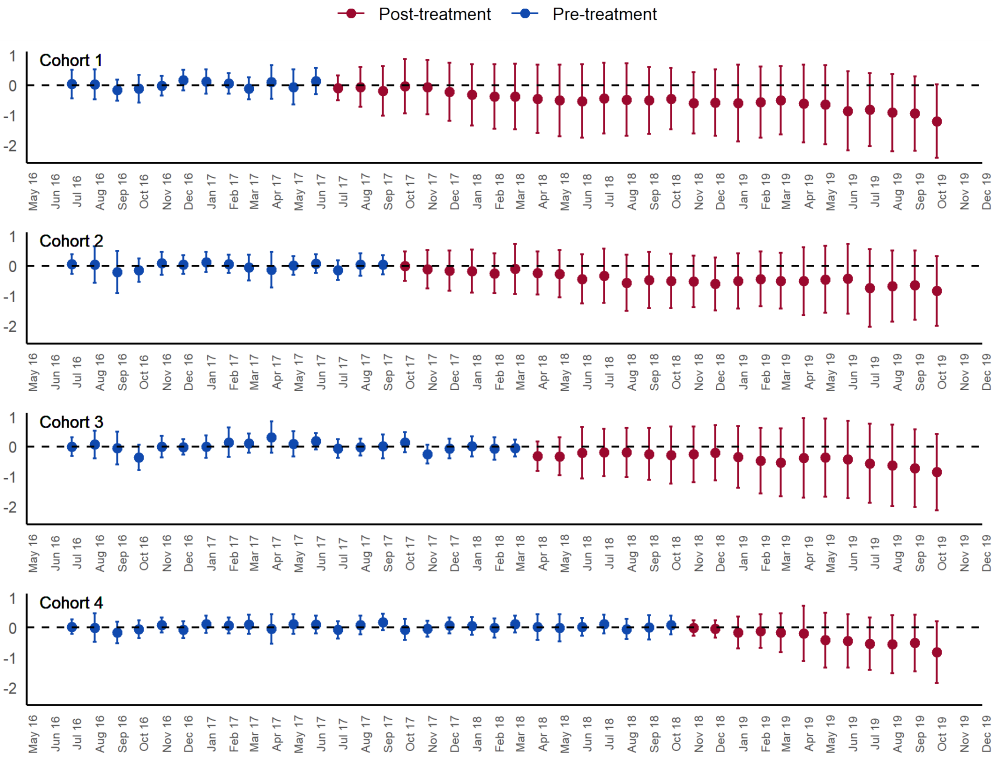


(b) NHS Leaver rates from 2010/11 to 2019/20



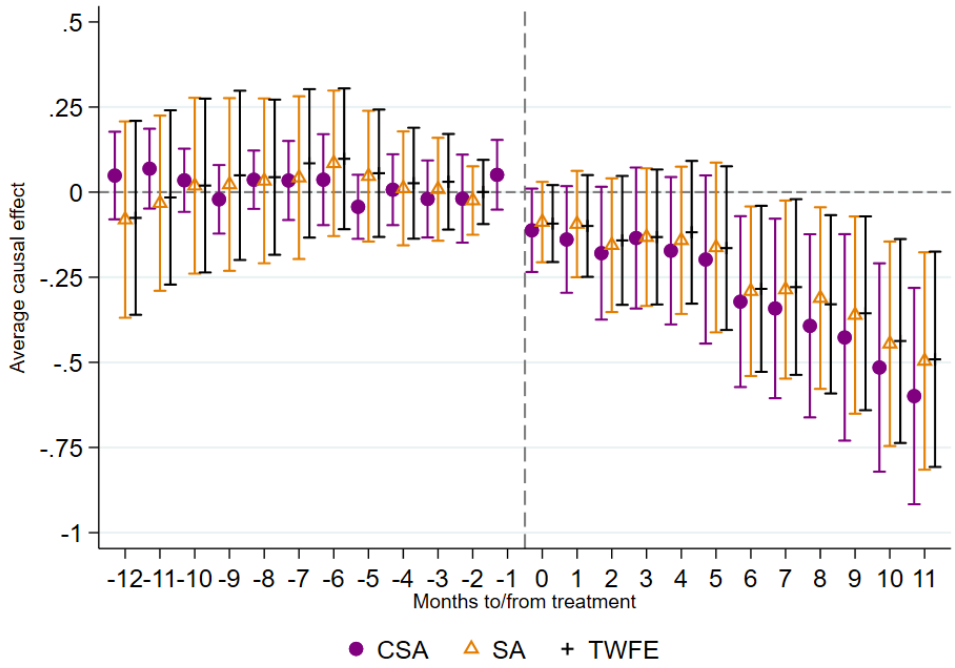
Notes: Cohort 5 includes 2 additional trusts that were not in the NHSI allocation. Vertical lines show the RDSP start dates for each cohort, and the thicker horizontal lines indicate post-RDSP period in each cohort.

Figure A3: RDSP cohort-time average treatment effects on NHS leaver rate



Notes: The effect of RDSP on nurses and midwives' leaving the NHS rates under the unconditional parallel trends assumption. The point estimates are shown with simultaneous 95% confidence bands from bootstrapped standard errors allowing for clustering at Trust level.

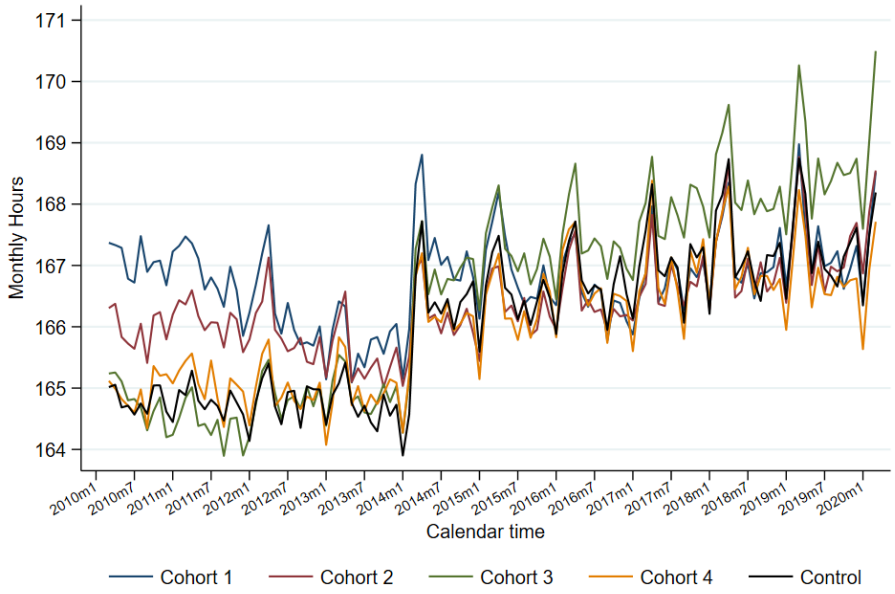
Figure A4: Dynamic treatment effects on leaving the NHS rate, alternative estimators



Notes: Event-study estimates under unconditional parallel trend assumption. To facilitate comparisons across different estimators, CSA estimates are illustrated with (asymptotic normal) clustered standard errors with 95% confidence intervals. In Sun and Abraham (2021) and TWFE specifications, the month before the RDSP, $k = -1$, is omitted to avoid multicollinearity; and periods $k < -12$ and $k > 12$ are binned instead of trimming the sample.

Figure A5: Full-time nursing staff and monthly hours worked

(a) Average monthly hours worked by full-time nursing workforce



(b) Share of full-time nursing staff

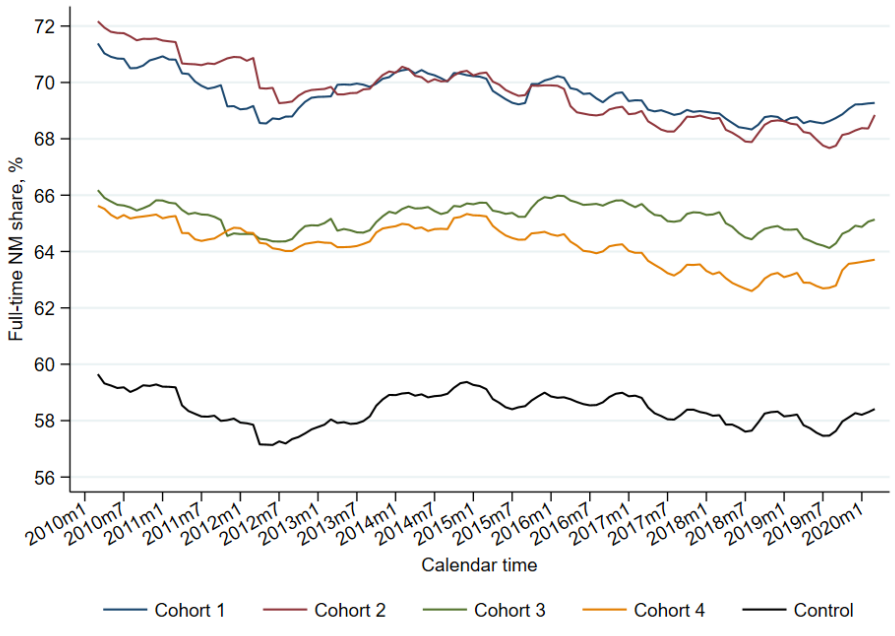
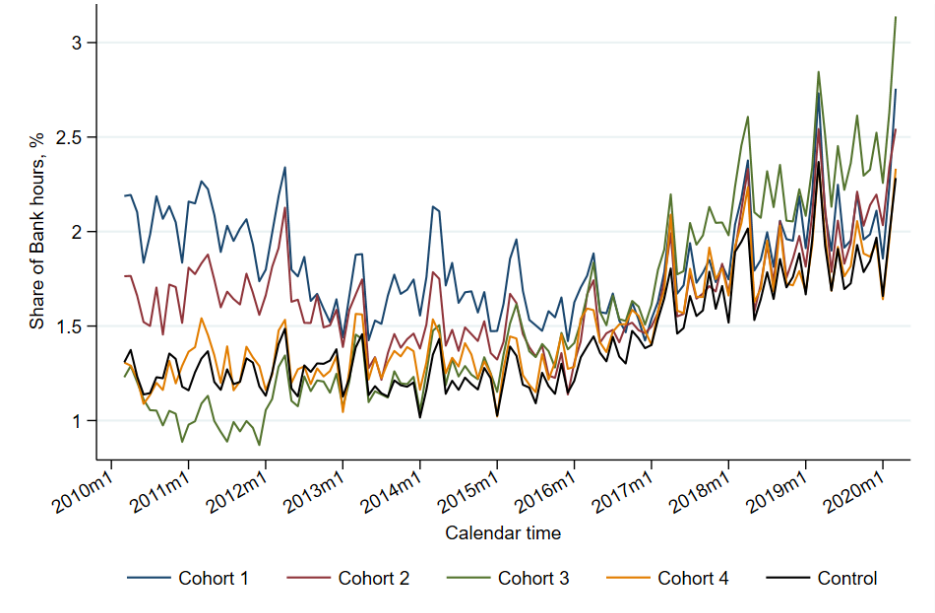
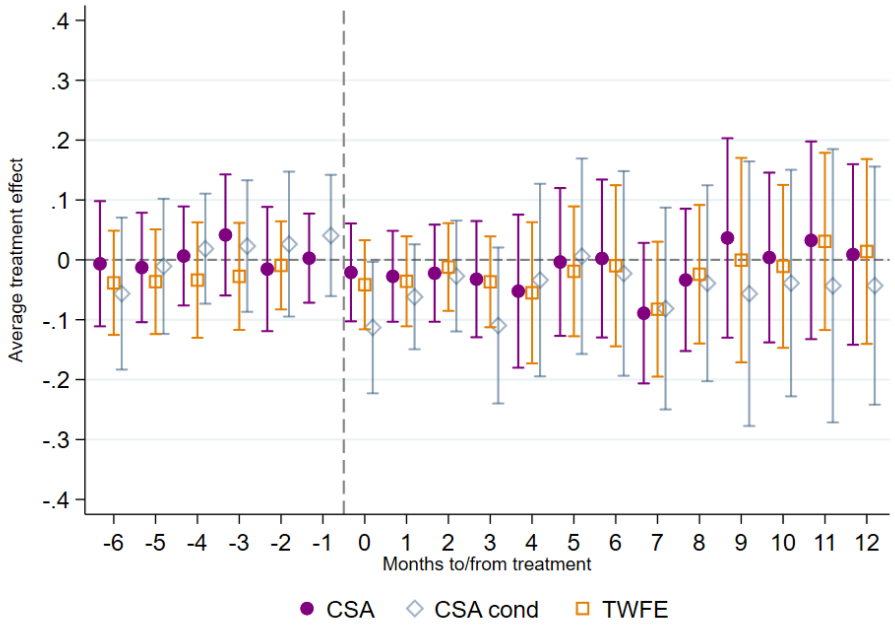


Figure A6: Share of Bank Hours within monthly hours worked by nursing staff



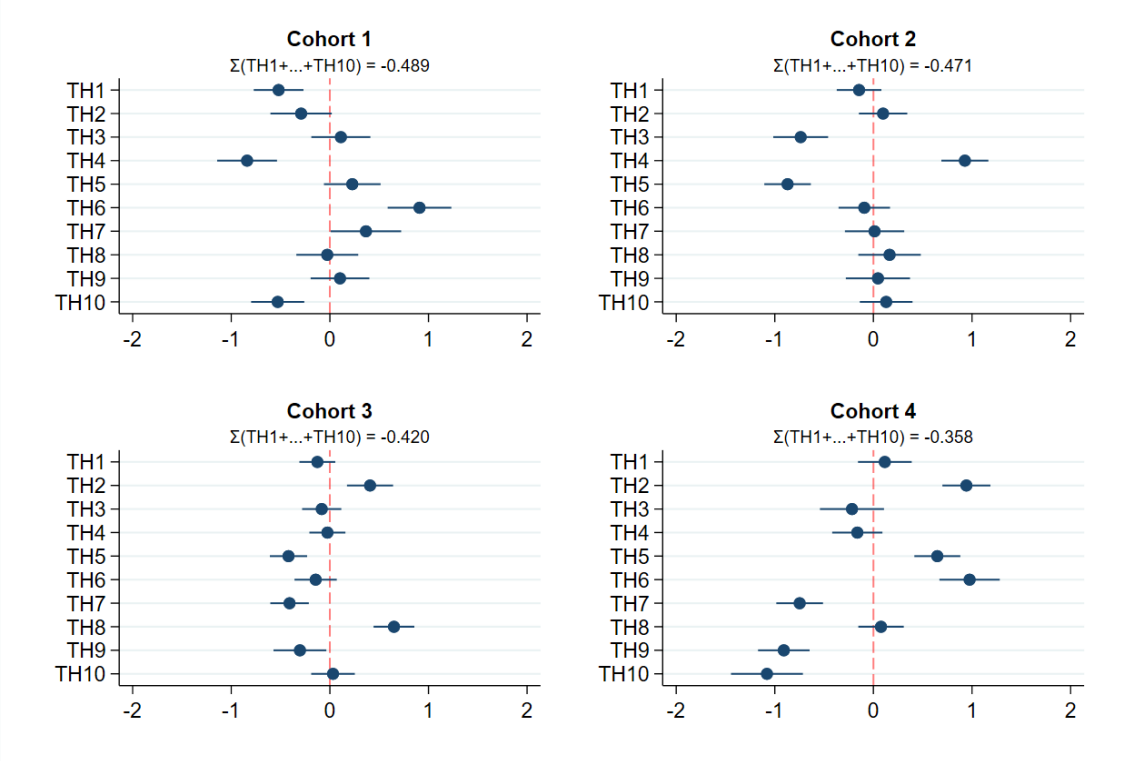
Notes: Average hours excludes negative and zero hours and includes both full-time and part-time working nurses and midwives.

Figure A7: Dynamic average treatment effects on share of Bank hours



Notes: CSA is under unconditional PTA, and "CSA cond" is the CSA estimation under conditional PTA. The set of covariates include nurses and midwives' absence rates, support from co-workers, and share of full-time nurses and midwives except for Bank work. Asymptotic standard errors are clustered at Trust level and shown with point-wise 95% confidence intervals. The p-value for the augmented Wald test for CSA that pre-treatment estimates for the 6 months preceding the treatment is 0.316 under unconditional PTA and 0.383 under conditional PTA. For the TWFE, the periods more than 6 months before and 12 months after the RDSP are binned and not shown in the figure.

Figure A8: Effects of RDSP Themes on NHS leaver rates for Cohorts 1-4



Notes: Results from estimating the constrained regression equation 3 using Trusts in Cohorts 1-4 with 95% confidence intervals from robust standard errors. The sum of theme parameters equal to cohort-specific ATTs from the model estimated using treated Trusts that submitted an action plan with themes (see Table A5, and aggregated in the same fashion as in Table 2. For details on the themes within Cohorts, see Table A4.

Appendix B: Heterogeneity analysis

This Appendix provides further discussion on the results from heterogeneity analysis on different sub-samples of nursing staff as described in Section 4.2.

The stability measure in the main analysis uses all nurses and midwives employed at a Trust between two time periods, and includes nursing staff of all ages under different contractual agreements. We have two motivations to include nursing staff who are close to or beyond the retirement age in our main stability measure: (i) The RDSP actions include strategies targeting staff close to retirement (e.g. Action Plan theme 8) such as introducing flexible retirement options and "retirement & return" policies. (ii) The rate of retirement among nurses and midwives was constant over time, and the difference is an intercept shift in stability rates. It is possible, however, that nurses nearing retirement age may be more likely to leave regardless. As a robustness check, we re-compute the stability rates by restricting our attention to nurses and midwives who are younger than 65. The estimated overall average treatment effect under this age restriction is slightly lower in magnitude, but both cohort-specific ATTs and the overall ATT presented in Column 1 in Table B1 present similar patterns to those of column 2 in Table 2 indicating that the impact of the RDSP does not work primarily through the prevention of retirements.

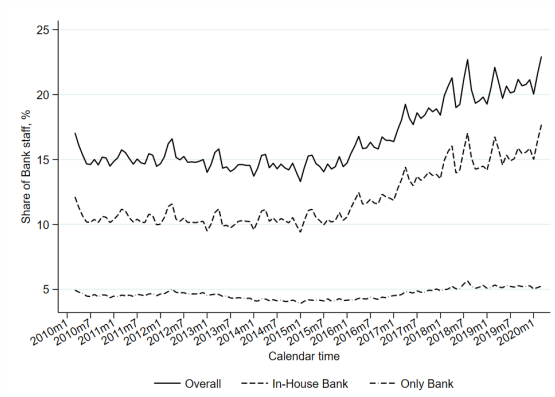
The main retention measures also include staff who employed as "staff Bank" workers by the hospital Trusts. "Staff Bank" work is carried out by employees who are registered to provide shifts on a temporary basis, mostly on a zero-hours contract, with no further obligation for regular work at hospital Trusts. It is different from other temporary nursing staff which are on fixed-term, non zero-hours contracts and provide regular work shifts. Bank work is very common among NHS nurses and midwives with an average of 16% of nurses and midwives registered as bank workers in each month in 2016. Bank staff may come either from the existing nursing staff employees of a hospital Trust (in-house bank) or from employees of an

outside organization who are only contracted as bank workers in the Trust (bank-only). The difference between Bank-only and in-house Bank staff is that Bank-only staff may leave the Trust once their period of temporary employment terminates, whereas in-house bank staff are nurses already employed within the Trust and providing additional labor as staff bank workers.

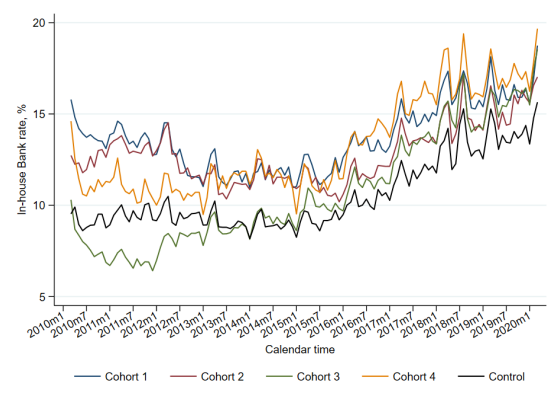
Starting from 2016, the share of nurses and midwives who registered as Bank has increased across all cohorts, some more than others, and the increase in the Bank workforce was driven by the in-House Bank registrations for all cohorts as shown in Figures B1. While the extent of the use of bank staff may signal staffing difficulties such as increasing need to cover staff, bank work also provides flexibility to nursing staff as they can choose which shifts to work (Buchan, 2002; Buchan et al., 2019).

Figure B1: Share of Bank staff over time

(a) Overall, in-house Bank and Bank-only nurses and midwives



(b) Share of in-house Bank work, by cohort



To understand whether the main estimates are affected by the Bank workforce, we re-compute our retention outcomes by excluding the nurses and midwives who are employed as Bank-only staff, as their inclusion might contaminate the retention outcome and bias the effects of interest, and instead we keep in-house Bank staff. B1 column 2 shows a very similar overall impact of the programme on nursing retention. The key difference is between the cohort-specific effects, where in the absence of Bank-only staff, the RDSP lead a significant increase in retention of nursing staff in Cohort 3 Trusts. This effect is slightly higher than

Cohort 4 Trusts. The impact of the retention programme is slightly limited, yet we find significant reduction in the nurses and midwives leavers' rates due to RDSP participation. We introduce a further restriction on the outcomes and exclude nurses and midwives who are on any temporary and fixed-term contracts. The results are similar to our baseline estimates, which is expected as the majority (97%) of the nurses and midwives work under permanent contracts. The overall average impact of the RDSP on nurses and midwives' retention, both for stability and NHS leavers' rate.

Lastly, we focus on nurses and midwives who work in acute care NHS Trusts. The health care services provided in acute care hospitals are different than mental health Trusts. As 91% of the mental health Trusts are treated in the first three cohorts, and the majority of control group consists of acute care Trusts, there might be some limits in the comparability across treatment and control groups for the mental health Trusts. However, our main results are robust to restricting the sample to acute Trusts: we find that overall the RDSP improved retention by 0.87 ppt on average for all treated Trusts, and reduced the leaver rates by 0.42 ppt.

Table B1: Robustness checks: Average treatment effects of RDSP on retention outcomes for sub-samples of nurses and midwives

	Stability rates				**NHS leaver rates**		
	Age < 65 y.o.	**No bank-only**	**Permanent**	**Acute Trusts**	**No bank-only**	**Permanent**	**Acute Trusts**
Overall ATT	0.798	0.839	0.789	0.868	-0.380	-0.356	-0.415
	(0.196)***	(0.201)***	(0.199)***	(0.200)***	(0.137)***	(0.137)***	(0.136)***
	[0.208]§	[0.201]§	[0.195]§	[0.200]§	[0.145]§	[0.146]§	[0.139]§
Cohort-specific ATTs							
Cohort 1	0.968	1.148	1.108	1.390	-0.533	-0.510	-0.561
	(0.371)***	(0.382)***	(0.387)***	(0.436)***	(0.258)**	(0.255)**	(0.311)*
	[0.372]§	[0.386]§	[0.386]§	[0.427]§	[0.283]	[0.264]	[0.313]
Cohort 2	0.520	0.417	0.391	0.429	-0.301	-0.261	-0.159
	(0.340)	(0.345)	(0.343)	(0.263)	(0.250)	(0.247)	(0.176)
	[0.329]	[0.348]	[0.345]	[0.264]	[0.247]	[0.240]	[0.186]
Cohort 3	0.750	0.942	0.901	0.511	-0.403	-0.393	-0.568
	(0.394)*	(0.395)**	(0.389)**	(0.479)	(0.237)*	(0.238)*	(0.310)*
	[0.392]	[0.389]§	[0.383]	[0.511]	[0.236]	[0.242]	[0.312]
Cohort 4	0.918	0.814	0.728	0.949	-0.292	-0.267	-0.361
	(0.266)***	(0.244)***	(0.248)***	(0.273)***	(0.162)*	(0.162)*	(0.185)*
	[0.266]§	[0.249]§	[0.263]§	[0.280]§	[0.165]	[0.165]	[0.186]
Pre-trend test p-value							
12 months, df = 48	0.673	0.286	0.462	0.509	0.652	0.749	0.002
6 months, df = 24	0.743	0.916	0.966	0.539	0.707	0.591	0.830

Notes: Under conditional parallel trends assumption with the same set of controls as reported in columns 2 and 4 of Table 2. Past retention rates are adjusted for sub-samples. Standard errors are clustered at Trust level. Asymptotic standard errors are in parentheses, p-values *p<0.1; **p<0.05; ***p<0.01. Clustered bootstrapped standard errors are in brackets and § indicates that the 95% simultaneous confidence band does not cover 0. Estimation period ends in November 2019 for stability rate and October 2019 for leaving the NHS rate.