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Resilience of the acute sector in recovery from COVID-19 pressures

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ABSTRACT

The COVID-19 pandemic had a profound impact on the management and delivery of acute healthcare. To tackle the pandemic, hospitals redesigned their organisational models to provide a rapid increase in acute care assessment and treatment capacity for patients with COVID-19 whilst also trying to maintain delivery of care for patients with non-COVID-19 healthcare needs. This capacity to adjust and recover after COVID-19 might be shaped by both measures taken by acute hospitals and wider hospital pre-pandemic characteristics. The aim of this study is to examine how hospital characteristics in acute care are associated with recovery of elective activity after the height of the COVID-19 pandemic compared to pre-pandemic levels. Using patient-level data from Hospital Episode Statistics aggregated at monthly-trust level for all English National Health Service (NHS) acute hospital trusts in 2019 and 2021, we estimate the associations between hospital recovery rate and hospital pre-pandemic characteristics by employing linear regressions of the proportional change over time in elective activity against a set of explanatory variables related to supply factors (e.g., hospital size, workforce, type of hospital, regional location), demand factors (e.g., population need, patient case-mix) and time factors. On average, English NHS acute hospital trusts did not fully recover from the COVID-19 pandemic in 2021. The results show that the explanatory variables are not systematically associated with hospital recovery rate, excepting regional differences. Hospital trusts not located in London, especially in the North of England, are associated with a lower recovery (less resilience) of total elective activity and orthopaedic and vascular surgical elective activity. The implication for policy development is that the evolution of hospital recovery rates in elective activity varied across English regions, especially for high-volume and high-risk elective specialties, with better recovery in London than elsewhere.

1. Introduction

Health system resilience is at the top of the policy agenda among OECD countries, particularly following the onset of the COVID-19 pandemic (OECD, 2023). Health system resilience implies the ability to be prepared for, manage, recover, and learn from shocks (European Observatory on Health Systems and Policies et al., 2020; Fleming et al., 2022). The COVID-19 pandemic, the most recent global shock to the health system, shaped how healthcare was provided through adjusting health system's organisational model to accelerate acute care assessment and expand treatment capacity for COVID-19 patients whilst ensuring the delivery and recovery of healthcare services for those with non-COVID-19 clinical needs. In most healthcare systems, most elective care is provided by the acute sector and therefore high levels of emergency activity (as were observed during the COVID-19 pandemic) may impair delivery of elective care. Although emergency care remained operational throughout the pandemic, elective care was highly disrupted by suspensions of elective activity during the COVID-19 waves, which led to the postponement of planned surgeries and a backlog of patients on waiting lists (OECD, 2022). The extent of recovery of elective

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care to levels performed before the COVID-19 pandemic provides insight into the resilience of the healthcare system, as it reflects its ability to rebound from disruptions. This capacity to adjust and recover after the COVID-19 pandemic may, in turn, have been affected by state and provider-led initiatives as well as wider pre-pandemic characteristics such as size, staffing levels, patient case-mix or geographical location, which may have predisposed providers to greater or lower levels of resilience.

This study aims to examine the associations between a range of hospital characteristics and the extent of recovery of elective activity performed by acute hospitals after the peak of the COVID-19 pandemic relative to their pre-pandemic levels. While our findings cannot be interpreted as causal, they can inform policymakers of specific hospital attributes which may either facilitate or constrain the recovery process of hospitals following disruptions to the healthcare system. Policymakers could then identify hospitals with similar characteristics and potentially low recovery of elective activity to design effective pre- and post-shock policy interventions.

Our analysis is centred around the English National Health Service (NHS). The English NHS is funded through general taxation and provides universal access to healthcare services free at the point of use (Anderson et al., 2022). Primary care is provided by general practitioners (GP), who act as gatekeepers to secondary or hospital care. Patients seeking elective (non-emergency) hospital treatment require a referral from a GP and are subsequently placed on a waiting list. Most hospital care for publicly funded patients is provided by public hospitals organised into entities known as NHS Trusts. However, a small proportion of publicly funded patients in need of elective care (6.0 % in 2019/20 and 6.7 % in 2021/22) receive treatment from independent sector (private) providers (Bagri and Scobie, 2023). Patients also have the option to choose private elective treatment at their own expense or through private health insurance.

England experienced three national lockdowns during the COVID-19 pandemic. The first lockdown came into force in March 2020 and phased out by the end of summer. In October 2020, a three-tiered system was introduced and categorised regions into tier 1, the least restrictive tier, with the option to move to tiers 2 or 3 in response to an increase in infection rates (Davies et al., 2021). Due to rising incidence, a second four-week lockdown started in November 2020. Beginning in December 2020, a four-tiered system was implemented alongside a third lockdown initiated in January 2021, placing all English regions into tier 4 (Brown and Kirk-Wade, 2021). This last lockdown gradually concluded by the end of March 2021 and led to a three-step scheme applied throughout England to cease all pandemic-related restrictions (Brown and Kirk-Wade, 2021). Central decision-making during the COVID-19 pandemic involved state initiatives such as NHS Test and Trace and vaccine distribution. However, the Department of Health and Social Care also delegated decision-making autonomy to local organisations through measures such as virtual wards, video consultations, and hospital clinical staff redeployment (Mannion et al., 2023a).

We focus on elective activity for two main reasons. First, elective care constitutes a substantial proportion of the total activity performed in the English NHS. For instance, elective admissions comprised 51.4 % (8.8 million) of hospital admissions in 2019/20 and increased by around 22.0 % from 2009/10 to 2019/20 (NHS Digital, 2020). Second, the English NHS experienced severe declines in elective care during the COVID-19 pandemic with cuts in elective volume of 31.2 % from 2019/20 to 2020/21 and of 10.9 % from 2019/20 to 2021/22 (Bagri and Scobie, 2023). Our findings may therefore be helpful to understand the recovery of elective activity after a shock to the health system in institutional contexts similar to the English NHS.

In this study, we use administrative health records from Hospital Episode Statistics (HES) comprising all publicly and privately funded patients treated in NHS providers. We aggregate patient-level HES data at the monthly-trust level in acute hospital trusts within the English NHS during the pre-pandemic year 2019 and the post-pandemic year 2021. We aim to assess associations between hospital recovery, defined as the rate of monthly elective activity in 2021 compared to that in 2019, and hospital pre-pandemic characteristics, which may explain variation in recovery over time and across hospitals. To estimate these associations, we employ linear regressions of the proportional change over time in elective activity against a set of explanatory variables evaluated in 2019 and related to supply factors (i.e., hospital size, performance in emergency department, elective activity by nearby providers, workforce, type of hospital, regional location), demand factors (i.e., patient case-mix), and time factors (i.e., month fixed effects).

The hospital recovery rate in total elective activity averaged 83.2 % in 2021, but descriptive analyses reveal a significant variation of 15.5 percentage points (pp.) across English NHS acute hospital trusts. This variation highlights the heterogeneous recovery patterns observed in the aftermath of the COVID-19 pandemic. The findings show that supply and demand factors are not systematically associated with hospital recovery rates. An exception is regional location, where hospitals situated in London exhibit a higher recovery rate in total elective activity than those in other regions. This difference is particularly striking for Northern regions. For instance, hospitals located in North East and Yorkshire, and North West are associated with a 22.0 % and 19.0 % lower recovery of total elective activity, respectively, than hospitals in London. Heterogeneity analyses indicate that differences in recovery across regions are driven by high-volume elective specialties, such as orthopaedic surgery, and high-risk elective specialties, such as vascular surgery. Lastly, the results also illustrate a positive trend in hospital recovery rates over time.

We contribute to the existing literature on health system resilience in three ways. First, this is the first empirical study unravelling the hospital determinants of recovery of elective activity after a shock to the health system, focusing on the context of the COVID-19 pandemic within the English NHS. Previous literature has primarily explored indicators to measure health system resilience (e.g., Fleming et al., 2022; Ignatowicz et al., 2023) and the disruption caused by the COVID-19 pandemic on healthcare activity (Arsenault et al., 2022; Dobbs et al., 2021; Friebel et al., 2022; Mannion et al., 2023b; Mulholland et al., 2020; Sutherland et al., 2020; Villaseñor et al., 2023; Warner et al., 2022; Ziedan et al., 2020). Our study fills a gap by evaluating how hospital factors may shape the pattern of hospital recovery in severely disturbed publicly funded health systems after the COVID-19 pandemic, an area that remains understudied. Second, our research involves novel evidence by examining the recovery of elective activity during the post-pandemic year 2021 compared to the pre-pandemic year 2019. This temporal focus distinguishes our study from previous work, which mainly looked at the period from the first lockdown to the end of 2020 (Dobbs et al., 2021; Friebel et al., 2022; Villaseñor et al., 2023), and enables us to circumvent the regional effects of the tiered systems implemented in 2020 (Brown and Kirk-Wade, 2021) and investigate the evolving trends in elective care between the initial pandemic shock and the introduction of recovery policies such as the Backlog Recovery Plan in 2022 (NHS England and NHS Improvement, 2022). Third, we delve into various categories of elective activity, including total, surgical, non-surgical, and specialty (e.g., orthopaedics, oncology). This granularity allows us to gain a wider perspective on the diverse recovery trajectories within the health system.

The remainder of the paper proceeds as follows. Section 2 describes the data and Section 3 outlines the research methods employed in the paper. The main results are presented in Section 4 and discussed in Section 5. Finally, Section 6 concludes.

2. Data

The main database used for this study is the Hospital Episodes Statistics (HES). HES is an administrative database of all admissions, emergency attendances, and outpatient appointments of all publicly and privately funded patients treated in NHS providers and publicly funded patients treated in private providers in England. HES includes diagnoses and procedures, patient characteristics (e.g., age, gender, ethnicity, area of residence), and administrative information (e.g., dates and methods of attendance, admission, and discharge). Given our focus on elective activity, we use the Admitted Patient Care (APC) dataset from the HES database as our source to construct our main dependent variable: the elective recovery rate. We also employ the Accident and Emergency (A&E) dataset from the HES database and publicly available data from NHS Digital and NHS England to control for hospital characteristics (e.g., emergency activity, workforce, hospital beds). Detailed information on variables and sources is in Table A1 in the Supplementary Appendix.

Given the focus on hospital recovery within the English NHS, we aggregate patient-level data at NHS trust level. Our sample is a balanced panel of monthly data for English NHS acute hospital trusts which have type 1 emergency departments (i.e., emergency departments with a consultant-led 24-h service with full resuscitation facilities for emergency care patients) and performed any elective activity in calendar years 2019 and 2021. We exclude all non-NHS (i.e., independent sector providers), non-acute (e.g., mental health providers), and specialist (e.g., orthopaedic trusts) hospital trusts.

2.1. Dependent variable

Our indicator of hospital resilience consists of the capacity of hospitals to recover their regular activity levels after a shock to the health system. Emergency care continued throughout the COVID-19 pandemic, but elective care was severely curtailed. Our main dependent variable is therefore the ratio of monthly hospital elective activity in 2021 to that in 2019, calculated using HES APC data. This involves comparing elective activity in month m in 2021 to that in corresponding month m in 2019 to capture the percentage recovery of elective activity performed by hospital trusts after the height of the COVID-19 pandemic (calendar year 2021) compared to its elective activity before the pandemic (calendar year 2019).

Hospital elective activity is defined as the number of finished consultant episodes of patients who had a hospital elective admission. A finished consultant episode is the time a patient spends under the care of one consultant in one hospital and finishes due to patient discharge, death or transfer to another consultant or hospital. Our definition of hospital elective activity closely aligns with the volume of elective treatments in each hospital. Considering hospital elective admissions or spells (i.e., the total continuous stay of a patient in a hospital under the care of one or more consultants) could instead underestimate this volume if patients had several elective treatments with different consultants. However, most admissions (over 80 %) involve only one finished consultant episode (NHS Digital, 2023).

We calculate hospital recovery rates for total elective episodes (total elective recovery rate), elective episodes under any surgical specialty (surgical elective recovery rate), and under any non-surgical specialty (non-surgical elective recovery rate). We also calculate hospital recovery rates for specific surgical and non-surgical specialties with the highest volume and risk: ophthalmic, orthopaedic, general, and vascular surgical specialties, and haematology, oncology, and gastroenterology non-surgical specialties. Finished consultant episodes are assigned to the main specialty of the consultant. Table A2 in the Supplementary Appendix reports the specialty codes.

Episodes with missing age, gender, or area of residence, patients aged older than 100, patients not residents in England, and adults admitted under paediatric specialty are omitted (0.8 %–1.8 % and 0.8 %–2.3 % of episodes in 2019 and 2021, respectively). Elective surgery episodes without an OPCS code (7.1 % and 7.2 % of the surgical elective activity in 2019 and 2021, respectively), hospital trusts with less than 20 elective episodes in 2019, and extreme outliers with hospital recovery rates above 500 % (relevant only for specialties) are also excluded.

2.2. Explanatory variables

We consider a set of explanatory variables related to hospital characteristics measured in 2019 as potential drivers which could explain variations in hospital recovery rates in elective activity. There are three groups of explanatory variables: (1) supply variables related to the features of the acute hospital trust where elective patients are admitted to; (2) demand variables capturing the characteristics of the local population and potential demand; and (3) time factors. We exclude one hospital trust due to missing data in any of these variables.

Regarding the supply side, the size of the hospital could affect its elective recovery after COVID-19. On the one hand, larger hospitals might recover faster due to their higher capacity to allocate patients and expand bed numbers, their facility to attract and retain staff, and their ability to exploit scale and scope economies (Gaughan et al., 2020). On the other hand, smaller hospitals may be in less urbanised areas where COVID-19 impacted less. We measure hospital size by the sum of overnight and day-case beds in general and acute sectors, using quarterly NHS England data.

Performance in emergency care might also impact elective activity. For instance, hospitals with more emergency attendances or longer emergency department waiting times may have a higher backlog of elective patients and thus perform less elective activity. Hospitals with a higher proportion of emergencies treated as day cases might have greater capacity to manage elective patients. We therefore control for the number of emergency department visits, the average waiting time in the emergency department (in minutes, from arrival to departure), and the percentage of same-day discharges of patients admitted through the emergency department over total emergency admissions. HES A&E includes information on emergency attendances and emergency waiting times and HES APC includes data to calculate same-day discharges.

The additional local capacity offered by nearby providers to admit patients could also affect hospital recovery rates. To account for this, we consider the elective activity (also by specialty) performed by independent sector providers and other NHS acute hospital trusts within a circular vicinity of 30 km radius from a specific NHS hospital trust. We consider a circular vicinity of 30 km radius given that hospital catchment area is defined as a 15 km radius circle (i.e., any provider located less than 30 km away from a hospital trust in question is within its vicinity since catchment areas overlap), following previous literature (Bloom et al., 2015; Propper et al., 2007). We use data from HES APC, NHS Digital and Open Geography portal datasets.

Hospitals may differ in their capacity to adjust their clinical and non-clinical staffing levels to meet unexpected demand. We therefore consider the turnover rate of doctors and nurses joining or leaving a hospital trust relative to the number of staff remaining and the proportion of managers to total staff. In our analysis, doctors include consultants, associate specialists, specialty doctors, staff grades, hospital practitioners, clinical assistants, other and local HCHS doctor grades, but exclude junior doctors who generally experience a higher turnover rate. Nurses in our analysis include nurses and allied health professionals. Managers include managers and senior managers. We use monthly (full-time equivalent) workforce figures reported by NHS Digital.

The type of hospital might also explain hospital recovery rates in elective activity. Given that foundation trusts have more financial and operational autonomy which could affect the activity performed in the hospital, we control for foundation trust status. We also include an indicator variable for teaching status given that teaching trusts might admit a more severe patient case-mix and differ in organisational and staffing schemes (Moscelli et al., 2023).

Regional differences may explain the recovery of hospitals located across the English geography. We therefore add dummy variables for each region in England: London (reference category), East of England, Midlands, North East and Yorkshire, North West, South East, and South West.

On the demand side, the characteristics of a hospital's catchment area population may also determine its recovery. Hospitals whose catchment population is older, more deprived, or sicker might have more difficulty in achieving their pre-pandemic level of elective activity. We consider the hospital's catchment area as the area and population of the (former) Clinical Commissioning Groups (CCGs) where patients attending the hospital trust were registered. CCGs were clinically-led organisations in charge of planning NHS healthcare services within their local area (National Audit Office, 2018). We control for the proportion of people who are female, aged 85 or older, income-deprived, and diagnosed with a specific condition (i.e., atrial fibrillation, cancer, coronary heart disease, chronic kidney disease, chronic obstructive pulmonary disease (COPD), dementia, depression, diabetes mellitus, heart failure, rheumatoid arthritis, and stroke) in the hospital's catchment area, using data from HES APC, NHS Digital and the 2019 Index of Multiple Deprivation. The Supplementary Appendix explains how these proportions are computed.

Finally, the demand for and the supply of acute hospital trusts experience seasonal variations (Gaughan et al., 2017). To account for these differences within a year, we add a set of dummy variables for each month, with January being the reference category.

3. Methods

The aim of this study is to examine how hospital characteristics (i.e., supply, demand and time factors) in acute care are associated with recovery of elective activity to pre-pandemic levels after the height of the COVID-19 pandemic. To investigate these associations, we estimate the following Ordinary Least Squares (OLS) model:

$$\ln\left(\frac{Y_{hm2021}}{Y_{hm2019}}\right) = \alpha + S'_{hm2019}\beta_1 + D'_{hm2019}\beta_2 + \mu_m + \varepsilon_{hm} \quad (1)$$

where $\ln\left(\frac{Y_{hm2021}}{Y_{hm2019}}\right)$ is the log of hospital recovery rate defined as the ratio of elective activity of hospital trust h performed in month m of calendar year 2021 (Y_{hm2021}) over elective activity performed in month m of calendar year 2019 (Y_{hm2019}). We solve transformation issues due to some hospital trusts performing no electives in 2021 by adding 0.01pp. to hospital recovery rates. S_{hm2019} is a vector of supply factors (e.g., beds, workforce, type of hospital, region) and D_{hm2019} is a vector of demand factors (i.e., proportion of hospital's catchment area population who are female, older, income-deprived, and diagnosed with a specific condition). We use calendar year 2019 data (rather than later) for these variables to control for hospital pre-pandemic characteristics and rule out endogenous effects that the COVID-19 pandemic could have had on these factors. μ_m is a vector of month fixed effects to capture seasonality and state-level policies such as national lockdowns (January is the reference category). Finally, ε_{hm} is the error term. We cluster standard errors at hospital trust level to allow for serial correlation within hospitals.

We compare the elective activity between the post-pandemic year 2021 and the pre-pandemic year 2019 to capture the steady recovery period following the height of the COVID-19 pandemic in 2020 (see Figure A1 in the Appendix). This approach also mitigates any effect of the tiered systems implemented in 2020, which varied across areas and over time (Brown and Kirk-Wade, 2021). Moreover, our results are broadly robust to an annual-level analysis as well as comparing financial year 2021/22, a period absent from lockdowns and tiered systems, to financial year 2019/20 (see Section 4).

In our main specification, we do not consider hospital fixed effects to control for any time-invariant hospital characteristic for two reasons. First, we are interested in exploiting the variation between and within hospitals to inform policy recommendations related to differences in hospital recovery both across hospitals and over time. Second, most of the variation in our explanatory variables comes from differences between hospitals (e.g., demand characteristics, type of hospital, or hospital location rarely vary over time), which might be relevant in understanding the evolving trends in hospital recovery rates across hospitals and time but would be removed by hospital fixed effects (see Table A3 in the Supplementary Appendix). We rule out estimating a within-between random effects model (Allison, 2009; Schunck, 2013) to avoid overfitting specification (1).

Our figures present the coefficients of interest β_1, β_2, and μ, which are estimates of the association between hospital recovery rates and each explanatory variable. Due to the nature of the logarithm of the hospital recovery rate, to get the percentage change effect of an increase of X units in an explanatory variable on an outcome variable, we multiply its coefficient times the increase of X units and 100. For instance, an increase of ΔS units in any of the supply factors is associated with a $100 \times \beta_1 \times \Delta S$ percent change in hospital recovery rate. Therefore, the explanatory variables are positively (negatively) associated with hospital recovery rate if the coefficients of interest are positive (negative). The findings should not be interpreted as proving causation since there is a risk of endogeneity due to omitted variable bias, but they can provide policymakers with valuable insights in relation to identifying those specific hospital drivers that may influence the capacity of hospitals to recover after a shock to the health system.

4. Results

4.1. Descriptive statistics

Table 1 presents descriptive statistics for hospital recovery rates. The number of hospital-month observations and hospital trusts ranges from 1130 to 97, respectively, for the vascular surgical elective recovery rate's sample to 1452 and 121, respectively, for the total, surgical and non-surgical elective recovery rates' samples.

As reported in Table 1 and Figure A1 in the Appendix, English NHS acute hospital trusts did not fully recover from the COVID-19 pandemic in 2021. The total elective recovery rate is 83.2 %, although variation across hospital trusts and over time is significant with a standard deviation equal to 15.5pp. The hospital recovery rate is 75.8 % for surgical elective activity (with 19.6pp. standard deviation) and 88.2 % for non-surgical elective activity (with 17.1pp. standard deviation). For surgical

Table 1
Descriptive statistics of hospital recovery rate.

Variable	N	Ts	Mean	SD	Min	Max
Total Elective Recovery Rate	1452	121	0.832	0.155	0.199	2.409
Surgical Elective Recovery Rate	1452	121	0.758	0.196	0.063	2.213
Non-Surgical Elective Recovery Rate	1452	121	0.882	0.171	0.288	2.687
Ophthalmic Surgical Elective Recovery Rate	1314	110	0.748	0.339	0.000	3.250
Orthopaedic Surgical Elective Recovery Rate	1452	121	0.662	0.310	0.000	2.566
General Surgical Elective Recovery Rate	1437	120	0.815	0.387	0.000	3.370
Vascular Surgical Elective Recovery Rate	1130	97	0.688	0.481	0.000	4.000
Haematology Non-Surgical Elective Recovery Rate	1441	121	0.926	0.267	0.000	3.837
Oncology Non-Surgical Elective Recovery Rate	1233	103	0.990	0.340	0.000	4.309
Gastroenterology Non-Surgical Elective Recovery Rate	1399	118	0.928	0.395	0.000	4.879

Note: Descriptive statistics of hospital recovery rates are reported for their own sample. N = number of observations, Ts = number of trusts, SD = standard deviation, Min = minimum, Max = maximum. *Source*: Hospital Episode Statistics (2018/19–2021/22), own calculations.

elective specialties, the hospital recovery rates are 74.8 % for ophthalmic surgery, 66.2 % for orthopaedic surgery, 81.5 % for general surgery, and 68.8 % for vascular surgery. Hospital recovery rates for non-surgical elective specialties are higher ranging from 92.6 % for haematology and 92.8 % for gastroenterology to 99.0 % for oncology.

Table A3 in the Supplementary Appendix reports descriptive statistics for the explanatory variables in 2019, 2021, and pooling both years together. The descriptive statistics for most hospital characteristics are stable across 2019 and 2021. Moreover, their within variation (across time) is smaller than their between variation (across hospitals). This further proves that most of the variation in our explanatory variables comes from differences between hospitals while variation across time is low and should not be uniquely exploited in a model with hospital fixed effects.

4.2. Main results

Fig. 1 reports the main results for total elective recovery rates, controlling for supply and demand characteristics and month fixed effects. The results show that there is no systematic association between total elective recovery rate and most of the supply and demand factors, with few exceptions. Regarding the supply side, the estimates for hospital size (i.e., beds) and performance in the emergency department (i.e., emergency visits, average emergency waiting times, and percentage of same-day emergency discharges) do not explain the recovery of total elective activity. Additional capacity from nearby independent sector providers (NHS acute hospital trusts) is positively (negatively) associated with total elective recovery rate at 10 % (1 %) significance level, although the effect size is small. Clinical staff joining and leaving a hospital are positively and negatively associated with total elective recovery rates, respectively, but only the estimate for nurses leaving is statistically significant at 1 %. The percentage of managers is not associated with total elective recovery rate. Similarly, having foundation trust or teaching status is not associated with recovery of total electives.

Fig. 1 shows a systematic pattern for regions: hospitals located outside London, especially those in Northern regions, are associated with a lower recovery (less resilience) of total elective activity. A hospital located in North East and Yorkshire or in North West is associated with a 22.0 % or 19.0 %, respectively, lower recovery of total elective activity than a hospital located in London. Similarly, a hospital located in East of England is associated with a 11.6 % lower total elective recovery rate, in the Midlands with a 13.5 % lower rate, and in South West with a 16.3 % lower rate than a hospital in London.

On the demand side, demand characteristics, in general, do not determine the total elective recovery rate. However, three demand characteristics are associated with total elective recovery rate at 5 % significance level. An increase of one standard deviation (0.5pp. and 0.7pp.) in the rate of hospital's catchment area population with atrial fibrillation and with diabetes mellitus is associated with a decrease of 18.1 % and 4.2 % in total elective recovery rate, respectively. Counterintuitively, an increase of one standard deviation (0.4pp.) in the rate of hospital's catchment area population with stroke is associated with an increase of 10.0 % in total elective recovery rate. Finally, total electives reached higher levels of recovery from February 2021 onward than in January 2021.

We conduct a set of sensitivity analyses in Figure A2 in the Appendix to check the robustness of the results against potential biases arising from model specification and sample selection. First, we consider economies of scale in hospitals with higher capacity and volume. To capture this, we enter into equation (1) dummies corresponding to categories for bed numbers (less than 400, 400–549, 550–699, 700–849, 850–999, 1000–1,149, and 1150+) as a proxy for hospital capacity, and visits to the emergency department (less than 10,000, 10,000–14,999, 15,000–19,999, and 20,000+) as an indicator of hospital emergency volume (Gaughan et al., 2020; Rachet-Jacquet et al., 2021). Panel a) in Figure A2 shows that our results remain robust when redefining these two supply factors. Second, panels b) and c) illustrate similar estimates and statistical significance after controlling for alternative definitions of patient-case mix using the Hospital Frailty Risk Score (Gilbert et al., 2018) and accounting for unavoidable cost differences between areas as

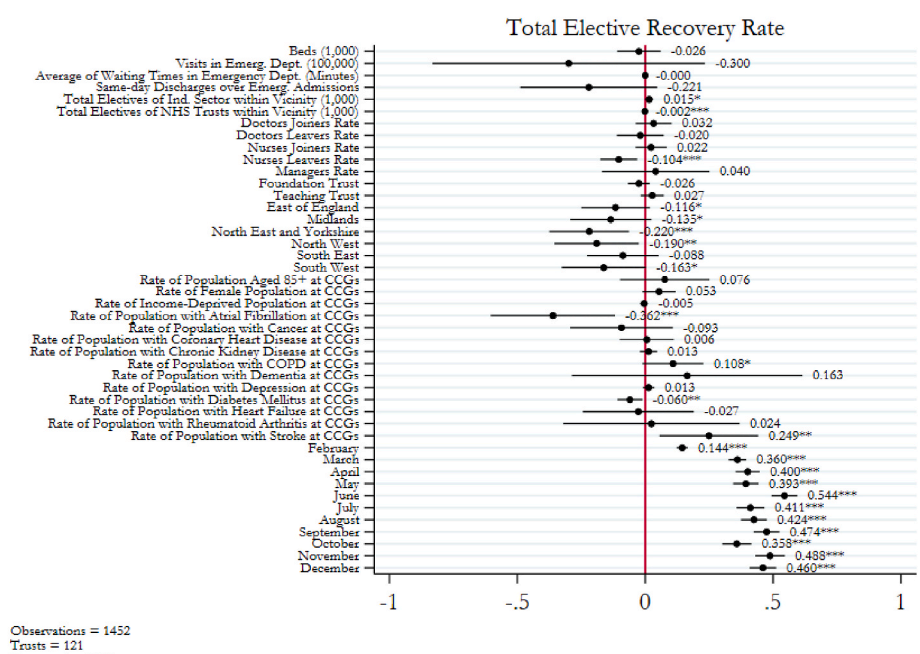

Fig. 1. Results for total elective recovery rate

Note: Estimates of OLS regressions of total elective recovery rates on supply and demand characteristics and month fixed effects. Workforce and demand characteristics estimates are divided by 10 and 100, respectively. Confidence intervals at 95 % from standard errors clustered at the hospital level. *p < 0.1; **p < 0.05; ***p < 0.01. *Source*: Hospital Episode Statistics (2018/19–2021/22) and publicly available data from NHS Digital and NHS England, own calculations.

proxied by the NHS Market Forces Factor. Third, we homogenise our sample by excluding the top and bottom 5 % of hospitals in terms of total elective recovery rate in panels d) and e). The coefficients closely resemble our baseline results, indicating that outliers are not distorting our findings. Fourth, we show that our results are fairly robust, although less precisely estimated, to controlling for hospital post-pandemic factors in 2021 despite being potentially affected by COVID-19 and, therefore, endogenous in panel f). We do not control for hospital factors simultaneously in 2019 and 2021 due to the high correlations between explanatory variables over time and the potential multicollinearity (see Table A4 in the Supplementary Appendix). Finally, we show that our results are similar when considering the financial year 2021/22 instead of the calendar year 2021 in panel g), and aggregating our sample at the annual level in panel h).

Despite removing variation between hospitals, we estimate our main specification controlling for hospital fixed effects in Figure A3 in the Appendix. Again, the results show that there is no systematic association between total elective recovery rate and most of the supply and demand factors, except for a negative association with nurses' turnover and the rate of hospital's catchment area population with chronic kidney disease and a positive association with the rate of hospital's catchment area population with COPD. Similar to Fig. 1, there is a positive trend of total elective recovery rate across months. Although controlling for time-invariant hospital factors, we cannot disentangle which hospital

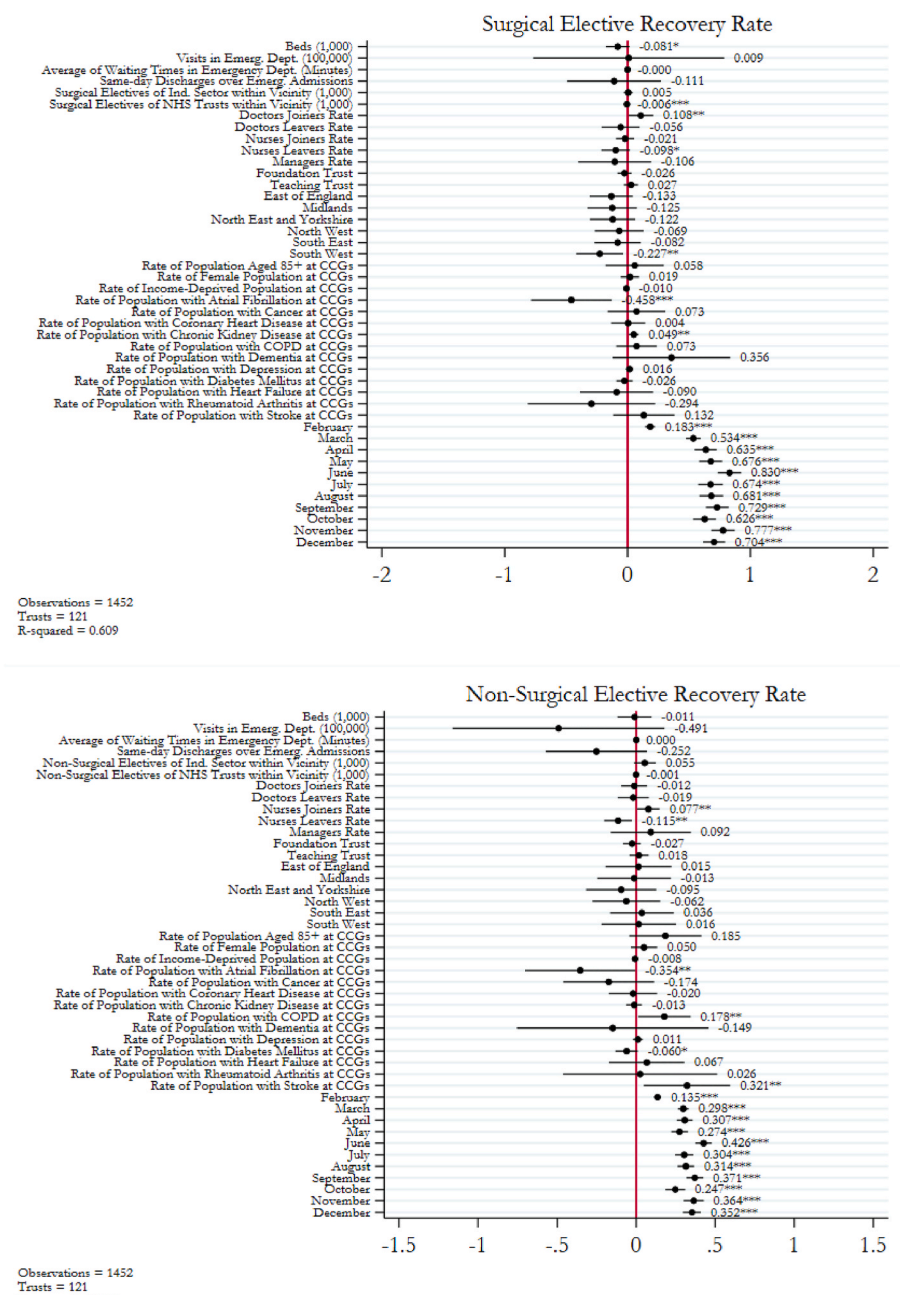

Fig. 2. Results for surgical and non-surgical elective recovery rate

Note: Estimates of OLS regressions of surgical and non-surgical elective recovery rates on supply and demand characteristics and month fixed effects. Workforce and demand characteristics estimates are divided by 10 and 100, respectively. Confidence intervals at 95 % from standard errors clustered at the hospital level. *p < 0.1; **p < 0.05; ***p < 0.01. *Source*: Hospital Episode Statistics (2018/19–2021/22) and publicly available data from NHS Digital and NHS England, own calculations.

characteristics (either teaching and foundations status, regional differences, or others) are associated with recovery from these hospital fixed effects.

4.3. Heterogeneity analysis

We analyse factors associated with variation in recovery rates for surgical and non-surgical elective activity separately as shown in Fig. 2. Fig. 2 illustrates that the associations between surgical and non-surgical elective recovery rates and supply and demand characteristics and month fixed effects are broadly analogous to the estimates for total elective activity in Fig. 1. Supply and demand characteristics do not systematically explain the variation in either surgical or non-surgical elective recovery rates across hospitals and over time. Geographical differences are more pronounced for surgical elective recovery rates, although the coefficients on regional dummies are less precisely estimated than for total elective recovery rates. We find that hospitals located in South West have a 22.7 % lower recovery rate of surgical elective activity than hospitals located in London. However, there are no geographical differences across English regions for non-surgical elective

Fig. 3. Results by initial impact in elective activity due to the COVID-19 pandemic

Note: Estimates of OLS regressions of total elective recovery rates on supply and demand characteristics and month fixed effects by the initial impact in elective activity due to the COVID-19 pandemic. Hospital trusts are categorised into high-impacted (with a relative decline in elective activity between April 2020 and February 2020 above the median) and low-impacted (with a relative decline in elective activity between April 2020 and February 2020 below the median). Workforce and demand characteristics estimates are divided by 10 and 100, respectively. Confidence intervals at 95 % from standard errors clustered at the hospital level. *p < 0.1; **p < 0.05; ***p < 0.01. *Source*: Hospital Episode Statistics (2018/19–2021/22) and publicly available data from NHS Digital and NHS England, own calculations.

recovery rates. We also conduct separate analyses by specialty in Figure A4 in the Appendix and show that differences in recovery across regions are especially pronounced for orthopaedic and vascular surgical electives.

To further explore the recovery in elective activity, we conduct a heterogeneity analysis based on the level of impact that the COVID-19 pandemic had on each hospital in 2020. Specifically, we classify hospitals into two groups according to whether their relative decline in elective activity from February to April 2020 was above (high-impacted) or below (low-impacted) the median (69.8 %). March 2020 is excluded from this comparison to ensure that we contrast a month fully unaffected by COVID-19 (February 2020) with a month fully impacted (April 2020). The results of this heterogeneity analysis, presented in Fig. 3, confirm that the observed differences in total elective recovery rates are driven by high-impacted hospital trusts. In particular, hospitals in the North East and Yorkshire and the North West exhibit significantly lower recovery rates—26.1 % and 25.2 %, respectively—compared to hospitals in London. Similarly, hospitals in the South West are associated with a 17.5 % lower recovery rate relative to those in London.

5. Discussion

This study undertakes a comprehensive examination of health system resilience in the aftermath of the COVID-19 pandemic, with an emphasis on recovery of elective care within the English NHS. We investigate how hospital pre-pandemic characteristics contributed to the recovery of elective activity performed by NHS acute hospitals after the peak of the COVID-19 pandemic. Our study serves a dual purpose. Firstly, it seeks to provide policymakers with insights into the hospital attributes that influence the capacity to recover following a pandemic. It therefore informs the development and implementation of policies aimed at enhancing health system resilience for future pandemics. Secondly, our findings may offer lessons applicable not only to pandemics but also during more common challenging periods such as winter pressures or staff strikes.

Despite a positive trend over time, our results show that, on average, hospital elective activity in 2021 remained below 2019 levels. This highlights the persistent and prolonged impact of COVID-19, indicating that more than one year was required for hospitals to adapt to the changes in care delivery resulting from the pandemic. Our findings align with previous evidence from both English and international contexts on the effect of the COVID-19 pandemic. The pandemic and associated national lockdowns imposed in England from March 2020 resulted in a substantial reduction in the delivery of non-COVID-19 healthcare services, including elective care (Friebel et al., 2022), surgical activity (Dobbs et al., 2021), and mental health services (Villaseñor et al., 2023). Similar conclusions are drawn by international studies focusing on the US, Australia, Mexico, and South Africa, among other countries, for several healthcare services such as primary care, outpatient care, or preventive care (Arsenault et al., 2022; Sutherland et al., 2020; Ziedan et al., 2020).

Our analysis indicates that hospital pre-pandemic characteristics related to supply and demand factors are, in general, not associated with hospital recovery rates in elective activity. This absence of a systematic relationship holds consistent across various dimensions of elective activity, including total, surgical, and non-surgical activity, and activity by specialty. The findings therefore suggest that policymakers cannot use hospital supply and demand characteristics as a guide for targeting policy interventions to improve recovery of elective activity.

An exception to the absence of a systematic association between hospital characteristics and hospital recovery rates is geographical location. Notably, our results reveal differences in the recovery process across English regions and highlight a more favourable evolution in hospital recovery in London compared to the rest of England, especially Northern regions. Although some hospital characteristics such as hospital size and patient case-mix are already considered in our analysis, we did not explore several factors including quality of the workforce, management quality, decision-making decentralisation to local organisations, slacking resources, and regional endowments which might explain the regional difference. This regional difference adds to the evidence of the long-lasting north-south health division, which shows higher healthcare needs in the North of England (e.g., Ellis and Fry, 2010; Langford and Bentham, 1996; Watt et al., 2022). Overall, our analyses provide further impetus for policymaking in this area, in that greater recovery of elective activity in London may produce an unequal and higher NHS capacity for patients living there than patients living in the rest of England. This insight is relevant for policymakers aiming to address regional disparities, reduce health inequalities, and ensure equitable access to healthcare across the country.

This study has several strengths. First, the paper demonstrates how regression analysis including a range of local demand and supply factors can be relevant in understanding health system resilience. Second, we employ administrative data covering all NHS patients (and privately funded patients in NHS hospitals) in all major acute hospitals in England. Third, our analysis includes a wide set of explanatory variables encompassing supply and demand factors thoughtfully selected as potential influencers of hospital recovery. Additionally, the breakdown of elective activity by specialty provides more detailed evidence by drawing attention to differences in resilience between different specialties. Fourth, the robustness of our results to alternative models is key and implies that the conclusions drawn are consistent and reliable, enriching the credibility of our findings.

Our analysis has three main limitations. The most important limitation relates to the omission of potentially relevant explanatory variables. Despite the inclusion of a broad range of explanatory variables, some hospital characteristics such as the quality of the workforce and of management, the digital maturity of hospitals (Konteh et al., 2022), or the use of slack in the system (Mannion et al., 2023a) could not be considered due to data constraints. This entails a risk of omitted variable bias, which implies that our findings are associative and causality cannot be inferred from them. Moreover, our setting does not allow us to employ causal techniques such as difference-in-differences, given the absence of a natural experiment, or methods such as propensity score matching, as matching hospitals based on their characteristics would eliminate the variation needed to disentangle the association between these characteristics and hospital recovery rates. However, our methodology still provides valuable evidence for policymakers to identify hospitals with similar characteristics and low recovery rates to inform targeting of policy interventions. Our findings highlight the need to understand the causal relationship between regional location and hospital recovery of elective activity after shocks to the NHS, as this could support policymaking that not only ensures equality of healthcare access across England but also contributes to a levelling up agenda in spreading opportunity more equally across the country, a current focus of the UK government (HM Government, 2022). Future research using a dataset including a wider range of hospital characteristics could provide a wider understanding of the factors influencing hospital recovery and shed light on the mechanisms behind regional health inequalities in hospital resilience. Another limitation lies in the data that do not capture privately funded patients attending independent sector providers, where elective care was transferred to relieve NHS providers (Friebel et al., 2022). Some patients may have decided to seek private elective care given the long NHS elective waiting lists following the pandemic. This gap highlights the need for a dataset that merges publicly and privately funded patients attending NHS and private providers to consider fully the dynamics of healthcare recovery following the pandemic. Finally, our analysis is centred around the early recovery period due to data constraints. Future research should aim at understanding how hospital factors are associated with elective recovery during the last recovery period from March 2022.

6. Conclusion

Our aim was to determine a range of factors in acute care which could be policy targets for governments to enhance health system resilience after a shock. We found that most hospital characteristics did not explain the capacity of public hospitals to recover after a shock to the health system and the regional variation suggests that wider factors may mediate the speed of recovery. Our results provide further support for the existence of a north-south healthcare division in England, especially in the recovery of elective care following a shock to the health system. They constitute new evidence for policymakers seeking to address regional disparities and ensure equitable access to healthcare services, that is, new evidence indicating that health inequalities may be exacerbated during stressful periods such as pandemics.

CRediT authorship contribution statement

Laia Bosque-Mercader: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Simon Conroy:** Writing – review & editing, Funding acquisition. **Daniel Lasserson:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. **Russell Mannion:** Writing – review & editing, Funding acquisition. **Catia Nicodemo:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. **Raphael Wittenberg:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization.

Ethics approval statement

This project was approved by the Yorkshire and Humber Research Ethics Committee (REC Reference: 20/YH/0287 and IRAS ID: 288138). Hospital Episode Statistics are Copyright 2018–2021, re-used with the permission of NHS Digital (DARS-NIC-378657-B8F3K-v0.13). All rights reserved.

Declaration of competing interest

None.

Acknowledgments

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2025.118062.

Appendix

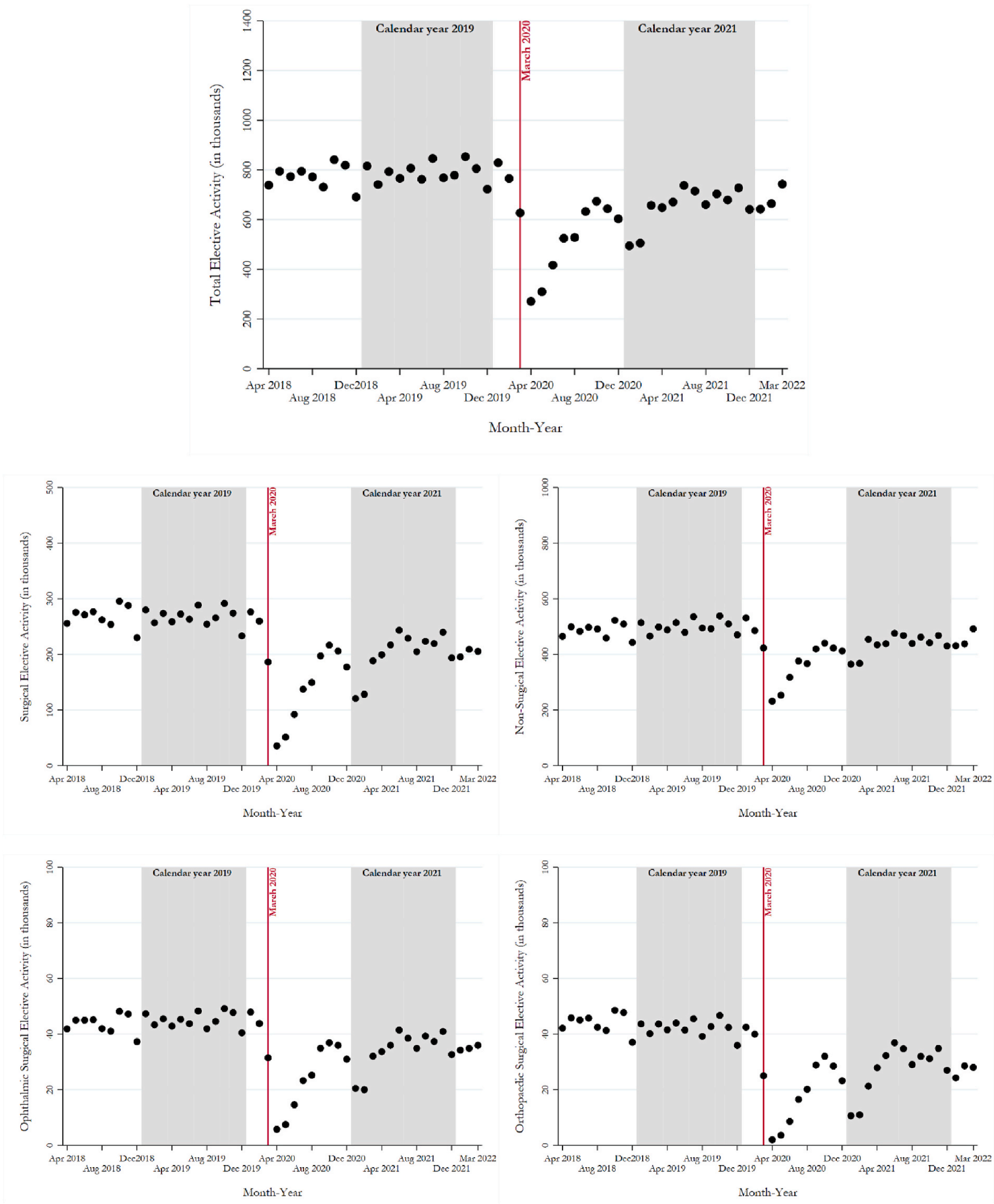


Fig. A1. Trends in elective activity (2018/19–2021/22)
Note: Trends in elective activity performed by English NHS acute hospital trusts between 2018/19 and 2021/22. Shadowed areas highlight the time periods included in the main analysis (calendar years 2019 and 2021) and the vertical line indicates the beginning of the COVID-19 pandemic (March 2020). *Source*: Hospital Episode Statistics (2018/19–2021/22), own calculations. Copyright © (2018–2021), NHS England. Re-used with the permission of NHS England. All rights reserved.

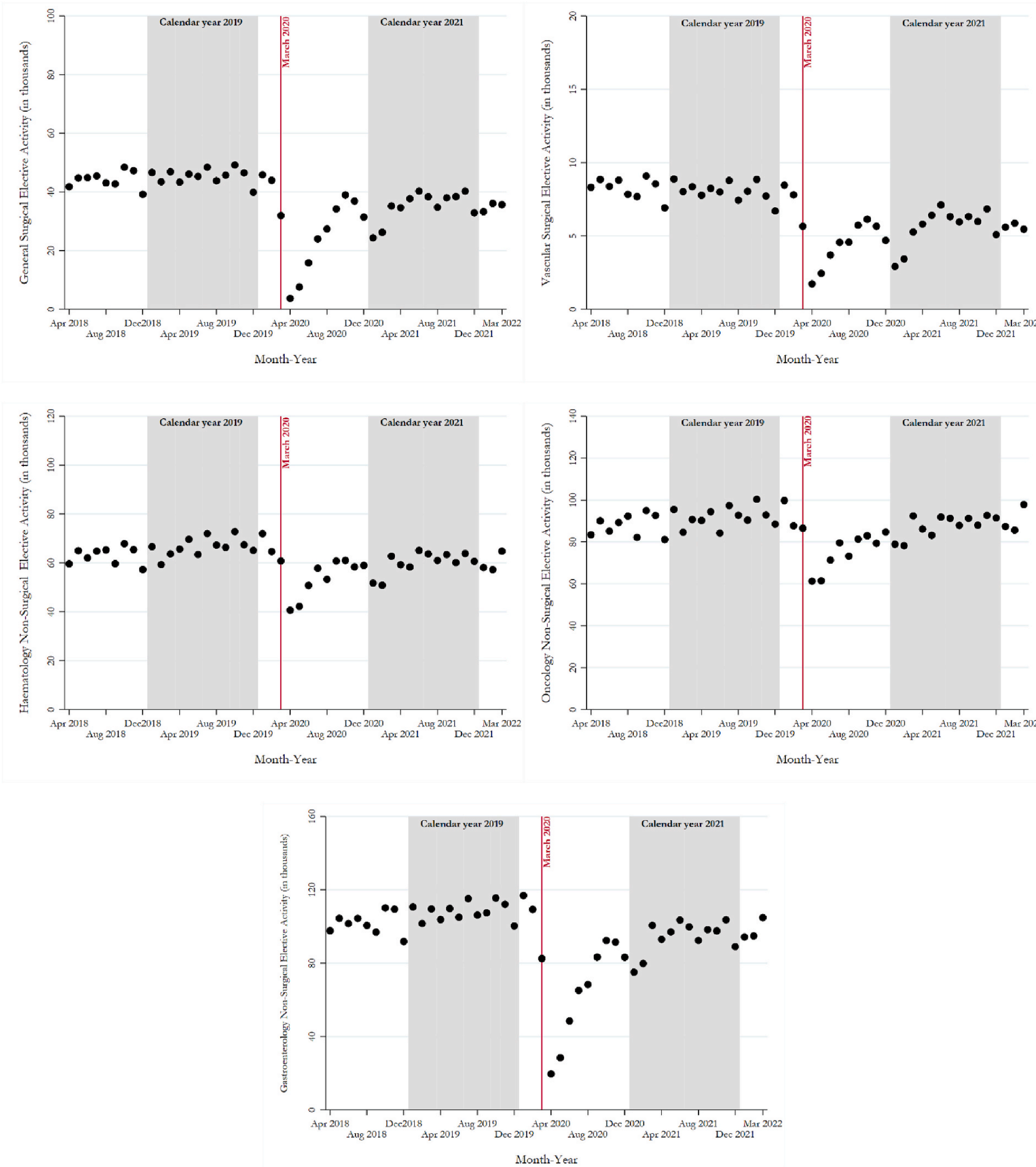
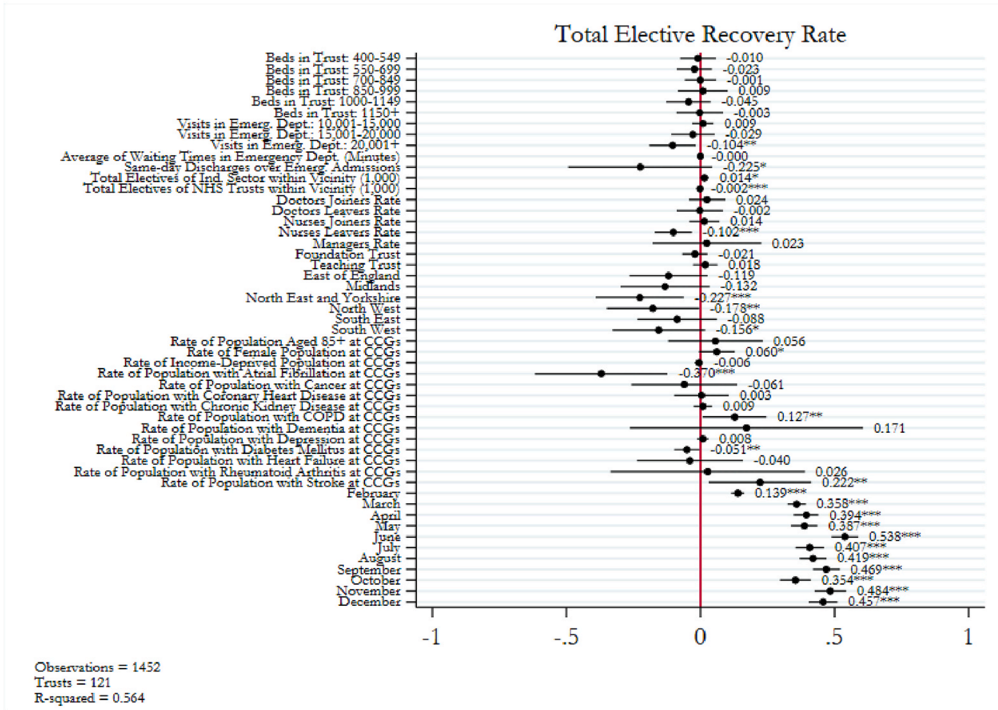


Fig. A1. (*continued*).

a) Bed numbers and visits to emergency department in categories as control variables



b) Hospital Frailty Risk Score as control variable

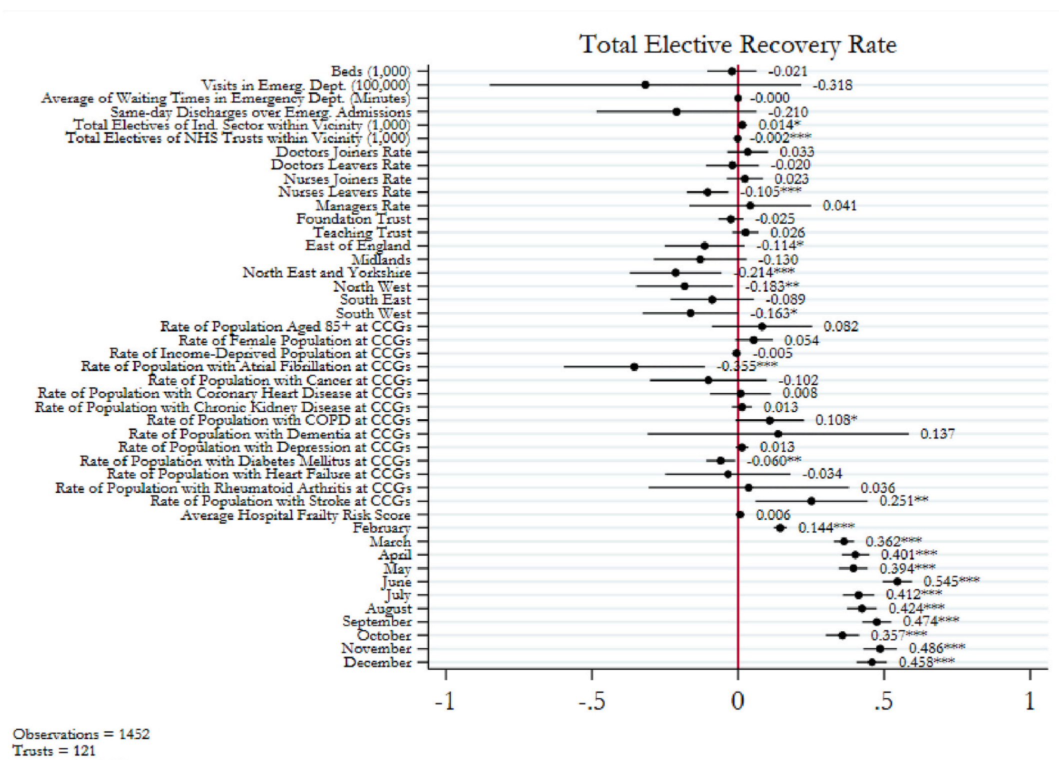
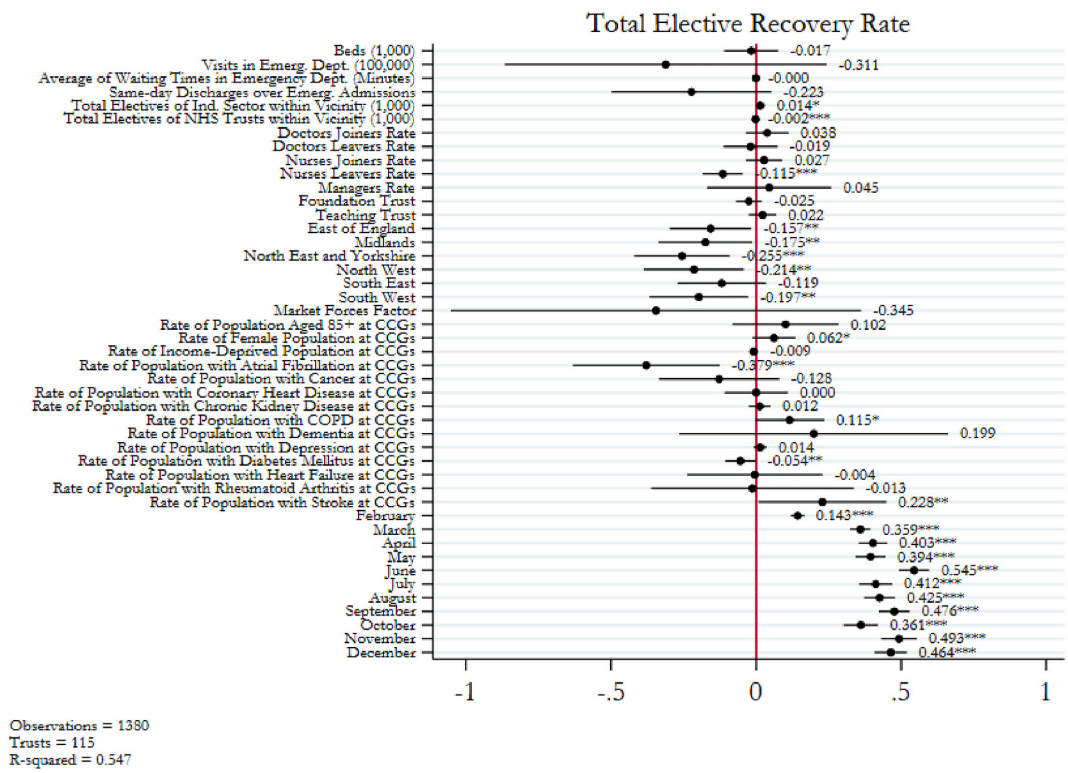


Fig. A2. Robustness checks

Note: Estimates of OLS regressions of total elective recovery rates on supply and demand characteristics and month fixed effects. Panel a) includes dummies corresponding to categories for beds (less than 400 as reference category, 400–549, 550–699, 700–849, 850–999, 1000–1,149, and 1150+), and visits to the emergency department (less than 10,000 as reference category, 10,000–14,999, 15,000–19,999, and 20,000+). Panel b) adds the Hospital Frailty Risk Score computed using older patients aged 75 or more for the calendar year 2019 and following Gilbert et al. (2018). Panel c) adds the Market Forces Factor for 2019/20 from NHS England. Panel d) excludes outliers at the 5 % top-right part of the distribution with total elective recovery rates above 1.042506. Panel e) excludes outliers at the 5 % bottom-left part of the distribution with total elective recovery rates below 0.5475994. Panel f) replaces hospital pre-pandemic characteristics in 2019 for their values in 2021. Panel g) runs the analysis for financial year 2021/22 instead of calendar year 2021. Panel h) aggregates observations at the annual level. Workforce and demand characteristics estimates are divided by 10 and 100, respectively. All estimates for panel h) are divided by 100. Confidence intervals at 95 % from standard errors clustered at the hospital level. *p < 0.1; **p < 0.05; ***p < 0.01. *Source*: Hospital Episode Statistics (2018/19–2021/22) and publicly available data from NHS Digital and NHS England, own calculations.

c) Market Forces Factor as control variable



d) Excluding 5% top-right outliers

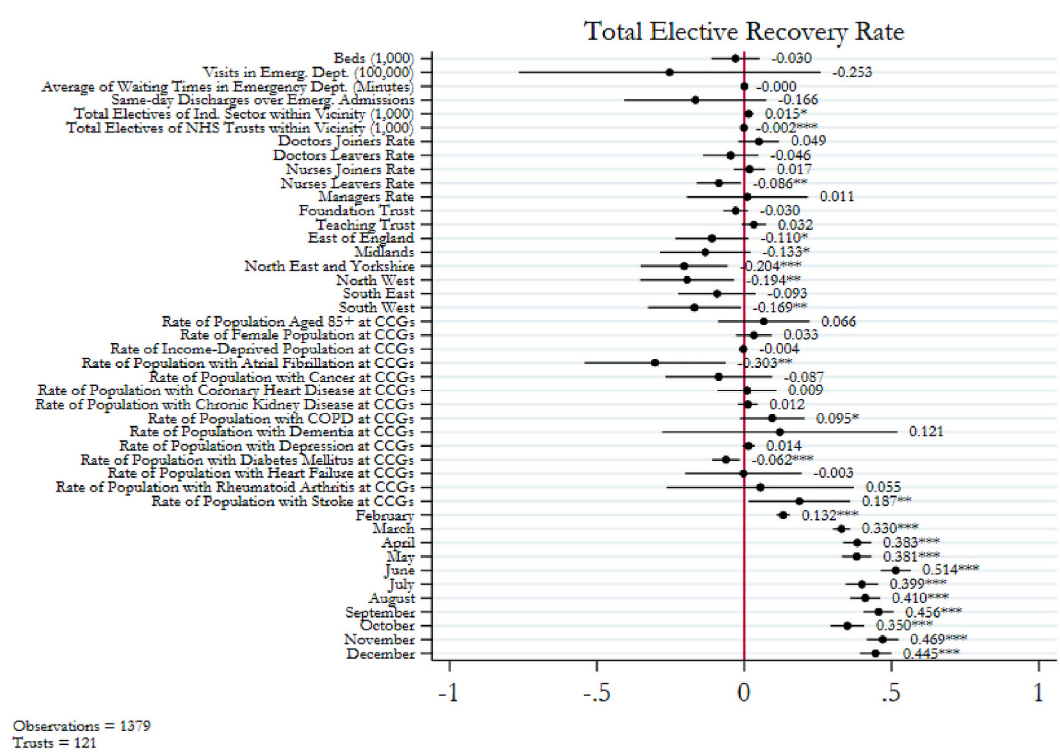
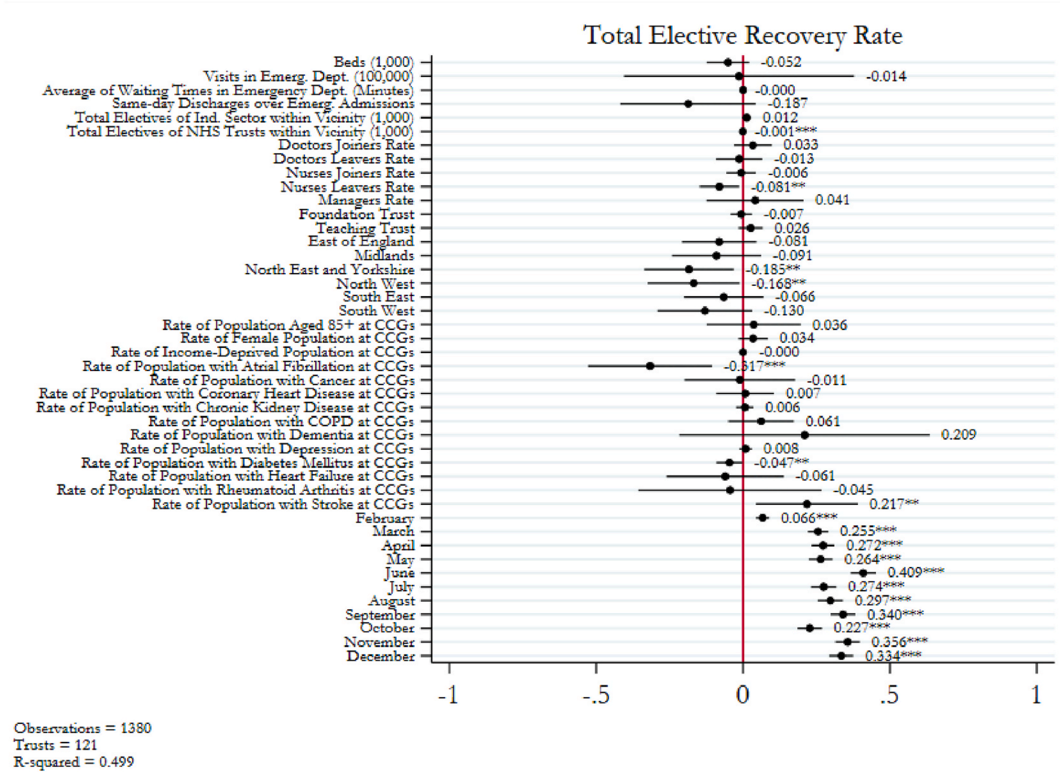


Fig. A2. (*continued*).

e) Excluding 5% bottom-left outliers



f) Hospital post-pandemic characteristics in 2021 as controls

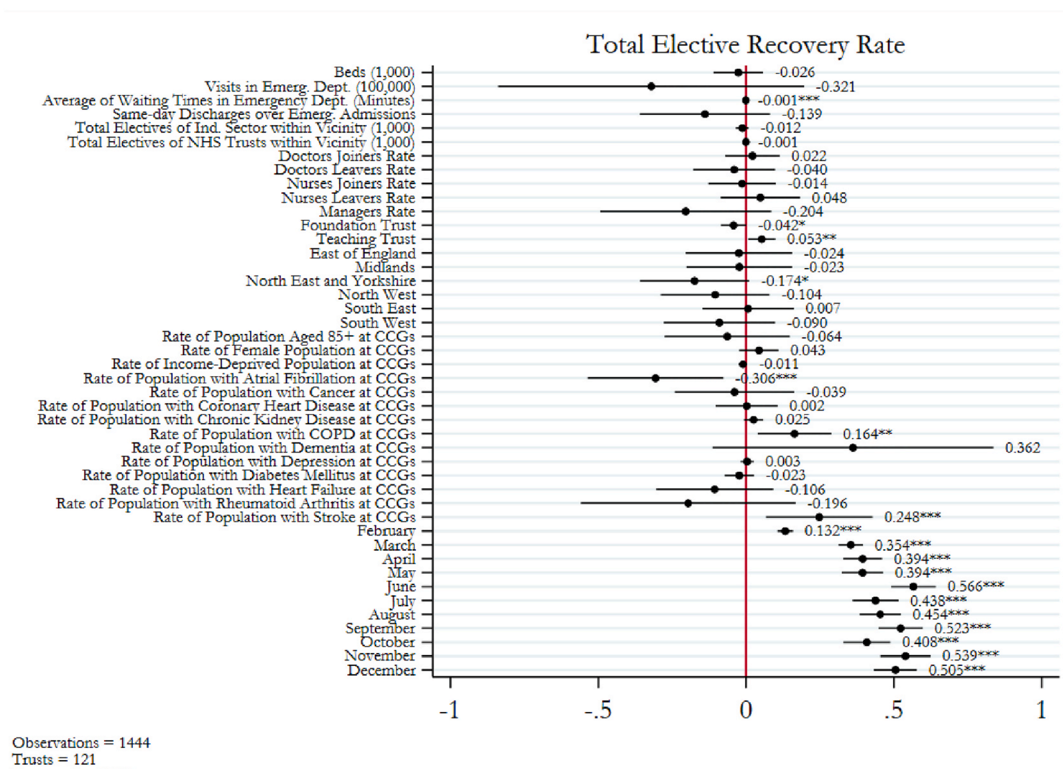
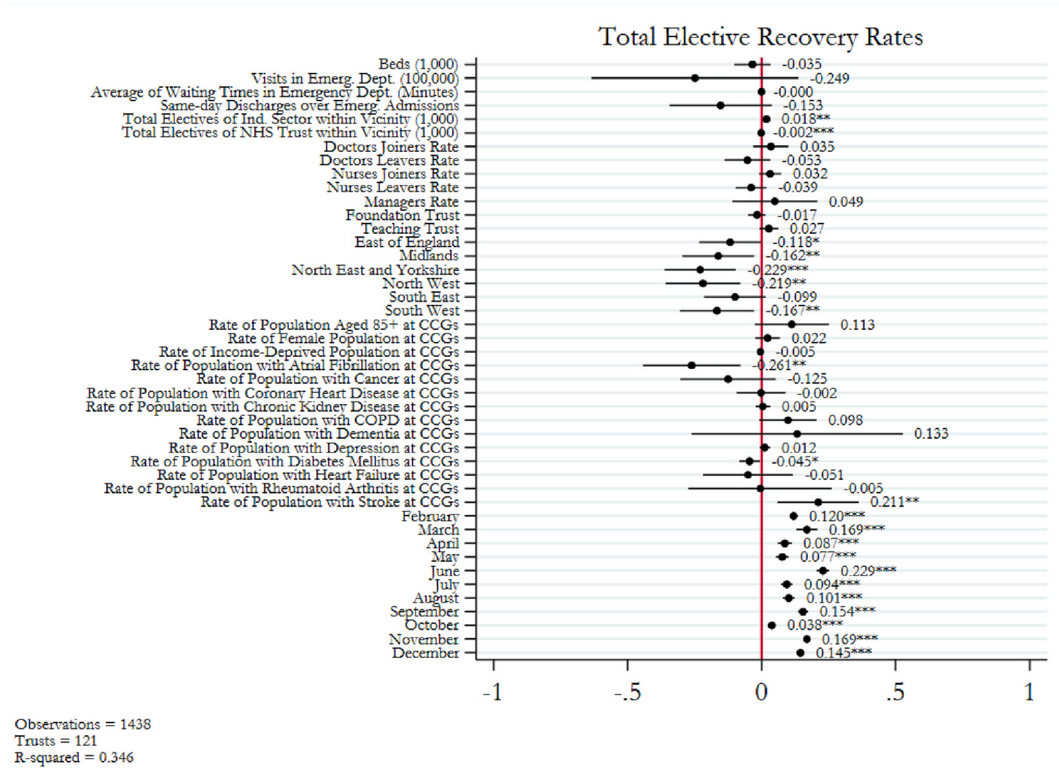


Fig. A2. (*continued*).

g) Financial year 2021/22



h) Annual aggregation

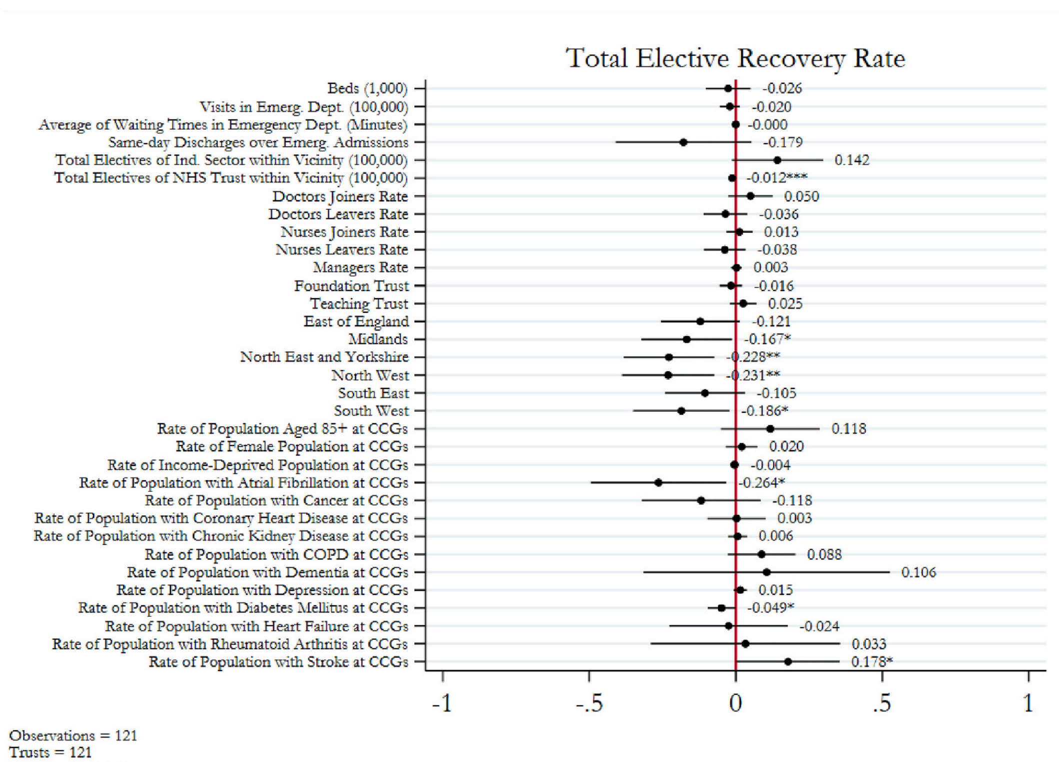


Fig. A2. (*continued*).

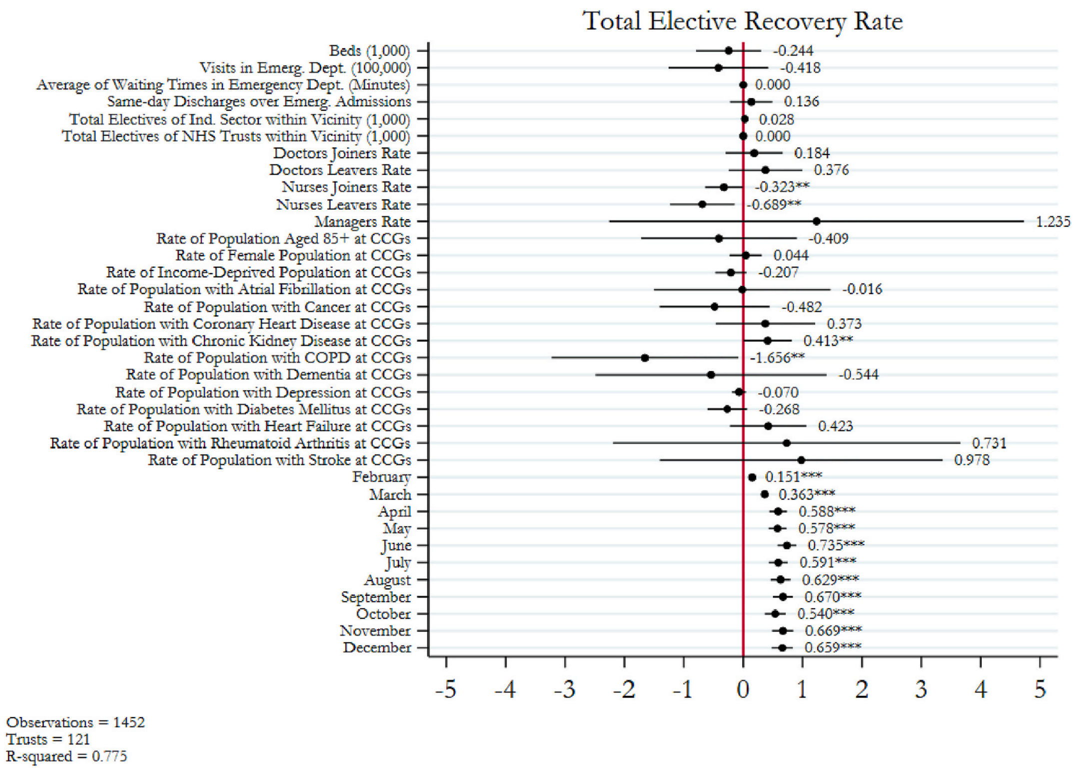
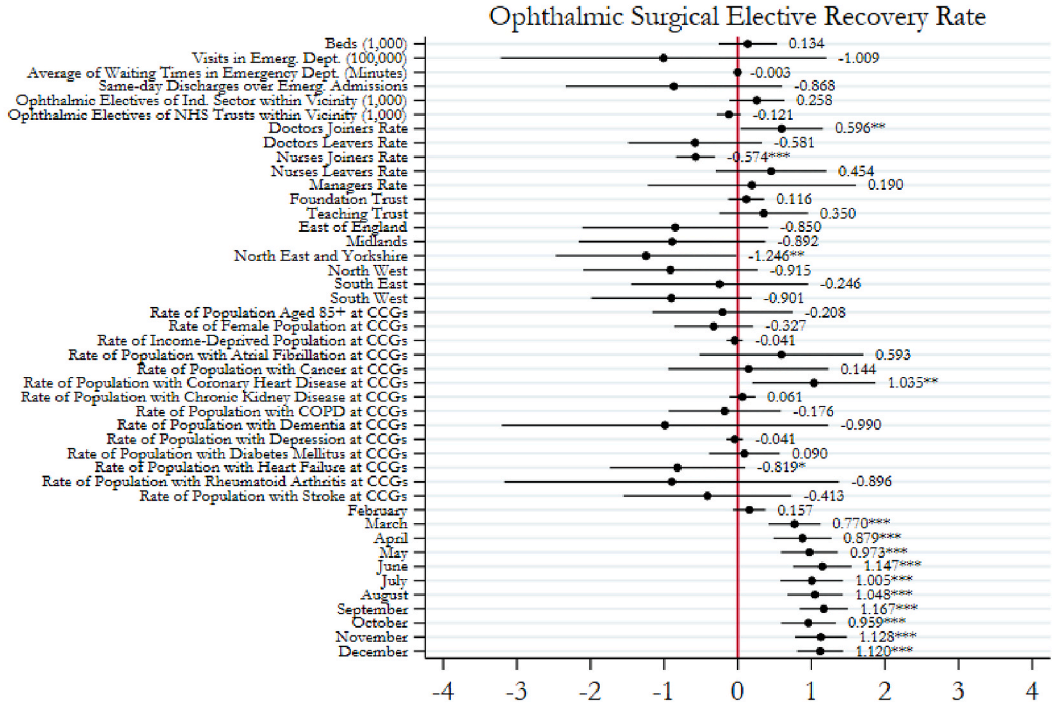
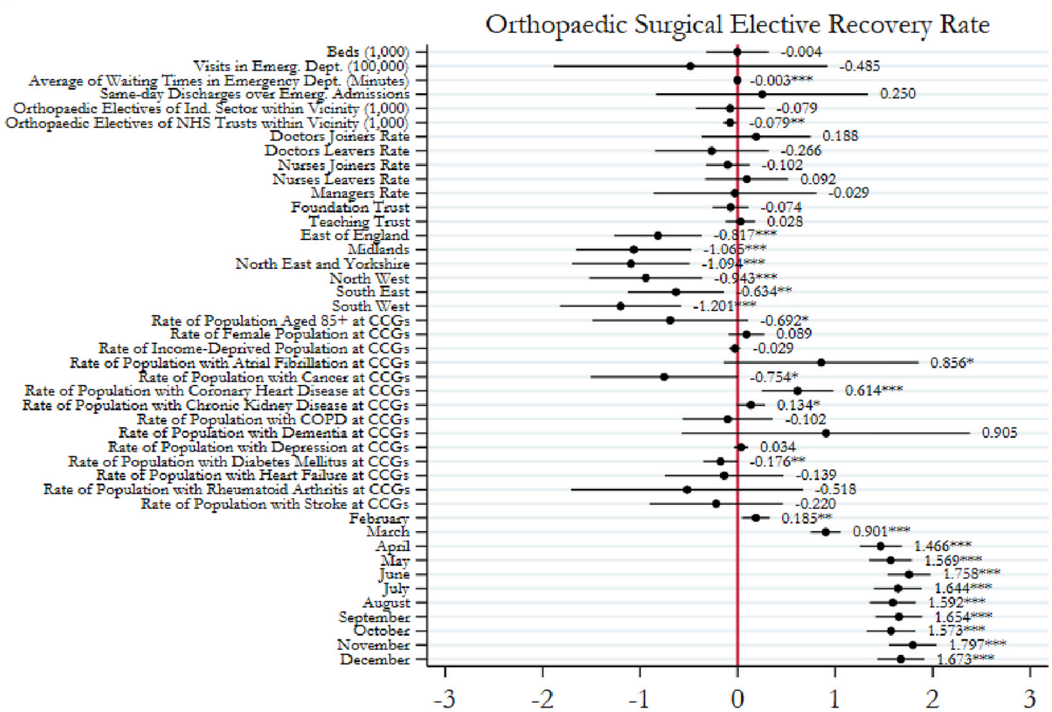


Fig. A3. Results for total elective recovery rate with hospital fixed effects

Note: Estimates of OLS regressions of total elective recovery rates on supply and demand characteristics and month and hospital fixed effects. Demand characteristics estimates are divided by 100. Confidence intervals at 95 % from standard errors clustered at the hospital level. *p < 0.1; **p < 0.05; ***p < 0.01. *Source*: Hospital Episode Statistics (2018/19–2021/22) and publicly available data from NHS Digital and NHS England, own calculations.

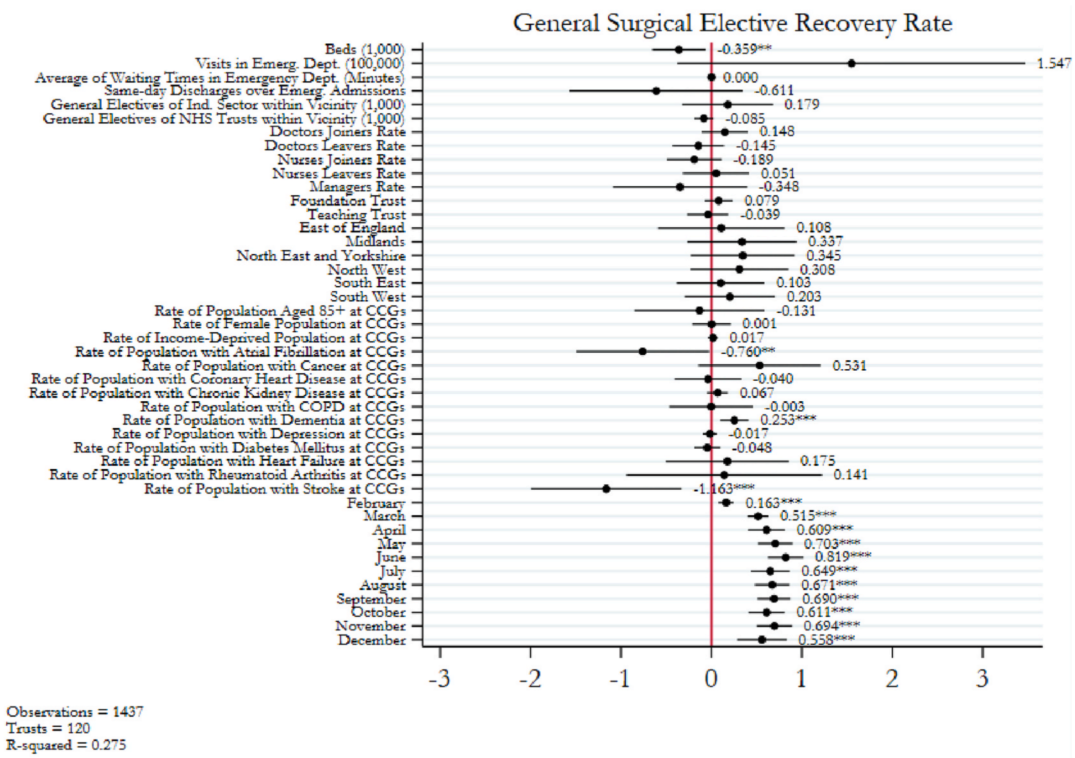


Observations = 1314
Trusts = 110
R-squared = 0.244



Observations = 1452
Trusts = 121
R-squared = 0.438

Fig. A4. Results for surgical and non-surgical specialties
Note: Estimates of OLS regressions of surgical and non-surgical elective recovery rates by specialty on supply and demand characteristics and month fixed effects. Workforce and demand characteristics estimates are divided by 10 and 100, respectively, for ophthalmic and orthopaedic surgical and haematology and gastroenterology non-surgical specialties. Estimate of rate of population with dementia is divided by 1000 for general surgical specialty; estimates of electives of independent sector providers, workforce and demand characteristics are divided by 100 for vascular surgical specialty; and estimate of elective of independent sector providers is divided by 100 for oncology non-surgical specialty. Confidence intervals at 95 % from standard errors clustered at the hospital level. *p < 0.1; **p < 0.05; ***p < 0.01. *Source*: Hospital Episode Statistics (2018/19–2021/22) and publicly available data from NHS Digital and NHS England, own calculations.



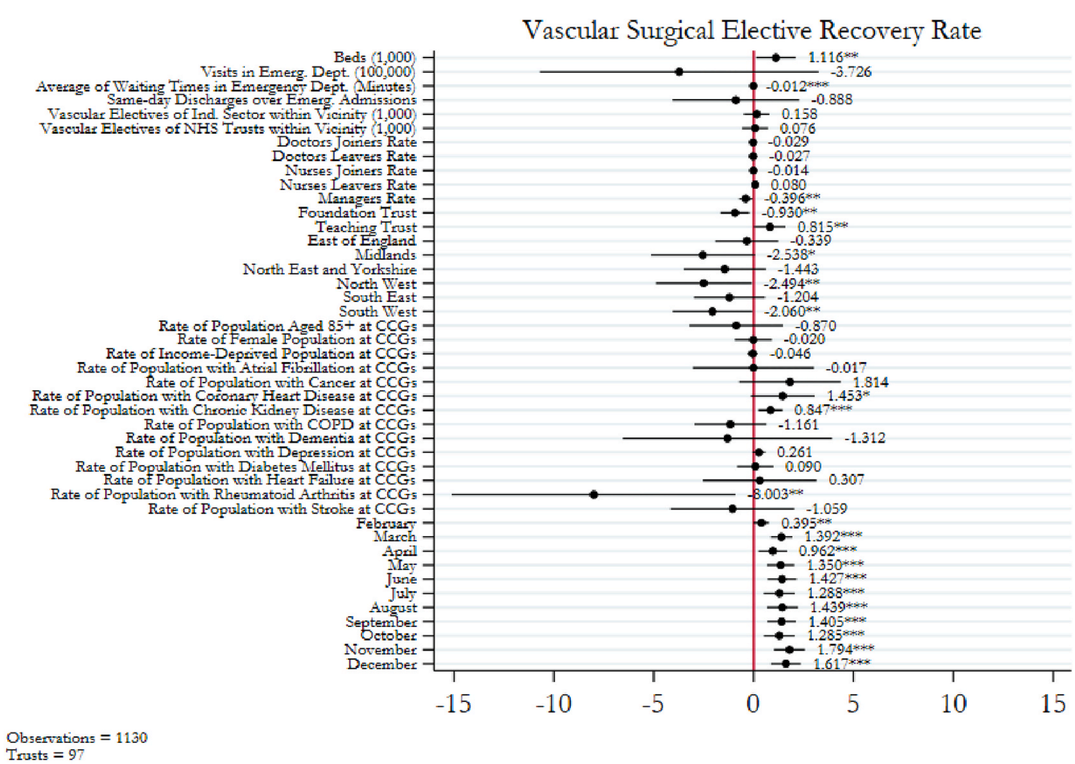
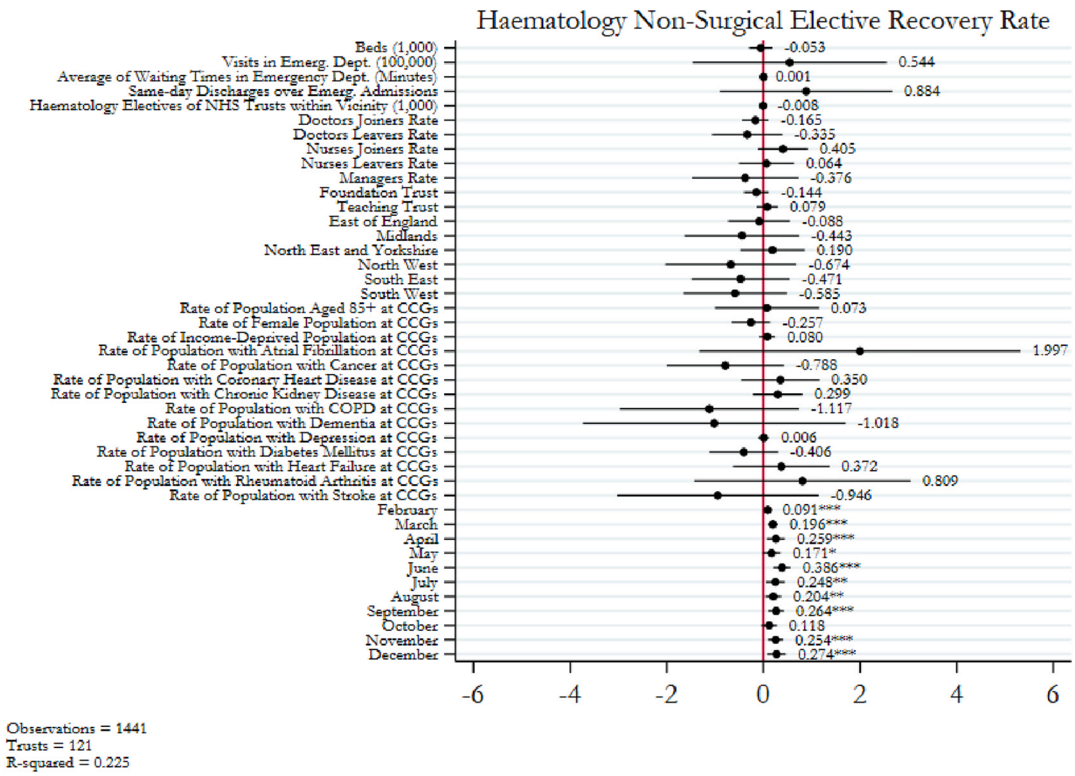


Fig. A4. (*continued*).



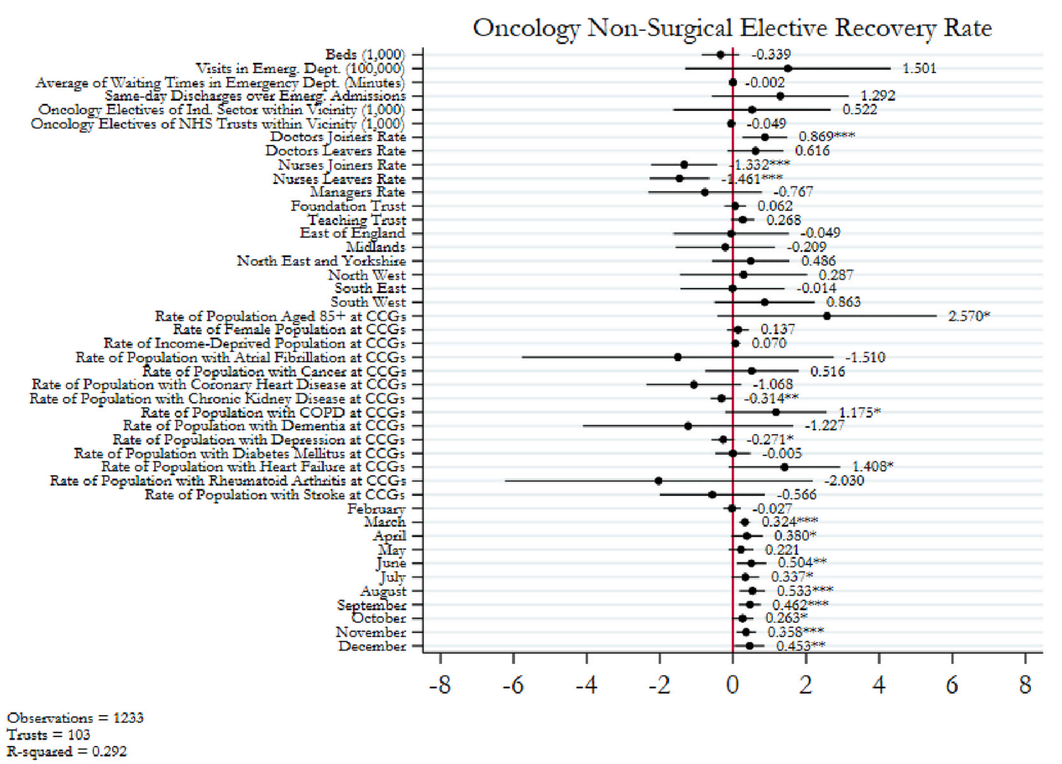


Fig. A4. (*continued*).

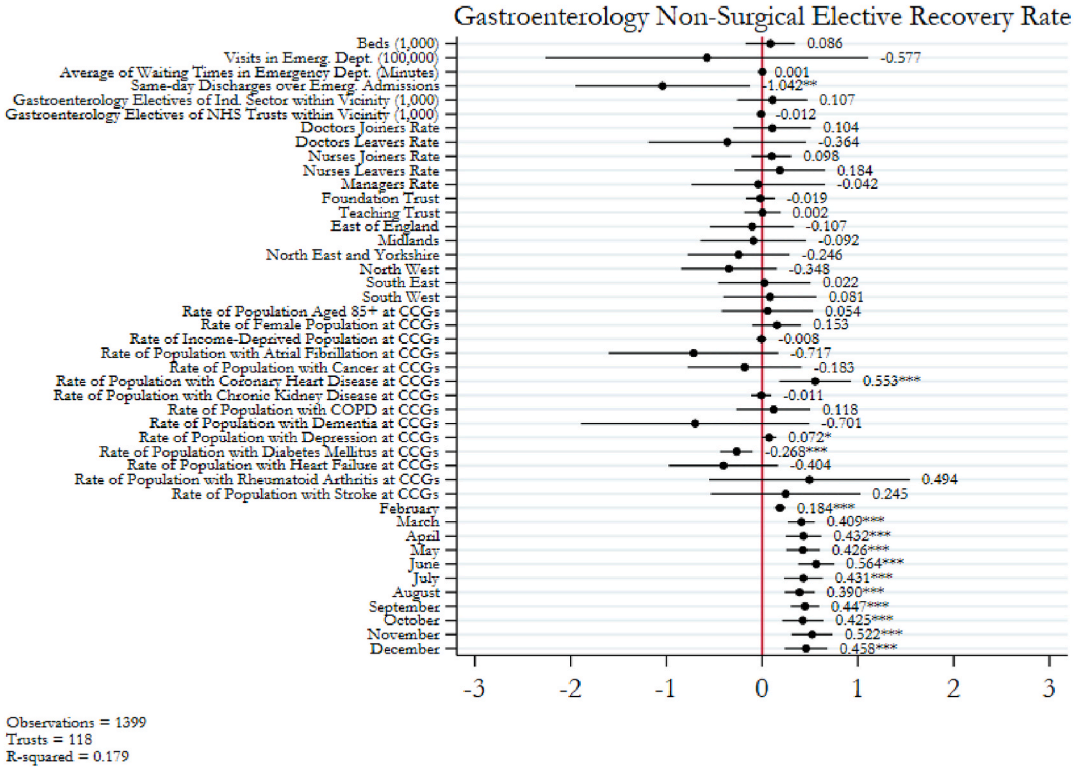


Fig. A4. (*continued*).

Data availability

The authors do not have permission to share data.

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