Impact of bariatric surgery on monthly earnings and employment: a national linked data study in England, 2014-2022

Charlotte R. Bermingham[1], Daniel Ayoubkhani[1], Francesco Zaccardi[2], Karen D. Coulman[3], Jonathan Valabhji[4], Kamlesh Khunti[2,5], Dimitri J. Pournaras[6], Rita Santos[7], Nazrul Islam[1,8], Cameron Razieh[1,2], Ted Dolby[1], Vahé Nafilyan[1]

1. Data and Analysis for Social Care and Health Division, Office for National Statistics, Newport, NP10 8XG, UK
2. Leicester Real World Evidence Unit, Diabetes Research Centre, University of Leicester, Leicester, LE5 4PW, UK
3. Population Health Sciences, Bristol Medical School, University of Bristol, Bristol, BS8 1NU
4. Department of Metabolism, Digestion and Reproduction, Faculty of Medicine, Chelsea and Westminster Hospital Campus, Imperial College London, London, SW10 9NH
5. NIHR Applied Research Collaboration. East Midlands, Diabetes Research Centre, University of Leicester, Leicester LE5 4PW
6. Department of Bariatric and Metabolic Surgery, North Bristol NHS Trust, Southmead Hospital, BS10 5NB, Bristol, UK.
7. Centre for Health Economics, University of York, Alcuin Block A, YO10 5DD
8. Primary Care Research Centre, Faculty of Medicine, University of Southampton, Southampton SO16 5ST

Correspondence to:
Charlotte R. Bermingham
Email: charlotte.bermingham@ons.gov.uk
Telephone: +44 1329 444110

Address: Government Buildings, Cardiff Road, Newport, South Wales, NP10 8XG
Competing interests: FZ has received consulting fees from Servier, Menarini, and Daiichi Sankyo, unrelated to this study, as well as honoraria from the European Association for the Study of Diabetes for providing methodological support in the development of clinical guidelines, also not related to this study. KK has acted as a consultant, speaker or received grants for investigator-initiated studies for Astra Zeneca, Bayer, Novo Nordisk, Sanofi-Aventis, Servier, Lilly and Merck Sharp & Dohme, Boehringer Ingelheim, Oramed Pharmaceuticals, Pfizer, Roche, Daiichi-Sankyo, Applied Therapeutics, Embecta and Nestle Health Science. DP has been funded by the Royal College of Surgeons of England. He receives consulting fees from Johnson and Johnson, GSK, Novo Nordisk and Pfizer and payments for lectures, presentations, and educational events from Johnson and Johnson, Medtronic, Novo Nordisk and Sandoz. JV was the national clinical director for diabetes and obesity at NHS England from April 2013 to September 2023.

Bermingham et al. Int J Obes (2026). https://doi.org/10.1038/s41366-025-01995-z

Abstract

BACKGROUND/OBJECTIVE

There is evidence that living with obesity can affect an individual's pay and employment, but there is little evidence on the impact of weight-management interventions in improving labour market outcomes of individuals. We evaluate the impact of bariatric surgery on monthly earnings and employee status among working-age adults, and examine variations across sociodemographic characteristics.

METHODS

This population-based, retrospective longitudinal cohort study for England included 40,662 individuals who had a bariatric surgery procedure and obesity diagnosis between 1 April 2014 and 31 December 2022, with no bariatric surgery history in the previous 5 years, and were 25 to 64 years old at the date of surgery. 49,921 individuals sampled from the general population who had not had bariatric surgery were also included, matched by age and sex. The main outcome measures were monthly employee pay – for all months and only months where the individual was in paid employment – expressed in 2023 prices and paid employee status.

RESULTS

Among people living with obesity who had bariatric surgery, there was a sustained increase in monthly employee pay from six months after surgery with a mean increase of £84 per month (95% confidence interval [CI]: 63 -106) 5 years after surgery compared with the six

months before surgery. There was a sustained increase in the probability of being a paid employee from 4 months after bariatric surgery, with a mean increase of 4.3 percentage points (95% Cl: 3.7-4.9) 5 years after surgery.

CONCLUSION

Bariatric surgery is associated with an increased probability of being employed, resulting in increased earnings. This suggests that living with obesity negatively impacts labour market outcomes and that obesity management interventions are likely to generate economic benefits both to individuals and on a macroeconomic level by increasing the likelihood of employment of people living with obesity.

Introduction

Poor health can affect an individual's ability to work, impacting on employment, income, productivity, and overall wellbeing (1). There is some evidence that ill-health can affect labour market outcomes (2), but little evidence on the impact of health interventions in improving labour market outcomes of individuals. Demonstrating the effect of health interventions on economic outcomes could help increase the funding allocated to healthcare for the working age population and the labour market supply, as well as support economic growth.

Prevalence of obesity has been increasing globally (3). In England, 29% of adults aged 18 years and over were estimated to be living with obesity in 2022 and 64% living with overweight (including obesity) (4). Obesity is associated with a wide range of chronic conditions, including type 2 diabetes, sleep apnoea, heart failure and hypertension, as well as premature morbidity (5,6). The increase in risk of morbidity and mortality with increased BMI is larger among those under 50 years of age (6). Obesity can affect an individual's labour market status through generally poorer health, via development of obesity related health conditions or through social discrimination (7). There is evidence that people living with obesity are less likely to be in paid employment (8), earn less on average than people not living with obesity, particularly among women (9), and have higher levels of sick leave (10,11) . Therefore, interventions to tackle obesity could improve labour market outcomes.

Bariatric surgery is the most effective obesity intervention for sustained weight-loss (12), leading to lower disease risk, particularly for type 2 diabetes, sleep apnea, nonalcoholic

steatohepatitis and hypertension (13,14). There is also observational evidence of a beneficial effect across multiple outcomes such as cancer (15) and reduced all-cause mortality (16–18). It is therefore an ideal intervention to study the impact of weight-loss on employment. In the 2022-2023 financial year in England, ~4,500 bariatric surgical procedures or gastric balloon procedures (not including revision procedures) were carried out (19). However, there is limited evidence on the impact of bariatric surgery and other obesity care interventions on labour market outcomes. There is significant interest from governments in understanding these impacts, for example in understanding the impacts of weight-loss drugs in the UK (20).

Previous studies have reported inconsistent findings on the impact of bariatric surgery on labour market outcomes; however, these have largely been based on small sample sizes with limited follow-up (21–26). Nationwide studies using register data have been conducted in Scandinavian countries, where linked population-level employment and health datasets are established, and in Belgium using health insurance data. Findings from these studies are inconclusive, with some reporting no changes in employment or earnings and others a positive or negative effect (27–30).

To our knowledge, no whole population study on the labour market impacts of bariatric surgery has been conducted in the UK. The UK has a publicly funded healthcare system that is free at the point of use. There are high levels of economic inactivity (people neither working nor seeking work) due to long-term ill health, which remains elevated compared with pre-pandemic levels (31). Therefore, this provides an ideal setting to investigate the labour market impacts of health interventions. We used a population-level linked dataset

for England, comprising electronic health records, sociodemographic information, and pay data for employees collected for tax purposes, to evaluate the long-term impact of bariatric surgery on pay and employment. We further examined heterogeneity in effects by sociodemographic characteristics.

Methods

Study data

We used a linked, individual-level dataset for residents of England, combining: (1) Hospital Episode Statistics (HES) Admitted Patient Care (APC) records from 1 April 2009 to 31 December 2022 (32); (2) sociodemographic characteristics from Census 2011, or from Census 2021 if there was no link for the individual to Census 2011 (10% of individuals had no link to the 2011 Census) (33); (3) Office for National Statistics (ONS) death registrations for deaths that occurred from 1 January 2014 to 31 December 2022 and were registered by 31 December 2022. (34); (4) Office for National Statistics (ONS) birth registrations for births that occurred from 1 January 2014 to 31 December 2022 and were registered by 31 December 2023 (35); (5) Pay As You Earn (PAYE) Real Time Information (RTI) records from His Majesty's Revenue and Customs (HMRC) covering 1 April 2014 to 31 December 2022. These are records of gross earnings paid to employees and recorded for tax purposes for the UK government, and are calendarised to monthly observations on employee status and pay (36).

The PAYE dataset was linked to the Census 2011 and 2021 through the ONS Demographic Index (37,38), which contains longitudinally linked administrative data providing information on the population in England and Wales (39,40). The HES and death registration datasets were linked to the 2011 Census through the linkage of 2011 Census and NHS Patient Registers 2011-13 and the 2021 Census through the linkage of 2021

Census and 2021 NHS Patient Demographic Service (41). All datasets were de-identified, prior to being harmonised and analysed.

Study population and follow-up

We included individuals who had at least one episode in HES starting on or after 1 April 2014 and finishing on or before 31 December 2022, recording a primary or secondary Office of Population Censuses and Surveys (OPCS) code for bariatric surgery, concurrently with either a primary International Classification of Diseases (ICD-10) code for obesity or a secondary code for obesity and a primary code for an obesity-related condition (code lists in **Supplementary Table 1**). Individuals were excluded if they had at least one record in HES for a prior bariatric surgery procedure with episode end from 1 April 2009 and episode start on or before 31 March 2014. The procedure date of each individual's first episode for bariatric surgery with an obesity diagnosis in the follow-up period was assigned as their index date.

An unexposed sample was created of individuals enumerated in the 2011 Census who did not have a record for bariatric surgery in HES either in the follow-up time (episode end date from 1 April 2014 to 31 December 2022) or in the five years prior. The purpose of this sample was to adjust more accurately for time-varying confounders, which would be partially collinear with the within-individual treatment effect in the exposed cohort. In order to apply the age-based study inclusion criteria to the unexposed cohort, an index date was randomly assigned to individuals in the unexposed sample using the same distribution of operation dates as the bariatric surgery cohort (**Supplementary Text 1**). The unexposed

population was sampled using stratified sampling by sex and five-year age band (for age at index date) to match the age-sex distribution in the bariatric surgery cohort.

We restricted the sample to individuals who could be linked to a valid Census record for at least one of the 2011 or 2021 Censuses, were resident in England and could be linked to at least one encrypted National Insurance number (NINo: the unique ID for each individual with data held by HMRC, including those paid via the PAYE system) and the Patient Registers 2011-13 (for individuals with a 2011 Census ID) or the 2019 Patient Demographic Service (for individuals with a 2021 Census ID) to enable linkage to the HES and deaths datasets. The sample was further restricted to individuals aged 25 to 64 years on the index date and who did not turn 65 of age before the end of that month, to include only individuals of working age and exclude the majority of students.

Individuals were followed up for a maximum of five years pre- and post-surgery, between 1 April 2014 and 31 December 2022 (the calendar time covered by reliable PAYE data for outcomes). Follow-up time was right-censored at the earliest of death or turning age 69, and left-censored before turning age 21, to provide four years of potential follow up time before and after surgery.

The dataset linking and sample selection process for both exposed and unexposed cohorts is illustrated in **Supplementary Figure 1** and a sample flow is provided in **Supplementary Tables 2 and 3.**

Exposure and outcome variables

The exposure was time before or after the bariatric surgery procedure, with the six months before surgery being the reference period. Exposure time was included as monthly time periods for the month of surgery and the following five months to capture short-term effects after surgery; and as six-monthly periods thereafter to capture long-term effects. The time before surgery was also included in the exposure time variable as six-monthly periods to enable testing for pre-surgery trends. The month in which surgery occurred was defined as exposure month 1. The reference period, to which all time periods were compared, is the six months before surgery (exposure time 0). The exposure time was fixed at 0 for individuals in the unexposed sample.

Two outcomes were analysed: monthly employee pay (numerical: 2023 Sterling values); and paid employee status (numerical: 0/1). Being a paid employee was defined as receiving any monthly pay greater than zero. For the pay outcome, analyses were conducted on both the full dataset (employee pay overall) and on a dataset including only the months for which individuals were a paid employee (employee pay among those in employment).

Information on all variables included in the models is reported in **Supplementary Table 4**.

Statistical analysis

We described the data using either mean or percentage for a range of sociodemographic variables for the exposed and unexposed individuals, and compared the two groups using

standardised mean differences. Standardised mean differences greater than 10% in absolute value indicated a large imbalance between the groups (42).

We compared the unadjusted outcomes (employee pay overall; employee pay among paid employees; paid employee status) over exposure time for the exposed and unexposed individuals. We also compared the unadjusted outcomes over calendar time and age.

We analysed the change in monthly earnings and employee status following surgery, with individuals acting as their own controls. We fitted linear regression models (or linear probability models in the case of employment status as an outcome), with individual-level and calendar-time fixed effects; exposure time was included in the model with a reference level of the six-month period before surgery for the exposed group and all time periods for the unexposed group (**Supplementary Text 2**). Individual fixed effects capture confounding that does not vary within individuals over time; calendar month-year fixed effects were included as there could be factors which vary over calendar time for all individuals, such as background labour market conditions in the macroeconomy. The model was also adjusted for age in years (on the last day of each month) as a time-varying covariate, to account for changes due to ageing. Age was modelled as a natural cubic spline with four internal knots at the 20^{th}, 40^{th}, 60^{th} and 80^{th} centiles and boundary knots at the 10^{th} and 90^{th} centiles of its distribution; the number of knots was chosen by minimising the BIC.

We estimated robust standard errors accounting for within-individual correlation to accompany the estimated treatment effects, as well as 95% confidence intervals.

Secondary analyses are described in **Supplementary Text 3**, sensitivity analyses in **Supplementary Text 4** and placebo tests in **Supplementary Text 5**.

All analyses were carried out in R version 3.5.1. Dataset linkage and cleaning was carried out in SparklyR using Spark version 2.4.0. The statistical software package "lfe" version 3.0.0 was used to carry out the fixed effects linear regression modelling.

Code availability

The code used for the analysis is available on Github (51).

Results

Characteristics of the study population

We identified 43,968 individuals who had bariatric surgery with a hospital obesity diagnosis during follow-up, with no prior history of bariatric surgery. After restricting to those aged 25-64 years at time of surgery, resident in England and who could link to census and PAYE datasets, 40,662 individuals (92.5%) remained for analysis (**Supplementary Table 2**). We included a cohort of 49,921 sex- and age-matched individuals in Census 2011 who had not had bariatric surgery (**Supplementary Table 3**).

The characteristics of the study population are shown in **Table 1** (variables are defined in **Supplementary Table 4**). Individuals who were living with obesity and had bariatric surgery had a mean age of 45 years, 80% were female and 85% were of White ethnicity. Compared with the cohort who had not had bariatric surgery, those who had a bariatric surgery procedure were broadly similar by ethnic group distribution, but were less likely of Asian and more likely of Black ethnicity. The largest differences between the two groups were observed for severity of comorbidities measured using the Charlson Comorbidity Score (**Supplementary Text 6**) , disability, region of residence and area-level socioeconomic deprivation, with people who had bariatric surgery more likely to have more severe comorbidities, have a disability and live in more deprived areas.

The overall median follow-up was 88 months, with a maximum of 105 months for both those who had bariatric surgery and those who did not. In those with bariatric surgery, median

follow-up time was 48 months pre-surgery and 57 months post-surgery (**Supplementary Table 5**).

The most common bariatric procedures were Roux-en-Y bypass (20,427; 50.2%) and sleeve gastrectomy (15,329; 37.7%) (**Supplementary Table 6**). The number of procedures performed each month remained consistent until the COVID-19 pandemic, where large decreases were seen in the number of operations performed (**Supplementary Figure 2**).

Unadjusted analyses

The unadjusted analyses do not account for differences between individuals who underwent bariatric surgery and those who did not, such as socioeconomic status, or changes over time such as aging and background economic conditions. Among individuals who underwent bariatric surgery, the employment rate was 56.2% in the pre-surgery and 52.9% in the post-surgery period (**Supplementary Table 7**). Unadjusted median monthly deflated earnings (with no winsorisation applied) were £1,368 in the pre-surgery and £1,337 in the post-surgery period; corresponding figures when omitting months for which people were not in work were £2,437 and £2,528. Earnings and employment rate were higher among those who did not undergo bariatric surgery, with median monthly earnings of £1,828 overall and £2,901 among those in work only, and an overall employment rate of 64.7%. Employment rate and overall earnings were lower post- than pre-index date, as they were for those who underwent bariatric surgery.

The unadjusted monthly mean deflated employee pay for people who underwent bariatric surgery, overall and among those in work, followed similar trends in exposure time as those

for people who did not undergo bariatric surgery. However, there was a reduction in the month of and following the operation for pay overall and among those in work, before a recovery to the pre-operation levels (**Figure 1**). There was a similar post-operation drop and recovery in the probability of employment for the people who underwent bariatric surgery. However, there was also a steeper decline in the probability of employment leading up to the operation than the overall decline in the probability of employment seen among the people who did not undergo bariatric surgery. Trends in pay and employment were broadly similar with some small differences by calendar time and age differed slightly between those who had bariatric surgery and those who did not (**Supplementary Text 7 and Supplementary Figures 3 and 4**).

Effect of bariatric surgery on employee pay and paid employee status

Bariatric surgery was associated with a sustained increase in the probability of being a paid employee (**Figure 2**; **Supplementary Table 8**). Compared to pre-surgery level, the probability of being a paid employee decreased by 0.8 (95% CI: 0.6-1.0) percentage points in the month after surgery, increasing to pre-surgery levels by the third month after the month of surgery. The employment probability then increased by 1.5 (95% CI: 1.3-1.8) percentage points in months 6-12 after surgery and continued increasing, reaching a maximum of 4.3 (3.7-4.9) percentage points higher than pre-surgery levels in the months 54-60 after surgery. There was evidence of pre-surgery trends, with increased probabilities in the months before surgery compared to the 6 months immediately prior to surgery.

Bariatric surgery was associated with a sustained average increase in employee pay, following a short decrease in pay in the first few months following surgery. Compared with the pre-surgery levels, employee earnings decreased in the month after surgery by an average of £117 (95% CI: 110-124), before increasing to pre-surgery levels by the fourth month after surgery (**Figure 2; Supplementary Table 9**). Compared to the six months before surgery, employee pay then increased to £61 (95% CI: 49-72) more than pre-surgery levels in months 18-24 after surgery, and continued to gradually increase compared to the six months before surgery to £84 (63-106) more than pre-surgery levels in months 54-60 after surgery. There were no pre-surgery trends for employee pay overall.

By contrast, bariatric surgery was not strongly associated with an increase in pay among those in work, where only the months in which individuals were in paid employment were included in the analysis (**Figure 2**; **Supplementary Table 10**). Pay among those in work initially decreased in the month after surgery, by an average of £206 (95% CI: 194-218) compared with pre-surgery levels, before increasing to pre-surgery levels by the fifth month after surgery. However, employee pay among those in work remained only slightly above or the same as pre-surgery levels in the following months, with a maximum of £21 (95% CI: 6-36) more than pre-surgery levels in months 18-24 after surgery.

There were no pre-surgery trends for employee pay overall and only a very small, possible downward trend in the pre-surgery trends for employee pay among those in work.

Secondary analyses

For most of the treatment interactions investigated, the overall trends were broadly similar for each group, with an initial decrease followed by an increase in employee pay and probability of paid employment and no change in pay among those in paid employment (**Supplementary Text 3**, **Supplementary Figures 5-22** and **Supplementary Table 11**). There was a higher increase in pay and probability of paid employment after bariatric surgery among those who had more severe comorbidities, however pretrends make the interpretation of the pay outcome in particular more challenging.

Sensitivity analyses

Results from sensitivity analysis looking at the impact of the timing and length of the reference period were consistent with the findings of the main analysis (**Supplementary Text 4** and **Supplementary Tables 12-17**). There were slightly higher estimates of the association of surgery with the probability of being a paid employee when omitting data from the COVID-19 pandemic period, starting from 12 months after surgery (**Supplementary Table 18**). Results from placebo tests supported the robustness of the analysis method (**Supplementary Text 5** and **Supplementary Figures 23** and **24**).

Discussion

Main findings

In this nationwide study in England, we found that bariatric surgery led to an increase in the probability of employment sustained from four months to five years after surgery (the end of the follow-up period). Individuals were on average 3.7 percentage points more likely to be in paid employment 1-5 years after surgery, reaching a maximum of 4.3 percentage points more likely to be in paid employment 54 to 60 months after surgery. This was also reflected in overall earnings: The total average cumulative increase in pay over 5 years after surgery was £3,180, which is a substantial part of the cost of surgery (43). however, there was little change in pay among only those in paid employment after the initial decrease, suggesting that the increase in pay was largely driven by the increased likelihood of being in paid employment, rather than changes in the rate of pay or hours worked.

The higher probability of being in paid employment after surgery, leading to increased overall pay, is likely to be driven by intentional weight-loss maintenance as a result of having had bariatric surgery, leading to an increase in general health, a lower likelihood of developing obesity related conditions, lower levels of social discrimination or stigma (44), or a combination of these factors. This either enables individuals who had left the workforce to return or decreases the rate at which individuals are leaving the workforce. The secondary analysis showing that the increase in probability of paid employment after bariatric surgery is larger among individuals with more severe comorbidities supports better health being a driver of the improvements in economic outcomes.

Comparison with other studies

There is substantial evidence that a higher BMI is associated with lower pay, lower probability of employment, and high levels of sickness leave (8–11). However, evidence for the effect of bariatric surgery on these outcomes is more limited, often based on smaller sample sizes (21–26). A UK based study of 1,011 bariatric surgery patients found an increase in employment post-surgery (25). However, follow-up was limited to 30 months and no comparison group who had not undergone bariatric surgery was included. To our knowledge, four nationwide, registry-based studies on the labour market effects of bariatric surgery have been carried out, with none in the UK. In Sweden, no change in pay or employment was observed over the 5 years after surgery (15,828 individuals who underwent bariatric surgery) (27); in Denmark, an increased probability of being in full-time employment 1-3 years after surgery was found but not in the longer term. There was a sustained increase in the probability of being in full-time employment for men, craftsmen and office workers (5,450 individuals who underwent bariatric surgery) (28). The third study, also conducted in Denmark, showed a lower risk of unemployment 5 years after surgery among men, but a higher risk in women and a higher risk of sickness absence up to 5 years after surgery in both men and women (10,328 individuals who underwent bariatric surgery) (30). A fourth study, in Belgium, found higher levels of employment 3 years after bariatric surgery (16,276 individuals who underwent bariatric surgery) (29).

Contrary to the Scandinavian registry-based studies, we found a sustained increase in employment after bariatric surgery in both men and women; however, we did not observe a

change in pay among those in employment. Some differences could be related to the national differences in healthcare or the labour market and welfare system.

Strengths and limitations of this study

To our knowledge, this is the largest population-wide study of labour market outcomes of bariatric surgery internationally, and the only such study outside of Scandinavia and Belgium. This investigation was made possible by a new national linked dataset comprising electronic health records, sociodemographic information and monthly pay records, which is the first linked dataset containing labour market and health data with near-complete coverage for individuals in England.

We did not have reliable data on hours worked, therefore we could not distinguish changes in hours worked from changes in rate of pay. In addition, individuals who were self-employed were not included in the PAYE dataset and would be classed as not a paid employee in our analysis, along with people who were employed but not receiving pay (for example, due to maternity leave or sick leave). We also did not have information on benefits received, such as sick leave and disability benefit, which could be impacted by having bariatric surgery (26).

We used a sample of people from the general population who had not undergone bariatric surgery to better account for time-varying confounding, independently of the effect of bariatric surgery. There were large differences between those who underwent bariatric surgery and those who did not for some sociodemographic characteristics, such as area-level socioeconomic deprivation, with a higher proportion of people who underwent bariatric surgery living in more deprived areas than in the general population. This may have

contributed to the pre-surgery trends seen in some subgroups. An unexposed group constructed of the population eligible for bariatric surgery, but who did not undergo surgery, using information such as BMI (not available for this analysis) could be used as a comparison group, which may enable time-varying confounders (i.e. calendar time and ageing) to be better accounted for.

Bariatric surgery is highly effective, making it an ideal intervention to study the impact of weight-loss on employment outcomes. However, only a small percentage of the population eligible for bariatric surgery receive it, and the population who do differs from those eligible but who do not receive bariatric surgery (45). Further studies of alternative obesity care interventions, such as pharmaceutical interventions and weight-management programmes, are needed to enable comparisons between different interventions and employment outcomes.

The impact of bariatric surgery on economic outcomes is one of the factors to consider when appraising the impacts, positive and negative, of the procedure, alongside impacts to individual's health, changes to future healthcare utilisation and potential complications. However, the impact of bariatric surgery on an individual's economic outcomes are not usually considered when calculating cost-effectiveness (47,48), or are estimated based on strong assumptions (12,24,49). Estimates such as those produced by this analysis will aid in providing a more complete picture of the impact of bariatric surgery, supporting more robust health-economic appraisal (50).

Conclusions

In our study, bariatric surgery resulted in a sustained increase in the probability of being a paid employee from four months after surgery over the five-year follow-up period, leading to increased earnings. This suggests that living with obesity negatively impacts labour market outcomes and obesity care interventions are likely to generate substantial economic benefits by increasing earnings and employment of people living with obesity, mediated by intentional weight-loss maintenance due to having had bariatric surgery (46).

Competing interests

FZ has received consulting fees from Servier, Menarini, and Daiichi Sankyo, unrelated to this study, as well as honoraria from the European Association for the Study of Diabetes for providing methodological support in the development of clinical guidelines, also not related to this study. KK has acted as a consultant, speaker or received grants for investigator-initiated studies for Astra Zeneca, Bayer, Novo Nordisk, Sanofi-Aventis, Servier, Lilly and Merck Sharp & Dohme, Boehringer Ingelheim, Oramed Pharmaceuticals, Pfizer, Roche, Daiichi-Sankyo, Applied Therapeutics, Embecta and Nestle Health Science. DP has been funded by the Royal College of Surgeons of England. He receives consulting fees from Johnson and Johnson, GSK, Novo Nordisk and Pfizer and payments for lectures, presentations, and educational events from Johnson and Johnson, Medtronic, Novo Nordisk and Sandoz. JV was the national clinical director for diabetes and obesity at NHS England from April 2013 to September 2023.

Data availability

The source data used in this study is subject to controlled access due to its sensitive nature.

References

1. Department for Work and Pensions, Department of Health and Social Care. A study of work and health transitions: analysis of Understanding Society [Internet]. 2021. Available from: https://www.gov.uk/government/publications/a-study-of-work-and-health-transitions-analysis-of-understanding-society/a-study-of-work-and-health-transitions-analysis-of-understanding-society#key-findings

2. Pintor MP, Fumagalli E, Sukrcke M. The impact of health on labour market outcomes: A rapid systematic review. Health Policy (New York). 2024;143:105057.

3. Phelps NH, Singleton RK, Zhou B, Heap RA, Mishra A, Bennett JE, et al. Worldwide trends in underweight and obesity from 1990 to 2022: a pooled analysis of 3663 population-representative studies with 222 million children, adolescents, and adults. Lancet. 2024;403(10431):1027–50.

4. NHS England. Adult overweight and obesity [Internet]. Health Survey for England, 2022 Part 2. 2024. Available from: https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/2022-part-2/adult-overweight-and-obesity

5. Haase CL, Eriksen KT, Lopes S, Satylganova A, Schnecke V, McEwan P. Body mass index and risk of obesity-related conditions in a cohort of 2.9 million people: Evidence from a UK primary care database. Obes Sci Pract. 2021;7(2):137–47.

6. Bhaskaran K, dos-Santos-Silva I, Leon DA, Douglas IJ, Smeeth L. Association of BMI with overall and cause-specific mortality: a population-based cohort study of 3·6 million adults in the UK. Lancet Diabetes Endocrinol [Internet]. 2018;6(12):944–53. Available from: http://dx.doi.org/10.1016/S2213-8587(18)30288-2

7. Dolado JJ, Minale L, Guerra A. Uncovering the roots of obesity-based wage discrimination: The role of job characteristics. Labour Econ [Internet]. 2023;85(July):102425. Available from: https://doi.org/10.1016/j.labeco.2023.102425

8. Campbell DD, Green M, Davies N, Demou E, Ward J, Howe LD, et al. Effects of increased body mass index on employment status: a Mendelian randomisation study. Int J Obes [Internet]. 2021;45(8):1790–801. Available from: http://dx.doi.org/10.1038/s41366-021-00846-x

9. Han E, Norton EC, Stearns SC. Weight and wages: fat versus lean paychecks. Health Econ. 2009;18:535–48.

10. Cawley J. An economy of scales: A selective review of obesity's economic causes, consequences, and solutions. J Health Econ [Internet]. 2015;43:244–68. Available from: http://dx.doi.org/10.1016/j.jhealeco.2015.03.001

11. Bramming M, Jorgensen MB, Christensen AI, Lau CJ, Egan KK, Tolstrup JS. BMI and Labor Market Participation : A Cohort Study of Transitions Between Work ,

Unemployment , and Sickness Absence. Obesity. 2019;27(10):1703–10.

12. Picot J, Jones J, Colquitt JL, Gospodarevskaya E, Loveman E, Baxter L, et al. The clinical effectiveness and cost-effectiveness of bariatric (weight loss) surgery for obesity: A systematic review and economic evaluation [Internet]. Vol. 13, Health Technology Assessment. 2009. Available from: https://www.journalslibrary.nihr.ac.uk/hta/hta13410/#/abstract

13. Noria SF, Grantcharov T. Biological effects of bariatric surgery on obesity-related comorbidities. Can J Surg. 2013;56(1):47–57.

14. Fakhry TK, Mhaskar R, Schwitalla T, Muradova E, Gonzalvo JP, Murr MM. Bariatric surgery improves nonalcoholic fatty liver disease: a contemporary systematic review and meta-analysis. Surg Obes Relat Dis. 2019;15(3).

15. Wilson RB, Lathigara D, Kaushal D. Systematic Review and Meta-Analysis of the Impact of Bariatric Surgery on Future Cancer Risk. Int J Mol Sci. 2023;24(7).

16. Wiggins T, Guidozzi N, Welbourn R, Ahmed AR, Markar SR. Association of bariatric surgery with all-cause mortality and incidence of obesity-related disease at a population level: A systematic review and meta-analysis. PLoS Med [Internet]. 2020;17(7):1–18. Available from: http://dx.doi.org/10.1371/journal.pmed.1003206

17. Syn NL, Cummings DE, Wang LZ, Lin DJ, Zhao JJ, Loh M, et al. Association of metabolic–bariatric surgery with long-term survival in adults with and without diabetes: a one-stage meta-analysis of matched cohort and prospective controlled studies with 174 772 participants. Lancet. 2021;397(10287):1830–41.

18. Avenell A, Broom J, Brown TJ, Poobalan A, Aucott L, Stearns SC, et al. Systematic review of the long-term effects and economic consequences of treatments for obesity and implications for health improvement [Internet]. Vol. 8, Health Technology Assessment. 2004 Jan. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0140673605177186

19. NHS England. National Obesity Audit - Primary Bariatric Surgical Procedures [Internet]. [cited 2024 Oct 2]. Available from: https://app.powerbi.com/view?r=eyJrIjoiOTIwMGU5YzctOTQ1OC00NTg4LWEwNzEtY2I0MWY1YzNkZWNmIiwidCI6IjM3YzM1NGIyLTg1YjAtNDdmNS1iMjIyLTA3YjQ4ZDc3NGVlMyJ9

20. BBC. Unemployed could get weight loss jabs to return to work [Internet]. Available from: https://www.bbc.co.uk/news/articles/cjd54zd0ezjo

21. Alfonso-cristancho R, King WC, Mitchell JE, Ramanathan R, Sullivan SD, Belle SH, et al. Longitudinal Evaluation of Work Status and Productivity After Bariatric Surgery. JAMA. 2017;316(15):1595–7.

22. Andersen JR, Hernæs UJ V, Hufthammer KO, Villy V. Employment status and sick-leave following obesity surgery : a five-year prospective cohort study. 2015;1–12.

23. Turchiano M, Saunders JK, Fernandez G, Navie L, Labrador L, Parikh M. Bariatric surgery may improve employment status in unemployed, underserved, severely obese patients. Obes Surg. 2014;24(5):692–5.

24. Tarride JE, Breau R, Sharma AM, Hong D, Gmora S, Guertin JR, et al. The Effect of Bariatric Surgery on Mobility, Health-Related Quality of Life, Healthcare Resource Utilization, and Employment Status. Obes Surg [Internet]. 2017;27(2):349–56. Available from: http://dx.doi.org/10.1007/s11695-016-2298-6

25. Courtney MJ, Mahawar K, Burnell P, Jennings N, Balupuri S, Schroeder N, et al. Occupational Outcomes of Obesity Surgery—Do the Employed Return to Work, and Do the Unemployed Find Work? Obes Surg. 2018;28(4):963–9.

26. Hawkins SC, Osborne A, Finlay IG, Alagaratnam S, Edmond J, Welbourn R. Paid Work Increases and State Benefit Claims Decrease after Bariatric Surgery. Obes Surg. 2007;17:434–7.

27. Norrbäck M, Neovius M, Ottosson J, Näslund I, Bruze G. Earnings and work loss from 5 years before to 5 years after bariatric surgery: A cohort study. PLoS One. 2023;18(5 May):1–13.

28. Juhl CB, Holst R, Mundbjerg LH, Stolberg C, Gran JM, Thomsen GF. Effect of bariatric surgery on employment status — a 7 years controlled nationwide registry study. 2021;1–10.

29. Van den Eynde A, De Cock D, Fabri V, Kestens W, Di Zinno T, Brabant S, et al. Back to Work After Bariatric Surgery? A Belgian Population Study. Obes Surg [Internet]. 2022;32(8):2625–31. Available from: https://doi.org/10.1007/s11695-022-06118-5

30. Bramming M, Becker U, Jørgensen MB, Neermark S, Bisgaard T, Tolstrup JS. Bariatric Surgery and Risk of Unemployment and Sickness Absence. Obes Surg. 2022;32(3):720–8.

31. Office for National Statistics. LFS: Econ. inactivity reasons: Long Term Sick: UK: 16-64:000s:SA [Internet]. 2024 [cited 2024 Oct 2]. Available from: https://www.ons.gov.uk/employmentandlabourmarket/peoplenotinwork/economicinactivity/timeseries/lf69/lms

32. NHS Digital. Hospital Episode Statistics (HES) [Internet]. [cited 2024 Apr 30]. Available from: https://digital.nhs.uk/data-and-information/data-tools-and-services/data-services/hospital-episode-statistics

33. Office for National Statistics. Census [Internet]. Available from: https://www.ons.gov.uk/census

34. Office for National Statistics. User guide to mortality statistics [Internet]. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/methodologies/userguidetomortalitystatisticsjuly2017

35. Office for National Statistics. User guide to birth statistics. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/methodologies/userguidetobirthstatistics

36. Office for National Statistics. Monthly earnings and employment estimates from Pay As You Earn Real Time Information (PAYE RTI) data: methods [Internet]. Available from: https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/methodologies/monthlyearningsandemploymentestimatesfrompayasyouearnrealtimeinformationpayertidatamethods

37. Office for National Statistics. 2011 Census linkage to DWP master key and encrypted NINo [Internet]. 2024. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandwellbeing/methodologies/2011censuslinkagetodwpmasterkeyandencryptednino

38. Office for National Statistics. 2021 Census linkage to DWP master key and encrypted NINo [Internet]. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandwellbeing/methodologies/2021censuslinkagetodwpmasterkeyandencryptednino

39. Archer R, Kenning E, Lloyd S, Vellanki P, Groom P, Ankeru S, et al. Evaluating Statistical Quality in the Demographic Index [Internet]. Available from: https://uksa.statisticsauthority.gov.uk/wp-content/uploads/2023/02/EAP182-Quality-work-for-Demographic-Index-MDQA.pdf

40. Office for National Statistics. Reference Data Management Framework [Internet]. Available from: https://www.ons.gov.uk/aboutus/whatwedo/programmesandprojects/referencedatamanagementframework

41. Office for National Statistics. Census 2021 to Personal Demographics Service linkage report [Internet]. 2023. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthinequalities/methodologies/census2021topersonaldemographicsservicelinkagereport

42. Austin PC. An introduction to propensity score methods for reducing the effects of confounding in observational studies. Multivariate Behav Res. 2011;46(3):399–424.

43. NHS England. National Cost Collection Data Publication: National Schedule 2022/23 [Internet]. p. Admitted Patient Care. Available from: https://app.powerbi.com/view?r=eyJrIjoiOTQwZjIwMjUtNDgwMi00MThmLWJhM2MtNmM5YWY2MTkwM2M4IiwidCI6IjM3YzM1NGIyLTg1YjAtNDdmNS1iMjIyLTA3YjQ4ZDc3NGVlMyJ9

44. Rooth D-O. Obesity, Attractiveness, and Differential Treatment in Hiring. J Hum Resour. 2009;44(3):710–35.

45. Coulman KD, Margelyte R, Jones T, Blazeby JM, Macleod J, Owen-Smith A, et al. Access to publicly funded weight management services in England using routine data from primary and secondary care (2007–2020): An observational cohort study. PLoS Med [Internet]. 2023;20(9 September):1–29. Available from: http://dx.doi.org/10.1371/journal.pmed.1004282

46. Department of Health and Social Care. Summary letter from Lord Darzi to the Secretary of State for Health and Social Care [Internet]. 2024. Available from: https://www.gov.uk/government/publications/independent-investigation-of-the-nhs-in-england/summary-letter-from-lord-darzi-to-the-secretary-of-state-for-health-and-social-care

47. Boyers D, Retat L, Jacobsen E, Avenell A, Aveyard P, Corbould E, et al. Cost-effectiveness of bariatric surgery and non-surgical weight management programmes for adults with severe obesity: a decision analysis model. Int J Obes. 2021;45(10):2179–90.

48. Gulliford MC, Charlton J, Booth HP, Fildes A, Khan O, Reddy M, et al. Costs and outcomes of increasing access to bariatric surgery for obesity: cohort study and cost-effectiveness analysis using electronic health records. Heal Serv Deliv Res. 2016;4(17):1–120.

49. Office of Health Economics. Shedding the pounds: Obesity management, NICE guidance and bariatric surgery in England.

50. McLaughlin J, Rejon CS, Bell M, Schwander B, Coulman K, McLeod H. Holistic modelling as a catalyst for effective obesity policy. Bmj. 2024;e077139.

51. Office for National Statistics. ONS-Health-modelling-hub/bariatric_surgery_lmo [Internet]. Available from: https://github.com/ONS-Health-modelling-hub/bariatric_surgery_lmo

Figure Legends

Figure 1: Unadjusted mean monthly employee pay and probability of being a paid employee over time before and after surgery for individuals with an obesity diagnosis who underwent bariatric surgery and individuals who did not undergo bariatric surgery

Figure 1 footnotes:

1. Pay is expressed in 2023 prices.
2. Month 0 is the month in which the surgery occurred for the treated cohort and a randomly assigned month for the unexposed sample.

Figure 2: Effect of bariatric surgery on monthly employee pay and probability of being a paid employee before and after surgery

Figure 2 footnotes:

1. Month 0 to 1 is the month in which the surgery occurred for the treated cohort and a randomly assigned month for the unexposed sample.
2. Months -6 to 0 is the reference period to which all other time periods are compared.

Acknowledgements

KK is supported by the National Institute for Health Research (NIHR) Applied Research Collaboration East Midlands (ARC EM), NIHR Global Research Centre for Multiple Long Term Conditions, NIHR Cross NIHR Collaboration for Multiple Long Term Conditions, NIHR Leicester Biomedical Research Centre (BRC) and the British Heart Foundation (BHF) Centre of Excellence. JV is supported by the NIHR Applied Research Collaboration North West London, and by CW+, the official charity of Chelsea and Westminster Hospital NHS Foundation Trust. KDC, receives funding from The NIHR Bristol Biomedical Research Centre (BRC-1215-20011) at University Hospitals Bristol NHS Foundation Trust and the University of Bristol. The views expressed in this publication are those of the authors and not necessarily those of the NIHR, NHS, or the UK Department of Health and Social Care.

Author Contributions

DA and VN conceived and designed the study. TD prepared the deidentified datasets for linking. CRB, carried out the analysis. All authors contributed to discussions on the methods and the interpretation of the results, which shaped the analysis. CRB drafted the manuscript. All authors revised the manuscript and approved the final version to be submitted. VN is the guarantor. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Funding

This work was funded by the Labour Markets Evaluation and Pilots Fund (2024 to 2025) and the Office for National Statistics.

Ethics approval

Ethical approval was obtained from the National Statistician's Data Ethics Advisory Committee (NSDEC23(18)).

609 **Table 1:** Characteristics of the study population. Numbers are mean (standard deviation)
610 or frequency (%).

Characteristic	Level	Bariatric surgery	No bariatric surgery	Absolute standardised difference
All people (n)	-	40,662	49,921	
Age (mean, SD)		45.4 (9.9)	45.4 (10.0)	0.1%
Sex (n, %)	Females	32,344 (79.5)	39,713 (79.6)	0.0%
Ethnic group (n, %)	Asian	1,650 (4.1)	4,231 (8.5)	23.9%
	Black	2,496 (6.1)	1,874 (3.8)	
	Mixed	1,002 (2.5)	857 (1.7)	
	Other	824 (2.0)	461 (0.9)	
	White	34,616 (85.1)	42,252 (84.6)	
	Missing or not stated	74 (0.2)	246 (0.5)	
Disability (n, %)	Yes - reduced a lot	6,742 (16.6)	2,397 (4.8)	55.0%
	Yes - reduced a little	6,667 (16.4)	3,165 (6.3)	
	No	27,179 (66.8)	44,113 (88.4)	
	Missing or not stated	74 (0.2)	246 (0.5)	
Charlson Comorbidity Score (n, %)	0	22,794 (56.1)	45,786 (91.7)	89.2%
	1	9,901 (24.3)	2,792 (5.6)	
	2	4,790 (11.8)	812 (1.6)	
	3+	3,177 (7.8)	531 (1.1)	
IMD decile (n, %)	1 (most deprived)	5,552 (13.7)	4,808 (9.6)	36.0%
	2	6,122 (15.1)	4,790 (9.6)	
	3	5,767 (14.2)	5,179 (10.4)	
	4	4,885 (12.0)	5,119 (10.3)	
	5	4,089 (10.1)	4,880 (9.8)	
	6	3,749 (9.2)	5,051 (10.1)	
	7	3,240 (8.0)	5,290 (10.6)	
	8	2,807 (6.9)	4,896 (9.8)	
	9	2,547 (6.3)	4,920 (9.9)	
	10 (least deprived)	1,904 (4.7)	4,988 (10.0)	
Region (n, %)	North East	4,460 (11.0)	2,308 (4.6)	40.5%
	North West	2,881 (7.1)	7,106 (14.2)	
	Yorkshire and The Humber	2,834 (7.0)	4,948 (9.9)	
	East Midlands	1,980 (4.9)	4,179 (8.4)	
	West Midlands	4,988 (12.3)	4,731 (9.5)	
	East of England	3,281 (8.1)	5,167 (10.4)	
	London	8,623 (21.2)	8,563 (17.2)	
	South East	8,112 (19.9)	8,181 (16.4)	
	South West	3,503 (8.6)	4,738 (9.5)	
NS-SEC (n, %)	Higher managerial, administrative and professional occupations	2,403 (5.9)	5,245 (10.5)	25.0%
	Lower managerial, administrative and professional occupations	8,637 (21.2)	12,144 (24.3)	
	Intermediate occupations	6,757 (16.6)	8,305 (16.6)	
	Small employers and own account workers	2,703 (6.6)	3,575 (7.2)	
	Lower supervisory and technical occupations	2,502 (6.2)	2,593 (5.2)	
	Semi-routine occupations	7,963 (19.6)	7,530 (15.1)	

	Routine occupations	4,423 (10.9)	4,206 (8.4)	
	Never worked	2,266 (5.6)	2,146 (4.3)	
	Long-term unemployed	1,086 (2.7)	957 (1.9)	
	Full-Time students	1,726 (4.2)	2,785 (5.6)	
	Missing or not stated	196 (0.5)	435 (0.9)	
Highest qualification (n, %)	No qualifications	6,423 (15.8)	5,693 (11.4)	25.5%
	Level 1 qualifications	7,449 (18.3)	7,673 (15.4)	
	Level 2 qualifications	8,353 (20.5)	8,823 (17.7)	
	Apprenticeship	682 (1.7)	757 (1.5)	
	Level 3 qualifications	6,272 (15.4)	7,163 (14.3)	
	Level 4 qualifications and above	9,691 (23.8)	16,914 (33.9)	
	Other: Vocational/Work-related qualifications/Foreign qualifications)	1,596 (3.9)	2,463 (4.9)	
	Missing or not stated	196 (0.5)	435 (0.9)	
Rural/Urban (n, %)	Urban	35,178 (86.5)	42,233 (84.6)	5.4%

611
612

613

Supplementary Material

Supplementary Text

Supplementary Text 1: Assignment of 'operation date' to individuals in the unexposed datasets

We randomly assigned an index date to individuals who did not undergo bariatric surgery, in the same proportions by calendar month as the number of operations each month for individuals who did undergo bariatric surgery. We then used stratified sampling to sample the dataset of individuals who did not undergo bariatric surgery in sex and five-year age group in the same proportions as for the individuals who underwent bariatric surgery and had an obesity diagnosis.

Supplementary Text 2: Modelling further details

The aim of this study is to evaluate the effect of bariatric surgery on monthly earnings and employee status among working-age adults in England. We conducted a retrospective cohort study with a pre-post design: we analysed the change in monthly earnings and employee status following surgery, with individuals acting as their own controls, like in Self-Controlled Case Series (SCCS). We used a non-exposed group to control for time-varying confounders such as age and calendar time, as is best practice in SCCS (1).

The equation for modelling is:

$$Y_{it} = \alpha_i + \lambda_t + \beta_1 T + \beta_2 f(Age_{it})$$

where Y_{it} is the outcome (monthly employee pay or paid employment status), which varies for individuals (i) and over time (t)), α_i are individual level fixed effects, λ_t are calendar time fixed effects, T is time to/since surgery and Age is age in years. Age was modelled as a natural cubic spline with four internal knots at the 20th, 40th, 60th and 80th centiles of its distribution and boundary knots at the 10th and 90th centiles of the age distribution, and coefficients β_2. The effect of time to/since surgery on the outcomes is given by the coefficients β_1.

1. Whitaker HJ, Farrington CP, Spiessens B, Musonda P. Tutorial in biostatistics: The self-controlled case series method. Stat Med. 2006;25(10):1768–97.

Supplementary Text 3: Secondary analyses

Methods

We investigated heterogeneity of treatment effects across sociodemographic factors with an interaction between each sociodemographic variable of interest and the exposure. When investigating each sociodemographic factor as a potential effect modifier, we also included two-way interactions between the sociodemographic variable and each of age and calendar time to account for heterogenous time-varying confounding. The sociodemographic factors we investigated were: age at index date (in 10-year age bands, from 25-34 to 55-64 years), sex, region of residence in England, ethnic group, Index of Multiple Deprivation (IMD) quintile group, whether resident in a rural or urban area and severity of comorbidities (**Supplementary Table 4**).

Giving birth can have a large effect on pay and employment (44), and the likelihood of birth may be different before and after surgery, we investigated the extent to which birth could affect the results by controlling for time-varying dummy variables (on a monthly basis) indicating whether an individual had given birth in the last year, or in the last five years not including the last year. As birth could also be hypothesised as a mediator rather than a confounder of the effect of bariatric surgery on pay and employment, in the main analysis it was not adjusted for.

Results

For most of the treatment interactions investigated, the overall trends were broadly similar for each group, with an initial decrease followed by an increase in employee pay and probability of paid employment and no change in pay among those in paid employment.

However, there were differing trends by age group (**Supplementary Figures 5-7**). For the group of 25-34 years of age, there was an increase in pay from six-months after surgery, mirroring the main analysis, but this reduced over time, reaching similar and then slightly lower levels than pre-surgery. This trend was also seen in the group of 35-44 years but at a later time after surgery. The probability of employment remained higher than pre-surgery levels for all age groups from six-months after surgery; however, for the group aged 25-34 years, pay among those in work decreased to lower than pre-surgery levels 24 months after surgery. Differences in pre-surgery trends may affect the results for this group.

The change in employee pay overall and employment after surgery was greater for men (**Supplementary Figures 8-10**). The probability of being a paid employee increased to a maximum of 5.8 percentage points higher than pre-surgery in months 54-60 in men compared to 3.9 in women. Employee pay for women plateaued at an average of £51 higher than pre-surgery from 18 months after surgery, whereas the effect for men was higher and continued increasing to reach £195 more than pre-surgery 54-60 months after surgery. Accounting for changes in birth rates among women before and after surgery had little

impact on the overall estimates, with only a slight increase in pay overall, within the confidence limits of the main analysis (**Supplementary Table 11**).

Employee pay overall did not increase after bariatric surgery for people of Asian or Mixed ethnic groups and the probability of being a paid employee did not increase for people of Asian ethnicity (**Supplementary Figures 11-13**). However, the number of people in these ethnic groups is low, therefore the uncertainty in the results was higher.

The trends were broadly similar by area deprivation (IMD quintile), with a greater increase in the probability of paid employment from six-months after surgery for people living in the more deprived areas (**Supplementary Figures 14-16**). The trends were also broadly similar by region (**Supplementary Figures 17-19**). However, there were notable differences in some pre-surgery trends for the analyses by region and IMD, which may have influenced the results.

The increase in pay and probability of paid employment was greater among individuals who have more sever comorbidities. However, there were pretrends, particularly in the pay results, which may have influenced the results.

Discussion

Reasons for differences in the increase in pay after bariatric surgery between men and women are not known. We found that, accounting for recent births, resulted only in a small change in the effect of bariatric surgery on the outcomes; therefore, factors other than differences in fertility after surgery are likely involved.

Some differences seen by ethnic group could be related to different eligibility criteria for bariatric surgery by ethnicity, with a lower BMI threshold determining procedure eligibility for people of South Asian, Chinese, other Asian, Middle Eastern, Black African or African-Caribbean family background (49).

It is possible that modelling trends in employment and pay is more challenging for younger people due to the volume of these people entering into the job market for the first time, therefore recording a large increase in pay, and higher differences between the unexposed and exposed samples, particularly in the 21-25 age range.

Supplementary Text 4: Sensitivity tests

We carried out sensitivity analyses to investigate the impact of changing the timing and duration of the reference time period, and to evaluate the extent to which changes in the outcomes due to the COVID-19 pandemic were accounted for.

We investigated the extent to which the baseline period specification (six months prior to the month of surgery in the main analysis) affected the results by varying the timing and length of the baseline period.

Extending the baseline period from 6 months to 12 or 24 months before surgery increased slightly the estimates for employee pay, particularly for pay among those in work, but decreased the estimates of probabilities of being a paid employee (**Supplementary Tables 12-14**). Changes in estimates were within the confidence limits of the main analysis estimates. Moving the six-month baseline period to earlier time periods before surgery (6-12 months, 12-18 months, and 24-30 months before surgery) sequentially reduced the estimated post-surgery rise in the probability of being a paid employee, with estimates outside the confidence limits of the main results (**Supplementary Tables 15-17**). Among those in work, there was little change to employee pay after the initial decrease in pay following surgery, and there was a slight increase in the estimates for employee pay overall when moving the baseline period to 6-12 months and 12-24 months before surgery. However, there was a slight decrease when moving it to 24-30 months before surgery, all within the confidence limits of the main analysis estimates.

The COVID-19 pandemic caused changes to macro-level average pay and employment rates, as well as to the scheduling of surgeries (with a reduced number of elective procedures taking place during the public health emergency). We therefore investigated the extent to which controlling for calendar time addressed these changes in the main analysis by re-running the model while omitting months from March 2020 onwards.

Omitting data from the COVID-19 pandemic period resulted in consistently higher estimates of the association of surgery with the probability of being a paid employee, starting from 12 months after surgery (**Supplementary Table 18**). Higher estimates were also seen for employee pay overall, although within the confidence limits of the main analysis. This could be due to the pandemic having a greater impact on people living with obesity compared to the general population (50), resulting in differences in the trends of employment in calendar time. This is seen in the unadjusted trends of probability of employment in calendar time, with a larger reduction in employment rate for people who underwent bariatric surgery (before undergoing the surgery) compared with people who did not undergo bariatric surgery.

Supplementary Text 5: Placebo tests

We conducted placebo tests for which we would expect to observe null results (i.e., no trends in outcomes before or after surgery) if our models were working as intended,

providing assurance that any non-null finding from the main analysis was a robust causal estimate.

We first tested for effects before surgery by censoring the data for the exposed cohort at the date of surgery using the period 30-36 months before surgery as the reference period, as well as all time-periods for the unexposed sample, as in the main analysis.

We also tested for effects in the unexposed population by using only this sample, randomly assigning individuals in this sample to be either 'treated' or 'untreated', and then using the randomly assigned index date to set a reference period and time periods before/after surgery for the 'treated' group.

No effects were found for employee pay overall or pay among those in work for either placebo test (**Supplementary Figures 20** and **21**). For the first placebo test, censoring the data at index date and setting the reference period to be 36 to 30 months before this date, there was a small negative change in probability of being a paid employee after surgery, which is in line with the pre-surgery trends seen for this outcome. For the second placebo test, using only the unexposed data and randomly 'treating' half of this population, no effects were found for the probability of being a paid employee.

Supplementary Text 6: Calculation of the Charlson Comorbidity Score

We used a five year diagnosis history up to and including the date of bariatric surgery of all primary and secondary diagnoses recorded in the Hospital Episode Statistics dataset to calculate the Charlson Comorbidity Score for all individuals in the study population. For individuals who had not undergone bariatric surgery, we used the 5 years up to and including the randomly assigned index date. We used the Quan version of the Charlson Comorbidity Index for ICD10 codes [1], with updated weights [2].

[1] H. Quan, V. Sundararajan, P. Halfon, A. Fong, B. Burnand, J.-C. Luthi, L. D. Saunders, C. A. Beck, T. E. Feasby and W. A. Ghali, "Coding Algorithms for Defining Comorbidities in ICD-9-CM and ICD-10 Administrative Data," *Medical Care,* vol. 43, no. 11, pp. 1130-1139, 2005.

[2] H. Quan, B. Li, C. M. Couris, K. Fushimi, P. Graham, P. Hider, J.-M. Januel and V. Sundararajan, "Updating and Validating the Charlson Comorbidity Index and Score for Risk," *American Journal of Epidemiology,* vol. 173, no. 6, pp. 676-682, 2011.

Supplementary Text 7: Unadjusted trends on outcomes in calendar time and by age and sex

We compared the unadjusted outcomes over calendar time (month-year) – including only the pre-surgery data for the exposed cohort to omit changes that may be due to the surgery – and by age at index date for each sex.

Trends in pay by calendar time were broadly similar for people who underwent bariatric surgery (both overall and including only pre-operation time) and people who did not undergo bariatric surgery (**Supplementary Figure 3**). However, employment trends increased overall over time for the people who underwent bariatric surgery, more so when omitting post-operation data, whereas they decreased overall for the people who did not undergo bariatric surgery. Both groups had a small drop in the probability of employment around April 2020, the first COVID-19 pandemic wave.

Trends in mean monthly deflated employee pay and the probability of being a paid employee differed slightly between the people who underwent bariatric surgery and those who did not by age and sex (**Supplementary Figure 4**). There was generally a larger difference in pay in midlife (ages ~40-50), with higher employee pay among the people who did not undergo bariatric surgery. The probability of being a paid employee increased from age 21 to 25 years among the people who did not undergo bariatric surgery but remained at a stable level for the exposed sample and started to decrease earlier among the people who underwent bariatric surgery (~ age 50 compared to ~age 54).

Supplementary Tables

Supplementary Table 1: Clinical codes used to define diagnoses and procedures in the Hospital Episode Statistics Admitted Patient Care dataset

Diagnosis or procedure	Codes
Bariatric surgery	**OPCS-4 codes, primary and secondary procedures**
One-anastomosis gastric bypass	G281, G302, G304, G312
Duodenal switch	G282, G283, G284, G716
Sleeve gastrectomy	G285
Gastric band	G303
Roux-en-Y bypass	G321, G331
Gastric balloon	G481, G485
Endoscopic sleeve gastroplasty	G301
Primary diagnosis of obesity	**ICD-10 codes, primary diagnosis** E660, E661, E662, E668, E669
Secondary diagnosis of obesity	**ICD-10 codes, secondary diagnosis** E660, E661, E662, E668, E669
Primary diagnosis of an obesity related condition	**ICD-10 codes, primary diagnosis**
Diaphragmatic hernia	K440, K441, K449
Gastro oesophageal reflux	K210, K219
Gastritis and duodenitis	K290-9
Nausea vomiting	R11X

Supplementary Table 2: Sample flow of individuals in the dataset who underwent bariatric surgery and had an obesity diagnosis

Sample selection criteria	Main sample (had bariatric surgery with an obesity diagnosis)
Is in HES dataset and has Census ID (has at least one finished episode in HES APC where the episode started on or after 1 April 2014 and finished on or before 31 December 2022, and has a census ID for either 2011 or 2021 Census)	43,238,218
Had bariatric surgery in follow up time (has at least one episode where they had a metabolic surgery 1 April 2014 to 31 December 2022)	57,787
No prior bariatric surgery (does not have a record of a previous metabolic surgery with the episode ending on or after 1 April 2009 and starting on or before 31 March 2014)	56,432
Has an obesity diagnosis (has a primary diagnosis of obesity or a secondary diagnosis of obesity with a primary diagnosis of an obesity related condition)	43,968
Resident in England (as recorded in HES, or if not available then in the Census)	43,701
Working age (is aged 25 to 64 on the surgery date and does not turn 65 within the month of the surgery)	40,754
Linkage to HMRC data (has a valid encrypted National Insurance Number that can be linked to a census ID for either 2011 or 2021 Census)	40,662

804 **Supplementary Table 3:** Sample flow of individuals in the dataset who did not undergo
805 bariatric surgery

Sample selection criteria	Unexposed sample (no bariatric surgery)
Is enumerated in 2011 Census	56,963,120
No bariatric surgery in follow up time (has not had any episode where they had metabolic surgery 1 April 2014 to 31 December 2022)	56,910,963
No prior bariatric surgery (does not have a record of a previous metabolic surgery (episode ending on or after 1 April 2009 and starting on or before 31 March 2014))	56,876,473
Can link to HES data (has linkage to the Patient Register 2011-13)	50,487,028
Resident in England (as recorded in the Census)	47,731,936
Working age (is aged 25 to 64 on the index date and does not turn 65 within the month of the index date)	25,353,079
Stratified sampling (in the same proportions by sex and five-year age band as the sample of people who underwent bariatric surgery)	50,001
Linkage to HMRC data (has a valid encrypted National Insurance Number that can be linked to a census ID for either 2011 or 2021 Census)	49,921

806

807

808 **Supplementary Table 4:** Variables used in the individual-month analysis dataset for
809 modelling

Variable	Description	Source
Outcomes		
Monthly employee pay (numerical)	Monthly employee pay is gross pay paid to employees as recorded in PAYE. Employees can be paid via the PAYE system according to a variety of payment frequencies: annual, quarterly, monthly, four-weekly, weekly, or irregularly. Payments were therefore calendarized such that the resulting linked dataset had a panel data structure, with monthly records for individuals. Monthly pay was imputed to be zero if it was negative. Where an individual had a Census ID that linked to multiple monthly PAYE records, the pay recorded in the PAYE RTI dataset was summed across all matching records for each month. Monthly pay was winszorised at the 99.9% centile and deflated to 2023 prices using the Consumer Price Index including owner occupiers' housing costs (CPIH).	PAYE RTI dataset
Employment (binary)	In employment was defined as receiving a monthly employee pay >£0. For the purposes of modelling, this was a numerical variable with value of either 0 or 1, rather than categorical, in order to produce probability estimates for the probability of being in paid employment.	PAYE RTI dataset
Exposure		
Time since operation (categorical)	Time period since the month in which the bariatric surgery operation (see date of operation variable). The month of operation and the following 5 months are included as month time-periods, after which time periods are grouped into six monthly periods. Time periods before the month of operation are also grouped in six monthly periods, with time period 0	Hospital Episode Statistics (HES)

	(the six months before the month of operation, set as the reference level for modelling. For the unexposed dataset, the time since operation was set to zero (the reference level) throughout the dataset.	
Covariates		
Calendar time (categorical)	The month-year for all from April 2014 to December 2022	-
Age (numerical)	Age in years on the last day of the month, calculated using Census date of birth	Census 2011 if available, Census 2021 if not
Other variables		
Operation date (date)	The date of operation for the bariatric surgery procedure entry in the HES episode identified as being the first instance of a bariatric surgery procedure with an obesity diagnosis in HES for the individual in the exposed dataset (the index episode). Where an individual had multiple episodes that met the inclusion criteria, the episode with the earliest start date was used. Records were further deduplicated within individuals by taking the record with the earliest operation date and then the maximum episode key (the unique record identifier derived as part of HES processing) to obtain one episode per individual. If no valid operation date was recorded for the relevant HES episode, the episode start date was used as the operation date, because the majority of bariatric surgery procedures occurred on the episode start date. An operation date was assigned to individuals in the unexposed dataset for the purposes of calculating an age on index date for sample selection and to use for some descriptives and placebo tests. See **Supplementary Methods**.	HES
Age at operation (numerical)	The age in years on the date of operation, calculated using the Census date of birth and operation date variable.	Census 2011/2021, HES
Sex (binary)	Sex recorded in the Census (male/female)	Census 2011 if available, Census 2021 if not

2011 LSOA of residence (categorical)	The 2011 LSOA recorded in the index episode for people in the exposed dataset. Where no LSOA was recorded, the LSOA from the linked Census entry was used. If the linked Census entry was from the 2021 Census, which records a 2021 LSOA, this was converted to the 2011 LSOA using a lookup from ONS Geography.	HES if available, Census 2011 if not, Census 2021 if not in either
Index of Multiple Deprivation decile (categorical)	The 2019 Index of Multiple Deprivation decile, linked to the 2011 LSOA of residence.	Census 2011 if available, Census 2021 if not, ONS Geography lookup
Index of Multiple Deprivation quintile (categorical)	The 2019 Index of Multiple Deprivation quintile, linked to the 2011 LSOA of residence.	Census 2011 if available, Census 2021 if not, ONS Geography lookup
Region (categorical)	The region of residence, linked to the 2011 LSOA of residence.	Census 2011 if available, Census 2021 if not, ONS Geography lookup
Rural/urban classification (binary)	The rural urban classification of the 2011 LSOA of residence.	Census 2011 if available, Census 2021 if not, ONS Geography lookup
Ethnic group (categorical)	Grouped ethnicity derived from the Census variable. Values: White, Black, Asian, Mixed, Other, Missing or not stated.	Census 2011 if available, Census 2021 if not
Birth in last year (binary)	Time-varying flag to indicate whether the individual had given birth (live birth or stillbirth) in the last year.	ONS birth registrations
Birth in last 1 to 5 years (binary)	Time-varying flag to indicate whether the individual had given birth (live birth or stillbirth) between 1 and 5 years ago.	ONS birth registrations

810

811

Supplementary Table 5: Follow up time, for the exposed individuals (had bariatric surgery with an obesity diagnosis) and the unexposed individuals (no bariatric surgery).

Dataset	Data	Minimum follow up (months)	Median follow up (months)	Maximum follow up (months)
Exposed only	Overall	3	88	105
Exposed only	Pre-surgery	1	48	60
Exposed only	Post-surgery	1	57	60
Unexposed only	Overall	2	88	105

Supplementary Table 6: Total numbers of operations by type

Operation type	Count	Percentage
Roux-en-Y bypass	20,426	50.2
Sleeve gastrectomy	15,329	37.7
One-anastomosis gastric bypass	1831	4.5
Gastric band	1429	3.5
Gastric balloon	1289	3.2
Duodenal switch	318	0.8
Endoscopic sleeve gastroplasty	40	0.1

Supplementary Table 7: Average pay before and after surgery, with no winsorisation applied, for the exposed individuals (had bariatric surgery with an obesity diagnosis) and the unexposed individuals (no bariatric surgery).

Individuals	Data	Median monthly deflated pay (overall) (£)	Median monthly deflated pay among those in work (£)	Maximum monthly deflated pay (£, nearest £100)	Percent in work (%)
Exposed only	Overall	1,351	2,485	2,722,400	54.4
Exposed only	Pre-surgery	1,368	2,437	2,471,700	56.2
Exposed only	Post-surgery	1,337	2,528	2,722,400	52.9
Unexposed only	Overall	1,878	2,901	8,628,700	64.7
Unexposed only	Pre-index date	1,889	2,839	8,628,700	66.5
Unexposed only	Post-index date	1,868	2,956	8,591,000	63.2

Supplementary Table 8: Model estimates for the probability of being in paid employment. Numbers in brackets indicate 95% CI.

Time since surgery (months)	Estimate (percentage points)	p value
-60 to -54	1.67 (1.03, 2.31)	<0.001
-54 to -48	1.51 (0.94, 2.08)	<0.001
-48 to -42	1.40 (0.89, 1.92)	<0.001
-42 to -36	1.26 (0.80, 1.73)	<0.001
-36 to -30	1.12 (0.71, 1.54)	<0.001
-30 to -24	0.70 (0.34, 1.06)	<0.001
-24 to -18	0.40 (0.08, 0.71)	0.013
-18 to -12	0.22 (-0.03, 0.47)	0.085
-12 to -6	0.10 (-0.07, 0.27)	0.255
0 to 1	-0.63 (-0.77, -0.48)	<0.001
1 to 2	-0.80 (-0.97, -0.63)	<0.001
2 to 3	-0.37 (-0.56, -0.18)	<0.001
3 to 4	0.06 (-0.15, 0.26)	0.571
4 to 5	0.47 (0.25, 0.68)	<0.001
5 to 6	0.66 (0.43, 0.89)	<0.001
6 to 12	1.50 (1.25, 1.75)	<0.001
12 to 18	2.47 (2.16, 2.77)	<0.001
18 to 24	3.12 (2.77, 3.46)	<0.001
24 to 30	3.47 (3.08, 3.86)	<0.001
30 to 36	3.65 (3.23, 4.07)	<0.001
36 to 42	3.90 (3.45, 4.36)	<0.001
42 to 48	4.24 (3.75, 4.74)	<0.001
48 to 54	4.19 (3.65, 4.73)	<0.001
54 to 60	4.32 (3.74, 4.91)	<0.001

Supplementary Table 9: Model estimates for monthly employee pay. Numbers in brackets indicate 95% CI.

Time since surgery (months)	Estimate (£)	p value
-60 to -54	-7.9 (-29.5, 13.8)	0.475
-54 to -48	-4.9 (-24.4, 14.5)	0.620
-48 to -42	-5.6 (-23.0, 11.7)	0.526
-42 to -36	-4.5 (-19.9, 10.9)	0.566
-36 to -30	-0.4 (-14.0, 13.3)	0.959
-30 to -24	0.5 (-11.2, 12.3)	0.927
-24 to -18	-3.1 (-13.2, 7.0)	0.550
-18 to -12	-4.3 (-12.4, 3.8)	0.299
-12 to -6	-1.7 (-7.6, 4.3)	0.579
0 to 1	-52.9 (-59.4, -46.4)	<0.001
1 to 2	-116.9 (-124.0, -109.8)	<0.001
2 to 3	-59.7 (-67.2, -52.2)	<0.001
3 to 4	-19.8 (-27.6, -12.0)	<0.001
4 to 5	-2.4 (-10.5, 5.6)	0.550
5 to 6	3.5 (-5.0, 12.0)	0.420
6 to 12	24.2 (16.2, 32.2)	<0.001
12 to 18	47.1 (37.2, 57.0)	<0.001
18 to 24	60.5 (48.9, 72.1)	<0.001
24 to 30	63.9 (50.8, 77.1)	<0.001
30 to 36	63.2 (48.5, 77.8)	<0.001
36 to 42	70.8 (54.6, 87.0)	<0.001
42 to 48	78.7 (60.7, 96.7)	<0.001
48 to 54	78.6 (58.9, 98.3)	<0.001
54 to 60	84.4 (63.1, 105.8)	<0.001

Supplementary Table 10: Model estimates monthly employee pay among those in paid employment

Time since surgery (months)	Estimate (£)	p value
-60 to -54	14.4 (-10.8, 39.6)	0.263
-54 to -48	5.0 (-18.3, 28.3)	0.676
-48 to -42	-2.0 (-23.0, 19.0)	0.852
-42 to -36	-2.9 (-21.5, 15.8)	0.762
-36 to -30	-4.6 (-21.5, 12.3)	0.595
-30 to -24	-3.7 (-18.6, 11.2)	0.627
-24 to -18	-6.0 (-19.3, 7.2)	0.373
-18 to -12	-3.3 (-14.1, 7.5)	0.544
-12 to -6	-3.3 (-12.1, 5.5)	0.463
0 to 1	-86.3 (-97.4, -75.1)	<0.001
1 to 2	-206.0 (-217.8, -194.2)	<0.001
2 to 3	-106.4 (-118.7, -94.2)	<0.001
3 to 4	-42.1 (-54.3, -29.9)	<0.001
4 to 5	-17.6 (-30.0, -5.1)	0.006
5 to 6	-10.1 (-23.2, 3.0)	0.131
6 to 12	5.9 (-5.0, 16.8)	0.289
12 to 18	18.8 (5.5, 32.2)	0.006
18 to 24	21.0 (6.0, 35.9)	0.006
24 to 30	14.9 (-2.0, 31.9)	0.085
30 to 36	8.3 (-10.0, 26.7)	0.373
36 to 42	14.1 (-5.9, 34.1)	0.168
42 to 48	16.3 (-5.8, 38.5)	0.149
48 to 54	17.5 (-6.6, 41.6)	0.155
54 to 60	17.4 (-8.8, 43.5)	0.194

Supplementary Table 11: Model estimate comparison table for the inclusion of birth variables (* = p value <0.05, ** = p value <0.01 and *** = p value < 0.001)

Time to/since surgery (months)	Main model pay	Main model pay with births in past year	Main model pay in work	Main model pay in work with births in past year	Main model employment	Main model employment with births in past year
-60 to -54	-7.9 (-29.5, 13.8)	-6.2 (-27.8, 15.5)	14.4 (-10.8, 39.6)	16.5 (-8.7, 41.7)	1.7*** (1.0, 2.3)	1.7*** (1.1, 2.3)
-54 to -48	-4.9 (-24.4, 14.5)	-3.6 (-23.0, 15.9)	5.0 (-18.3, 28.3)	7.0 (-16.3, 30.3)	1.5*** (0.9, 2.1)	1.5*** (1.0, 2.1)
-48 to -42	-5.6 (-23.0, 11.7)	-4.2 (-21.6, 13.2)	-2.0 (-23.0, 19.0)	0.3 (-20.6, 21.3)	1.4*** (0.9, 1.9)	1.4*** (0.9, 2.0)
-42 to -36	-4.5 (-19.9, 10.9)	-3.0 (-18.4, 12.4)	-2.9 (-21.5, 15.8)	-0.7 (-19.3, 18.0)	1.3*** (0.8, 1.7)	1.3*** (0.8, 1.8)
-36 to -30	-0.4 (-14.0, 13.3)	1.2 (-12.5, 14.8)	-4.6 (-21.5, 12.3)	-2.2 (-19.1, 14.7)	1.1*** (0.7, 1.5)	1.2*** (0.7, 1.6)
-30 to -24	0.5 (-11.2, 12.3)	1.9 (-9.8, 13.6)	-3.7 (-18.6, 11.2)	-2.0 (-16.9, 13.0)	0.7*** (0.3, 1.1)	0.7*** (0.4, 1.1)
-24 to -18	-3.1 (-13.2, 7.0)	-2.1 (-12.2, 8.0)	-6.0 (-19.3, 7.2)	-4.6 (-17.9, 8.6)	0.4* (0.1, 0.7)	0.4** (0.1, 0.7)
-18 to -12	-4.3 (-12.4, 3.8)	-3.6 (-11.7, 4.5)	-3.3 (-14.1, 7.5)	-2.1 (-12.9, 8.7)	0.2 (-0.0, 0.5)	0.2 (-0.0, 0.5)
-12 to -6	-1.7 (-7.6, 4.3)	-1.4 (-7.3, 4.6)	-3.3 (-12.1, 5.5)	-2.7 (-11.6, 6.1)	0.1 (-0.1, 0.3)	0.1 (-0.1, 0.3)
0 to 1	-52.9*** (-59.4, -46.4)	-53.1*** (-59.6, -46.5)	-86.3*** (-97.4, -75.1)	-86.5*** (-97.6, -75.4)	-0.6*** (-0.8, -0.5)	-0.6*** (-0.8, -0.5)
1 to 2	-116.9*** (-124.0, -109.8)	-117.1*** (-124.2, -110.0)	-206.0*** (-217.8, -194.2)	-206.4*** (-218.2, -194.6)	-0.8*** (-1.0, -0.6)	-0.8*** (-1.0, -0.6)
2 to 3	-59.7*** (-67.2, -52.2)	-59.9*** (-67.4, -52.4)	-106.4*** (-118.7, -94.2)	-106.8*** (-119.1, -94.6)	-0.4*** (-0.6, -0.2)	-0.4*** (-0.6, -0.2)
3 to 4	-19.8*** (-27.6, -12.0)	-20.1*** (-27.8, -12.3)	-42.1*** (-54.3, -29.9)	-42.6*** (-54.8, -30.4)	0.1 (-0.1, 0.3)	0.0 (-0.2, 0.3)
4 to 5	-2.4 (-10.5, 5.6)	-2.8 (-10.8, 5.3)	-17.6** (-30.0, -5.1)	-18.1** (-30.5, -5.6)	0.5*** (0.2, 0.7)	0.5*** (0.2, 0.7)
5 to 6	3.5 (-5.0, 12.0)	3.2 (-5.3, 11.7)	-10.1 (-23.2, 3.0)	-10.6 (-23.8, 2.5)	0.7*** (0.4, 0.9)	0.6*** (0.4, 0.9)
6 to 12	24.2*** (16.2, 32.2)	23.8*** (15.8, 31.8)	5.9 (-5.0, 16.8)	5.2 (-5.7, 16.1)	1.5*** (1.3, 1.7)	1.5*** (1.2, 1.7)
12 to 18	47.1*** (37.2, 57.0)	46.9*** (37.0, 56.8)	18.8** (5.5, 32.2)	18.6** (5.2, 31.9)	2.5*** (2.2, 2.8)	2.4*** (2.1, 2.8)
18 to 24	60.5*** (48.9, 72.1)	60.9*** (49.3, 72.5)	21.0** (6.0, 35.9)	22.1** (7.2, 37.0)	3.1*** (2.8, 3.5)	3.1*** (2.8, 3.5)
24 to 30	63.9*** (50.8, 77.1)	64.6*** (51.5, 77.7)	14.9 (-2.0, 31.9)	17.0* (0.1, 34.0)	3.5*** (3.1, 3.9)	3.5*** (3.1, 3.8)
30 to 36	63.2*** (48.5, 77.8)	63.9*** (49.3, 78.5)	8.3 (-10.0, 26.7)	10.3 (-8.0, 28.6)	3.7*** (3.2, 4.1)	3.6*** (3.2, 4.1)
36 to 42	70.8*** (54.6, 87.0)	71.5*** (55.4, 87.7)	14.1 (-5.9, 34.1)	15.6 (-4.4, 35.6)	3.9*** (3.4, 4.4)	3.9*** (3.4, 4.4)
42 to 48	78.7*** (60.7, 96.7)	79.5*** (61.5, 97.5)	16.3 (-5.8, 38.5)	18.1 (-4.0, 40.2)	4.2*** (3.7, 4.7)	4.2*** (3.8, 4.7)
48 to 54	78.6*** (58.9, 98.3)	79.7*** (60.0, 99.4)	17.5 (-6.6, 41.6)	19.9 (-4.2, 44.0)	4.2*** (3.7, 4.7)	4.2*** (3.7, 4.7)
54 to 60	84.4*** (63.1, 105.8)	85.5*** (64.2, 106.8)	17.4 (-8.8, 43.5)	19.5 (-6.6, 45.7)	4.3*** (3.7, 4.9)	4.3*** (3.8, 4.9)
Birth in last year		-319.7*** (-376.8, -262.5)		-722.6*** (-811.4, -633.8)		-6.2*** (-8.0, -4.4)
Birth in last 1-5 years		-104.8*** (-155.3, -54.4)		-177.6*** (-248.3, -106.9)		-6.2*** (-7.8, -4.6)

AIC	133496786	133495757	80892311	80890431	-63897	-66395
BIC	134755488	134754487	81814531	81812678	1194805	1192334

837

838

Supplementary Table 12: Model estimate comparison table for pay overall, extending the baseline period (* = p value <0.05, ** = p value <0.01 and *** = p value < 0.001)

Time to/since surgery (months)	Main model (£)	Baseline period 12 months (£)	Baseline period 24 months (£)
-60 to -54	-7.9 (-29.5, 13.8)	-7.0 (-27.9, 13.9)	-5.6 (-25.1, 14.0)
-54 to -48	-4.9 (-24.4, 14.5)	-4.1 (-22.9, 14.7)	-2.6 (-20.0, 14.7)
-48 to -42	-5.6 (-23.0, 11.7)	-4.8 (-21.4, 11.8)	-3.3 (-18.4, 11.7)
-42 to -36	-4.5 (-19.9, 10.9)	-3.7 (-18.3, 10.9)	-2.3 (-15.2, 10.7)
-36 to -30	-0.4 (-14.0, 13.3)	0.5 (-12.2, 13.2)	1.9 (-9.0, 12.7)
-30 to -24	0.5 (-11.2, 12.3)	1.4 (-9.4, 12.1)	2.8 (-5.7, 11.3)
-24 to -18	-3.1 (-13.2, 7.0)	-2.3 (-11.0, 6.5)	
-18 to -12	-4.3 (-12.4, 3.8)	-3.5 (-10.0, 3.1)	
-12 to -6	-1.7 (-7.6, 4.3)		
0 to 1	-52.9*** (-59.4, -46.4)	-52.1*** (-59.0, -45.2)	-50.8*** (-58.8, -42.8)
1 to 2	-116.9*** (-124.0, -109.8)	-116.1*** (-123.4, -108.7)	-114.8*** (-123.1, -106.5)
2 to 3	-59.7*** (-67.2, -52.2)	-58.9*** (-66.7, -51.1)	-57.6*** (-66.4, -48.9)
3 to 4	-19.8*** (-27.6, -12.0)	-19.0*** (-27.1, -10.9)	-17.7*** (-26.7, -8.7)
4 to 5	-2.4 (-10.5, 5.6)	-1.6 (-9.9, 6.7)	-0.4 (-9.6, 8.9)
5 to 6	3.5 (-5.0, 12.0)	4.3 (-4.5, 13.1)	5.6 (-4.1, 15.3)
6 to 12	24.2*** (16.2, 32.2)	25.0*** (16.6, 33.4)	26.3*** (16.9, 35.7)
12 to 18	47.1*** (37.2, 57.0)	47.9*** (37.7, 58.0)	49.1*** (38.1, 60.2)
18 to 24	60.5*** (48.9, 72.1)	61.3*** (49.4, 73.2)	62.5*** (49.8, 75.3)
24 to 30	63.9*** (50.8, 77.1)	64.7*** (51.3, 78.2)	66.0*** (51.6, 80.3)
30 to 36	63.2*** (48.5, 77.8)	64.0*** (49.0, 79.0)	65.2*** (49.4, 81.0)
36 to 42	70.8*** (54.6, 87.0)	71.6*** (55.1, 88.1)	72.8*** (55.4, 90.1)
42 to 48	78.7*** (60.7, 96.7)	79.5*** (61.1, 97.9)	80.7*** (61.5, 99.8)
48 to 54	78.6*** (58.9, 98.3)	79.4*** (59.4, 99.5)	80.6*** (59.7, 101.4)
54 to 60	84.4*** (63.1, 105.8)	85.2*** (63.5, 106.9)	86.4*** (63.9, 108.8)
AIC	133496786	133496784	133496782
BIC	134755488	134755472	134755442

Supplementary Table 13: Model estimate comparison table for pay among those in work, extending the baseline period (* = p value <0.05, ** = p value <0.01 and *** = p value < 0.001)

Time to/since surgery (months)	Main model (£)	Baseline period 12_months (£)	Baseline period 24_months (£)
-60 to -54	14.4 (-10.8, 39.6)	16.1 (-8.1, 40.3)	17.7 (-4.8, 40.2)
-54 to -48	5.0 (-18.3, 28.3)	6.6 (-15.7, 29.0)	8.2 (-12.3, 28.7)
-48 to -42	-2.0 (-23.0, 19.0)	-0.4 (-20.3, 19.5)	1.2 (-16.8, 19.2)
-42 to -36	-2.9 (-21.5, 15.8)	-1.2 (-18.8, 16.3)	0.3 (-15.2, 15.8)
-36 to -30	-4.6 (-21.5, 12.3)	-2.9 (-18.5, 12.6)	-1.4 (-14.7, 11.9)
-30 to -24	-3.7 (-18.6, 11.2)	-2.1 (-15.8, 11.6)	-0.5 (-11.5, 10.4)
-24 to -18	-6.0 (-19.3, 7.2)	-4.4 (-15.9, 7.1)	
-18 to -12	-3.3 (-14.1, 7.5)	-1.7 (-10.6, 7.2)	
-12 to -6	-3.3 (-12.1, 5.5)		
0 to 1	-86.3*** (-97.4, -75.1)	-84.7*** (-95.9, -73.4)	-83.3*** (-95.4, -71.3)
1 to 2	-206.0*** (-217.8, -194.2)	-204.4*** (-216.1, -192.7)	-203.1*** (-215.5, -190.7)
2 to 3	-106.4*** (-118.7, -94.2)	-104.9*** (-117.0, -92.7)	-103.5*** (-116.4, -90.7)
3 to 4	-42.1*** (-54.3, -29.9)	-40.5*** (-52.7, -28.3)	-39.2*** (-52.1, -26.3)
4 to 5	-17.6** (-30.0, -5.1)	-16.0* (-28.3, -3.7)	-14.6* (-27.7, -1.6)
5 to 6	-10.1 (-23.2, 3.0)	-8.5 (-21.5, 4.5)	-7.2 (-20.9, 6.5)
6 to 12	5.9 (-5.0, 16.8)	7.5 (-3.5, 18.5)	8.8 (-3.1, 20.7)
12 to 18	18.8** (5.5, 32.2)	20.4** (7.2, 33.6)	21.7** (7.8, 35.6)
18 to 24	21.0** (6.0, 35.9)	22.5** (7.5, 37.6)	23.8** (8.1, 39.6)
24 to 30	14.9 (-2.0, 31.9)	16.5 (-0.5, 33.6)	17.8* (0.0, 35.5)
30 to 36	8.3 (-10.0, 26.7)	9.9 (-8.6, 28.5)	11.1 (-8.1, 30.4)
36 to 42	14.1 (-5.9, 34.1)	15.7 (-4.5, 35.8)	16.9 (-4.0, 37.7)
42 to 48	16.3 (-5.8, 38.5)	17.9 (-4.5, 40.3)	19.1 (-4.0, 42.2)
48 to 54	17.5 (-6.6, 41.6)	19.0 (-5.3, 43.4)	20.2 (-4.8, 45.2)
54 to 60	17.4 (-8.8, 43.5)	18.9 (-7.5, 45.3)	20.1 (-7.0, 47.1)
AIC	80892311	80892310	80892307
BIC	81814531	81814516	81814487

Supplementary Table 14: Model estimate comparison table for probability of employment, extending the baseline period (* = p value <0.05, ** = p value <0.01 and *** = p value < 0.001)

Time to/since surgery (months)	Main model (percentage points)	Baseline period 12 months (percentage points)	Baseline period 24 months (percentage points)
-60 to -54	1.7*** (1.0, 2.3)	1.6*** (1.0, 2.2)	1.5*** (0.9, 2.1)
-54 to -48	1.5*** (0.9, 2.1)	1.5*** (0.9, 2.0)	1.3*** (0.8, 1.8)
-48 to -42	1.4*** (0.9, 1.9)	1.4*** (0.9, 1.9)	1.2*** (0.8, 1.7)
-42 to -36	1.3*** (0.8, 1.7)	1.2*** (0.8, 1.7)	1.1*** (0.7, 1.5)
-36 to -30	1.1*** (0.7, 1.5)	1.1*** (0.7, 1.5)	0.9*** (0.6, 1.3)
-30 to -24	0.7*** (0.3, 1.1)	0.7*** (0.3, 1.0)	0.5*** (0.3, 0.8)
-24 to -18	0.4* (0.1, 0.7)	0.3* (0.1, 0.6)	
-18 to -12	0.2 (-0.0, 0.5)	0.2 (-0.0, 0.4)	
-12 to -6	0.1 (-0.1, 0.3)		
0 to 1	-0.6*** (-0.8, -0.5)	-0.7*** (-0.8, -0.5)	-0.8*** (-1.0, -0.6)
1 to 2	-0.8*** (-1.0, -0.6)	-0.9*** (-1.0, -0.7)	-1.0*** (-1.2, -0.7)
2 to 3	-0.4*** (-0.6, -0.2)	-0.4*** (-0.6, -0.2)	-0.5*** (-0.8, -0.3)
3 to 4	0.1 (-0.1, 0.3)	0.0 (-0.2, 0.2)	-0.1 (-0.4, 0.1)
4 to 5	0.5*** (0.2, 0.7)	0.4*** (0.2, 0.7)	0.3* (0.0, 0.6)
5 to 6	0.7*** (0.4, 0.9)	0.6*** (0.4, 0.9)	0.5*** (0.2, 0.8)
6 to 12	1.5*** (1.3, 1.7)	1.5*** (1.2, 1.7)	1.3*** (1.1, 1.6)
12 to 18	2.5*** (2.2, 2.8)	2.4*** (2.1, 2.7)	2.3*** (2.0, 2.6)
18 to 24	3.1*** (2.8, 3.5)	3.1*** (2.7, 3.4)	3.0*** (2.6, 3.3)
24 to 30	3.5*** (3.1, 3.9)	3.4*** (3.0, 3.8)	3.3*** (2.9, 3.7)
30 to 36	3.7*** (3.2, 4.1)	3.6*** (3.2, 4.0)	3.5*** (3.1, 3.9)
36 to 42	3.9*** (3.4, 4.4)	3.9*** (3.4, 4.3)	3.8*** (3.3, 4.2)
42 to 48	4.2*** (3.7, 4.7)	4.2*** (3.7, 4.7)	4.1*** (3.6, 4.6)
48 to 54	4.2*** (3.7, 4.7)	4.1*** (3.6, 4.7)	4.0*** (3.5, 4.6)
54 to 60	4.3*** (3.7, 4.9)	4.3*** (3.7, 4.9)	4.2*** (3.6, 4.8)
AIC	-63897	-63897	-63871
BIC	1194805	1194791	1194789

Supplementary Table 15: Model estimate comparison table for pay overall, changing the baseline period timing to an earlier pre-surgery period (* = p value <0.05, ** = p value <0.01 and *** = p value < 0.001)

Time to/since surgery (months)	Main model (£)	Baseline period 6 months earlier (£)	Baseline period 12 months earlier (£)	Baseline period 24 months earlier (£)
-60 to -54	-7.9 (-29.5, 13.8)	-6.2 (-26.8, 14.4)	-3.6 (-23.2, 16.1)	-8.4 (-25.7, 8.9)
-54 to -48	-4.9 (-24.4, 14.5)	-3.2 (-21.8, 15.3)	-0.6 (-18.1, 16.8)	-5.5 (-20.3, 9.4)
-48 to -42	-5.6 (-23.0, 11.7)	-3.9 (-20.3, 12.4)	-1.3 (-16.6, 14.0)	-6.2 (-18.8, 6.4)
-42 to -36	-4.5 (-19.9, 10.9)	-2.8 (-17.2, 11.6)	-0.2 (-13.4, 13.0)	-5.1 (-15.2, 5.0)
-36 to -30	-0.4 (-14.0, 13.3)	1.3 (-11.1, 13.7)	3.9 (-7.4, 15.2)	-0.9 (-8.1, 6.3)
-30 to -24	0.5 (-11.2, 12.3)	2.2 (-8.3, 12.7)	4.8 (-4.0, 13.7)	
-24 to -18	-3.1 (-13.2, 7.0)	-1.4 (-9.7, 6.9)	1.2 (-5.2, 7.6)	-3.6 (-10.3, 3.1)
-18 to -12	-4.3 (-12.4, 3.8)	-2.6 (-8.7, 3.5)		-4.8 (-13.7, 4.0)
-12 to -6	-1.7 (-7.6, 4.3)		2.6 (-3.5, 8.7)	-2.2 (-12.7, 8.3)
-6 to 0		1.7 (-4.3, 7.6)	4.3 (-3.8, 12.4)	-0.5 (-12.3, 11.2)
0 to 1	-52.9*** (-59.4, -46.4)	-51.2*** (-59.7, -42.7)	-48.6*** (-58.9, -38.4)	-53.5*** (-66.8, -40.1)
1 to 2	-116.9*** (-124.0, -109.8)	-115.2*** (-124.0, -106.4)	-112.6*** (-123.2, -102.0)	-117.4*** (-130.8, -104.1)
2 to 3	-59.7*** (-67.2, -52.2)	-58.0*** (-67.2, -48.9)	-55.4*** (-66.3, -44.5)	-60.3*** (-74.1, -46.4)
3 to 4	-19.8*** (-27.6, -12.0)	-18.1*** (-27.6, -8.7)	-15.5** (-26.6, -4.4)	-20.4** (-34.5, -6.3)
4 to 5	-2.4 (-10.5, 5.6)	-0.8 (-10.4, 8.9)	1.8 (-9.5, 13.2)	-3.0 (-17.3, 11.3)
5 to 6	3.5 (-5.0, 12.0)	5.2 (-4.9, 15.3)	7.8 (-3.9, 19.5)	2.9 (-11.6, 17.5)
6 to 12	24.2*** (16.2, 32.2)	25.9*** (16.0, 35.7)	28.5*** (17.0, 39.9)	23.6** (9.1, 38.1)
12 to 18	47.1*** (37.2, 57.0)	48.8*** (37.4, 60.1)	51.4*** (38.4, 64.3)	46.5*** (30.6, 62.5)
18 to 24	60.5*** (48.9, 72.1)	62.2*** (49.1, 75.2)	64.8*** (50.3, 79.3)	60.0*** (42.5, 77.4)

24 to 30	63.9*** (50.8, 77.1)	65.6*** (51.1, 80.1)	68.2*** (52.3, 84.2)	63.4*** (44.5, 82.2)
30 to 36	63.2*** (48.5, 77.8)	64.9*** (48.8, 80.9)	67.5*** (50.1, 84.8)	62.6*** (42.4, 82.9)
36 to 42	70.8*** (54.6, 87.0)	72.5*** (55.0, 89.9)	75.1*** (56.2, 93.9)	70.2*** (48.5, 91.9)
42 to 48	78.7*** (60.7, 96.7)	80.4*** (61.1, 99.7)	83.0*** (62.4, 103.6)	78.1*** (54.7, 101.6)
48 to 54	78.6*** (58.9, 98.3)	80.3*** (59.4, 101.3)	82.9*** (60.6, 105.2)	78.1*** (53.1, 103.1)
54 to 60	84.4*** (63.1, 105.8)	86.1*** (63.6, 108.7)	88.7*** (64.9, 112.6)	83.9*** (57.4, 110.4)
AIC	133496786	133496786	133496786	133496786
BIC	134755488	134755488	134755488	134755488

856

857

Supplementary Table 16: Model estimate comparison table for pay among those in work, changing the baseline period timing to an earlier pre-surgery period (* = p value <0.05, ** = p value <0.01 and *** = p value < 0.001)

Time to/since surgery (months)	Main model (£)	Baseline period 6 months earlier (£)	Baseline period 12 months earlier (£)	Baseline period 24 months earlier (£)
-60 to -54	14.4 (-10.8, 39.6)	17.7 (-6.2, 41.7)	17.8 (-5.1, 40.7)	18.1 (-2.6, 38.8)
-54 to -48	5.0 (-18.3, 28.3)	8.3 (-14.0, 30.5)	8.3 (-12.5, 29.2)	8.7 (-9.4, 26.8)
-48 to -42	-2.0 (-23.0, 19.0)	1.3 (-18.4, 21.0)	1.3 (-17.2, 19.9)	1.7 (-14.1, 17.5)
-42 to -36	-2.9 (-21.5, 15.8)	0.4 (-17.1, 17.9)	0.5 (-15.6, 16.5)	0.8 (-12.0, 13.6)
-36 to -30	-4.6 (-21.5, 12.3)	-1.3 (-16.7, 14.2)	-1.2 (-15.5, 13.0)	-0.9 (-10.8, 9.0)
-30 to -24	-3.7 (-18.6, 11.2)	-0.4 (-14.2, 13.4)	-0.4 (-12.1, 11.4)	
-24 to -18	-6.0 (-19.3, 7.2)	-2.7 (-14.0, 8.5)	-2.7 (-12.0, 6.6)	-2.3 (-11.8, 7.1)
-18 to -12	-3.3 (-14.1, 7.5)	-0.0 (-9.0, 8.9)		0.4 (-11.4, 12.1)
-12 to -6	-3.3 (-12.1, 5.5)		0.0 (-8.9, 9.0)	0.4 (-13.4, 14.2)
-6 to 0		3.3 (-5.5, 12.1)	3.3 (-7.5, 14.1)	3.7 (-11.2, 18.6)
0 to 1	-86.3*** (-97.4, -75.1)	-83.0*** (-96.0, -70.0)	-82.9*** (-97.5, -68.3)	-82.6*** (-100.4, -64.7)
1 to 2	-206.0*** (-217.8, -194.2)	-202.7*** (-215.9, -189.5)	-202.7*** (-217.7, -187.7)	-202.3*** (-220.1, -184.5)
2 to 3	-106.4*** (-118.7, -94.2)	-103.1*** (-116.8, -89.5)	-103.1*** (-118.4, -87.8)	-102.7*** (-121.1, -84.4)
3 to 4	-42.1*** (-54.3, -29.9)	-38.8*** (-52.5, -25.1)	-38.8*** (-54.2, -23.3)	-38.4*** (-57.0, -19.8)
4 to 5	-17.6** (-30.0, -5.1)	-14.3* (-28.0, -0.5)	-14.2 (-29.7, 1.3)	-13.9 (-32.5, 4.8)
5 to 6	-10.1 (-23.2, 3.0)	-6.8 (-21.2, 7.6)	-6.7 (-22.7, 9.2)	-6.4 (-25.5, 12.7)
6 to 12	5.9 (-5.0, 16.8)	9.2 (-3.6, 22.0)	9.2 (-5.1, 23.6)	9.6 (-8.3, 27.5)
12 to 18	18.8** (5.5, 32.2)	22.1** (7.5, 36.7)	22.2** (6.0, 38.4)	22.5* (2.9, 42.1)
18 to 24	21.0** (6.0, 35.9)	24.3** (7.7, 40.8)	24.3** (6.6, 42.0)	24.7* (3.5, 45.8)
24 to 30	14.9 (-2.0, 31.9)	18.2 (-0.1, 36.5)	18.3 (-1.4, 38.0)	18.6 (-4.3, 41.6)
30 to 36	8.3 (-10.0, 26.7)	11.6 (-8.2, 31.5)	11.7 (-9.4, 32.7)	12.0 (-12.3, 36.4)
36 to 42	14.1 (-5.9, 34.1)	17.4 (-3.9, 38.7)	17.4 (-5.2, 40.1)	17.8 (-8.1, 43.7)

42 to 48	16.3 (-5.8, 38.5)	19.6 (-3.9, 43.2)	19.7 (-5.1, 44.4)	20.0 (-7.9, 48.0)
48 to 54	17.5 (-6.6, 41.6)	20.8 (-4.6, 46.1)	20.8 (-5.8, 47.5)	21.2 (-8.5, 50.9)
54 to 60	17.4 (-8.8, 43.5)	20.7 (-6.8, 48.1)	20.7 (-7.9, 49.4)	21.1 (-10.5, 52.6)
AIC	80892311	80892311	80892311	80892311
BIC	81814531	81814531	81814531	81814531

861

862

Supplementary Table 17: Model estimate comparison table for probability of employment, changing the baseline period timing to an earlier pre-surgery period (* = p value <0.05, ** = p value <0.01 and *** = p value < 0.001)

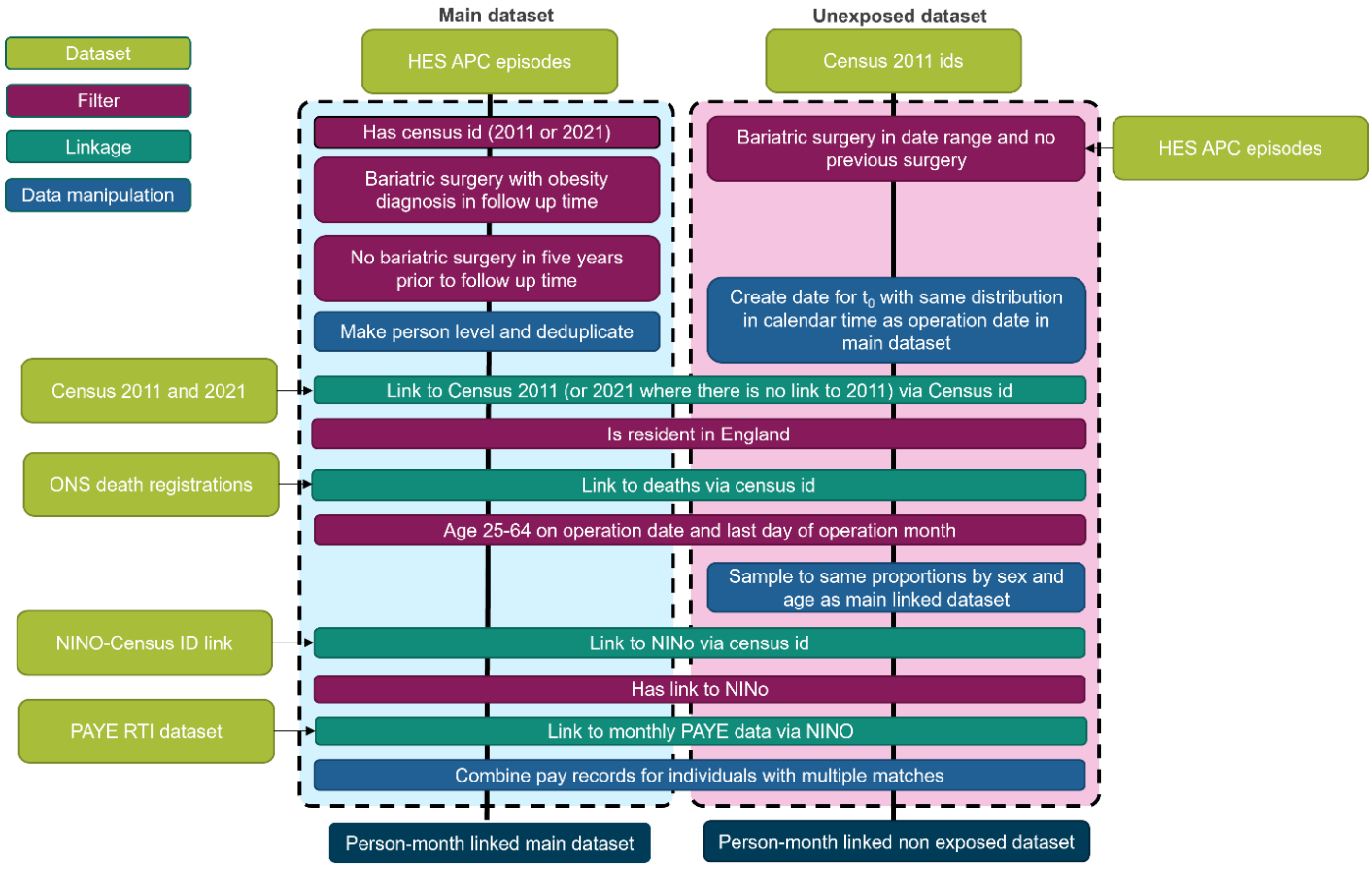
Time to/since surgery (months)	Main model (percentage points)	Baseline period 6 months earlier (percentage points)	Baseline period 12 months earlier (percentage points)	Baseline period 24 months earlier (percentage points)
-60 to -54	1.7*** (1.0, 2.3)	1.6*** (1.0, 2.2)	1.5*** (0.9, 2.1)	1.0*** (0.4, 1.5)
-54 to -48	1.5*** (0.9, 2.1)	1.4*** (0.9, 2.0)	1.3*** (0.8, 1.8)	0.8*** (0.3, 1.3)
-48 to -42	1.4*** (0.9, 1.9)	1.3*** (0.8, 1.8)	1.2*** (0.7, 1.7)	0.7*** (0.3, 1.1)
-42 to -36	1.3*** (0.8, 1.7)	1.2*** (0.7, 1.6)	1.0*** (0.6, 1.5)	0.6*** (0.2, 0.9)
-36 to -30	1.1*** (0.7, 1.5)	1.0*** (0.6, 1.4)	0.9*** (0.6, 1.3)	0.4*** (0.2, 0.6)
-30 to -24	0.7*** (0.3, 1.1)	0.6*** (0.3, 0.9)	0.5*** (0.2, 0.8)	
-24 to -18	0.4* (0.1, 0.7)	0.3* (0.0, 0.6)	0.2 (-0.0, 0.4)	-0.3** (-0.5, -0.1)
-18 to -12	0.2 (-0.0, 0.5)	0.1 (-0.1, 0.3)		-0.5*** (-0.8, -0.2)
-12 to -6	0.1 (-0.1, 0.3)		-0.1 (-0.3, 0.1)	-0.6*** (-0.9, -0.3)
-6 to 0		-0.1 (-0.3, 0.1)	-0.2 (-0.5, 0.0)	-0.7*** (-1.1, -0.3)
0 to 1	-0.6*** (-0.8, -0.5)	-0.7*** (-1.0, -0.5)	-0.8*** (-1.1, -0.6)	-1.3*** (-1.7, -0.9)
1 to 2	-0.8*** (-1.0, -0.6)	-0.9*** (-1.2, -0.7)	-1.0*** (-1.3, -0.7)	-1.5*** (-1.9, -1.1)
2 to 3	-0.4*** (-0.6, -0.2)	-0.5*** (-0.7, -0.2)	-0.6*** (-0.9, -0.3)	-1.1*** (-1.5, -0.7)
3 to 4	0.1 (-0.1, 0.3)	-0.0 (-0.3, 0.2)	-0.2 (-0.5, 0.2)	-0.6** (-1.1, -0.2)
4 to 5	0.5*** (0.2, 0.7)	0.4** (0.1, 0.6)	0.2 (-0.1, 0.6)	-0.2 (-0.6, 0.2)
5 to 6	0.7*** (0.4, 0.9)	0.6*** (0.3, 0.9)	0.4** (0.1, 0.8)	-0.0 (-0.5, 0.4)
6 to 12	1.5*** (1.3, 1.7)	1.4*** (1.1, 1.7)	1.3*** (0.9, 1.6)	0.8*** (0.4, 1.2)
12 to 18	2.5*** (2.2, 2.8)	2.4*** (2.0, 2.7)	2.2*** (1.9, 2.6)	1.8*** (1.3, 2.2)
18 to 24	3.1*** (2.8, 3.5)	3.0*** (2.6, 3.4)	2.9*** (2.5, 3.3)	2.4*** (1.9, 2.9)
24 to 30	3.5*** (3.1, 3.9)	3.4*** (3.0, 3.8)	3.2*** (2.8, 3.7)	2.8*** (2.2, 3.3)
30 to 36	3.7*** (3.2, 4.1)	3.6*** (3.1, 4.0)	3.4*** (3.0, 3.9)	3.0*** (2.4, 3.5)
36 to 42	3.9*** (3.4, 4.4)	3.8*** (3.3, 4.3)	3.7*** (3.2, 4.2)	3.2*** (2.6, 3.8)
42 to 48	4.2*** (3.7, 4.7)	4.1*** (3.6, 4.7)	4.0*** (3.5, 4.6)	3.5*** (2.9, 4.2)
48 to 54	4.2*** (3.7, 4.7)	4.1*** (3.5, 4.7)	4.0*** (3.4, 4.6)	3.5*** (2.8, 4.1)
54 to 60	4.3*** (3.7, 4.9)	4.2*** (3.6, 4.8)	4.1*** (3.5, 4.7)	3.6*** (2.9, 4.3)
AIC	-63897	-63897	-63897	-63897
BIC	1194805	1194805	1194805	1194805

Supplementary Table 18: Model estimate comparison table for omitting COVID-19 pandemic period (* = p value <0.05, ** = p value <0.01 and *** = p value < 0.001)

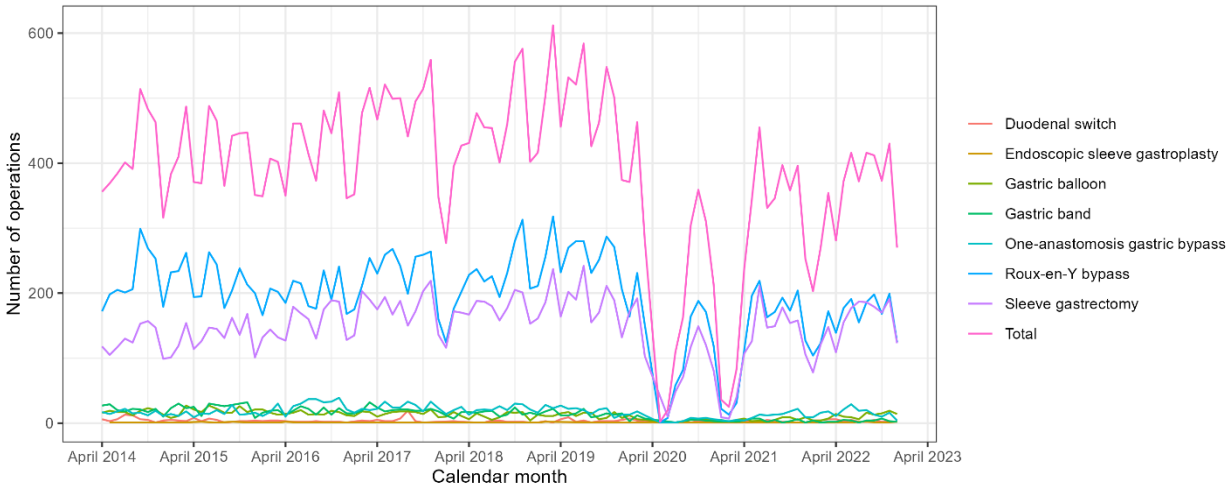
	Pay overall		Pay among those in work		Probability of employment	
Time to/since surgery (months)	Main model	Omitting COVID-19	Main model	Omitting COVID-19	Main model	Omitting COVID-19
-60 to -54	-7.9 (-29.5, 13.8)	-1.8 (-25.4, 21.8)	14.4 (-10.8, 39.6)	37.1** (9.9, 64.3)	1.7*** (1.0, 2.3)	1.3*** (0.6, 2.0)
-54 to -48	-4.9 (-24.4, 14.5)	-0.0 (-21.6, 21.5)	5.0 (-18.3, 28.3)	28.7* (3.2, 54.2)	1.5*** (0.9, 2.1)	1.1*** (0.5, 1.8)
-48 to -42	-5.6 (-23.0, 11.7)	-0.1 (-19.4, 19.3)	-2.0 (-23.0, 19.0)	18.9 (-4.3, 42.1)	1.4*** (0.9, 1.9)	1.1*** (0.5, 1.7)
-42 to -36	-4.5 (-19.9, 10.9)	-0.1 (-17.5, 17.2)	-2.9 (-21.5, 15.8)	13.5 (-7.3, 34.3)	1.3*** (0.8, 1.7)	1.0*** (0.5, 1.5)
-36 to -30	-0.4 (-14.0, 13.3)	3.6 (-12.0, 19.2)	-4.6 (-21.5, 12.3)	10.4 (-8.7, 29.5)	1.1*** (0.7, 1.5)	0.9*** (0.4, 1.4)
-30 to -24	0.5 (-11.2, 12.3)	4.0 (-9.6, 17.6)	-3.7 (-18.6, 11.2)	10.2 (-6.8, 27.2)	0.7*** (0.3, 1.1)	0.5* (0.1, 0.9)
-24 to -18	-3.1 (-13.2, 7.0)	-0.9 (-12.5, 10.8)	-6.0 (-19.3, 7.2)	4.7 (-10.4, 19.8)	0.4* (0.1, 0.7)	0.2 (-0.1, 0.6)
-18 to -12	-4.3 (-12.4, 3.8)	-2.7 (-12.0, 6.7)	-3.3 (-14.1, 7.5)	5.6 (-6.7, 17.9)	0.2 (-0.0, 0.5)	0.1 (-0.2, 0.4)
-12 to -6	-1.7 (-7.6, 4.3)	0.4 (-6.6, 7.3)	-3.3 (-12.1, 5.5)	2.2 (-7.9, 12.3)	0.1 (-0.1, 0.3)	0.1 (-0.1, 0.3)
0 to 1	-52.9*** (-59.4, -46.4)	-50.9*** (-58.3, -43.6)	-86.3*** (-97.4, -75.1)	-86.5*** (-99.2, -73.7)	-0.6*** (-0.8, -0.5)	-0.6*** (-0.8, -0.4)
1 to 2	-116.9*** (-124.0, -109.8)	-117.3*** (-125.2, -109.3)	-206.0*** (-217.8, -194.2)	-212.1*** (-225.5, -198.8)	-0.8*** (-1.0, -0.6)	-0.8*** (-1.0, -0.6)
2 to 3	-59.7*** (-67.2, -52.2)	-62.4*** (-70.7, -54.0)	-106.4*** (-118.7, -94.2)	-116.5*** (-130.1, -102.9)	-0.4*** (-0.6, -0.2)	-0.3** (-0.6, -0.1)
3 to 4	-19.8*** (-27.6, -12.0)	-21.1*** (-29.9, -12.4)	-42.1*** (-54.3, -29.9)	-47.7*** (-61.4, -34.0)	0.1 (-0.1, 0.3)	0.1 (-0.2, 0.3)
4 to 5	-2.4 (-10.5, 5.6)	-5.0 (-13.9, 3.9)	-17.6** (-30.0, -5.1)	-28.0*** (-41.6, -14.3)	0.5*** (0.2, 0.7)	0.5*** (0.3, 0.8)
5 to 6	3.5 (-5.0, 12.0)	4.1 (-5.5, 13.8)	-10.1 (-23.2, 3.0)	-17.2* (-32.1, -2.3)	0.7*** (0.4, 0.9)	0.8*** (0.5, 1.1)
6 to 12	24.2*** (16.2, 32.2)	21.9*** (12.7, 31.0)	5.9 (-5.0, 16.8)	-4.8 (-17.1, 7.5)	1.5*** (1.3, 1.7)	1.7*** (1.4, 1.9)
12 to 18	47.1*** (37.2, 57.0)	49.6*** (37.9, 61.2)	18.8** (5.5, 32.2)	9.8 (-5.8, 25.4)	2.5*** (2.2, 2.8)	2.9*** (2.5, 3.3)
18 to 24	60.5*** (48.9, 72.1)	66.7*** (52.8, 80.6)	21.0** (6.0, 35.9)	13.3 (-4.4, 31.0)	3.1*** (2.8, 3.5)	3.7*** (3.3, 4.1)
24 to 30	63.9*** (50.8, 77.1)	69.0*** (52.7, 85.2)	14.9 (-2.0, 31.9)	1.9 (-19.0, 22.7)	3.5*** (3.1, 3.9)	4.1*** (3.6, 4.6)
30 to 36	63.2*** (48.5, 77.8)	74.3*** (55.9, 92.7)	8.3 (-10.0, 26.7)	-1.2 (-24.1, 21.8)	3.7*** (3.2, 4.1)	4.4*** (3.9, 5.0)
36 to 42	70.8*** (54.6, 87.0)	88.7*** (68.1, 109.4)	14.1 (-5.9, 34.1)	2.3 (-23.5, 28.1)	3.9*** (3.4, 4.4)	5.0*** (4.4, 5.6)
42 to 48	78.7*** (60.7, 96.7)	96.8*** (73.2, 120.3)	16.3 (-5.8, 38.5)	5.1 (-24.4, 34.5)	4.2*** (3.7, 4.7)	5.3*** (4.6, 6.0)
48 to 54	78.6*** (58.9, 98.3)	98.4*** (71.7, 125.1)	17.5 (-6.6, 41.6)	11.3 (-21.6, 44.2)	4.2*** (3.7, 4.7)	5.2*** (4.4, 6.0)
54 to 60	84.4*** (63.1, 105.8)	102.3*** (72.3, 132.2)	17.4 (-8.8, 43.5)	-0.5 (-36.9, 35.9)	4.3*** (3.7, 4.9)	5.6*** (4.7, 6.5)
AIC	133496786	96166071	80892311	58590530	-63897	-745497
BIC	134755488	97395155	81814531	59470488	1194805	483587

Supplementary Figures

Supplementary Figure 1: Dataset linkage and sample selection process



879 **Supplementary Figure 2:** Number of bariatric surgery operations, total and by type, over
880 calendar time

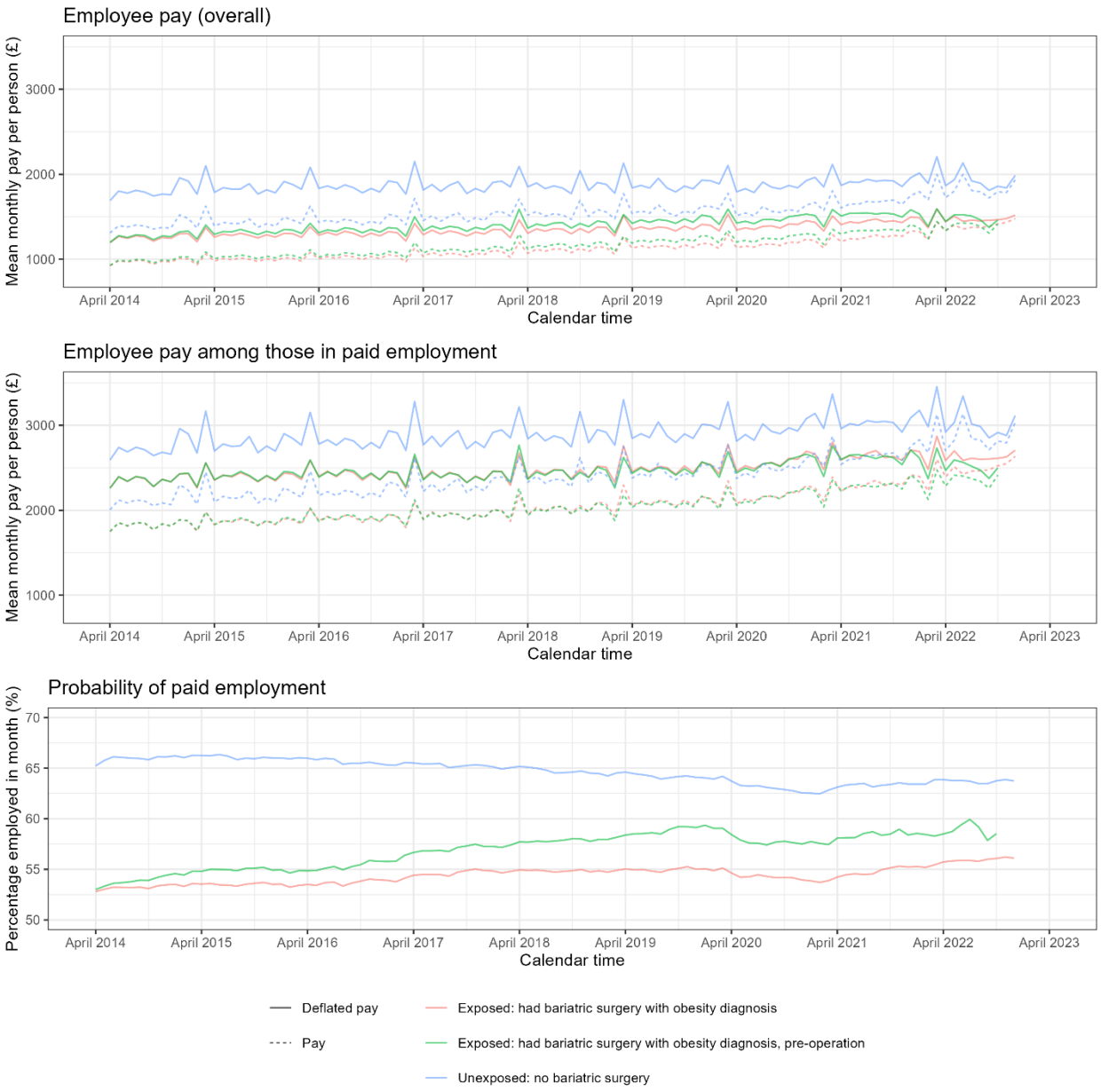


881

882

883

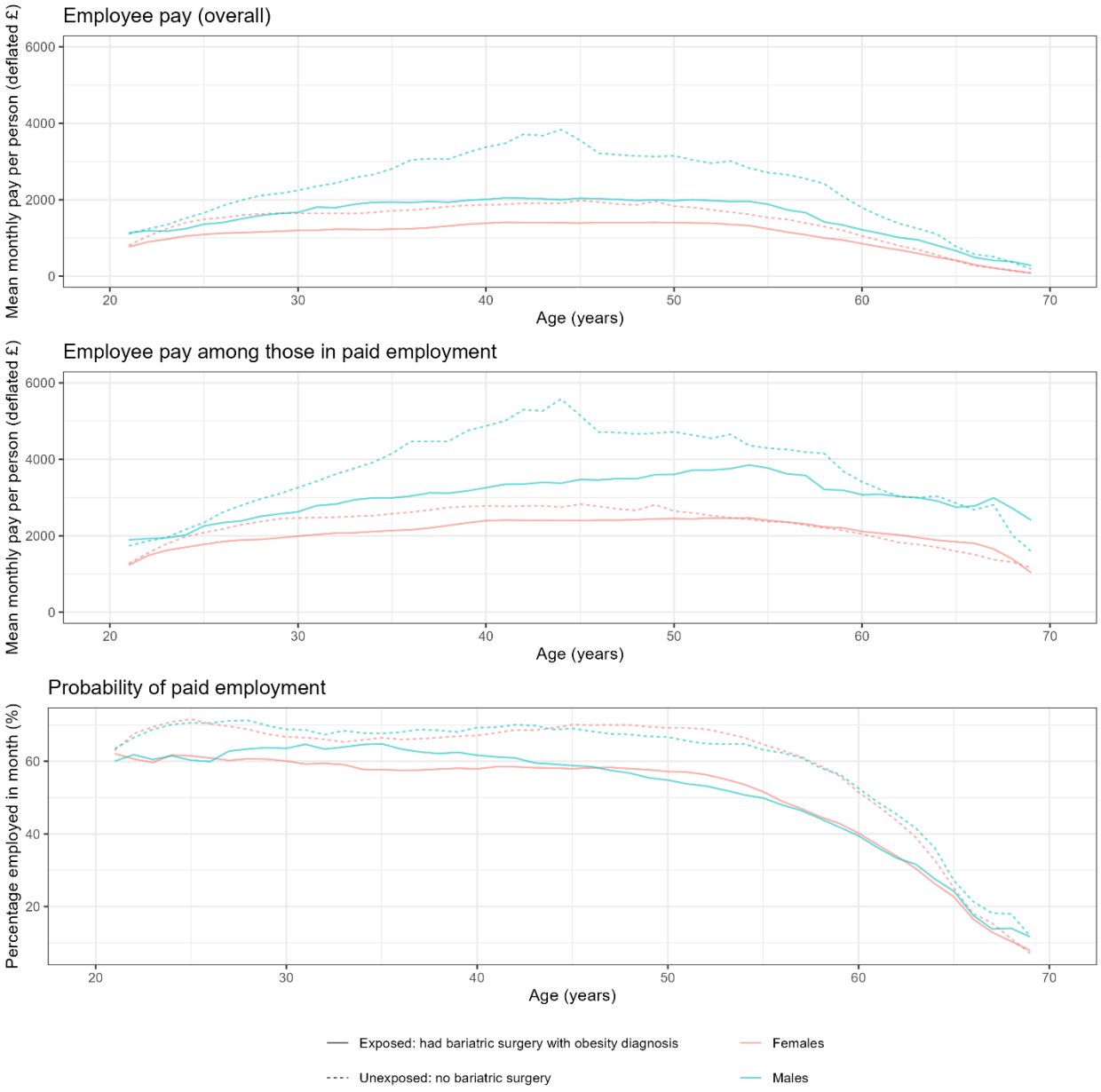
884 **Supplementary Figure 3:** Mean monthly pay and employment in calendar time



885

886

887 **Supplementary Figure 4:** Mean monthly pay and employment by age and sex

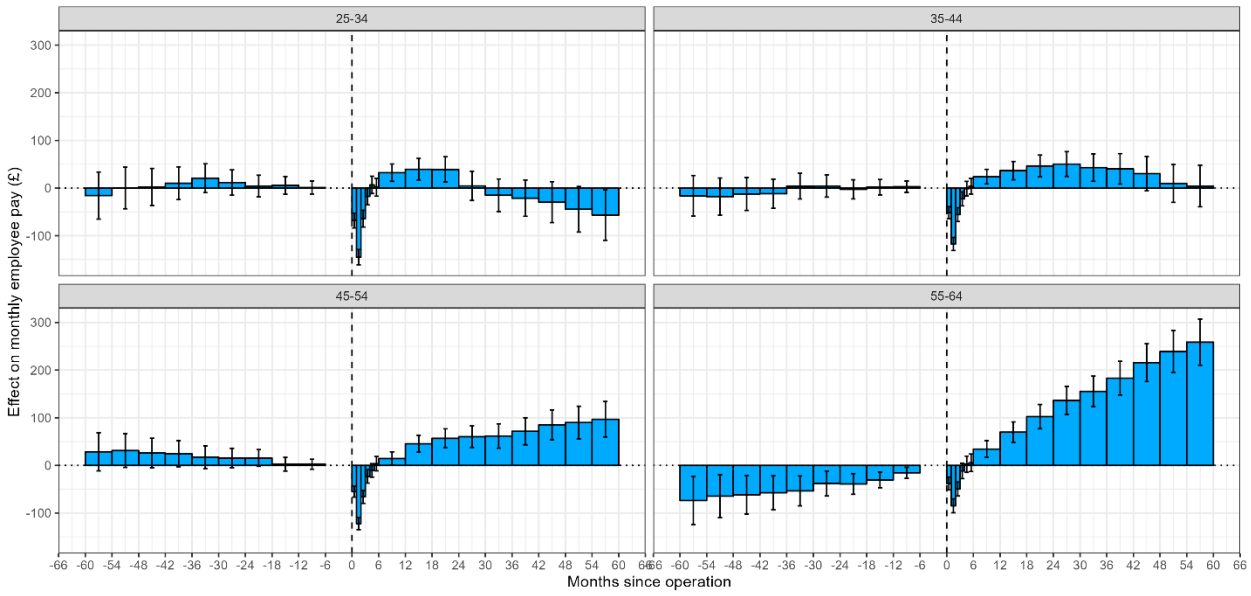


888

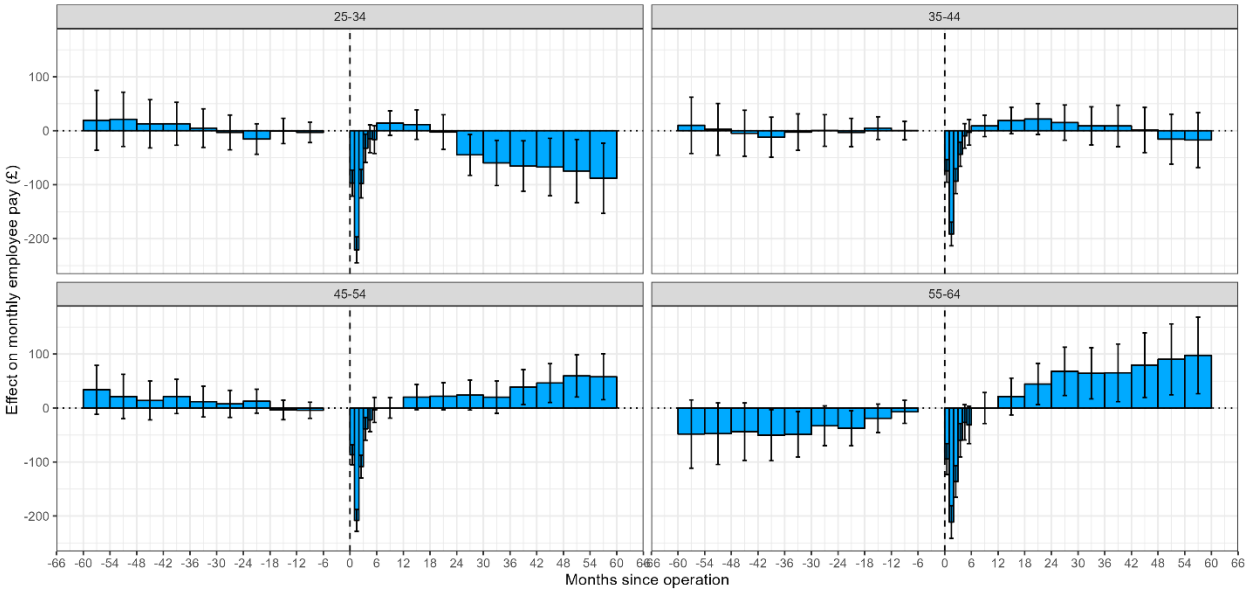
889

890

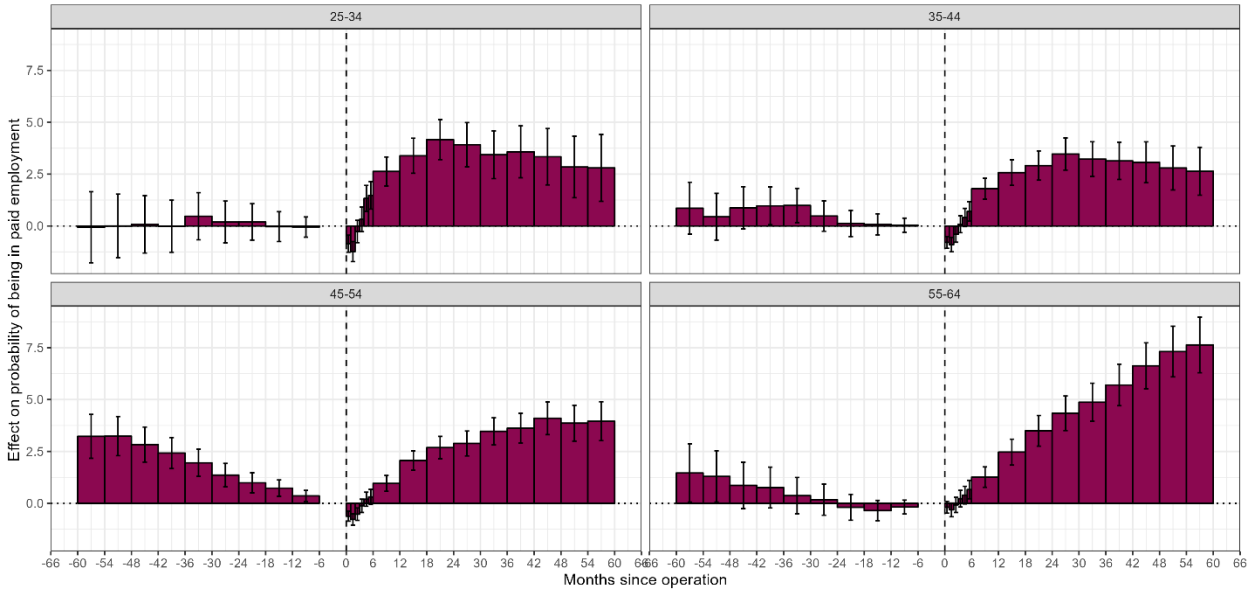
Supplementary Figure 5: Effect of bariatric surgery on monthly employee pay (overall) before and after surgery, across age groups



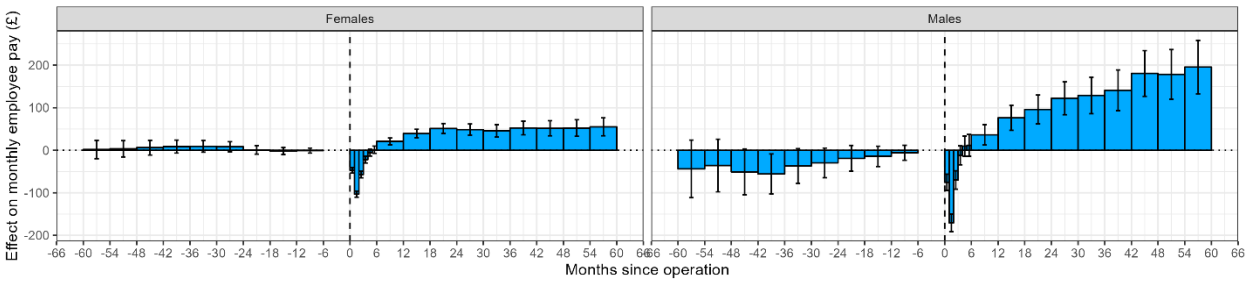
Supplementary Figure 6: Effect of bariatric surgery on monthly employee pay among those in work before and after surgery, across age groups



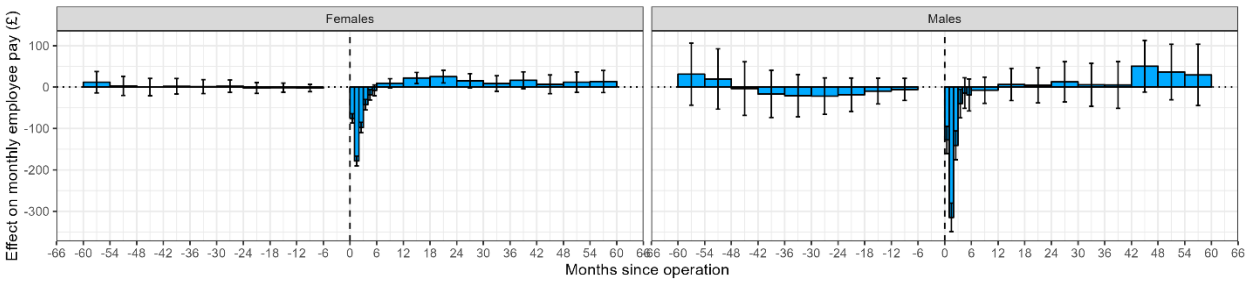
Supplementary Figure 7: Effect of bariatric surgery on probability of being a paid employee before and after surgery, across age groups



Supplementary Figure 8: Effect of bariatric surgery on monthly employee pay (overall) before and after surgery, by sex

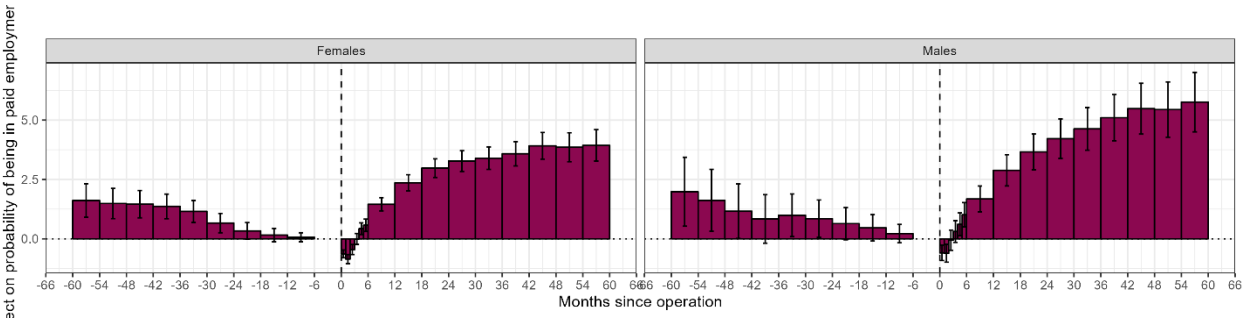


Supplementary Figure 9: Effect of bariatric surgery on monthly employee pay among those in work before and after surgery, by sex

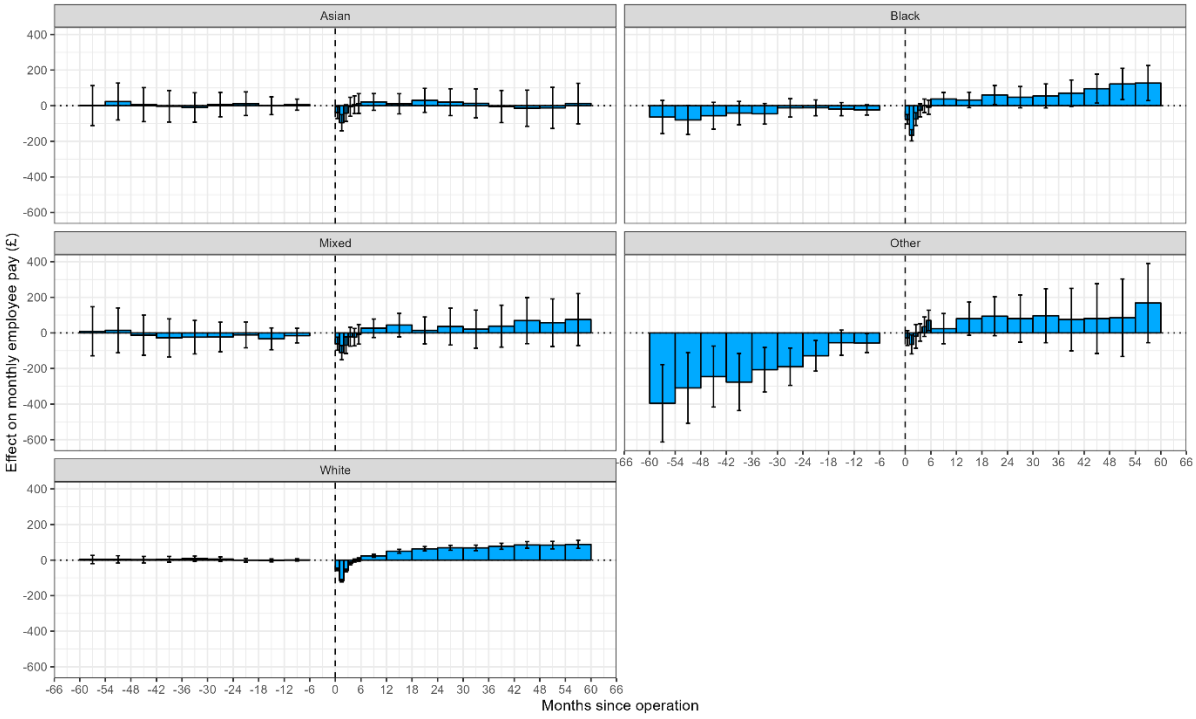


Bermingham et al. Int J Obes (2026). https://doi.org/10.1038/s41366-025-01995-z

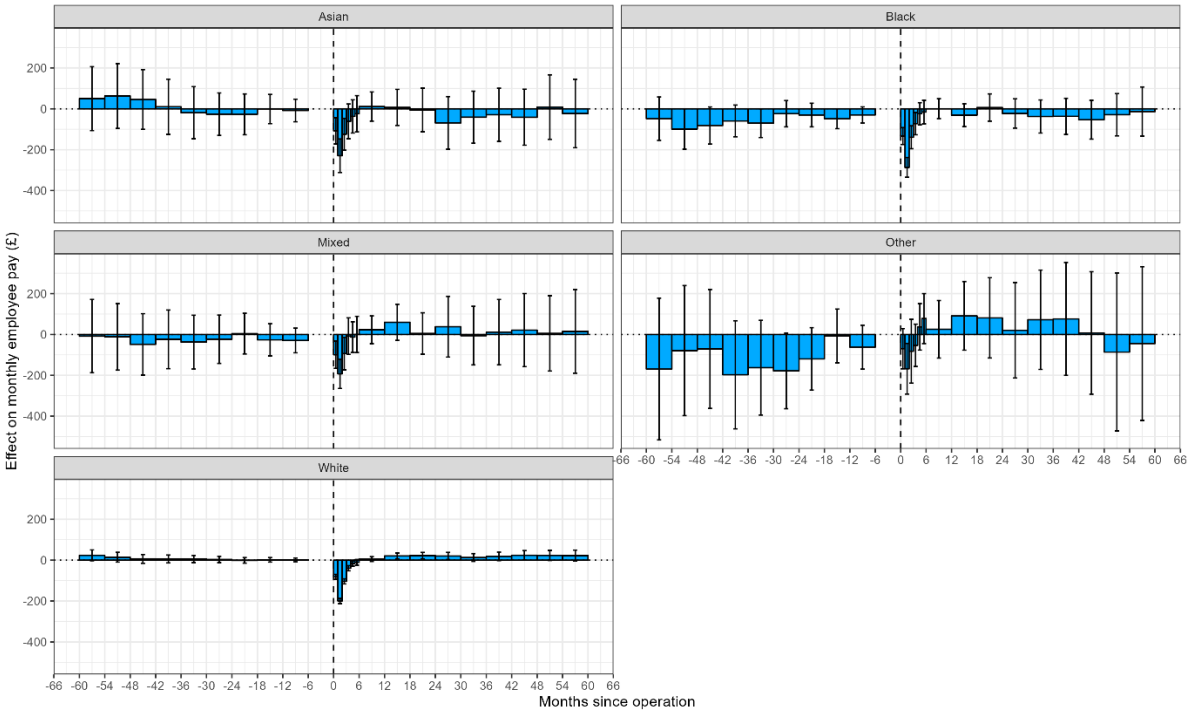
Supplementary Figure 10: Effect of bariatric surgery on probability of being a paid employee before and after surgery, by sex



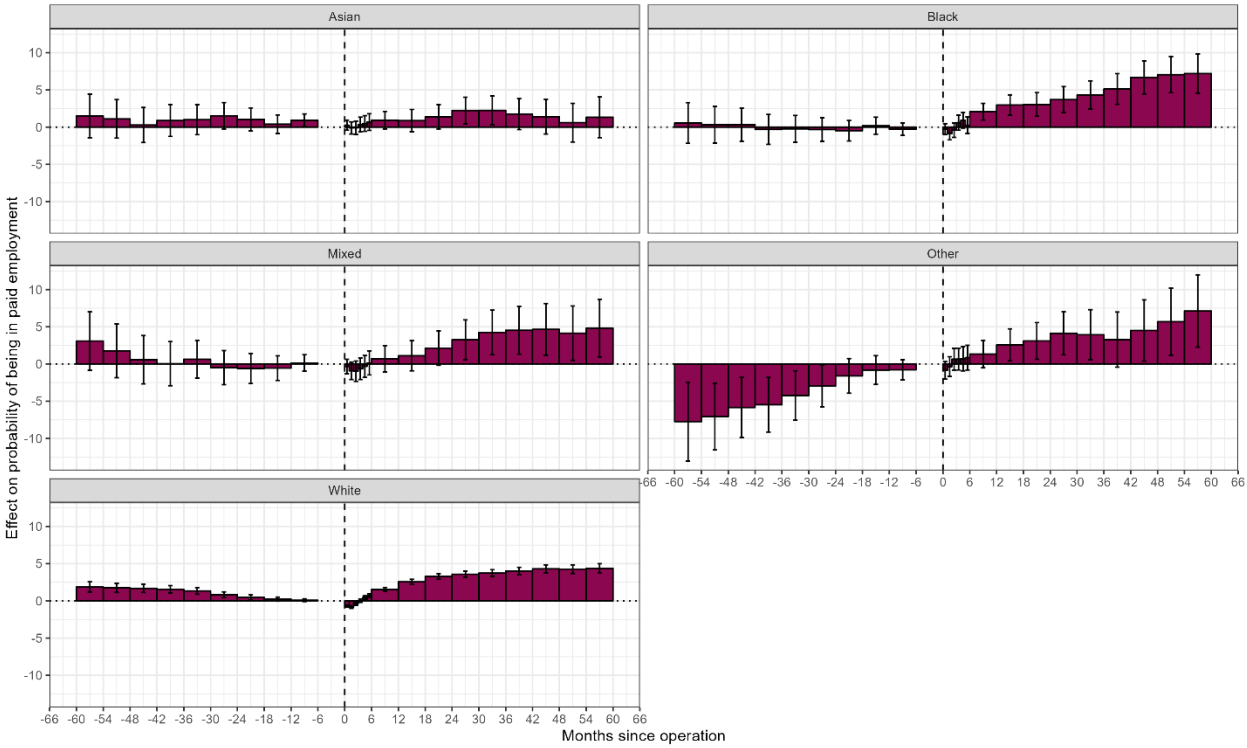
Supplementary Figure 11: Effect of bariatric surgery on monthly employee pay (overall) before and after surgery, across ethnic groups



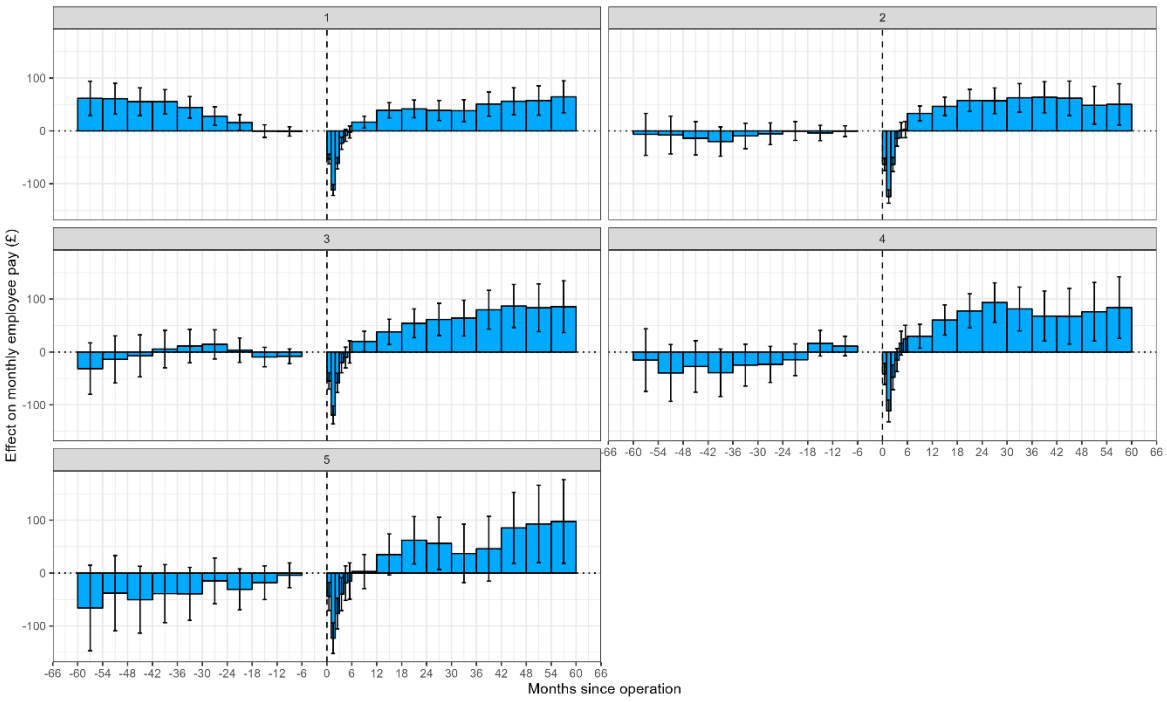
Supplementary Figure 12: Effect of bariatric surgery on monthly employee pay among those in work before and after surgery, across ethnic groups



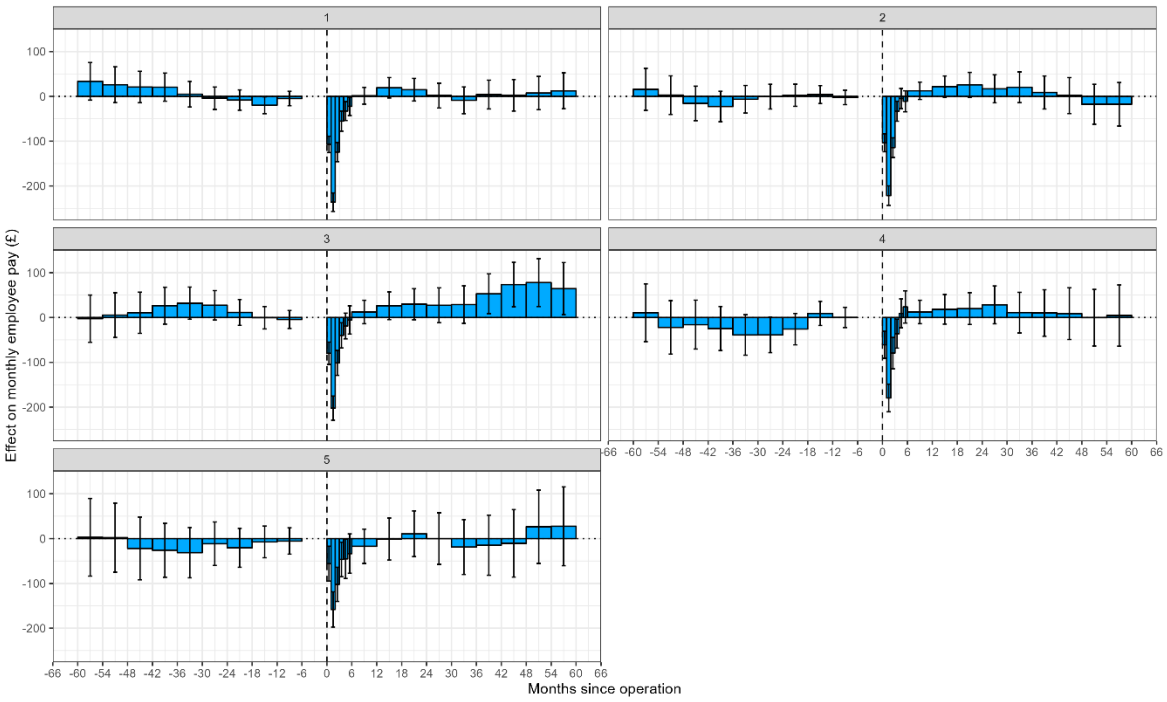
Supplementary Figure 13: Effect of bariatric surgery on probability of being a paid employee before and after surgery, across ethnic groups



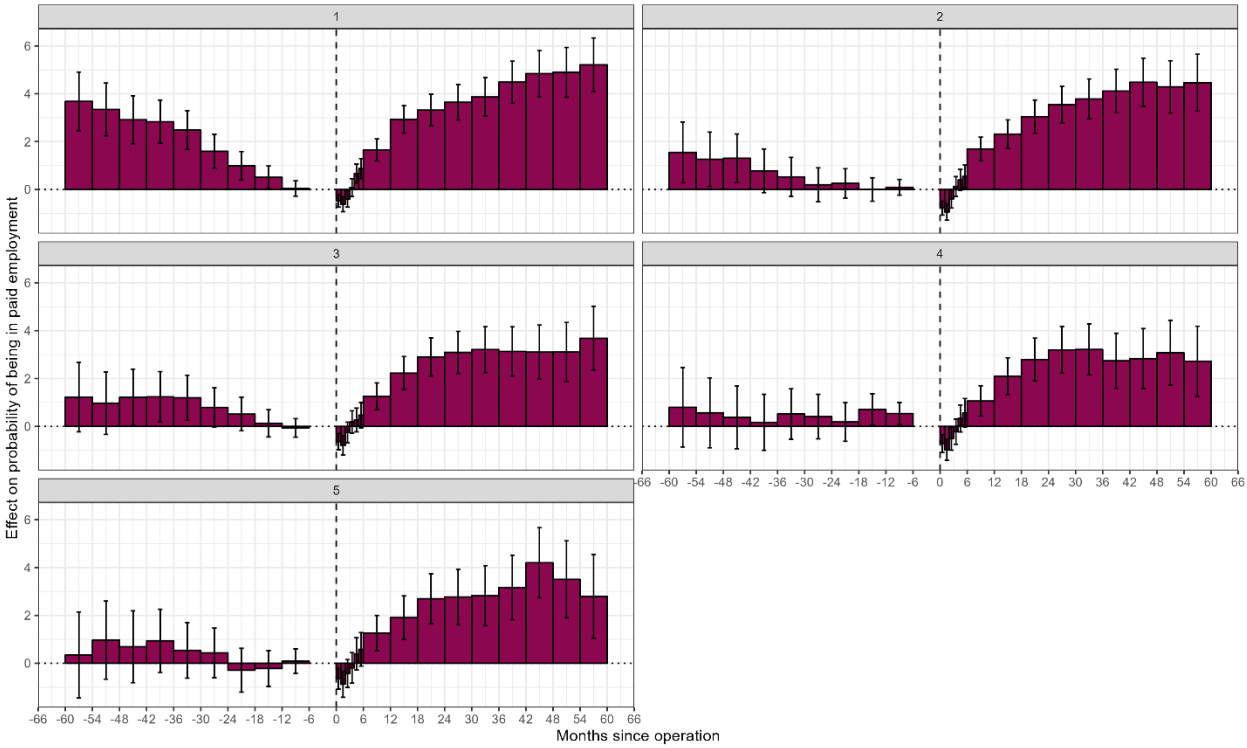
Supplementary Figure 14: Effect of bariatric surgery on monthly employee pay (overall) before and after surgery, across Index of Multiple Deprivation quintiles



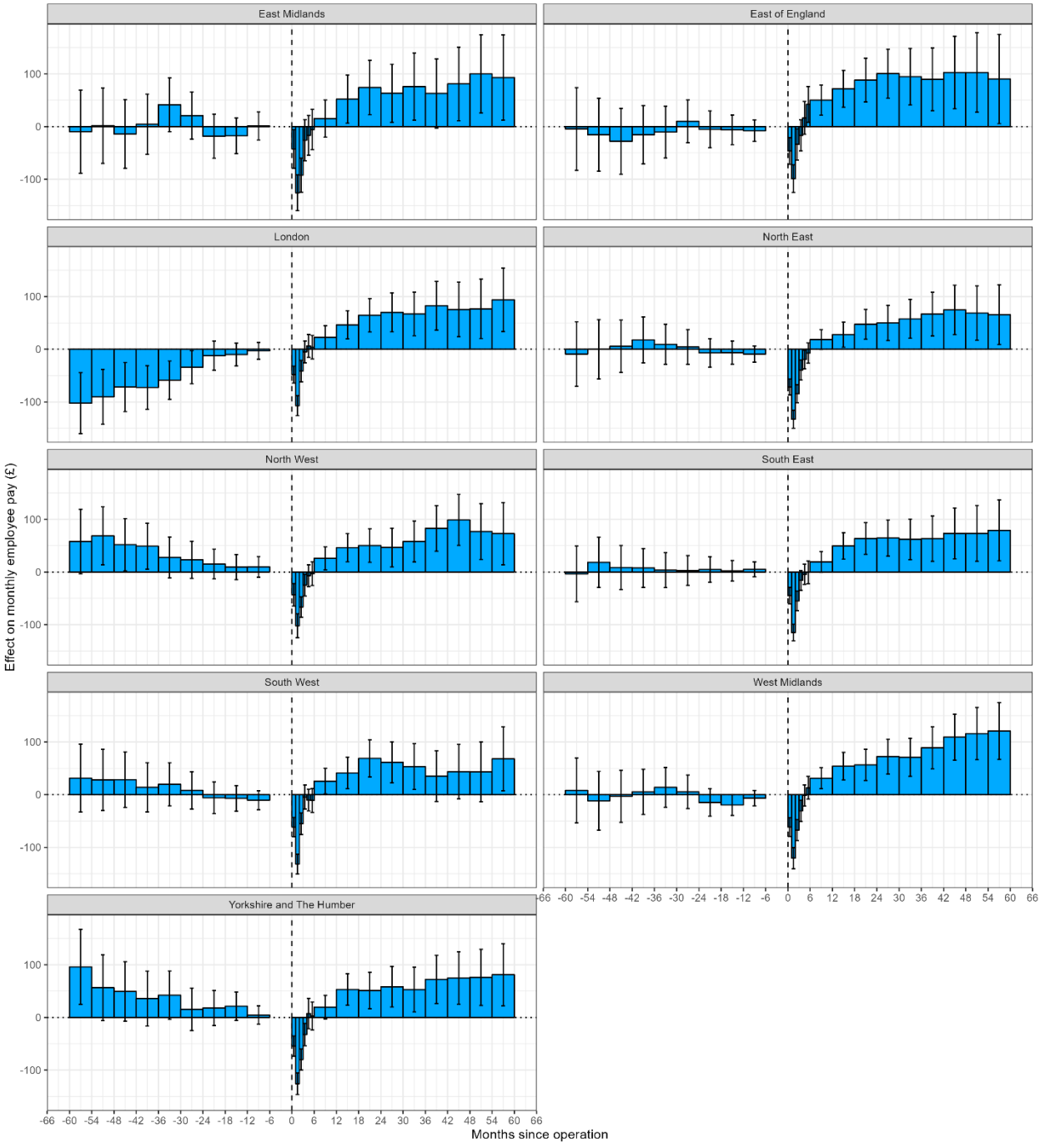
Supplementary Figure 15: Effect of bariatric surgery on monthly employee pay among those in work before and after surgery, across Index of Multiple Deprivation quintiles



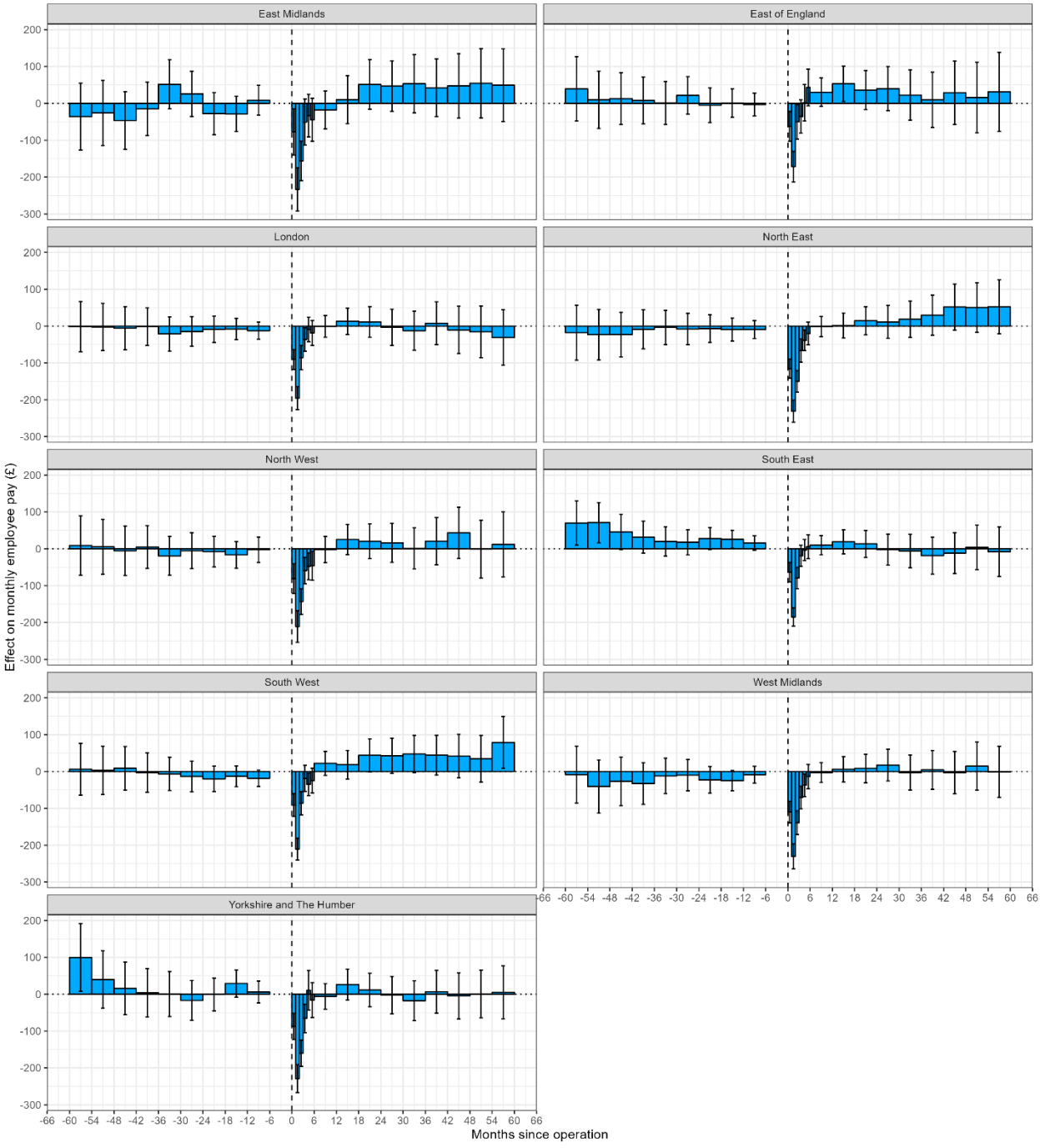
Supplementary Figure 16: Effect of bariatric surgery on probability of being a paid employee before and after surgery, across Index of Multiple Deprivation quintiles



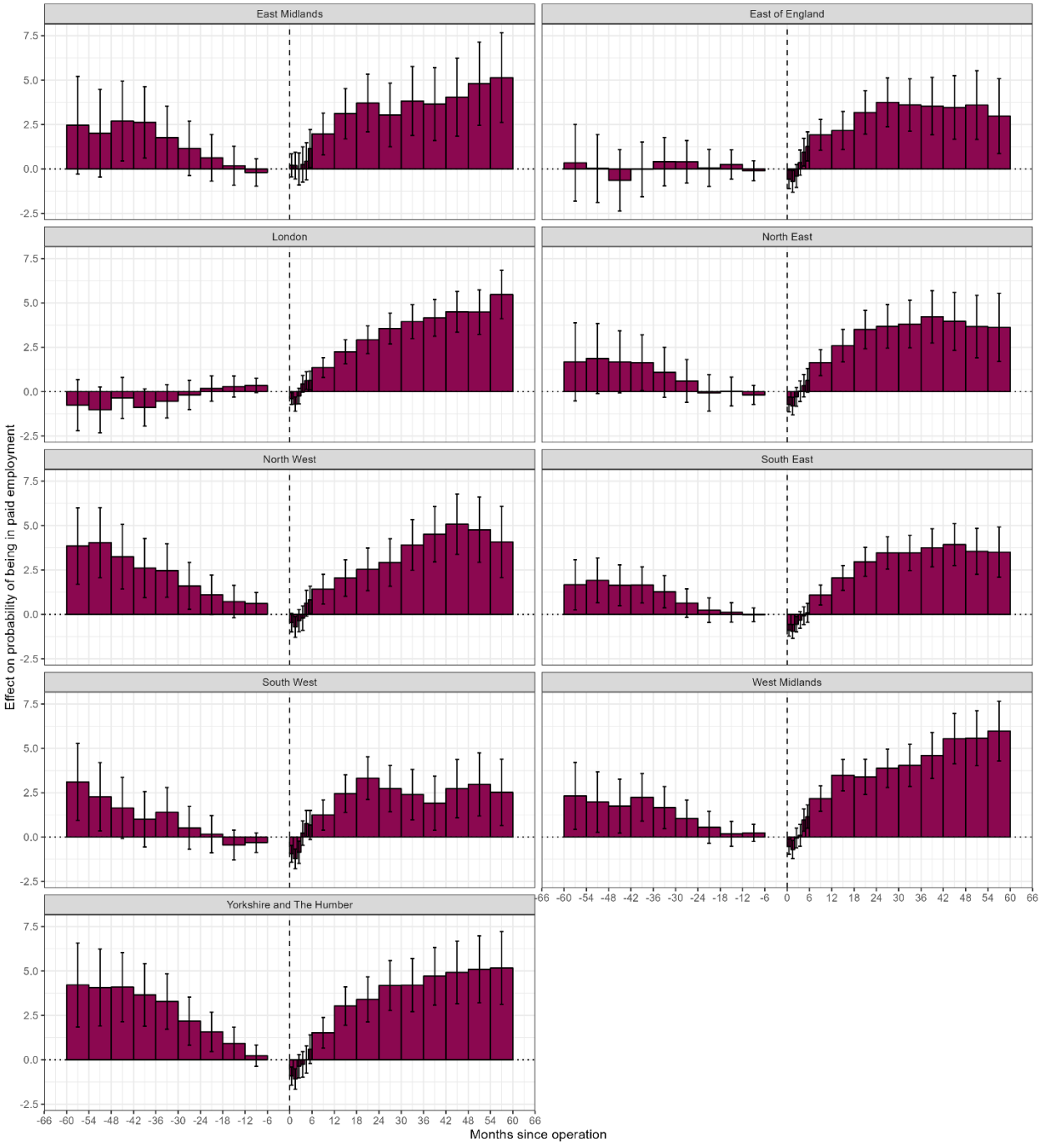
Supplementary Figure 17: Effect of bariatric surgery on monthly employee pay (overall) before and after surgery, across regions



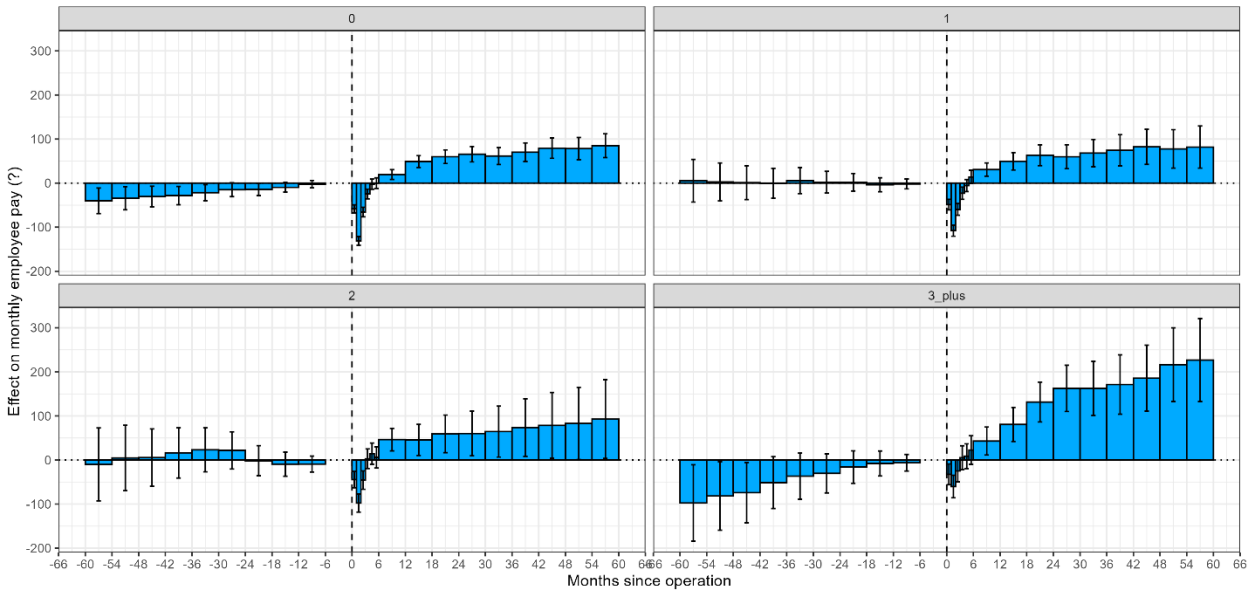
Supplementary Figure 18: Effect of bariatric surgery on monthly employee pay among those in work before and after surgery, across regions



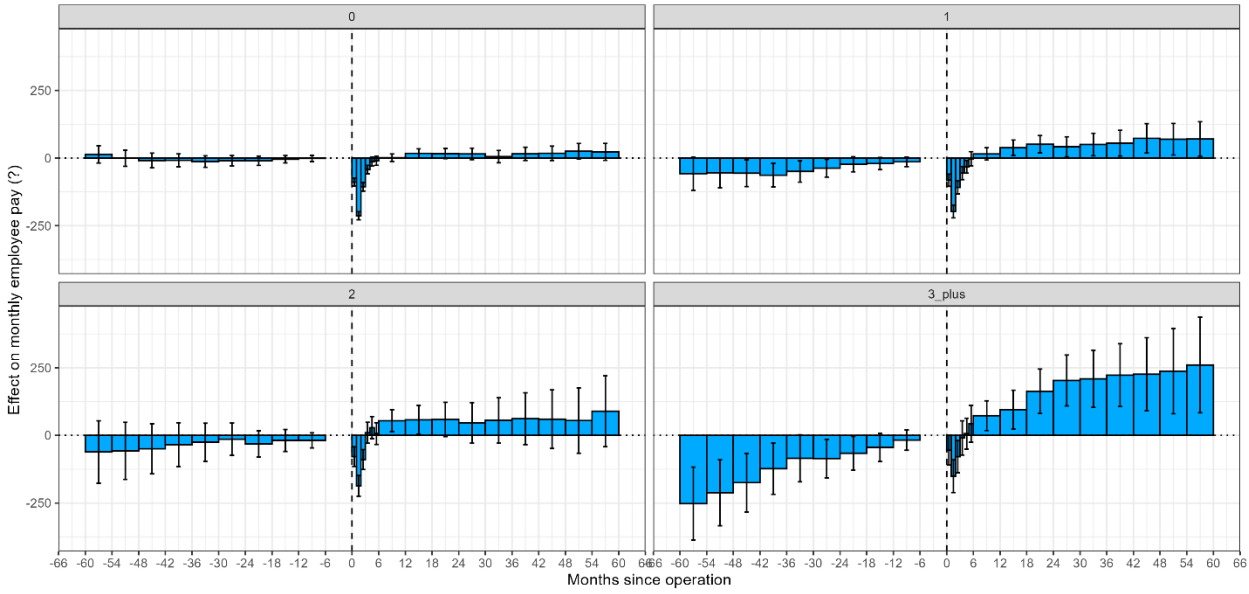
Supplementary Figure 19: Effect of bariatric surgery on probability of being a paid employee before and after surgery, across regions



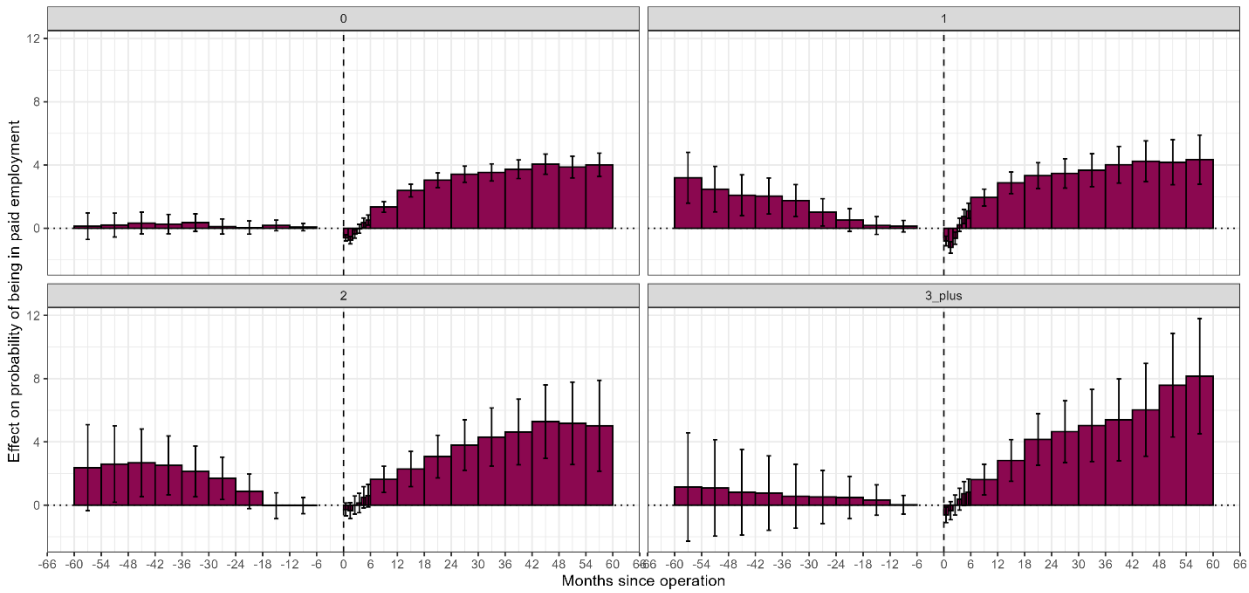
Supplementary Figure 20: Effect of bariatric surgery on monthly employee pay (overall) before and after surgery, across Charlson Comorbidity Score



Supplementary Figure 21: Effect of bariatric surgery on monthly employee pay among those in work before and after surgery, across Charlson Comorbidity Score



Supplementary Figure 22: Effect of bariatric surgery on probability of being a paid employee before and after surgery, across Charlson Comorbidity Score



965

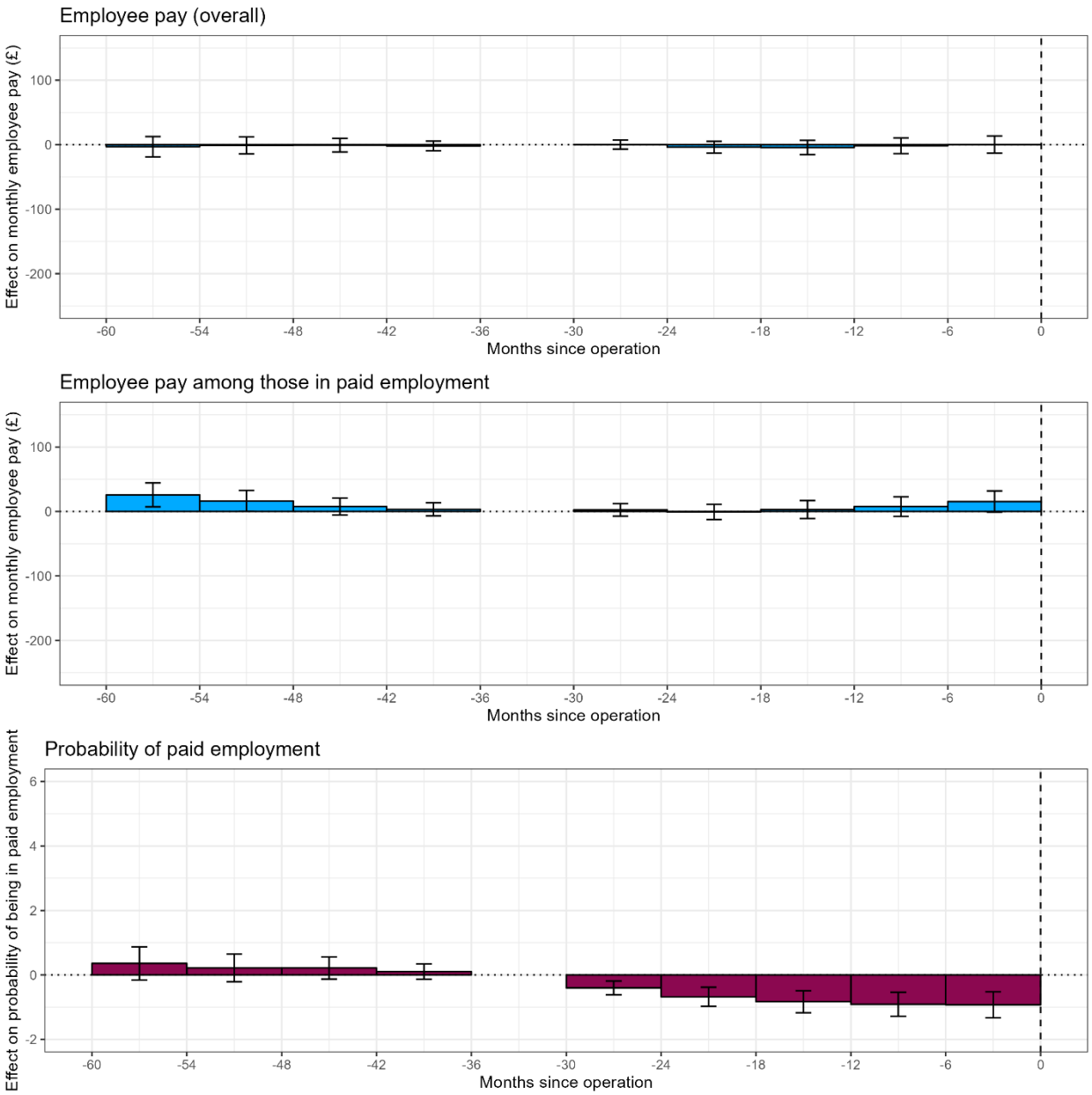
966

967

968

969

Supplementary Figure 23: Placebo test censoring at surgery



Supplementary Figure 24: Placebo test with unexposed only