The Impact of Hospital Mergers and Acquisitions: Evidence from Germany

Esra Eren Bayindir, Reinhard Busse, and Jonas Schreyögg*

Acknowledgments: This research was supported by the German Research Foundation (Grant No. 556603662; Bayindir, Busse, and Schreyögg, co-principal investigators) and Project G-BA Innovationsfonds (Grant No. 01VSF19040; Schreyögg, principal investigator). Schreyögg is the deputy chair of the German Council of Experts in Health and Care at the German Federal Ministry of Health. We thank Wissenschaftliches Institut der AOK for data provision and Robert Messerle for his help with data curation. Anna Polensky, Benedikt Langenbeck, Simon Hennig, Fatih Cihan Tatar provided excellent research assistance.

Abstract

Hospital markets have been consolidating in many countries in the past decades. In this study, we examine the impact of hospital mergers and acquisitions in Germany, where prices are set at the federal level hence hospitals are expected to compete in other dimensions. We use patient-, hospital-, and market-level administrative datasets from 2012 to 2019 to analyze 210 hospital merger and acquisitions that occurred between 2013 and 2018 in Germany employing a staggered difference-in-differences framework. We assess the impact of mergers and acquisitions on both acquired hospitals and the hospital market. At the hospital level, we examine the quality of care, hospital finances, patient volume, and employment of medical staff. At the market level, we evaluate all-cause mortality rates, provision of services, and

*Bayindir: Hamburg Center for Health Economics, University of Hamburg (e-mail:esra.eren.bayindir@uni-hamburg.de); Busse: Department of Health Care Management, Technical University of Berlin (e-mail: mig@tu-berlin.de); Schreyögg: Hamburg Center for Health Economics, University of Hamburg (e-mail: jonas.schreyoegg@uni-hamburg.de).

hospital utilization rates. Additionally, we analyze hospital closures as a counterfactual case in the market-level assessment.

At the hospital level, we find no evidence that quality of care declines for either emergency or elective cases following hospital mergers and acquisitions. In fact, quality of care improves significantly for acute myocardial infarction (AMI), appendectomy, and hip replacement. Hospital mergers and acquisitions result in higher net profits and increased payments to medical doctors per patient day. Additionally, patient volume increases overall, with the largest increase observed in admissions with low medical urgency.

At the county level, we find no evidence that hospital mergers and acquisitions affect all-cause mortality. However, hospital utilization rates decline in certain diagnostic categories in markets that experienced mergers, compared to markets with no changes in hospital ownership. We find that provision of geriatric services increases in markets affected by hospital mergers and acquisitions.

Our findings suggest that hospital mergers and acquisitions lead to improvements in the quality of emergency care, with no evidence of an adverse effect on the quality of care in hospitals. We observe small declines in hospital utilization rates for certain diagnoses, with no effect on all-cause mortality at the market level. The improvement in quality of care may, in part, be explained by increases in patient volume and efficiency wages.

JEL No. I11, I13, I18

I. Introduction

As a result of the measures taken by governments to limit and reduce the soaring health care expenditures, hospital markets in Germany[1,2,3,4] and abroad have

experienced a stream of consolidations.[5,6,7,8,9] Most of the empirical work on hospital mergers and acquisitions has focused on the effects on prices[10,11,12] and several studies found evidence of modest cost savings from mergers in the US. [13,14,15,16,17] Empirical work on hospital mergers and acquisitions in Germany mainly focused on technical efficiency; conversions from public to for-profit status,[18] corporatization of public-law hospitals,[19] and joining a health system[20] were associated with an increase in technical efficiency.

In theory, hospital mergers and acquisitions may lead to improvement or decline in quality of care.9,[21] On the one hand, mergers and acquisitions may lead to quality improvement through transfer of managerial or clinical expertise between merged or acquired and acquiring hospitals and volume-outcome effects (better clinical performance as a result of greater scale). On the other hand, quality may deteriorate as a result of mergers and acquisitions due to increased market power and lower competitive pressure to provide high quality care to attract patients. Theoretical models of hospital competition predict that hospital competition would lead to higher quality of care for diseases with greater demand elasticity.[22] Hence, in theory, hospital merger and acquisitions are more likely to have an impact on quality for elective conditions than emergency conditions.

There is limited empirical work examining the relationship between consolidation and quality in hospital markets and they find no significant relationship or negative relationship.[23,24,25,26,27] Empirical work examining hospital competition has also mixed findings; higher competition leads to better health outcomes for acute myocardial infarction (AMI) patients in England[28] and Norway,[29] which is not the case in Germany.[30] Examining the impact of competition on non-emergency treatment in England, Moscelli et al. (2021) find negative impacts of competition on quality of care for hip and knee replacement and no effect on quality of care for coronary artery bypass graft.[31]

Germany has a highly regulated hospital market in which not-for-profit, for-profit, and public hospitals coexist with roughly equal shares. Administrative bodies of counties are in charge of the public hospitals. Hence counties/communities often decide between closure of a public hospital or selling the hospital to a corporation or health system leading to a merger. To sum up, the effects of hospital market consolidation on quality of care is not clear in the US and in England and the effects of mergers and acquisitions on quality of care in Germany have not been studied to the best of our knowledge.

In this work, we examine the impact of hospital mergers and acquisitions on a wide range of outcomes both at the hospital and hospital market level employing a staggered difference-in-differences framework. Moreover, we consider hospital closure as a counterfactual case for hospital mergers and acquisitions at the hospital market level analysis. We find that quality of care was not adversely affected and in fact improved for some services; hospital profits and medical doctor payments per patient day improved, with no adverse effect on health outcomes, supporting that hospital mergers and acquisitions lead to improvements in hospital care in Germany.

II. Data Sources

We utilized several datasets in our analysis. We describe the main data sources below.

A. Hospital Quality Reports

We use hospital quality reports from 2012 to 2019 to obtain hospital characteristics such as ownership, location, number of admissions by diagnosis, and medical staff size. We identify hospital mergers and acquisitions by tracking changes in hospital ownership. To validate the potential mergers and acquisitions

we detect, we cross-check hospital quality reports with public registry records provided by federal and state governments. We use mergers and acquisitions interchangeably throughout the manuscript.

We analyze changes in aggregate patient volume as well as volume by major diagnostic categories (ICD chapters). Additionally, we examine variations in medical staff composition, including doctors, specialists, nurses, and nursing assistants, across hospital departments.

To account for potential spillover effects, we obtain the geographical coordinates of hospitals and exclude those within a 15 km radius of acquired hospitals from the control group in the hospital-level analysis.

B. DRG Statistics

Even though hospital quality reports contain information on the number of admissions by diagnosis at hospital level, it does not contain information on the location of patients. Given that patients can be admitted to any hospital within Germany with no payment differences, patients might be admitted to out of county hospitals. Hence, we cannot obtain reliable information on market utilization rates by relying on hospital quality reports. Therefore, we derive county-level hospital utilization rates using DRG statistics from 2012-2019, which includes administrative patient records for all hospital admissions in Germany, and county population by age group and sex from the Federal Statistical Office. Moreover, we group the hospital admissions by medical urgency level (low, medium, and high urgency) using the classification developed by Krämer et al. (2019).[32]

B. Hospital Quality Indicators

As primary outcome of interest, we examine risk adjusted adverse outcomes for emergency and elective conditions obtained from the research institute of the

largest statutory health insurance company in Germany, which covers about one third of the population. We focus on AMI, appendectomy, and stroke as emergency cases; hip and knee replacement as elective cases. We examine mortality rates for AMI and stroke; complications, infections, and mortality for appendectomy; revision surgery, complications, and mortality for hip and knee replacements. Indicators are consistently risk adjusted for the study period, enabling comparison of hospital quality over time.[†] Table 1 lists the indicators used in the analysis. Detailed information on indicators are provided in Appendix A.

C. Hospital Financial Reports

We obtain data on hospital finances such as net profits, revenues, and medical doctor payments using hospital financial reports from 2012-2019. These reports do not necessarily contain information at hospital unit level. Hence, there is no one-to-one match between hospital quality reports and hospital financial reports. We derive the financial variables per admission and patient day by calculating average hospital patient days using the number of admissions by ICD codes from hospital quality reports and average length of stays by four-digit ICD codes from hospital statistics files from the federal statistical office.

D. Mortality Statistics

We examine all-cause mortality rate by age group using death statistics and population at county level from the federal statistical office. Using official death statistics at county level rather than in-hospital deaths ensures that the impact of hospital mergers and acquisitions on the population whose access to care were

[†] . Even though hospital quality reports also include quality indicators, risk adjustment of those indicators are performed on an annual basis; hence, risk-adjusted quality indicators from hospital quality reports does not allow comparisons over time.

adversely affected and could not go to the hospital were also included in the analysis.

III. Empirical Strategy

We estimate the effect of hospital mergers and acquisitions on a wide range of outcomes employing a staggered difference-in-differences framework following Callaway and Sant'anna.[33] We perform analysis at hospital and market level.

For hospital level analysis, our main regression model is:

$$E(Q_{it}) = \beta_0 + \beta_1 Acquired_i * Postacquisitionyear_{it}$$

$$+\beta_2 Acquired_i * Acquisitionyear_{it} + \beta_3 H_i + \beta_4 Y_t$$

where Q_{it} is the value of the outcome of interest for hospital *i* and year *t*. $Acquired_i$ is the dummy variable which takes value 1 if hospital *i* is acquired from 2013-2018 and 0 if the hospital is in the control group. $Postacquisitionyear_{it}$ is the vector of indicators denoting the postacquisition year for the acquired hospital and takes value zero for the control hospitals. In Germany, the effect of changes in hospital ownership types on technical efficiency is amplified over time.[18] To examine whether a similar relationship exists between acquisition and quality and to examine how quality adjusts as a result of acquisition, we allow the post-acquisition years to have different effects on quality. Hence, β_1 is the vector of coefficients of interest, which shows the differential change in the quality of the acquired hospital relative to control hospitals for each year after the acquisition year. Therefore, we evaluate the dynamic nature of the treatment effects by running an event study difference-in-differences specification. $Acquisitionyear_{it}$ takes value 1 if hospital *i* is acquired in year *t* and 0 otherwise. By including the term $Acquired_i * Acquisitionyear_{it}$ in our model, we treat the acquisition year as a transitionary period and do not consider the changes in quality in this year while examining the impact of acquisition on outcomes of interest. H_i, and Y_t are hospital,

and year fixed effects, respectively. To allow for at least one-year pre-period and one-year post-period, we examine the impact of hospital mergers and acquisitions taking place from 2013-2018. We exclude hospitals that were acquired from 2010-2012 and from 2019-2021 to exclude the impacts of mergers that took place prior to our study period and because hospitals' outcomes might have changed in the pre-period (Beaulieu et al., 2020).

The validity of difference-in-differences analysis hinges on the assumption that the difference in outcomes between the acquired and control hospitals would have remained constant over time if the acquisitions had not taken place (parallel trends assumption). We test the parallel trends assumption by estimating the following model:

$$E(Q_{it}) = \beta_0 + \beta_1 Acquired_i * Postacquisitionyear_{it}$$

$$+\beta_2 Acquired_i * Acquisitionyear_{it} + \beta_3 Acquired_i * Year_t + \beta_4 H_i + \beta_5 Y_t$$

We include $Acquired_i * Year_t$, the interaction between the indicator for hospital *i* being acquired during our study and year, specified as a continuous variable, to the main model. If the linear change in the difference between the outcome of acquired and control hospitals over the pre-acquisition period is not statistically significantly different from zero, we will fail to reject that β_3 is equal to 0 and we will find no evidence for violation of the parallel trends assumption.

For market level analysis, we define hospital markets as counties.[‡] Our main regression model is:

$$E(Q_{ct}) = \beta_0 + \beta_1 Acquired_c * Postacquisitionyear_{ct}$$

$$+\beta_2 Acquired_c * Acquisitionyear_{ct} + \beta_3 C_c + \beta_4 Y_t$$

[‡] There are 401 counties in Germany.

where Q_{ct} is the value of the outcome of interest for county *c* and year *t*. $Acquired_c$ is the dummy variable which takes value 1 if a hospital merger or acquisition took place in county *c* during our study period and 0 if the county is in the control group. $Postacquisitionyear_{ct}$ is the vector of indicators denoting the postacquisition year for the market in which a hospital acquisition took place and takes value zero for the control counties. We also evaluate the dynamic nature of the treatment effects by running an event study difference-in-differences specification at county level. $Acquisitionyear_{ct}$ takes value 1 if county *c* is acquired in year *t* and 0 otherwise. By including the term $Acquired_c * Acquisitionyear_{ct}$ in our model, we treat the acquisition year as a transitionary period and do not consider the changes in outcomes in this year while examining the impact of acquisition on outcomes. C_c, and Y_t are county, and year fixed effects, respectively. Given that hospital closures are expected to have an effect on outcomes of interest, we exclude all counties with hospital closure from 2010-2021 from both treatment and control groups. This leaves us with 110 treatment counties that experienced hospital mergers and acquisitions but no hospital closure and 196 control counties that experienced neither hospital mergers and acquisitions nor hospital closures during our study period. As an additional analysis, we also compare the effect of hospital closures and acquisitions on outcomes, considering hospital closures as a potential counterfactual of hospital acquisitions. In that case, we use the 35 counties that experienced a hospital closure but no hospital merger or acquisition as an alternative control group.

We test the parallel trends assumption at county level analysis by estimating the following model:

$$E(Q_{ct}) = \beta_0 + \beta_1 Acquired_c * Postacquisitionyear_{ct}$$

$$+\beta_2 Acquired_c * Acquisitionyear_{ct} + \beta_3 Acquired_c * Year_t + \beta_4 C_c + \beta_5 Y_t$$

We include $Acquired_c * Year_t$, the interaction between the indicator for county *c* having an acquired hospital during our study and year, specified as a continuous variable, to the main model. If the linear change in the difference between the outcome of acquired and control counties over the pre-acquisition period is not statistically significantly different from zero, we will fail to reject that β_3 is equal to 0 and we will find no evidence for violation of the parallel trends assumption.

At county level, we also compare the effect of hospital closures and acquisitions on outcomes, considering hospital closures as a potential counterfactual of hospital acquisitions estimating the model below:

$$E(Q_{ct}) = \beta_0 + \beta_1 Acquired_c * Postacquisitionyear_{ct}$$
$$+\beta_2 Acquired_c * Acquisitionyear_{ct} + \beta_3 Closed_c * Postclosureyear_{ct}$$
$$+ \beta_4 Closed_c * Closureyear_{ct} + \beta_5 C_c + \beta_6 Y_t$$

where $Closed_c$ is a dummy variable which takes value 1 if a hospital closure took place in county *c* during our study period and 0 otherwise. $Postclosureyear_{ct}$ is the vector of indicators denoting the post closure year for the market in which a hospital closure took place and takes value zero otherwise. We also evaluate the dynamic nature of the treatment effects by running an event study difference-in-differences specification at county level. $Closureyear_{ct}$ takes value 1 if at least one hospital closure took place in county *c* in year *t* and 0 otherwise. By including the term $Closed_c * Closureyear_{ct}$ in our model, we treat the closure year as a transitionary period and do not consider the changes in outcomes in this year while examining the impact of acquisition on outcomes. We test $\beta_1 = \beta_3$ to examine if the effect of hospital acquisition in a county differs from that of hospital closure.

IV. Results

A. Effects on Merged/acquired Hospitals

We examine the impact of hospital mergers and acquisitions on a wide range of hospital-level outcomes, which are discussed below. For ease of interpretation, we report the average treatment effect for the post-merger periods in this section. Results of the dynamic treatment effects are reported in Appendix B.

Quality of Care.— We examine excess rates of adverse events, defined as the difference between the observed and expected rates for the hospital quality indicators listed in Table 1. The expected rate is predicted using time-consistent risk adjustment (details on risk adjustment are provided in appendix A). Table 2 presents the average treatment effect for the post-merger periods; dynamic treatment effects are reported in Graph B1 in Appendix B.

For AMI and stroke, we analyze excess 30-day mortality rates. We find that, on average, the excess AMI mortality rate at acquired hospitals declines by 1.09 per 100 AMI admissions (statistically significant at the 1% level), which corresponds to a 9% reduction in the 30-day mortality rate following AMI admissions, compared to control hospitals. However, we find no evidence that hospital mergers and acquisitions affect the excess 30-day mortality rate for stroke admissions.

Excess total complications following appendectomy (indicator 1035) decline by 1.03 per 100 appendectomy admission (statistically significant at the 1% level), which corresponds to a 22% reduction in the total complication rate. For elective cases, hospital acquisitions lead to a 0.41 decline (statistically significant at the 10% level), corresponding to a 17% reduction in the risk-adjusted revision surgery rate within one year following hip replacement surgery.

The estimates for other adverse events related to hip replacement and adverse events for knee replacement surgery have the expected sign with the exception of

surgical complications within 90 days of knee replacement surgery (indicator 1011), indicating an improvement in quality of care following acquisitions. However, these estimates are not statistically significant at the 10% level, suggesting that we may lack sufficient statistical power to detect the impact of hospital mergers and acquisitions on hip and knee replacement outcomes due to the very low adverse event rates for these procedures.

Finances.— We examine net profits, inpatient and outpatient revenues, payments to medical doctors[§] to assess changes in profitability and identify mechanisms driving changes in the quality of care following hospital mergers and acquisitions. Table 3 reports the average treatment effect for the post-merger periods; dynamic treatment effects are reported in Graph B2 in Appendix B.

We find that acquisitions lead to an increase of €9.5 in net profits per patient day, €113.7 in inpatient revenues per patient day, and €36.4 in outpatient revenues per case. Additionally, payments increase by €6 per patient day for medical doctors.

Patient Volume.— Table 4 reports the average treatment effect on patient volume for the post-merger periods; dynamic treatment effects are reported in Graph B3 in Appendix B. Patient volume increases following acquisitions, particularly for elective admissions, with an average increase of 128 low urgency admissions, 43 medium urgency admissions, and 81 high urgency admissions per hospital-year. These correspond to increases of 3.3%, 2.7%, and 3.0%, respectively. Examining number of admissions per bed, we find that low, medium, and high urgency admissions per bed increased by 0.82 and 0.21 and 0.25 admissions per bed on average, corresponding to increases of 5.3%, 3.8%, and 2.6%, respectively,

[§] Hospital financial reports report payments to medical doctors and payments to staff in general with no separate category for other medical staff. Hospital quality reports report number of medical staff but do not contain information on number of total hospital staff. Hence, we examine payments to medical doctors among the medical staff since we can observe both the payments to the medical doctors and the number of medical doctors at hospital level.

statistically significant at 1% level for low and medium urgency admissions and at 10% for high urgency admissions.

Examining patient volume by major diagnostic categories, we find that hospital admissions increased by 7.8% for mental health and behavioral disorders, 4.8% for respiratory conditions, and 9.8% for musculoskeletal conditions on average following hospital acquisitions (all statistically significant at 1% level). Also, injuries increase by 2.4% on average (statistically significant at 10% level) following hospital acquisitions. We find no significant impact of hospital acquisitions on the other major diagnostic categories considered.

Employment.— Table 5 reports the average treatment effect on number of medical staff per hospital admission and patient day for the post-merger periods; dynamic treatment effects are reported in Graph B4 in Appendix B. At the hospital level, on average, number of nurses, and nursing assistants per patient day declines following hospital mergers and acquisitions.

We also examine staff per patient day for the quality indicators using department-level data on medical staff and admissions. We find no impact of acquisitions on staff per patient day or staff per case for AMI, appendectomy, and stroke admissions. However, for hip and knee replacements, the number of medical doctors and specialists per patient case/day increases. In contrast, the number of nurses, nursing assistants, and operating assistants per patient case/day shows no significant change at the department level following hospital acquisitions.

B. Effects on the Hospital Market

For the market level analysis, to examine whether hospital mergers and acquisitions affected the outcomes of interest, we compare the changes in outcomes of counties that experienced a hospital acquisition but no hospital closure from pre-acquisition to post-acquisition to that of the counties that experienced neither a

hospital acquisition nor a hospital closure. In an additional specification, we also include the counties that experienced only hospital closures but no hospital mergers and acquisitions to compare the impact of hospital mergers and acquisitions and the impact of hospital closures on the outcomes of interest.

All-cause Mortality.— To examine whether hospital mergers and acquisitions affected all-cause mortality, we analyze the mortality rate of counties that experienced a hospital acquisition but no hospital closure, and counties that experienced neither a hospital acquisition nor a hospital closure. Table 6 presents the estimation results and Graph B5 in Appendix B shows the dynamic treatment effects.

The results suggest that hospital mergers and acquisitions have no effect on all-cause mortality at the market level. Moreover, the effect of hospital acquisitions was not statistically different from that of hospital closures, suggesting that neither acquisitions nor closures adversely affected market-level all-cause mortality.[**,††]

Provision of Services.— Following mergers and acquisitions, the services supplied by the acquired hospital may differ from those supplied in the pre-acquisition period, as the supply decisions of the merged hospital will be made to maximize the objective function of the joint entity, rather than that of the individual hospitals. However, if other hospitals in the market respond to that change by adjusting their service lines, the effect of hospital mergers and acquisitions on the supply of care may be mitigated at the market level.

[**] We also examine heterogeneity by age group and find no effect of hospital acquisitions on any age group, including individuals aged 65 and older.

[††] As an additional analysis, we examine the impact of hospital privatizations, which are the conversions of public hospitals to not-for-profit or for-profit hospitals, and conversions of public and not-for-profit hospitals to for-profit hospitals, which we call for-profit conversions. We find no significant effect of privatization on all-cause mortality but conversions to for-profit lead to declines (7%) in county level all-cause mortality rate. We will finish examining the impact of privatizations and for-profit conversions on all outcomes of interest shortly.

We examine the number of beds per 10,000 population by department to test whether market supply was affected by hospital mergers and acquisitions. Table 7 presents the results and Graph B6 in Appendix B shows the dynamic treatment effects. On average, the supply of hospital beds was not affected by hospital mergers and acquisitions. However, beds per 10,000 population decreased in obstetrics and gynecology (4.5%), ear-nose-throat (3.4%), pediatrics (3.1%), and urology (3.8%), while geriatrics beds per population increased by 10.9%.

When comparing the impact of hospital mergers and acquisitions on the supply of county-level hospital beds to that of hospital closures, we find that hospital closures lead to a larger decline in total hospital beds resulting in 2.6 fewer beds per 10,000 population than that of mergers and acquisitions, corresponding to 4.3% of average bed rate, and 1.2 fewer beds per 10,000 population than that of mergers and acquisitions, corresponding to 6.5% of average internal medicine beds per 10,000 population on average. However, the difference between the effects of mergers and closures is statistically significant only for the geriatrics and internal medicine departments. For geriatrics, the difference is primarily driven by the increase in geriatrics beds following hospital mergers. Therefore, if the merged hospitals had been closed in the absence of the merger, the market would likely face greater difficulty in compensating for the reduction in internal medicine beds.

Hospital Utilization Rates.— Even though acquired hospitals may change their service composition as a result of the acquisition, leading to changes in the composition of hospital admissions, the impact of hospital mergers and acquisitions on population's hospital utilization rates is unclear since other hospitals in the market may respond to the changes in the acquired hospital. Hence, we examine the market level hospital utilization rates to investigate the impact of hospital mergers and acquisitions on the population. Table 8 reports the estimated impact of mergers on county level hospital utilization rates. Comparing the changes in hospital utilization rates from the pre-merger to post-merger period in counties that

experienced a hospital merger but no closure, to those in counties that experienced neither a merger nor a closure, we find that hospital mergers led to a 2.2% decline in the infectious diseases admission rate and a 1.9% decline in the neurological disease admission rate, on average. We find no statistically significant impact of hospital acquisitions on hospital utilization for other major diagnostic categories considered.

When comparing the impact of hospital acquisitions to that of closures on county-level hospital utilization, we find that acquisitions led to 1.9% more digestive system disease admissions than closures. There was no statistically significant difference between the impact of acquisitions and closures on county-level hospital utilization rates for other major diagnostic categories considered.

IV. Discussion and conclusions

Examining the impact of hospital mergers and acquisitions on a wide range of outcomes both at hospital level and market level, we find that hospital mergers and acquisitions lead to improvements in quality of care in general and declines in market level hospital utilization for some medical conditions but does not have an effect on all-cause mortality rate at the market level.

Exploring the mechanisms for improvements in quality of care, increases in patient volume suggests that volume-outcome relationship might have played a role. To explore whether volume-outcome relationship is the main driver of the quality improvement following hospital mergers and acquisitions, we repeat the analysis utilizing entropy balancing on number of relevant cases both in the pretreatment and posttreatment period; the positive impact of hospital mergers and acquisitions on quality of care for emergency conditions persist, suggesting other mechanisms in addition to the volume-outcome relationship.

Number of medical doctors per patient day increased in some departments but on average number of nurses and nursing assistants per patient day decreased in the acquired hospitals compared to the hospitals with no change in ownership. Hence only more staff per patient day does not explain the improvements in quality of care, especially for AMI and appendectomy.

Increase in elective admissions following acquisitions suggests cream skimming whereas increase in quality of emergency care, which is unlikely to affect patient choice suggests altruistic motives and reputation effects. Studying privatization and conversions to for-profit hospitals would help investigate the impact of altruistic motives on the findings.

Increases in payments to medical doctors suggests that efficiency wages might have led to an improvement in performance of medical doctors. Hospital profits per patient day increases despite increases in payments to medical doctors, suggesting cost reductions as a result of hospital mergers and acquisitions.

Declines of hospital utilization for some major diagnostic categories following hospital mergers and acquisition does not translate into increases in mortality rate, suggesting overutilization of hospital services in the pre-merger period. Similarly, changes in hospital bed composition does not lead to changes in mortality rate. As an alternative explanation, changes in outpatient utilization, which we do not observe, might have substituted for the changes in hospital utilization.

One may argue that the right counterfactual for hospital mergers and acquisitions is not "no change in ownership structure" but "hospital closure". When we examine this alternative scenario while performing market level analysis, we find that hospital mergers and acquisitions do not lead to worse outcomes for any dimensions we consider and lead to improvements in health care system in general.

Examining the time trends in the pre-merger period, we fail to reject the parallel trends hypothesis in general. However, the graphs for dynamic effects suggest that the quality of acquired hospitals fluctuated for hip and knee replacement surgeries

three to five years prior to the acquisition. Similarly, utilization rates for poisoning were lower for the acquired hospitals than that of the hospitals with no change in ownership structure five years before the acquisition. However, there were no significant differences between the acquired and control hospitals in the two years before the acquisition. Even though we cannot reject the parallel trends assumption for most of the outcomes we consider, one would not expect hospital mergers and acquisitions to occur randomly. Hospitals with financial difficulties but have a potential to become profitable or rival hospitals are presumably more likely to be acquired. Hence, as a robustness check, we repeat our analysis utilizing entropy balancing using the number of hospital beds to account for hospital size, predicted Herfindahl Hirschman Index to account for the competitive structure of the hospital markets, and earnings before interest and taxes per bed to account for the financial situation of the hospitals, which leads to qualitatively similar findings.

Given that quality of care was not adversely affected and in fact improved for some services, hospital profits and medical doctor payments per patient day improved, with no adverse effect on health outcomes, our findings support that hospital mergers and acquisitions lead to improvements in hospital care in Germany.

REFERENCES

1. Tiemann O, Schreyögg J. Effects of ownership on hospital efficiency in Germany. *Business Research.* 2009;2(2):115-145. http://dx.doi.org/10.1007/BF03342707.

2. Tiemann O, Schreyögg J, Busse R. Hospital ownership and efficiency: a review of studies with particular focus on Germany. *Health Policy*. 2012;104(2):163-171. http://dx.doi.org/10.1016/j.healthpol.2011.11.010.

3. Schmid A, Ulrich V. Consolidation and concentration in the German hospital market: the two sides of the coin. *Health Policy.* 2013;109(3):301-310. http://dx.doi.org/10.1016/j.healthpol.2012.08.012.

4. Kurz C, Beerheide R. Krankenhausinsolvenzen: Versorgung bleibt stabil. Dtsch Artztebl. 2024; 121(6):A-360/B-324. Accessed on July 7, 2024. Available from: https://www.aerzteblatt.de/archiv/238190/Krankenhausinsolvenzen-Versorgung-bleibt-stabil.

5. Dafny L. Hospital industry consolidation-still more to come? *New England Journal of Medicine.* 2014;370(3):198-199. http://dx.doi.org/10.1056/NEJMp1313948.

6. Fulton BD. Health care market concentration trends in the United States: evidence and policy responses. *Health Affairs.* 2017;36:1530-1538. http://dx.doi.org/10.1377/hlthaff.2017.0556.

7. Spencelayh E, Dixon J. *Mergers in NHS: Lessons from the decision to block the proposed merger of hospitals in Boumemouth and Poole. Policy Analysis*. The Health Foundation London; 2014.

8. Gaynor M, Moreno-Serra R, Propper C. Death by Market Power: Reform, Competition, and Patient Outcomes in the National Health Service. *American Economic Journal: Economic Policy.* 2013;5(4):134-166. http://dx.doi.org/10.1257/pol.5.4.134.

9. Bloom N, Propper C, Seiler S, van Reenen J. The impact of competition on management quality: Evidence from public hospitals. *Review of Economic Studies.* 2015;82:457-489. http://dx.doi.org/10.1093/restud/rdu045.

10. Dafny L. Estimation and identification of merger effects: an application to hospital mergers. *Journal of Law and Economics.* 2009;52:523-550. http://dx.doi.org/10.1086/600079.

11. Gaynor M, Ho K, Town RJ. The industrial organization of health care markets. *Journal of Economic Literature.* 2015;53:235-284. http://dx.doi.org/10.1257/jel.53.2.235.

12. Cooper Z, Craig SV, Gaynor M, van Reenen J. The price ain't right? Hospital prices and health spending on the privately insured. *Quarterly Journal of Economics.* 2019;134:51-107. http://dx.doi.org/10.1093/qje/qjy020.

13. Cuellar AE, Gertler PJ. How the expansion of hospital systems has affected consumers. *Health Affairs.* 2005;24:213-219. http://dx.doi.org/10.1377/hlthaff.24.1.213.

14. Dranove D, Lindrooth R. Hospital consolidation and costs: Another look at the evidence. *Journal of Health Economics.* 2003;22(6):983-997. http://dx.doi.org/10.1016/j.jhealeco.2003.05.001.

15. Harrison T. Do mergers really reduce costs? Evidence from hospitals. *Economic Inquiry*. 2011;49(4):1054-1069. http://dx.doi.org/10.1111/j.1465-7295.2010.00246.x.

16. Schmitt M. Do hospital mergers reduce costs? *Journal of Health Economics.* 2017;52:74-94. http://dx.doi.org/10.1016/j.jhealeco.2017.01.007.

17. Spang HR, Bazzoli GJ, Arnould RJ. Hospital mergers and savings for consumers: Exploring new evidence. *Health Affairs.* 2001;20(4):150-158. http://dx.doi.org/10.1377/hlthaff.20.4.150.

18. Tiemann O, Schreyögg J. Changes in efficiency after hospital privatization. *Health Care Management Science*. 2012;15(4):310–326. http://dx.doi.org/10.1007/s10729-012-9193-z.

19. Lindlbauer I, Winter V, Schreyögg J. Antecedents and consequences of Corporatization: An empirical analysis of German public hospitals. *Journal of Public Administration Research and Theory*. 2016;26(2):309–326. http://dx.doi.org/10.1093/jopart/muv016.

20. Büchner A, Hinz V, Schreyögg J. Cooperation for a competitive position: The impact of hospitals' cooperation behavior on organizational performance. *Health Care Management Review*. 2015;40(3):214–224. http://dx.doi.org/10.1097/HMR.0000000000000027.

21. Dafny L, Lee TH. The good merger. *New England Journal of Medicine*. 2015;372:2077-2079. http://dx.doi.org/10.1056/NEJMp1502338.

22. Colla C, Bynum J, Austin A, Skinner J. Hospital competition, quality, and expenditures in the US Medicare population. National Bureau of Economic Research; working paper 22826, 2016 Nov 14.

23. Ho V, Hamilton BH. Hospital mergers and acquisitions: Does market consolidation harm patients? *Journal of Health Economics.* 2000;19(5):767-791. http://dx.doi.org/10.1016/S0167-6296(00)00052-7.

24. Hayford TB. The impact of hospital mergers on treatment intensity and health outcomes. *Health Services Research.* 2012;47(3):1008-1029. http://dx.doi.org/10.1111/j.1475-6773.2011.01351.x.

25. Neprash HT, McWilliams JM. Provider consolidation and potential efficiency gains: a review of theory and evidence. *Antitrust Law Journal.* 2019;82(2):551-578.

26. Beaulieu ND, Dafny LS, Landon BE, Dalton JB, Kuye I, McWilliams JM. Changes in quality of care after hospital mergers and acquisitions. *New England Journal of Medicine.* 2020;382:51-59. http://dx.doi.org/10.1056/NEJMsa1901383.

27. Arnold DR, King JS, Fulton BD, Montague AD, Gudiksen KL, Greaney TL, Scheffler RM. New evidence on the impacts of cross-market hospital mergers on commercial prices and measures of quality. Health Services Research. 2024 Apr 23. http://dx.doi.org/10.1111/1475-6773.14291

28. Cooper Z, Gibbons S, Jones S, McGuire A. Does hospital competition save lives? Evidence from the English NHS patient choice reforms. The Economic Journal. 2011 Aug 1;121(554):F228-60. http://dx.doi.org/10.1111/j.1468-0297.2011.02449.x.

29. Brekke KR, Canta C, Siciliani L, Straume OR. Hospital competition in a national health service: Evidence from a patient choice reform. Journal of Health Economics. 2021 Sep 1;79:102509. http://dx.doi.org/10.1016/j.jhealeco.2021.102509

30. Bayindir EE, Jamalabadi S, Messerle R, Schneider U, Schreyögg J. Hospital competition and health outcomes: Evidence from acute myocardial infarction admissions in Germany. Social Science & Medicine. 2024;349:116910. http://dx.doi.org/10.1016/j.socscimed.2024.116910.

31. Moscelli G, Gravelle H, Siciliani L. Hospital competition and quality for non-emergency patients in the English NHS. The RAND Journal of Economics. 2021 Jun;52(2):382-414. http://dx.doi.org/10.1111/1756-2171.12373.

32 Krämer, J., Schreyögg, J., Busse, R. Classification of hospital admissions into emergency and elective care: a machine learning approach. Health care management science 2019, *22*, 85-105.

33. Callaway B, Sant'Anna PH. Difference-in-differences with multiple time periods. *Journal of Econometrics.* 2021;225(2):200-30.

Tables

Table 1. Hospital quality indicators.

Department	Performance Area	ID	Indicator title
Abdominal surgery	Appendectomy	1032	Indicator therapy-related complications requiring intervention / surgery within 90 days
		1033	Indicator Infection, Sepsis, wound infections, transfusions within 90 days
		1035	Total complications indicator
Cardiology	Heart attack (AMI)	2001	30-day mortality indicator
Neurology	Stroke	2002	30-day mortality indicator
Orthopedics / trauma surgery	Implantation of a hip joint endoprosthesis for coxarthrosis (Hip)	1001	Indicator revision surgery within 365 days
		1002	Indicator surgical complications within 90 days
		1004	Periprosthetic femur fracture within 90 days
		1018	Total complications indicator
	Implantation of a total knee joint endoprosthesis for gonarthrosis (Knee)	1010	Indicator revision surgery within 365 days
		1011	Surgical complications indicator within 90 days
		1020	Total complications indicator

Notes: Indicators are obtained from Wissenschaftliches Institut der AOK.

Table 2. Hospital quality indicator results

Table 2. Hospital quality indicator results

	Appendectomy			AMI	Stroke	Hip				Knee		
	1032	1033	1035	2001	2002	1001	1002	1004	1018	1010	1011	1020
Post	-0.79***	-0.58**	-1.03***	-1.09***	-0.36	-0.41*	-0.19	-0.17	-0.33	-0.31	0.11	-0.21
	(0.26)	(0.27)	(0.33)	(0.38)	(0.35)	(0.22)	(0.23)	(0.21)	(0.35)	(0.23)	(0.23)	(0.27)
	[-28%]	[-19%]	[-22%]	[-9%]	[-3%]	[-17%]	[-6%]	[-9%]	[-5%]	[-10%]	[4%]	[-4%]
# obs.	3744	3744	3744	4190	4504	3742	3742	3742	3742	3601	3601	3601
AR2	0.11	0.11	0.01	0.36	0.24	0.10	0.18	0.13	0.20	0.16	0.18	0.19
Mean rate	2.83	3.09	27.32	12.64	13.34	2.44	3.11	1.96	5.97	3.14	2.87	4.78

Notes: Post is the coefficient of interest, which is the average effect of merger and acquisition on outcome of interest in the years following merger and acquisition. Heteroskedasticity robust standard errors are reported in parenthesis and the magnitude of the estimated effect as percentage of mean rate is reported in square brackets. Unit of observation is hospital-year. # obs is the number of observations and AR2 is the adjusted R2. Mean rate is the mean adverse event rate in sample per 100 relevant hospital admission.

*** Significant at the 1 percent level. ** Significant at the 5 percent level.* Significant at the 10 percent level.

Table 3. Hospital finances results

	Profit per day	Inpatient revenue per day	Outpatient revenue per case	MD payment per MD	MD payment per case	MD payment per day
Post	9.51**	113.69***	36.35**	2987.66**	35.78**	5.99**
	(4.63)	(32.13)	(17.98)	(1506.48)	(16.38)	(2.56)
# obs.	2588	1739	1711	1645	1645	1645
AR2	0.31	0.91	0.91	0.55	0.53	0.51

Notes: Post is the coefficient of interest, which is the average effect of merger and acquisition on outcome of interest in the years following merger and acquisition. Heteroskedasticity robust standard errors are reported in parenthesis. Unit of observation is hospital-year. # obs is the number of observations and AR2 is the adjusted R2. *** Significant at the 1 percent level. ** Significant at the 5 percent level.

Table 4. Hospital volume results

	Low		Medium		High	
	# cases	#cases per bed	# cases	#cases per bed	# cases	#cases per bed
Post	128.23**	0.82***	42.98**	0.21***	81.46**	0.25*
	(53.11)	(0.28)	(17.78)	(0.08)	(32.06)	(0.14)
	[3.3%]	[5.3%]	[2.7%]	[3.8%]	[3.0%]	[2.6%]
# obs.	6406	6299	6406	6299	6406	6299
AR2	0.98	0.68	0.99	0.33	0.99	0.26
Mean rate	3847.0	15.7	1566.4	5.5	2729.7	9.6

Notes: Post is the coefficient of interest, which is the average effect of merger and acquisition on outcome of interest in the years following merger and acquisition. Low, medium, and high denote the urgency level of admissions. Heteroskedasticity robust standard errors are reported in parenthesis and the magnitude of the estimated effect as percentage of mean rate is reported in square brackets. Unit of observation is hospital-year. # obs is the number of observations and AR2 is the adjusted R2. Mean rate is the mean number of hospital admissions and admissions per bed.

*** Significant at the 1 percent level. ** Significant at the 5 percent level.* Significant at the 10 percent level.

Table 4 continued, by major diagnostic category for selected diagnoses

	Infectious diseases	Neoplasms	Mental health	Neurological	Circulatory	Respiratory	Digestive	Musculoskeletal	Urogenital	Injuries
Post	7.22	14.44	45.97***	-9.85	16.87	32.14***	18.13	94.59***	12.39	25.05*
	(4.74)	(18.23)	(15.82)	(9.51)	(21.91)	(10.73)	(15.68)	(20.36)	(10.78)	(13.32)
	[2.1%]	[1.6%]	[7.8%]	[-2.4%]	[1.1%]	[4.8%]	[1.7%]	[9.8%]	[2.3%]	[2.4%]
# obs.	6406	6406	6406	6406	6406	6406	6406	6406	6406	6406
AR2	0.98	0.96	0.98	0.97	0.99	0.98	0.98	0.98	0.98	0.98
Mean rate	338.54	917.97	592.46	414.05	1520.91	665.00	1053.41	966.32	547.10	1056.56

Table 5. Number of staff per case and day

	MD		Specialist		Operating assistant		Nurse		Nursing assistant	
	Per 10k case	Per 10k day	Per 10k case	Per 10k day	Per 10k case	Per 10k day	Per 10k case	Per 10k day	Per 10k case	Per 10k day
Post	-1.00	-0.20	-0.41	-0.10	-0.26	-0.06	-15.10**	-2.10**	-1.52**	-0.24***
	(2.03)	(0.24)	(1.18)	(0.14)	(0.35)	(0.05)	(6.57)	(0.89)	(0.75)	(0.08)
	[-1.3%]	[-2.0%]	[-1.0%]	[-1.9%]	[-7.8%]	[-11.2%]	[-6.6%]	[-7.6%]	[-6.1%]	[-9.3%]
# obs.	5673	5673	5673	5673	5673	5673	5673	5673	5673	5673
AR2	0.82	0.77	0.77	0.71	0.53	0.51	0.78	0.55	0.78	0.69
Mean rate	76.04	10.00	42.22	5.61	3.29	0.53	228.53	27.61	25.00	2.59

Notes: Post is the coefficient of interest, which is the average effect of merger and acquisition on outcome of interest in the years following merger and acquisition. Heteroskedasticity robust standard errors are reported in parenthesis and the magnitude of the estimated effect as percentage of mean rate is reported in square brackets. Unit of observation is hospital-year. # obs is the number of observations and AR2 is the adjusted R2. Mean rate is the mean medical staff per 10,000 admissions and per 10,000 patient days. *** Significant at the 1 percent level. ** Significant at the 5 percent level.

Table 6. County level all-cause mortality

	All cause mortality rate	
	I	II
Post acquisition	-0.10	-0.19
	(0.58)	(0.57)
	[-0.1%]	[-0.2%]
Post closure		0.21
		(0.78)
		[0.2%]
# obs.	19584	21824
AR2	0.99	0.99
mean rate	111.35	111.35
p-value		0.65

Notes: Unit of observation is county-year. Post acquisition is the average effect of merger and acquisition on outcome of interest in the years following merger and acquisition; post closure is the average effect of hospital closure on outcome of interest following hospital closure. Heteroskedasticity robust standard errors are reported in parenthesis and the magnitude of the estimated effect as percentage of mean rate is reported in square brackets. # obs is the number of observations and AR2 is the adjusted R2. Mean rate is the mean all-cause mortality rate per 1,000 population. P-value is the p-value of the test comparing the effects of acquisition and closure on outcome of interest.

Table 7. Bed per 10k population, county level

	All		Opthalmology		Surgery		OBGYN		Ear, nose, throat		Dermatology		Internal medicine		Geriatrics	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
PMA	-0.20	-0.18	-0.01	-0.01	-0.10	-0.09	-0.17***	-0.16***	-0.04**	-0.04**	0.00	0.00	-0.08	-0.07	0.21***	0.23***
	(0.33)	(0.33)	(0.01)	(0.01)	(0.13)	(0.13)	(0.05)	(0.05)	(0.02)	(0.02)	(0.01)	(0.01)	(0.14)	(0.14)	(0.05)	(0.05)
	[-0.3%]	[-0.3%]	[-2.2%]	[-2.4%]	[-0.7%]	[-0.6%]	[-4.5%]	[-4.4%]	[-3.4%]	[-3.6%]	[0.3%]	[0.1%]	[-0.4%]	[-0.4%]	[10.9%]	[11.5%]
PC		-2.80***		-0.03**		-0.26		-0.27***		-0.05*		0.01		-1.28***		-0.11
		(0.49)		(0.02)		(0.19)		(0.08)		(0.02)		(0.01)		(0.21)		(0.08)
		[-4.6%]		[-6.0%]		[-1.8%]		[-7.3%]		[-3.7%]		[1.4%]		[-6.9%]		[-5.8%]
# obs.	2448	2728	2448	2728	2448	2728	2448	2728	2448	2728	2448	2728	2448	2728	2448	2728
AR2	0.99	0.99	0.98	0.98	0.97	0.97	0.96	0.95	0.98	0.98	0.99	0.99	0.98	0.97	0.92	0.92
p-value		0.00***		0.24		0.41		0.18		0.99		0.47		0.00***		0.00***
Mean rate	60.89	60.89	0.56	0.56	14.44	14.44	3.72	3.72	1.23	1.23	0.59	0.59	18.65	18.65	1.96	1.96

Notes: Unit of observation is county-year. PMA denotes post merger and acquisition and PC denotes post closure. Heteroskedasticity robust standard errors are reported in parenthesis and the magnitude of the estimated effect as percentage of mean rate is reported in square brackets. # obs is the number of observations and AR2 is the adjusted R2. Mean rate is the mean beds per 10,000 population. P-value is the p-value of the test comparing the effects of acquisition and closure on outcome of interest. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 7, continued

	Pediatrics		Neurology		Orthopedics		Urology		C&A Psychiatry		Psychiatry		Psychotherapy	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II
PMA	-0.07**	-0.07**	0.03	0.03	-0.08	-0.10	-0.07***	-0.07***	0.00	0.00	0.11	0.10	-0.01	-0.01
	(0.03)	(0.03)	(0.05)	(0.05)	(0.10)	(0.10)	(0.02)	(0.02)	(0.01)	(0.01)	(0.10)	(0.10)	(0.06)	(0.06)
	[-3.1%]	[-3.1%]	[1.0%]	[1.1%]	[-2.9%]	[-3.5%]	[-3.8%]	[-3.9%]	[-0.3%]	[0.1%]	[1.6%]	[1.6%]	[-0.9%]	[-0.5%]
PC		-0.03		0.09*		-0.30*		-0.09***		0.05*		-0.28		-0.13**
		(0.05)		(0.05)		(0.17)		(0.03)		(0.03)		(0.29)		(0.06)
		[-1.3%]		[3.2%]		[-10.4%]		[-5.1%]		[6.7%]		[-4.3%]		[-10.3%]
	2448	2728	2448	2728	2448	2728	2448	2728	2448	2728	2448	2728	2448	2728
	0.98	0.98	0.96	0.96	0.92	0.92	0.98	0.98	0.99	0.99	0.99	0.98	0.97	0.97
		0.43		0.37		0.27		0.53		0.09*		0.18	0.13	0.07*
	2.28	2.28	3.01	3.01	2.90	2.90	1.76	1.76	0.75	0.75	6.66	6.66	1.31	1.31

Table 8. County level hospital utilization rates

	Infectious diseases		Neoplasms		Psychological disorders		Nervous s.d.		Circulatory s.d.		Respiratory s.d.	
	I	II	I	II	I	II	I	II	I	II	I	II
PMA	-1.65***	-1.57***	2.06	2.07	-1.47	-1.07	-1.86***	-1.83***	2.43	2.62	0.44	0.56
	(0.53)	(0.52)	(2.42)	(2.40)	(1.04)	(1.03)	(0.67)	(0.66)	(2.76)	(2.74)	(1.23)	(1.21)
	[-2.2%]	[-2.1%]	[0.8%]	[0.9%]	[-0.9%]	[-0.6%]	[-1.9%]	[-1.9%]	[0.7%]	[0.7%]	[0.3%]	[0.4%]
PC		-1.36**		3.19		-1.57		-1.48		-2.21		-1.29
		(0.68)		(3.58)		(1.68)		(0.91)		(3.85)		(1.70)
		[-1.8%]		[1.3%]		[-0.9%]		[-1.5%]		[-0.6%]		[-0.8%]
	44064	49104	44064	49104	44064	49104	44064	49104	44064	49104	44064	49104
util rate	0.87	0.87	0.85	0.85	0.69	0.69	0.84	0.85	0.95	0.95	0.83	0.83
p-value		0.78		0.77		0.79		0.73	356.76	0.27	155.87	0.33
	76.70	75.96	243.96	241.90	167.12	166.27	99.61	98.21	353.40	353.40	155.01	155.01

Notes: Unit of observation is county-year. PMA denotes post merger and acquisition and PC denotes post closure. Heteroskedasticity robust standard errors are reported in parenthesis and the magnitude of the estimated effect as percentage of mean rate is reported in square brackets. # obs is the number of observations and AR2 is the adjusted R2. Mean rate is the mean utilization rate per 10,000 population. P-value is the p-value of the test comparing the effects of acquisition and closure on outcome of interest. *** Significant at the 1 percent level. ** Significant at the 5 percent level.

Table 8, continued

	Digestive s.d.		Musculoskeletal s.d.		Urogenital s.d.		Injuries, poisoning	
	I	II	I	II	I	II	I	II
PMA	-0.22	-0.21	-1.12	-1.12	1.61	1.50	1.94	1.88
	(0.99)	(0.98)	(1.35)	(1.33)	(1.03)	(1.03)	(1.41)	(1.41)
	[-0.1%]	[-0.1%]	[-0.5%]	[-0.5%]	[1.3%]	[1.2%]	[0.8%]	[0.8%]
PC		-2.03		0.59		1.69		-2.59
		(1.41)		(1.73)		(1.55)		(1.73)
		[-0.9%]		[0.3%]		[1.3%]		[-1.1%]
	44064	49104	44064	49104	44064	49104	44064	49104
util rate	0.93	0.94	0.92	0.92	0.79	0.79	0.91	0.91
p-value	239.37	0.24	217.58	0.39	129.32	0.91	238.95	0.03**
	238.00	238.00	214.82	214.82	128.20	128.20	237.25	237.25

Appendix A

Inclusion/Exclusion criteria and risk adjustment factors of health outcome indicators.

APPENDECTOMY

Inclusion procedure: 5-470.

Inclusion diagnoses (main diagnoses): K35, K36, K37, K38, R10.

Exclusion diagnosis (secondary diagnosis): C, D00-D09, K50, K55.0, O.

Exclusion procedures: 5-467.3, 5-467.4, 5-467.6, 5-467.7, 5-467.8, 5-467.9, 5-467.a, 5-467.x, 5-467.y, 5-471, 5-511, 5-652, 5-653, 5-683, 5-685.

Risk factors: Age, sex, surgical procedure, inflammatory process, anththrombotic medication in the previous year and concomitant illnesses in the initial case according to Elixhauser et al. (1998) with the exceptions: solid tumors without metastases, metastatic cancers and lymphomas, since all malignant neoplasms are an exclusion criterion for this clinical area; in each case: if the given factor has a significant influence.

Indicator ID 1032: Therapy-related complications requiring intervention / surgery within 90 days

Definition: Therapy-dependent (in connection with the appendectomy) complications requiring intervention/surgery occurring after appendectomy within 90 days.

Inclusion procedures: 5-455.0, 5-455.2, 5-455.3, 5-455.4, 5-467.0, 5-467.1, 5-467.2, 5-467.5, 5-469.0, 5-469.1, 5-469.2, 5-469.d, 5-469.e, 5-469.s3, 5-541.0, 5-541.1, 5-541.2, 5-541.3, 5-541.4, 5-541.x, 5-541.y, 5-545.0, 5-545.x, 5-545.y, 5-549.0, 5-549.5, 5-896.1b, 5-896.2b, 5-916.a0, 5-916.a3, 8-176, 8-190.

Inclusion diagnoses (secondary diagnoses): K63.1.

Indicator ID 1033: Infect., Sepsis, wound infections, transfusions within 90 days

Definition: General surgical complications within 90 days of surgery.

Inclusion procedure: 8-800.

Inclusion diagnosis (in primary admission as secondary diagnosis, in readmission as main diagnoses): A41, K65, T81.2, T81.3, T81.4.

Indicator ID 1034: 90 day mortality.

Definition: mortality within 90 days of hospital admission.

Indicator ID 1035: Total complications

Definition: therapy related complications listed for indicator 1032 or general surgical complications listed for indicator 1033 or mortality within 90 days of hospital admission.

Heart attack (AMI)

Definition: Patients older than 30 years of age with heart attack main diagnoses.

Inclusion diagnosis (main diagnoses): I21, I22.

Risk factors: Age, sex, type of myocardial infarction (acute transmural myocardial infarction of the anterior wall, acute transmural myocardial infarction of the posterior wall, acute transmural myocardial infarction at other locations, acute subendocardial myocardial infarction, acute transmural myocardial infarction at unspecified location, other myocardial infarction), atherosclerosis, dilated cardiomyopathy, heart failure, cardiogenic and NOS shock, 3rd degree atrioventricular block, ventricular tachycardia, ventricular fibrillation/flutter, cerebral infarction, intracerebral hemorrhage, status post stroke or cerebral hemorrhage, severe kidney disease, malignant neoplasm, metastases.

Indicator ID 2001: mortality within 30 days of hospital admission.

STROKE

Definition: Patients older than 30 years of age with cerebral infarction or intracerebral haemorrhage main diagnoses.

Inclusion diagnosis (main diagnoses): I61, I63, I64.

Risk factors: Age, sex, type of stroke (intracerebral hemorrhage, cerebral infarction, stroke-not referred to as haemorrhage or infarction), atrial fibrillation/flutter, atherosclerosis, congestive heart failure, dilated cardiomyopathy, 3rd degree AV block, aortic and mitral valve defects, ventricular tachycardia, atherosclerosis of the limb arteries, severe kidney disease, chronic renal failure, malignant neoplasms, metastases.

Indicator ID 2002: mortality within 30 days of hospital admission.

Orthopedics / Trauma surgery

HIP

Inclusion procedures: 5-820.0, 5-820.8, 5-820.9, 5-820.x.

Inclusion diagnosis (main diagnoses): M05, M06, M07, M08, M16.0, M16.1, M16.2, M16.3, M16.6, M16.7, M16.9, M87.

Exclusion diagnosis (secondary diagnosis): C, D00-D09, M80.05, M80.85, M84.15, M84.45, M84.85, M84.95, M85.05, M85.45, M85.55, M85.65, M90.75, M96.88, Q65.0, Q65.1, Q74.2, S32.4.

Exclusion procedures: 5-785.4d, 5-822, 5-829.c, 5-829.g, 5-829.k, 5-829.m.

Risk factors: Age, sex, BMI (30-34, 35-39, and ≥40 kg/m^2, in the initial admission), antithrombotic medication in the previous year and concomitant

diseases on admission according to Elixhauser et al. (1998) with the exceptions: solid tumors without metastases, metastasizing cancers and lymphomas, since all malignant neoplasms are an exclusion criterion for this clinical area; obesity, since BMI classes are considered separately; in each case: if the given factor has a significant influence.

Indicator ID 1001: revision surgery within 365 days

Definition: revision surgery at the same hip joint in the initial admission or up to 365 days after implantation of the hip arthroplasty.

Inclusion procedures: 5-780[]d, 5-780[]e, 5-780[]f, 5-780[]g, 5-800.0g, 5-800.1g, 5-800.2g, 5-800.3g, 5-800.4g, 5-800.5g, 5-800.6g, 5-800.8g, 5-800.ag, 5-800.xg, 5-821.0, 5-821.2, 5-821.3, 5-821.4, 5-821.5, 5-821.7, 5-821.a, 5-821.b, 5-821.c, 5-821.d, 5-821.g, 5-821.h, 5-821.j, 5-821.k, 5-821.x, 5-821.y, 5-829.0, 5-829.1, 5-829.2, 5-829.h, 5-869.1, 5-892[]c, 5-892[]d, 5-892[]e, 5-894[]c, 5-894[]d, 5-894[]e, 5-895[]c, 5-895[]d, 5-895[]e, 5-896[]c, 5-892[]d, 5-892[]e, 5-900[]c, 5-900[]d, 5-900[]e, 5-916.a0, 5-916.a1.

Indicator ID 1002: surgical complications within 90 days

Definition: Dislocations, complications from orthopedic endoprostheses, implants or transplants, complications from interventions in the initial admission or within 90 days.

Inclusion diagnosis (on initial admission secondary diagnosis, on readmission main diagnoses): S73, T81.2, T81.3, T81.5, T84.0, T84.04, T84.5, T84.8, T84.9.

Inclusion procedure: 8-201.g.

Indicator ID 1005: 90-day mortality indicator.

Definition: Mortality within 90 days of hospital admission.

Indicator ID 1018: Total complications indicator

Definition: revision surgery within 365 days or surgical complications within 90 days or femur fracture in the initial admission or within 90 days of discharge or mortality within 90 days of hospital admission.

KNEE

Inclusion procedures: 5-822.0, 5-822.g, 5-822.h, 5-822.j, 5-822.k.

Inclusion diagnosis (main diagnoses): M05, M06, M07, M08, M17.0, M17.1, M17.4, M17.5, M17.9, M87.

Exclusion diagnosis (secondary diagnosis): C, D00-D09, D16.2, M80.00, M80.05, M80.80, M80.85, M84.00, M84.05, M84.06, M85.05, M85.06, M85.45, M85.46, M85.55, M85.56, M85.65, M85.66, Q74.1.

Exclusion procedures: 5-820, 5-829.c, 5-829.k, 5-829.m.

Indicator ID 1010

Definition: Revision procedure of the same knee joint in the initial admission or up to 365 days after implantation of the knee joint endoprosthesis.

Inclusion procedures: 5-800.0h, 5-800.1h, 5-800.2h, 5-800.3h, 5-800.4h, 5-800.5h, 5-800.6h, 5-800.8h, 5-800.ah, 5-800.xh, 5-810.0h, 5-810.1h, 5-810.2h, 5-810.3h, 5-810.4h, 5-810.5h, 5-810.7h, 5-810.9h, 5-810.xh, 5-823.0, 5-823.1, 5-823.2, 5-823.5, 5-823.7, 5-823.b, 5-823.c, 5-823.d, 5-823.e, 5-823.f, 5-823.g, 5-823.k, 5-829.6, 5-855[]8, 5-855[]9, 5-869.1, 5-892[]e, 5-892[]f, 5-894[]e, 5-894[]f, 5-895[]e, 5-895[]f, 5-896[]e, 5-896[]f, 5-900[]e, 5-900[]f, 5-916.a0, 5-916.a1.

Indicator ID 1011

Definition: dislocations, complications from orthopedic endoprostheses, implants or transplants, complications from interventions in the initial admission or within 90 days.

Inclusion diagnosis (in the initial admission as secondary diagnosis, in readmission as main diagnoses): M96.6, S83, T81.2, T81.3, T81.5, T84.0, T84.05, T84.5, T84.8, T84.9.

Inclusion procedure: 8-201.h.

Indicator ID 1013

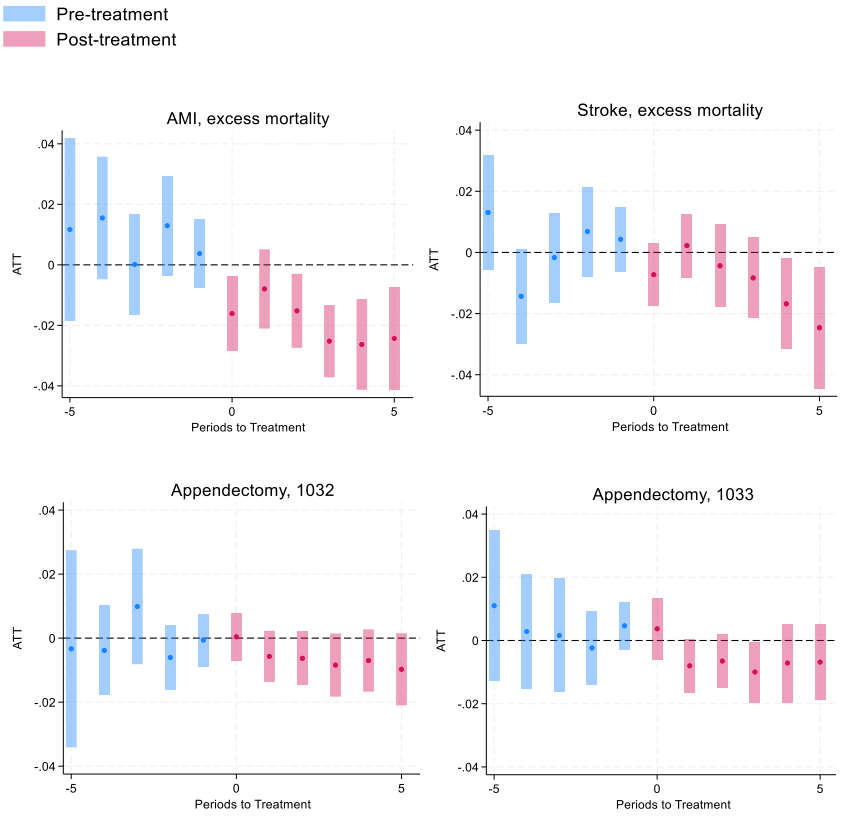
Definition: Mortality within 90 days of hospital admission.

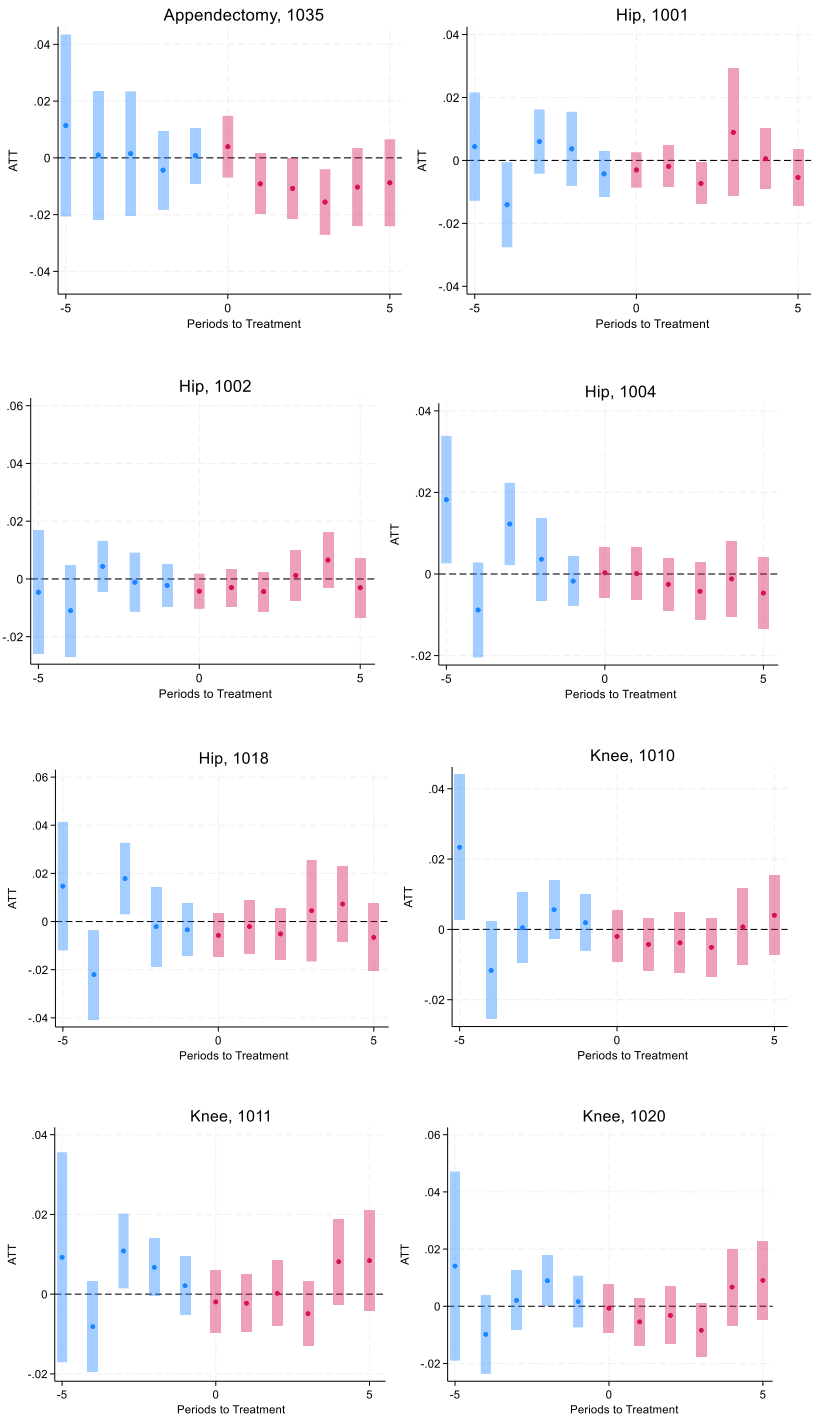
Indicator ID 1020

Definition: revision procedure as in indicator ID 1010, surgical complication as in indicator ID 1011, or 90 day mortality as in indicator ID 1013.

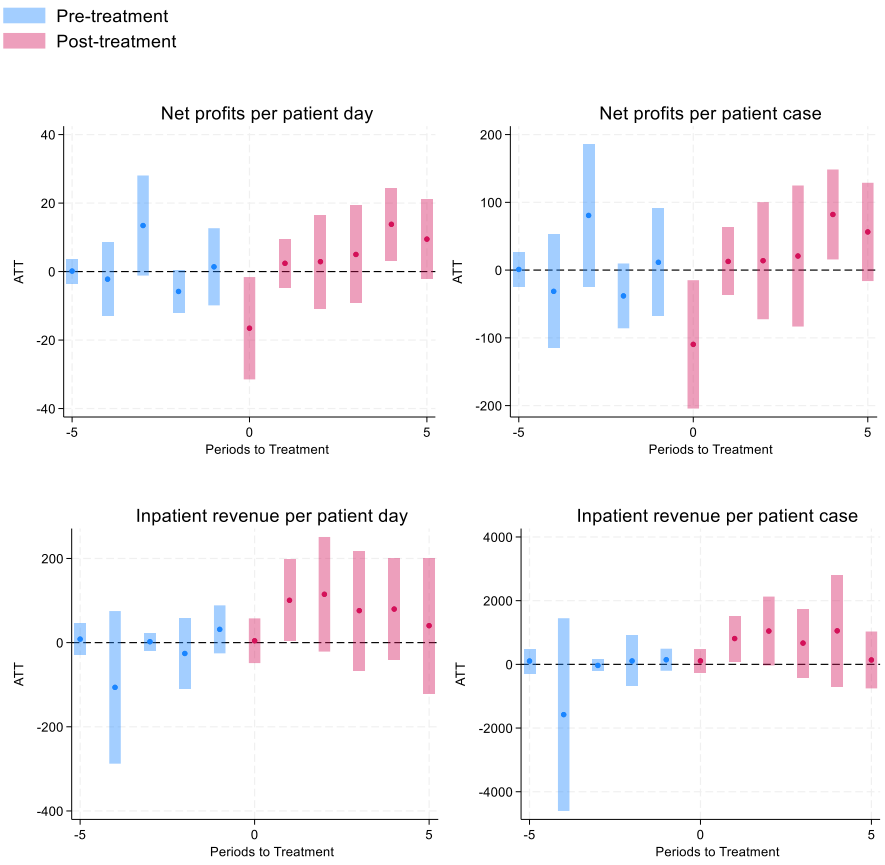
APPENDIX B. Graphs for dynamic effects

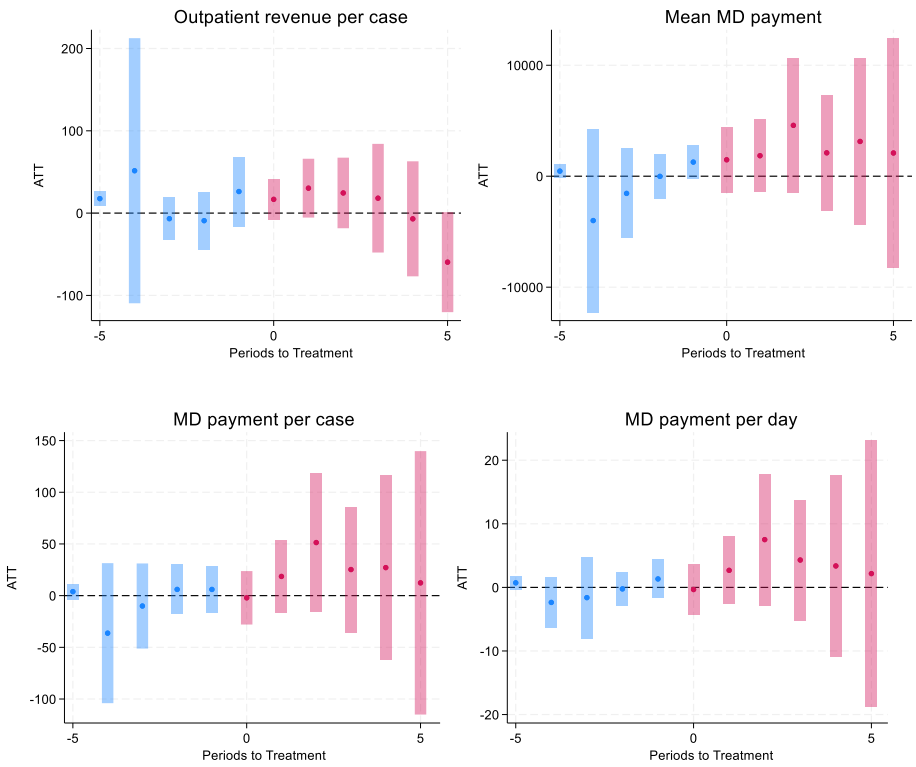
Graph B1. Dynamic effects of hospital mergers and acquisitions on hospital quality of care



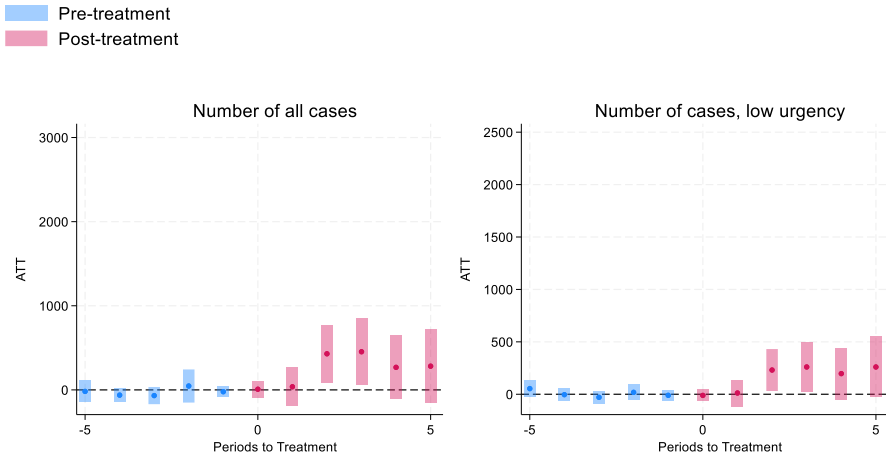

Appendectomy, 1035
Hip, 1001
Hip, 1002
Hip, 1004
Hip, 1018
Knee, 1010
Knee, 1011
Knee, 1020
ATT
Periods to Treatment

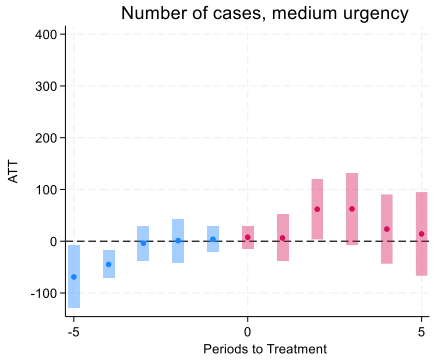
Graph B2. Dynamic effects of hospital mergers and acquisitions on hospital finances

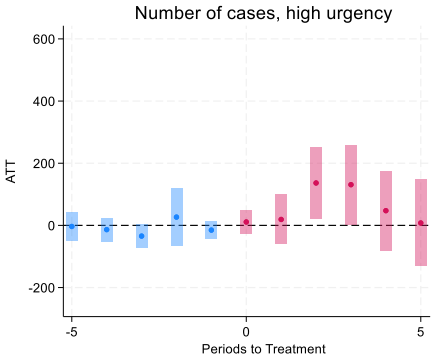




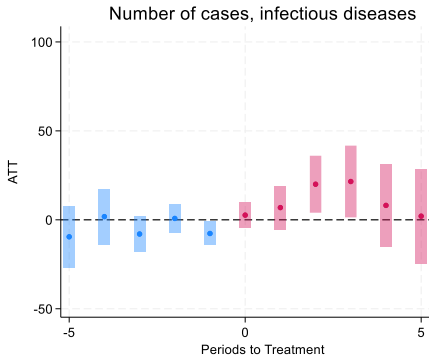
Graph B3. Dynamic effects of hospital mergers and acquisitions on volume

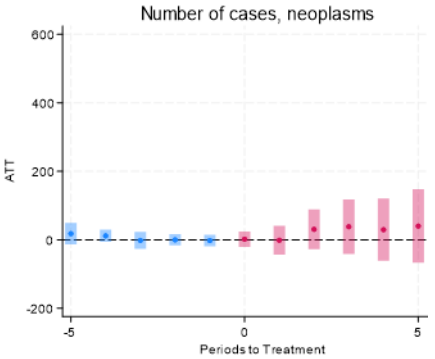


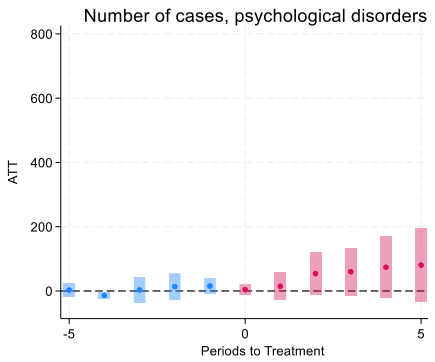


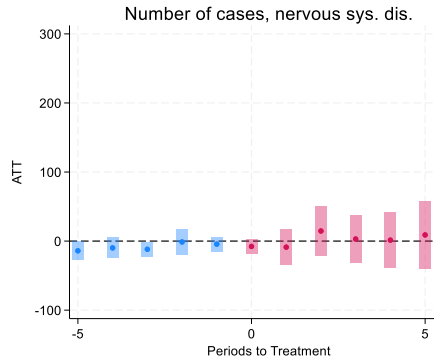


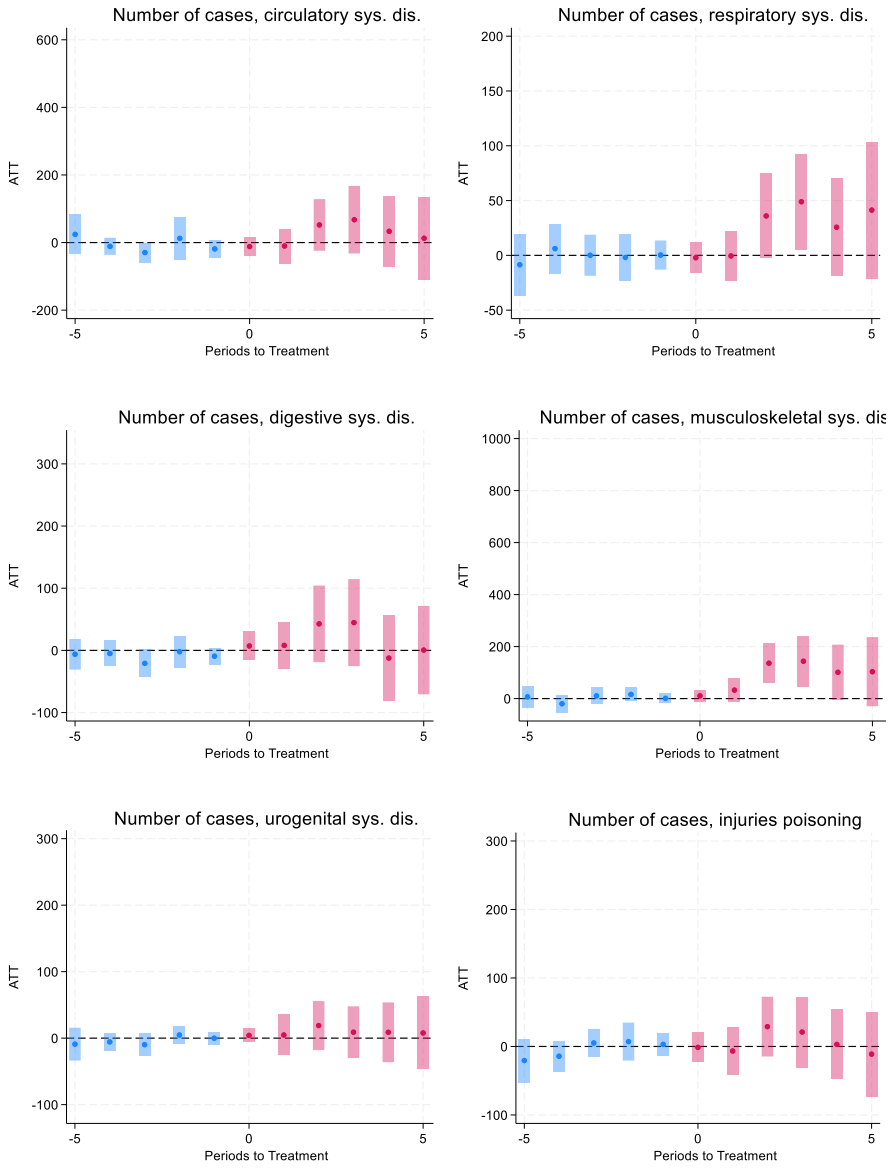
By major diagnostic category



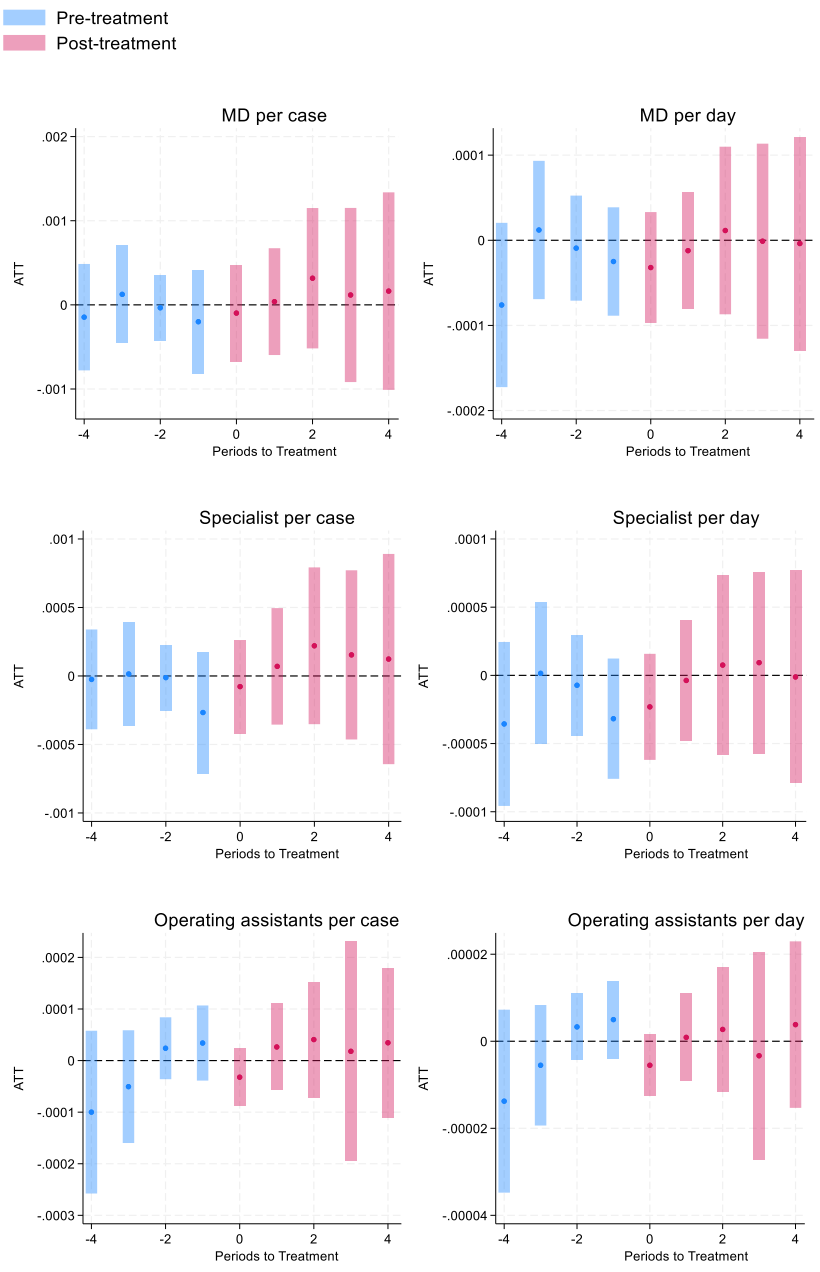


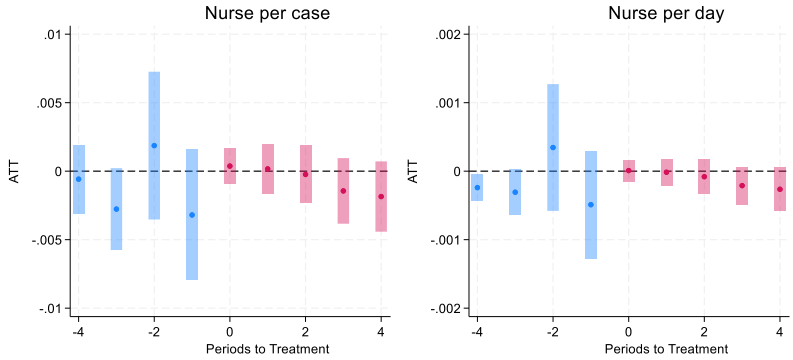




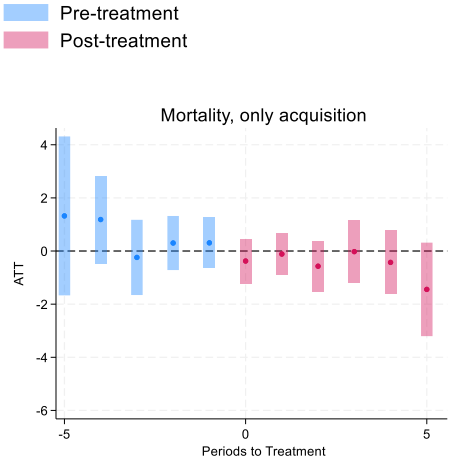

Number of cases, circulatory sys. dis.
Number of cases, respiratory sys. dis.
Number of cases, digestive sys. dis.
Number of cases, musculoskeletal sys. dis
Number of cases, urogenital sys. dis.
Number of cases, injuries poisoning
ATT
Periods to Treatment
-5
0
5

Graph B4. Dynamic effects of hospital mergers and acquisitions on employment

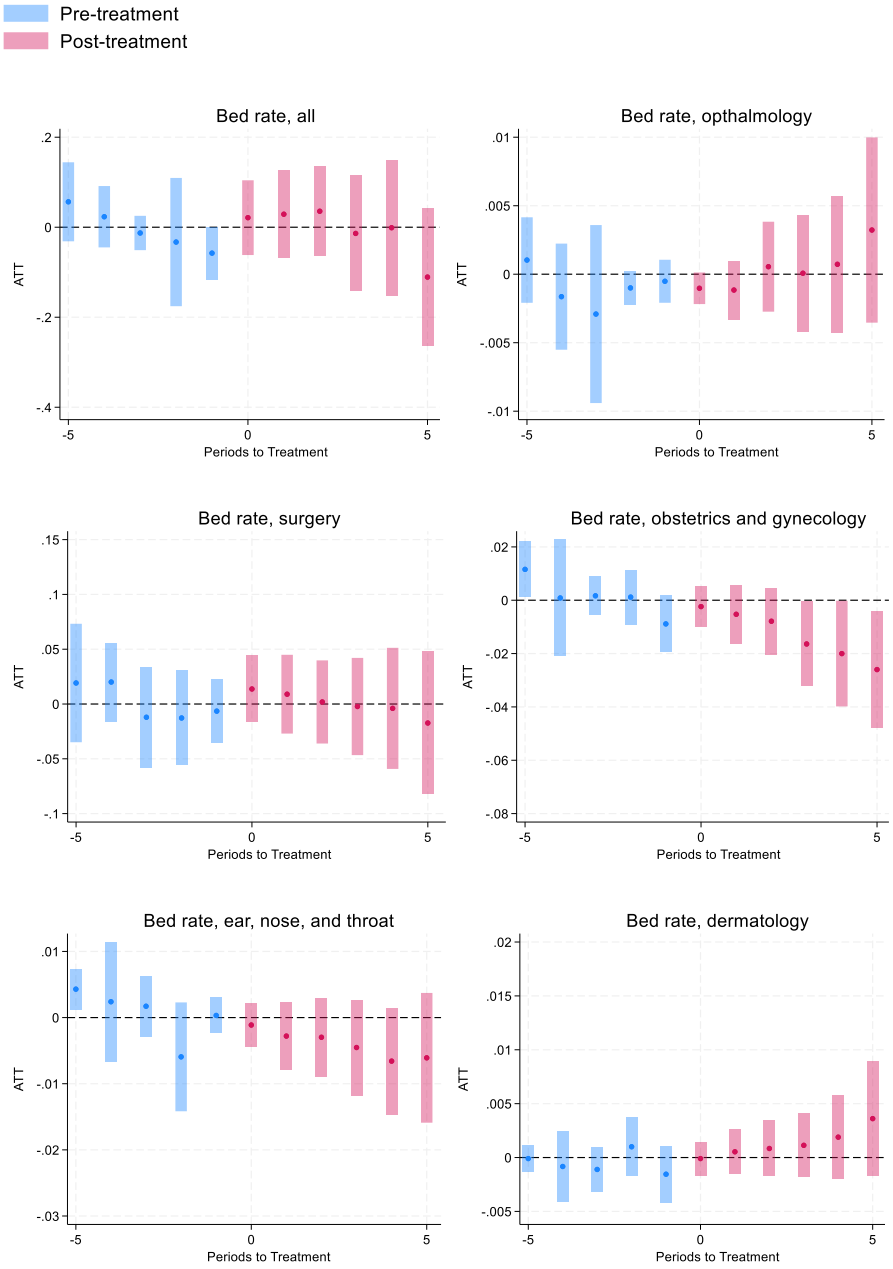


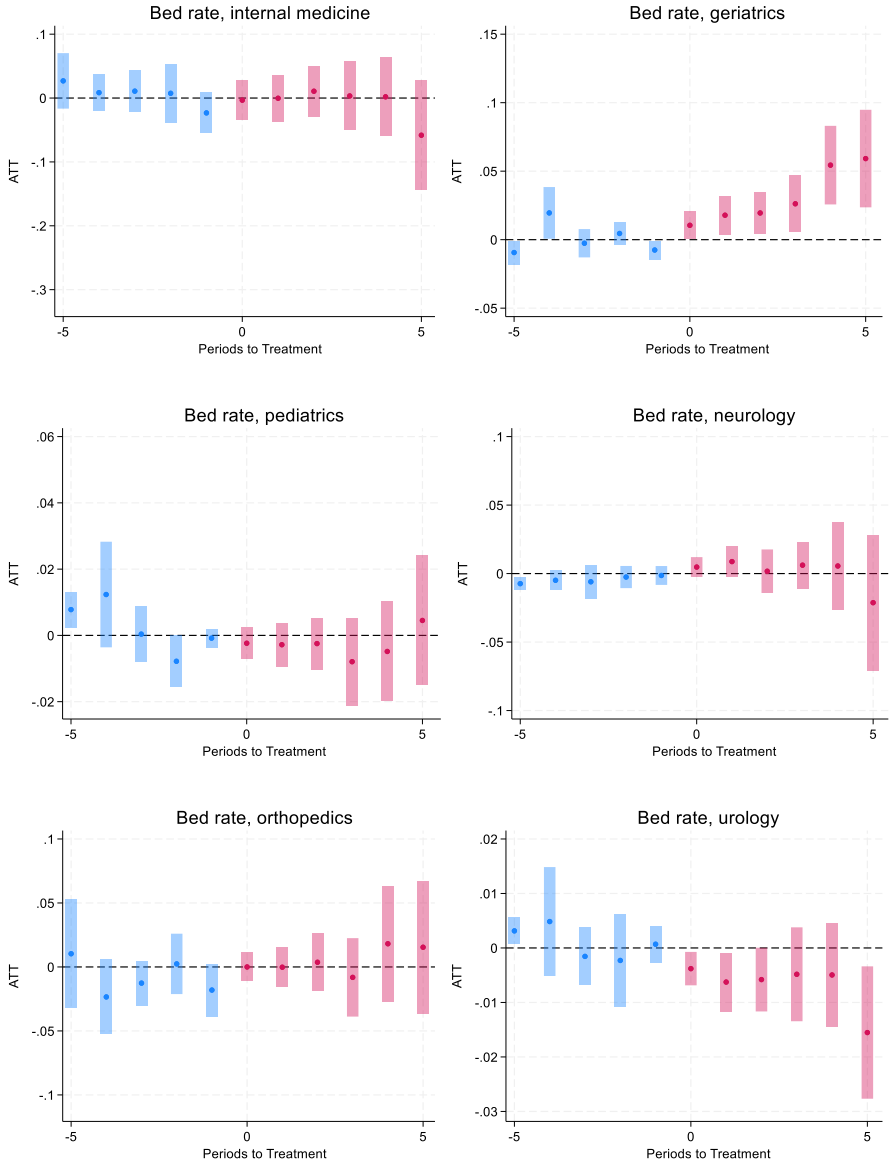


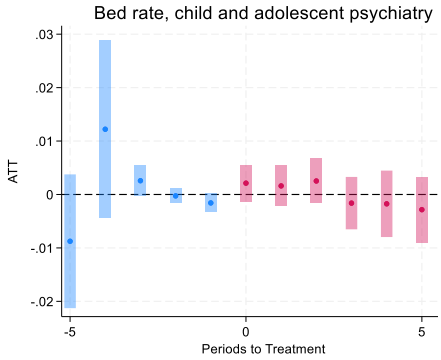
Graph B5. Dynamic effects of hospital mergers and acquisitions on all-cause mortality

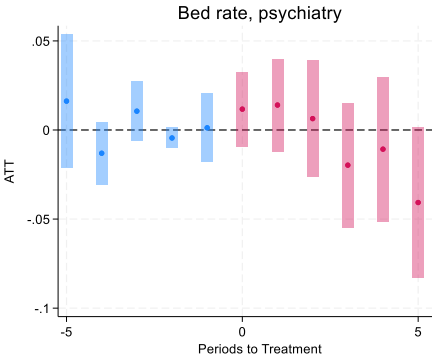


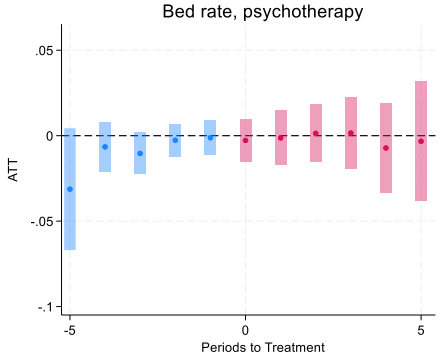
Graph B6. Dynamic effects of hospital mergers and acquisitions on number of hospital bed per 10,000 population at county level for all beds and by specialty



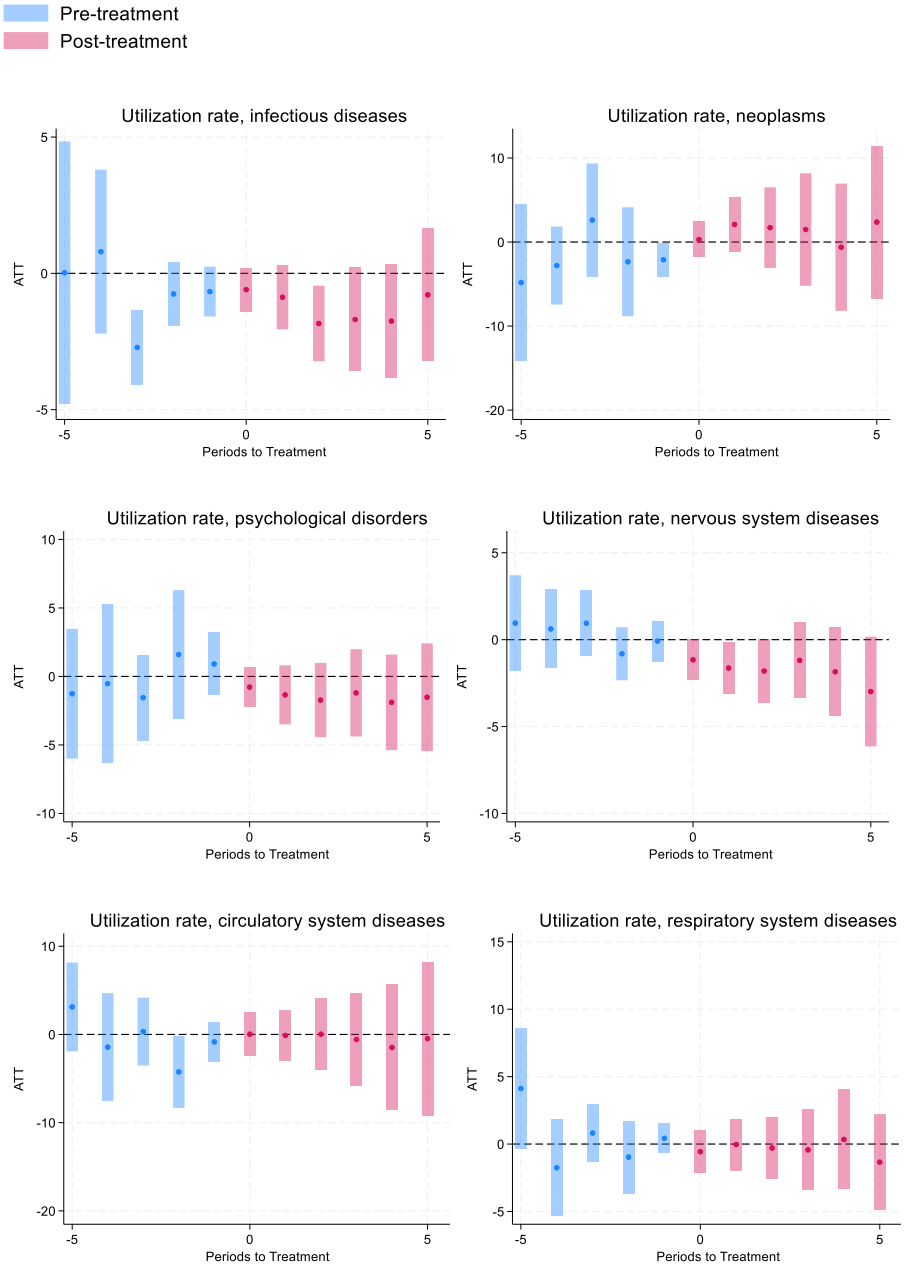

Bed rate, internal medicine
ATT
.1
0
-.1
-.2
-.3
-5
0
5
Periods to Treatment
Bed rate, geriatrics
ATT
.15
.1
.05
0
-.05
-5
0
5
Periods to Treatment
Bed rate, pediatrics
ATT
.06
.04
.02
0
-.02
-5
0
5
Periods to Treatment
Bed rate, neurology
ATT
.1
.05
0
-.05
-.1
-5
0
5
Periods to Treatment
Bed rate, orthopedics
ATT
.1
.05
0
-.05
-.1
-5
0
5
Periods to Treatment
Bed rate, urology
ATT
.02
.01
0
-.01
-.02
-.03
-5
0
5
Periods to Treatment

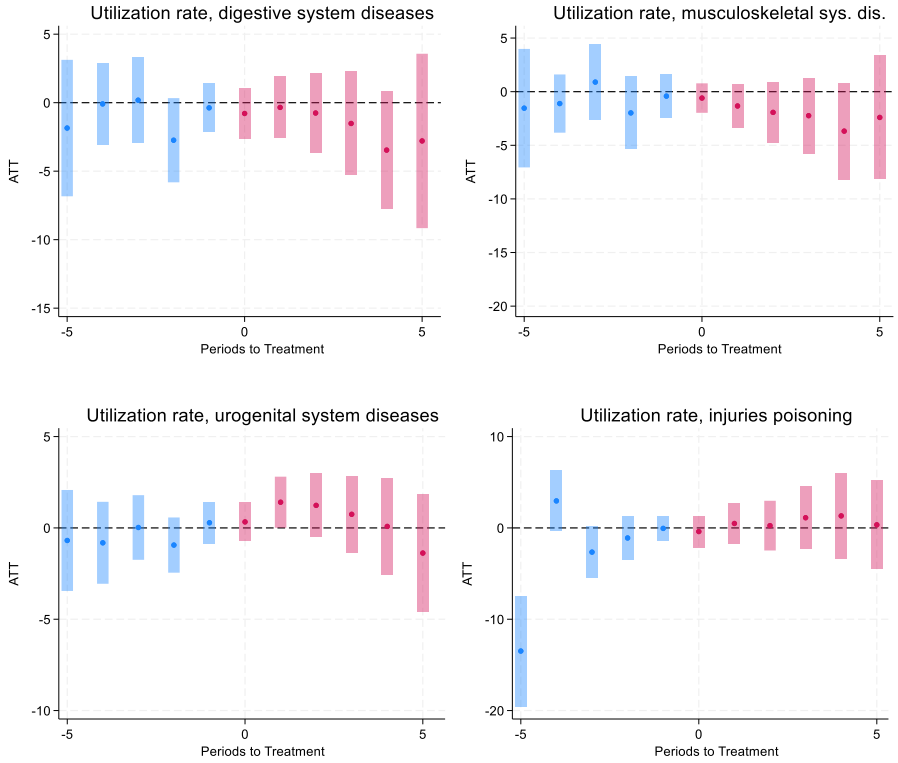

Bed rate, child and adolescent psychiatry
ATT
.03
.02
.01
0
-.01
-.02
-5
0
5
Periods to Treatment


Bed rate, psychiatry
ATT
.05
0
-.05
-.1
-5
0
5
Periods to Treatment


Bed rate, psychotherapy
ATT
.05
0
-.05
-.1
-5
0
5
Periods to Treatment

Graph B7. Dynamic effects of hospital mergers and acquisitions on county level hospital utilization rates




Utilization rate, digestive system diseases
ATT
5
0
-5
-10
-15
-5
0
5
Periods to Treatment
Utilization rate, musculoskeletal sys. dis.
ATT
5
0
-5
-10
-15
-20
-5
0
5
Periods to Treatment
Utilization rate, urogenital system diseases
ATT
5
0
-5
-10
-5
0
5
Periods to Treatment
Utilization rate, injuries poisoning
ATT
10
0
-10
-20
-5
0
5
Periods to Treatment