

Schlenker, Oliver

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The deadly consequences of labor scarcity: Evidence from hospitals

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DISCUSSION PAPER

// OLIVER SCHLENKER

The Deadly Consequences of Labor Scarcity: Evidence From Hospitals

The Deadly Consequences of Labor Scarcity: Evidence from Hospitals*

Oliver Schlenker[†]
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Abstract

Healthcare systems worldwide face increasing nurse shortages, but the consequences remain poorly understood. This paper studies how nurse scarcity in hospitals affects care provision and patient health. I exploit the 2011 Swiss franc stabilization, which increased the salience to cross-border commute from Germany to Switzerland and led to an outflow of nurses in German hospitals depending on their distance to the border. Using rich universal patient-, hospital-, and county-level German and Swiss administrative data in a matched difference-in-differences design, I show that border hospitals lose around 12 percent of their nursing staff. This leads to lower care intensity and a reallocation of services towards urgent cases (triage) while healthcare demand or supply outside hospitals remains unchanged. Consequently, in-hospital mortality rises by 4.4 percent – concentrated among emergency and older patients – and life expectancy decreases by 0.28 statistical life years, with no evidence of offsetting gains in Switzerland. These results highlight that nurse scarcity shapes hospital production and widens health disparities across patients and regions.

Keywords: Labor scarcity, cross-border commuting, nurse shortages, hospital production, healthcare provision, triage, patient mortality

JEL classification: F22, I11, I18, J22, J61, R23

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[†]Ifo Institute, LMU Munich & IAB Nuremberg, Germany (e-mail: schlenker@ifo.de)

1 Introduction

Across advanced economies, demographic change has raised concerns about persistent labor scarcity. As populations age, the effective labor supply shrinks while the demand for many services, especially health care, expands. In healthcare, this tension is amplified by institutional frictions and regulations – such as licensing requirements, collective agreements, and fixed prices – which increase wage and price rigidity and hinder market adjustment to rising labor market tightness (Blanchard and Galí, 2010; Shapiro and Stiglitz, 1984). Building on the disequilibrium framework of Barro and Grossman (1971), Michaillat and Saez (2015) show that tighter labor markets translate into product market tightness, i.e. excess demand, in such fixed-price settings. In hospitals, excess demand means delayed or rationed care and can have serious – even deadly – consequences for patients.

Registered nurses are at the center of this problem. They form the backbone of hospital care and are expected to become an especially scarce resource in many high-income countries. Nurses are the primary interface between patients and the health system by performing continuous bedside care, monitoring, coordination, and assistance in procedures. Evidence from recent work in the English NHS, the USA, and other settings shows that nurse staffing is tightly linked to mortality and other patient outcomes, particularly in acute hospital care (Griffiths et al., 2023; Zaranko et al., 2023; Stevens et al., 2015; Aiken et al., 2021). Yet despite widespread concern about shortages, relatively little is known about how nurse scarcity in hospitals affects the quantity, quality, and allocation of care – and how and which patients are affected in terms of health.

Conceptually, the impact of labor scarcity is difficult to assess. In competitive labor markets, a fall in labor supply triggers wage increases and other adjustments in market conditions, so "scarcity" is hard to define and measure separately from these responses (Arrow and Capron, 1959). Even in healthcare, where wages and prices are often regulated, staffing levels are typically endogenous to unobserved hospital quality, patient severity, and local demand conditions (Lin, 2014; Romley and Sood, 2013). Hospitals may also adjust case mix, treatment intensity, or discharge policies in response to the staffing situation, further blurring the relationship between observed inputs and outcomes. As a result, much of the existing evidence is correlational, with only a few quasi-experimental studies and limited evidence on who bears the burden of nurse shortages across diagnoses, ages, and regions (Friedrich and Hackmann, 2021; Propper and Van Reenen, 2010). From a policy perspective, however, the key questions concern exactly these causal and distributional effects.

This paper provides empirical evidence on how nurse scarcity in hospitals affects (i) the quantity, quality, and allocation of healthcare services and (ii) patient and population health. I exploit a policy-induced increase in the salience to cross-border commute from Germany to Switzerland for registered nurses, which generated a negative labor supply shock in German hospitals. The empirical variation comes from the 2011 Swiss franc stabilization, when the Swiss National Bank unexpectedly introduced a minimum exchange rate that effectively locked in a strongly appreciated Swiss franc. This policy preserved large and predictable wage differentials between Swiss and German healthcare jobs and received broad media coverage, making commuting to Switzerland particularly salient for residents of the German border region. At the

same time, German hospitals operated under DRG-based case payments, collective wage agreements, and care mandates that limited their ability to adjust prices, wages, and the number or selection of patients. Compared to other occupations, German registered nurses faced low legal barriers and strong demand in Switzerland, making them especially responsive to the improved commuting opportunity. Together, these features generate a plausibly exogenous, occupation-specific negative labor supply shock for nurses that differentially affects hospitals depending on their proximity to the Swiss border.

I assemble rich German and Swiss administrative data spanning between 2006–2017 that allow me to track the response to this shock at the worker, hospital, patient, and county level. Universal labor market data on all employees subject to social security contributions and on all German cross-border commuters working in Switzerland, combined with hospital-level staffing and vacancy records, identify which hospitals are exposed to nurse outflows and how their occupational composition changes. Case-level data covering the universe of roughly 18 million inpatient cases per year in all 2,000 German hospitals provide detailed information on diagnoses, procedures, and in-hospital mortality. This allows me to measure changes in treatment intensity and mortality at a fine level of granularity while conditioning on patients' medical needs. County-level data on mortality, life expectancy, and healthcare supply outside hospitals allow me to assess whether in-hospital effects translate into aggregate health impacts and to rule out confounding changes in demographics, healthcare demand, and non-hospital care.

Empirically, I use a matched multi-period difference-in-differences ("event study") design that compares outcomes in the German border region, where cross-border commuting is feasible, to unaffected matched control counties further inland. Treated counties are defined based on pre-2011 commuting patterns and travel times to the Swiss border, while control counties are selected using propensity score matching on pre-event characteristics. This ensures that treated and control counties are similar in terms of urbanization, economic conditions, and demographic trends, mitigating concerns about differential trends such as hospital closures in rural areas (Stuart and Rubin, 2008a). I estimate event-study models at the hospital, patient, and county level to assess the staffing, care, and health effects as well as to examine pre-trends and perform extensive robustness checks to assess potential confounders such as changes in healthcare demand, economic conditions, and healthcare supply outside hospitals.

Four sets of findings emerge. First, the Swiss franc stabilization substantially increases the salience of commuting to Switzerland for German healthcare workers evidenced by a strong and sudden increase in the number of new cross-border commuters. As a result, hospitals in the German border region lose around 12 percent of their nursing staff. Vacancies for nurses rise, while staffing levels and vacancies for other occupational groups in and outside hospitals remain statistically unchanged. This pattern is consistent with a negative labor supply shock for registered nurses rather than a change in demand for hospital care.

Second, hospitals mainly respond to nurse scarcity by reallocating care, not by treating fewer patients. Given the low substitutability between nurses and other input factors as well as the limited scope to adjust output at the extensive margin, the decline in nurse staffing translates into a roughly 10 percent decline in the nurse-to-patient ratio and a 12 percent reduction in patients' probability of receiving surgery conditional on medical needs. However, this contraction in

surgical treatment is not uniform across patient groups: hospitals shift care away from patients with lower marginal returns to nursing, i.e. those with less urgent diagnoses. This pattern holds across age groups, implying that nurse scarcity leads hospitals to increasingly prioritize patients based on medical urgency ("triage").

Third, nurse scarcity has sizable and unequal health effects. On average, in-hospital mortality increases by about 0.09 percentage points from a baseline of roughly 2 percent, corresponding to a relative increase of around 4.4 percent. The mortality effects are substantially larger for vulnerable patients: urgent cases aged 75 or older experience an increase of around 0.4 percentage points and mortality for emergency cases such as sepsis and myocardial infarction rises by 2.35 and 1.56 percentage points (11.6 and 17.7 percent), respectively. These findings are in line with evidence that crowding and staffing shortfalls disproportionately harm patients with high medical needs.¹ The case-level effects are mirrored in aggregate health statistics: life expectancy at birth falls by about 0.28 statistical life years, with roughly two-thirds of this decline driven by individuals over 60, who exhibit the largest increases in mortality both inside hospitals and in aggregate statistics. This reduction corresponds to roughly one-third of a cross-county standard deviation in life expectancy, shifting the average treated county from the median to about the 34th percentile of the national distribution.

Finally, when I compare Swiss border regions to regions further inland, I do not find that the inflow of German nurses is associated with higher life expectancy in Switzerland. Taken together, these results imply that policies and labor market forces that attract foreign nurses can reduce overall life expectancy on net, even when language barriers and recognition of qualifications do not limit productivity in the destination country.

These findings have two main implications. First, they show that nurse scarcity in the hospital sector can lead to product market rationing and substantial losses in consumer welfare. In the language of Michaillat and Saez (2015), a negative labor supply shock in a fixed-price market raises product market tightness: hospitals cannot raise prices or wages, cannot easily close services due to care mandates, and instead ration care through lower treatment intensity and triage. Second, if triage responses are not sufficient to shield vulnerable patients with high marginal returns to nursing from a reduction in care, nurse scarcity can ultimately exacerbate health inequalities across patient groups and regions. From a policy perspective, the results highlight that international recruitment of nurses can impose sizable health costs on origin populations, especially when sending countries face common institutional frictions that limit wage adjustment – such as collective bargaining and DRG-style reimbursement.

The paper contributes to three strands of literature. First, it relates to research on the drivers and consequences of labor scarcity and demographic change (e.g., Acemoglu and Restrepo, 2022; Benmelech and Zator, 2025; Sellars and Alix-Garcia, 2018; Acemoglu, 2010; Samuelson, 1965). Existing work has largely focused on how firms adjust production and technology when labor becomes scarce (e.g., Lipowski, 2025; San, 2023; Acemoglu and Restrepo, 2022). I instead study an occupation with limited scope for capital substitution and assess the consequences of labor scarcity for consumer welfare. By identifying a clean, occupation-specific negative labor supply

¹For instance, Hoe (2022) finds that in periods with high emergency admissions ("hospital crowding"), unplanned readmission rates especially increase for patients with high medical needs.

shock under stable prices and wages, I add to the hospital production function literature by showing that nurse scarcity causally reduces the ability of hospitals to convert inputs into health outcomes – a relationship that is otherwise difficult to identify due to endogenous staffing, patient selection, and unobserved severity (Romley and Sood, 2013). The findings provide empirical support for the predictions of Michaillat and Saez (2015), grounded in Barro and Grossman (1971), that in fixed-price settings labor scarcity translates into product market rationing – with sizable welfare losses.

Second, the paper contributes to the literature linking nurse staffing to the quality of care and patient outcomes (e.g., Friedrich and Hackmann, 2021; Aiken et al., 2021; Stevens et al., 2015; Propper and Van Reenen, 2010). Friedrich and Hackmann (2021) exploit a parental-leave reform that temporarily reduces nurse staffing to estimate returns to nursing input for patient outcomes. I complement their work by showing that market-induced shocks – here, exchange-rate-driven wage differentials – can generate structural nurse shortages of similar magnitude and by documenting how hospitals endogenously reallocate care when staffing becomes persistently tighter. Closely related, Propper and Van Reenen (2010) use regional variation in outside options for NHS nurses to link staffing rates to heart attack mortality. I build on their findings by showing that also cross-country wage differentials affect nurse staffing and increase mortality, not only for heart attack patients but across a broad set of diagnoses. By accounting for patients' medical needs when estimating the impact of nurse shortages on treatment intensity, the paper also connects to the literature on regional health and practice-style disparities (e.g., Card et al., 2023; Cutler et al., 2019; Finkelstein et al., 2016; Skinner, 2011), demonstrating how regional variation in nurse availability can shape local practice styles and health outcomes.

Third, the paper adds to the extensive literature on the causes and consequences of migration and cross-border commuting (e.g., Dustmann et al., 2017; Foged and Peri, 2016; Dustmann et al., 2015, 2013; Glitz, 2012; Card, 2009, 2001). Much of this work focuses on high-skilled "brain drain" (e.g., Docquier and Veljanoska, 2022; Docquier and Rapoport, 2012; Gibson and McKenzie, 2012) or on the impact of cross-border commuting on receiving countries (e.g., Beerli et al., 2021; Dustmann et al., 2017). I instead study middle-skilled nurses and emphasize the consequences for the sending country's healthcare system and population health. In this sense, the paper is complementary to two more recent papers: Dodini et al. (2025), who show that physician outflows to Norway reduce Sweden's health system capacity and raise mortality in the origin country and to Castro-Pires et al. (2025), who document that workforce composition shifts in the English NHS triggered by Brexit are associated with deteriorations in hospital performance and patient outcomes. In addition, the stable cross-country wage gap in my setting allows me to quantify the labor supply elasticity of nurses at the extensive margin, which aligns with more elastic within-country estimates found in Hanel et al. (2014) and Gottlieb and Zenilman (2024). Finally, given that nearly 1 percent (1.8 million) of the EU workforce consists of cross-border commuters (European Commission, 2024), the findings underscore that free movement within integrated labor markets can have unintended distributional consequences for health systems and consumers on both sides of national borders.

The remainder of the paper is organized as follows. Section 2 describes the institutional environment, focusing on the German hospital sector, the role of nurses, and the 2011 Swiss franc

stabilization. Section 3 introduces the data. Section 4 outlines the empirical strategy, including the assignment of counties to treatment and control groups via propensity score matching, the event-study specification, and the identifying assumptions. Section 5 shows the main results and the heterogeneity analysis across patient groups. Section 6 presents extensive robustness checks and the extension of the analysis to Switzerland in order to assess net health effects. Section 7 concludes with a discussion of the broader implications for labor markets, health policy, and the design of healthcare systems.

2 Institutional Setting

This section describes the institutional environment in which I study how nurse scarcity affects hospital production and patient health. I first summarize how the German hospital sector is organized, how it compares to healthcare systems in other high-income countries, and why registered nurses are a central, hardly substitutable input to hospital production. Secondly, I discuss the limited margins along which hospitals can adjust to nurse scarcity and how these constraints shape the allocation of care across patients with different medical needs. Finally, I describe the Swiss Franc Stabilization event in 2011, which increased the salience of cross-border commuting to Switzerland for German nurses and provides the quasi-experimental variation that underlies the empirical analysis.

2.1 The German Healthcare Sector

Germany provides universal healthcare coverage, with around 90% of the population insured under statutory social health insurance and the remainder holding comprehensive private coverage (Busse et al., 2017). Healthcare employs roughly 12% of the German workforce (about 5.2 million workers), a share comparable to the United States and Switzerland (OECD, 2017). Within this system, hospitals form a central pillar: they account for around 29% of total healthcare expenditures, treat more than 18 million inpatient cases per year, and provide roughly 6 beds per 1,000 inhabitants (Statistisches Bundesamt, 2012; Busse et al., 2017). Appendix Figures A.1 and A.2 show that both the composition of the hospital workforce as well as the nurse density per capita in Germany are in the same range as the G7 average.

Regulations. The German hospital sector is characterized by a high degree of regulation, much of it set at or above the state (Länder) level. Hospitals operate under three main constraints. First, inpatient care is reimbursed through DRG-based case payments that are standardized at the state level, so individual hospitals cannot charge higher prices in response to higher local costs or tighter labor markets (Geissler et al., 2012).² Second, wages and working conditions for the workforce are largely governed by collective agreements negotiated at the state

²DRG case-based payments group hospital cases by diagnoses and treatments and are converted into payments via a state-level base rate (“Landesbasisfallwert”). This base rate is negotiated annually between regional hospital associations and sickness funds and was designed to harmonize prices across hospitals and increase cost efficiency (Klein-Hitpaß and Scheller-Kreinsen, 2015; Busse et al., 2013a). By construction, it limits hospitals’ scope to respond to local cost shocks, including higher wages, through higher prices.

level.³ These contracts are binding for all public hospitals and most non-profit providers, and privately owned hospitals typically follow them closely Busse et al. (2017). Third, hospital plans and statutory care mandates, anchored in the Hospital Financing Act (KHG), assign hospitals defined care obligations and bed capacities. These care mandates ensure access to essential services but prevent hospitals from unilaterally closing departments, reducing bed capacity, or withdrawing from specific services if such changes would jeopardize regional coverage (Braun et al., 2011; Busse et al., 2013b). Compared to the United States, where prices and contracts are more frequently negotiated at the hospital–insurer level, this combination of uniform reimbursement, sector-wide wage agreements, and legally defined supply obligations gives German hospitals relatively little direct control over prices and base wages. At the same time, Appendix Table A.1 and OECD (2024) highlight that similar elements of central planning and regulation are also present in other high-income countries such as Canada, suggesting that the institutional frictions I exploit are not unique to Germany.

The role of registered nurses in hospitals. Both in terms of numbers and the range of tasks they perform, registered nurses are a central production factor in (German) hospitals with limited scope for substitution. Nursing staff account for roughly 40% of total hospital employment, and around 80% of this group are registered nurses. (Blum et al., 2019; Busse et al., 2017). Registered nurses complete a three-year vocational training program culminating in a state examination and are responsible for core clinical activities: they provide bedside care (e.g., wound care, hygiene, mobilization), monitor and document vital signs and treatment progress, administer medications prescribed by physicians, and assist surgeons and anesthesiologists during procedures. By contrast, nursing assistants typically have shorter training, focus on basic personal care, and are neither authorized nor trained to perform most clinical tasks or documentation. Appendix Table A.2 summarizes these differences in scope of practice and shows that legal, skill, and efficiency constraints severely limit the potential to substitute registered nurses with other occupational groups, including nursing assistants, medical assistants, or physicians (Zaranko et al., 2023; Busse et al., 2017).

2.2 Hospital’s Resilience to Negative Labor Supply Shocks

Hospitals have limited means to adjust when the outside options of registered nurses improve. Given the regulatory environment described above, three margins are particularly constrained.

First, on the retainment margin: wages are largely determined by state-level collective agreements and DRG-based prices are fixed at the Länder level. Thus, hospitals cannot selectively raise pay for nurses who consider taking up outside options and broad wage increases are financially not sustainable as they would not be matched by higher DRG revenues (Busse et al., 2013b). As fixed prices apply to public and non-profit hospitals bound by collective contracts as well as to most private providers, retainment is limited independent of provider type.

Second, on the substitution margin: registered nurses cannot be easily replaced by other occupational groups. Nursing assistants and other auxiliary staff lack both the legal authorization

³These collective agreements (“Tarifverhandlungen”) between employers’ associations and trade unions specify pay scales, working hours, vacation entitlements, and other working conditions.

and the training to carry out core clinical and documentation tasks, while physicians are too expensive to provide routine nursing care at scale (Blum et al., 2019, 2017; Zaranko et al., 2023). Appendix Table A.2 summarizes these legal, skill, and efficiency barriers and highlights that potential substitutes either lack the required qualifications, are not authorized to perform key nursing activities, or are economically infeasible as a replacement. Moreover, in the early 2010s, capital substitution such as automation technologies played only a negligible role in German hospitals.

Third, on the output margin: hospitals cannot freely reduce the number of beds and patients treated or the range of services offered. Care mandates and state hospital plans (KHG) define service obligations and bed capacities and require providers to maintain coverage for their catchment area (Braun et al., 2011; Busse et al., 2013b).

Implications. Taken together, these institutional constraints imply that when the outside options of registered nurses improve, hospitals experience a negative labor supply shock that cannot be offset by local wage or price adjustments. Following the theoretical predictions in Michaillat and Saez (2015), in such a fixed-price setting this negative labor supply shock (i.e. higher labor market tightness) translates into higher product market tightness, meaning a reduction in hospital care per patient. Given that care mandates keep the number and composition of patients largely fixed, a decline in nursing staff does likely not translate into fewer patients treated, but rather into less treatment per patient. This raises two central questions: (i) do hospitals target reductions in care according to patients’ medical needs and (ii) how are the resulting health effects distributed?

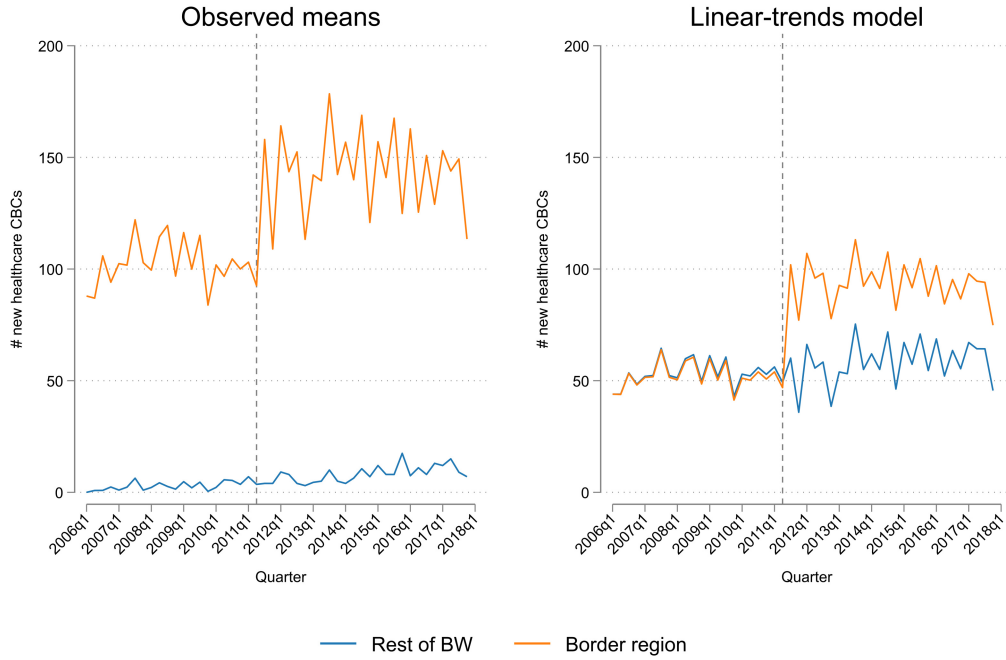
2.3 The Swiss Franc Stabilization of 2011 and Its Consequences For German Hospitals

To empirically assess how hospitals react to increasing nurse scarcity and how patients are affected, I exploit the *Swiss Franc Stabilization* of 2011 as a quasi-experimental shock to nurses’ outside options. By raising the salience to cross-border commute to Switzerland for German nurses living near the border, the policy induced an outflow of staff from German hospitals – whereby exposure to the shock is determined by hospitals’ distance to the Swiss border.

The Origins. In the course of the European financial and currency crisis, the Swiss franc appreciated strongly, putting pressure on the Swiss export sector and raising concerns about a recession in the small open Swiss economy. After conventional monetary policy instruments had largely been exhausted, the Swiss National Bank (SNB) intervened in September 2011 and unexpectedly introduced a minimum exchange rate of 1.20 Swiss francs (CHF) per euro (EUR) to prevent further appreciation of the franc (Landmann et al., 2011). This policy effectively stabilized the exchange rate, as Appendix Figure A.3 shows, indicating that market forces indeed would have led to a stronger CHF if the policy had not been in place.⁴

⁴This becomes even more evident in the Swiss Franc Shock in 2015, when the SNB finally lifted its minimum exchange rate policy, which led to a sizeable appreciation of the CHF (Bernholz et al., 2015).

Figure 1: New cross-border commuters in the healthcare sector



Notes: This graph shows the number of German cross-border commuters newly starting to work in the Swiss healthcare sector in raw means (left panel) and after accounting for linear trends (right panel). Assignment to sectors is based on the General Classification of Economic Activities (NOGA), the Swiss pendant to the Statistical Classification of Economic Activities in the European Community (NACE). "Border region" refers to German counties at the Swiss-German border, i.e., the treatment group as defined in Section 4, which are prone to cross-border commuting. "Rest of BW" refers to all other counties in the Federal State of Baden-Württemberg. Data is obtained from the Swiss Cross-Border Commuter Statistic, described in detail in Section 3.

Implications for Cross-Border Commuting. For Germans living close to the border, this *Swiss Franc Stabilization* increased the salience of cross-border commuting to Switzerland for several reasons. First, it locked in a high and persistent cross-country wage differential. Appendix Figure A.6 shows that the gross yearly earnings gap between registered nurses in Germany and healthcare workers in Switzerland increased from roughly 30,000 euros at the beginning of 2010 to around 40,000 euros by the end of 2011 and remained at that level thereafter. Second, by stabilizing the CHF–EUR exchange rate around the floor, the policy sharply reduced exchange-rate volatility and thus the variance of earnings from cross-border commuting (Appendix Figure A.7). Such a reduction in long-term volatility is especially important when considering that cross-border commuters start ... Third, the stabilization attracted substantial media attention. Both national and regional outlets framed the currencies as "brothers" and highlighted that cross-border commuting had become more attractive (Appendix Figure A.4), which is mirrored by a contemporaneous spike in Google search intensity in Germany for "Working in Switzerland" and related queries (Appendix Figure A.5).

Reaction of German healthcare workers. In line with these incentives, German healthcare workers responded strongly at the extensive margin, i.e. by increasingly working in Switzerland.⁵ Figure 1 documents that, from the third quarter of 2011 onwards, the number of Germans living in the border region and *newly* starting to work in the Swiss healthcare sector increases from roughly 100 to about 145 per quarter, whereas counties further inland in the same federal state do not experience a similar change. Figure 2 shows that this increase *in the slope* is concentrated in the Swiss healthcare sector, while the average trend across other sectors remains unchanged.

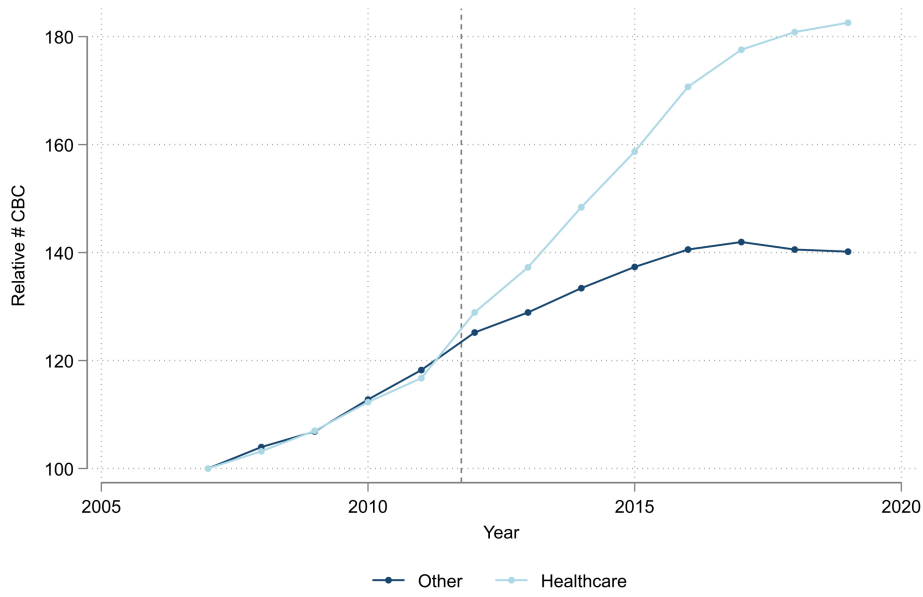
Several features of the Swiss and German healthcare labor markets help explain why this response is concentrated among the healthcare sector – and (registered) nurses within it. First, Switzerland had a high demand for nurses in the early 2010s. Existing literature shows that the appreciation and subsequent stabilization of the Swiss franc had only minor average effects on total employment in Switzerland (Kaiser and Siegenthaler, 2016; Flückiger et al., 2016), but limited access to the Swiss labor market for Germans who were willing to start working in Switzerland. As Appendix Figure A.8 shows, vacancy rates in nursing averaged around 6% between 2011 and 2013, compared to roughly 3% economy-wide. However, demand for nursing occupations was also higher compared to many occupations within healthcare, for instance nursing assistants (0.7%) and physicians (2.5%) (Lobsiger and Kägi, 2016). Second, under the European–Swiss Agreement on the Free Movement of Persons and the EU Directive 2005/36, German nursing qualifications are directly recognized in Switzerland, meaning that registered nurses can transfer to Swiss hospital jobs without major legal or retraining barriers.⁶ Consistent with this, Appendix Figure A.9 shows that the number of recognized foreign nursing diplomas in Switzerland increases from about 1,500 per year before 2011 to more than 2,000 thereafter, whereas other licensed healthcare occupations (such as midwives, medical-technical professionals, or therapists) do not exhibit a comparable jump. Third, on the German side, collective wage agreements and DRG-based financing constrain hospitals’ ability to counteract higher outside options through selective wage increases – in contrast to, for instance, the private (nursing) sector.

Consequences for German hospitals. Taken together, these patterns indicate that the Swiss Franc Stabilization translated into a negative nurse supply shock in Germany – and hospitals being exposed to it based on their distance to the Swiss border. Together with the regulations highlighted above, this empirical setting provides an ideal natural experiment to study how hospitals reallocate care when facing a negative labor supply shock under otherwise stable institutional conditions. To also assess the net effect of cross-border migration of nurses, I will turn to the Swiss side in an extension in Section 6.

⁵This paper does not attempt to causally decompose the relative contribution of higher average wage differentials, lower earnings volatility, and heightened media attention to increased commuting. I interpret the Swiss Franc Stabilization as a composite shock that raised the salience of cross-border commuting to Switzerland for German nurses.

⁶Under the European–Swiss Agreement on the Free Movement of Persons and the EU Directive 2005/36 (applicable to Switzerland), European diplomas in all healthcare professions are recognized by the relevant Swiss authorities. Depending on the occupation, recognition can take several months. For registered nurses a so-called *PreCheck* typically shortens the effective waiting time to a few weeks.

Figure 2: Cross-border commuters by sector



Notes: This figure shows the number of active German cross border commuters (CBCs) working in the Swiss healthcare sector (light blue) or in all other Swiss sectors (dark blue), relative to the year 2007. Assignment to sectors is based on the General Classification of Economic Activities (NOGA), the Swiss pendant to the Statistical Classification of Economic Activities in the European Community (NACE). The grey dotted line indicates the year 2012, the first year of the treatment. Data is obtained from the Swiss Cross-Border Commuter Statistic, described in detail in Section 3.

3 Data Sources

This section describes the rich administrative data covering the years 2006 to 2017 that allow me to analyse the consequences of the 2011 Swiss franc stabilization for (i) staffing rates in German hospitals, (ii) the provision of medical services, and (iii) patient- and population-level health outcomes.

Commuting patterns. In order to determine which German regions, and thus hospitals, actually see an outflow of healthcare workers to Switzerland, I use the **Swiss Cross-Border Commuter Statistic** (Schweizer Grenzgängerstatistik, henceforth: GGS). This dataset is a quarterly panel covering individual-level data for all foreign individuals employed but not residing in Switzerland. It is provided by the Swiss Federal Statistical Office (SBFS) and calculated based on the cross-border commuter permits in the Central Migration Register (ZEMIS).⁷ The dataset has been available since 1996 and contains information on the place of residence and workplace (both at the country-specific ZIP code level) as well as the sector (according to

⁷In the case of an unlimited employment contract, such a permit is valid for 5 years. Since it does not have to be reported if a cross-border commuter stops working in Switzerland despite a valid permit, the number of active cross-border commuters tends to be overestimated by the number of cross-border commuter permits. This is accounted for by a weighting procedure based on data from the Pension and Survivors Insurance (AHV).

NOGA).⁸ Assuming that cross-border commuters working in the Swiss healthcare sector (NOGA 86) formerly worked in the German healthcare sector, these data allow me to illustrate in detail their commuting patterns over time and space.⁹

Staffing rates. To assess whether the outflow of healthcare workers was driven by registered nurses formerly working in German hospitals and thus staffing rates decreased, I use the **German Hospital Statistic** (Krankenhausstatistik, henceforth: KS). This dataset is a yearly panel of all accredited German hospitals since 1990, numbering around 2,000 in 2011.¹⁰ The dataset contains general information on hospitals (e.g., number of beds, number of patients, ownership), as well as detailed staffing rates by occupational groups such as doctors, registered nurses, and nursing assistants. Since the geographic location of hospitals is only specified at the NUTS2 level, I infer a more precise location based on the residences of admitted patients.¹¹ More specifically, hospitals are assigned to counties based on the place of residence of the majority of inpatient cases they treat in 2011. Furthermore, I use county-occupation level vacancy information from Bossler and Popp (2024) to investigate whether observed patterns are consistent with a negative labor supply shock rather than a demand contraction.¹² The data from Bossler and Popp (2024) originate from the Federal Employment Agency (FEA) and consist of the stock of registered vacancies as of June 15th for each year from 2007 onwards.

Employment structure. In order to determine whether the composition and compensation of nurses changed in treated hospitals, I use the **Integrated Employment Biographies** (Integrierte Erwerbsbiographien, henceforth: IEB), which contain administrative labor market records of all workers subject to social security contributions (Müller and Wolter, 2020).¹³ The IEB include daily records of employment spells subject to social security contributions, including start and end dates, occupation codes, industry classifications, employer identifiers, and earnings up to the social security contribution ceiling. In addition, they contain periods of registered unemployment, participation in labor market programs, and basic demographic data such as age, nationality, education, and gender. I use the yearly averages of workers' employment outcomes (wage, days employed (overall, in the same occupation, at the same establishment), and earnings) and socio-demographic characteristics (education, age, and gender) and aggregate them at

⁸The General Classification of Economic Activities (NOGA) is the Swiss pendant to the Statistical Classification of Economic Activities in the European Community (NACE).

⁹I solely rely on the sector information as, unfortunately, a further distinction based on the occupation is not reliable due to data limitations.

¹⁰Accredited German hospitals are "facilities in which medical and nursing care is used to diagnose, cure or alleviate illness, suffering or physical injuries are to be diagnosed, cured or alleviated or obstetrics is provided and in which the persons to care can be accommodated and fed" (Statistisches Bundesamt, 2014). This definition includes all hospitals, regardless of ownership (public, private) or type of accreditation (university hospital, hospital with or without care mandate).

¹¹The NUTS2 level refers to the German regional administrative unit of "Regierungsbezirke," functioning between the federal state and the counties.

¹²The data are available at the 5-digit occupation level (according to Kldb 2010) and the NUTS07-3-digit region level, referring to the German counties ("Kreise"). However, I aggregate the vacancies to the 4-digit occupation level for clearer presentation of the findings, as this is sufficient to meaningfully distinguish healthcare occupations. Results at the 5-digit occupation level are available upon request.

¹³More specifically, I use the Integrated Employment Biographies (IEB v16.01.00) prepared by the Institute for Employment Research under access regulation according to Section 75 of the German Social Code (Book X). The dataset is available from 1975 onwards for West Germany and from 1992 onwards for East Germany.

the county-occupation level. In addition, I construct a binary indicator of whether an individual works in their county of residence, as well as indicators of whether a worker switched residence across counties and federal states. These indicators allow me to not only assess if nurses switched employers or occupation within the same county but also moved to the treated border region to fill open vacancies and, by that, generate spillovers to the counties further inland.

Patient-level information. To capture how the decrease in healthcare personnel led hospitals to adjust the medical services provided and how this, in turn, affected patients, I leverage the **German Patient Statistic** (Patientenstatistik, henceforth: PS). These individual-level administrative records cover all inpatient cases treated in all German hospitals, amounting to between 18 and 19 million observations each year. For each case, the dataset contains information on age, sex, place of residence (at the municipality level), the exact date of admission, the length of stay, the department in which a patient remained the longest, the ICD-10 main diagnosis (5-digit), as well as binary indicators of whether surgery was performed and whether death occurred. This richness of information allows me to compare individuals with similar characteristics who went to the hospital for the same reason, e.g., a heart attack, but likely differ in (i) how they are treated due to labor scarcity and (ii) how this then affects their probability of dying. Further, I can assess if and how hospitals target their adjustment mechanisms using age (as a proxy for innate health) and the urgency of the diagnosis reflected by the urgency score obtained from Krämer et al. (2019). Additionally, this urgency score allows me to restrict the analysis to emergency cases, i.e., patients that are not able to, a priori, willingly select into hospitals and for which hospitals need to react fast, meaning they are unlikely to be able to transfer patients to other hospitals.

Regional information. I complement the patient-level health information with data on life expectancy and mortality at the county level to validate and extend the results and to further investigate potential confounders. To this end, I combine administrative records on demographic, social, economic, and health characteristics from the **INKAR Database** of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) and the **Regional Statistics** of the German Federal Statistical Office to construct a balanced yearly panel covering all 401 German counties. To see if the patient-level health effects of labor scarcity in hospitals translate into aggregate health effects, I use life expectancy as another main outcome. It is defined as the average number of years a person at a certain age is expected to live on, assuming the mortality rates observed remain constant throughout the rest of the person’s life. This number is a widely used indicator reflecting regional differences in mortality and the average health status of the population and has three major advantages. Firstly, it is calculated from actual deaths. Thus changes over time reflect changing mortality rates without distortions due to changes in age or population structure, which gives me another well-suited measure to capture the effect of labor scarcity in hospitals on populations’ health. Secondly, it is free from selection into hospitals. Although care mandates prevent hospitals from refusing patients, patients could still be more likely treated in outpatient instead of inpatient care and thus not appear in the data. Thirdly, the health consequences of nursing scarcity for patients could appear after being discharged from the hospital. Thus, observed mortality effects using solely hospital data are

likely downward biased. The database contains the life expectancy for newborns and at age 60, using a rolling average over the most recent three years, which allows me to see to what extent changes in life expectancy are driven by changes in mortality at higher or lower ages. Additionally, to see which detailed age group is most strongly affected by labor scarcity in hospitals, I use age group-specific mortality rates.¹⁴

4 Empirical Strategy

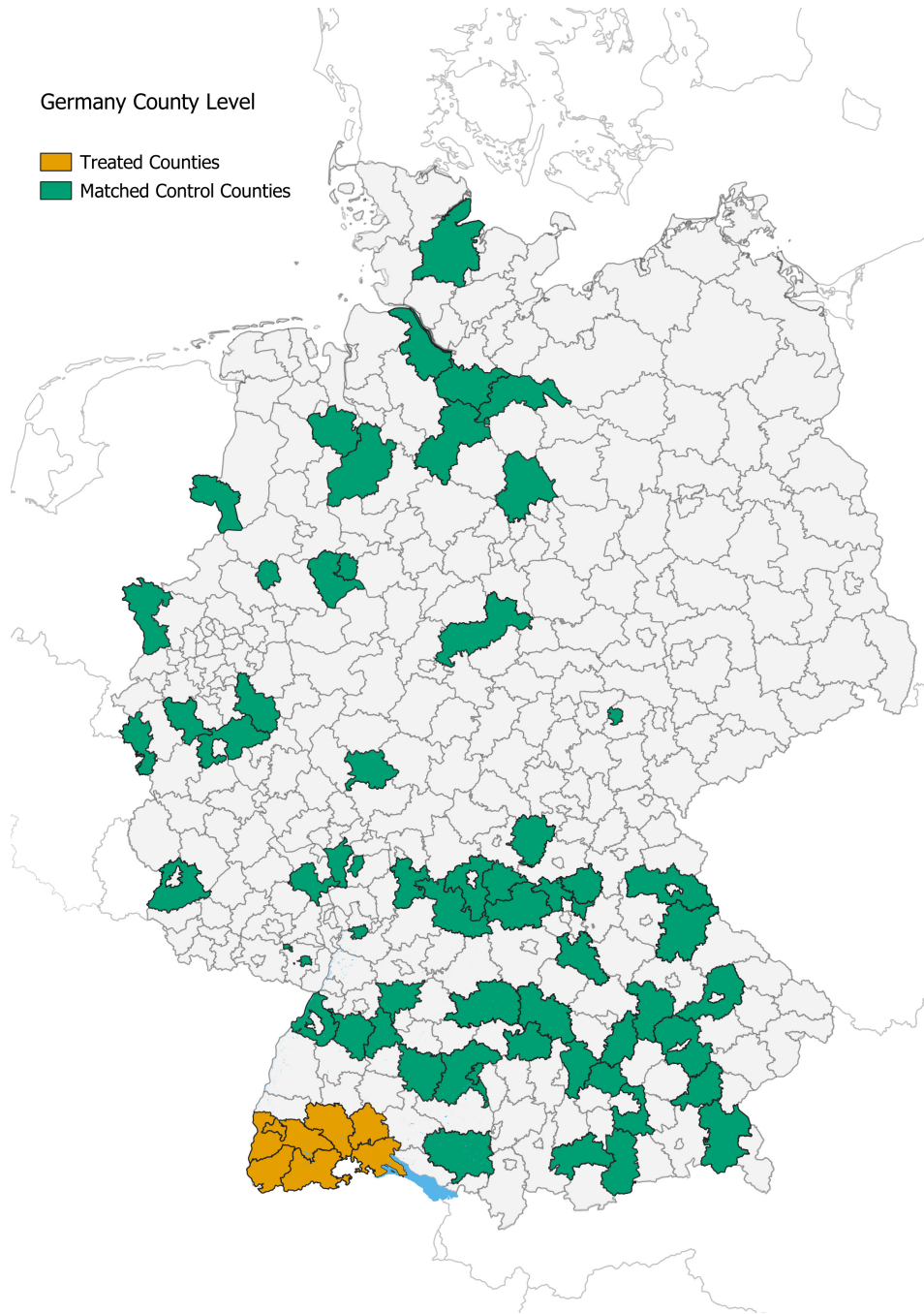
In this section, I first describe how I assign counties to the treatment group and match them to suitable control counties using propensity score matching. I then explain the multi-period difference-in-differences (“event study”) design, which exploits the 2011 Swiss franc stabilization as an exogenous increase in the salience to cross-border commute for German nurses. The design compares border and matched control counties to estimate how this shock affected hospital staffing rates, access to medical services, and patient- and population-level mortality.

Treatment and control group assignment. I define treated counties as those where commuting to Switzerland is both feasible and empirically common and match them to observably similar inland counties. The Swiss franc stabilization in 2011 increased the salience and attractiveness of cross-border commuting for German healthcare workers, but hospitals are only exposed to nurse outflows where commuting is actually possible. Using information from the GGS on where German cross-border commuters already working in the Swiss healthcare sector in 2011 live, Appendix Figure A.10 shows that counties in close proximity to the Swiss border are, unsurprisingly, particularly prone to cross-border commuting. However, as the GGS does not allow me to distinguish further between occupations, assigning counties based solely on past patterns of Germans working in the Swiss healthcare sector implicitly assumes that these commuters previously worked in the German healthcare sector. I therefore complement this information with a more general exposure measure based on travel times to the Swiss border using Open Street Maps (OSM).¹⁵ As Appendix Figure A.11 shows, most new cross-border commuters drove 45 minutes or less to the nearest border crossing in 2012. To incorporate both general commuting patterns and specific patterns of healthcare workers, I assign to the treatment group all counties (i) whose centroid lies within a 45-minute drive to the border or (ii) that are among the five counties with the highest count of cross-border commuters working in the Swiss healthcare sector prior to the event.

¹⁴The mortality rate is calculated, both for each age group as well as overall, as the number of deaths per 100,000 inhabitants. To this end, I combine information on age-specific population from INKAR with age-specific mortality from the Regional Statistics. I aggregate age groups to those where both data sources have an overlap in their age group definition: below 25, 25-49, 50-64, 65-74, 75 and older (see Appendix Table A.3). Further, to ensure comparability across aggregate health measures, I use a three-year rolling average.

¹⁵More specifically, for every municipality, I calculate the shortest travel time by car among the four metrically closest border crossings. Data on border crossings are obtained from the Online Appendix of Beerli et al. (2021). To calculate the distance and, thus, the travel time, I use the geographic centroid of each municipality and county.

Figure 3: Treatment and matched control counties in Germany



Notes: This map of Germany shows treated (orange) and matched control counties (blue). Treated counties are defined to be (i) lying within a 45-minute drive to the border or (ii) one of the five counties with the highest count of cross-border commuters working in the Swiss healthcare sector prior to the event. The assignment to the control group is based on a 10-nearest neighbor propensity score matching approach using regional characteristics (population size, population density, GDP per inhabitant, and average age of the population) in 2011. For details regarding the assignment to the treatment and control group, see Section 4.

Border counties are economically similar to the German average but have lower population density (Table A.4), which might expose them to confounding factors such as time-varying differences in health-related behavior, health literacy, or changes in access to medical services due to the over-proportional closure of smaller hospitals in rural areas (Klauber et al., 2015;

Augurzky et al., 2012). To ensure that treated and control counties are comparable and similarly exposed to such trends, I match counties based on pre-event characteristics. Before matching, I omit counties adjacent to the treated border region from the pool of possible control units to reduce the risk that the control group is affected by spillovers. I then use a 10-nearest neighbor propensity score matching with a caliper of one-quarter of the standard deviation of the propensity score, as suggested by Stuart and Rubin (2008a,b).¹⁶ The propensity score is based on the number of inhabitants, population density, GDP per inhabitant, and the average age of the population in 2011.¹⁷ The resulting sample of treated (orange) and matched control counties (blue) is depicted in Figure 3. Overall, most control counties lie in the wealthy south of Germany and often in the same state, meaning that they are subject to similar legal requirements and institutional regulations (e.g., hospitals face the same remuneration per inpatient case). Figure A.12 shows the distribution of the propensity score in the final sample as well as the bias across the covariates used for matching. In all four dimensions, but especially regarding urbanity, the matched control counties are much more similar to the treated counties compared to the German average.

Final sample. The resulting estimation sample consists of 66 counties (7 treated and 59 matched controls) and 277 hospitals with around 2.45 million inpatient cases per year, corresponding to roughly 13–14% of all German hospitals and cases. Appendix Table A.4 compares baseline characteristics of treated counties to the German average, to the averages for southern Germany and the entire affected federal state of Baden-Württemberg, as well as to the matched control counties. Relative to Germany as a whole, the matched control counties closely resemble treated counties not only in terms of covariates used for matching, but also in other dimensions such as the sectoral structure, indicating that the matching procedure substantially reduces observable cross-county differences. However, because the matching is implemented at the county level and patients are assigned based on the location of the hospital in which they are treated rather than their place of residence, balance at lower levels of aggregation may not need be exact.¹⁸

Appendix Tables A.5 and A.6 report analogous comparisons for hospitals and inpatient cases. On average, hospitals in the border region are smaller and therefore have lower total costs. However, relative to the number of patients, border hospitals spend around 350 euros more per patient, and nurses treat on average five patients fewer – with patients being similar in their demographics and clinical characteristics but more likely to undergo surgery and less likely to die in treated border hospitals prior to the event. In the later described empirical

¹⁶I use a larger number of neighbors to ensure a sufficiently large sample. At the same time, the caliper ensures that the similarity between matches is sufficiently strong, i.e., propensity scores are close.

¹⁷I use 2011 as a reference year due to the German "census shock", i.e., many inferred or projected statistics were corrected due to the German full census in 2011, causing partially stark disparities between 2010 and 2011.

¹⁸This assignment based on the place of treatment increases the precision of the results as it is known whether a patient was exposed to skill shortages during treatment, but might induce selection bias if patients are aware of differences in staffing rates and the potentially resulting lower care quality, and adjust accordingly by selecting hospitals. Although almost 65% of individuals in Germany are treated in the same county, I later investigate this by looking at whether the share of individuals treated in their county of residence changes and by restricting the sample to patients with emergency diagnoses and, as case studies, sepsis and myocardial infarction, also known as "heart attacks." For the latter, it is unlikely that patients willingly choose their hospitals or that hospitals are able to refuse treatment or transfer patients to other hospitals.

design, these pre-existing differences in hospital size and case mix are absorbed by hospital fixed effects, bed weights, and rich case-level controls in the main specifications. However, the matching procedure successfully addresses the key concern of hospital closures differentially affecting the rural (albeit wealthy) border region as the share of continuously existing hospitals and patients being treated in such facilities is similar compared to the matched control counties.¹⁹ To additionally ensure that results are not driven by changes in the hospital sample, I restrict the main analysis to hospitals that continuously operate during the entire period of investigation, i.e., between 2006 and 2017. This focus on economically more resilient facilities likely makes the estimates conservative, as such hospitals likely are better able to cope with the consequences of labor scarcity. However, in Section 6, I show that relaxing this restriction leaves the main results largely unchanged.

Event study design. The empirical strategy exploits that the 2011 Swiss franc stabilization sharply increased the salience of commuting to Switzerland for German nurses in close proximity to the border. Using a multi-period difference-in-differences (“event study”) design, I compare the evolution of outcomes in border counties with their counterparts in matched control counties further inland.

At the hospital level, I estimate for each outcome Y of hospital h in year t :

$$Y_{ht} = \alpha + \sum_{t=2006; t \neq 2011}^{2017} \delta_t I_t \times I_{g(h)} + \zeta_t + \theta_h + \epsilon_{ht}, \quad (1)$$

where $g(h) \in \{\text{Treatment, Control}\}$ denotes the treatment status of the county in which hospital h is located. Thus, $I_{g(h)}$ is an indicator equal to one for hospitals in treated border counties and zero otherwise, and I_t is a year indicator. δ_t reflects the dynamic effect of a hospital being located in the border region relative to the matched control group and the reference base year 2011. ζ_t are year fixed effects and θ_h are hospital fixed effects, capturing time-invariant differences between hospitals such as size, ownership, and case mix. As Appendix Table A.5 indicates that border hospitals are on average smaller than control hospitals, I weight observations by the number of beds in 2011 to additionally account for size differences.²⁰ Robust standard errors are clustered at the county level – i.e., the level of treatment assignment – to allow for arbitrary correlation of shocks within counties over time. (Bertrand et al., 2004). This is important as hospitals within counties tend to be connected as they often share a common provider.

In an analogous way, I estimate event-study specifications at the county and case level. For county-level outcomes, I replace hospital fixed effects with county fixed effects and do not weight observations given that the matching largely removed observable differences between groups. For patient-level outcomes, I retain hospital fixed effects but cannot include patient fixed effects as cases are only observed once. Instead, I control for gender, age-group fixed effects (eight groups),

¹⁹Over the period of investigation, Germany saw a decline in the number of hospitals by 7.7% from initially around 2,100 (Statistisches Bundesamt, 2023). This decline was especially pronounced in rural areas as the implementation of the DRG (Diagnosis Related Groups) in 2005 increased the financial pressure, especially for small hospitals lacking economies of scale, as it replaced the per diem payment scheme with fixed payments (Messerle and Schreyögg, 2024; Herwartz and Strumann, 2014).

²⁰As the main weight, I use the number of beds in 2011. In a sensitivity analysis in Section 6, I present results using the number of patients and the number of care days as alternative weights, as well as unweighted results.

and 3-digit ICD-10 main-diagnosis fixed effects so that I compare patients with similar observable characteristics and medical conditions who differ primarily in being treated in hospitals in the affected border region versus hospitals in matched control counties.

To ease presentation of the findings, I also report estimates from the corresponding two-period difference-in-differences specification using the same set of fixed effects, the same clustering, and the same weighting scheme as in Equation (1)

Outcomes of interest. I organize the analysis around three sets of outcomes that trace the link from nurse outflows to hospital inputs, care provision, and health. At the *hospital level*, I first examine staffing levels across healthcare occupations, measured both in headcounts and full-time equivalents (FTEs), which is particularly informative given the high share of part-time work in healthcare (OECD, 2013). I then study the number of patients and patient-to-staff ratios by occupation group to distinguish whether labor scarcity triggers adjustments at the extensive margin (fewer patients) or at the intensive margin (less staff per patient). At the *case level*, I focus on an indicator for whether surgery was performed and in-hospital mortality as main outcomes. I further use demographic characteristics and detailed information on diagnoses to monitor changes in case mix that could reflect shifts in healthcare demand or selection on the side of hospitals or patients. In addition, I use the urgency score from Krämer et al. (2019) as a measure of medical need to study heterogeneity in treatment responses by urgency and to restrict the analysis to emergency cases for whom selection into treatment are unlikely to confound the results. At the *county level*, I use mortality and life expectancy as complementary outcomes that aggregate the health effects of hospital staffing shortages. Life expectancy – available at birth and at age 60 and constructed as three-year rolling averages – is calculated from actual deaths and thus captures changes in mortality without being affected by shifts in age structure or hospital utilization. It is not subject to selection into inpatient care and also reflects deaths occurring after discharge. To further characterize distributional effects across the life cycle, I additionally use age-group specific mortality rates, also constructed as three-year rolling averages.

Identifying assumptions. The coefficients δ_t in Equation (1) capture differential changes in outcomes over time between treated and control units, relative to 2011, and requires several conditions for causal interpretation:

First, the **parallel trends assumption** requires that, absent treatment, outcomes in treated and matched control units would have evolved similarly over time. While this is not directly testable, I assess it by inspecting pre-event coefficients in the event-study plots and testing whether $\delta_t \approx 0$ for all $t \leq 2011$.

Second, there should be **no anticipation** of the policy. If hospitals or patients in the border region adjusted behavior in expectation of future staffing shortages, pre-trends would be contaminated. As discussed in Section 2, the Swiss franc appreciated fastly and the Swiss National Bank introduced the minimum exchange rate unexpectedly, which is consistent with the sharp increase in cross-border commuting into the Swiss healthcare sector documented in Figure 1. This pattern suggests that neither hospitals nor patients were able to systematically anticipate the event.

Third, the **stable unit treatment value assumption (SUTVA)** requires that the Swiss franc stabilization does not affect the outcomes of control units. Such spillovers would arise, for example, if treated and untreated hospitals were linked, e.g. through the transfer of patients or staff. To minimize this concern, I exclude all counties directly neighboring the border region from the donor pool prior to matching. Butts (2023) show that such an exclusion “ring” eliminates bias from spillovers if it is sufficiently wide. Given that hospital systems are typically organized at the county level and matched controls lie further inland than is practical for cross-border commuting, this assumption appears plausible. I also test for further ripple effects driven by healthcare workers moving to the German side of the border from further inland, both within the same county, across counties in the same federal state, and across federal states in Section 6.

Fourth, there should be **no confounding events** that differentially affect treated and control counties around 2011. There were no major policy changes in Switzerland or Germany directly targeting cross-border commuting during this period.²¹ However, in 2013 the German Health Care Structure Act reformed needs-based planning for primary care and led to an overproportional reduction in general practitioner density in the border region. In robustness checks in Section 6, I therefore control for county-level general practitioner density to show that my results are not driven by this reform.

Finally, the estimates should reflect **direct effects of hospital staffing shortages** rather than other channels through which the strong and stabilized Swiss franc could affect health at the border (e.g., via local demand, commuting of non-healthcare workers, or changes in traffic and accidents). I address this threat in two ways. At the case level, I examine changes in case mix to rule out that the results are driven by shifts in the composition of patients and restrict the analysis to high-urgency diagnoses – such as myocardial infarction – where endogenous selection is unlikely. At the county level, I study the evolution of demographics, economic conditions, and other components of healthcare supply (e.g., staff in nursing homes, general practitioners, specialists) to test for coincident shocks that could confound the interpretation of the main estimates.

5 Results

This section presents the main results on how the 2011 Swiss franc stabilization affects nurse staffing in German border hospitals and how hospitals respond when registered nurses become scarce. I first show that the shock generates a large and occupation-specific decline in staffing rates of registered nurses. I then examine how hospitals adjust to this negative labor supply shock in a highly regulated sector with limited scope to reduce output at the extensive margin. The evidence suggests that hospitals mainly adjust at the intensive margin by rationing and reallocating care towards more care sensitive patients. I therefore place particular emphasis on heterogeneity in treatment intensity and mortality across urgency and age groups.

²¹Later, in 2015, the SNB suddenly and surprisingly lifted the minimum exchange rate, known as the Swiss franc shock (Bernholz et al., 2015). Around the same time, in 2014, a referendum was passed in Switzerland which requested the government within three years to impose quotas on residence and work permits for foreigners, also from EU and EFTA member states.

5.1 Nurse Shortages in German Hospitals

I begin by estimating event-study models based on Equation (1) for hospital employment.

Figure 4a shows a pronounced and persistent decline in nursing employment in treated border hospitals after 2011, with flat pre-trends. Relative to 2011, staffing falls by roughly 25 full-time equivalents (FTEs) in 2012 and by about 50 FTEs in the longer run. This effect is both statistically and economically sizeable, corresponding to an average decline of about 12 percent relative to the 2011 mean. Figures 4c and 4d decompose nursing staff into registered and assistant nurses and show that the decline is driven entirely by the former group: the number of registered nurses employed in German border hospitals falls by around 50 nurses (also about 12 percent), while the number of assistant nurses remains essentially unchanged.²²

By contrast, occupational groups that are the closest substitutes to registered nurses do not exhibit corresponding staffing changes. Figure 4b shows that, despite a small drop in 2012, physician employment in treated border hospitals evolves similarly to that in matched control hospitals further inland. The same holds true across other healthcare occupation groups in hospitals, although employment of medical technical assistants (MTAs), functional staff, and surgical staff increases slightly but imprecisely (Appendix Table A.7).

The registered-nurse decline is consistent with a negative labor supply shock rather than reduced labor demand (e.g., through downsizing), as vacancies for nurses rise sharply in treated counties relative to matched controls. Column (1) in Table A.8 shows that vacancies for general health and nursing care occupations (without specialization, i.e. reflecting the majority of nurses employed in hospitals) increase by 9.5 open positions at the county level, measured on June 15 of each year. This corresponds to an increase of around 60 percent relative to 2011. Although vacancies are observed on a single day each year and cover general health occupations beyond hospitals, the pattern indicates a substantially tighter nursing labor markets in the treated region. That vacancies for other broad healthcare occupations – such as doctors (with and without specialization), MTAs, and pharmacists – do not change statistically significantly further supports the interpretation that the shock is concentrated among (registered) nurses.²³

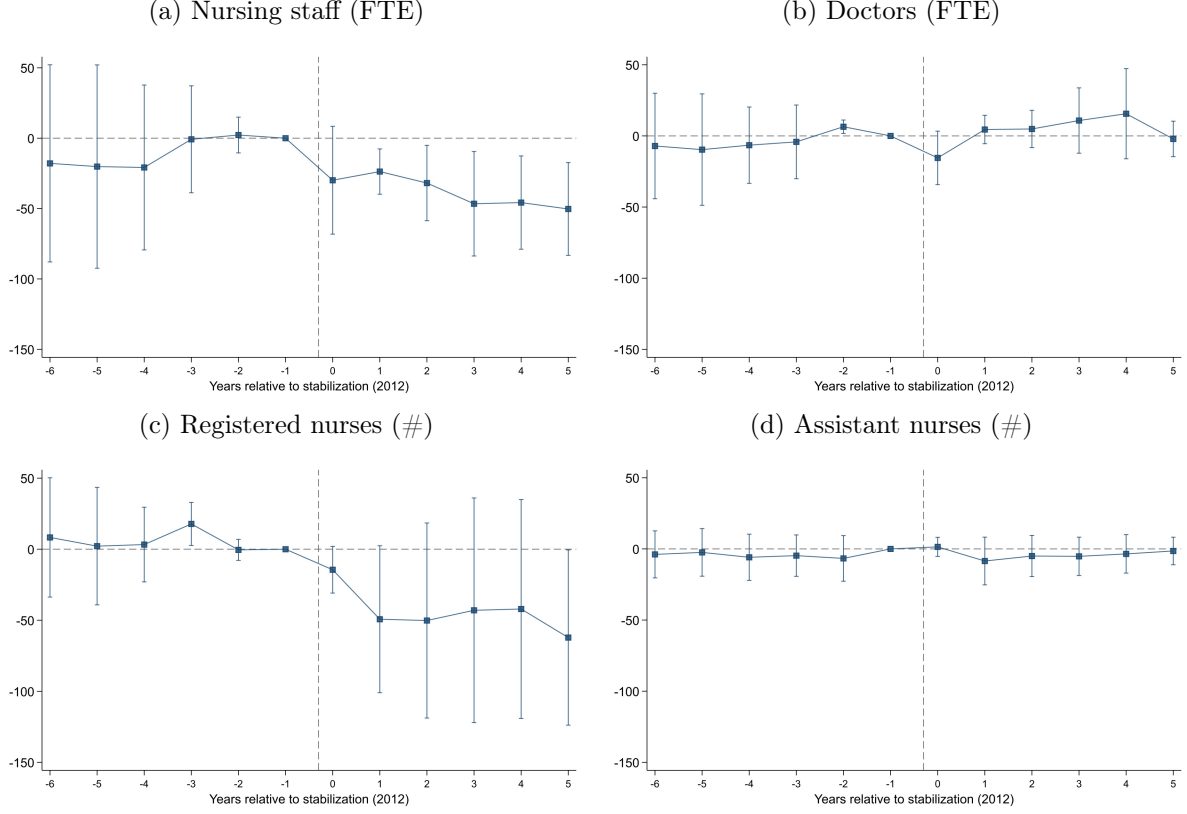
Although the number of registered nurses declines significantly, the composition of the remaining nursing workforce remains similar. Table A.9 shows no differential change in nurse demographics regarding age and gender in the border region relative to the matched control region. It also shows little evidence that selection of the workforce into the border region changes: neither do more nurses start commuting from other counties (column 3), nor do more nurses move their residence toward the border, either within the same state (column 4) or across states (column 5). This suggests limited ripple effects further inland through nurses relocating to fill vacancies in the border region. Table A.10 provides one explanation: nurse wages, employment, and annual earnings do not increase differentially (columns 1–3), underscoring that hospitals face binding wage- and price-setting constraints and cannot retain nurses by raising pay when outside options improve (see Section 2). Given that composition along tenure – in the same occupation or the same establishment – and education also does not change differentially, the

²²The aggregate category "nursing staff" includes additional, smaller specialized nursing occupations (e.g., geriatric nurses), so the registered- and assistant-nurse categories do not fully reflect the aggregate.

²³In economic terms, vacancies for medical doctors (without specialization) also increase. However, this could reflect a reform of GP care, discussed in more detail in Section 2 and assessed in a robustness check in Section 6.

results indicate that hospitals lose the "average" nurse. I therefore interpret the subsequent effects primarily as reflecting a contraction in the quantity of available nursing input, rather than a pronounced shift in the skill composition of the nursing workforce.

Figure 4: Effect on staffing rates in hospitals



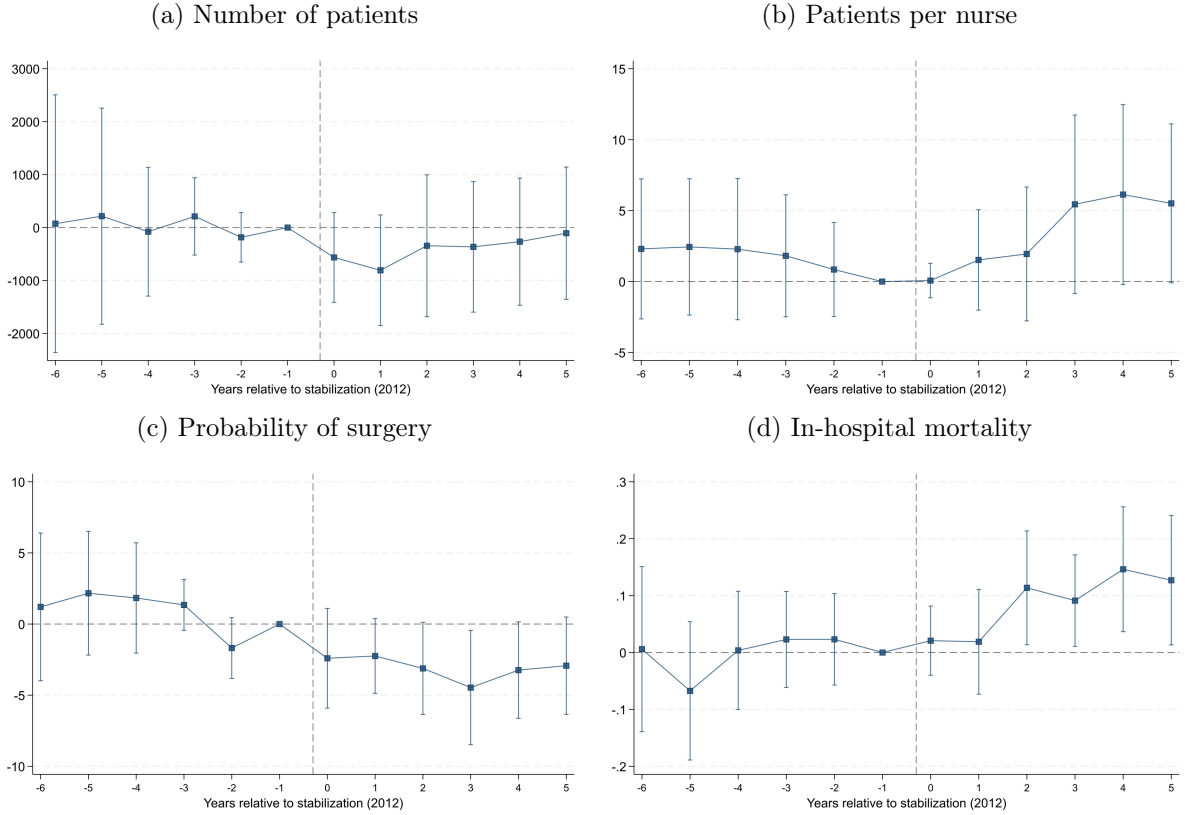
Notes: This figure shows the effect of the Swiss franc stabilization (SFS) in 2011 on staffing rates in hospitals. Staffing rates are measured in full-time equivalents (FTE) or in numbers and the respective occupation group is displayed above each sub-figure. All sub-figures display the multi-period difference-in-differences estimates obtained from Equation 1. Vertical bars indicate 95% confidence intervals based on robust standard errors clustered at the county level. The sample is restricted to continuously operating hospitals in the border region (treatment group) and in matched counties further inland (control group). The matching procedure is explained in detail in Section 4. Observations are weighted using the number of beds in 2011 at the hospital level due to imbalances regarding hospital size between the treatment and control group.

5.2 Hospital Production Under Nurse Scarcity

Hospitals respond to this reduction in nurse supply not by treating fewer patients (extensive margin) but primarily by reducing the intensity of care per patient (intensive margin). Given the institutional constraints described in Section 2, German hospitals have limited scope to refuse patients, shut down wards, or adjust prices, so reduced access to medical care is more likely to manifest through changes in treatment intensity rather than case volumes. Consistent with this, Figure 5a shows that case volumes remain broadly stable in treated hospitals after 2011, with at most a modest and temporary dip in 2012–2013. Given the staffing decline in Figure 4a, this stability implies a deterioration in nurse-to-patient ratios: Figure 5b shows that inpatients per nursing FTE increase by up to about five cases per nurse, roughly a 10 percent

rise relative to the baseline.

Figure 5: Effect on hospital output and mortality



Notes: This figure shows the effect of the Swiss franc stabilization (SFS) in 2011 on (i) the number of patients and the number of patients per nursing FTE (measured at the hospital level) and (ii) patients' probability of receiving surgery and dying (measured at the case level). All panels display the multi-period difference-in-differences estimates obtained from Equation (1). Vertical bars denote 95% confidence intervals based on robust standard errors clustered at the county level. The sample is restricted to continuously operating hospitals in the border region (treatment group) and in matched counties further inland (control group). The matching procedure is described in Section 4. At the hospital level, observations are weighted by the number of beds in 2011. At the case level, I additionally control for female, age bins, and 3-digit ICD-10 diagnosis fixed effects.

This pattern extends to a more direct measure of care provision: surgery. Patients treated in border hospitals become less likely to receive surgery conditional on observable medical needs. Using individual-level information on surgeries performed together with patient characteristics (gender, age, and main diagnosis), I compare patients treated under nurse scarcity in border hospitals to otherwise similar patients treated in unaffected hospitals. On average, the probability of receiving surgery declines by 3.85 percentage points after 2011 (column 2 in Appendix Table A.11); Figure 5c confirms parallel pre-trends. Relative to a 2011 mean of 31.4 percent, this corresponds to a statistically and economically meaningful decline of roughly 12 percent.

The reduction in overall care intensity raises the question of whether hospitals target reductions in care according to patients' medical needs in order to mitigate mortality effects. If the marginal returns to nursing care are increasing in urgency and clinical severity, an optimizing hospital facing scarce nursing inputs should disproportionately reduce care for patients with well-plannable procedures and low urgency – an adjustment mechanism often referred to as

triage (Jenkins, 2024). To test for triage, I exploit diagnosis-level urgency scores from Krämer et al. (2019) and classify cases as urgent when the urgency score exceeds 50 (on a scale between 0 and 100) and as low-urgency otherwise.

Table 1: Effect on surgery probability, by age and urgency

	Overall	−24	25–49	50–64	65–74	75+
Post × Treatment	−4.60** (1.99)	−3.57** (1.57)	−5.13* (2.59)	−4.60** (1.95)	−5.20*** (1.94)	−4.46** (1.89)
Post × Treatment × Emergency	3.04*** (0.85)	2.69*** (0.86)	3.23** (1.54)	2.91*** (0.87)	2.93*** (0.97)	2.67*** (0.78)
Mean of Y (2011)	31.41	21.74	37.46	36.54	34.72	25.87
Std. dev. of Y	46.41	41.25	48.40	48.16	47.61	43.79
Observations	25,145,786	3,546,715	4,865,729	5,273,569	4,660,874	6,798,807

Notes: This table shows the effect of the Swiss franc stabilization (SFS) in 2011 on patients’ probability of receiving surgery at the case level, overall (column 1) and separately by age group (columns 2–6). Displayed coefficients reflect difference-in-differences estimates based on Equation (1), additionally interacted with an indicator for emergency cases (urgency score above 0.75 based on the classification in Krämer et al. (2019)). Case-level controls include indicators for female, age bins, and 3-digit ICD-10 diagnosis fixed effects. For Panel B, all lower-order interaction terms between $I(\text{post})$, $I(\text{treatment})$, and $I(\text{emergency})$ are included. Robust standard errors clustered at the county level are shown in parentheses. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The sample is restricted to continuously operating hospitals in the border region (treatment group) and in matched counties further inland (control group). The matching procedure is described in Section 4.

The results are consistent with triage: hospitals disproportionately reduce care for low-urgency cases by cutting well-plannable surgeries. Column 2 in Table A.11 shows that, in the full sample, surgery rates fall sharply for low-urgency cases by -3.45 percentage points. In contrast, the reduction is substantially attenuated for urgent cases, which experience a much smaller decline in surgery of around 1.9 percentage points.²⁴ This heterogeneity becomes even more pronounced when comparing emergency cases²⁵ to all other patients: non-emergency cases see a reduction of -4.60 percentage points, whereas emergency cases experience a much smaller decline of around 1.56 percentage points (column 1 in Table 1). Columns 2–6 in Table 1 show that this pattern is uniform across age groups: within each age bracket, the non-emergency DiD estimate is negative, with economically larger relative declines at the extremes of the age distribution (-24 and $75+$). The interaction with the emergency indicator is positive and remarkably stable across ages, but again relatively larger at the extremes of the age distribution. Nevertheless, even among emergency cases, the net decline in surgery provision is largest for older patients (-6.54 percent for ages 65–74 and -6.92 percent for ages 75+).

²⁴A qualitatively similar pattern holds for length of stay, measured as inpatient days. Column 3 in Table A.11 shows that length of stay increases only for urgent cases.

²⁵Defined as patients with a main diagnosis scored 75 or higher according to Krämer et al. (2019).

5.3 In-Hospital Health Effects

This reduction in care translates into health consequences for patients. Figure 5d shows that in-hospital mortality rises in treated hospitals after 2011 – with no evidence of differential pre-trends – by 0.09 percentage points on average (see Panel A of Table A.11) resulting in around 282 additional deaths per year in the border region. Relative to the 2011 mean, this corresponds to an increase of roughly 4.4 percent.²⁶

This average effect, however, masks substantial heterogeneity by patients medical needs. Panel B of Table A.11 shows that negative health effects are concentrated among patients with urgent diagnoses: their in-hospital mortality increases by 0.42 percentage points more relative to non-urgent cases. To facilitate comparison with the prior literature and to mitigate concerns about endogenous patient selection into hospitals in response to changing conditions in the border region, Table A.12 reports results for two conditions that are commonly studied and clinically salient: myocardial infarction (heart attack) and sepsis, a "severe complication of infections and a leading cause of preventable deaths" (WHO, 2024; van den Berg et al., 2022). Reassuringly, the prevalence of both diagnoses does not change differentially in treated relative to control regions. Conditional on admission, however, in-hospital mortality rises sharply: for heart attacks, mortality increases by 1.56 percentage points relative to a baseline mean of 8.82 percent (a 17.6 percent increase), and for sepsis by 2.35 percentage points. Given the higher baseline mortality for sepsis (above 20 percent), the latter effect is smaller in relative terms (11.6 percent).

Using age as an alternative proxy for medical needs, the same pattern emerges: mortality effects increase with age. Panel A of Table A.13 shows no increase in mortality for younger and, on average, healthier patients. Effects become larger with age and are statistically distinguishable from zero only for patients aged 75 or older, whose in-hospital mortality increases by 0.33 percentage points – more than 3.5 times the average mortality effect displayed in Panel A of Table A.11.

5.4 Aggregate Health Effects

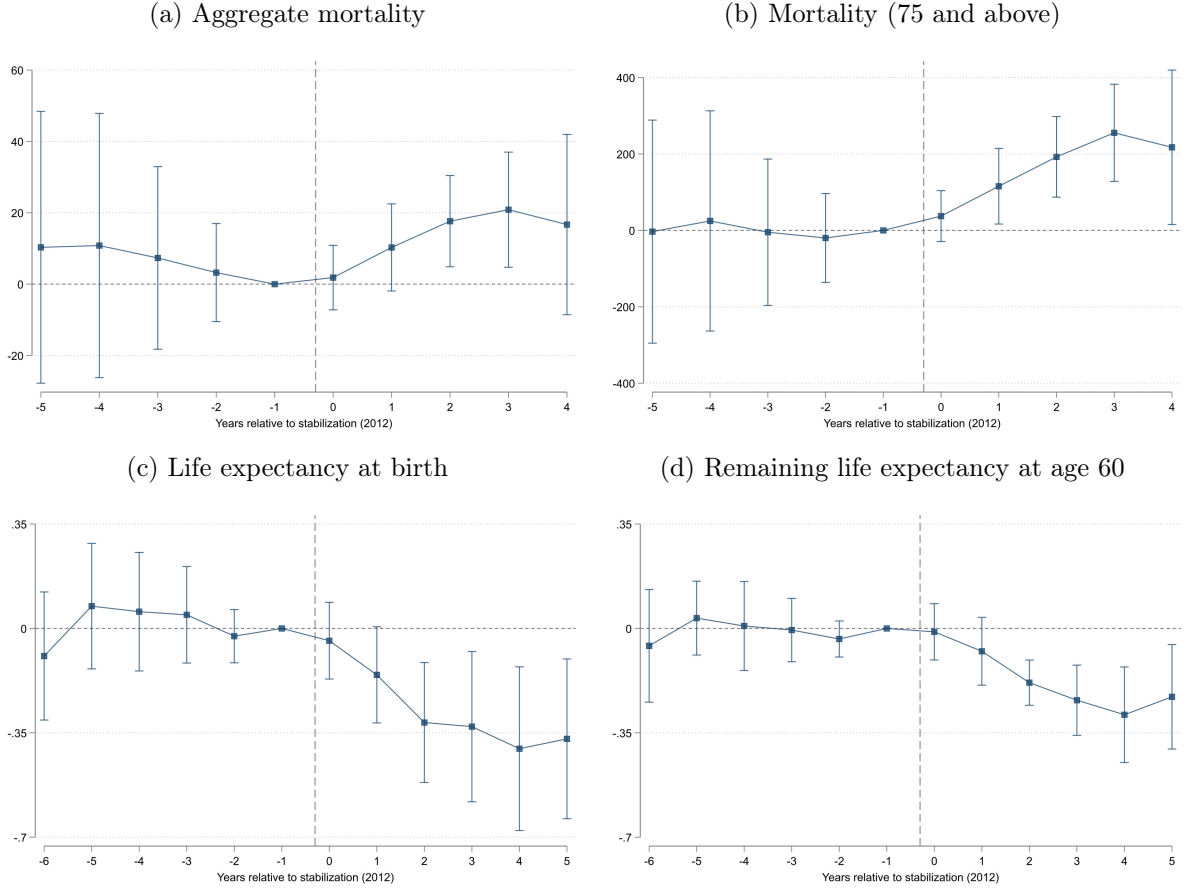
In addition to in-hospital mortality, it is important to consider aggregate health outcomes for two reasons. First, although I find little evidence of changes in patients' selection of hospitals or vice versa (for a detailed assessment of endogenous selection of patients and hospitals, see Section 6), there could still be unobservable selection into hospital care (e.g., substitution between inpatient and outpatient treatment). By studying aggregate outcomes, I can circumvent this concern and assess whether the patterns observed within hospitals are also visible at the population level. Second, patients discharged without adequate care or postponed surgery may experience health consequences later, i.e. outside of hospitals. Focusing solely on in-hospital mortality would therefore provide a lower bound of the health costs of nurse scarcity.

Consistent with the within-hospital evidence, aggregate mortality increases in the treated border region relative to the matched control region, particularly among older residents. Figure 6a shows that, relative to 2011, deaths per 100,000 inhabitants rise steadily to around 20

²⁶Notably, the increase in in-hospital mortality over time closely follows the evolution of the patient-to-nurse ratio (see Figure 5b).

additional deaths in the longer run. This corresponds to 290 additional deaths in aggregate – which is reassuring as it is close to the estimated number of death cases in hospitals and suggests that the health consequences occur during an inpatient stay, not thereafter. Further in line with the patient-level results, the aggregate mortality increase is substantially larger for the population aged 75 and above (Figure 6b): mortality rises by up to around 200 deaths per 100,000 in the longer run, with an average increase of 165 deaths per 100,000 per year between 2012–2017 relative to 2006–2011.

Figure 6: Effect on aggregate health



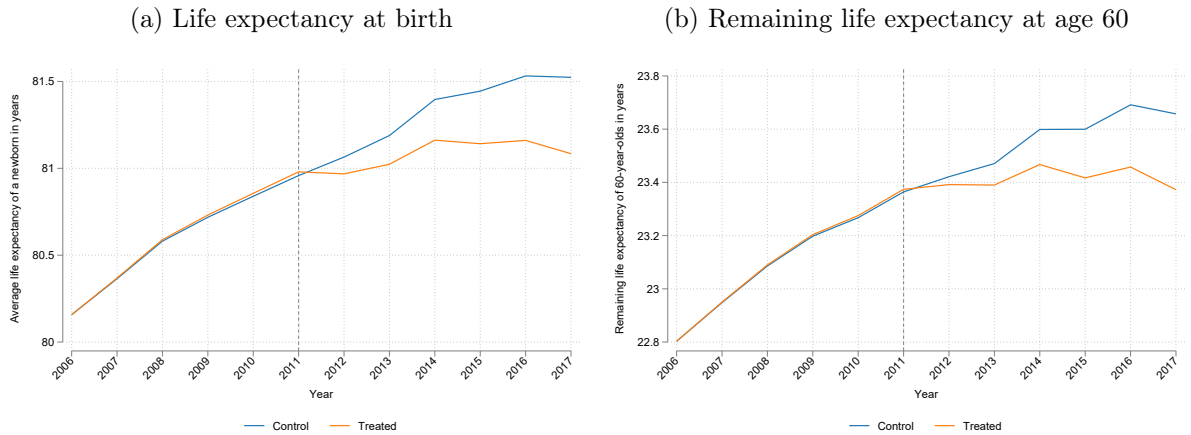
Notes: This figure shows the effect of the Swiss franc stabilization (SFS) in 2011 on aggregate mortality (average and for individuals 75 and above) and life expectancy (calculated at birth and at age 60) at the county level. Mortality is measured as the number of death cases per 100,000 inhabitants. All sub-figures display the multi-period difference-in-differences estimates obtained from Equation 1. Vertical bars indicate 95% confidence intervals based on robust standard errors clustered at the county level. The sample contains counties in the border region (treatment group) and matched counties further inland. The matching procedure is described in Section 4.

These mortality patterns translate into a decline in life expectancy in treated border counties relative to matched controls, again concentrated among older ages. Life expectancy is a commonly used measure that reflects mortality conditions for a cohort at a given time (e.g., individuals aged 60 in Germany in 2011). It has the advantage compared to mortality (whether in-hospital or in aggregate) that it addresses potential confounding of the results through compositional changes, e.g. from changes in population size or age structure. Figure 6c shows that

life expectancy in treated border counties diverges downward after 2011. The estimates imply a reduction of roughly 0.28 statistical life years at birth (column 1 in Panel B of Table A.13), which is both statistically and economically meaningful as it corresponds to 30 percent of a standard deviation in life expectancy across counties in the sample. More than half of this decline (57 percent) reflects higher mortality at older ages: remaining life expectancy at age 60 falls by 0.16 years (column 2 in Panel B of Table A.13). This is consistent with the within-hospital results and indicates that the mortality consequences of nurse scarcity increase sharply with age.

The negative health effects of nurse scarcity in hospitals also break the trend of rising longevity. Figure 7 shows that life expectancy – both at birth and at age 60 – increases over time in treated and control counties prior to 2011, mirroring the broader pattern for Germany and most high-income countries. From 2012 onward, however, life expectancy stagnates in the affected border region while it continues to increase in the control counties. In the next Section, I assess the net effect of nurse shortages in hospitals on life expectancy, i.e. whether losses in the border region of the sending country are offset by corresponding gains in the border region of the receiving country.

Figure 7: Linear trend models of aggregate health statistics



Notes: This figure shows life expectancy (calculated at birth and at age 60) at the county level after controlling for linear trends using the *trendplots* command. The sample contains counties in the border region (treatment group) and matched counties further inland. The matching procedure is described in Section 4.

6 Robustness and Extension

Section 5 interprets the post-2011 decline in registered nurse staffing as a negative labor supply shock that tightens a central input to hospital production and that resulting mortality effects stem from hospitals responses by rationing care at the intensive margin and imperfectly reallocating toward urgent patients (triage). This section evaluates alternative explanations for these patterns, assesses sensitivity to key modeling choices, and extends the analysis to Switzerland to explore whether the nurse outflow is associated with offsetting population health gains in destination regions.

I organize the robustness analysis around five threats. First, the stabilization may induce differential changes in healthcare demand or patient sorting across hospitals, which could mechani-

cally alter treatment intensity and mortality. Second, it may coincide with local demographic or economic shocks that affect health directly. Third, concurrent changes in healthcare supply outside hospitals (long-term care, ambulatory care, primary care) could confound the county-level mortality and life expectancy results. Fourth, results may be sensitive to weighting and specification choices. Fifth, conclusions may depend on the treatment definition and the construction of the comparison group. Throughout, I emphasize threats that are particularly relevant for the triage interpretation: shifts in case mix or sorting that would mimic intensive-margin rationing, and alternative channels that could generate urgency-by-age mortality patterns without changes in hospital staffing.

In-hospital healthcare demand and endogenous selection. A first concern is that the triage patterns documented in Section 5 reflect changes in the composition of patients treated rather than changes in treatment under nurse scarcity. For instance, if border hospitals increasingly admit patients with different diagnoses or baseline risk, observed declines in surgery rates and increases in mortality could be driven by selection.

I assess this concern at two levels. At the *hospital* level, case volumes per hospital remain broadly stable after 2011 (Figure 5a), which is difficult to reconcile with large demand-driven shifts in admissions as the primary driver of the results. At the *case* level, Figure B.13 indicates that also the case mix evolves similar in the treatment and control group as there is not differential shift in the prevalence across major diagnoses groups. Table B.14 further shows that also other proxies for the medical needs of patients remain unchanged: the share aged 75+, the share of emergency diagnoses, and the urgency score distribution do not change differentially. The only statistically significant demographic shift is a economically small change in gender composition (column 1 of Table B.14).

Aggregate demographic and economic conditions. A second concern is that the Swiss franc stabilization may generate other local shocks correlated with health outcomes. If the stabilization differentially affects demographic trajectories or local economic conditions in border counties, health could change even absent nurse shortages.

Table B.15 shows that population size, age structure, dependency ratios, and birth rates evolve similarly in treated and control counties, providing no evidence of differential demographic trends that could generate the observed divergence in mortality and life expectancy.

The stabilization may also affect mobility patterns and, mechanically, traffic-related mortality. Table B.16 shows that inbound commuting remains similar, while outbound commuting increases, consistent with increased commuting to Switzerland. While car ownership and the number of road accidents do not change differentially, road fatalities increase. This pattern – a rise in the severity of accidents rather than in the accident rate – is consistent with the interpretation that acute-care capacity is tighter after 2011 and that time-sensitive emergencies bear a disproportionate burden.

More broadly, economic conditions of residents in the border region do not appear to change differentially. Table B.17 shows no systematic changes in GDP per capita, unemployment, or gross earnings. Finally, I assess whether the border region was differentially affected by inflows of asylum seekers or migrants, which could affect local public budgets and thereby health – and

is relevant given the large inflow of asylum seekers in 2015 and thereafter.²⁷ However, I find no evidence of a differential change in the share of asylum seekers or in net total migration.

Healthcare supply outside hospitals and primary care A third concern is that population health could change because healthcare inputs outside hospitals change in response to the stabilization – which is particularly relevant for the analysis of county-level mortality and life expectancy.

Table B.18 documents that some healthcare inputs outside hospitals do change. While staffing in nursing homes evolves similarly across treated and control counties, nurse-to-patient ratios in outpatient nursing services decline by around three nurses per 100 outpatient cases (about 6 percent). In addition, general practitioner (GP) density decreases by about 5.2 percent. This decline is plausibly related to the Health Care Structure Act, which altered needs-based planning for primary care and disproportionately affected the border region.²⁸

To assess whether contemporaneous changes in primary care confound the aggregate health results, I re-estimate the county-level models controlling for GP density. Figure B.14c shows that the post-2011 decline in life expectancy is nearly unchanged when including GP density as an additional control and Figure B.14a shows similarly stable mortality patterns across age groups. If anything, estimates become more precise and pronounced, suggesting that the aggregate health effects are not an artifact of coincident changes in primary care supply.

Specification choices and weighting. The hospital-level regressions weight observations by baseline (2011) bed capacity to align estimands across hospitals of different size and to avoid giving disproportionate influence to small facilities.²⁹ Appendix Table B.19 shows that the estimated reduction in nurse staffing is robust to alternative weighting schemes (unweighted, occupancy-day weights, and case-count weights). While point estimates in levels vary, percentage changes relative to baseline means remain similar across schemes (between 9.09 and 12.05 percent). Re-estimating key outcomes under alternative specifications and sample restrictions yields qualitatively unchanged results.

Treatment definitions, matching, and comparison groups The baseline design defines treated counties based on pre-2011 commuting patterns and proximity to the Swiss border and constructs matched control counties using propensity score matching on pre-event characteristics.

To assess sensitivity, I implement an alternative treatment definition based on administrative boundaries, comparing counties in the *Regierungsbezirk Freiburg* (i) to matched control counties and (ii) to all other counties in Southern Germany (Baden-Württemberg and Bavaria). Figure B.15 shows that the first stage remains unchanged in both comparisons: nurse staffing declines, while physician employment remains stable.

²⁷In Germany, asylum seekers' healthcare was governed mainly by the Asylum Seekers' Benefits Act (*Asylbewerberleistungsgesetz*, AsylbLG). In practice, treatment was delivered by the regular health system but paid for by local public authorities, which can put additional financial pressure on municipalities.

²⁸For more details on the reform, see Brüll et al. (2025).

²⁹This is especially important given imbalances in hospital size between treated border hospitals and matched controls.

Likewise, the aggregate health effects are qualitatively similar. Figure B.16 shows that life expectancy and mortality patterns remain closely aligned with the baseline estimates (Figure 6) when comparing the affected *Regierungsbezirk Freiburg* with the rest of Southern Germany. If anything, effects are more pronounced.³⁰

6.1 Assessing the Net Health Effect

Section 5 shows that increased cross-border commuting of healthcare workers imposes sizeable health costs in the country of origin. To shed light on the net health effect, I assess whether these losses are accompanied by offsetting health gains in Switzerland, the destination country.

Empirical design. I construct a canton-level panel and estimate event-study specifications analogous to Equation 1, comparing cantons that receive an inflow of German cross-border healthcare commuters to cantons further inland in terms of nurse staffing, hospital utilization, and aggregate health outcomes. I combine several open-source datasets from the Swiss Federal Statistical Office (SBFS), which provide canton-level information on staffing (by nationality), hospital outcomes (e.g., number of patients and beds), and aggregate mortality and life expectancy.³¹ I define the six cantons bordering Germany as treated (Figure C.17) and cantons further inland as controls. Because Switzerland is geographically small, I cannot restrict the control group to be far enough away to rule out spillovers, nor can I implement a matching strategy comparable to the German setting (Figure C.18 illustrates the close proximity of treated and control cantons). Table C.20 highlights substantial baseline differences: treated cantons are larger, more urban, wealthier, and have higher healthcare density. For these reasons, the Swiss analysis should be interpreted as descriptive: the estimates capture associations rather than causal effects.

Results. Treated cantons exhibit increases in hospital staffing and hospital utilization but no corresponding improvements in aggregate life expectancy. Table C.21 shows that hospital staffing levels in treated cantons increase after 2011 (overall and for nurses), though estimates are imprecise. The increase is driven to a large extent by health care workers with German nationality, in particular German nurses: Swiss cantons employ on average around 300 FTE more German workers in hospital care (+21.6 percent relative to the 2011 mean) of which around 156 FTE (+27.6 percent) are German registered nurses. The number of German physicians employed also increases, but to a smaller extent and less statistical precision (similarly for MTAs). Table C.22 indicates that these staffing increases coincide with higher hospital utilization despite largely unchanged capacity: population and hospital beds evolve similarly in treated and control cantons, while inpatient cases increase by about 12.2 percent. Columns 4 and 5 of Table C.22 show no evidence of gains in aggregate longevity: if anything, life expectancy is slightly lower (about -0.16 years), albeit imprecisely estimated, while mortality remains essentially unchanged.

³⁰Additional sensitivity checks that vary distance cutoffs, include counties adjacent to the treated region, and restrict the sample to alternative regional subsets yield similar conclusions.

³¹Staffing rates are available from 2010 onwards; all other outcomes are available from 2009 onwards.

7 Conclusion

This paper examines how nurse scarcity in hospitals affects the quantity, quality, and allocation of care and, ultimately, patient and population health. I exploit the 2011 Swiss franc stabilization as a plausibly exogenous shock that communicated and locked in large wage differentials between Switzerland and Germany and made cross-border commuting particularly salient for residents of the German border region. Low legal barriers and strong demand for nurses in Switzerland, combined with rigid wages in the German hospital sector, generated an occupation-specific negative labor supply shock for registered nurses in German border hospitals. Using German and Swiss administrative data at the worker, hospital, patient, and county level and a matched multi-period difference-in-differences design, I trace how this shock translates through hospital production to health outcomes.

Four main findings emerge. First, the Swiss franc stabilization induces a substantial outflow of German nurses to Switzerland: vacancies for nurses rise sharply in treated counties and border hospitals lose about 12 percent of their nursing staff, driven by registered nurses, while staffing of doctors and other hospital occupations remains largely unchanged. Second, hospitals respond primarily by rationing care at the intensive margin rather than by treating fewer patients. For every one-percent reduction in nursing staff, the patient-to-nurse ratio increases by about 0.8 percent and the probability that a patient receives surgery falls by about 1 percent relative to the baseline, conditional on patients' medical needs. Consistent with triage, hospitals disproportionately reduce well-plannable surgeries for low-urgency cases, while reductions are substantially smaller for urgent and emergency cases. Third, the reduction in care translates into sizable and unequal health effects. On average, a one-percent reduction in nursing staff raises in-hospital mortality by about 0.4 percent corresponding to 24 additional deaths per year. These negative health effects are concentrated among older patients with urgent diagnoses and emergency cases, such as myocardial infarction and sepsis: they exhibit an increase in mortality of 1.47 and 0.97 percent per 1 percent reduction in nursing staff. Fourth, these individual-level effects translate into aggregate health statistics. At the county level, life expectancy declines in the treated border region relative to matched control counties by 0.28 statistical life years, or one-third of the cross-county standard deviation. Expressed per one-percent reduction in nursing staff, life expectancy falls by about 9 days at birth and by about 5 days at age 60 – corresponding to 283 forgone statistical life years per percent reduction for each birth cohort in the border region.³² In levels, the estimates imply about 290 additional deaths per year in the border region.

Two figures illustrate the substantial welfare costs of nurse scarcity. First, each newborn in the border region would be willing to pay 3,662 euros to prevent a decrease in nurse staffing by 1 percent.³³ Second, while life expectancy continued to rise throughout Germany, the border region experienced a stagnation from 2012 onward. This suggests that labor scarcity may not only impede economic growth – as pointed out by Jones (2022) – but also the rise in life

³²This is in magnitude close to recent OECD estimates that relate country-level nurse densities to life expectancy at birth and at older ages (Amiri and Solankallio-Vahteri, 2019).

³³This number is based on Schlander et al. (2018), who present 158,500 euros as an estimate for the 2014 value of a statistical life in Europe, multiplied by the number of forgone years per cohort (283) and divided by cohort size in 2011 (12,120 births).

expectancy.

With these findings, the paper contributes to the growing literature on the consequences of labor scarcity for production and consumer welfare. More broadly, the results speak to regulated sectors in which output is difficult to scale down and input prices adjust slowly: when a central input becomes scarce, adjustment occurs through rationing and reallocation, with distributional consequences for consumers. They also speak to cross-border labor markets more generally, where wage differentials can generate labor outflows with external costs in sending regions.

These findings yield three central messages. First, nurse shortages shape hospital production and local practice style as hospitals react by reducing and reallocating care across patients. Second, nurse shortages widen health disparities as health consequences of nurse scarcity are concentrated among vulnerable subgroups. Third, an extension to Switzerland finds no evidence of offsetting gains in aggregate longevity in receiving border cantons, even when legal and language barriers are low, highlighting that cross-border recruitment can impose sizeable welfare consequences for sending regions.

Several questions remain for future research. This paper focuses primarily on in-hospital surgery and mortality as outcomes. While highly relevant, these measures omit that nurse shortages likely affect patient care and health along other dimensions. In particular, effects for younger patients that may translate into reduced labor market attachment and productivity are not captured. Examining long-run morbidity, patient-reported outcomes, and quality of life would therefore provide a more comprehensive assessment of the costs of nurse scarcity in hospitals. In addition, little is known about how the working conditions, mental health, and labor supply decisions of remaining nurses respond to persistent shortages or how hospitals in destination countries reorganize care when they receive additional foreign nurses. Understanding these responses is important for designing policies that mitigate not only the effects of nurse scarcity on patients but also the burden on the workforce and for identifying when international recruitment can improve health outcomes without imposing large external costs on sending countries.

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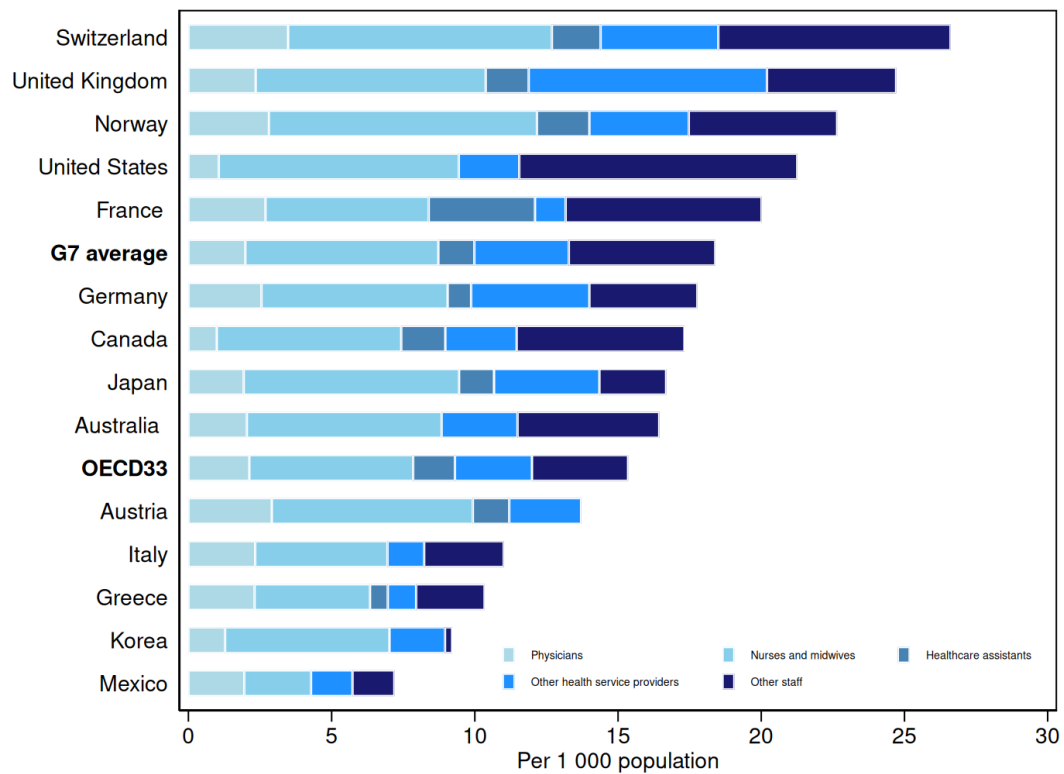
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Appendix

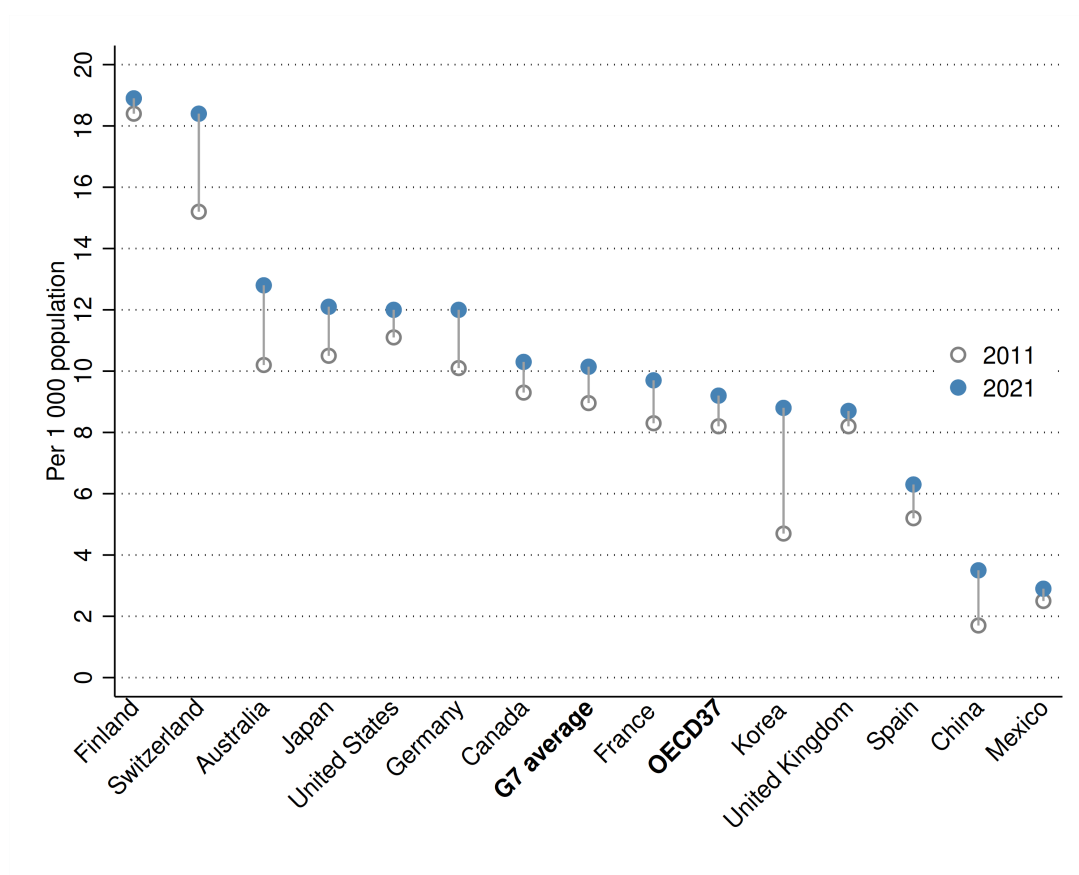
A Additional Tables and Figures

Figure A.1: Hospital Workforce Across OECD Countries



Notes: This figure summarizes the composition and size of the hospital workforce across selected OECD member countries. Data is obtained from OECD (2023) and reflects full-time equivalents (FTEs) per 1,000 inhabitants across major occupational groups.

Figure A.2: Practicing Nurses per 1,000 Inhabitants Across OECD Countries



Notes: This figure reports the number of practicing nurses per 1,000 inhabitants across selected OECD member countries in 2011 and 2021. Data is obtained from OECD (2023) and follows the OECD definition of practicing nurses, adjusted for country-specific differences regarding licenses, qualification, and occupational definitions (for more details, see OECD (2023)).

Table A.1: Comparison of selected healthcare system characteristics

	United States	Canada	Germany
Coverage	Multi-payer system without universal entitlement. Coverage is obtained through employer-sponsored or individually purchased private insurance, supplemented by Medicare and Medicaid.	Single-payer system with universal, publicly financed coverage for medically necessary hospital and physician services. Private insurance is mainly supplemental.	Statutory social health insurance with near-universal coverage. About 90% of residents are enrolled in non-profit Sickness Funds; the remainder holds comprehensive private insurance.
Ownership	Mix of public, nonprofit, and for-profit hospitals. For-profit hospitals account for a meaningful share of acute-care capacity.	Hospitals are predominantly public or nonprofit.	Public, nonprofit, and for-profit hospitals operate under Länder hospital plans.
Reimbursement	Inpatient care is reimbursed via DRG-type prospective payments in public programs, while private insurers negotiate prices directly with hospitals. Patient cost-sharing varies by insurer and plan type.	Hospitals are funded through budgets set by provincial authorities. Limited co-payments.	Hospitals are reimbursed through a nationwide DRG-based payment system. Operating costs are covered by DRGs, and capital investment is financed by the Länder. Limited co-payments.
Regulation	Regulatory authority is divided across federal and state levels. CMS governs Medicare and Medicaid, while states regulate private insurance and hospital licenses.	Provincial governments are responsible for hospital planning, budgets, and physician remuneration.	Länder regulate hospital capacity and capital investment, while the Federal Joint Committee (G-BA) defines nationwide quality standards. Statutory insurers negotiate contracts directly with hospitals within federal rules.

Notes: This table summarizes key institutional characteristics of the healthcare systems of the United States, Canada, and Germany, including coverage, ownership, reimbursement, and regulatory structure.

Table A.2: Substitutability of registered nurses in hospital care

Potential Substitute	Description	Permitted Tasks	Not Permitted Tasks
Nursing assistants	Short vocational training.	Basic personal care (e.g., hygiene, feeding, mobility).	No medication administration or clinical documentation.
Medical assistants (MFA)	Outpatient-focused occupation.	Administrative duties; selected technical tasks (e.g., phlebotomy).	Not authorized for inpatient nursing activities.
Physicians	Medical degree.	All medical acts within scope of practice.	Not a practical substitute for routine nursing care due to role specialization and cost.
Foreign-trained nurses	Often employed as aides prior to recognition of credentials.	Basic nursing tasks under supervision.	No independent clinical decision-making or medication administration.
Temporary agency nurses	Fully licensed registered nurses.	Full nursing responsibilities.	Limited availability; potentially disrupting the team structure.

Notes: This table summarizes the potential substitutability of registered nurses in hospital care through other occupation groups based on differences in training, authorization, and feasible task allocation. “Permitted tasks” reflect activities legally or customarily delegated within German hospital settings, while “Not permitted tasks” capture scope-of-practice restrictions that limit substitution possibilities.

Figure A.3: The evolution of the CHF–EUR exchange rate



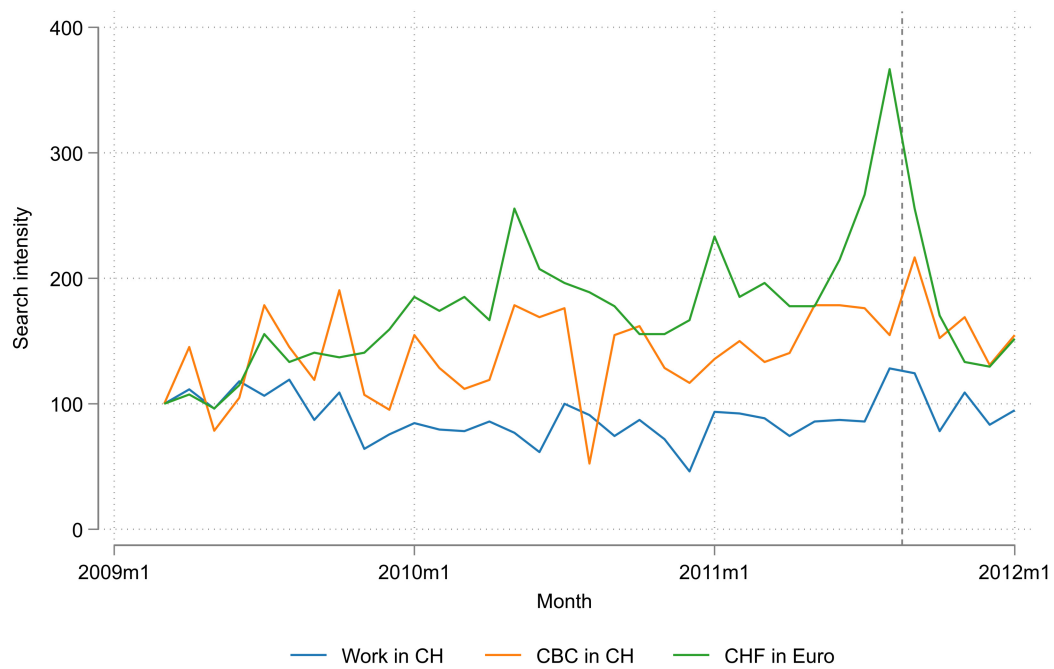
Notes: This figure plots the daily nominal CHF-EUR exchange rate over the period 2006 to 2014, obtained from the German National Bank. The dashed line marks the introduction of the Swiss National Bank’s minimum exchange rate of 1.20 CHF per euro in September 2011.

Figure A.4: Newspaper coverage of the Swiss Franc Appreciation



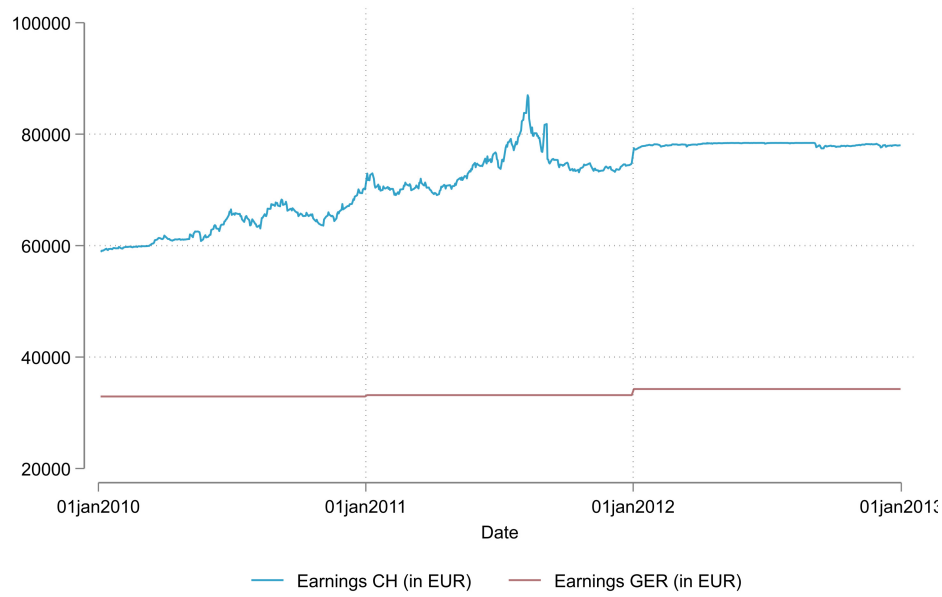
Notes: This figure displays selected German newspaper articles in national outlets (*Bild*, *Tagesschau*, *FAZ*) and the leading regional outlet (*SK*) between August 2011 and January 2012, illustrating how the Swiss franc appreciation and the introduction of a minimum exchange rate were portrayed in the media. *Bild* (2011-09-06) reports that “Euro and franc are now brothers” and highlights that Switzerland set a minimum exchange rate. *SK* (2011-08-20) announces an “Unexpected wage increase,” noting that the strong franc benefits Swiss shoppers and indirectly raises the pay of cross-border commuters. *Tagesschau* (2011-09-06) reports that the “Swiss franc is pegged to the euro,” explaining that the Swiss National Bank established a minimum rate of 1.20 CHF per euro and stands ready to purchase unlimited foreign currency to hold it. *FAZ* (2011-09-06) likewise headlines that “Switzerland pegs the franc to the euro.” The later *SK* article (2012-01-05) states that the “Strong franc attracts many.”

Figure A.5: Google search intensity for Swiss franc-related queries



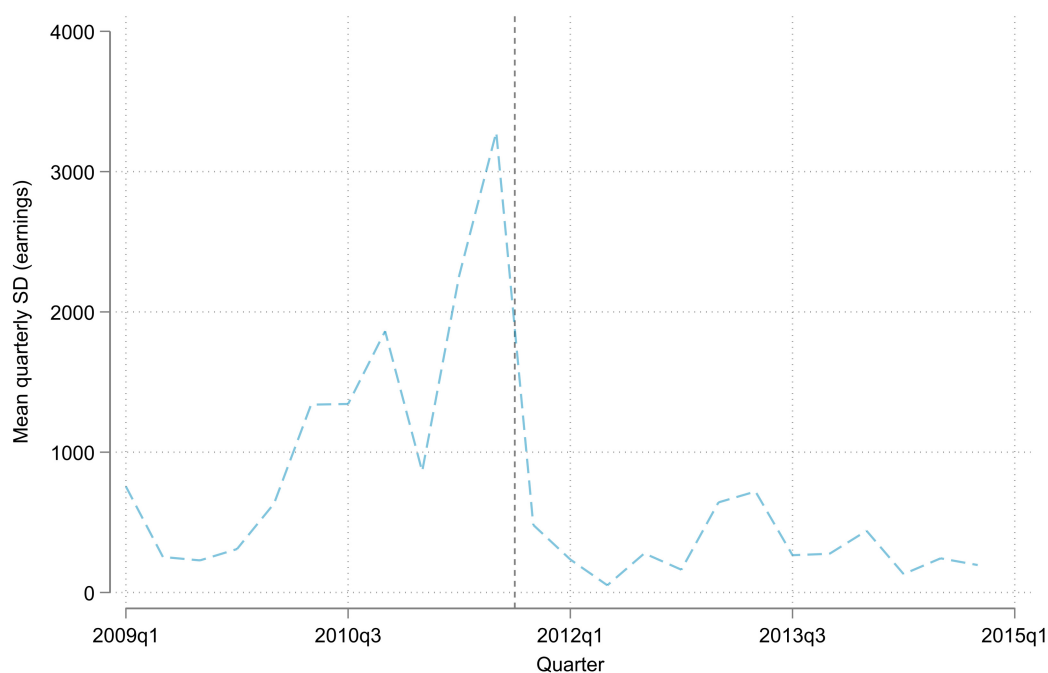
Notes: This figure displays the search intensity of keywords between 2009 and 2011 and relative to April 2009. Data is obtained from Google Trends and keywords reflect the following searches: "Working in Switzerland" (blue), "Cross-border commuting to Switzerland" (orange), and "Swiss franc in euros" (green). The dashed line marks the introduction of the Swiss National Bank's minimum exchange rate of 1.20 CHF per euro in September 2011.

Figure A.6: Gross yearly earnings of registered nurses in Germany and Switzerland



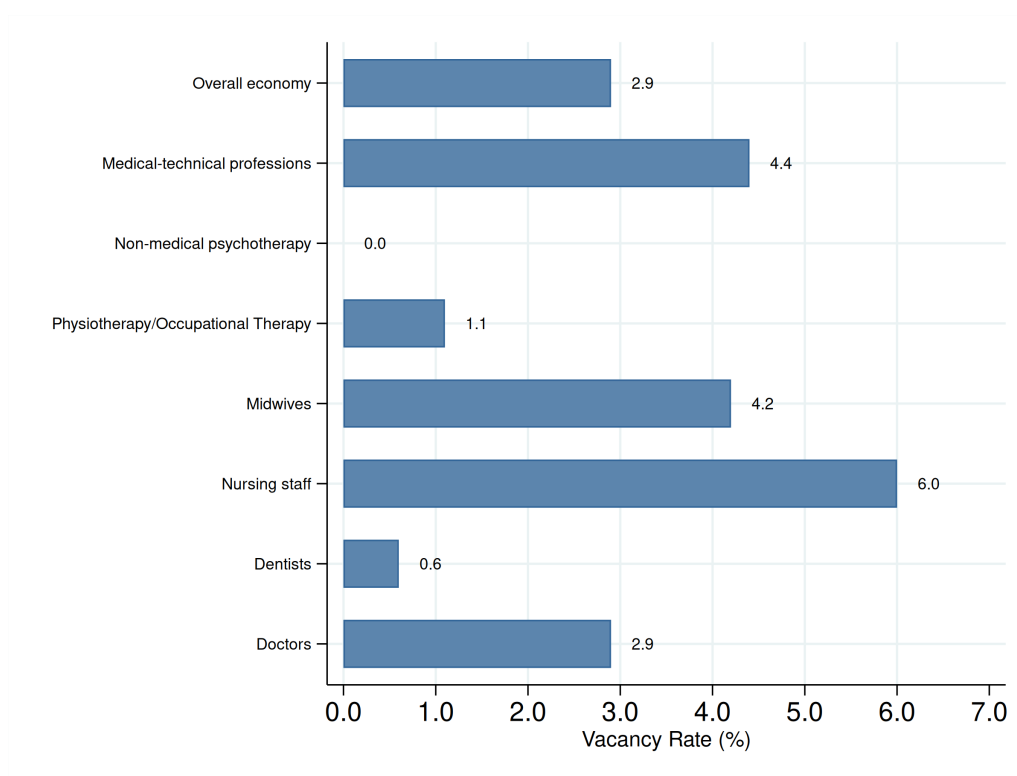
Notes: This figure compares gross yearly earnings (in euros) of registered nurses in Germany and Switzerland between 2010 and 2012. Swiss earnings are based on the *Lohnstrukturhebung* (LSE) and reflect the overall annual gross wage of all qualification levels in the health and social care sector. As the LSE is conducted biannually, earnings in uneven years have been extrapolated using a three-year rolling average. Using all qualification levels and occupations captures the potential occupational mobility of German cross-border commuters within Swiss healthcare. Values are converted into euros using the daily CHF-EUR exchange rate from the German National Bank. German earnings refer to the collective wage agreement *Tarifvertrag für den Öffentlichen Dienst der Länder* (TV-L), pay group TVöD-K E7a, level 3, corresponding to a fully trained registered nurse. Because of annual averages and stepwise collective bargaining adjustments, the series exhibit discrete year-to-year jumps.

Figure A.7: Dispersion of gross yearly earnings in Switzerland



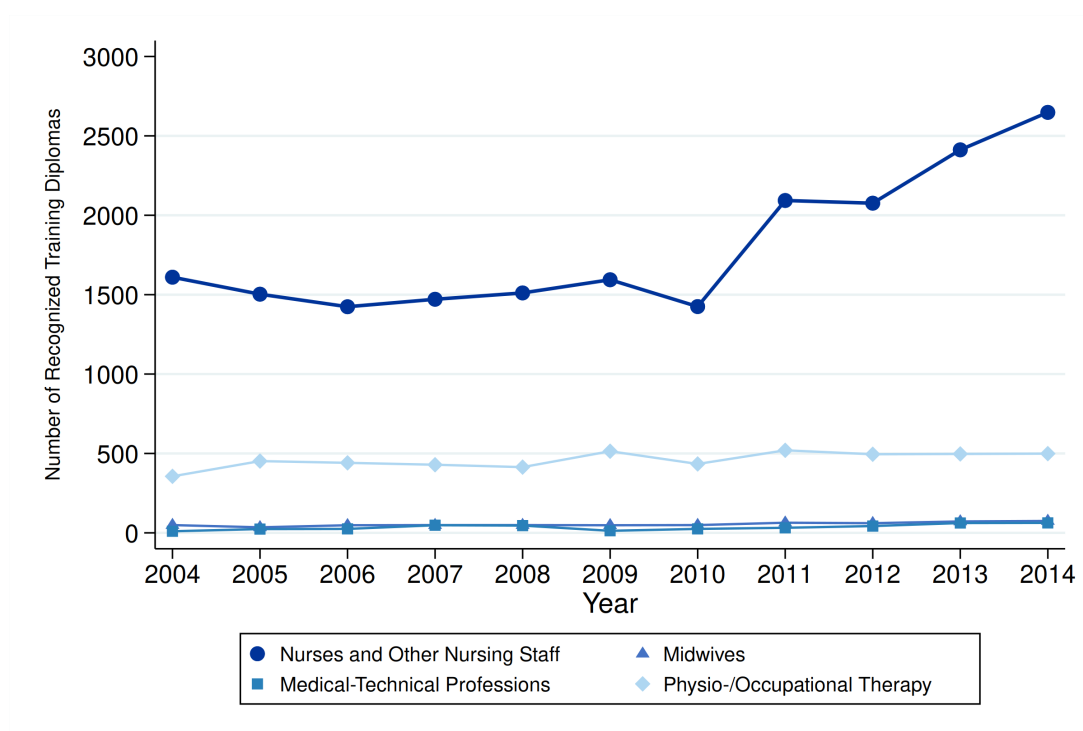
Notes: This figure reports the quarterly variance of gross yearly earnings in the Swiss healthcare sector converted to euro. Swiss earnings are based on the *Lohnstrukturhebung* (LSE) and reflect the overall annual gross wage of all qualification levels in the health and social care sector. As the LSE is conducted biannually, earnings in uneven years have been extrapolated using a three-year rolling average. Using all qualification levels and occupations captures the potential occupational mobility of German cross-border commuters within Swiss healthcare. Values are converted into euros using the daily CHF-EUR exchange rate from the German National Bank. The dashed line marks the introduction of the Swiss National Bank's minimum exchange rate of 1.20 CHF per euro in September 2011. The subsequent stabilization of the CHF-EUR rate is therefore reflected in a decline in earnings variance.

Figure A.8: Vacancies in the Swiss healthcare sector, 2011–2013



Notes: This figure shows average vacancy rates, i.e. the share of open positions, across occupations in the Swiss healthcare sector and in the overall economy between 2011 and 2013, reproduced from Lobsiger and Kägi (2016).

Figure A.9: Recognized Foreign Training Diplomas in Switzerland



Notes: This figure shows the annual number of recognized foreign training diplomas across healthcare occupations in Switzerland between 2004 and 2014, reproduced from Lobsiger and Kägi (2016) and based on the Swiss Red Cross (SRK) statistics.

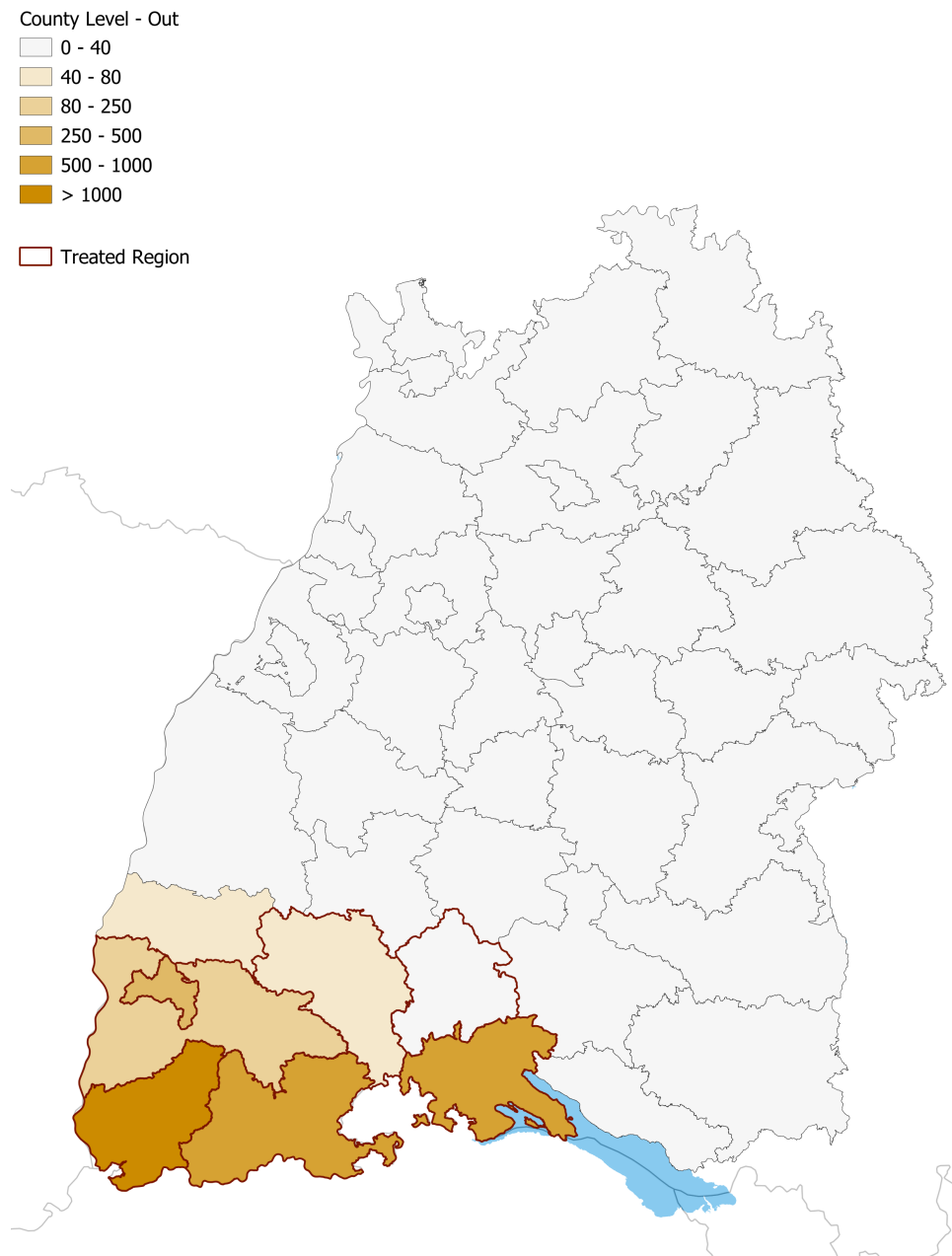
Table A.3: Crosswalk from INKAR to Regional Statistics for age-specific mortality

Regional Statistics (Mortality)	Inkar (Population)	Overlapping groups
Below 1	Below 3	Below 25
1–4	3–5	
5–9	6–17	
10–14		
15–19		
20–24	18–24	
25–29	25–29	25–49
30–34	30–49	
35–39		
40–44		
45–49		
50–54	50–64	50–64
55–59		
60–64		
65–69	65–74	65–74
70–74		
75–79	75 and older (until 2010) 75–84	75 and older
80–84		
85 and older	85 and older (from 2011 only)	

Notes: This table shows the age-group specific mortality (obtained from Regional Statistics) and the age-group specific population (obtained from INKAR) as well as the crosswalk between the two datasets used in the paper.

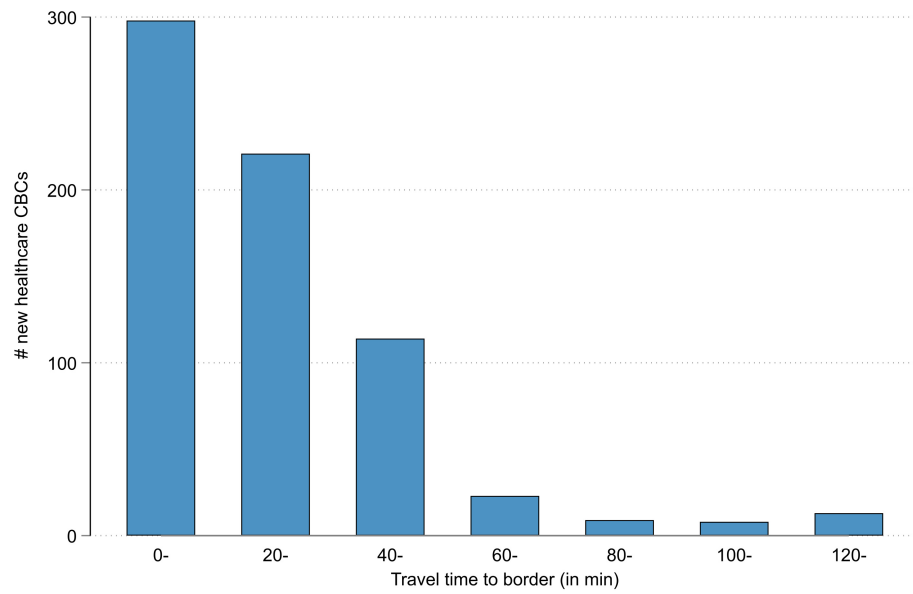
Figure A.10: County-level cross-border commuters in the healthcare sector

Germany Healthcare Commuters 2011



Notes: This map shows the number of active German cross-border commuters (CBCs) working in the Swiss healthcare sector at the county level for the entire state of Baden-Württemberg in 2011. "Treated region" refers to counties in the border region that are assigned to the treatment group based on travel distance and commuting patterns prior to the event. The assignment process is described in detail in Section 4. Lake Constance, a natural obstacle to mobility between Germany and Switzerland, is indicated in light blue.

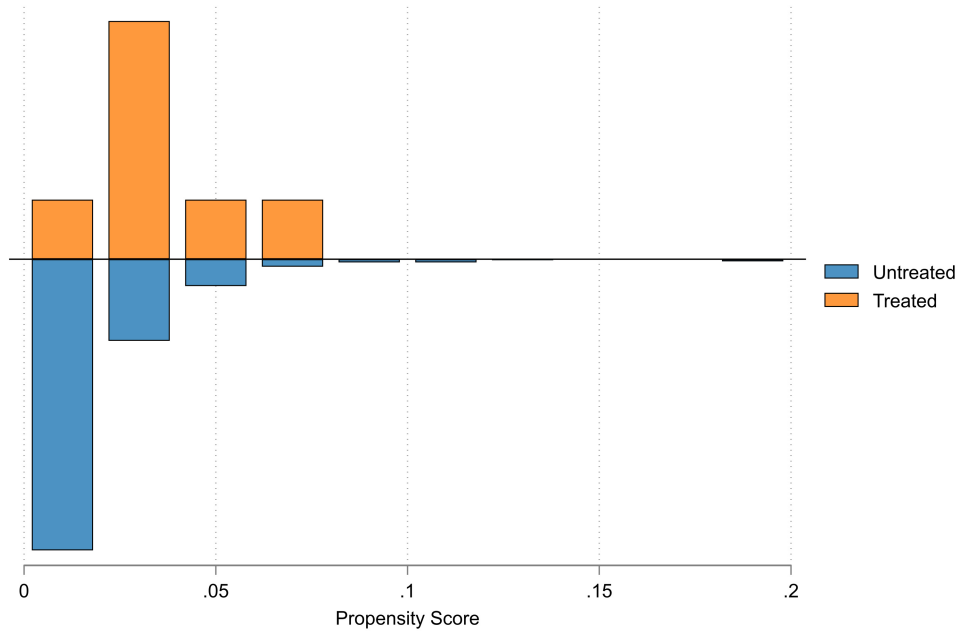
Figure A.11: Travel time to the border for new cross-border commuters in the healthcare sector



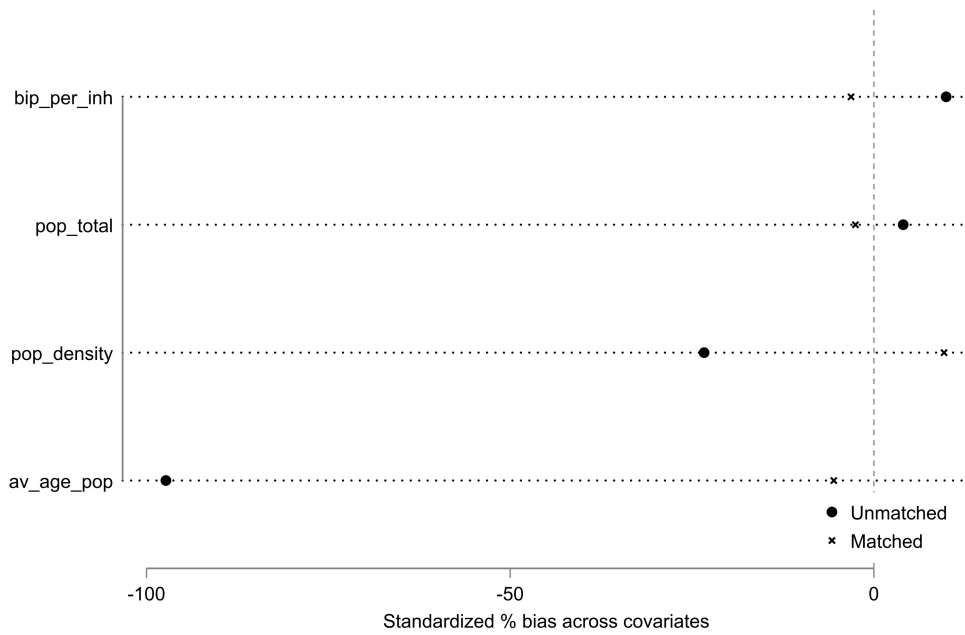
Notes: This figure shows how far inland German cross-border commuters (CBCs) newly starting to work in the Swiss healthcare sector in 2012 live. The x-axis displays the minutes it takes by car to reach the border crossing with the shortest travel time among the four metrically closest border crossings. Data on border crossings is obtained from the Online Appendix of Beerli et al. (2021); cross-border commuter data is obtained from the Swiss Cross-Border Commuter Statistic, described in detail in Section 3.

Figure A.12: Matching procedure

(a) Propensity score distribution



(b) Covariate bias



Notes: Figure A.12a shows the distribution of the propensity score between treated and untreated counties. The covariates used to calculate the propensity score are population size (*pop_total*), population density (*pop_density*), GDP per inhabitant (*bip_per_inh*), and the average age of the population (*av_age_pop*) in 2011. Figure A.12b shows the bias of these covariates for treated counties relative to untreated counties, either with or without matching. Data are obtained from the INKAR Database and the Regional Statistics, described in detail in Section 3. For more details regarding the matching procedure see Section 4.

Table A.4: Summary statistics of counties in 2011

	Germany	South	BW	Control	Treated
Population density (per sq km)	512.71 (665.62)	464.46 (629.63)	515.26 (584.01)	319.92 (324.74)	385.97 (451.43)
Population (in 1,000)	200.32 (225.87)	163.97 (146.56)	238.92 (128.13)	214.42 (166.49)	206.82 (46.63)
GDP per inhabitant (in 1,000 Euro)	31.39 (13.92)	36.53 (15.44)	37.46 (11.40)	32.17 (13.48)	32.46 (7.18)
Average age (in years)	43.78 (1.74)	42.86 (1.19)	42.48 (1.16)	42.47 (0.81)	42.36 (1.22)
Gross monthly earnings (per employed)	2310.57 (350.13)	2470.17 (319.82)	2585.47 (283.63)	2376.23 (344.83)	2397.51 (147.02)
Employment rate (in %)	54.12 (4.02)	55.71 (3.49)	55.32 (4.59)	54.47 (4.15)	51.00 (6.55)
Share of women	51.10 (0.67)	51.05 (0.78)	51.03 (0.67)	50.83 (0.63)	51.43 (0.80)
Fertility rate	1.42 (0.10)	1.39 (0.11)	1.43 (0.11)	1.43 (0.10)	1.41 (0.12)
Share in secondary sector	27.65 (8.92)	31.64 (9.12)	33.01 (9.50)	28.38 (8.63)	31.89 (13.03)
Share in tertiary sector	70.08 (9.60)	65.97 (9.98)	65.54 (9.99)	68.63 (9.42)	66.57 (13.10)
Observations	401	140	44	59	7

Notes: This table shows the means and standard deviations across multiple variables in 2011, separately for all counties in Germany, counties in the south of Germany, counties in Baden-Württemberg, treated counties, and control counties. The assignment to the treatment and control group is described in detail in Section 4. The secondary (tertiary) sector refers to the manufacturing (service) sector. Fertility rate is defined as the mean number of children per woman, and the share of women refers to the whole population living in a given county. Data are obtained from the INKAR Database and the Regional Statistics, described in detail in Section 3.

Table A.5: Summary statistics of hospitals in 2011

	Germany	South	BW	Control	Treated
Beds	253.17 (293.46)	211.70 (284.30)	215.57 (295.53)	245.40 (266.18)	181.47 (285.32)
Patients	9247.06 (11818.54)	7767.40 (11561.00)	7795.33 (12221.01)	9088.66 (10535.33)	6568.72 (11825.91)
FTE doctors	68.67 (132.82)	59.69 (140.08)	61.86 (150.23)	72.49 (136.71)	59.75 (167.98)
FTE nursing staff	153.13 (215.99)	129.39 (224.69)	131.38 (239.57)	154.71 (205.89)	123.28 (257.81)
FTE med. techn. staff	66.50 (175.74)	62.42 (198.23)	66.56 (228.87)	75.81 (201.04)	67.93 (252.07)
FTE functional staff	46.83 (76.69)	39.97 (79.52)	41.29 (81.31)	45.79 (64.96)	35.24 (76.05)
Total staff costs	24.43 (43.68)	21.52 (44.61)	22.63 (50.43)	26.53 (47.06)	21.52 (55.50)
Total hospital costs	40.35 (74.23)	34.70 (72.64)	35.90 (80.84)	42.99 (77.52)	33.53 (85.50)
Plan hospital	81.91 (38.51)	74.50 (43.62)	70.53 (45.67)	85.15 (35.63)	61.70 (49.14)
Continuously existing	83.13 (37.46)	81.37 (38.96)	82.46 (38.10)	84.72 (36.06)	85.11 (35.99)
Observations	2045	655	285	229	47

Notes: This table shows the means and standard deviations across multiple variables in 2011, separately for all hospitals in Germany, hospitals in the south of Germany, hospitals in Baden-Württemberg, hospitals in treated counties, and hospitals in control counties. The assignment to the treatment and control group is described in detail in Section 4. FTE refers to full-time equivalents. Costs are in millions of euros. "Plan hospital" refers to hospitals subject to contracted supply mandates (see § 109 SGB V). "Continuously existing" refers to the share of hospitals that continuously report between 2006 and 2017. Data are obtained from the German Hospital Statistic, described in detail in Section 3. Hospitals are assigned to counties based on the place of residence of the majority of inpatient cases treated (see Section 3 for details).

Table A.6: Summary statistics of patients in 2011

	Germany	South	BW	Control	Treated
Male	47.26 (49.92)	47.64 (49.94)	47.76 (49.95)	47.16 (49.92)	48.25 (49.97)
Mortality	2.11 (14.38)	2.00 (14.01)	1.97 (13.91)	2.10 (14.35)	1.82 (13.37)
Surgery	29.79 (45.74)	32.75 (46.93)	31.99 (46.64)	30.65 (46.10)	35.21 (47.76)
Days in care	7.43 (10.10)	7.28 (10.31)	7.37 (10.55)	7.24 (9.85)	7.34 (10.90)
Age	54.04 (25.07)	53.61 (25.26)	53.31 (25.51)	53.39 (25.44)	52.99 (25.67)
Urgency score	42.45 (31.55)	42.72 (31.72)	42.78 (31.88)	43.91 (31.68)	42.91 (31.47)
Emergency case	41.06 (49.19)	41.76 (49.32)	41.92 (49.34)	43.12 (49.52)	41.84 (49.33)
Same county	64.91 (47.72)	57.30 (49.46)	61.50 (48.66)	65.52 (47.53)	58.05 (49.35)
Continuously existing	93.47 (24.70)	94.19 (23.40)	92.70 (26.02)	92.57 (26.22)	91.81 (27.42)
Observations	18521722	4942517	2087976	2109806	313537

Notes: This table shows the means and standard deviations across multiple variables in 2011, separately for all patients treated in Germany, patients treated in the south of Germany, patients treated in Baden-Württemberg, patients treated in hospitals in treated counties, and patients treated in hospitals in control counties. The assignment to the treatment and control group is described in detail in Section 4. "Mortality"/"Surgery" refers to the likelihood of death/surgery (in %). "Emergency case" and "Male" refer to the shares of individuals with an urgency score above 50 and being male. Data are obtained from the German Patient Statistic, described in detail in Section 3. The urgency score is obtained from Krämer et al. (2019). It is a numerical value between 0 and 100, reflecting the degree to which a patient needs immediate treatment based on the patient's diagnosis. "Continuously existing" refers to the share of patients treated in hospitals that continuously report between 2006 and 2017. The assignment of patients to counties is based on the location of the hospitals in which they are treated (see Section 3 for details).

Table A.7: Staffing effect across nursing and other healthcare occupations

	RN	AN	Physicians	MTA	Functional staff	Surgical staff
Post $\times$ Treatment	-48.70** (23.06)	0.23 (2.94)	6.52 (15.61)	29.17 (33.97)	24.49 (20.25)	3.34 (4.99)
Mean of Y	404.24	16.71	236.00	343.41	144.11	42.45
Std. Dev. of Y	372.83	22.31	295.09	561.28	141.09	45.67
Observations	2789	2789	2801	2789	2789	2789

Notes: This table shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on the number of staff across occupation groups in hospitals. Displayed coefficients reflect difference-in-differences estimates based on Equation 1. "RN" and "AN" refer to registered and assistant nurses; "MTA" refers to medical technical assistant. Standard errors in parentheses are robust and clustered at the county level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The relative effect size is computed as $100 \times \frac{\text{Post} \times \text{Treatment}}{\text{Mean of Y}}$. The sample of hospitals contains continuously operating hospitals in the border region (treatment group) and hospitals in matched counties further inland (control group). The matching procedure is explained in detail in Section 4. Observations are weighted using the number of beds in 2011 at the hospital level due to imbalances in hospital size between the treatment and control groups.

Table A.8: Effect on the number of vacancies among healthcare occupations

	Nursing	Doctors	Dentist	Veterinarian	Laboratory	Pharmacists
Post $\times$ Treatment	9.54** (4.74)	1.85* (0.93)	0.15 (0.17)	-0.04 (0.16)	0.32 (0.38)	0.40 (0.55)
Mean of Y	15.41	3.18	0.33	0.24	0.68	1.35
Std. Dev. of Y	12.92	3.59	0.73	0.47	2.35	1.74
Observations	726	726	725	726	726	726

Notes: This table shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on the number of reported open vacancies at the county level as of June 15 every year across healthcare occupation groups. Occupations refer to the Kldb 2010 4-digit occupations 8130, 8140, 8147, 8150, 8121, and 8180. Displayed coefficients reflect difference-in-differences estimates based on Equation 1. Standard errors in parentheses are robust and clustered at the county level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The sample contains counties in the border region (treatment group) and matched counties further inland. The matching procedure is explained in detail in Section 4.

Table A.9: Effect on the demographic occupational composition of nurses and commuting

	Age	Female	Within county	Mover (county)	Mover (state)
Post $\times$ Treatment	0.03 (0.28)	0.12 (0.27)	1.52* (0.79)	-0.26 (0.23)	-0.06 (0.10)
Mean of Y	37.23	86.73	69.57	3.26	1.06
Std. Dev. of Y	1.31	4.01	16.06	1.53	0.81
Observations	924	924	924	924	924

Notes: This table shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on the occupational composition of nurses (Kldb 1992-occupation group 853) across demographic and commuting outcomes at the county level. "Age" refers to the average age, and "Female" refers to the share of female employees. "Within county" is the share of employees commuting within the same county. "Movers" reflects the number of individuals switching residence from another county or state. Displayed coefficients reflect difference-in-differences estimates based on Equation 1. Standard errors in parentheses are robust and clustered at the county level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The sample contains counties in the border region (treatment group) and matched counties further inland. The matching procedure is explained in detail in Section 4.

Table A.10: Effect on the economic occupational composition of nurses

	Wage	Earnings	Days employed	Tenure (occ)	Tenure (est)	College share
Post $\times$ Treatment	0.55 (1.22)	89.01 (366.57)	-0.43 (0.43)	-130.66 (98.31)	-170.31 (115.75)	0.27 (0.68)
Mean of Y	77.97	28145.39	350.80	2917.69	3426.04	16.91
Std. Dev. of Y	5.05	1793.86	2.01	537.50	714.11	7.39
Observations	924	924	924	924	924	924

Notes: This table shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on the occupational composition of nurses (Kldb 1992-occupation group 853) across economic outcomes at the county level. "Wage" refers to daily, and "Earnings" and "Days employed" to yearly averages. Tenure is measured as the number of days employed in the same occupation (column 4) or same establishment (column 5). Displayed coefficients reflect difference-in-differences estimates based on Equation 1. Standard errors in parentheses are robust and clustered at the county level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The sample contains counties in the border region (treatment group) and matched counties further inland. The matching procedure is explained in detail in Section 4.

Table A.11: Effect on patients' outcomes

Panel A: Average	Unconditional			Conditional on surgery	
	Mortality	Surgery	Length of stay	Mortality	Length of stay
Post $\times$ Treatment	0.09* (0.04)	-3.85* (1.99)	0.03 (0.10)	0.07 (0.04)	-0.00 (0.15)
Panel B: Heterogeneity	Unconditional			Conditional on surgery	
	Mortality	Surgery	Length of stay	Mortality	Length of stay
Post $\times$ Treatment	0.06 (0.04)	-3.45** (1.62)	-0.01 (0.11)	0.06 (0.04)	-0.02 (0.15)
Post $\times$ Treatment $\times$ Urgent	0.42** (0.17)	1.54** (0.65)	0.30** (0.13)	0.44 (0.56)	0.11 (0.63)
Mean of Y	2.07	31.41	7.58	1.19	7.51
Std. Dev. of Y	14.25	46.41	11.26	10.83	9.51
Observations	25,145,786	25,145,786	25,145,786	7,768,039	7,768,039

Notes: This table shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on patients' outcomes at the case level, separately for all patients (columns 1-3) and for patients conditional on undergoing surgery (columns 4-5). Outcome variables are the probability of dying, the probability of receiving surgery, and days in inpatient hospital care. Displayed coefficients reflect difference-in-differences estimates based on Equation 1, in Panel B additionally interacted with an indicator for urgent cases (urgency score above 0.5 based on the classification in Krämer et al. (2019)). Case-level controls include indicators for female, age bins, and 3-digit ICD-10 diagnosis fixed effects. All lower-order interaction terms between $I(post)$, $I(treatment)$, and $I(urgent)$ are included. Case-level controls are female, age-bin, and 3-digit ICD-10 diagnosis code fixed effects. Standard errors in parentheses are robust and clustered at the county level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The sample consists of all inpatient cases treated in continuously operating hospitals in the border region (treatment group) and in hospitals in matched counties further inland (control group). The matching procedure is explained in detail in Section 4.

Table A.12: Effect on in-hospital prevalence and mortality: heart attack and sepsis

	Heart attack		Sepsis	
	Prevalence	Mortality	Prevalence	Mortality
Post $\times$ Treatment	-0.02 (0.18)	1.56** (0.65)	0.01 (0.07)	2.35** (1.10)
Mean of Y	1.17	8.82	0.42	20.30
Std. Dev. of Y	10.77	28.36	6.45	40.22
Observations	27,516,415	325,447	27,516,415	128,890

Notes: This table shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on in-hospital outcomes for patients with heart attack and sepsis at the case level. Outcome variables are the prevalence of heart attack and sepsis among inpatient cases and the probability of dying in hospital conditional on having heart attack or sepsis (in percentage points). Displayed coefficients reflect difference-in-differences estimates based on Equation 1. Case-level controls include indicators for female and age bin fixed effects. Standard errors in parentheses are robust and clustered at the county level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The sample consists of all inpatient cases treated in continuously operating hospitals in the border region (treatment group) and in hospitals in matched counties further inland (control group). The matching procedure is explained in detail in Section 4.

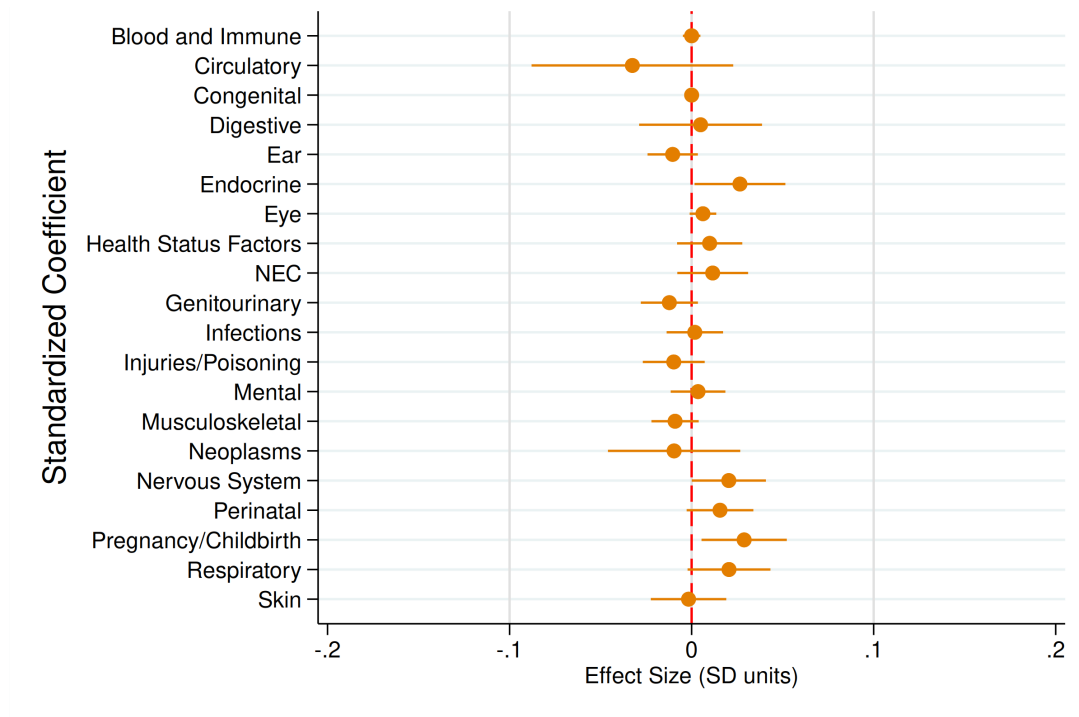
Table A.13: In-hospital mortality effects by age and life expectancy

<i>Panel A: Mortality (case level)</i>	25–49	50–64	65–74	75+
Post $\times$ Treatment	0.00 (0.03)	0.08 (0.07)	0.10 (0.09)	0.33** (0.13)
Mean of Y	0.34	1.43	2.48	5.28
Std. Dev. of Y	5.79	11.88	15.55	22.36
Observations	6,157,731	5,284,844	4,666,506	6,805,325
<hr/>				
<i>Panel B: Life expectancy (county level)</i>	Life expectancy (born)		Life expectancy (60)	
Treated $\times$ Post 2012	-0.28*** (0.07)		-0.16** (0.07)	
Mean of Y	80.27		23.00	
Std. Dev. of Y	0.93		0.60	
Observations	792		792	

Notes: This table shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on mortality and life expectancy, separately for in-hospital mortality at the case level (Panel A) by age group (restricted to ages 25+) and for county-level life expectancy (Panel B). Panel A reports the effect on the probability of dying during an inpatient stay. Panel B reports effects on life expectancy at birth and at age 60. Displayed coefficients reflect difference-in-differences estimates based on Equation 1. Case-level controls in Panel A include indicators for female, age bins, and 3-digit ICD-10 diagnosis fixed effects. Standard errors in parentheses are robust and clustered at the county level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The sample in Panel A consists of all inpatient cases treated in continuously operating hospitals in the border region (treatment group) and in hospitals in matched counties further inland (control group). The sample in Panel B contains counties in the border region (treatment group) and matched counties further inland. The matching procedure is explained in detail in Section 4.

B Robustness Checks and Sensitivity Analyses

Figure B.13: Case composition of inpatient cases



Notes: This figure shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on the probability of hospitalization by patients' main diagnosis across ICD-10-GM major categories. Displayed coefficients reflect difference-in-differences estimates based on Equation 1, expressed in standard deviation units of the outcome variable. Case-level controls include indicators for female and age bins. Vertical bars indicate 95% confidence intervals based on robust standard errors clustered at the county level. The sample consists of all inpatient cases treated in continuously operating hospitals in the border region (treatment group) and in hospitals in matched counties further inland (control group). The matching procedure is explained in detail in Section 4.

Table B.14: Patient characteristics

	Male	Elderly	Urgency	Emergency case
Post $\times$ Treatment	-0.80** (0.34)	-0.71 (0.67)	-0.33 (0.65)	-0.15 (0.65)
Mean of Y	47.41	23.83	43.83	42.92
Std. Dev. of Y	49.93	42.60	31.64	49.50
Observations	27516415	27516415	25145786	25145786

Notes: This table shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on patient characteristics at the case level. The outcome variables refer to patients' gender, whether a patient is 75 and older (elderly), the urgency score of main diagnosis, and whether a patient is classified as emergency case based on the urgency score obtained from Krämer et al. (2019). Displayed coefficients reflect difference-in-differences estimates based on Equation 1. Standard errors in parentheses are robust and clustered at the county level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The sample consists of all inpatient cases treated in continuously operating hospitals in the border region (treatment group) and in hospitals in matched counties further inland (control group). The matching procedure is explained in detail in Section 4.

Table B.15: Demographic characteristics

	Population	Age	Dependency rate	Births	Fertility rate
Post $\times$ Treatment	0.25 (1.10)	-0.32 (0.23)	-0.53* (0.28)	0.10 (0.12)	-0.01 (0.01)
Mean of Y	200.27	43.80	32.25	7.90	1.42
Std. Dev. of Y	227.28	1.75	4.31	0.95	0.11
Observations	792	792	792	792	792

Notes: This table shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on demographic outcomes at the county level. Outcome variables are the population (in thousands), the average age of the population (in years), the ratio of people above 65 to the working population (in percent), the number of births (in thousands), as well as the fertility rate. Displayed coefficients reflect difference-in-differences estimates based on Equation 1. Standard errors in parentheses are robust and clustered at the county level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The sample contains counties in the border region (treatment group) and matched counties further inland. The matching procedure is explained in detail in Section 4.

Table B.16: Commuting and road safety

	Commuter				
	Inbound	Outbound	Car density	Road accidents	Road fatalities
Post $\times$ Treatment	-0.23 (0.55)	0.89** (0.40)	1.12 (4.46)	7.23 (8.03)	1.42*** (0.48)
Mean of Y	37.54	41.63	546.95	513.62	5.92
Std. Dev. of Y	14.80	13.50	59.49	87.34	3.79
Observations	792	792	792	792	789

Notes: This table shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on commuting patterns, car density, and road safety outcomes at the county level. Outcome variables are the shares of inbound and outbound commuters, the number of cars per 1,000 inhabitants, road traffic accidents, and the number of road fatalities (both per 100,000 inhabitants). Displayed coefficients reflect difference-in-differences estimates based on Equation 1. Standard errors in parentheses are robust and clustered at the county level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The sample contains counties in the border region (treatment group) and matched counties further inland. The matching procedure is explained in detail in Section 4.

Table B.17: Economic characteristics

	GDP per person	UE rate	Earnings	Asylum seekers	Net migration
Post $\times$ Treatment	0.28 (0.69)	0.02 (0.10)	-6.95 (20.64)	0.00 (0.05)	1.10 (1.30)
Mean of Y	31.37	6.64	2,308.00	0.53	2.28
Std. Dev. of Y	14.01	3.23	351.23	0.38	5.49
Observations	792	792	792	726	792

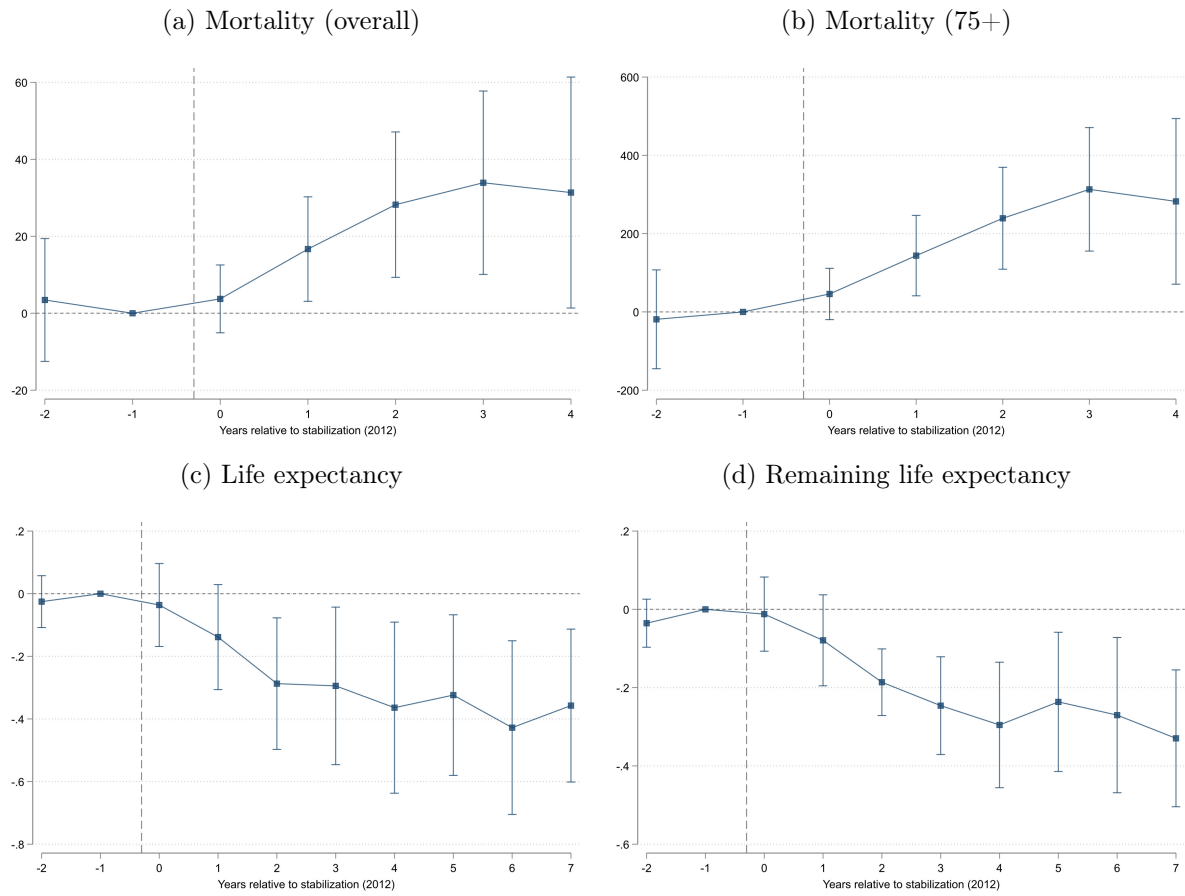
Notes: This table shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on economic and migration outcomes at the county level. Outcome variables are the GDP per inhabitant (in thousands), the unemployment rate (in percent), gross monthly earnings, the share of asylum seekers in the population, and total net migration per 1,000 inhabitants. Displayed coefficients reflect difference-in-differences estimates based on Equation 1. Standard errors in parentheses are robust and clustered at the county level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The sample contains counties in the border region (treatment group) and matched counties further inland. The matching procedure is explained in detail in Section 4.

Table B.18: Healthcare supply outside hospitals

	Staff NH	Staff NS	GPs	Hospitals
Post $\times$ Treatment	-0.17 (0.77)	-2.94** (1.46)	-6.85*** (1.71)	-0.03 (0.36)
Mean of Y	90.00	48.80	130.63	4.67
Std. Dev. of Y	11.88	12.96	158.73	4.13
Observations	594	594	594	594

Notes: This table shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on healthcare supply outside hospitals at the county level. Outcome variables are staff in nursing homes (per 100 inpatient cases), staff in outpatient nursing services (per 100 outpatient cases), the number of general practitioners (GPs), and the number of hospitals (per 1,000 inhabitants). Information on healthcare supply is available from 2009 onwards. Displayed coefficients reflect difference-in-differences estimates based on Equation 1. Standard errors in parentheses are robust and clustered at the county level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The sample contains counties in the border region (treatment group) and matched counties further inland. The matching procedure is explained in detail in Section 4.

Figure B.14: Aggregate health effects when controlling for GP density



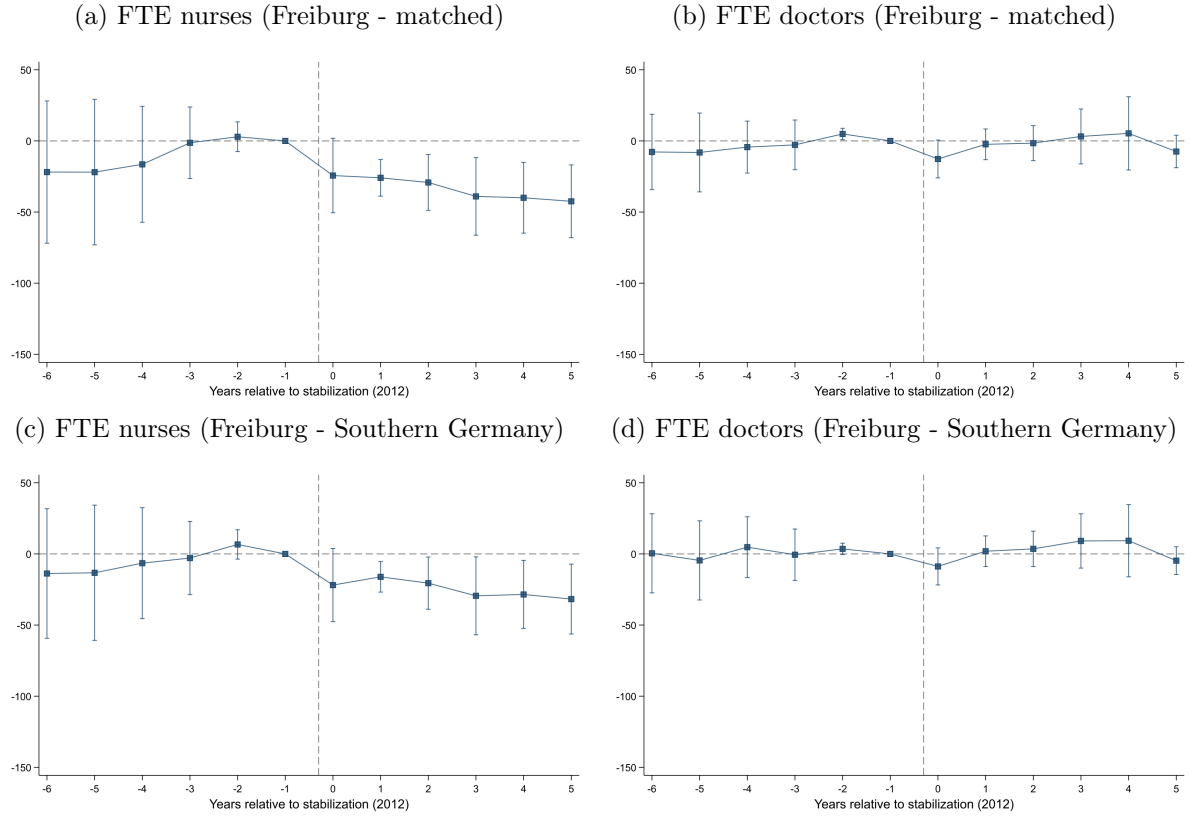
Notes: This figure shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on the aggregate life expectancy (for newborns) and the remaining life expectancy (for individuals age 60), as well as mortality across age groups. All sub-figures display the multi-period difference-in-differences estimates obtained from Equation 1, but additionally controlling for the number of general practitioners (GPs) per capita at the county level. Information on GPs at the county level is only available from 2010 onwards and mortality only until 2016, thus restricting the period of observation. Vertical bars indicate 95% confidence intervals based on robust standard errors clustered at the county level. The sample contains counties in the border region (treatment group) and matched counties further inland. The matching procedure is explained in detail in Section 4.

Table B.19: Effect comparison across weighting procedures

	No weight	Beds (2011)	Occ. days (2011)	Patients (2011)
Post $\times$ Treatment	-14.9762** (6.980)	-48.6965** (21.883)	-49.3288** (21.749)	-47.1574* (25.099)
Mean of Y	164.73	404.24	416.15	417.26
Std. Dev. of Y	218.32	372.83	378.85	376.34
Rel. effect size	-9.09%	-12.05%	-11.85%	-11.30%
Observations	2,789	2,789	2,789	2,789

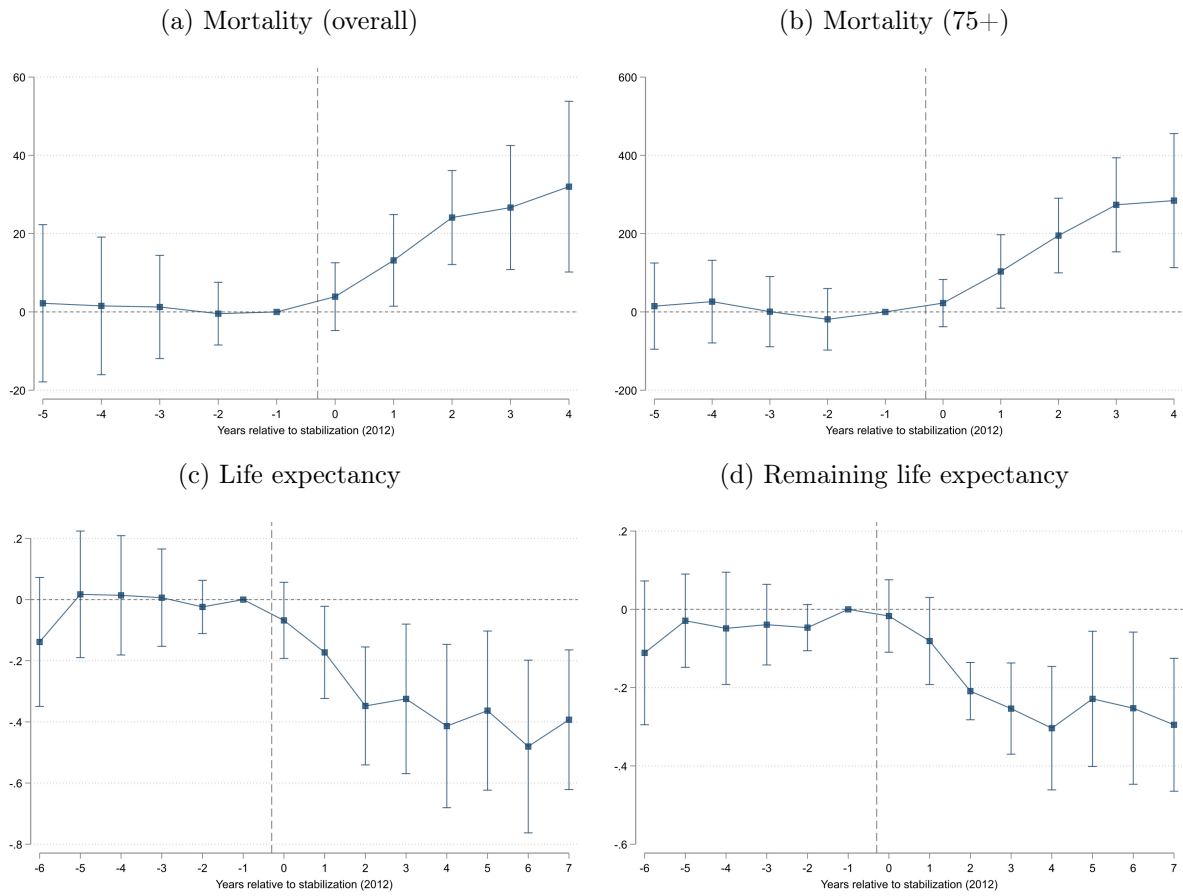
Notes: This table shows the effect of the Swiss Franc Stabilization (SFS) in 2011 on the number of registered nurses in hospitals using different weighting procedures. Displayed coefficients reflect difference-in-differences estimates based on Equation 1. Weights are the number of beds in 2011 (column 2), the number of occupancy days in 2011 (column 3), and the number of inpatient cases in 2011 (column 4). Column 1 displays coefficients without weighting. Standard errors in parentheses are robust and clustered at the county level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The relative effect size is computed as $100 \times \frac{\text{Post} \times \text{Treatment}}{\text{Mean of } Y}$. The sample of hospitals contains continuously operating hospitals in the border region (treatment group) and hospitals in matched counties further inland (control group). The matching procedure is explained in detail in Section 4.

Figure B.15: Treatment/control group sensitivity for staffing rates



Notes: This figure shows the effect of the Swiss franc stabilization (SFS) in 2011 on staffing rates in hospitals. Staffing rates are measured in full-time equivalents (FTE) and the respective occupation group is displayed above each sub-figure. All sub-figures display the multi-period difference-in-differences estimates obtained from Equation 1. Sub-figures in the first row use the baseline comparison of continuously operating hospitals in the border region (treatment group) and hospitals in matched counties further inland (control group), while sub-figures in the second row compare hospitals in the government district of Freiburg to hospitals in the remaining government districts of Baden-Württemberg and Bayern. Vertical bars indicate 95% confidence intervals based on robust standard errors clustered at the county level. The matching procedure is explained in detail in Section 4. Observations are weighted using the number of beds in 2011 at the hospital level due to imbalances regarding hospital size between the treatment and control group.

Figure B.16: Treatment/control group sensitivity for aggregate health outcomes



Notes: This figure shows the effect of the Swiss franc stabilization (SFS) in 2011 on aggregate health outcomes at the county level. Mortality is measured as the number of death cases per 100,000 inhabitants (overall and for individuals aged 75 and above) and life expectancy is measured at birth and at age 60. All sub-figures display the multi-period difference-in-differences estimates obtained from Equation 1. This specification compares counties in the government district of Freiburg to counties in the remaining government districts of Baden-Württemberg and Bayern (instead of the baseline comparison of the treated border region and matched control counties). Vertical bars indicate 95% confidence intervals based on robust standard errors clustered at the county level.

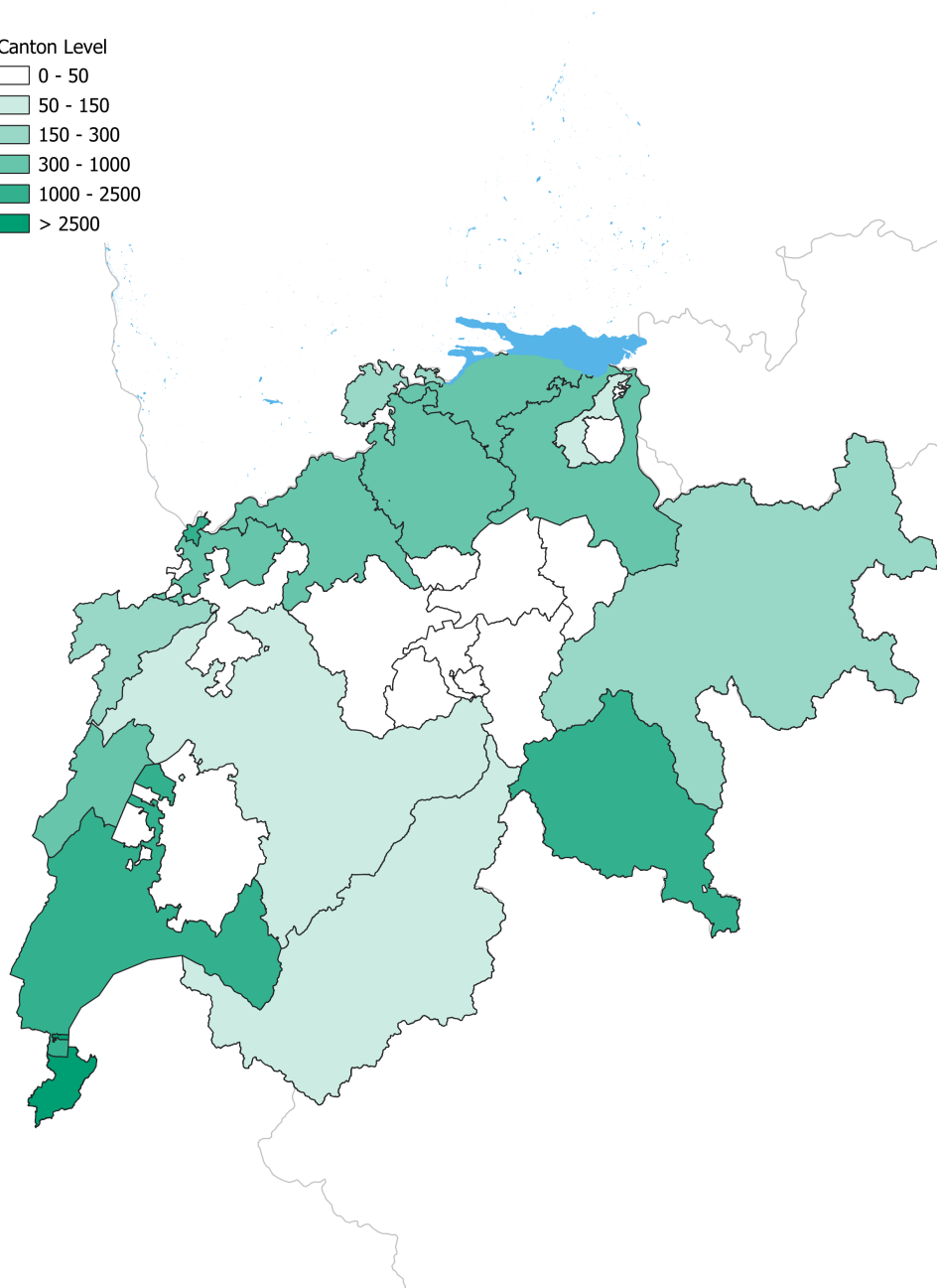
C Extension: Switzerland

Figure C.17: Cross-border healthcare commuters in Switzerland (2011)

Switzerland All Healthcare Commuters 2011

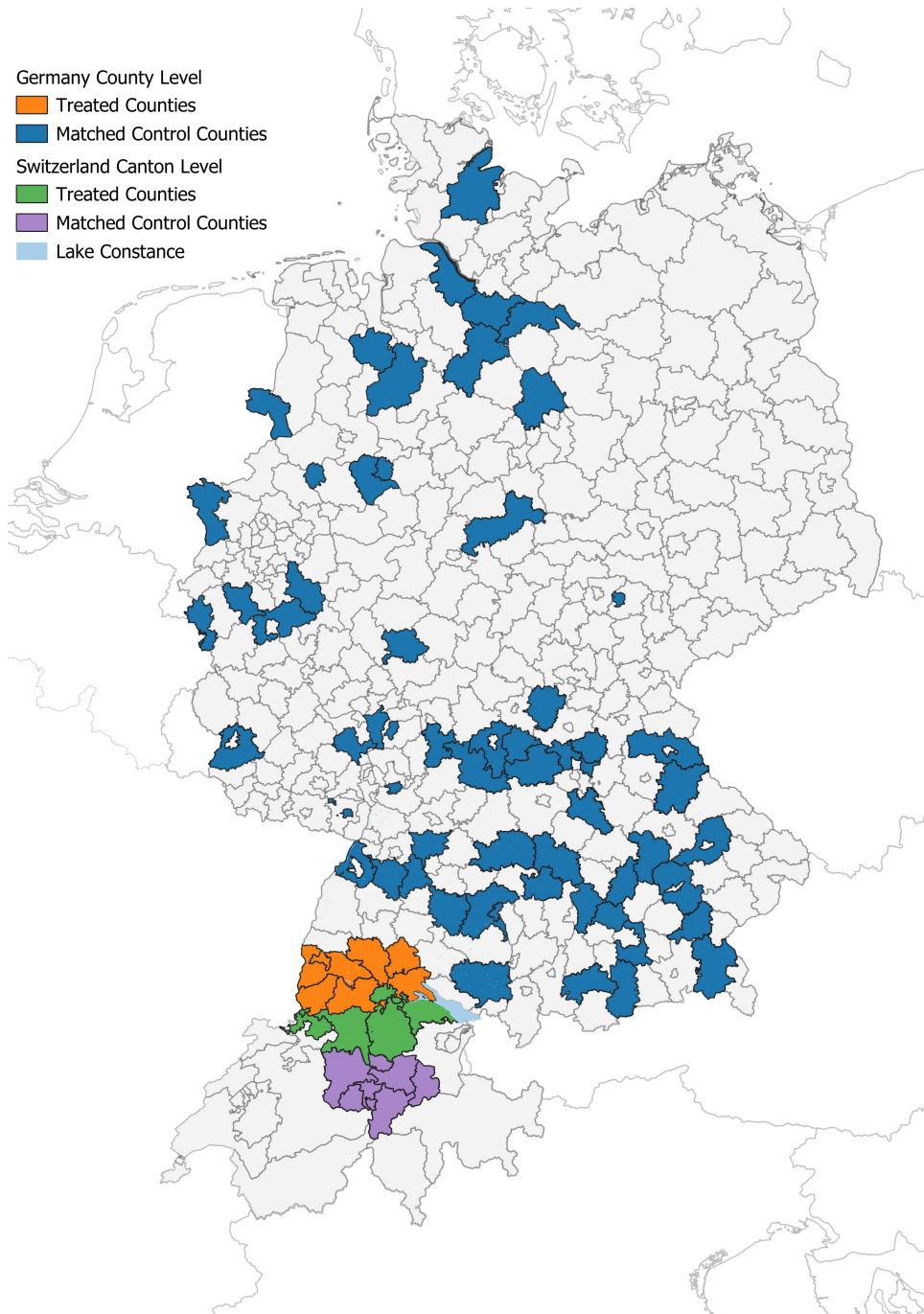
Canton Level

0 - 50
50 - 150
150 - 300
300 - 1000
1000 - 2500
> 2500



Notes: This map of Switzerland displays the absolute number of cross-border commuters working in the Swiss healthcare sector in 2011.

Figure C.18: Treated and matched control regions (Switzerland and Germany)



Notes: This map shows the geographic definition of treated and matched control regions on both sides of the Swiss-German border. For Germany, treated regions are defined to be (i) lying within a 45-minute drive to the border or (ii) among the regions with the highest count of cross-border commuters working in the Swiss healthcare sector prior to the event. The assignment to the control group is based on a propensity score matching approach (see Section 4 for details). For Switzerland, the cantons with the highest number of German cross-border commuters are assigned to the treatment group (Aargau, Basel Landschaft, Basel Stadt, Schaffhausen, Thurgau, and Zürich). Cantons with close to zero cross-border commuters further inland are assigned to the control group (Glarus, Luzern, Nidwalden, Obwalden, Schwyz, Uri, and Zug).

Table C.20: Summary statistics by canton group

	Switzerland	Control	Treated
Population	305,948.54 (324,562.22)	113,824.14 (126,566.97)	466,903.50 (488,471.22)
Population density	485.76 (998.69)	190.51 (180.62)	1,233.03 (1,873.64)
Average age	41.67 (1.20)	41.40 (0.68)	42.28 (1.40)
GDP per inhabitant	76,590.82 (28,201.56)	74,949.10 (35,672.15)	91,680.93 (39,825.60)
FTE hospital staff	17.32 (8.65)	11.98 (4.57)	22.16 (15.31)
FTE doctors	2.34 (1.70)	1.46 (0.65)	3.46 (3.11)
FTE nursing staff	7.27 (2.99)	5.42 (2.07)	8.75 (5.39)
German cross-border healthcare commuters (CBCs)	550.01 (1,056.55)	2.86 (3.06)	715.34 (588.46)
Life expectancy at birth	82.28 (0.68)	82.58 (0.85)	82.19 (0.51)
Observations	26	7	6

Notes: This table shows the means and standard deviations across multiple variables in 2011, separately for all Swiss cantons, treated cantons, and control cantons. Treated cantons are those with the highest number of German cross-border healthcare commuters (Aargau, Basel Landschaft, Basel Stadt, Schaffhausen, Thurgau, and Zürich). Control cantons are cantons with close to zero cross-border commuters further inland (Glarus, Luzern, Nidwalden, Obwalden, Schwyz, Uri, and Zug). Population density is measured as inhabitants per square kilometer and GDP per inhabitant is measured in current prices. Healthcare staffing variables are measured in full-time equivalents (FTE) per 1,000 inhabitants. Life expectancy is measured in years.

Table C.21: Staffing rates in Switzerland

	Overall		Germans			
	Hospital staff	Nursing	Hospital staff	Nursing	Doctors	MTA
Post $\times$ Treatment	778.91 (606.97)	383.21 (297.76)	298.09** (112.62)	156.43** (58.63)	43.01 (29.74)	-6.52 (10.85)
Mean of Y	7,440.53	3,054.81	1,378.12	567.88	394.30	166.92
Std. Dev. of Y	7,650.99	3,107.37	1,382.37	600.40	411.74	164.82
Rel. effect size	+10.47%	+12.55%	+21.63%	+27.55%	+10.91%	-3.91%
Observations	70	70	70	70	70	70

Notes: This table shows the association between the Swiss Franc Stabilization (SFS) in 2011 and hospital staffing outcomes in Switzerland at the canton level. Outcome variables are full-time equivalents (FTE) of hospital personnel, overall and by occupation group, and separately for staff of German nationality (GER). Displayed coefficients reflect difference-in-differences estimates based on Equation 1. Standard errors in parentheses are robust and clustered at the canton level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The relative effect size is computed as $100 \times \frac{\text{Post} \times \text{Treatment}}{\text{Mean of } Y}$. Treated cantons are those with the highest number of German cross-border healthcare commuters (Aargau, Basel Landschaft, Basel Stadt, Schaffhausen, Thurgau, and Zürich). Control cantons are cantons with close to zero cross-border commuters further inland (Glarus, Luzern, Nidwalden, Obwalden, Schwyz, Uri, and Zug).

Table C.22: Hospital capacity, utilization, and health outcomes in Switzerland

	Population	Beds	Inpatients	Mortality	Life expectancy
Post $\times$ Treatment	18,494.21 (11,753.88)	-34.00 (44.02)	4,104.96** (1,810.33)	-0.02 (0.18)	-0.16 (0.21)
Mean of Y	276,783.85	1,314.00	33,703.85	7.93	82.40
Std. Dev. of Y	375,488.55	1,758.64	46,155.66	1.37	0.71
Rel. effect size	+6.68%	-2.59%	+12.18%	-0.25%	-0.19%
Observations	104	104	104	104	104

Notes: This table shows the association between the Swiss Franc Stabilization (SFS) in 2011 and population size, hospital capacity and utilization, and health outcomes in Switzerland at the canton level. Outcome variables are total population, the number of hospital beds, the number of inpatient cases, mortality (death cases per 100,000 inhabitants), and life expectancy at birth (years). Displayed coefficients reflect difference-in-differences estimates based on Equation 1. Standard errors in parentheses are robust and clustered at the canton level. Stars denote significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The mean and standard deviation of the outcome variable Y refer to the year 2011. The relative effect size is computed as $100 \times \frac{\text{Post} \times \text{Treatment}}{\text{Mean of } Y}$. Treated cantons are those with the highest number of German cross-border healthcare commuters (Aargau, Basel Landschaft, Basel Stadt, Schaffhausen, Thurgau, and Zürich). Control cantons are cantons with close to zero cross-border commuters further inland (Glarus, Luzern, Nidwalden, Obwalden, Schwyz, Uri, and Zug).



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**ZEW – Leibniz-Zentrum für Europäische
Wirtschaftsforschung GmbH Mannheim**

ZEW – Leibniz Centre for European
Economic Research

L 7,1 · 68161 Mannheim · Germany

Phone +49 621 1235-01

info@zew.de · zew.de

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