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# The reaction of wages to skill shortage in nursing

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**Abstract:** This study investigates wage responses to labor shortages in nursing, based on data from the German Structure of Earnings Survey and the German Employment Agency. We employ a fixed effects instrumental variables approach to address endogeneity concerns. Our findings reveal that wages in privately owned institutions and among nurses not bound by collective agreements adjust in response to labor shortages, unlike their counterparts in public institutions or those under collective agreements. We find wage reactions at smaller employers but not at large ones, indicating employer market power. The wage responsiveness is primarily observed in long term care facilities, with no significant changes in hospital settings, irrespective of ownership or collective agreement status or size. Our results suggest the presence of market frictions and highlight areas for policy intervention to alleviate nursing shortages.

**Keywords:** nurses; labor demand; labor supply; wages

**JEL-Classification:** I11; J21; J22; J31

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# 1 Introduction

Skilled labor shortage and labor market tightness have become issues in several industries in developed economies. A lively debate of the scope and consequences of the issue ranges from the scientific (Cappelli 2015, Brunello & Wruuck 2021) to the public discussion (*Why American unemployment needs to rise* 11/24/2022, Fuest & Jäger 2023). Recently, the debate has further been stirred up by an aggravation of the shortage on the labor market as a result of the Covid pandemic (Autor et al. 2023). One publicly advocated mean to tackle the shortages put forward by politicians as well as economists is to rise wages. Economic theory indicates that the price of labor should rise as scarcity increases, albeit not uniformly across the economy (Burdett & Mortensen 1998, Mortensen & Pissarides 1999, Elsby 2009, Autor et al. 2023). This paper analyses the reactions to demand-induced changes in skill shortage and how they differ by employer and institutional characteristics.

In our study, we focus on the market for nurses in health and care institutions, which is especially well suited to analyze this question. Firstly, it is particularly affected by increasing skill shortages (European Centre for the Development of Vocational Training. 2015, Drennan & Ross 2019). Secondly, this shortage is partly a result of the growing shares and populations of elderly people (Sachverständigenrat 2018), a development that we consider to be independent of wage-setting behavior in the care sector, and which we therefore use to identify a causal local effect of increasingly tight market conditions. Thirdly, this particular labor market offers valuable insights because nurses in Germany, despite their rather uniform educational backgrounds, work under varying market conditions and institutional settings, such as private versus public employers and facilities of different sizes. These factors may lead to diverse reactions to changes in labor market tightness prompted by fluctuating demand. Lastly, labor shortages in the nursing sector are of significant public concern, given the critical role nurses play in providing health and geriatric care services.

To study the wage reactions, we analyze data for the years 2010 to 2018, a period of increasing skill shortage in nursing (Bundesagentur für Arbeit 2023). We employ three waves of the German Structure of Earnings Survey (GSES), a linked employer-employee data set, combined with information on regional skill shortage from the German Federal Employment Agency. As wages and labor demand as well as supply are determined simultaneously, we employ an instrumental variable

approach to address endogeneity issues. We use the fact that the demand for health and care services increases significantly with age and instrument regional labor shortage by the regional share of inhabitants who are at least 65 years old. To account for unobserved regional factors such as the regional economic performance, we employ a fixed effects estimation approach. As wage reactions may be differentiated and considerably mitigated by specific institutional conditions or employer characteristics, we analyze the reactions in different settings – hospitals and long term care institutions – , in different ownership structures – publicly owned and privately owned – , as well as differentiated by size and collective bargaining participation.

We find wage reactions to skill shortages in some parts of the nursing labor market, only. Nurses receive higher wages when skill shortage is higher if they are employed in private institutions. For public institutions, we find no significant relation. We further find wage reactions if nurses are not employed under a collective agreement, as opposed to when their wage is set in a collective bargaining process. Also, we find wages to react in smaller institutions but not in large ones. The differences in wage reactions partly match economic theory and earlier findings. Wage setting under collective agreements, at public employers, and in larger institutions may be rigid, limiting wage adjustment not only downward but also upward (Elsby 2009, Babecký et al. 2010). Hospitals may be more productive and therefore pay higher wages to start with than long term care institutions, the stronger wage reaction of the latter is therefore in line with theoretical arguments and previous findings (Brunow et al. 2022, Autor et al. 2023).

Further explanations for different reactions and the straight-out missing of reactions in parts of the market can be rooted in the institutional setting in the health and care sector in Germany. Public employers often offer contracts subject to collective bargaining rules and we find firms operating under such contracts do not react to shortages. This seems reasonable as the collective agreements for hospitals and care institutions are often supra-regional in nature. What is more, public employers, public hospitals, in particular, are often large institutions with relatively low regional competition, and their number is relatively small compared to the number of long term care institutions, shrinking further during our study period, while the number of the latter grew (Simon 2021). These employers may be able to exert market power, being less inclined to raise wages in shortage periods (Prager & Schmitt 2021). Lastly, the restrictive price-setting in the market for health and care services in Germany, set out in section 3 may significantly restrict market reactions to demand increases, resulting in a significant delay in price adjustments. Overall, we find wage reactions to demand-induced changes in tightness of the market for relatively

homogeneous nursing labor to be heterogeneous with respect to employer characteristics and the related institutional differences.

The contribution of this paper lies, on the one hand, in the evidence on wage reactions in the market, as a whole, and, on the other hand, in the differentiated analysis of these reactions, or their absence. As our work uses the example of care workers, it is further closely related to the literature on the influence of wages on the labor supply of nurses, where many studies analyze nurses' labor supply, but wage reactions to shortages are hardly analyzed. We also provide fresh evidence on the role of employer characteristics and institutional settings in the wage structure.

The rest of the paper is organized as follows. We give an overview over the economic background and the related literature in section 2. We provide background on the relation between demographic aging, the demand for care services, and nursing wages and the institutional setting of care provision in Germany in section 3. In section 4, we describe our data sources. In section 5, we lay out our methodological approach. We present the results of our empirical analysis in section 6 before we offer a discussion of our results and concluding remarks in section 7.

## **2 Economic background and literature**

Economic models of the labor market suggest that wages will rise in response to an intensification of the labor shortage due to increased demand. The canonical model under full-competition as well as models in a search and matching framework, whether under perfect or imperfect competition predict higher wages in a tighter labor market as reaction to such changes (Burdett & Mortensen 1998, Mortensen & Pissarides 1999, Manning 2021, Autor et al. 2023). However, further differentiation of these mechanisms along different market conditions and employer characteristics yield different predictions of the models with respect to whether and how strong wages react to demand induced shifts on the labor market. Wage reactions may be heterogeneous due to differences in employer productivity, leading us to expect stronger wage reactions in less productive firms (Burdett & Mortensen 1998, Autor et al. 2023). Wage reactions can further be attenuated if wages are not fully flexible due to constraints imposed by labor market institutions or collective bargaining agreements. Such rigidity should not only hinder cuts in (nominal or real) wages, but also, and as a result, mitigate wage increases, as the employers affected by downward

wage rigidity should on average already pay higher wages and forward looking employers will dampen wage rises in the knowledge that they will not be able to enforce wage cuts in the future (Elsby 2009).

In line with theory, empirical studies which examine the relationship between labor market tightness and wages, largely find a positive relationship between tightness and wages. Though Fang (2009) finds no evidence that employers raise wages as response to labor shortages using longitudinal survey data from Canada, other, more recent studies establish such a positive relation. Notowidigdo (2020) uses a Bartik (1991)-type identification strategy to estimate responses to local labor demand shocks and presents evidence on significant positive wage reactions to such shocks; Frohm (2020) analyses data from a large representative business survey in Sweden and also finds a significant association between reported shortage and wage growth. Taking a macro perspective, Domash & Summers (2022) show a positive relation between wage inflation and several indicators of labor market tightness, among them vacancy rates, for the U.S. labor market. In a recent study, Autor et al. (2023) analyze the effects of the increase in labor market tightness resulting from the Covid-19 pandemic on wages and wage compression. Consistent with the imperfectly competitive model they employ, they find significant overall wage growth following increases in tightness, which is stronger for low-wage employees at less productive firms, leading to wage compression. In a report covering several developed countries and the European Union, Duval et al. (2022) describe a positive relation between labor market tightness and wage growth, particularly among low-pay jobs, high-paying jobs are less affected.

On a more specific level, wage reactions to shortages of (well-educated) skilled workers have been analyzed only sporadically and mostly descriptively so far. Using survey data on Australian small- and medium-sized enterprises (SMEs), Healy et al. (2015) find that firms report to react to skill shortage by—among other measures—offering higher wages or improving working conditions. However, these measures cannot be differentiated because of the design of the survey. A couple of studies analyze reactions to skill shortages in Germany. Brunow et al. (2022) analyze how labor market tightness at market entry affects the wage growth of young workers. The authors assume that differences in labor market tightness are exogenous and therefore not simultaneously determined with individual wages. They find significant effects on wages, which are however significantly dampened for health-care workers, which they attribute to institutional specificity in the health care sector. Like Autor et al. (2023), Brunow et al. (2022) find stronger effects on wages at the lower part of the wage distribution. Burstedde & Schüler (2020), employing fixed-

effects estimation of data on full-time employees in Germany, find mixed associations between skill shortage and wages. Whereas the highest trained individuals can gain higher wages because of skill shortage, the medium trained individuals do not. The authors focus on wage reactions at occupation level and control for changes in the age composition and the share of full time employed. They do not account for further composition effects because of individual factors, such as experience or firm characteristics, and the simultaneous determination of wages and labor supply and demand. In a further report employing German data, Arnold et al. (2017) present results from establishment surveys, showing that employers with problems staffing open positions report to be willing to pay higher wages to overcome these problems. They further analyze linked employer-employee data to study effects of skill shortage on entrance wages relative to wages of the existing labor force and find significant effects only for wages of low skilled employees. The authors point to possible biases in the wage response estimates and the possibility of addressing these with an instrumental variable approach, do not apply such an approach due to the small number of cases, however. Overall, causal evidence on wage reactions to shortages in skilled labor is scarce.<sup>1</sup> Regarding widely missing nursing personnel such evidence is, to our best knowledge, missing.

Rigid wage setting circumstances can be important in our analysis setting, as wage rigidity does not only compress wage cuts but also wage increases (Elsby 2009). Wage rigidity has been broadly documented in several studies. Based on the model and in line with the findings presented by Elsby (2009), Stüber & Beissinger (2012) yield further evidence for a compression of wage increases based on German data. Most recently, Ehrlich & Montes (2024) identify a substantial extent of wage rigidity in West-Germany throughout the 90s and early 2000s. Further studies have established a link between rigid wage setting and market and firm conditions. Dustmann & Schönberg (2009) document stronger wage compression in unionized firms in Germany. Using data from a survey on European firms, Babecký et al. (2010) find that collective bargaining coverage and employment protection as well as firm size and more labor intensive work are associated with wage rigidity.

We differentiate our analysis over different parts of the health and care market in Germany and find differences in terms of whether the effects of increased demand actually pass through to wages. Those differences can possibly be explained by different levels of wage rigidity, productivity,

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<sup>1</sup>In their literature review on skill mismatch, covering skill shortage, McGuinness et al. (2018) only consider two papers, analyzing this relation.

and the institutional restrictions. We discuss the respective background and further institutional circumstances and possible market frictions in section 3.

Our study explores wage reactions to tightness-inducing demand changes on the example of nurses. Some studies have made arguments with respect to wage setting in the nursing labor market, specifically. A major topic of discussion is whether the labor market for nurses - a classic example of monopsonistic competition in the past - is in fact a monopsonistic market (Hirsch & Schumacher 1995, 2005, Staiger et al. 2010, Hirsch & Schumacher 2012, Matsudaira 2014). In two U.S. studies with quasi-experimental design, Matsudaira (2014) finds no evidence of monopsonistic wage setting in long-term care facilities, whereas Staiger et al. (2010) find evidence of a monopsonistic labor market for hospital nurses. Addressing the issue more directly, Prager & Schmitt (2021) study the effects of employer consolidation in the hospital market and find decelerated wage growth of nursing staff because of increased employer market power. Heyes (2005) puts forward another argument than simple profit maximizing reasons for why nurses' wages may further be artificially low, i.e., that public institutions could set artificially low wages in order to use them as a sorting device, attracting only the sort of nurses with the "right" motivation, not those who are motivated by high pay.

In the political and public debate, wage raises for the scarce nursing personnel are motivated by the argument that rising wages increase nurse labor supply. Empirical results support this argument. Though a number of studies that focus on the intensive margin find nurses' labor supply to be rather unresponsive to wage changes or yield inconclusive results (Antonazzo et al. 2003, Shields 2004, Di Tommaso et al. 2009, Andreassen et al. 2017), reactions have been found to be significant and positive when effects on both the intensive and the extensive margin are taken into account (Hanel et al. 2014). Higher wages have further been found to have a positive effect on the attractiveness of care jobs (Scott 2001, Doiron et al. 2014, Scott et al. 2015, Song et al. 2015, Fields et al. 2018, KroczeK & Späth 2022), nurses' job and occupation retention (Holmås 2002, Frijters et al. 2007, Kankaanranta & Rissanen 2008, KroczeK 2023), and pupils' decision to enter the nursing profession (Kugler 2021). Moreover, nurse shortages have been found to be higher where nurses' remuneration is less competitive (Elliott et al. 2007, Combes et al. 2015, 2018). Political and public demands for increased wages for nurses with the intention to increase nurse labor supply are therefore far from irrational. On the aggregate level, such wage increases only seem to occur slowly and unequally, however (Carstensen et al. 2022).



### 3 Institutional background and outset

#### 3.1 Demographic aging, skill shortage in nursing, and wages

Demographic aging is a global trend that does not spare Germany (Bloom 2020). In recent decades, the average age of the German population and the number of aged people in Germany increased strongly. As the probability that an individual needs care services increases sharply from the late sixties on and rises almost exponentially after the age of 75, the demand for health and care services increased significantly (Bogai 2017, Sachverständigenrat 2018). Already, demographic aging induced a shortage in skilled nursing labor (Sachverständigenrat 2018) that continues to this day and is reflected in a very tight labor market for nursing staff (Bundesagentur für Arbeit 2024). Demographic aging could also reduce the supply of workers and thus exacerbate the shortage. So far, however, the number of employees in Germany has risen steadily across all professions as well as in the care sector. This situation could change as soon as the so called baby boomers leave the labor market (Klinger & Fuchs 2020).

	Skilled Nurses				
	Average Age (years)	Share of pop. aged 65+	Vacant Positions	Vacancy Time (days)	Hourly Wage (real, in Euro)
Year					
2010	43.23	0.206	11,937	90	17.889
2014	43.90	0.211	13,792	115	17.634
2018	44.06	0.215	21,858	169	18.939

**Table 1** – Measures of demographic aging, skill shortage in nursing, and hourly wages of skilled nurses

**Source:** Own calculations based on data from Bundesagentur für Arbeit (2022), BBSR (2022), and GSES 2010, 2014, and 2018. Survey weights were used for all calculations with GSES 2010, 2014, and 2018.

Our study covers the years 2010 to 2018, a period clearly affected by the developments described. As can be seen in table 1, the average age of the German population rose from 43.23 to 44.06 years and the share of individuals of at least 65 years of age increased by four percent from 0.206 to 0.215. The number of open positions for skilled nurses increased by just over 80 percent and the time such positions could not be staffed increased by almost 90 percent. With an increase of

six percent between 2010 and 2018, real wages of skilled nurses did only rise slightly in the same period. Although demographic change and skill shortage did not develop uniformly throughout Germany, the corresponding association between demographic change and skill shortage transfers to a more fine-grained level. We elaborate more on this association at the regional level in section 5.1.

The past decades have seen a rising demand for nursing labor in the German labor market. The market for care and health services grew, both visible in the number of hospital treatments and the increase in the number of providers of geriatric care (Simon 2021). Yet, nurses' labor supply did not keep up with demand, leading to an increasingly tight nursing labor market.

## **3.2 Market conditions and market frictions**

Though nurses are rather homogeneous with regard to their qualification and training, the market for health and care services in Germany is highly heterogeneous. More specifically, the market is characterized by heterogeneous employer characteristics and institutional settings, which levy different frictions on wage responses.

### **Nursing occupations in Germany**

In Germany, the profession of registered nursing is subject to stringent regulations. To qualify as a registered nurse, one must complete a three-year training program. This standardization results in a workforce that is relatively homogeneous in terms of training duration. While the specific content of the training programs for health and geriatric nurses differs, graduates from both streams are employed in hospitals as well as long-term care services. However, geriatric nurses are significantly less likely to work in hospitals compared to how frequently health nurses work in outpatient or inpatient long-term care facilities (refer to A11 in the appendix). Recently, the differentiation between the various vocational training courses was eliminated, leading to a unified training curriculum for nurses across Germany.

## The role of the institutional setting in Germany

In Germany, health and care services are delivered across three primary settings. Firstly, hospitals, which employ the majority of nurses. In 2020, approximately 486,000 individuals worked in the nursing departments of German hospitals (Statistisches Bundesamt 2022*b*). In terms of ownership, publicly owned hospitals account for nearly 50 percent of all hospital beds; non-profit organizations, such as religious groups, provide around 30 percent, while privately owned commercial hospitals supply about 20 percent of the beds (numbers for 2018, see Simon 2021). Secondly, inpatient care services, predominantly nursing homes, focus mainly on geriatric care. These facilities are primarily managed by non-profit and commercial private entities, with public ownership playing a minimal role. In 2019, about 313,000 nurses were employed in inpatient care services (Simon 2021). Thirdly, outpatient care services cater to geriatric and general healthcare needs, with a similar ownership structure to inpatient care services where commercial and non-profit private sectors dominate. In this sector, approximately 222,000 nurses were working in 2019 (Simon 2021). Specific market frictions can occur in each of these settings.

From the perspective of a profit-maximizing employer, the most significant differences in this fragmented market are found in the strict regulation of pricing and cost reimbursement for health and care services within the predominantly public insurance system. In all settings, care services are primarily funded by statutory insurance carriers (health and long-term care insurance), although the methods and amounts of reimbursement to service providers vary. The services provided and the fees that institutions can charge for health and geriatric care are tightly regulated and vary between the settings described above (Simon 2021). In the healthcare sector, including hospitals and outpatient services, health insurance typically covers the full costs of services. Conversely, geriatric nursing services are financed by long-term care insurance, which only pays a portion of the expenses; the remainder must be covered by the care recipients (Bogai 2017).

Due to significant restrictions on price setting, an increasing demand for health and care services may not necessarily lead to higher prices. This is particularly true in healthcare, where nearly all costs are borne by statutory insurances. Moreover, while the prices for long-term care services are negotiated between care providers and payers at the state level, health service prices are negotiated nationally. Therefore, prices for health services do not reflect regional variation in demand. To account for the possible differences in market frictions, our analysis distinguishes between hospitals and long-term care institutions (both outpatient and inpatient facilities). Given

that the division between private and public facilities is a defining characteristic of the German health and care services market, our analysis further differentiates by type of institution, whether private or public.

The institutional framework in Germany significantly influences wage setting. The introduction of a specific minimum wage for nurses in 2010 establishes a lower bound for nurse salaries, although its impact has been limited since few nurses earned wages below this threshold (Harsch & Verbeek 2012). Furthermore, wages are frequently determined by collective agreements that encompass a substantial portion of care personnel, especially in hospitals. In contrast, collective agreements are less prevalent in both inpatient and outpatient care settings (Bogai 2017). Our analyses are conducted separately, depending on whether an employer is governed by a collective agreement.

Hospitals and long term care institutions differ significantly in size. According to the German Federal Statistical Office, in 2022, general hospitals in Germany had between under 50 and over 1,000 hospital beds (Statistisches Bundesamt 2023). In 2021, long term inpatient care facilities cared for between less than ten and over 300 care recipients, though the overwhelming number cared for between ten and 150 recipients. Also in 2021, outpatient care providers had between below ten and more than 150 care recipients (Statistisches Bundesamt 2022a). As employer size has long been recognized to be positively correlated with wages (Green et al. 1996, Oi & Idson 1999), we differentiate between institutions of different size, measured by the number of employees.

## **Differences in wages**

Wage disparities across different parts of the care labor market are evident, as detailed in table A12, which breaks down average wages by employer characteristics. The most significant differences occur between care settings. Nurses in hospitals command the highest wages, followed by those in inpatient long-term care, who earn more than outpatient care nurses but considerably less than hospital nurses. There are also differences by type of ownership, collective bargaining situation and size. Wages are higher in organizations that are predominantly publicly owned, in companies covered by collective agreements and in large companies. The wage trends also vary across these characteristics. Hospital nurses, nurses in public institutions, and those covered by collective agreements experienced wage growth from 2010 to 2014 and again from 2014 to 2018.

In contrast, wages for nurses in outpatient and long-term inpatient care, in private institutions, and not covered by a collective agreement declined in real terms between 2010 and 2014. With regard to the size of the institution, the differences in wage growth are less distinct.

Year	2010	2014	2018
Field of care			
All Institutions	17.889	17.634	18.939
Hospitals	19.167	19.408	20.910
Outpatient care	15.448	15.112	16.087
Long Term care	16.386	15.589	16.826
Ownership			
Public institution	19.227	19.421	20.986
Private institution	17.406	17.109	18.370
Collective bargaining situation			
Collective agreement	18.958	19.018	20.588
No collective agreement	16.832	16.454	17.025
Size by group			
Small or medium institution	16.526	15.955	17.163
Large institution	19.109	19.101	20.605

**Table 2** – Average real hourly wages by type of institution in Euro by year

**Source:** Own calculations based on GSES 2010, 2014, and 2018. Survey weights were used for all calculations.

## 4 Data and definitions

To analyze how nurse wages respond to skill shortages, we utilize data from the German Structure of Earnings Survey (GSES). This quadrennial survey is conducted by the Federal Statistical Office and is mandatory for respondents. Our analysis includes data from the 2010, 2014, and 2018 survey waves, which provide comprehensive information on both employers and employees. Crucially, the GSES offers detailed insights into employees' hourly wages and other aspects of compensation, such as supplements and bonuses, which are particularly pertinent in care profes-

sions.<sup>2</sup> Additionally, the data encompass a variety of employee characteristics (e.g., age, sex, and education), job details (e.g., workload and tenure), and employer information (e.g., firm size and industry classification).

The German Structure of Earnings Survey (GSES) offers specific advantages over other datasets for our analysis, chiefly its high reliability due to its mandatory nature and the detailed information it provides on hourly wages. This detail is particularly critical given the high prevalence of part-time employment in nursing, as noted by (Bogai 2017). However, a notable limitation of the GSES is that it contains repeated cross-sectional data; that is, it does not track individuals and firms over time. This absence precludes the use of panel data methods at the individual level. Additionally, due to the two-stage random sampling procedure, analyses must be conducted using appropriate sample weights. These weights are included in the dataset and are employed in our analysis, which concentrates on nurses working in the health and social sectors. Table A1-A3 present summary statistics on the socio-economic characteristics of the nurses included in our data.

The other data source we use is information on the regional level containing measures of skill shortage as well as further characteristics indicating the demand for care services. To measure shortage in skilled labor, particularly in nursing, we use indicators on the level of Planning Regions. Skill shortages have long been interpreted as difficulties in filling vacancies (Green et al. 1998, McGuinness et al. 2018), which have been operationalized through firms' reports on hard-to-fill vacancies (Bennett & McGuinness 2009), the number of vacancies (Haskel & Martin 1993, Bellmann & Hübler 2014, Horbach & Rammer 2022), the vacancy rate (Bennett & McGuinness 2009), and the duration for which positions have remained vacant (Osterman & Weaver 2014). Most often, these measures are derived from employer surveys.

Since our data lack firm-level information on skill shortages and because survey data on skill shortages can be susceptible to reporting biases by employers (Cappelli 2015), we utilize regional-level data from the German Federal Employment Agency (BA). The German Federal Employment Agency (BA) collects data on the number of vacancies, the average duration of vacancies at the

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<sup>2</sup>Other potentially relevant datasets for wage analysis, such as administrative data from the German Social Insurance at the Federal Employment Agency, lack sufficient information on working hours. Additionally, voluntary surveys like the German Socio-Economic Panel have much smaller sample sizes, especially concerning the specific occupations central to this paper.

occupational level, occupation-specific unemployment rates, and the unemployment-to-job ratio by occupation (German Federal Employment Agency, BA). Although all these measures provide information on shortage situations, we use the Federal Employment Agency's primary shortage indicator, the average time positions remain unfilled, as the shortage indicator in our analysis. This is because, first, it reflects the outcomes of actual market processes. While a long vacancy duration can also be due to other reasons than a shortage, such as inefficient search processes or poor working conditions, the (market) result of a long vacancy clearly indicates problems in filling certain positions. Conversely, the number of vacancies by itself might merely reflect the time it takes to match skills to jobs (Cappelli 2015). Second, unlike the number of job vacancies, the indicator does not depend on the size of the labor market under review. Third, by focusing on the actual market outcome, the indicator abstracts from measures of potential labor supply, like occupation-specific unemployment rates or the unemployment-to-job ratio. Such measures are subject to inaccuracies. For example, it is unclear how many people are fundamentally available to the labor market but are not registered as seeking employment, or how many are registered as job-seekers but are not actually available to the labor market (Statistik der Bundesagentur für Arbeit 2020).

The indicator is available for vacancies across all job types, including those in skilled nursing occupations. It is derived from administrative data, specifically notifications from employers about job vacancies submitted to the BA, and includes various measures involving vacancies reported to the BA by employers (Bundesagentur für Arbeit 2020).

Lastly, we utilize additional indicators on the socio-economic structure and dynamics provided by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) through the INKAR-online tool (BBSR 2022). Specifically, we employ information on the regional age composition of the population in the Planning Regions as a proxy for regional demand for nursing services as instruments. We integrate this information on regional characteristics with GSES data at the level of 96 Planning Regions (RORs).

Tables A1-A3 in the appendix provide summary statistics of the individual, firm, and regional characteristics of the observations used in our analyses.

## 5 Identification strategy

We investigate wage reactions to skilled labor shortage in nursing occupations. Equation 1 presents the structural equation, analyzing the effect of regional skilled labor shortage on individual wages.

$$Y_{it} = \alpha_j + \lambda_t + \rho s_{jt} + \mathbf{X}'_{it}\beta + \varepsilon_{it} \quad (1)$$

In equation 1, the dependant variable  $Y_{it}$  is the natural logarithm of the real hourly wage of individual  $i$  in year  $t$ .  $s_{jt}$  is a measure of regional scarcity of nursing labor in region  $j$  at time  $t$ .  $\mathbf{X}_{it}$  includes individual and firm characteristics which possibly affect wages, such as age, tenure, level of education, and whether a firm is covered by a collective agreement. Regional labor scarcity (and further regional variables) are measured on the level of Planning Regions (ROR). The main parameter of interest is  $\rho$ , representing the influence of regional labor shortage on wages. Unobserved persistent regional differences, as well as a common time trend, may influence wages and regional skill shortages. We account for such influence by incorporating regional and time fixed effects, represented by  $\alpha_j$  and  $\lambda_t$ , in equation 1.

The identification of  $\rho$  is complicated by the fact that wages are determined simultaneously by both sides of the labor market—supply and demand. Our main hypothesis is that wages should rise in regions where nursing labor is scarce. However, nursing labor supply should increase (or scarcity should at least not increase as fast) where wages are higher or where wages rise faster. In effect, we cannot distinguish between scarcity-induced changes in wages and wage-induced changes in regional labor scarcity. To address this simultaneity issue, we employ an instrumental variables approach (Angrist & Pischke 2009). We discussed the association between the share of highly-aged individuals and the scarcity of nursing labor in section 3.1. We use this relation and instrument  $s_{jt}$  in equation 1 by the share of high-aged individuals.

$$s_{jt} = \gamma_j + \tau_t + \phi z_{jt} + \mathbf{X}'_{it}\eta + v_{jt} \quad (2)$$

Equation 2 presents the first stage, i.e., how the instrument determines regional skilled labor shortage.  $z$  represents the share of highly-aged individuals,  $\gamma_j$  are regional fixed effects,  $\tau_t$  are time fixed effects, and  $\mathbf{X}_{it}$  comprises the same individual and firm characteristics as in equation 1.

We apply two-stage least squares (2SLS) to analyze the effect of changes in nursing labor shortage on nurse wages induced by demographic aging. Under certain assumptions, the estimate of  $\rho$  in



equation 1 gives this local average treatment effect (LATE). The 2SLS results do not apply to wage effects of nursing labor shortage attributable to other causes (Angrist & Pischke 2009). We further discuss these assumptions and the validity of our instrument in section 5.1.

## 5.1 Validity of the instrument

In section 3.1 we described how an aging German population demands more health and care services, which leads to an increasing scarcity in skilled nursing labor. In our analysis, we take up this notion and instrument the regional shortage in skilled nursing labor via an indicator of demographic change. Specifically, we use the natural logarithm of the regional share of individuals aged 65 and older as an instrument. To factor out migration movements of the denominator of our instrument, we employ a linear extrapolation of regional population size since 2009 based on the time series from 1995 to 2009. Our instrument is

$$z_{jt} = \log \left( \frac{N_{65+}}{\tilde{N}_{total,09}} \right), \quad (3)$$

where  $N_{65+}$  is the number of individuals aged 65 and older and  $\tilde{N}_{total,09}$  is the total population size, extrapolated since 2009, i.e., net of shocks in the overall population development.

Under certain assumptions, which we discuss in the following, we can identify the average causal effect of differences in skilled labor shortage induced by demographic aging on nurse wages conditional on covariates  $X$ .

*Independence and exclusion:* We assume  $\{Y_{it}, s_{jt}\} \perp\!\!\!\perp z_{jt} | \mathbf{X}_{it}$ , which means that, conditional on covariates  $\mathbf{X}_{it}$ , our instrument is both independent of the vector of potential outcomes and regional scarcity of nursing labor and affects  $Y$  via  $s$ , only (see, e.g., Angrist & Pischke 2009). A threat to this assumption can be posed by time-constant differences between regions which are associated with nursing wage levels as well as the share of older individuals—e.g., that older individuals systematically cluster in regions with weak economic performance. Another threat arises from shared developments of associations over time—e.g., general economic development and the steady growth of the high-aged population. We account for such associations by introducing regional and time fixed effects. The independence assumption would also be violated by associations between regionally differing changes in the age structure and nursing wages, e.g., due to regional economic shocks and associated migration patterns.

A potential concern specifically relates to the nursing workforce. Identification may be affected if older people migrate from regions with high nursing wages to regions with lower nursing wages in order to forego high costs of care. As outlined in section 3, in health care, in hospitals as well as in outpatient health care, health insurances cover the full costs of the respective services, whereas geriatric nursing services are paid for by the long-term care insurance, which only covers a part of the expenditures; the rest has to be borne by the care recipient. Costs of wage raises in geriatric nursing—particularly in long-term inpatient care—could therefore partly be passed on to the care recipients, which may drive old-age migration away from regions with rising wages in geriatric nursing facilities. To analyze this potential issue, we present the results of an estimation of the association between regional average wages and old-age migration in columns (1) and (2) of table A4 in the appendix. We find no significant association and take this as an indication that the identification strategy is not impacted by old-age migration.

Even if there is no association between old age migration and nursing wages, overall migration may be associated with wages in nursing via migration to regions where wages rise more strongly. We present results of regressions of overall net migration on regional average nursing wages in columns (3) and (4) of table A4 in the appendix. Accounting for region and time fixed effects, we do not find a significant association between nursing wages and migration behavior. As overall internal and external migration exceeds migration of older people and may still be specifically prone to economic shocks, we factor out migration movements of the denominator of our instrument. Specifically, instead of the actual observed regional population at time  $t$ ,  $N_{total}$ , we use the extrapolated population size  $\tilde{N}_{total,09}$  as the numerator in our instrument.<sup>3</sup>

The independence assumption could also be violated, if regions which exhibit a stronger increase in the share of older individuals substantially differ from those regions with a weaker increase. Differences in the economic situation are of special concern due to their relation to wages. We study the association between, mostly economic, regional characteristics and our instrument and with the variation remaining in our instrument after accounting for regional and time fixed-effects via the following regression analysis (Caliendo et al. 2017 follow a similar approach in their identification strategy and call this the adjusted instrument):

$$z_{jt} = \alpha_j + \lambda_t + V_{jt}, \quad (4)$$

$$\hat{V}_{jt} = \delta X_{jt} + U_{jt}. \quad (5)$$

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<sup>3</sup>A specification where we extrapolate the population development since 2005 yields comparable results.

In the first step, we regress the instrument  $z$  on regional and time fixed effects,  $\alpha_j$  and  $\lambda_t$ , thereby adjusting the instrument by accounting for fixed regional differences and a common time trend. The remaining residual  $\hat{V}_{jt}$ —the adjusted instrument—is then the instrument net of regional and time fixed effects. In a second step, we analyze relations between  $\hat{V}_{jt}$  and regional characteristics  $X_{jt}$ . A graphical representation illustrates how the inclusion of regional and time fixed effects removes potentially problematic correlations between our instrument and regional characteristics. Figure A1 in the appendix shows scatter plots of  $z$  versus the log of several regional characteristics. All plots seem to point to some association between our instrument and the regional characteristics. Figure A2 shows scatter plots of the residual from equation 4— $\hat{V}_{jt}$ —on the same regional characteristics. After accounting for regional and time fixed effects, hardly any association between the adjusted instrument and the regional characteristics is visible. We also analyze this arithmetically. To test whether the residual is associated with changes in regional characteristics, we regress the residual  $\hat{V}_{jt}$  on regional characteristics  $X_{jt}$ . The results of the regression are given in table A9, in the appendix. When we regress  $z$  on the regional characteristics, the coefficients on five characteristics are significant on the five percent level and explain a large part of the variation in  $z$  ( $R^2 = 0.6$ ). After accounting for region and year fixed effects, the regional variables explain only 1.2 percent of the variance in the adjusted instrument  $\hat{V}_{jt}$  and only one characteristic is significant on the five percent level. To further check whether a possible association between the adjusted instrument  $\hat{V}_{jt}$  and the local economic situation affects our identification, we calculate additional specifications of our main estimates using regional GDP per capita as an additional covariate. Table A8 in the appendix presents the respective results. We do not find a statistically significant relationship with GDP per person and our results remain largely unchanged.<sup>4</sup>

The assumption that the share of older individuals affects wages via labor shortage will be invalid if the instrument has a direct influence on wages. A possible direct path would be via the age composition of the workforce. With demographic aging, the average age (and thus, experience) of the workforce is increasing, leading to rising wages. We control for this by taking into account individual characteristics in our wage regression. In order to investigate whether the process of demographic aging in itself—i.e., independently of skills shortages—has an influence on the wage

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<sup>4</sup>We further investigate whether there is a statistically significant relation between changes in regional average nursing wages and GDP per capita. Controlling for region and time fixed effects, we do not find a statistical significant relation. We present the results in table A5 in the appendix.

structure, we examine the correlation with wages in other occupations that are less affected by skill shortages despite demographic trends. Table A7 in the appendix presents corresponding results of regressions of the regional share of older persons on wages in sectors which are not affected by skill shortages. We analyze three groups: individuals in the management and technical services industry, individuals in wholesale and retail, and a comparison group of individuals employed in industries, in which former nurses often work, mostly social institutions. We do not find statistically significant relations between the local share of inhabitants of at least 65 years and wages, neither in the two first, relatively different, industries nor in the relatively similar comparison group. We therefore find no direct influence of older peoples' population share on wages.

*First stage:* We further assume that the share of high aged individuals  $z$  actually has an effect on the regional scarcity of nursing labor  $s$ , i.e., that  $\phi$  in equation 2 is different from zero. A widely used rule of thumb for this assumption is that the respective F-Statistics of the instruments in the first stage regression should exceed 10 (Staiger & Stock 1997). Table 3 shows the results of linear regressions of the natural logarithm of the average vacancy time in days of positions of all skilled nurses, nurses in inpatient and outpatient long term care institutions, and nurses in hospitals on the natural logarithm of the regional share of individuals aged 65 years and older. The table presents results including region and year fixed effects as well as the individual level control variables we employ in our main analysis.<sup>5</sup> For all specifications, the results show that the vacancy times are significantly higher where the number of high-aged individuals is higher. Also, the results point to a strong association between the instrument and the endogenous variables as the F-Statistic exceed 10.<sup>6</sup>

*Monotonicity:* Last, we assume monotonicity. This assumption rules out the possibility of decreases in skilled labor shortage in nursing as a result of demographic aging. It seems in fact implausible that an increasing share of high aged individuals would reduce shortages in the nurse labor force by supplying labor in such a physically and mentally demanding occupation above pension age or

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<sup>5</sup>We estimate the model  $s_{jt} = \alpha_j + \lambda_t + \gamma z_{jt} + \varepsilon_{jt}$  and test the hypothesis of  $\gamma$  being equal to zero.

<sup>6</sup>Table A6 in the appendix shows the respective results regarding the average vacancy time of positions of health nurses, geriatric nurses, and all skilled nurses on the regional share of individuals aged 65 years and older. The table presents results including solely region fixed effects and including region as well as year fixed effects, and including region and year fixed effects as well as the individual level control variables. Again, the results point to a strong association between the instrument and the endogenous variables.

by becoming more healthy.

	All controls		
	All Skilled Nurses	Care Institutions	Hospitals
log(share individuals aged 65+)	3.518*** [0.731]	4.121*** [0.979]	3.002*** [0.682]
Year 2010 (base)			
Year 2014	0.192*** [0.039]	0.222*** [0.047]	0.137*** [0.043]
Year 2018	0.398*** [0.071]	0.429*** [0.956]	0.332*** [0.074]
Constant	-6.189*** [2.222]	-7.927*** [2.376]	-4.701** [2.070]
Region FEs	X	X	X
Individual level controls	X	X	X
F-Statistic	23.15	17.71	19.35
N	58,769	16,433	33,190

**Table 3** – Results from fixed effects regressions on the association between average vacancies in days and share of individuals aged 65+ years

**Notes:** Standard errors are clustered by Planning Region and given in square brackets. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Regressions further include Planning Region fixed effects where stated, respective coefficients are omitted due to reasons of clarity. F-Statistic refers to the F-Statistic of the instrument, Individuals of at least 65 years of age.

**Source:** Own calculations based on data from Bundesagentur für Arbeit (2022) and BBSR (2022).

## 5.2 Accounting for institutional differences

The specific institutional setting in Germany, as described in section 3, may mitigate the effect of skill shortage on wages, or, under certain circumstances, even obstruct it. To analyze whether different institutional circumstances for hospitals and long term care facilities lead to differences in wage reactions, we calculate separate estimations for the different institutional settings. To

account for differences according to employer size, we further differentiate with respect to the number of employees. Differences may further arise between institutions which pay in accordance with a collective agreement and those which do not as well as between public and private institutions. To study these possible differences, we differentiate our estimations along all these groups.

## 6 Results

In tables 4 and 5, we report the results of our OLS and 2SLS estimations of nurse wages on regional skill shortage. The upper parts of the tables present the results of the fixed effects regressions of log hourly wages on the log of the average vacancy time. The lower parts show the results of the 2SLS fixed effects estimations, where we instrumented log vacancy time with the log of the regional share of individuals aged 65 and older. Estimates in the lower parts therefore represent LATEs, reflecting the effects of changes in labor scarcity induced by demographic aging. All estimated models include region and year fixed effects.

Estimation results for skilled nurses across all care settings (long-term care and hospitals) are presented in table 4. Column (1) of table 4 presents estimation results without differentiation based on the presence of a collective agreement, ownership structure, or firm size. Without such differentiation, we find no significant effect of the average vacancy duration of nursing positions on nurse wages.

When differentiating based on these characteristics, the wages of private sector nurses and those not covered by a collective agreement are positively related to the regional average vacancy duration, whereas wages of nurses employed in the public sector or under collective agreements are not. Wages are also related to shortages in smaller institutions, but not in larger ones.

In cases where significant positive effects are found, the LATEs estimated in the 2SLS estimation are notably larger than the OLS coefficients. This suggests that the relationship between wages and labor scarcity is indeed endogenous. Specifically, this points to a simultaneous determination of wages and labor scarcity: wages rise as a result of higher demand, as scarcity increases, and supply rises as a result of higher wages, reducing scarcity. Since the two effects are not separated in the OLS estimation, and solely the 2SLS estimation focuses on demand-induced effects, the

Regression results, dependent variable: log of gross hourly wage							
All Skilled Nurses							
Subsample	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Collective agreement	-	Yes	No				
Public sector	-		Yes	No			
Large institution	-			Yes	No	Yes	No
OLS results							
log(vacancy time)	0.025	-0.018	0.079***	0.001	0.040	-0.008	0.066*
Standard error	[0.019]	[0.018]	[0.030]	[0.024]	[0.025]	[0.013]	[0.019]
N	58,769	31,811	26,958	16,718	42,051	34,141	24,628
2SLS results							
log(vacancy time)	0.069	0.014	0.177**	-0.064	0.147**	-0.003	0.206**
Standard error	[0.049]	[0.037]	[0.082]	[0.061]	[0.064]	[0.038]	[0.090]
N	58,769	31,811	26,958	16,718	42,051	34,141	24,628
F-Stat. 1st stage	23.15	30.89	17.10	14.78	21.59	23.48	20.34

**Table 4** – Results of OLS and 2SLS regressions – log-wage, all skilled nurses

**Notes:** Standard errors are clustered by Planning Region. All regressions include year and Planning Region fixed effects, age grouped in three categories, tenure grouped in three categories, type of qualification, sex, and the natural logarithm of regional GDP per capita. Company size categories are not included in the regressions differentiated by size; the other regressions include company size in three groups. \*\*\*, \*\*, \*,: Asterisks indicate significance of coefficients at the conventional significance levels of 1%, 5%, and 10%, respectively. Abbreviations: *sum* refers to total number of vacancies for skilled health and geriatric nursing positions. *Health N.* refers to vacancies for skilled health nursing positions. **Source:** Own calculations based on GSES 2010, 2014, and 2018, and data from Bundesagentur für Arbeit (2022) and BBSR (2022). Survey weights were used for all calculations.

Regression results, dependent variable: log of gross hourly wage														
	Care institutions						Hospitals							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Subsample	-	Yes	No					-	Yes	No				
Collective agreement	-			Yes	No			-			Yes	No		
Public sector	-					Yes	No	-					Yes	No
Large institution	-						Yes	No					Yes	No
	OLS Results						OLS Results							
log(vacancy time)	0.067**	0.002	0.096***	-0.133	0.077***	0.041	0.076**	0.004	0.008	-0.009	0.024	-0.015	0.000	-0.021
Standard error	[0.029]	[0.037]	[0.036]	[0.152]	[0.029]	[0.047]	[0.034]	[0.014]	[0.016]	[0.026]	[0.024]	[0.019]	[0.012]	[0.075]
N	16,433	4,367	12,066	1,048	15,385	3,506	12,927	33,190	24,857	8,333	16,075	17,115	28,980	4,210
	2SLS Results						2SLS Results							
log(vacancy time)	0.135*	0.066	0.151*	-1.134	0.169**	-0.002	0.166**	0.003	-0.033	0.125	-0.064	0.051	-0.036	0.085
Standard error	[0.070]	[0.084]	[0.088]	[1.065]	[0.071]	[0.099]	[0.084]	[0.038]	[0.050]	[0.088]	[0.072]	[0.050]	[0.052]	[0.122]
N	16,433	4,367	12,066	1,048	15,385	3,506	12,927	33,190	24,857	8,333	16,075	17,115	28,980	4,210
F-Stat: 1st stage	17.71	22.54	13.91	1.36	17.22	15.14	16.06	19.35	18.38	14.06	7.78	19.46	16.62	20.27

**Table 5** – Results of 2SLS regressions – log-wage, by institution, all nurses

**Notes:** Standard errors are clustered by Planning Region. All regressions include year and Planning Region fixed effects, age grouped in three categories, tenure grouped in three categories, type of qualification, sex, and the natural logarithm of regional GDP per capita. Company size categories are not included in the regressions differentiated by size; the other regressions include company size in three groups. \*\*\*, \*\*, \*, Asterisks indicate significance of coefficients at the conventional significance levels of 1%, 5%, and 10%, respectively. Abbreviations: *sum* refers to total number of vacancies for skilled health and geriatric nursing positions. *Health N.* refers to vacancies for skilled health nursing positions. **Source:** Own calculations based on GSES 2010, 2014, and 2018, and data from Bundesagentur für Arbeit (2022) and BBSR (2022). Survey weights were used for all calculations.



coefficients from the OLS estimation are expected to be smaller if the market outcome is indeed simultaneously determined.

In table 5, we present differentiated results for the care settings. Columns (1) to (7) show estimation results for nurses working in inpatient long-term care and outpatient care institutions, while columns (8) to (14) present results for nurses in hospitals. The results indicate that the significant effects observed when analyzing the wages of nurses across all institutions combined (without differentiation by collective agreement, private or public sector, and institution size) are primarily driven by long-term care institutions. In contrast, we find no significant relationship between nurse shortages and wages for nurses in hospitals.

For nurses working in long-term care institutions, the results are qualitatively comparable to those for all nursing institutions combined. There are no significant effects on the wages of nurses who are employed under a collective agreement, work with a public employer or are employed at a large institution. Once again, the 2SLS estimates are larger than the OLS results, suggesting that the relationship between skill shortages and wages is simultaneously determined.

The magnitude of these effects varies. Our IV estimates indicate that in the absence of a collective agreement, a 1 percent increase in vacancy time, induced by an increase in the proportion of people aged 65 and older, leads to an increase in wages by 0.18 percent for all skilled nursing staff and 0.15 percent for nurses in long-term care facilities. For employees in the private sector, the increase is 0.15 percent and 0.17 percent, respectively. At employers that are not part of the largest third by size, the same increase in average vacancy time leads to a wage increase of 0.21 percent for all skilled nursing staff and 0.17 percent for nurses in long-term care facilities. Additionally, we find a positive effect of nurse shortages on wages in long-term care institutions, even without differentiating the estimations by employer characteristics.

Taken together, we observe stark differences in effects across care settings and institutional characteristics. First, irrespective of ownership structure, size, and bargaining process, wages of nurses in hospitals do not respond to shortages induced by demographic change, whereas they do in long-term care. A likely reason for this difference lies in the distinct institutional settings. Costs for health care services are predominantly covered by statutory insurance, whereas costs for long-term care are partly borne by care recipients. Additionally, prices for health services are negotiated at the national level, while long-term care service prices are negotiated between

care providers and payers at the state level. As a result, prices for health services do not reflect regionally varying demand patterns. The lack of wage response for hospital nurses aligns with the findings of Brunow et al. (2022), who identify a significantly smaller wage effect of skill shortages for health and care workers, attributing this to the specific institutional features of the German health care system.

We observe further differences between employers offering or not offering collectively bargained contracts, publicly and non-publicly owned employers, and large and small employers. These differences may be explained by upward wage rigidities in specific contexts. Theoretical and empirical literature suggests that collective bargaining fosters wage rigidities. Additionally, wages tend to be more rigid at public and large employers. Such wage rigidities constrain wages not only downward but also upward (Elsby 2009).

When we compare the effects with the wage levels in table A12, it becomes apparent that wage reactions occur predominantly in contexts where wages are generally lower. This aligns with theoretical considerations and earlier findings, which suggest that wages in less productive companies or sectors with lower wages respond more strongly to bottleneck situations than those in more productive companies with higher wages (Brunow et al. 2022, Autor et al. 2023). However, a resulting wage compression is not apparent in the aggregate data. On the contrary, wage differences by sector and institutional characteristics have tended to increase over time, as shown in table A12.

Moreover, even though we observe wage reactions in parts of the labor market for nurses, these reactions remain quite small. The complete lack of, or minimal responses in certain areas of the market, combined with the observed heterogeneity in responses, suggest the presence of at least local employer market power. The differences between the hospital sector and other sectors indicate that this market power may be more pronounced in hospitals, which are generally larger and have been decreasing in number in recent years, unlike providers of inpatient and outpatient long-term care.

The differences in effects could also be attributed to other factors, particularly differences and adjustments in non-wage working conditions. Research has shown that non-wage working conditions, which we do not examine here, are particularly important for the attractiveness of work in the care sector (see, e.g., Frijters et al. 2007, Doiron et al. 2014, Lu et al. 2019, Kroczeck &

Späth 2022). For example, working conditions in collectively bargained employment will differ from those without, and public and large institutions may offer amenities that private ones cannot, such as greater job security. The analysis of career exits has also shown that larger employers are more likely to retain nursing staff in the profession, regardless of salary (Frijters et al. 2007, Kroczek 2023).

Overall, our finding that nurse wages do not react to regional shortages in large parts of the labor market for nurses suggests inefficiencies in this labor market, which is a central part of the health and care sector. As long as the overall supply of nursing labor does not increase significantly – whether in response to general wage increases or improvements in amenities – institutions with the greatest need for nursing labor will face recruitment challenges if they do not offer higher wages. To date, an increase in average nursing wages has not led to a reduction in labor market tightness. A decrease in labor supply, as the baby boomer generation reaches retirement age, combined with an increase in demand due to a further aging society, may exacerbate the problem.

## **7 Discussion and Conclusions**

In this analysis, we examine whether shortages of skilled labor in nursing affect nurse wages. Our investigation draws on three waves (2010, 2014, and 2018) of the German Structure of Earnings Survey, a large, representative employer-employee dataset provided by the German Federal Statistical Office. Additionally, we utilize regional data from various sources on skilled labor shortages and on the characteristics of regional supply and demand for health services. To address endogeneity issues, we apply a fixed-effects instrumental variables approach.

For the majority of nurses and institutions, we find that wages do not respond to skill shortages. This may be rooted in peculiarities within the institutional setup. First, the institutional framework in the health and care sector in Germany may limit potential wage adjustments, as increasing labor costs can be difficult to pass through higher prices (Jacobs et al. 2020).

More specifically, in hospitals, the ability to raise wages may be constrained by the fixed pricing for the treatment of specific diseases. Long-term care providers, on the other hand, operate as price-takers in a monopsonistic market, where their negotiating position regarding service remuneration is relatively weak (Bogai 2017).

Even under such institutional constraints, we find that wages at smaller institutions, privately owned institutions, and at institutions not covered by collective agreements react to increased shortages of skilled nurses, whereas wages at large institutions, publicly owned institutions, and institutions participating in collective bargaining processes do not. Consequently, wage adjustments tend to occur where wage levels are lower and remain stagnant at higher-paying, potentially more productive firms.

Additionally, the fact that collectively bargained wages do not respond to local shortages in nursing labor, whereas non-collective wages do, may be due to the supra-regional nature of the collective agreements. This consideration is also likely relevant for public employers, who often adhere to collective agreements.

Our results only provide indications of possible channels that limit wage reactions. Other explanations are plausible. For instance, larger and state-owned employers may have greater capacity to implement improvements in non-wage working conditions. Additionally, public employers may exhibit reduced market orientation compared to private employers. However, the fact remains that a key instrument for the efficient allocation of scarce labor – wage adjustments – is not being used.

The absence of wage reactions to skill shortage in large parts of the labor market is noticeable for three main reasons. First, it conflicts with public and political demands for higher wages in nursing occupations facing skill shortages. Second, it suggests the presence of market frictions in the nursing labor market. Third, it highlights inefficiencies in wage formation within the nursing sector, as previous studies indicate that increased wages could actually boost the labor supply of nurses.

Some limitations of our study and areas for future research should be noted. Our analysis of wage reactions is conducted at an aggregate level, treating the wage formation process as a black box. While certain deductions can be made from the results regarding the potential reasons why higher levels of skill shortages in nursing may not always lead to higher wages, more in-depth studies of the underlying processes are necessary. Future research could explore this question by employing a different, possibly more qualitative research approach, such as case studies and a thorough analysis of the underlying processes—an endeavor that lies beyond the scope of this paper.

Additionally, our analysis focuses on wage reactions to skill shortages in nursing within Germany, and the specific institutional context clearly influences the results. These findings may be transferable to other cases and countries with comparable institutional settings, such as publicly owned hospitals in France. However, due to country-specific conditions and institutional frameworks in the health care provision, further research on different countries is required. Comparing the respective findings would enrich the debate on the functionality of health care and remuneration systems.

Moreover, in a labor market so strongly shaped by public regulation, such as the hospital market, an analysis based on the assumption that the underlying market for health services and the respective labor market adhere to concepts of economic efficiency could be misguided. The absence of an efficient market reaction could be rooted in political decisions rather than distortions of otherwise functioning market mechanisms, as seen in a monopsonistic labor market.

Whether the market for the nursing labor force actually functions “as it should” is primarily a political or normative question. The observed mechanisms only partly align with the calls for higher wages as a response to shortages voiced by politicians.

Overall, our findings suggest that the institutions and market setup do not appear to enable wage reactions as a means to contribute to an efficient allocation of nursing labor in large parts of the market. Potential reasons for this lie in market frictions that affect wage setting. Addressing these frictions could be a starting point for future research. However, these limitations are based on considerations that extend beyond a pure efficiency analysis.

## References

- Andreassen, L., Di Tommaso, M. L. & Strøm, S. (2017), 'Nurses and physicians: a longitudinal analysis of mobility between jobs and labor supply', *Empirical Economics* **52**(4), 1235–1269.
- Angrist, J. D. & Pischke, J.-S. (2009), *Mostly harmless econometrics: An empiricist's companion*, Princeton University Press, Princeton, N.J. and Oxford.
- Antonazzo, E., Scott, A., Skatun, D. & Elliott, R. F. (2003), 'The labour market for nursing: a review of the labour supply literature', *Health Economics* **12**(6), 465–478.
- Arnold, D., Hillerich-Sigg, A. & Nolte, A. (2017), 'Fachkräftemangel: Reaktionen der betriebe sowie auswirkungen auf investitionsentscheidungen und wachstum: Studie im auftrag des bundesministeriums für wirtschaft und energie', *Abschlussbericht ZEW Mannheim* .
- Autor, D., Dube, A. & McGrew, A. (2023), 'The unexpected compression: competition at work in the low wage labor market', *NBER Working Paper* (31010).
- Babecký, J., Du Caju, P., Kosma, T., Lawless, M., Messina, J. & Rööm, T. (2010), 'Downward nominal and real wage rigidity: Survey evidence from european firms\*', *The Scandinavian Journal of Economics* **112**(4), 884–910.
- Bartik, T. J. (1991), *Who benefits from state and local: Economic development policies?*, W. E. Upjohn Inst. for Employment Research, Kalamazoo, Mich.  
**URL:** <http://www.jstor.org/stable/j.ctvh4zh1q>
- BBSR (2022), 'Inkar – indikatoren und karten zur raum- und stadtentwicklung'.  
**URL:** <https://www.inkar.de/>
- Bellmann, L. & Hübler, O. (2014), 'The skill shortage in german establishments before, during and after the great recession', *Jahrbücher für Nationalökonomie und Statistik* **234**(6), 800–828.
- Bennett, J. & McGuinness, S. (2009), 'Assessing the impact of skill shortages on the productivity performance of high-tech firms in northern ireland', *Applied Economics* **41**(6), 727–737.
- Bloom, D. E. (2020), 'Population 2020: Demographics can be a potent driver of the pace and process of economic development', *Finance & Development - A Quarterly Publication of the International Monetary Fund* **57**(1), 5–9.

- Bogai, D. (2017), *Der Arbeitsmarkt für Pflegekräfte im Wohlfahrtsstaat*, De Gruyter, Oldenbourg.
- Brunello, G. & Wruuck, P. (2021), 'Skill shortages and skill mismatch: A review of the literature', *Journal of Economic Surveys* **35**(4), 1145–1167.
- Brunow, S., Lösch, S. & Okhrin, O. (2022), 'Labor market tightness and individual wage growth: evidence from germany', *Journal for Labour Market Research* **56**(1).
- Bundesagentur für Arbeit (2022), 'Zeitreihe ausgewählter engpass-indikatoren (pflegeberufe): Zu- und abgang: Jahressumme; bestand: Jahresschnitt', *Arbeitsmarktstatistik* .
- Bundesagentur für Arbeit (2023), 'Fachkräftebedarf'.
- URL:** <https://statistik.arbeitsagentur.de/DE/Navigation/Statistiken/Themen-im-Fokus/Fachkraeftebedarf/Fachkraeftebedarf-Nav.html>
- Bundesagentur für Arbeit (2024), 'Qualified specialists urgently required: Shortages in 183 occupations', *Press release* (no. 24).
- Bundesagentur für Arbeit, S. (2020), 'Statistik über gemeldete arbeitsstellen', *Kurzinfo* .
- Burdett, K. & Mortensen, D. T. (1998), 'Wage differentials, employer size, and unemployment', *International Economic Review* **39**(2), 257–273.
- Burstedde, A. & Schüler, R. M. (2020), 'Reagieren löhne in deutschland auf den fachkräftemangel?', *IW-Trends* (4/2020).
- Caliendo, M., Künn, S. & Mahlstedt, R. (2017), 'The return to labor market mobility: An evaluation of relocation assistance for the unemployed', *Journal of Public Economics* **148**, 136–151.
- Cappelli, P. H. (2015), 'Skill gaps, skill shortages, and skill mismatches: Evidence and arguments for the united states', *ILR Review* **68**(2), 251–290.
- Carstensen, J., Seibert, H. & Wiethölter, D. (2022), 'Entgelte von pflegekräften 2021', *IAB Aktuelle Daten und Indikatoren* .
- Combes, J.-B., Delattre, E., Elliott, B. & Skåtun, D. (2015), 'Hospital staffing and local pay: an investigation into the impact of local variations in the competitiveness of nurses' pay on the staffing of hospitals in france', *The European Journal of Health Economics* **16**(7), 763–780.

- Combes, J.-B., Elliott, R. F. & Skåtun, D. (2018), 'Hospital staff shortage: the role of the competitiveness of pay of different groups of nursing staff on staff shortage', *Applied Economics* **50**(60), 6547–6552.
- Di Tommaso, M. L., Strøm, S. & Saether, E. M. (2009), 'Nurses wanted is the job too harsh or is the wage too low?', *Journal of Health Economics* **28**(3), 748–757.
- Doiron, D., Hall, J., Kenny, P. & Street, D. J. (2014), 'Job preferences of students and new graduates in nursing', *Applied Economics* **46**(9), 924–939.
- Domash, A. & Summers, L. (2022), 'How tight are u.s. labor markets?', *NBER Working Paper* (No. 29739).
- Drennan, V. M. & Ross, F. (2019), 'Global nurse shortages-the facts, the impact and action for change', *British Medical Bulletin* **130**(1), 25–37.
- Dustmann, C. & Schönberg, U. (2009), 'Training and union wages', *The Review of Economics and Statistics* **91**(2), 363–376.
- Duval, R., Shibata, I., Ji, Y., Pizzinelli, C., M. Tavares, M., Li, L., Oikonomou, M. & Sozzi, A. (2022), 'Labor market tightness in advanced economies', *IMF Staff Discussion Notes* (SDN/2022/001).
- Ehrlich, G. & Montes, J. (2024), 'Wage rigidity and employment outcomes: Evidence from administrative data', *American Economic Journal: Macroeconomics* **16**(1), 147–206.
- Elliott, R. F., Ma, A. H. Y., Scott, A., Bell, D. & Roberts, E. (2007), 'Geographically differentiated pay in the labour market for nurses', *Journal of Health Economics* **26**(1), 190–212.
- Elsby, M. W. (2009), 'Evaluating the economic significance of downward nominal wage rigidity', *Journal of Monetary Economics* **56**(2), 154–169.
- European Centre for the Development of Vocational Training. (2015), 'Skill shortages and gaps in european enterprises: striking a balance between vocational education and training and the labour market.', *Cedefop reference Series* (No 102).
- Fang, T. (2009), 'Workplace responses to vacancies and skill shortages in canada', *International Journal of Manpower* **30**(4), 326–348.



- Fields, B. E., Bell, J. F., Bigbee, J. L., Thurston, H. & Spetz, J. (2018), 'Registered nurses' preferences for rural and urban jobs: A discrete choice experiment', *International Journal of Nursing Studies* **86**, 11–19.
- Frijters, P., Shields, M. A. & Price, S. W. (2007), 'Investigating the quitting decision of nurses: panel data evidence from the british national health service', *Health Economics* **16**(1), 57–73.
- Frohm, E. (2020), 'Labor shortages and wage growth', *Sveriges Riksbank Working Paper Series* (No. 394).
- Fuest, C. & Jäger, S. (2023), 'Können höhere löhne zur überwindung des fachkräftemangels beitragen?', *Wirtschaftsdienst* **103**(4), 253–258.
- Green, F., Machin, S. & Manning, A. (1996), 'The employer size-wage effect: Can dynamic monopsony provide an explanation?', *Oxford Economic Papers* **48**(3), 433–455.
- Green, F., Machin, S. & Wilkinson, D. (1998), 'The meaning and determinants of skills shortages', *Oxford Bulletin of Economics and Statistics* **60**(2), 165–187.
- Hanel, B., Kalb, G. & Scott, A. (2014), 'Nurses' labour supply elasticities: the importance of accounting for extensive margins', *Journal of Health Economics* **33**, 94–112.
- Harsch, K. & Verbeek, H. (2012), 'Der mindestlohn in der pflegebranche – die folgen eines mindestlohns in einer wachstumsbranche', *Journal for Labour Market Research* **45**(3-4), 355–378.
- Haskel, J. & Martin, C. (1993), 'The causes of skill shortages in britain', *Oxford Economic Papers* **45**(4), 573–588.
- Healy, J., Mavromaras, K. & Sloane, P. J. (2015), 'Adjusting to skill shortages in australian smes', *Applied Economics* **47**(24), 2470–2487.
- Heyes, A. (2005), 'The economics of vocation or 'why is a badly paid nurse a good nurse'?', *Journal of Health Economics* **24**, 561–569.
- Hirsch, B. & Schumacher, E. (1995), 'Monopsony power and relative wages in the labor market for nurses', *Journal of Health Economics* **14**(4), 443–476.
- Hirsch, B. & Schumacher, E. (2012), 'Underpaid or overpaid? wage analysis for nurses using job and worker attributes', *Southern Economic Journal* **78**(4), 1096–1119.

- Hirsch, B. T. & Schumacher, E. J. (2005), 'Classic or new monopsony? Searching for evidence in nursing labor markets', *Journal of Health Economics* **24**(5), 969–989.
- Holmås, T. H. (2002), 'Keeping nurses at work: A duration analysis', *Health Economics* **11**(6), 493–503.
- Horbach, J. & Rammer, C. (2022), 'Skills shortage and innovation', *Industry and Innovation* **29**(6), 734–759.
- Jacobs, K., Kuhlmeier, A., Greß, S., Klauber, J. & Schwinger, A., eds (2020), *Pflege-Report 2019*, Springer Berlin Heidelberg, Berlin, Heidelberg.
- Kankaanranta, T. & Rissanen, P. (2008), 'Nurses' intentions to leave nursing in finland', *The European Journal of Health Economics* **9**(4), 333–342.
- Klinger, S. & Fuchs, J. (2020), 'Effects of population changes on the labour market in germany', *IAB-Forum* .
- Kroczek, M. (2023), 'Analyzing nurses' decisions to leave their profession-a duration analysis', *The European Journal of Health Economics* pp. 1–26.
- Kroczek, M. & Späth, J. (2022), 'The attractiveness of jobs in the german care sector: results of a factorial survey', *The European Journal of Health Economics* **23**(9), 1547–1562.
- Kugler, P. (2021), 'The role of wage beliefs in the decision to become a nurse', *Health Economics* **31**(1), 94–111.
- Lu, H., Zhao, Y. & While, A. E. (2019), 'Job satisfaction among hospital nurses: A literature review', *International Journal of Nursing Studies* **94**, 21–31.
- Manning, A. (2021), 'Monopsony in labor markets: A review', *ILR Review* **74**(1), 3–26.
- Matsudaira, J. D. (2014), 'Monopsony in the low-wage labor market? evidence from minimum nurse staffing regulations', *The Review of Economics and Statistics* **96**(1), 92–102.
- McGuinness, S., Pouliakas, K. & Redmond, P. (2018), 'Skills mismatch: Concepts, measurement and policy approaches', *Journal of Economic Surveys* **32**(4), 985–1015.
- Mortensen, D. T. & Pissarides, C. A. (1999), Chapter 18 job reallocation, employment fluctuations and unemployment, in 'Handbook of Macroeconomics', Vol. 1, Elsevier, pp. 1171–1228.

- Notowidigdo, M. J. (2020), 'The incidence of local labor demand shocks', *Journal of Labor Economics* **38**(3), 687–725.
- Oi, W. Y. & Idson, T. L. (1999), Chapter 33 firm size and wages, in 'Handbook of Macroeconomics', Vol. 3, Elsevier, pp. 2165–2214.
- Osterman, P. & Weaver, A. (2014), Skills and skill gaps in manufacturing, in R. M. Locke & R. L. Wellhausen, eds, 'Production in the innovation economy', MIT Press, Cambridge, Massachusetts, pp. 17–50.
- Prager, E. & Schmitt, M. (2021), 'Employer consolidation and wages: Evidence from hospitals', *American Economic Review* **111**(2), 397–427.
- Sachverständigenrat (2018), *Jahresgutachten: Vor Wichtigen Wirtschaftspolitischen Weichenstellungen*, Statistisches Bundesamt, Wiesbaden.
- Scott, A. (2001), 'Eliciting gps' preferences for pecuniary and non-pecuniary job characteristics', *Journal of Health Economics* **20**(3), 329–347.
- Scott, A., Witt, J., Duffield, C. & Kalb, G. (2015), 'What do nurses and midwives value about their jobs? results from a discrete choice experiment', *Journal of health services research & policy* **20**(1), 31–38.
- Shields, M. A. (2004), 'Addressing nurse shortages: What can policy makers learn from the econometric evidence on nurse labour supply?', *The Economic Journal* **114**(499), F464–F498.
- Simon, M. (2021), *Das Gesundheitssystem in Deutschland*, 7. edn, Hogrefe Verlag.
- Song, K., Scott, A., Sivey, P. & Meng, Q. (2015), 'Improving chinese primary care providers' recruitment and retention: a discrete choice experiment', *Health Policy and Planning* **30**(1), 68–77.
- Staiger, D. O., Spetz, J. & Phibbs, C. S. (2010), 'Is there monopsony in the labor market? evidence from a natural experiment', *Journal of Labor Economics* **28**(2), 211–236.
- Staiger, D. & Stock, J. H. (1997), 'Instrumental variables regression with weak instruments', *Econometrica* **65**(3), 557.
- Statistik der Bundesagentur für Arbeit (2020), *Methodenbericht-Engpassanalyse-Methodische Weiterentwicklung*, Nürnberg.

Statistisches Bundesamt (2022a), 'Pfleigestatistik - pflege im rahmen der pflegeversicherung'.

**URL:** <https://www.destatis.de>

Statistisches Bundesamt (2022b), 'Zahl der beschäftigten im pflegedienst in kliniken binnen zehn jahren um 1 % gestiegen', *Pressemitteilung* (Nr. N026).

Statistisches Bundesamt (2023), 'Statistischer bericht - grunddaten der Krankenhäuser 2022'.

**URL:** <https://www.destatis.de>

Stüber, H. & Beissinger, T. (2012), 'Does downward nominal wage rigidity dampen wage increases?', *European Economic Review* **56**(4), 870–887.

*Why American unemployment needs to rise* (11/24/2022), *The Economist* .

## A Appendix

<b>Individual characteristics</b>			
Year	2010	2014	2018
Wage in euros	17.889 (0.030)	17.634 (0.047)	18.939 (0.055)
Age in years	41.834 (0.092)	42.956 (0.127)	43.959 (0.156)
Tenure in years	10.662 (0.083)	11.162 (0.109)	11.639 (0.139)
Sex (female)	0.837 (0.003)	0.848 (0.004)	0.836 (0.005)
Education level			
Below A-Levels & No vocational degree	0.019 (0.001)	0.014 (0.001)	0.014 (0.002)
Below A-Levels & Vocational degree	0.806 (0.003)	0.784 (0.005)	0.761 (0.006)
A-Levels & No vocational degree	0.005 (0.001)	0.003 (0.001)	0.006 (0.001)
A-Levels & Vocational degree	0.072 (0.002)	0.137 (0.004)	0.159 (0.005)
University degree	0.051 (0.002)	0.017 (0.002)	0.014 (0.001)
Unknown	0.047 (0.001)	0.045 (0.002)	0.046 (0.003)
N	36,030	11,493	11,246

**Table A1** – Summary statistics: Weighted means of individual characteristics by year, standard deviations in parentheses

**Notes:** We excluded Saxony-Anhalt from our analysis because of changes in the regional organization due to a local government reorganization (*Gebietsreform*) within our analysis period.

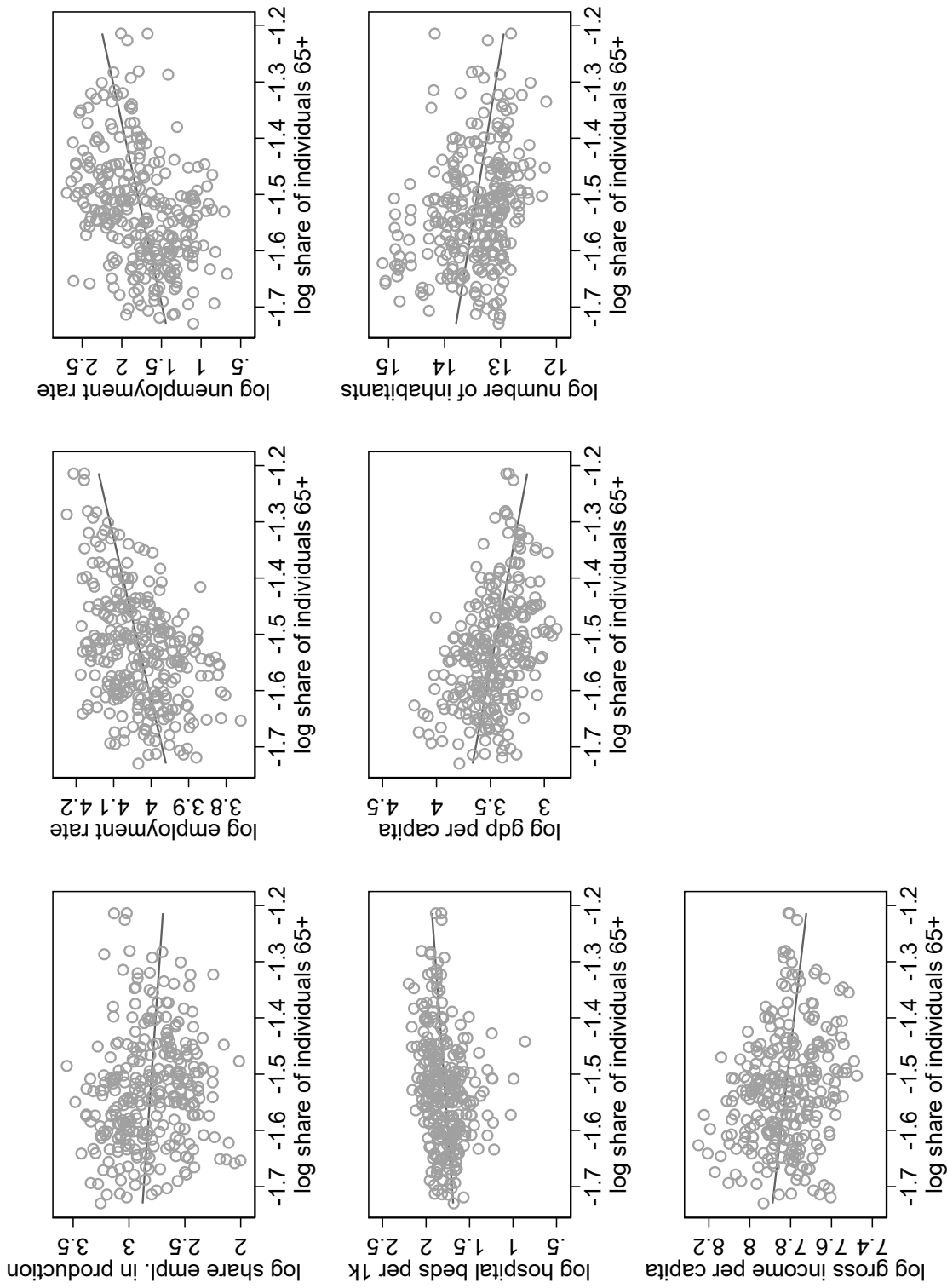
**Source:** Own calculations based on GSES 2010, 2014, and 2018. Survey weights were used for all calculations.

<b>Firm characteristics</b>			
Year	2010	2014	2018
# Employees	2926.412	1712.202	2152.585
Collective agreement			
No collective agreement	0.503 (0.004)	0.540 (0.006)	0.463 (0.007)
On sectoral level	0.418 (0.004)	0.374 (0.005)	0.425 (0.007)
On firm level	0.079 (0.002)	0.087 (0.003)	0.112 (0.004)
Sector			
Hospital	0.526 (0.004)	0.537 (0.006)	0.519 (0.007)
Nursing homes	0.233 (0.003)	0.238 (0.005)	0.248 (0.006)
Outpatient care	0.083 (0.002)	0.121 (0.003)	0.143 (0.005)
Outpatient care	0.265 (0.004)	0.227 (0.004)	0.216 (0.005)
N	36,030	11,493	11,246

**Table A2** – Summary statistics: Weighted means of firm characteristics by year, standard deviations in parentheses

**Notes:** We excluded Saxony-Anhalt from our analysis because of changes in the regional organization due to a local government reorganization (*Gebietsreform*) within our analysis period.

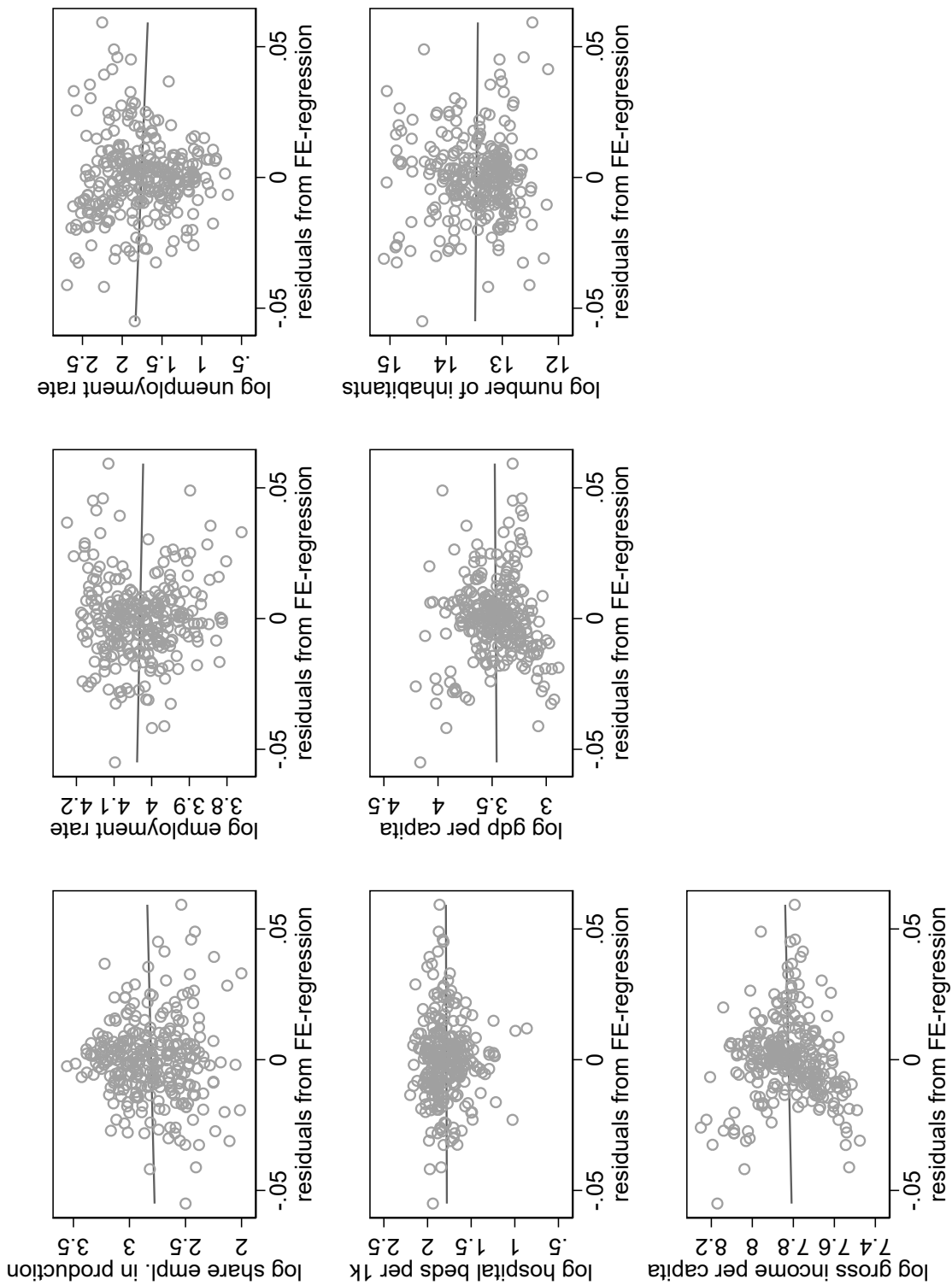
**Source:** Own calculations based on GSES 2010, 2014, and 2018. Survey weights were used for all calculations.



**Figure A1** – Scatter plots log share of individuals of age 65 and older versus log of several regional characteristics

**Notes:** The  $x$  axis shows standard deviations from the means; the  $y$  axis shows the log share of individuals of age 65 and older (the instrument,  $z$ ). The circles indicate observations.  
**Source:** Own figure based on data from Bundesagentur für Arbeit (2022) and BBSR (2022).





**Figure A2** – Scatter plots residual of regression from fixed effects regression versus log of several regional characteristics

**Notes:** The  $x$  axis shows standard deviations from the means; the  $y$  axis shows the residuals from equation 4 (the adjusted instrument,  $\hat{V}_{jt}$ ). The circles indicate observations.

**Source:** Own figure based on data from Bundesagentur für Arbeit (2022) and BBSR (2022).

Regional characteristics			
Year	2010	2014	2018
Mean (weighted)	2010	2014	2018
Share individuals 65 years and older	43.447 (1.417)	44.276 (1.563)	44.549 (1.662)
Average age	20.868 (1.857)	21.443 (1.969)	22.172 (2.387)
N	96	96	96

**Table A3** – Summary statistics: Means of regional characteristics by year, standard deviations in parentheses

**Notes:** We excluded Saxony-Anhalt from our analysis because of changes in the regional organization due to a local government reorganization (*Gebietsreform*) within our analysis period.

**Source:** Own calculations based on data from BBSR (2022).

Dependent variable: Net internal migration				
	65+ Year Olds		Population	
	(1)	(2)	(3)	(4)
Regional average nursing wage	-0.037		-0.034	
	[0.040]		[0.119]	
log(regional average nursing wage)		-0.585		-0.171
		[0.688]		[2.197]
Year 2010 (base)	-	-	-	-
Year 2014	0.104	0.105	5.572***	5.577***
	[0.070]	[0.070]	[0.250]	[0.250]
Year 2018	0.194*	0.187*	4.268***	4.237***
	[0.103]	[0.101]	[0.327]	[0.329]
Constant	1.124	2.151	1.510	1.404
	[0.706]	[1.979]	[2.123]	[6.313]
N	273	273	273	273

**Table A4** – Fixed effects regression results for migration employing regional values

**Notes:** Standard errors are clustered by Planning Region and given in square brackets. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Regressions further include Planning Region fixed effects where stated, respective coefficients are omitted due to reasons of clarity. F-Statistic refers to the F-Statistic of the instrument, Individuals of at least 65 years of age.

**Source:** Own calculations based on data from GSES 2010, 2014, and 2018 and BBSR (2022). Survey weights were used for all calculations with GSES 2010, 2014, and 2018.

	Dependent Variable: log(GDP per capita)		Dependent Variable: log(Average gross earnings)	
	(1)	(2)	(3)	(4)
Regional average nursing wage	0.002 [0.002]		0.001 [0.001]	
log(regional average nursing wage)		0.031 [0.023]		0.021 [0.018]
Year 2010 (base)	-	-	-	-
Year 2014	0.146*** [0.004]	0.031 [0.032]	0.113*** [0.002]	0.113*** [0.002]
Year 2018	0.252*** [0.005]	0.146*** [0.004]	0.221*** [0.003]	0.220*** [0.003]
Constant	3.319*** [0.032]	0.252*** [0.005]	7.704*** [0.018]	7.659*** [0.052]
Region FEs	X	X	X	X
N	273	273	273	273

**Table A5** – Fixed effects regression results for GDP and wages employing regional values

**Notes:** Standard errors are clustered by Planning Region and given in square brackets. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Regressions further include Planning Region fixed effects where stated, respective coefficients are omitted due to reasons of clarity. F-Statistic refers to the F-Statistic of the instrument, Individuals of at least 65 years of age.

**Source:** Own calculations based on data from GSES 2010, 2014, and 2018 and BBSR (2022). Survey weights were used for all calculations with GSES 2010, 2014, and 2018.

	Region FEs			Year & Region FEs			All controls		
	Geriatric Nurses	Health Nurses	All Skilled Nurses	Geriatric Nurses	Health Nurses	All Skilled Nurses	Geriatric Nurses	Health Nurses	All Skilled Nurses
log(share individuals aged 65+)	11.146*** [0.575]	7.930*** [0.529]	9.887*** [0.491]	3.622*** [0.793]	3.397*** [0.982]	3.537*** [0.729]	3.771*** [0.979]	2.909*** [0.707]	3.518*** [0.731]
Year 2010 (base)			-		-	-			
Year 2014				0.280*** [0.040]	0.093** [0.044]	0.208*** [0.036]	0.234*** [0.044]	0.130*** [0.043]	0.192*** [0.039]
Year 2018				0.599*** [0.057]	0.362*** [0.060]	0.508*** [0.050]	0.458*** [0.093]	0.331*** [0.076]	0.398*** [0.071]
Constant	-29.322*** [1.761]	-19.607*** [1.622]	-25.515*** [1.504]	-6.560*** [2.404]	-5.874** [2.983]	-6.297*** [2.211]	-6.824** [2.969]	-4.409** [2.144]	-6.189*** [2.222]
Region FEs	X	X	X	X	X	X	X	X	X
Individual level controls									
F-Statistic	376.21	224.34	406.00	20.86	11.95	23.54	14.84	16.93	23.15
N	281	272	266	281	272	266	17,838	42,965	58,769

**Table A6** – Results from fixed effects regressions on the association between average vacancies in days and regional share of individuals aged 65+ years

**Notes:** Standard errors are clustered by Planning Region and given in square brackets. All regressions include year and Planning Region fixed effects. Regressions with all controls further include age in three groups, tenure in three groups, the type of qualification, sex, the natural logarithm of regional GDP per capita, and company size in three groups. \*\*\*, \*\*, \*, Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Regressions further include Planning Region fixed effects where stated, respective coefficients are omitted due to reasons of clarity. F-Statistic refers to the F-Statistic of the instrument, Individuals of at least 65 years of age.

**Source:** Own calculations based on data from Bundesagentur für Arbeit (2022) and BBSR (2022). Survey weights were used for all calculations with GSES 2010, 2014, and 2018.

	Comparison group				Management and technical services				Wholesale and retail			
	All	No Collective Agreement	Private sector	No Large institution	All	Collective Agreement	Public sector	Large institution	All	Collective Agreement	Public sector	Large institution
log(Share individuals aged 65+)	0.045 [0.221]	0.045 [0.221]	0.045 [0.221]	0.045 [0.221]	0.152 [0.234]	0.371 [0.254]	0.298 [0.264]	0.138 [0.224]	0.285 [0.192]	0.429 [0.312]	0.304 [0.193]	0.278 [0.262]
Year 2010 (base)												
Year 2014	-0.049*** [0.013]	-0.049*** [0.013]	-0.049*** [0.013]	-0.049*** [0.013]	-0.023* [0.012]	-0.040*** [0.014]	-0.031** [0.013]	-0.023** [0.011]	-0.038*** [0.009]	-0.048*** [0.012]	-0.039*** [0.009]	-0.045*** [0.012]
Year 2018	0.039* [0.020]	0.039* [0.020]	0.039** [0.020]	0.039* [0.020]	0.006 [0.020]	-0.012 [0.024]	-0.018 [0.023]	0.016 [0.022]	-0.015 [0.018]	-0.038 [0.030]	-0.017 [0.018]	-0.022 [0.026]
Constant	2.318*** [0.675]	2.318*** [0.675]	2.318*** [0.675]	2.318*** [0.675]	1.922*** [0.712]	1.285 [0.774]	1.472* [0.804]	1.972*** [0.682]	1.516** [0.588]	1.067 [0.953]	1.460** [0.591]	1.542* [0.802]
N	43,779	43,779	43,779	43,779	162,031	111,868	141,586	125,970	150,885	92,861	147,847	92,963

**Table A7 – Results from fixed effects regressions on the association between log hourly wage and regional share of individuals aged 65+ years for sectors not or significantly less affected by skill shortage**

**Notes:** Standard errors are clustered by Planning Region and given in square brackets. All regressions include year and Planning Region fixed effects, age in three groups, tenure in three groups, the type of qualification, sex, the natural logarithm of regional GDP per capita. We do not include company size categories in the regressions differentiated by size; the other regressions include company size in three groups. \*\*\*, \*\*, \*, Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Regressions further include Planning Region fixed effects where stated, respective coefficients are omitted due to reasons of clarity. F-Statistic refers to the F-Statistic of the instrument, Individuals of at least 65 years of age.

**Source:** Own calculations based on GSES 2010, 2014, and 2018, and data from data from Bundesagentur für Arbeit (2022) and BBSR (2022). Survey weights were used for all calculations.

Regression results, dependent variable log of gross hourly wage, additional covariate: GDP per capita							
All Skilled Nurses							
Subsample	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Collective agreement	-	Yes	No				
Public sector	-			Yes	No		
Large institution	-					Yes	No
log(vacancy time)	0.064	0.013	0.170**	-0.070	0.141**	-0.004	0.196**
Standard error	[0.051]	[0.040]	[0.080]	[0.064]	[0.067]	[0.041]	[0.093]
N	58,769	31,811	26,958	16,718	42,051	34,141	24,628
F-Stat. 1st stage	26.95	29.91	24.29	15.49	25.97	25.75	26.12

**Table A8** – Results of OLS and 2SLS regressions – log-wage, all skilled nurses

**Notes:** Standard errors are clustered by Planning Region. All regressions include year and Planning Region fixed effects, age in three groups, tenure in three groups, the type of qualification, sex, the natural logarithm of regional GDP per capita. We do not include company size categories in the regressions differentiated by size; the other regressions include company size in three groups. \*\*\*, \*\*, \*, Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Abbreviations: *sum* refers to the sum of vacancies regarding skilled health and geriatric nursing positions. *Health N* refers to vacancies regarding skilled health nursing positions.

**Source:** Own calculations based on GSES 2010, 2014, and 2018, and data from Bundesagentur für Arbeit (2022) and BBSR (2022). Survey weights were used for all calculations.

	Unconditional instrument $z$	Adjusted instrument $\hat{V}$
	(1)	(2)
First stage (equation 4)		
		Fixed-effects regression on instrument
Year 2010 (base)		-
Year 2014		0.030*** [0.002]
Year 2018	-	0.095*** [0.004]
Constant		-1.572*** [0.002]
Region FEs		X
$R^2$		0.977
N		288
Second stage (equation 5)		
	Dependent Variable:	Dependent Variable:
	$z$ : log(Share individuals aged 65+)	$\hat{V}$ : Residual from fixed-effects regression
	Number of statistically significant regional characteristics at the 5%-level	
Characteristics in the model	7	7
Significant at 5%-level	5	1
$R^2$	0.641	0.012
N	288	288

**Table A9** – Fixed effects regression results for GDP and wages employing regional values

**Notes:** Standard errors are clustered by Planning Region and given in square brackets. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Regressions further include Planning Region fixed effects where stated, respective coefficients are omitted due to reasons of clarity.

The regional characteristics in the models are: logarithms of: share of industry employment, share employed, share unemployed, GDP per capita, hospital beds per 1 thousand inhabitants, inhabitants.

**Source:** Own calculations based on data from GSES 2010, 2014, and 2018 and BBSR (2022).



Regression results, dependent variable log of gross hourly wage														
	Skilled Geriatric Nurses						Skilled Health Nurses							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Subsample	-	Yes	No	Yes	No	Yes	No	-	Yes	No	Yes	No	Yes	No
Collective agreement	-	Yes	No	Yes	No	Yes	No	-	Yes	No	Yes	No	Yes	No
Public sector	-	Yes	No	Yes	No	Yes	No	-	Yes	No	Yes	No	Yes	No
Large institution	-	Yes	No	Yes	No	Yes	No	-	Yes	No	Yes	No	Yes	No
<b>OLS Results</b>														
log(vacancy time)	0.095	-0.019	0.127***	-0.109	0.102***	0.029	0.117***	-0.019	-0.006	-0.023	0.018	-0.030	0.001	-0.079*
Standard error	[0.031]	[0.040]	[0.042]	[0.116]	[0.032]	[0.034]	[0.039]	[0.017]	[0.017]	[0.029]	[0.024]	[0.020]	[0.043]	[0.011]
N	17,838	5,780	12,058	1,600	16,238	4,416	13,422	42,965	27,568	15,397	16,508	26,457	31,275	11,690
<b>2SLS Results</b>														
log(vacancy time)	0.207	0.144	0.259**	-0.507*	0.242***	-0.016	0.283***	-0.009	-0.043	0.099	-0.082	0.062	-0.035	0.066
Standard error	[0.082]	[0.105]	[0.113]	[0.263]	[0.086]	[0.096]	[0.105]	[0.053]	[0.058]	[0.083]	[0.077]	[0.067]	[0.046]	[0.118]
N	17,838	5,780	12,058	1,600	16,238	4,416	13,422	42,965	27,568	15,397	16,508	26,457	31,275	11,690
F-Stat. 1st stage	14.84	17.45	12.57	7.06	14.04	19.30	12.11	16.93	17.97	13.20	7.48	16.68	16.43	12.76

**Table A10** – Results of 2SLS regressions – log-wage, by institution, all nurses

**Notes:** Standard errors are clustered by Planning Region. All regressions include year and Planning Region fixed effects, age in three groups, tenure in three groups, the type of qualification, sex, the natural logarithm of regional GDP per capita. We do not include company size categories in the regressions differentiated by size; the other regressions include company size in three groups. \*\*\*, \*\*, \*: Asterisks indicate significance of coefficients at the conventional significance levels 1%, 5%, 10%, respectively. Abbreviations: *sum* refers to the sum of vacancies regarding skilled health and geriatric nursing positions. *Health N* refers to vacancies regarding skilled health nursing positions.

**Source:** Own calculations based on data from Bundesagentur für Arbeit (2022) and BBSR (2022). Survey weights were used for all calculations.

	Mean (weighted)	SD (weighted)
<b>In Hospitals</b>		
Health nurses	0.972	0.002
Geriatric nurses	0.028	0.002
N	33,866	
<b>In Inpatient Care</b>		
Health nurses	0.226	0.006
Geriatric nurses	0.774	0.006
N	11,085	
<b>In Outpatient Care</b>		
Health nurses	0.468	0.009
Geriatric nurses	0.532	0.009
N	5,990	

**Table A11** – Distribution of Nursing Occupations over Facilities

**Source:** Own calculations based on GSES 2010, 2014, and 2018. Survey weights were used for all calculations.

Year	2010	2014	2018
Field of care			
All Institutions	16.672	17.546	19.659
Hospitals	17.864	19.311	21.705
Outpatient care	14.397	15.036	16.698
Long Term care	15.272	15.511	17.465
Ownership			
Public institution	17.920	19.324	21.784
Private institution	16.222	17.024	19.068
Collective bargaining situation			
Collective agreement	17.669	18.923	21.370
No collective agreement	15.687	16.372	17.672
Size by group			
Small or medium institution	15.403	15.875	17.815
Large institution	17.809	19.024	21.388

**Table A12** – Average real nominal wages by type of institution in Euro by year

**Source:** Own calculations based on GSES 2010, 2014, and 2018. Survey weights were used for all calculations.