Measuring the Returns of Nurses: Evidence from a Parental Leave Program

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Abstract

Nurses define the largest health profession. In this paper, we measure the return of nurses on health care delivery and patient health outcomes using a natural experiment, which led to a sudden, unintended, and persistent 12% reduction in nurse employment. Our findings indicate detrimental effects on hospital care delivery as indicated by an increase in 30-day readmission rates and a distortion of technology utilization. Our findings for nursing homes are more drastic indicating a 13% increase in nursing home mortality among the elderly aged 85 and older.

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1 Introduction

Nurses define the largest health profession. In the U.S. there were 3.4 million employed licensed nurses in 2014, about 30% of all health professionals.[1] Nurses play an important role in the delivery of health care services in hospital, primary, and nursing home care and are important to the success of emerging patient-oriented care models.

In this paper, we measure the return of nurses on health care delivery and patient health outcomes using a natural experiment in Denmark, which led to a sudden and persistent 12% reduction in nurse employment. In 1994, the Danish government introduced a federally funded parental leave program, which offered parents the opportunity to take up to one year of absence per child aged 0-8. The large program take-up among women led to a substantial unintended reduction in nurse employment because nurses are a predominantly female, licensed profession with regulated training and wages that health care providers were not able to replace on net.

An important advantage of our empirical context is that we can combine detailed employment data of health care providers with individual patient records on diagnoses, procedures and health outcomes for the entire Danish population. This allows us to quantify the mechanisms through which nurses affect the delivery of care for different patient populations and to measure heterogeneous returns on patient health outcomes across different health care sectors. Comparing the returns of nurses between sectors allows us to test whether this important occupation is allocated towards sectors with the highest returns, which is of growing importance as the population ages and the demand for health care services is growing.

Using detailed employer-employee matched data for the years 1990-2000, we first quantify program take-up decisions for three different occupations: nurses, who hold a B.Sc., nursing assistants, who have completed up to 24 months of practical training, and doctors, who hold an M.D. Exploring variation in eligibility based on the age distribution of children, we find that a large fraction of eligible nurses and nursing assistants take advantage of the parental leave program. For example, the fraction of previously employed nurses with 0-1 year old children on leave increases by 15-20 percentage points following the introduction of the parental leave program. On the other hand, we find only very small take-up rates for doctors.

Despite the substantial program take up rates for both nurses and nursing assistants, the net employment effects for health care providers are very different. We find that hospitals and nursing homes are not able to replace nurses on leave on net, leading to a persistent reduction in the stock of working nurses of 12%. We also document differential effects on net employment among health care sectors and counties based on differences in the demographic composition of the respective workforces. This indicates that the labor market for nurses is at least partially segmented at health sector and county level.

[1] http://www.bls.gov/spotlight/2015/employment-and-wages-in-healthcare-occupations/pdf/employment-and-wages-in-healthcare-occupations.pdf last accessed 12/10/16.

This is not true for nursing assistants. We find that hospitals and nursing homes are able to fully replace nurse assistants on leave by hiring nursing assistants from other occupations and by hiring newly trained nursing assistants. We do not see an increase in nurse assistant employment indicating that health care providers cannot substitute nurses by nursing assistants. Therefore, we focus on nurses in the remainder of the paper.

We next exploit the exogenous variation in nurse employment at the health sector-county level to quantify the effects of nurses on the delivery of care and patient outcomes in a difference-in-differences analysis. Combining the employment data with detailed information from hospital patient records and mortality data, we find detrimental effects on hospital quality as evidenced by a persistent increase in 30-day hospital readmission rates for newborns as well as the general patient population. However, we neither find evidence for changes in hospital inpatient mortality nor detect changes in access to care.

We contrast these findings with the evidence from nursing homes where the consequences are more drastic. In the first three years following the reform, we notice a 13% increase in nursing home mortality among the elderly aged 85 and older. In absolute numbers, we find that the parental leave program reduced the number of nurses by 1,200 and raised mortality by 1,700 elderly per year. The absolute increase in mortalities is muted in the following years 1998-2000, in part because of an endogenous exit of nursing home residents who have access to outpatient long term care alternatives in the community. Taking selection into account, our findings indicate a persistent increase in the nursing home mortality rate over the entire post-reform period.

We then study the mechanisms behind these differential effects across health care sectors. For hospitals, we detect three mechanisms that mitigate the detrimental consequences of the nurse reduction. First, hospitals postpone the adoption of new technologies that can bind significant resources in the short term. Second, hospitals partially manage their patient mix by moving non-acute patient to less affected hospitals, which allows them to focus on local acute care patients. Third, hospitals coordinate leave taking decisions of their workforce effectively, which allows them to avoid peek shortages that can be particularly harmful to the patient population.

For nursing homes, we leverage detailed information on causes of death and nursing home hospital transitions to quantify the mechanisms behind the increase in mortality. We find a substantial increase in heart attack mortalities among residents with disproportionately small hospitalization rates in the month preceding their death. This indicates that the lack of nurses on staff impedes the monitoring of the most vulnerable residents, who may in these circumstances forgo more appropriate hospital treatments.

Overall, our findings indicate that nurses play a particularly important role in the delivery of nursing home care, suggesting that nursing homes are constrained in hiring nurses to meet their urgent staffing needs.

This paper makes two main contributions. First, we contribute to the literature on the role of nurses in the health production function. A large number of studies has investigated the effect of nurses on patient health outcomes, see **kane2007association** for a review. These studies have focused on one sector at the time and relied on cross-sectional variation in nurse employment with a limited attention to the endogeneity concerns regarding nurse employment. Notable exceptions are **cook2010effect** and Lin (2014), who exploit variation from changes in minimum nurse staffing staffing regulations in hospitals and nursing homes, respectively. Gruber and Kleiner (2012) study the effect of nurse strikes on patient health using data from the State of New York and find a large increase in in-hospital mortality for heart attack patients. Propper and Van Reenen (2010) and Stevens et al. (2014) exploit the effect of local labor market variation on nurse staffing ratios and how that affects heart attack mortalities and nursing home mortality, respectively. Hackmann (2015) estimates a structural model of the nursing home sector in Pennsylvania using variation in Medicaid reimbursement rates and finds a large willingness to pay of $126,000 for an additional nurse on staff.

Our analysis contributes to this literature in four important ways. First, we exploit a sudden, sizable, and persistent reduction in nurse employment, which allows us to assess the timing and the dynamics of changes in the delivery of care and patient health outcomes. Second, the unintended nature of our quasi-experimental variation indicates that our estimates are potentially more informative about the returns of nurses than aforementioned approaches. While changes in local labor markets conditions and minimum staffing regulations are subject to selection on ability in the nurse workforce, the parental leave program selects on age of children and does not affect outside options of employees. Selection effects imply that business cycle variation may yield an upper bound on the marginal effect of nurses, while minimum staffing regulation may provide a lower bound. Third, we combine detailed administrative data for the entire Danish population served in different health care sectors, which allows us to quantify differences in the effect of nurses on health care delivery and patient health outcomes between health care sectors. While there is substantial mobility between private sector and health sector for nursing assistants, we find little evidence for nurses. Instead, the margin between health care providers is crucial for the allocation of nurses. Fourth, we exploit data on causes of death, hospital patient records and nursing home residents to analyze the mechanisms how nurses affect health care delivery across providers and across patient groups.

In addition to quantifying the return of a key input in the health production function, we also contribute to the literature on parental leave programs. Over the past 50 years, parental leave programs have become a prevalent and important feature of labor markets in developed countries (see Dahl et al. 2013). Previous studies have vastly focused on the labor market effects for affected parents and on outcomes of children but the empirical evidence remains mixed.[2] In this paper, we argue that publicly funded parental leave programs can

[2]On one hand, several studies find positive effects on health, educational, and earning outcomes for children

have significant negative externalities for employers and ultimately consumers if the program affects imperfectly substitutable employees in limited supply. This applies to employees who hold firm- or industry-specific human capital and occupations that require a licensed degree in particular. The specifics of the parental leave program may amplify the employment effects. Employers are required to guarantee the same position for the returning leave taker. Therefore, the employer may leave the position vacant if she cannot find a temporary replacement. To the best of our knowledge, we are the first to quantify this externality. We evaluate this externality in a particularly important context, given that women are more likely to take advantage of the parental leave program and that more than 97% of Danish nurses are female.

The remainder of this paper is organized as follows. Section 2 provides institutional background of the Danish health care sector and the policy reform that we study. In Section 3 we describe our econometric approach. In Section 4, we discuss the data and we present our empirical findings in Section 5. Finally, we conclude in Section 9.

2 Institutional Background

This section discusses important regulatory features of the Danish health care sector as well as the parental leave program. The goal of this section is to provide relevant background information to allow for a discussion of external validity and to motivate the empirical analysis at the regional (county) level. For additional details on the Danish health care sector see Pedersen et al. (2005).

2.1 The Danish Health Care Sector

Similar to other Scandinavian countries, Denmark's heath care system applies the "Beveridge" model. Health care expenses are primarily tax financed and most health care providers are publicly owned. In contrast to most other European countries, however, the Danish health care system is decentralized. For the period we study, the country was divided into 13 counties and three municipalities with county status, which are politically responsible for the financing, capacity planning and delivery of key health care services including hospitals.[3] Hospital financing is based on a system of politically fixed budgets, which provides cost control as a function of heterogeneous patient mix. The main objective of public hospitals is equal and free access to health care with a focus on professional quality and efficiency, patient safety and satisfaction. Private hospitals account for less than 1% of the total number of hospital

(see e.g. Ruhm (2000), Rossin (2011), Carneiro et al. (2011)) and positive or only slightly negative effects on parental labor force participation (see e.g. Ruhm (1998), Waldfogel et al. (1999), Baker and Milligan (2008), and Schönberg and Ludsteck (2014)). On the other hand, other studies do not find evidence for positive health or educational attainments for children (see e.g., Rasmussen (2010), Liu and Skans (2010), Dustmann and Schönberg (2012), and Dahl et al. (2013)) and suggest negative net employment effects (see Dahl et al. (2013)).

[3]See Figure 17 in the Appendix.

beds in the 1990s. Long term care services, including nursing home services, are organized at an even more granular level: the municipality level.[4] Overall, this suggests that health care systems are vastly integrated at the county level.

Moreover, counties constitute separate labor markets for health care workers. 20% of nurses and 16% of nursing assistants switch jobs every year, but only 2% of assistants and 4% of nurses start a job in a different county. 88% of nurses and nursing assistants live and work in the same county and this share increases to 96% when excluding the counties related to the capital city.[5]

Finally, wage setting and working conditions are highly regulated in the Danish health sector with a long tradition of cooperation between health worker unions and health care providers. Nursing assistants are members of the Danish Union of Public Employees (FOA) with almost universal membership and the Danish Council of Nurses (DNO) organizes more than 90% of nurses over the sample period. Wages depend on seniority and only differ slightly across counties and municipalities but not across health providers within geographic area. There is modest wage growth for nurses over the sample period. Real entry-level wages for nurses were increased by 3.3% in 1994 and again by 4.9% in 1998. Individual hospitals were unable to deviate from these industry agreements to attract more workers. Regulation also limits the patient responsibilities that can legally be performed by other health workers except nurses.

Our empirical analysis takes advantage of these institutional and geographic features and explores variation in the effects of the parental leave program across counties.

Our main findings, discussed below, indicate a substantial increase in nursing home mortalities because of the negative nurse employment effects of the parental leave program. To put these findings into perspective, we compare elderly demographics and nursing home characteristics between Denmark and the U.S. in Table 1. Both the share of elderly people in the population and the average age and share of elderly people living in nursing homes are very similar in Denmark and in the U.S. in 1993. This similarity in nursing home relevance is observed towards the end of a transition away from institutional care and towards community based care in Denmark between 1983 and 1995. Ribbe et al. (1997) report that in 1993, there are 1,075 nursing homes in Denmark offering 39,000 beds. Their study implies that the average nursing home size in the U.S. is about twice as large as in Denmark.[6] We also find a generally higher nurse to resident staffing ratio in Denmark of 0.32 in 1993, which exceeds a

[4] The number of municipalities was reduced from 271 in our sample period to 100 in 2007. This reform reduced the number of regions from 16 to only 5.

[5] These figures are for the period 1990-1993 before the reform. We introduce the data in more detail in section 4 below.

[6] For the US, Ribbe et al. (1997) report 21,000 nursing homes and 256.6 million*12.7% elderly people. Based on the first row in Table 1, this implies 53/1000*(256.6 million *12.7%)=1.7 million beds. Hence, about 82 beds per nursing home.

Table 1: Elderly Demographics and Nursing Homes in Denmark and the US

	Denmark	U.S.
NH beds/ per 1k elderly$^{(a)}$	48	53
Fraction elderly in nursing home$^{(a)}$	4%	5%
Fraction of population older than 65$^{(a)}$	15.4%	12.7%
Fraction of population older than 80$^{(a)}$	3.9%	2.9%
Average age in nursing home	82.2$^{(b)}$	82.2$^{(c)}$
Avg Nursing home size in beds$^{(d)}$	36.3	82
Nurse to resident ratio	0.32	0.25

Sources: (a) Ribbe et al. (1997) for the year 1993, (b) Nursing home survey for Denmark 1994, Statistics Denmark, (c) Nursing home survey for Pennsylvania, US 1996, (d) Ribbe et al. (1997) for the year 1993 and own calculations.

comparable ratio in the U.S. by about 28%.[7]

2.2 Parental Leave Programs in Denmark

Denmark has a long tradition of maternity leave support going back more than 100 years, see Rasmussen (2010). After several extensions over the 1970s and 1980s, the status quo in the early 1990s was an 18-week maternity leave starting four weeks prior to birth with full job security and generous income dependent support.[8] In addition, fathers were offered a compensated 2-week leave immediately after childbirth. Finally, parents could extend the post-birth leave time to 24 weeks, with the additional 10 weeks of parental leave to be taken by the mother or the father.

Motivated at least in parts by high unemployment rates, the newly elected social democratic Danish government introduced several policies in 1993 that became effective in 1994 and were aimed at rotating the workforce, see Westergaard-Nielsen (2002). Most importantly, the government introduced an educational, a sabbatical, and an additional parental leave program.[9] The hope was that these programs would give unemployed people the opportunity to fill the opening positions and to gain valuable work experience. The analysis in Westergaard-Nielsen (2002) suggests that the parental leave program had the largest overall impact on labor market participation, while the sabbatical and educational leave had much lower take-

[7]Based on the estimated elderly fraction in nursing homes from Table 1, we conclude that the Danish nurse staffing ratio in nursing homes equals 11,000 nurses divided by 4% of 850,000 elderly people: 11,000/(0.04*850,000)=0.32. We use data from Long Term Focus from the U.S. to construct the average number of skilled nurse hours per resident day. Considering registered and licensed practical nurses, we find a staffing ratio of 1.44 hours per resident day. Assuming that nurses work 2,080 hours per year (52 40h weeks), we find a nurse to resident ratio of 1.44*365/2,080=0.25.

[8]The minimum of 90% of income and DKK 2,008 (about $335 in 1983-1985) per week. Most mothers received 90% of their salary, so the income effects of leave taking were relatively minor, see Rasmussen (2010).

[9]In addition, transition pay for unemployed workers between 50 and 60 was offered over 1992-1995. The offer included 82% of the highest UI benefits if the worker leaves the labor force into early retirement and further reduced the available worker pool.

up rates.[10] Our approach uses eligibility rules of the parental leave program to analyze the effects of this program.

The parental leave program offers a parent the opportunity of taking up to one year of absence if the child is aged 8 or younger.[11] The program guarantees job security[12] and offers a compensation of 80 percent of unemployment benefits, see Jensen (2000). Unemployment benefits equal 90% of previous wages up to a maximum of $463[13] per week, see Westergaard-Nielsen (2002). Soon after the reform, policy makers noticed that the reform led to a "bottleneck" problem in the public sector in particular, where licensed professionals could not be replaced that easily (e.g., teachers and nurses). As a result, policymakers gradually cut back on the generosity of the program. Guaranteed coverage length was reduced in 1995 for children older than 1 year of age. Benefits were reduced to 70 percent of unemployment benefits in 1995 and subsequently to 60 percent in 1997 before the program was abolished in 2002 in the context of a comprehensive reform of the parental leave policies, see Pedersen et al. (2005) and Andersen and Pedersen (2007).

3 Empirical Strategy

In this section, we develop a simple empirical strategy that allows us to quantify the effects of the parental leave program on program take-up, net employment, health care delivery, and patient health outcomes. We first investigate the parental leave program take-up using variation in program eligibility across workers and over time. Second, we aggregate the take-up rates by county and health sector and investigate the effects on health outcomes in a difference-in-differences analysis.

3.1 Program Take-up at the Worker Level

We start with an analysis of parental leave program take up in year t in the sample of individuals that were employed in the previous year $t-1$. We focus on the previously employed because we can assign these health care professionals to a specific health care sector using the employer data from the previous year.

Specifically, we analyze the employment decision of parent i, whose youngest child is a years old, before and after the reform:

[10] Using data on social benefit receipts 1995-2000, we find that these leave programs jointly account for 23 percent of total paid leave time among nurses, while parental leave accounts for 77 percent, see Appendix Table 9. Moreover, a large share of education leave among nurses is due to participation in short term continuing training, see Figure 18, and both education and sabbatical leave always require employer approval.

[11] The program guaranteed 26 weeks, see Jensen (2000), to employed employees but employees could take up to one year conditional upon employer support, see Pedersen et al. (2005).

[12] At least for publicly employed individuals, the vast majority of individuals in our sample, see Pylkkänen and Smith (2003).

[13] DKK 2,940 at an annual average exchange rate of 6.35 DKK per USD in 1994.

$$Y_{ita} = \alpha + \sum_{a=0}^{8} \alpha_a \cdot 1(ageCH_a) + \alpha_{post} \cdot Post_t + \sum_{a=0}^{8} \beta_a \cdot 1(ageCH_a) \cdot Post_t + \epsilon_{it} \ . \tag{1}$$

Here the dependent variable, Y_{ita}, is an indicator variable that takes the value 1 if person i is not employed in year t. $1(ageCH_a)$ refers to a series of indicator variables that take the value 1 if the youngest child is of age a. Post is an indicator variable that takes the value 1 for post-reform years. Our key parameters of interest are β_0-β_8, which indicate the take-up effects for eligible parents.

We estimate equation 1 for different sample populations. First, we separately investigate the immediate take-up effects for doctors, nurses, and nursing assistants by focusing on the sample years 1993 and 1994. In a separate set of regressions, we investigate the effects of the program in 1995 compared to 1993. These effects may be smaller, as the program became less generous over time and because parents can only once take advantage for an eligible child.

3.2 Employment, Health Care Delivery and Outcomes at the County Level

To quantify the effects of the parental leave program on net employment, health care delivery, and patient health outcomes we aggregate the estimated takeup decisions at the county-health-sector-year level. Counties define segmented health care markets as evidenced by little labor and patient movements between counties and because the financing and the coordination of health care delivery is organized at the county or even more granular levels, see Section 2.1. We also find quite different employment effects among hospitals and nursing homes in a given county suggesting that health care markets are further segmented at the sector level. This is consistent with disconnected regulatory boards for hospital and nursing home care, which coordinate the delivery of care at the county and the municipality level, respectively.

Specifically, we cross-multiply the take-up parameters, $\beta_0, .., \beta_8$, in 1995 by the number of eligible workers in any given health sector and county in the last pre-reform year 1993 to construct a conservative proxy for program take-up that varies between health sectors and counties. Focusing on eligible workers in the last pre-reform year provides a time-invariant measure of program take-up, which is not affected by endogenous job transitions in the post-reform years. We use the estimated take-up parameters in 1995 which are smaller than the immediate take-up probabilities and relatively stable over the following years. We refer to these as steady state take-up probabilities. Finally, we divide the product of take-up probabilities and stock of eligible nurses (predicted number of employees on parental leave) by the total number (eligible and ineligible) of employed nurses in 1993 at the county-health-sector level, and refer to this measure as "Exposure":

$$\text{Exposure}_c^s = \frac{\text{Eligible nurses}_c^s * \text{Estimated take-up parameters}}{\text{All nurses}_c^s}.$$

Similar to Finkelstein (2007) and Clemens and Gottlieb (2014), we then estimate the effect of exposure on outcomes by year as follows::

$$Y_{ct}^s = \mu_c^s + \mu_t^s + \phi * log\,(pop_{ct}) + \sum_{t=1990}^{2000} \lambda_t^s \cdot Exposure_c^s + u_{ct}^s\ . \tag{2}$$

Here, Y_{ct}^s denotes the respective outcome measure in county c, year t, and health sector s. We distinguish between three sectors: nursing homes, hospitals, and all other industries combined. We are primarily interested in the coefficients $\{\lambda_t^s\}$ that show the pattern of the outcome variable over time across counties with different exposure to the reform. Hence, any structural break of the λ's around the reform year 1993 will be attributed to the reform effect. We include log population as well as county fixed effects μ_c^s and year fixed effects μ_t^s as controls. This specification allows graphical inspection of potential pre-trends across counties and will guide the subsequent difference-in-difference estimation of the average reform effect on employment and mortality rates.

4 Data

An important advantage of our empirical context is that we can combine a variety of administrative data sources including employer-employee match data, patient registry data, and cause of death registers covering the entire Danish population over the period 1990-2000. We discuss these data sources in detail below.

The Danish integrated database for labor market research (IDA) covers the universe of firms and workers in Denmark over 1980-2011. The data contain information about primary employment in November each year, including plant and firm identifiers, location and industry of the establishment, and detailed worker characteristics such as gender, age, education, experience, tenure, hourly wages and annual earnings. We add additional household characteristics such as municipality of residence, marital status, number of children and the age of the youngest child from the population register. The latter will be particularly useful to measure eligibility of workers for the parental leave program since only parents with children aged 8 years or younger can apply for these benefits.[14]

The education variable reports the highest degree that a person has achieved from school-

[14]From 1995, social benefits records report the beginning and end date of parental leave and other welfare receipts. We use these data to complement our annual employment indicator in November and to analyze timing and duration of leave.

ing, vocational training or university education. In particular, the variable contains detailed categories of health workers that allow us to distinguish medical doctors, nurses and nursing assistants. We define doctors as all individuals with an M.D. or Ph.D. in medicine. Nurses are defined as all individuals with a Bachelor degree or equivalent training of theory and clinical practice in nursing or midwifery, as well as nurses that completed additional specialization training as home nurses, health visitors, head nurses, nurse teachers or participated in post-graduate training (Nursing diploma, Master in Nursing Science).[15] Finally, we define unskilled nurses or nursing assistants as social and health care aides and health care assistants with 14 months of theoretical and practical training.[16]

Next, we use industry information of plants to identify hospitals and nursing homes. Our definition of nursing homes includes residential institutions for the elderly and for adults with disabilities. We summarize all other employment as the outside sector.[17] Moreover, workers without establishment affiliation in a given year are reported as unemployed or non-participating. Because of the wide age range in the data, this group of individuals includes young workers in training and retired individuals as well.

Figure 1 reports aggregate trends for employment of nurses and nursing assistants in different health care sectors and the private sector over time. Nurses primarily work in hospitals and their employment share in hospitals increases over time, whereas a large and increasing share of nursing assistants work in nursing homes. The aggregate trend for nurses shows a striking drop in employment in all sectors in 1994 that is consistent with a labor supply shock from the leave program. In contrast, the change in employment is less pronounced for nursing assistants, where the structural break is most visible outside of hospitals and nursing homes. One interpretation of these trends is that nursing assistants in the health sector are easily substitutable from the private sector and therefore we do not observe a structural break in aggregate health care employment. Health care providers simply replace leaving nursing assistants by hiring additional nursing assistants from other occupations and by hiring newly trained nursing assistants. As a result, our analysis will mainly focus on the labor supply shock for skilled nurses.

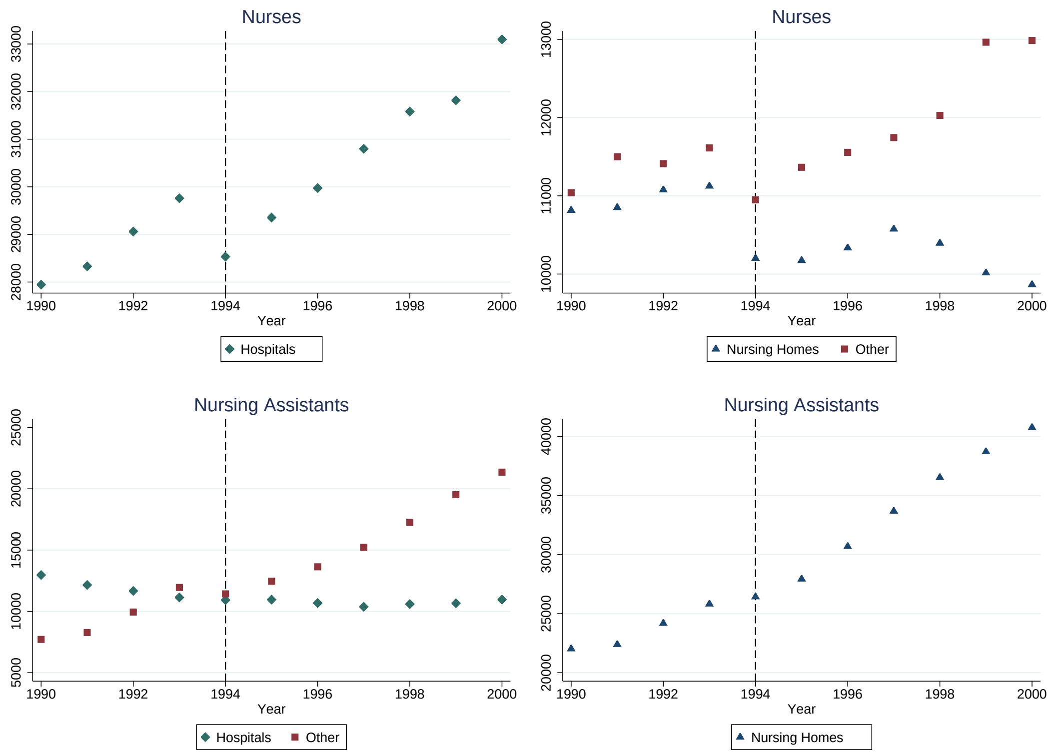
We combine employer-employee data with information on the universe of inpatient hos-

[15] Nursing is a licensed profession in Denmark and only workers authorized by the National Board of Health can practice as nurses. The Act on Certified Nurses 1933 establishes "Sygeplejerske" (certified nurse) as a reserved title.

[16] The relevant professions include "Plejer", "Social- og sundhedshjaelper", "Sygehjaelper", "Plejehjemsassistent", "Social- og sundhedsassistent".

[17] There are three structural changes in industry classifications in Denmark over the time period that we study, these changes occur in 1993, 2003 and 2007. We define health sectors sufficiently broadly to be able to provide a consistent definition of institutions over time. This prevents us from separately measuring other health care providers such as physicians, home nursing, and midwifery. We rely on imputing industry information for a share of plants before 1993 but the time series of employment in different sectors do not suggest that this is a major concern.

Figure 1: Employment of Nurses and Nursing Assistants in Denmark



pitalizations between 1990-2000 from the Danish National Patient Register.[18] The patient register provides information on admission and discharge dates, potential wait times, detailed diagnosis and procedure codes. We can also link the patients between the patient register, the employer-employee match data, and population registers, providing us with rich demographic information on the patient population. We leverage the information to measure the effect of nurses on access and quality of hospital care, e.g., the 30-day hospital readmission rate. We use the diagnosis code information to study patient subpopulations, e.g., acute care patients, and explore procedure code information to quantify the effect of nurses on technology substitution and adoption. One limitation of the diagnosis and procedure codes is that Denmark changed its classification system from ICD9 to ICD10 in 1994. We use extensive documentation sources to construct accurate time series. However, we also construct other patient populations, using additional data, that do not rely on the procedure code information, e.g. newborns.

Finally, we add mortality information from the Danish Register of Causes of Death at the person level for the years 1991-2000. The death register provides information on the death date, the cause of death, as well as the location of death. The death location information

[18]We also observe outpatient data starting in 1994. Since we require a balanced time series for the pre and the post-reform years, we focus on inpatient data in our baseline analysis.

allows us to distinguish between mortality originating from a hospital, a nursing home, and their home.[19] We use this information to construct unconditional nursing home mortalities (we do not condition on being in the nursing home). We then construct the nursing home population by matching location information for nursing homes with individual addresses from the population register. This allows us to study conditional nursing home mortalities and patient selection as well.

5 Results

In this section, we provide graphical and regression-based evidence on parental leave take-up and the subsequent effects on employment, health care delivery, and patient health.

5.1 Program Participation

We first analyze the immediate take-up rates of the parental leave program. The first row of Figure 2 displays the fraction of leave takers for different health care workers by the age of their youngest child. Leave takers are defined as workers who were employed in the previous year but are non-participating in the current year. The black dashed line documents the fraction of leavers in the pre-reform year 1993, while the solid line shows the fraction of workers that take one year off in the first post-reform year 1994.[20]

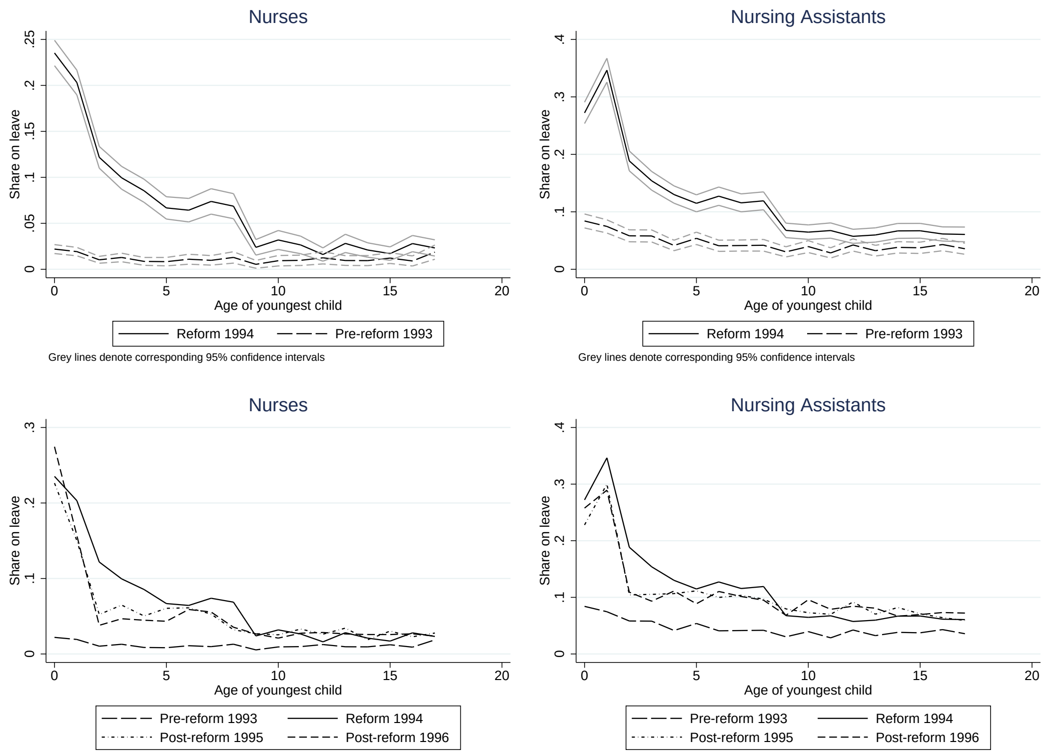
For both nurses and nursing assistants, we find that eligible parents, parents with a child aged 8 or younger, are much more likely to be on leave in the post-reform year in particular if they have young children aged 0 or 1. We attribute the differential effects for parents with children aged 8 or younger to the introduction of the parental leave program. Quantitatively, we interpret the vertical difference between the solid and the dashed line, relative to the difference for children aged 9 or older, as the program's take up effect. The effects are substantial. The evidence suggests that the fraction of nurses that take one year of absence increases from 3 percent in 1993 to about 23 percent in 1994, if they have a child less than one year old, see Table 10 for details. We also find evidence for bunching for children aged 6-8. This is reasonable given that this is the last chance for parents with an 8-year-old child to take advantage of the program.

The pattern is very similar for nursing assistants; here we find an increase of 16 and 24 percentage points for children in the first and second year of life, respectively. We also notice a slight increase in leave taking among ineligible nursing assistants with children aged 9 or

[19]Mortality rates in nursing homes are recorded from 1991. This is why we restrict the sample period for mortality outcomes to 1991-2000.

[20]All figures pool both male and female employees. Separate analysis by gender reveals that a large share of the effect is driven by mothers, whereas fathers do not usually participate in long-term leave taking. Note that 95% of nursing assistants and 97% of nurses in the labor market are female over the 1990s. For doctors, the share of women steadily increases from 28% in 1990 to 36% in 2000.

Figure 2: Immediate and Steady State Program Take-Up



older, suggesting that nursing assistants are more likely to take advantage of the education and or sabbatical program, also introduced in 1994, which do not condition on the age of the child. Yet these changes in leave taking are small compared to the increase in leave taking for young parents. Finally, we find only very small increases in leave taking among doctors of about 2 percentage points for a child less than one year old. There is no evidence for an increase in leave taking for older children, see Figure **??** and Table 10 for details. Facing different career dynamics, doctors may risk potential career advancements if they take a leave of absence or they might have better access to child care facilities for example.

We next turn to the take-up rates in the following years to describe take-up in steady state. The immediate program take-up includes considerable bunching around the age threshold for program eligibility. We expect these initial effects to fade out over subsequent years because many parents with older children have already taken advantage of the program in previous years. The second row of Figure 2 illustrates the convergence of take-up rates after the immediate surge in program participation in 1994 to what we consider "steady state" levels in the years 1995 and 1996. The left panel provides evidence for nurses and the right panel presents analogous evidence for nursing assistants respectively. Compared to immediate program take-up, the evidence suggests smaller steady-state take-up rates for parents with children aged 2 or older. We provide the analogous regression-based evidence for 1995 in column (4)-(6) of Table 10.

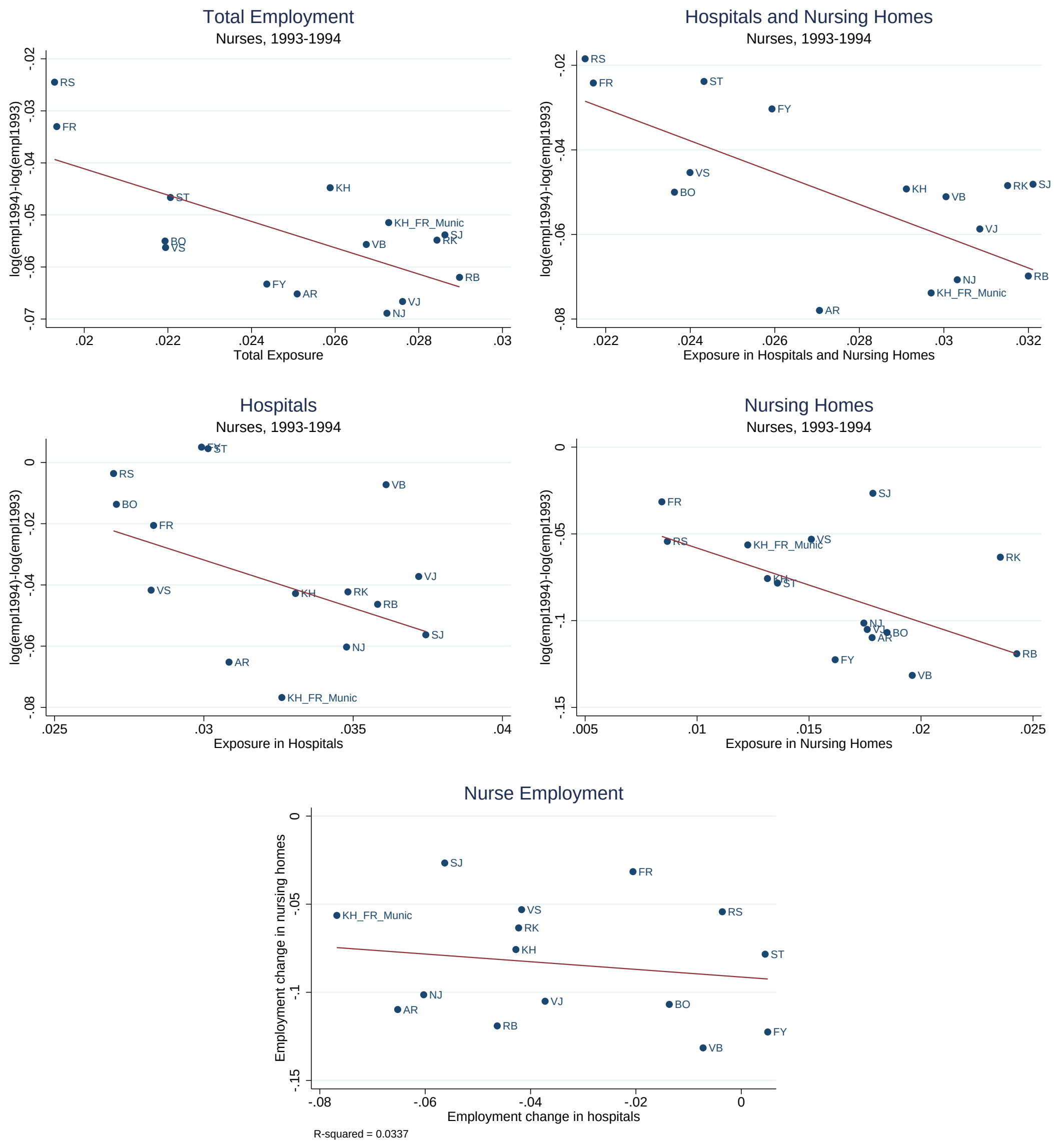
Overall, we find large reform effects on individual leave taking for nurses and nursing assistants. Yet health care providers are able to replace nursing assistants on leave as indicated by the smooth aggregate time trends presented in Figure 1. In contrast, Figure 1 indicates a substantial and persistent decline in nurse employment in the post-reform years. As a result, we expect the largest labor supply shock from the reform for nurses and focus our subsequent analysis on these workers.

5.2 Aggregate Effects on Employment

To reconcile the time series evidence from Figure 1 and the program take-up estimate from the previous section, we now turn to the effects of the parental leave program on net employment. Following the strategy outlined in Section 3.2, we aggregate the estimated take-up probabilities at the county and health care sector level, based on the demographic composition in 1993 and the estimated take-up parameters from 1995.

We first illustrate the statistical relationship between this reform exposure measure and immediate changes in employment after the reform in Figure 3. We compute the log change in employment by county between 1993 and 1994 for each health worker type and sector and plot these changes relative to exposure by county in 1993. There is a stronger decline in employment for counties with higher exposure to the reform. Many counties with high exposure lose more than 5 percent of nurses in hospitals and more than 10 percent in nursing homes in the first year of the reform. The effects are even larger if we take the positive trend in nurse employment into account. On the other hand, counties with small exposure face considerably smaller reductions in nurse employment of less than 5 percent in nursing homes and even increases in the case of hospitals. Overall, our conservative exposure measure can reconcile about 30.5% (13.5%) of the substantive variation in employment changes in nursing homes (hospitals) between counties. Furthermore, we find a negative correlation between employment changes in hospitals and nursing homes by county of -0.1835. This suggests that labor markets are at least partially segmented at health care sector and county level.

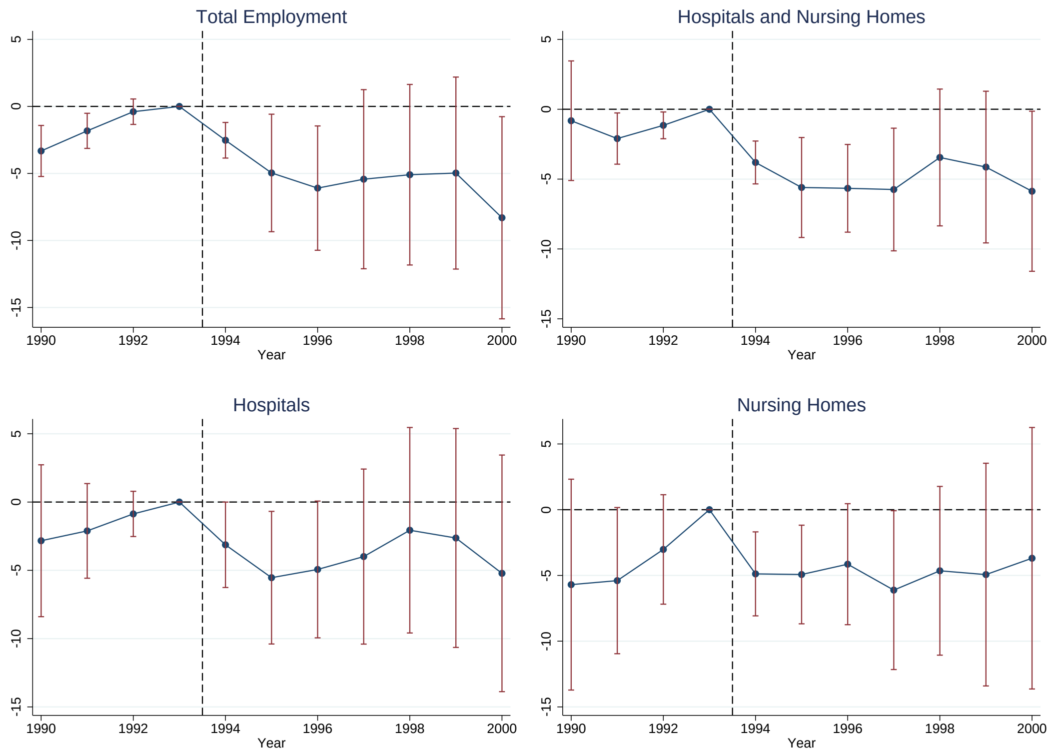
Figure 3: Reform Exposure and Employment Change 1993-1994



We next turn to the λ estimates of the main specification, outlined in equation (2). The first row of Figure 4 shows estimates using total employment and employment in both health sectors respectively. The second row shows employment effects of exposure separately for hospitals and nursing homes. For all specifications, there is an initial upward trend in the coefficient estimates, indicating that counties with higher exposure in 1993 grew faster in the years before the reform. This pre-trend is more pronounced at the individual health care sector level, in particular for nursing homes. All figures show a strong structural break in this growth path in 1994 when the reform starts and persistent effects in subsequent years.[21] The

[21] All corresponding regressions are reported in Table 11 in the Appendix.

Figure 4: Lambda Estimates for Employment Effects by Sector Exposure



negative λ estimates in the post-reform years confirm the negative effect of exposure on net employment.

We report the net employment effects in Table 2. Following the structure in Figure 4, we present the effects on total employment in column 1 and columns 2-4 display more detailed effects for employment in the health care sector, hospitals, and nursing homes, respectively. The first row of Table 2 reports the average effect of exposure on aggregate employment for nurses in the post-reform years. Specifically, we estimate a difference-in-differences regression model with separate county and year fixed effects for the years 1991-1996 and report the effect of exposure interacted with a post-reform indicator variable.[22] We also control for linear county time trends to address potential pre-trends at the county level. The point estimates suggest negative net-employment effects for total employment as well as employment in nursing homes and hospitals. To put the point estimates into perspective, we quantify the average reform effect by multiplying the point estimates with the average reform exposure in the respective sector, see the last row of Table 2. The estimates suggest a net reduction in nurse employment of 13% (3,800 nurses) and 11% (1,200 nurses) in hospitals and nursing

[22]We focus on a symmetric sample period with three pre and post-reform years. We only observe nursing homes mortality outcomes in the years 1991 onwards. Therefore, we omit the year 1990 (1997) to construct a consistent time window for our main findings.

homes, respectively. This suggests that the parental leave exposure can fully account for the observed net reductions in nurse employment outlined in Figure 1.[23]

Table 2: Net Employment Effects for Nurses

	(1) Total	(2) Hosp and NH	(3) Hosp	(4) NH
λ	-2.355	-4.034***	-3.952*	-6.698***
	[-5.724,1.014]	[-6.649,-1.42]	[-8.311,.407]	[-11.018,-2.378]
Δ_1	-2.918***	-4.96***	-4*	-7.904**
	[-4.65,-1.187]	[-7.288,-2.633]	[-8.266,.266]	[-15.521,-.287]
Δ_2	-6.785***	-7.696***	-7.651**	-10.325***
	[-11.922,-1.649]	[-12.246,-3.147]	[-15.283,-.019]	[-18.095,-2.555]
Δ_3	-9.416***	-6.479**	-7.768*	-9.844*
	[-14.393,-4.44]	[-12.075,-.883]	[-16.948,1.413]	[-20.489,.8]
Pre-Reform Value	52443	40886	29761	11125
Avg. Effect	-.059	-.111	-.127	-.109

The 95% confidence interval is displayed in brackets.
Standard errors are clustered at the county level. The specifications control for county and year fixed effects, log population, and linear county trends.
* $p < 0.10$ ** $p < 0.05$ *** $p < 0.001$

We revisit the role of pre-trends in rows 2-4 of Table 2. Following the methodology in Finkelstein (2007), we construct deviations from pre-trends captured by the time series of lambda coefficient in Figure 4. Specifically, we construct the average effect over $\tau = 1, 2, 3$ years as follows:

$$\Delta_\tau = \frac{1}{\tau} \sum_{t=1}^{\tau} \left[(\lambda^s_{1993+t} - \lambda^s_{1993}) - (\lambda^s_{1993} - \lambda^s_{1993-t}) \right]. \tag{3}$$

Each summand in equation (3) compares the change in trends relative to the reference year 1993 for t periods before and after the reform. This specification implies that the pre-trends would have continued at the same rate after the reform. We find significant negative effects in all specifications, both for total employment and for sectoral employment changes. Interestingly, the effects increase over time, indicating a cumulative reduction in employment that is

[23] Note that the point estimates for exposure are less than -1. A coefficient of minus 1 is an interesting benchmark because it indicates that nurses on parental leave reduce net employment one-to-one, suggesting that employers are unable to replace any leaver on net. A coefficient of less than one in absolute value would suggest that employers can at least partially replace nurses on parental leave, for example by reactivating nurses outside the labor force. Our point estimates suggests the opposite: employment decreases by more than the number of predicted leavers. However, our exposure measure is likely to understate the amount of leave taking for several reasons. First, our take-up estimates measure the probability of leave conditional on working in the previous year and do not consider take-up among the previously unemployed. Second, based on the maximum program duration of 12 months, we implicitly assume that nurses return after one year of absence. However, less than 70 percent of nurses on parental leave return to the same county and sector within five years. If 30 percent of leavers do not return, the stock of leavers after five years with an equal number of leavers per year increases by a factor of 2.5. Third, we use leave taking behavior in 1995, which understates the immediate reform outcomes as shown in the first row of Figure 2. Another explanation for the large coefficients is a negative externality on co-workers, who might have to fill in the missing hours/shifts. This may encourage some co-workers to leave the employer.

consistent with low re-entry rates of leave takers and negative spill-over effects on co-workers. The size of the average effect over three years is larger than the exposure effects for the post-reform period estimated in the first two rows, which may indicate that the assumption of persistent pre-trends in (3) provides an upper bound to the effect.

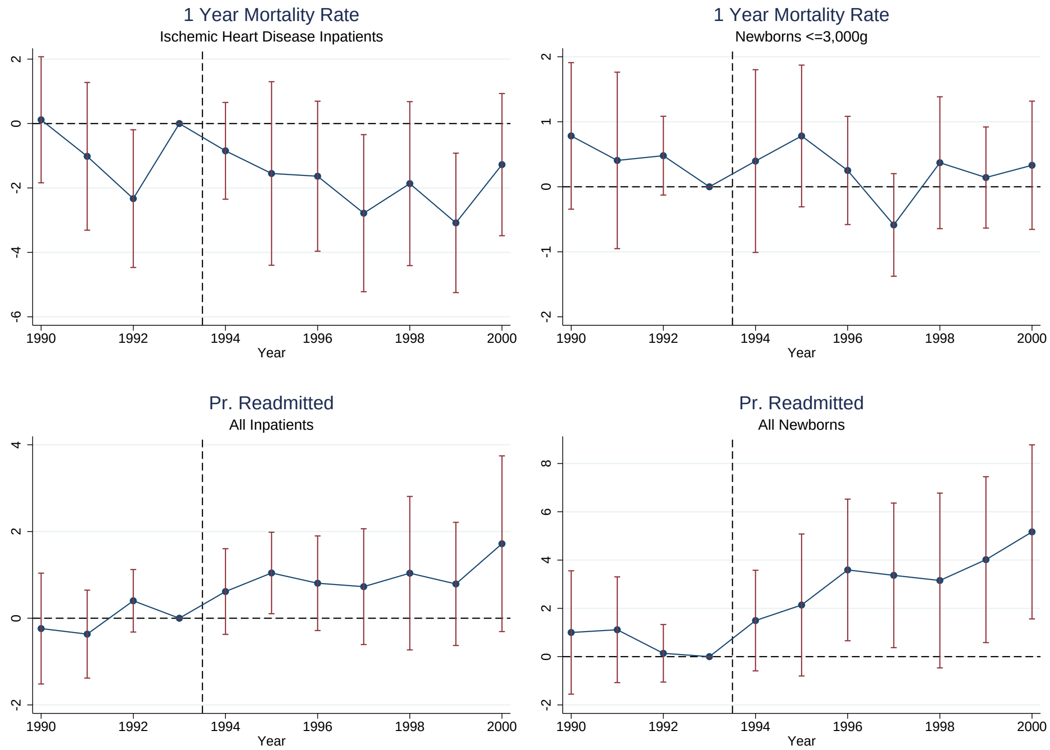
In sum, we find large effects of the parental leave program on aggregate employment of nurses, in particular in counties and subsectors with high exposure to begin with.

5.3 Health Outcomes in Hospitals

Next, we turn the effects of the net reduction in nurse employment on hospital health outcomes exploring variation in hospital exposure between counties. We start with an analysis of hospital mortality. A canonical challenge for the identification of mortality effects are confounding changes in the patient population. We respond in several ways. First, we link health outcomes based on the patient's county of residence, as opposed to the county of the hospital address, to purge off potential variation from hospital selection. Second, to address selection at the extensive margin (overall hospital utilization) we consider the 1-year mortality rates among acute care patients. Specifically, we follow Propper and Van Reenen (2010) and focus on heart attack patients, which we identify using detailed ICD diagnosis codes. The top left graph of Figure 5 presents the analogous λ coefficients for the one-year hospital mortality rate of heart attack patients. We find no evidence for a systematic change in the 1-year mortality rate. The corresponding average λ and Δ estimates are presented in the first column of Table 3. We repeat the analysis for inpatients whose primary diagnosis is pneumonia. We also find no evidence for a systematic change in the 1-year mortality rate.

One potentially confounding factor could be the change in the ICD classification in 1994 to the extent that differential changes in measurement across counties are also correlated with our exposure measure. In a placebo check, we find no evidence for changes in acute care visits, which provides evidence against this concern. Nevertheless, we also revisit one-year mortalities among newborns, which we observe in a different database and do not depend on the ICD classification. Specifically, we focus on babies at risk with a birth weight of less than 3,000g. We observe 138k babies at risk (about 12.5k per year) with an average 1-year mortality rate of 1.9%. We find no systematic evidence for changes in the one-year mortality rate as evidenced by the top right graph of Figure 5. Finally, we also consider the unconditional annual mortalities among the elderly aged 65 and older as an alternative approach to mitigate biases arising from selection at the intensive or extensive margin. Here we simply divide the overall number of mortalities by the county population aged 65 and older and investigate the statistical relationship with hospital exposure. Again, we find no evidence for a change in the annual mortality rate.

Figure 5: Lambda Estimates for Mortality Effects by Sector Exposure



Next we turn to a less drastic quality outcome measure, the 30-day hospital readmission rate, which is commonly assumed to be a signal of negative hospital quality, see e.g. the Readmission Reduction Program (HRRP) as part of the Affordable Care Act.[24] We display the corresponding λ coefficients for the universe of inpatient visits and newborns at risk in the bottom left and right graphs of Figure 5, respectively. In both figures, we see a persistent increase in readmission rates following the reduction in nurse employment in 1994, which is consistent with the persistent nurse employment effects. The corresponding average λ and Δ estimates are presented in the third and the fourth column of Table 3. The average λ effect for the three post-reform years 1994-1996 is statistically significant for both patient populations, see the first row, and implies a 17% and a 89% increase for inpatients and newborns, respectively, see the the last two rows.

5.4 Health Outcomes in Nursing Homes

Next we turn to the effects on nursing home health outcomes using variation in nursing home exposure. We first investigate unconditional mortality rates, which is the overall number of mortalities in a given year, which originate from a nursing home, divided by the county

[24]https://www.cms.gov/medicare/medicare-fee-for-service-payment/acuteinpatientpps/readmissions-reduction-program.html, last accessed 12/26/16.

Table 3: Hospital Outcomes

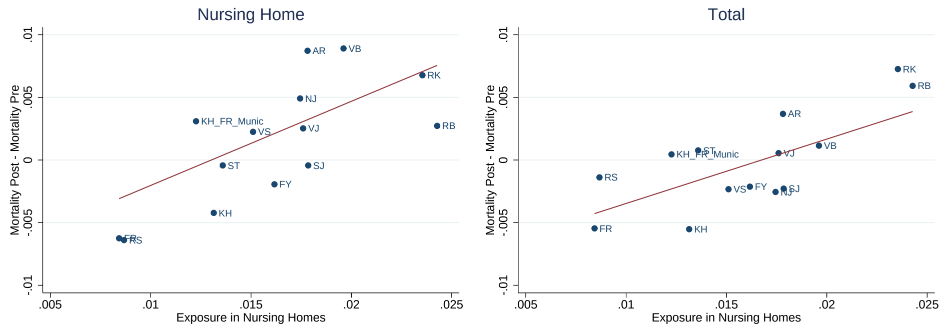
	(1) Mortality Acute	(2) Mortality Newborns	(3) Readmission	(4) Readmission Newborn
λ	-.17	.321	.787*	1.568*
	[-2.156,1.817]	[-.47,1.113]	[-.083,1.657]	[-.118,3.255]
Δ_1	-.847	.397	.615	1.334
	[-2.642,.949]	[-1.294,2.089]	[-.567,1.797]	[-1.032,3.699]
Δ_2	-.034	.352	.629	1.494
	[-1.977,1.91]	[-.852,1.556]	[-.344,1.601]	[-.874,3.862]
Δ_3	-.228	.184	.81*	1.75*
	[-4.767,4.466]	[-.512,.88]	[-.095,1.716]	[-0.15,3.651]
Pre-Reform Value	.101	.019	.147	.056
Avg. Effect	-.005	.01	.025	.05

The 95% confidence interval is displayed in brackets.
Standard errors are clustered at the county level.
* $p < 0.10$ ** $p < 0.05$ *** $p < 0.001$

population. While we do not condition on nursing home residence explicitly, we focus on the elderly population, aged 85 and older, who are likely to demand institutional nursing home care, see Table 1. We present the corresponding λ coefficients in the top left graph of Figure 7. There are no pre-trends of exposure on mortality rates, but there is a striking increase in mortality rates in nursing homes in the post-reform years. The average λ estimate is statistically significant at the 1% level as indicated by the first row in the column of Table 4. The point estimate suggests a 1 percentage point (12.8%) increase in the mortality rate, see the last two rows. To put this estimate into perspective, we multiply the mortality effect with the elderly population aged 85 and older, which equals 0.01x90,000=900. This suggests that the 12% reduction in nurse employment (about 1,200 nurses per year) increases the number of mortalities by 900 elderly people per year (this increases to 1,700 if we consider the elderly aged 65 and older). We revisit differences in the mortality effects between counties in the left graph of Figure 6, where we plot the average change in nursing home mortality between the post-reform years 1994-1996 and the pre-reform years 1991-1993 on the vertical axis against nursing home exposure on the horizontal axis. Consistent with the previous evidence, we see a larger increase in nursing home mortality in counties with a higher exposure in the nursing home sector. This evidence emphasizes the importance of nurses in nursing homes and is consistent with the results in Hackmann (2015) who finds that nursing home residents highly value the number of skilled nurses per resident. [25]

[25] Using data from Pennsylvania, Hackmann (2015) estimates that residents jointly value an additional skilled nurse by about $126,000 per year. Assuming that dying residents lose only one year of the residual life time and that residents only value life expectancy, we find an upper bound on the value of the last year of a nursing home resident of about $126,000*1,200/1,700=$89,000, which is in the ballpark of estimates from the literature. Cutler et al. (1997), for example, find a "quality-adjusted-life-year" (QALY) factor of 0.62 for an 85 year old person in 1990. This suggests a value of a year of life of about $62,000 for an 85 year old based on a value of $100,000 in the best possible health state.

Figure 6: Mortality Effects of Nurse Shortages in Nursing Homes: Age 85 and older



We also quantify the average reform effect over $\tau = 1, 2, 3$ years as follows:

$$\Delta_\tau = \frac{1}{\tau} \sum_{t=1}^{\tau} \left[\lambda^s_{1993+t} - \lambda^s_{1994-t} \right] . \tag{4}$$

Motivated by the graphical evidence, we consider a more parsimonious specification without pre-trends. The point estimates are presented in rows 2-4 and are quite similar to the average lambda estimate, providing evidence for relatively constant adverse mortality effects in the years 1994-1996. However, the effects reverse back to zero in the later post reform years 1997-2000. We will come back to this observation below.

Next, we turn to total deaths at the county level, see the top right graph of Figure 4. Again, we see a quantitatively similar increase in mortalities in the first three post-reform years. The average λ estimate is statistically significant at the 1% level and falls short of the former estimate by only 23%, see the second column of Table 4. For a comparison of the mortality effects between counties see the right graph of Figure 6. This result emphasizes that nurse reductions in nursing homes lead to an overall increase in mortality and do not merely shift the incidence of mortality from private homes and hospitals into nursing homes. Consistent with this assessment, we find no evidence for as systematic link between nursing home exposure and hospital mortality among the elderly, see the left graph in the second row of Figure 7 and the third column of Table 4.

Finally, we return to the middle run effects on nursing home mortality for the years 1997-2000. One possibility for the reduction in the unconditional nursing home mortalities is a reduction in nursing home attendance. To address this possibility, we match location information for nursing homes and individual addresses to measure nursing home residents.[26] Next, we investigate the effect of a nurse reduction on nursing home attendance. The right graph in the second row of Figure 7 shows the corresponding λ coefficients. The time series

[26] In practice, we face some limitations in the administrative data set to define nursing home addresses. At the moment we define nursing home addresses based on individuals who die in a nursing home. We will be able to refine this definition after we receive the revised address data on establishments from Denmark Statistics.

Figure 7: Health Outcomes in Nursing Homes

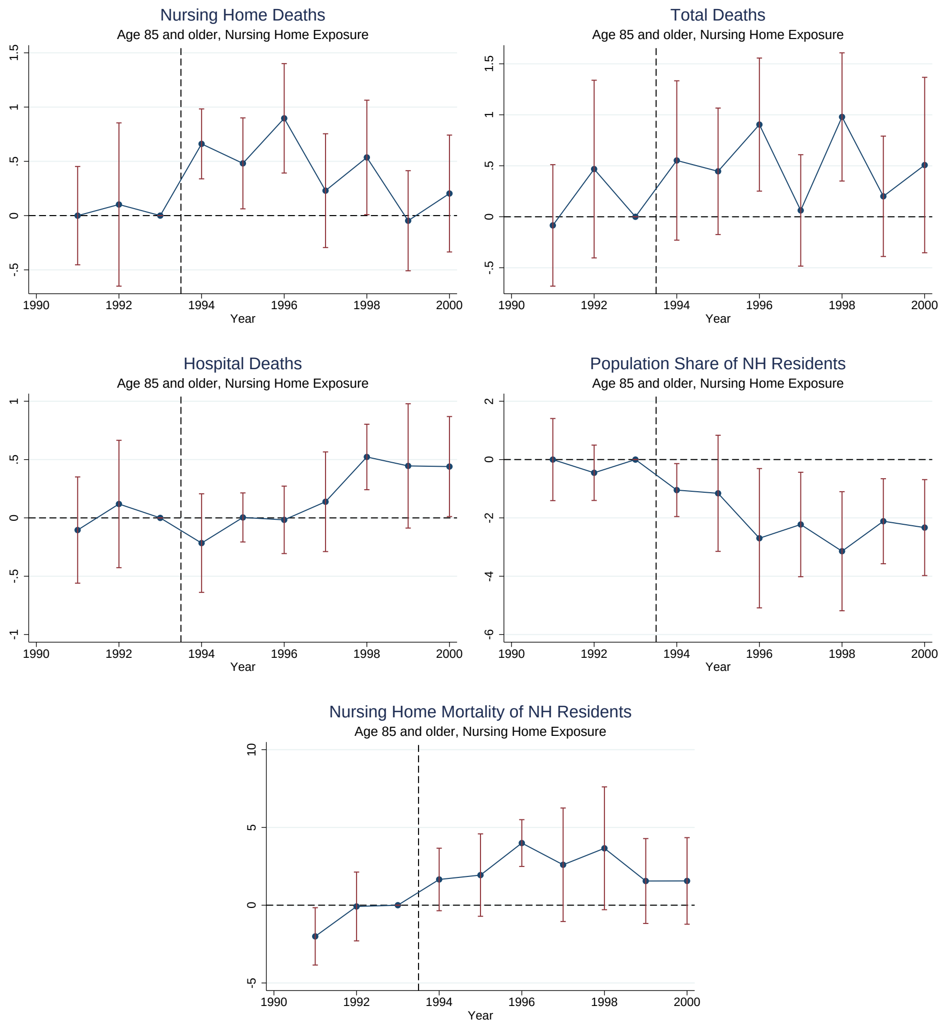


Table 4: Health Outcomes in Nursing Homes Among the Elderly Aged 85 and older

	(1) NH (uncond.)	(2) Total	(3) Hosp	(4) NH (cond.)	(5) NH Pop Share
λ	.626***	.485***	-.087	3.212***	-1.738***
	[.297,.956]	[.188,.781]	[-.439,.264]	[1.851,4.572]	[-3.051,-.425]
Δ_1	.661***	.552	-.216	1.655	-1.046*
	[.276,1.046]	[-.382,1.486]	[-.721,.289]	[-.746,4.056]	[-2.131,.039]
Δ_2	.52***	.265	-.166	1.836**	-.875
	[.151,.889]	[-.095,.625]	[-.516,.185]	[.165,3.508]	[-2.715,.965]
Δ_3	.646***	.506***	-.081	3.224***	-1.482
	[.264,1.027]	[.14,.872]	[.288,-.451]	[1.911,4.538]	[-3.867,.902]
Pre-Reform Value	.078	.16	.055	.364	.249
Avg. Effect	.01	.008	-.001	.052	-.028

Note: The dependent variable in columns (1)-(3) is mortality relative to the county population, column (4) mortality relative to NH residents, column (5) the population share of NH residents. The 95% confidence interval is displayed in brackets. Standard errors are clustered at the county level.
* $p < 0.10$ ** $p < 0.05$ *** $p < 0.001$

indicates an 11% reduction in nursing home attendance on average over 1994-96, see the fourth column of Table 4. A simple back-of-the -envelope calculation indicates that roughly 66% of this decrease in attendance can be explained by nursing home mortalities.[27] The remaining 34% largely reflect seniors who decide to exit the nursing home in favor of alternative (potentially informal) forms of long term care support. We will come back to this point in the the mechanism section.

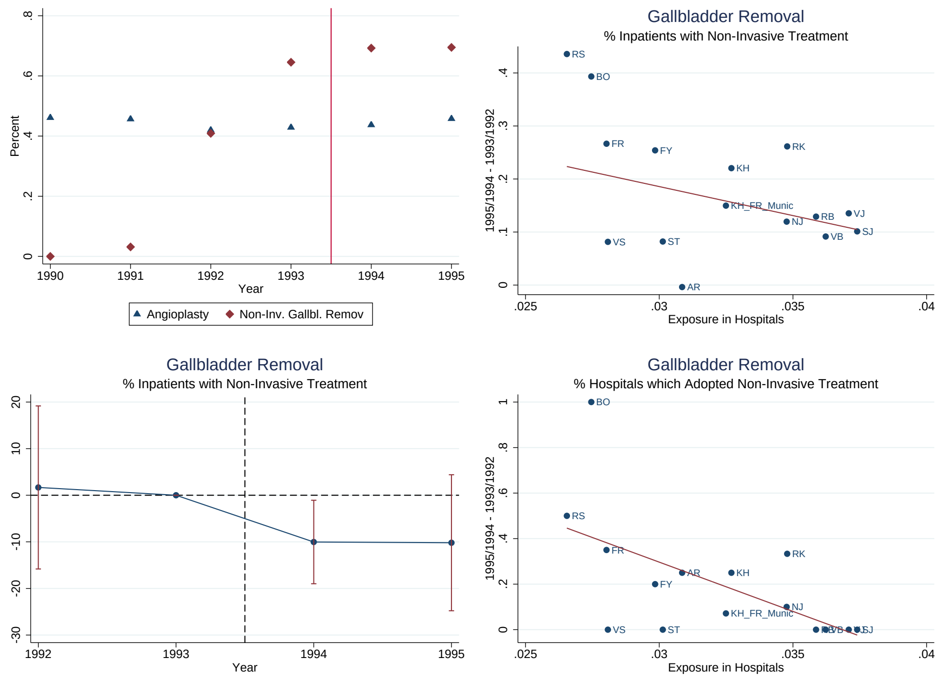
Taking the change in nursing home attendance into account, we also investigate the conditional mortality rate among nursing residents, see the bottom graph of Figure 7. We now see a smaller reduction in the mortality rate after 1996, which suggests persistent adverse mortality effects even 7 years after the introduction of the parental leave program. The corresponding point estimates are summarized in the fifth column of Table 4.

6 Mechanisms

The previous evidence indicates large returns of nurses on elderly mortality in nursing homes. On the other hand, we find no evidence for adverse mortality effects in hospitals. In this section, we provide details on mechanisms that can reconcile these differences and shed light on the role of nurses in the different health care sectors.

[27] If mortality in nursing homes increases by 5.2% on average over 1994-96 and initially 24.9% of elderly age 85 and older live in a nursing home, this NH share decreases to 22.1% after three years if mortality outside of nursing homes remains unchanged.

Figure 8: Technology Substitution and Adoption



6.1 Technology Adoption and Substitution in Hospitals

A potential response of hospitals to a persistent reduction in nurse employment is to substitute towards technologies that share fewer complementarities with nurses and to postpone the adoption of new technologies that can bind significant resources in the short term. We investigate these hypotheses in the context of two conditions that each allow for a traditional invasive surgical treatment option and a technology-intense non-invasive treatment option.

The first treatment decision applies to patients whose blood flow is compromised or even completely blocked due to built-up plague inside coronary arteries. The invasive treatment option is to connect a health artery or vein to the blocked artery to bypass the blocked part of the coronary artery, commonly referred to as a Coronary Artery Bypass Graft (CABG). The non-invasive angioplastic treatment option is to introduce a collapsed balloon to the artery and move it via a catheter to the clogged portion of the coronary artery where it is inflated to widen the artery. Both treatments are applied at similar frequency in our sample population as indicated by the top left graph of Figure 8. The blue triangles indicate the annual share of non-invasive angioplasty relative to the total number of invasive and non-invasive treatments. Using the detailed procedure code information from the National Patient Register for the years 1990-1995 we investigate whether hospitals that see a larger decline in their nurse workforce are more likely to substitute to the non-invasive angioplastic treatment option. However, we find no evidence to support this hypothesis, see the online appendix for details.

The second treatment is applied to patients who develop gallstones, which can irritate the gallbladder and thereby induce intense tummy pain. The invasive treatment (open cholecystectomy) requires a larger incession to the tummy in order to access and to remove the gallbladder. The non-invasive treatment option (laparoscopic cholecystectomy) requires only very small cuts as fine surgical instruments are used to remove the gallbladder. The latter treatment option was effectively non-existent in 1990 and 1991 as indicated in the top left graph of Figure 8, which again measures the ratio of the non-invasive over both treatment options on the vertical axis. Hospitals started to adopt this technology in 1992 and it gained a market share of almost 70 percent by 1995. We test whether hospitals with the largest reductions in nurse employment delay the adoption of this new technology in the top right graph of Figure 8. Here, we plot the change in the fraction of laparoscopic treatments against the exposure in hospitals. The negative slope supports our hypothesis, indicating smaller increases in laparoscopic treatments in counties with the largest reductions in nurse employment. The left graph in the second row plots the corresponding λ coefficients for the two relevant pre- and post-reform years 1992-1995. The significant decline in the λ coefficients in 1994 further corroborates the negative effect of hospital exposure on technology adoption.

The presented patterns combine adjustments along the intensive margin, the number of patients being treated, as well as the extensive margin, any patient being treated. To decompose this pattern, we analyze the extensive margin separately in the bottom right graph of Figure 8. Here, we measure the fraction of hospitals in the county that have adopted the non-invasive technology as indicated by treating at least one patient in the given year. To address potential specialization of hospitals, we restrict the analysis to hospitals that treat at least one patient with either the invasive or the non-invasive procedure in each year of our sample period. Next, we construct averages in the pre- and post-reform period and plot the change for each county on the vertical axis of the bottom left graph of Figure 8. We find a clear negative pattern suggesting that hospitals are less likely to adopt the non-invasive technology in counties with higher hospital exposure.[28]

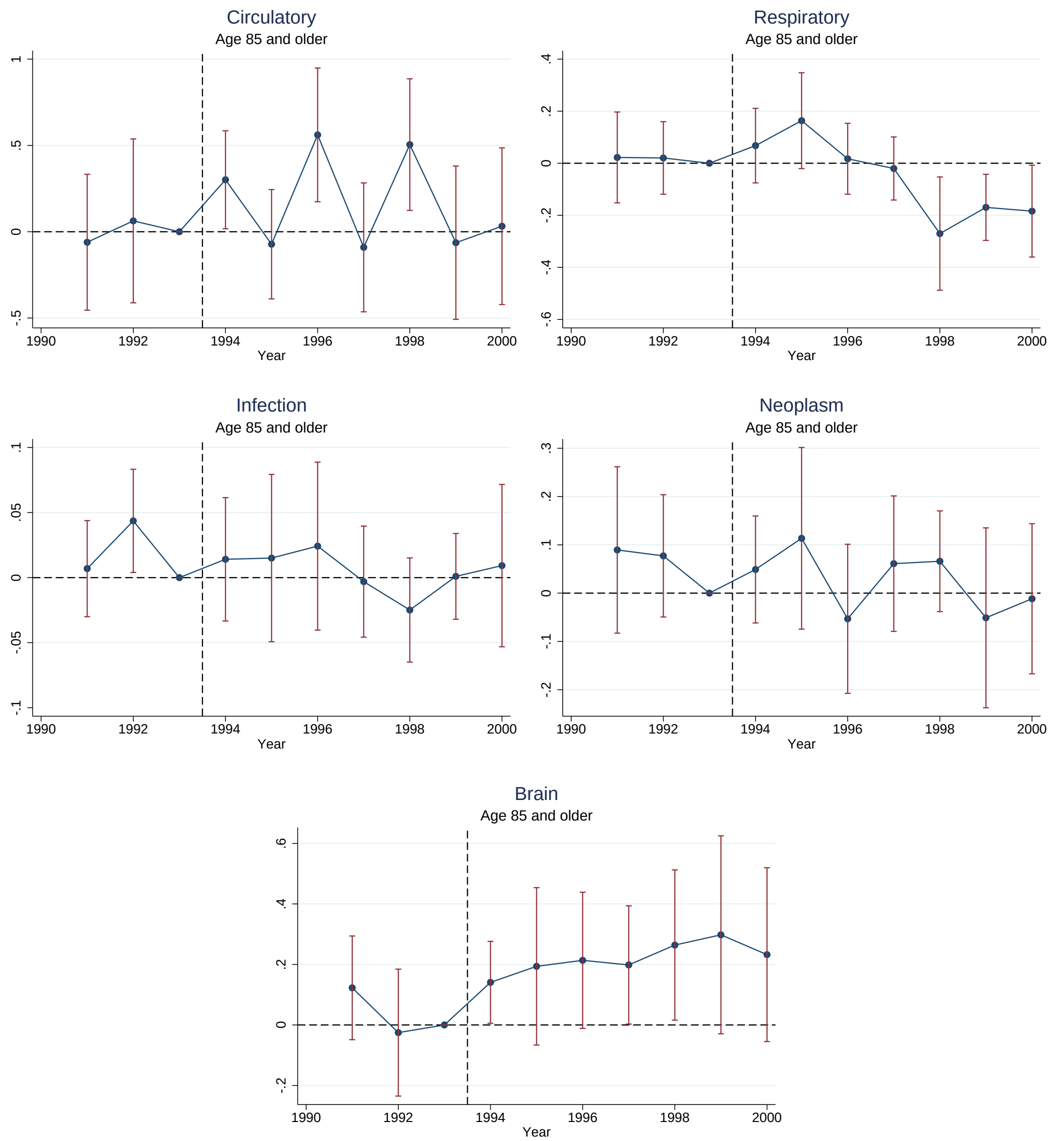
6.2 Resident Monitoring and Nursing Home Mortalities

To shed light on the reasons for the increase in nursing home mortality on the role of nurses, we decompose the mortality effects for individuals age 85 and older in Figure 9, distinguishing cardiovascular and respiratory deaths, infections, cancer, and degenerative brain diseases. Table 5 reports the corresponding regression results. We find that the increase in nursing home mortality rates is mainly driven by cardiovascular deaths and an increase in brain

[28]One concern is that several counties already reach 100 percent adoption rates in the pre-reform period, which would imply by construction a weakly negative change in the adoption rate. To address this concern, we drop counties with 100 percent adoption rates in 1992 or 1993. The result is presented in Figure 21, which implies a qualitatively and quantitatively similar relationship.

diseases. These two categories account for two-thirds of the overall increase in mortality among the population age 85 and older. Brain diseases include dementia and senility and are most common among the oldest and weakest patients in nursing homes, suggesting a disproportionately large mortality effect for this group. However, the effect on cardiovascular related mortality is 75% larger which may include mortalities of overall healthier residents as well.[29]

Figure 9: Lambda Estimates for Mortality Effects by Cause of Death in Nursing Homes



[29]Finally, we find very similar effects regarding the cause of death when considering overall mortality at the county level. This suggests again that the increase in nursing home mortality does not primarily reflect patient reallocation between hospitals and nursing homes. The corresponding tables and figures are available upon request.

Table 5: Mortality Effects by Cause of Death in Nursing Homes: Age 85 and older

	(1) All	(2) Cir	(3) Neop	(4) Inf	(5) Res	(6) Bra
λ^{post}	.626***	.256***	-.023	0	.074	.145**
	[.297,.956]	[.097,.415]	[.104,-.15]	[-.049,.05]	[-.047,.194]	[.016,.274]
Δ_1	.661***	.301*	.049	.014	.068	.141*
	[.276,1.046]	[-.038,.64]	[-.083,.181]	[-.043,.071]	[-.104,.239]	[-.021,.303]
Δ_2	.52***	.083	.043	-.007	.105*	.18***
	[.151,.889]	[-.177,.343]	[-.084,.169]	[-.069,.055]	[-.008,.219]	[.05,.31]
Δ_3	.646***	.263***	-.019	.001	.069	.15*
	[.264,1.027]	[.092,.434]	[-.166,.128]	[-.052,.053]	[-.076,.213]	[-.006,.306]
Pre-Reform Value	.078	.046	.007	0	.008	.007
Avg. Effect	.01	.004	0	0	.001	.002

The causes of death are: Cir-Circulatory, Neop-Neoplasms, Inf-Infections, Res-Respiratory, Bra-brain diseases.
The 95% confidence interval is displayed in brackets. Standard errors are clustered at the county level.
* $p < 0.10$ ** $p < 0.05$ *** $p < 0.001$

The increase in cardiovascular mortalities raises the concern that some residents forgo more appropriate treatments in hospitals. One possible explanation is that the reduced number of nurses on staff reduces the quality of resident monitoring, which may increase the response time to emergencies. To investigate this hypothesis, we now turn to changes in hospitalization rates of nursing home patients before their death, both for the full sample and separately for patients with a heart attack or pneumonia. We choose these specific resident populations in part because they are typically treated in a hospital and because we can track these populations consistently over time despite classification changes in ICD codes. Specifically, we construct the one-month pre-mortality hospitalization rate, which is the fraction of residents who were admitted to a hospital within one month of the time of death. Figure 10 shows the corresponding λ coefficients for the three resident populations. Overall, we see a statistically significant decrease in the post-reform years, suggesting that the reduction of nurses in nursing homes decreases important access to hospitals among residents with high mortality risks.

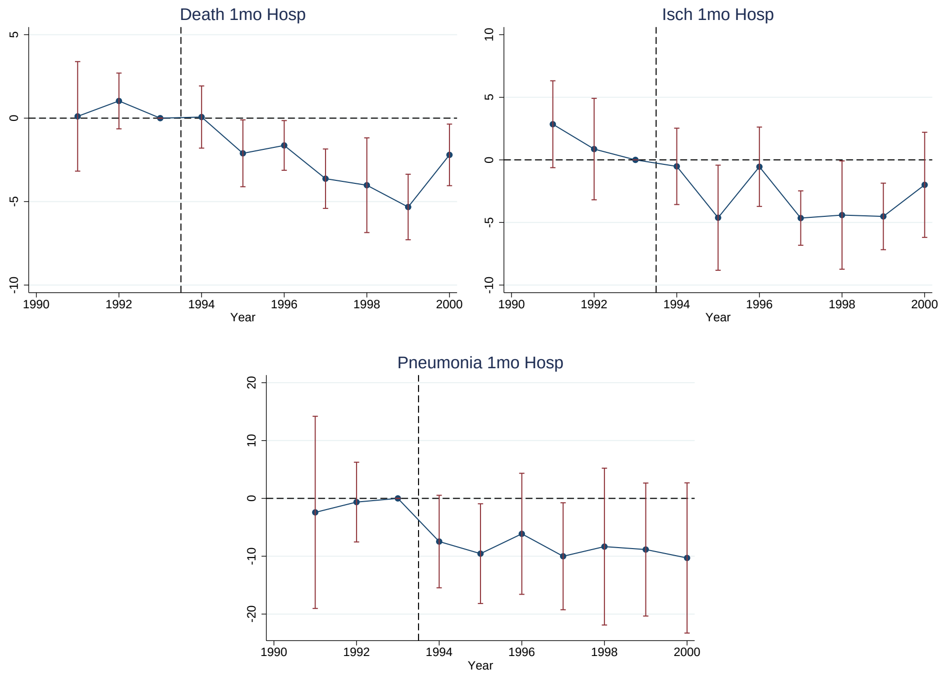
6.3 Patient Management

Health care providers may also adjust the volume and the risk composition of incoming patients to mitigate the adverse health outcomes resulting from a net reduction of nurses on staff.

6.3.1 Hospitals

We first turn to changes in access to hospital care. We find no evidence for systematic changes in overall access to care measured by the number of visits per person in the population or the number of wait days prior to treatment, see the online Appendix Figure 22 for details. We also find no evidence for changes in overall number of hospital days per person in the

Figure 10: Hospitalizations of Nursing Home Patients



population, which combines access to care and the length of stay, see the top left graph of Figure 11. We present the average λ coefficient in the first column of Table 6. Next, we consider patient switching between counties. To this end, we quantify the fraction of patients who choose a hospital outside their county of residence and test whether patients from highly exposed counties, based on exposure in hospitals, are more likely to switch counties. The top right graph presents the λ coefficients which provide first suggestive evidence in favor of this hypothesis, however the effects are relatively small in economic magnitude. The pooled λ estimate suggests an average increase in county switching of only 1.1 percentage points, see the fourth column of Table 6.

We revisit this hospital switching in the second row of Figure 11, where we split the sample population into non-acute and acute patients in the left and right graph, respectively. The graphical evidence suggests a positive relationship for non-acute patients and a negative relationship between acute patients, indicating that hospitals located on the most affected counties focus their resources on the less mobile acute care population. The average effects are not statistically significant, however, we can reject the null hypothesis of a equal slopes for non-acute patients at the 5% level which corroborates our main conclusion regarding selective patient management. Overall, this evidence provides a mechanism though which hospitals mitigate adverse patient health outcomes.

Figure 11: Patient Management in Hospitals

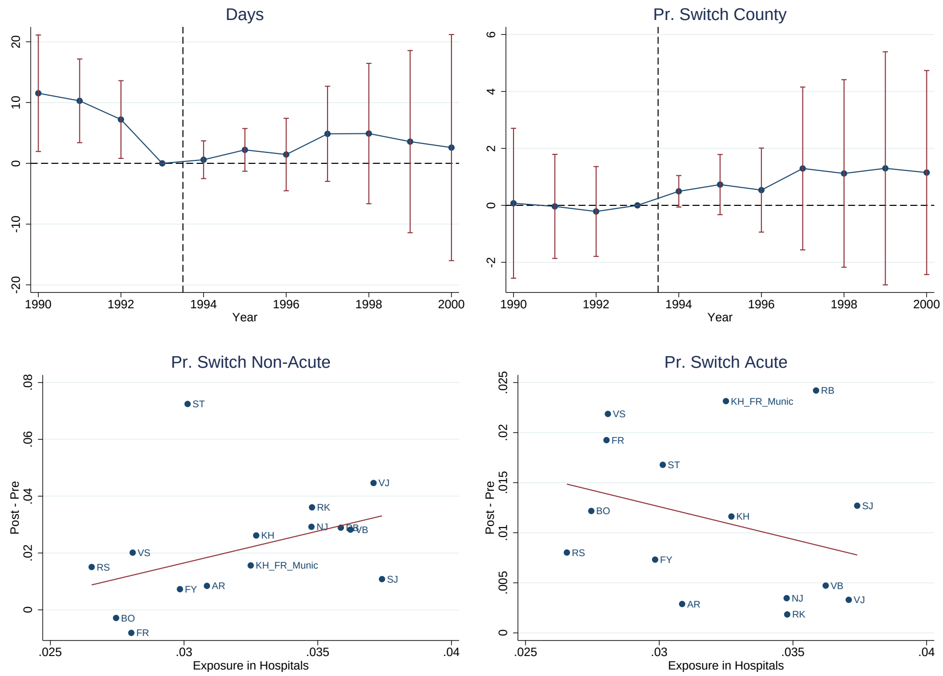


Table 6: Patient Management in Hospitals

	(1) Visits	(2) Days	(3) Wait Days	(4) Switch
λ^{post}	-.23	-.62	-.16	.353
	[-1.081,.621]	[-3.012,1.772]	[-4.609,4.289]	[-.648,1.355]
Δ_1	-.065	.011	-1.142	.406
	[-.617,.488]	[-1.938,1.961]	[-3.384,1.101]	[-.183,.996]
Δ_2	-.166	.078	.133	.594
	[-.981,.649]	[-1.904,2.059]	[-3.507,3.772]	[-.254,1.441]
Δ_3	-.236	-.604	-.15	.494
	[-1.11,.639]	[-3.106,1.898]	[-4.767,4.466]	[-.752,1.74]
Pre-Reform Value	.159	.742	.37	.118
Avg. Effect	-.007	-.02	-.005	.011

The 95% confidence interval is displayed in brackets.
Standard errors are clustered at the county level. We control for log population. The delta estimates take pre-trends into account.
* $p < 0.10$ ** $p < 0.05$ *** $p < 0.001$

6.3.2 Nursing Homes

Next we turn to resident selection in nursing homes. The evidence from Figure 7 indicates a decline in the nursing home population in the later post-reform years 1997-2000, which can partially explain the reduction in the unconditional mortality rate in these years. In this section, we provide more details on patient selection, which allows us to identify subpopulations that are less affected by the nurse reductions to the extent that they have access to alternative informal sources of long term cares.

Our analysis distinguishes between entry decisions of elderly individuals who do not currently live in a nursing home and exit decisions of nursing home patients. Table 7 reports the results.[30] Panel A shows a decrease in entry into nursing homes across the entire population, but the decline is not precisely estimated. For the full population aged 85 and older, we estimate a reduction by 0.4 percentage points over the first three years after the reform, which corresponds to a moderate reduction in the share of nursing home residents by 4%. Using the Δ estimates following equation 2 to account for pre-existing trends, we estimate slightly larger reduction in entry rates over time. These results on entry behavior are similar across gender and marital status. Individuals who currently live on their own - either with or without family support - have access to alternative sources of care using home nursing and informal care arrangements.

The situation changes when we consider exit decisions for current nursing home residents in Panel B. Given the extent of irreversibility in deciding to live in a nursing home, both a sufficiently good health status and family support may be necessary to leave. The results illustrate that there are higher exit rates in nursing homes with higher nurse shortages after the reform. But this increase is entirely driven by widowed and divorced women, who constitute more than 70% of women age 85 and older. Nursing home residents in this group are more than 40% more likely to leave the nursing home over the entire period 1994-2000 after the reform. In contrast, married women whose spouse is still alive and single women do not change their propensity to move out of the nursing home. This finding is consistent with the role of family support and differential health selection into nursing homes. The average health of women who live in a nursing home despite their partner still being alive is likely worse than for other groups. Single women who were never married are less likely to have children to support them. Finally, we find that only women but not men increase their exit rate from nursing homes, and this result holds even when comparing only the groups of widowers. This difference could be explained by age differences of children, for example, because at a given age, women have older children who are more likely to be retired and whose informal care provision is less likely to be affected by their job. Women might also be more likely to move in with their children in general. As a result, separated women are the marginal residents

[30] We provide the corresponding graphical evidence in Appendix Figures 23 and 24.

that show the strongest response to worsening conditions in nursing homes.

In sum, we find some patient response at the entry margin where all population groups are less likely to enter a nursing home. This effect increases over time, which suggests some learning about the deterioration in health care provision in nursing homes. At the same time, nursing home patients with outside options from informal care become more likely to move out of the nursing home after the reform. This patient selection might help explain the increase in hospital mortality rates in counties with higher exposure in nursing homes as illustrated in Figure 7 if sicker patients live at home.

6.4 Employee Management

Finally, we analyze whether hospitals and nursing homes differ systematically in terms of the staffing fluctuation that they face due to the reform.

6.4.1 Staffing management

Better capacity management may be an important explanation why hospitals prevent adverse mortality effects. In order to compare fluctuations in leave taking across providers with different staffing levels, we construct the coefficient of variation for leave taking at the individual provider level based on the exact timing of leave taking reported by social benefit data for 1995-2000. Since both hospitals and nursing homes face strong seasonality in leave taking, we analyze capacity management of health care providers within months.[31] In particular, we take the standard deviation of leave takers per day within each month relative to the average monthly number of leave takers. Figure 12 shows the distribution of monthly coefficients of variation for hospitals and nursing homes, winsorized at 1.[32] Months without any inflow or outflow of leavers are common in nursing homes, but at the same time these providers face very high fluctuation in other months. Overall, this evidence suggests that hospitals are more likely to avoid peak shortages which might have large adverse effects.

Next, we further use the data on benefit spells to analyze whether health care providers differ in their influence on take-up and leave duration. To this end, we display the OLS regression coefficient of exposure on a leave taking indicator variable, that turns on if the eligible nurse is on leave in the given year, and a leave duration indicator variable among leave takers, that turns on if the leave exceeds 26 weeks, in odd and even columns of Table 8, respectively. The first two columns present the coefficients for the full sample of hospitals and nursing homes before we split the sample into hospitals, columns (3) and (4), and nursing homes, columns (5) and (6). The table shows two main results. First, both hospitals and

[31] Appendix Figure 12 illustrates these seasonal differences in leave taking. In general, the number of nurses on leave peaks in June and July and decreases during the winter months.

[32] We focus on all individual providers with at least two skilled nurses and set the coefficient of variation to zero for months without leavers.

Table 7: Patient Selection: Entry and Exit Decisions

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Entry	Total	All Men	All Women	Women by Marital Status		
				Married	Separated	Sing
λ^{94-96}	-.24	-.032	-.346	.065	-.289	-1.1
	[-1.446,.966]	[-1.199,1.136]	-1.586,[.894]	[-1.94,2.07]	[-1.554,.975]	[-2.653,
λ^{97-00}	-.024	-.656	.222	-1.095	.547	-1.0
	[-1.111,1.062]	[-1.706,.394]	[-.952,1.396]	[-2.974,.784]	[-.553,1.647]	[-3.326,
Δ_1	-1.673	-1.509	-1.845	1.987	-2.355	-1.7
	[-4.435,1.089]	[-5.341,2.322]	[-4.817,1.127]	[-1.798,5.772]	[-6.048,1.338]	[-6.884,
Δ_2	-1.859	-1.017	-2.295	-2.613*	-1.616	-7.087
	[-5.876,2.158]	[-5.18,3.146]	[-6.412,1.821]	[-5.599,.373]	[-6.4,3.168]	[-11.914
Δ_5	-2.599	-3.358	-2.334	-3.745**	-1.354	-8.151
	[-6.356,1.158]	[-7.581,.866]	[-6.093,1.425]	[-7.427,-.063]	[-5.714,3.006]	[-12.639,
Pre-Reform Value	.103	.107	.095	.093	.107	.11
Avg. Effect, 94-96	-.004	-.006	-.001	.001	-.005	-.01
Avg. Effect, 97-00	0	.004	-.011	-.018	.009	-.01

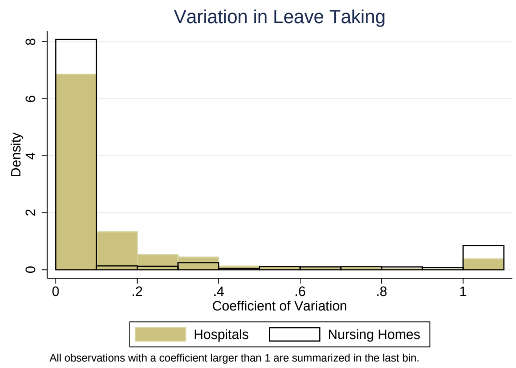
Panel B: Exit	Total	All Men	All Women	Women by Marital Status		
				Married	Separated	Sing
λ^{94-96}	1.28	-.21	1.597	-3.735	1.995*	.62
	[-1.348,3.909]	[-4.327,3.908]	[-.736,3.929]	[-9.366,1.897]	[-.286,4.276]	[-3.673,
λ^{97-00}	1.948	.593	2.235*	2.226	2.334*	1.69
	[-.486,4.382]	[-2.553,3.74]	[-.101,4.57]	[-1.287,5.739]	[-.108,4.775]	[-2.195,
Δ_1	2.543	-.767	3.56	-9.827	4.969***	-2.20
	[-2.369,7.455]	[-10.278,8.744]	[-.78,7.9]	[-22.694,3.04]	[1.126,8.813]	[-13.669,
Δ_2	-.42	-6.743**	1.394	-9.993	3.228*	-6.50
	[-5.117,4.278]	[-13.438,-.048]	[-2.847,5.635]	[-28.135,8.149]	[-.533,6.99]	[-18.496,
Δ_5	2.707	-2.801	4.412**	-4.803	5.868***	-2.03
	[-1.31,6.724]	[-8.663,3.061]	[.529,8.295]	[-19.383,9.777]	[2.408,9.328]	[-13.689,
Pre-Reform Value	.079	.076	.093	.08	.076	.07
Avg. Effect, 94-96	.021	.026	-.003	-.061	.032	.01
Avg. Effect, 97-00	.032	.036	.01	.036	.038	.02

The 95% confidence interval is displayed in brackets. Standard errors are clustered at the county level.

Separated includes divorced and widowed. Married is based on the partner being still alive.

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.001$

Figure 12: Parental Leave and Staffing Management



nursing homes cannot affect the extensive margin of leave taking among eligible parents. Columns (1), (3) and (5) show that higher exposure does not affect the probability of leave taking among eligible parents. The parental leave reform entitled all parents with children up to 8 years of age to take 26 weeks of leave without employer approval. In line with the policy design, leave taking depends on worker preferences and cannot be influenced by employers. Second, columns (2), (4) and (6) analyze the intensive margin of leave taking among leavers. Even though parents are entitled to leave, employers can influence the duration of leave because extended leave of up to 52 weeks had to be approved by the employer. As a result, the probability of extended leave reflects employer preferences. We find that hospitals that are more exposed to the reform are more likely to prevent *extended* leave taking of their nurses, as indicated by the statistically significant negative coefficient in column 4. Yet while hospitals with average exposure reduce the probability of extended leave among leavers by 18.3 percentage points, there is no significant reduction in nursing homes with higher exposure. One explanation for the differences in behavior across providers could be that hospitals have higher bargaining power to retain their employees if necessary. As a result, hospitals may be better able to retain qualified workers and to stabilize the workforce overall. This adjustment may explain why mortality effects are largest in nursing homes that do not benefit from this type of employee management.

These adjustment mechanisms in combination with the differences in mortality effects across hospitals and nursing homes suggest an important role for nonlinearities in the health production function. Specifically, we hypothesize that large exposures lead to disproportionately drastic negative consequences if left unaddressed. We revisit the employer efforts to mitigate the adverse staffing implications of large policy exposures in Figure 13, where we present nonparametric Epanechnikov kernel estimates and 95% confidence intervals for the conditional probability of extended leave among leavers. We find that the share of extended leave takers is much lower at providers with high exposure. Yet hospitals proportionately

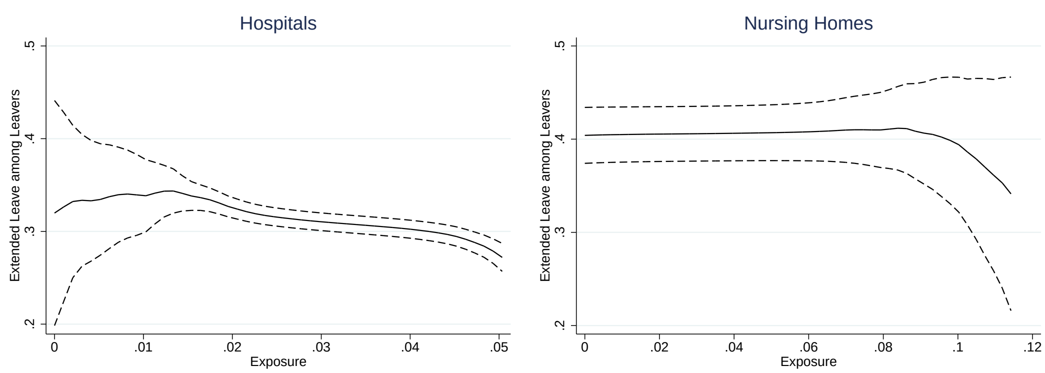
Table 8: Employer Approval for Extended Leave

	(1) leave	(2) >26 wks | l=1	(3) leave	(4) >26 wks | l=1	(5) leave	(6) >26 wks | l=1
exposure	0.140	-1.696***	-0.522	-5.547***	-0.0485	-0.531
	(1.323)	(-3.959)	(-1.145)	(-4.618)	(-0.348)	(-0.655)
Observations	91,218	12,854	71,100	11,003	13,024	1,216
R-squared	0.232	0.045	0.242	0.044	0.181	0.090
Share of Leavers	0.137	0.289	0.155	0.275	0.0923	0.366
Av. Effect	0.00400	-0.0540	-0.0170	-0.183	-0.00100	-0.0110

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

reduce the share of extended leave according to the overall fraction of leavers, whereas the share of extended leave in nursing homes is stable across a wide range of exposure and only declines for facilities with very high exposure levels.[33] Figure 13 also emphasizes the level differences in extended leave taking across hospitals and nursing homes, with hospitals avoiding extended leave much more frequently. In sum, providers with the largest exposure show the strongest endogenous response to prevent large nurse shortages and adverse health outcomes for patients. Hospitals are more effective in avoiding staffing fluctuations and in preventing extended leave and as a result the relationship between exposure and patient health outcomes is weaker and noisier for these providers.

Figure 13: Nonlinearities in Employer Responses

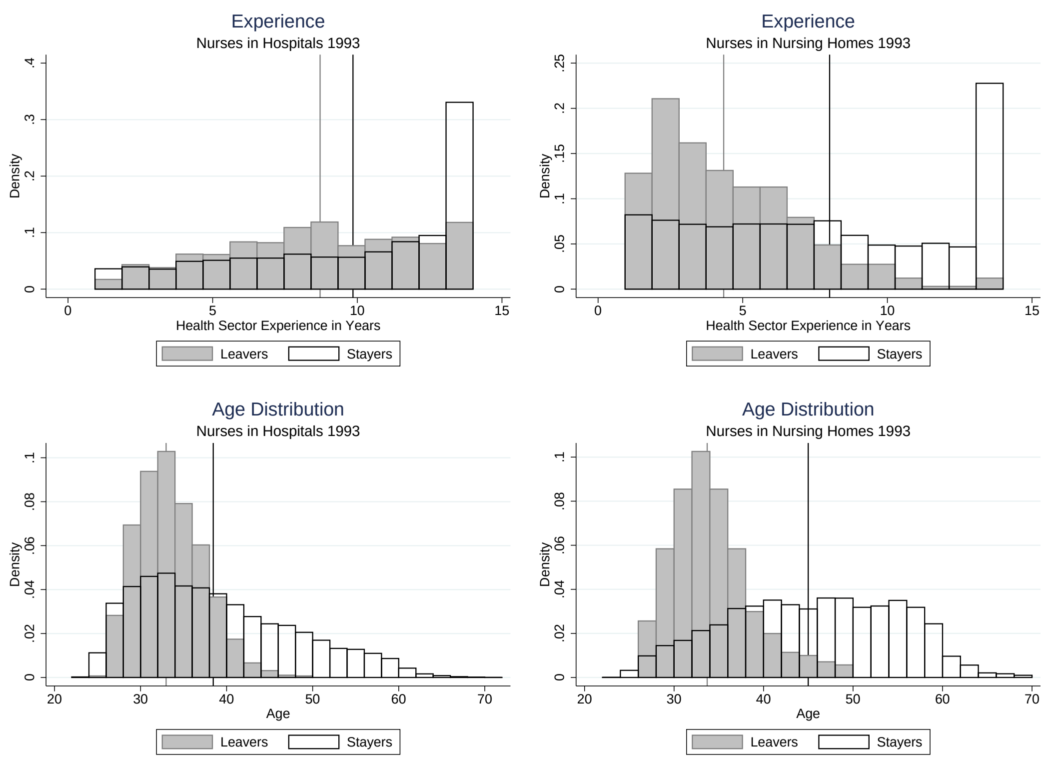


[33]In general, estimates of health effects at the provider level will be biased if endogenous adjustments are strongest at providers with highest exposure because this response leads to a nonlinear relationship between exposure and health outcomes. Our aggregation at the county level mitigates this potential bias at the provider level.

6.4.2 Human capital and workforce composition

Secondly, we analyze the relative change in average experience of nurses in hospitals and nursing homes. Nurses acquire industry-specific human capital over time, for example by treating similar types of patients repeatedly. The large mortality effects in nursing homes could be explained by a stronger reduction in this human capital stock compared to hospitals. Our main analysis focuses on the number of nurses and abstracts from this channel. In order to assess the importance of this mechanism, this section takes the relative change in nurse experience into account.

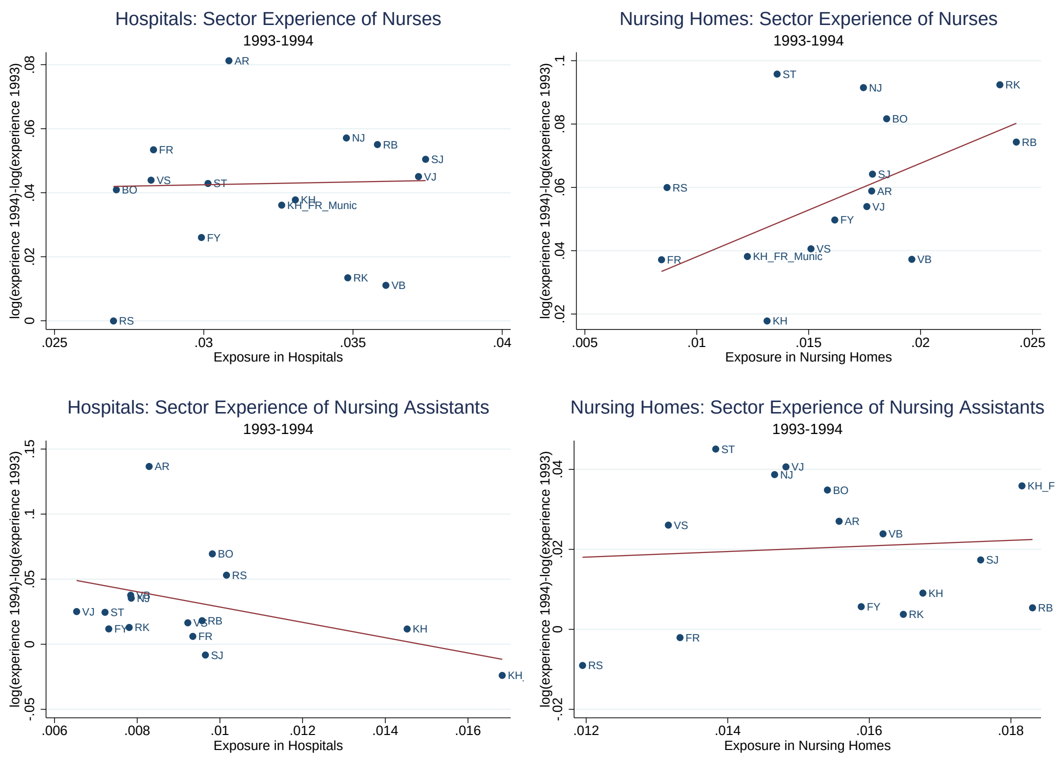
Figure 14: Industry Experience and Age of Leavers and Stayers among Nurses 1993-1994



Specifically, we measure experience of each nurse by health care sector as the number of years the person has been employed in hospitals or nursing homes respectively. In practice, the distribution of total experience is truncated because we only observe individuals from 1980 onwards. Figure 14 illustrates differences in industry experience between parental leave takers, defined as nurses who take a leave of absence in 1994 and were eligible for the child leave program at that time, and stayers who continuously work in the sector in 1993 and 1994. The vertical lines in the figure represent average experience of stayers and leavers in the two sectors. The key result is that leavers in nursing homes are less experienced than in hospitals, both in levels and relative to stayers. Overall, the age distribution of leavers with children age

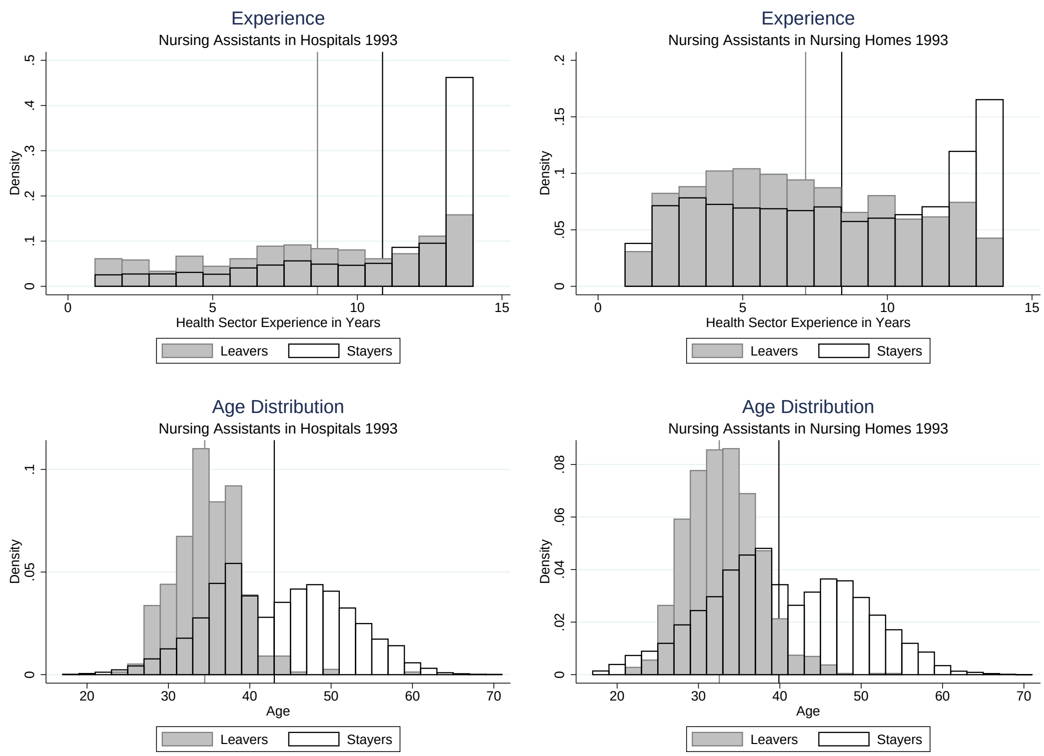
8 or younger is very similar for hospitals and nursing homes. And despite the older nursing home staff on average, many of them have low industry experience because they have worked in hospitals and other sectors for part of their previous career. As a result, average experience of stayers in nursing homes is lower and a composition effect will lead to a stronger increase of average experience in nursing homes than in hospitals after the reform. This channel is reflected in Figure 15, which shows a stronger increase in average experience of nurses in counties with higher exposure to the reform and this patterns is particularly pronounced for nursing homes. Based on this evidence, we conclude that the increase in mortality rates in nursing homes is not mainly caused by a loss in the average human capital stock of nurses but rather the result of the strong reduction in the number of nurses.

Figure 15: Change in Average Industry Experience 1993-1994



Another alternative explanation could be compositional changes in the stock of nursing assistants. Figure 1 emphasized that the number of nursing assistants in hospitals and nursing homes is unaffected by the parental leave program. Yet Figure 2 implies that this smooth aggregate trend is based on a high number of new entrants and switchers from the private sector to counterbalance the large number of leavers among nursing assistants. As a result, average experience among assistants decreases more in counties with higher exposure that need to recruit more job switchers and newly educated assistants. In general, this pattern could contribute to adverse patient health effects in counties with higher exposure. Yet as the second row of Figure 15 illustrates, average experience is only negatively correlated with exposure in hospitals. Nursing homes in counties with higher exposure do not systematically lose a larger fraction of their human capital stock among nursing assistants. The reason for this difference is the much lower experience distribution among nursing assistants in nursing homes. Figure 16 shows that the majority of leave takers have less than five years of experience and hence the experience composition is hardly affected by replacing these leavers with inexperienced job switchers or entrants. In sum, this evidence suggests that the large health effects in nursing homes are unlikely to be driven by systematic loss of experience among nursing assistants.

Figure 16: Industry Experience and Age of Leavers and Stayers among Nursing Assistants 1993-1994



7 Conclusion

Nurses make up the largest health profession in most OECD countries and play a critical role in the delivery of health care services in hospitals and nursing homes. At the same time, there is a growing concern about potential nurse shortages in several high-income countries as the population and the nursing workforce ages. Understanding the marginal effect of nurses on the delivery of care across markets and health care sectors is therefore of high policy relevance as countries consider different policies to address the growing demand for this profession.

In this paper, we take advantage of a parental leave program in Denmark to provide new evidence on the role of nurses for health care delivery across providers. This analysis can help to improve allocative efficiency in the health care sector at the intensive margin and to assess the benefits of recruiting additional staff through higher wages and extended education programs at the extensive margin.

We find that the policy reform led to a persistent reduction in nurse employment in hospitals and nursing homes by 13% and 11% respectively. Based on this negative labor supply shock, we combine administrative employer-employee data with detailed patient records, the population register and the causes of death register to study effects of nurses on health care delivery in hospitals and nursing homes. Mortality rates in hospitals are unaffected, but we find a deterioration in quality of care as evidenced by an increase in the 30-days readmission rate of hospital inpatients. Our results show that hospitals are able to prevent adverse outcomes by managing leave times and by focusing on acute patients with high mortality risk at the expense of other patients. Moreover, hospitals delay technology adoption in response to lower staffing.

The results for nursing homes are more drastic. The reduction in nurse employment leads to a 12.8% increase in nursing home mortality among the population aged 85 and older. In particular, circulatory deaths among nursing home patients increase strongly and we provide evidence of a deterioration in patient monitoring; heart attack and pneumonia patients in nursing homes with higher staffing reduction are less likely to be transferred to a hospital in the month prior to their death. We show that the increase in nursing home mortality cannot be explained by patient reallocation from hospitals and private homes to nursing homes. Instead, the increase in nursing home mortality for age 85 and older maps one-to-one into an increase in total mortality, while leaving hospital mortality unaffected. Patients respond to the deteriorating conditions in nursing homes by lower entry rates across all population groups and higher exit rates for patients with access to informal care alternatives. Accounting for the change in the share of nursing home residents in the population aged 85 and older, we find a persistent increase in nursing home mortality even several years after the policy reform. In sum, this paper suggests that nurses play an important role in the delivery of care in the nursing home industry, which is a sector of growing importance as the population ages.

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Online Appendix

A Institutions and Policy Reform

Figure 17: Counties of Denmark 1970-2006

	Description	Our Code
1+2	Copenhagen and Frederiksberg Municipalities	CPH-FR Munic
3	Copenhagen County	KH
4	Frederiksborg County	FR
5	Roskilde County	RS
6	West Zealand County	VS
7	Storstrom County	ST
8	Funen County	FY
9	South Jutland County	SJ
10	Ribe County	RB
11	Vejle County	VJ
12	Ringkjobing County	RK
13	Viborg County	VB
14	North Jutland County	NJ
15	Aarhus County	AR
16	Bornholm	BO

Table 9: Leave Program Take-Up

Number of full-time equivalent leavers among nurses			
	Parental leave	Education leave	Sabbatical leave
1995	2108	516	129
1996	1606	575	<10
1997	1296	517	<10
1998	1114	317	<5
1999	1133	282	<5
2000	1130	205	<5

Figure 18: Duration of Leave Benefits: Education and Parental Leave

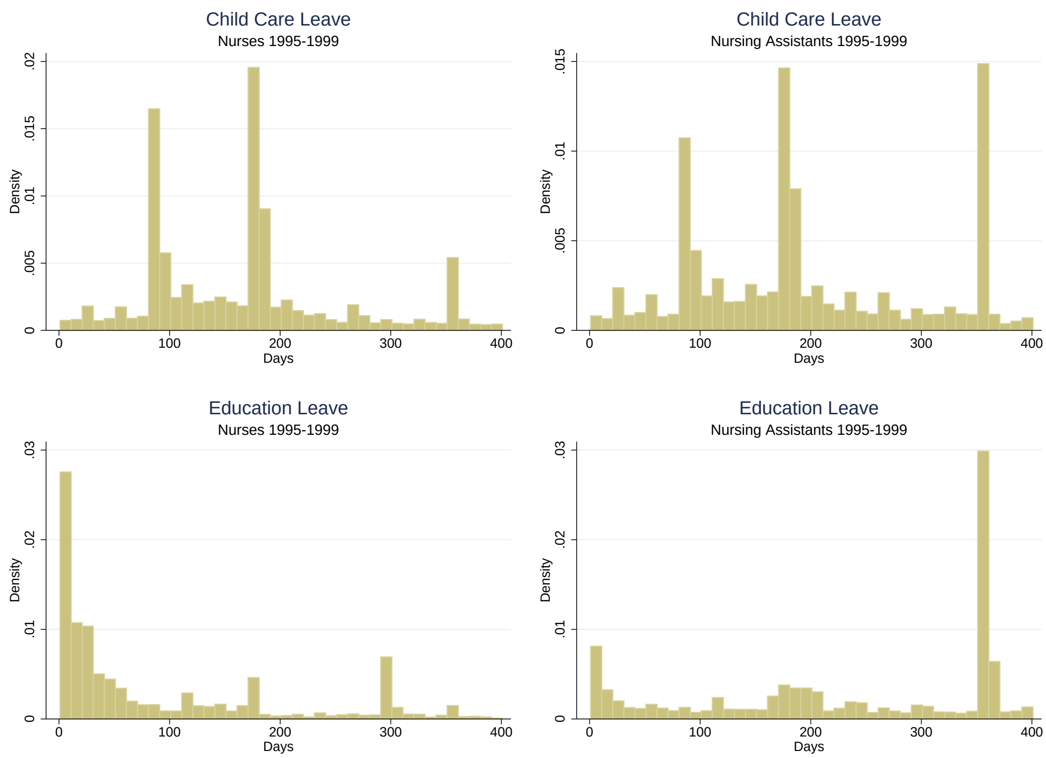
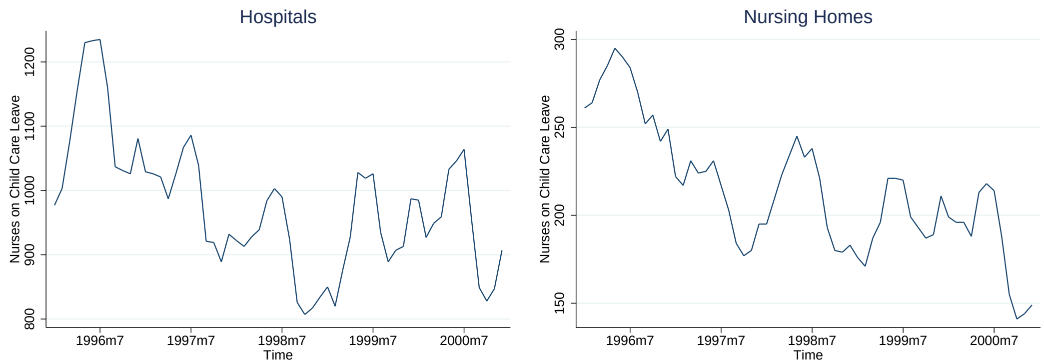


Figure 19: Timing of Parental Leave Taking



B Estimation Results and Robustness

B.1 Regression Results for Program Takeup

Table 10: Program Take-Up

	(1)	(2)	(3)	(4)	(5)	(6)
	Nurses	Assistants	Doctors	Nurses	Assistants	Doctors
	1993 vs 1994			1993 vs 1995		
Age0 x Post-Reform	0.2000***	0.1607***	0.0173**	0.1877***	0.1068***	0.0161**
	(0.006)	(0.010)	(0.007)	(0.006)	(0.009)	(0.007)
Age1 x Post-Reform	0.1706***	0.2445***	-0.0024	0.1142***	0.1885***	0.0126*
	(0.006)	(0.010)	(0.007)	(0.006)	(0.010)	(0.007)
Age2 x Post-Reform	0.0982***	0.1029***	-0.0004	0.0253***	0.0090	-0.0072
	(0.007)	(0.010)	(0.007)	(0.006)	(0.011)	(0.007)
Age3 x Post-Reform	0.0734***	0.0686***	-0.0112	0.0352***	0.0102	0.0003
	(0.007)	(0.010)	(0.008)	(0.007)	(0.010)	(0.008)
Age4 x Post-Reform	0.0636***	0.0611***	0.0047	0.0251***	0.0281***	-0.0060
	(0.008)	(0.010)	(0.009)	(0.007)	(0.010)	(0.008)
Age5 x Post-Reform	0.0452***	0.0336***	-0.0093	0.0355***	0.0206**	-0.0060
	(0.008)	(0.010)	(0.009)	(0.008)	(0.010)	(0.009)
Age6 x Post-Reform	0.0401***	0.0589***	-0.0028	0.0335***	0.0219**	-0.0061
	(0.009)	(0.011)	(0.009)	(0.008)	(0.010)	(0.009)
Age7 x Post-Reform	0.0508***	0.0469***	0.0006	0.0264***	0.0251**	0.0007
	(0.009)	(0.011)	(0.009)	(0.008)	(0.010)	(0.009)
Age8 x Post-Reform	0.0425***	0.0499***	-0.0007	0.0025	0.0179*	-0.0023
	(0.009)	(0.011)	(0.009)	(0.008)	(0.011)	(0.009)
Post-Reform	0.0132***	0.0274***	0.0021	0.0167***	0.0371***	-0.0002
	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Observations	58,532	52,517	17,358	56,363	50,445	17,420
R-squared	0.088	0.064	0.008	0.073	0.043	0.008

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

B.2 Details on Estimation Results

Table 11: Regression Results for Employment

	(1) Total	(2) Hosp and NH	(3) Hosp	(4) NH
λ_{1990}	-3.322**	-0.820	-2.833	-5.699
	[-5.811,-0.834]	[-6.417,4.776]	[-10.10,4.438]	[-16.19,4.787]
λ_{1991}	-1.822**	-2.098*	-2.113	-5.395
	[-3.535,-0.110]	[-4.496,0.300]	[-6.644,2.419]	[-12.67,1.875]
λ_{1992}	-0.393	-1.152*	-0.869	-3.023
	[-1.635,0.848]	[-2.404,0.100]	[-3.035,1.296]	[-8.467,2.421]
λ_{1994}	-2.525***	-3.808***	-3.131	-4.881**
	[-4.263,-0.786]	[-5.816,-1.801]	[-7.220,0.959]	[-9.058,-0.704]
λ_{1995}	-4.963*	-5.599**	-5.538*	-4.929**
	[-10.69,0.768]	[-10.28,-0.920]	[-11.89,0.812]	[-9.835,-0.0240]
λ_{1996}	-6.094**	-5.658**	-4.935	-4.145
	[-12.16,-0.0279]	[-9.764,-1.553]	[-11.48,1.614]	[-10.16,1.873]
λ_{1997}	-5.429	-5.745**	-3.993	-6.117
	[-14.17,3.308]	[-11.48,-0.00469]	[-12.37,4.388]	[-14.02,1.784]
λ_{1998}	-5.095	-3.450	-2.064	-4.647
	[-13.90,3.712]	[-9.854,2.953]	[-11.90,7.775]	[-13.04,3.744]
λ_{1999}	-4.972	-4.138	-2.632	-4.936
	[-14.34,4.395]	[-11.24,2.961]	[-13.11,7.849]	[-16.01,6.141]
λ_{2000}	-8.304*	-5.868	-5.220	-3.692
	[-18.17,1.558]	[-13.36,1.624]	[-16.55,6.108]	[-16.70,9.313]
Controls				
N	165	165	165	165

95% confidence intervals in brackets
Note: Standard errors are clustered at the county level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B.3 Robustness to Differences in Mortality Risks

We address potential differences in mortality risks between counties and over time in additional robustness checks. To this end, we combine age and gender information from IDAP with information on inpatient acute care hospitalizations from the Danish National Patient Register. Specifically, we calculate the number and the total length of this and the previous year's hospital visits for each elderly person. To leverage the rich demographic and health utilization information in our analysis we proceed in three steps. First, we regress a mortality indicator variable on age-gender fixed effects, county-year fixed effects, as well as current and last year's length and number of hospital visits at the person-year level. Second, we keep the predicted county-year fixed effects which capture differences in mortalities between counties and over time conditional on differences in the mortality risks as measured by the age-gender composition and the frequency of hospitalizations. Finally, we use these residualized mortality rates in our following county-year level regression analysis.

Table 13: Mortality by Nursing Home Exposure: Age 85 and older

	(1) Tot	(2) Tot	(3) Hosp	(4) Hosp	(5) NH	(6) NH
λ_{1991}	-0.084	-0.38	-0.10	-0.30	-0.00044	-0.080
	[-0.86,0.69]	[-1.24,0.49]	[-0.70,0.49]	[-0.80,0.20]	[-0.59,0.59]	[-0.71,0.56]
λ_{1992}	0.47	0.24	0.12	-0.038	0.10	0.049
	[-0.67,1.61]	[-0.82,1.31]	[-0.59,0.83]	[-0.63,0.55]	[-0.88,1.09]	[-0.91,1.01]
λ_{1994}	0.55	0.56	-0.22	-0.21	0.66^{***}	0.64^{***}
	[-0.47,1.57]	[-0.31,1.44]	[-0.77,0.34]	[-0.66,0.24]	[0.24,1.08]	[0.25,1.04]
λ_{1995}	0.45	0.52	0.0038	0.040	0.48^{*}	0.49^{*}
	[-0.37,1.26]	[-0.22,1.26]	[-0.27,0.28]	[-0.17,0.25]	[-0.067,1.03]	[-0.072,1.05]
λ_{1996}	0.90^{**}	0.90^{**}	-0.017	-0.069	0.90^{**}	0.90^{**}
	[0.051,1.76]	[0.13,1.68]	[-0.39,0.36]	[-0.36,0.22]	[0.24,1.56]	[0.23,1.58]
λ_{1997}	0.062	0.095	0.14	0.11	0.23	0.24
	[-0.65,0.78]	[-0.60,0.79]	[-0.42,0.70]	[-0.45,0.66]	[-0.46,0.92]	[-0.50,0.97]
λ_{1998}	0.98^{**}	0.85^{**}	0.52^{***}	0.36^{**}	0.54	0.51
	[0.16,1.80]	[0.032,1.66]	[0.16,0.89]	[0.053,0.68]	[-0.15,1.23]	[-0.18,1.20]
λ_{1999}	0.20	0.077	0.45	0.27	-0.047	-0.048
	[-0.57,0.97]	[-0.57,0.72]	[-0.25,1.14]	[-0.082,0.62]	[-0.65,0.56]	[-0.81,0.71]
λ_{2000}	0.51	0.18	0.44	0.11	0.20	0.17
	[-0.62,1.63]	[-0.72,1.07]	[-0.12,1.00]	[-0.10,0.31]	[-0.50,0.91]	[-0.59,0.93]
Controls	✗	✓	✗	✓	✗	✓
N	150	150	150	150	150	150

95% confidence intervals in brackets
Note: Standard errors are clustered at the county level. In columns 2, 4, and 6 we added further controls including previous hospitalizations and age-gender fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Acute Care Patient Sample Based on Doyle et al. (2014)

Principal Diagnosis	ICD 9	ICD 10	Category	WE Adm Rate	Obs	%
Septicemia	038	A41	All Other			
Malignant Neoplasm of Trachea, Bronchus, and Lung	162	C33, C34	All Other			
Secondary Malignant Neoplasm of Respiratory and Digestive Systems	197	C78	All Other			
Acute Myocardial Infarction[1]	411,412, 413,414	I2	Circulatory			
Intracerebral Hemorrhage	431	I61	Circulatory			
Occlusion and Stenosis of Precerebral Arteries , Occlusion of Cerebral Arteries	433, 434	I63, I65	Circulatory			
Transient Cerebral Ischemia	435	G45	Circulatory			
Other Bacterial Pneumonia[2]	482		Respiratory			
Pneumonia, Organism Unspecified[3]	486.99	J189	Respiratory			
Pneumonitis Due to Solids and Liquids	507	J69	Respiratory			
Other Diseases of Lung[2]	518		Respiratory			
Diseases of Esophagus	530	K20, K21, K22	Digestive			
Gastric Ucler	531	K25	Digestive			
Duodenal Ulcer	532	K26	Digestive			
Vascular Insufficiency of Intestine[2]	557		Digestive			
Other and Unspecified Noninfectious Gastroenteritis and Colitis[2]	558		Digestive			
Intestinal Obstruction without Mention of Hernia	560	K56	Digestive			
Other Disorders of Urethra and Urinary Tract[2]	599		All Other			
Disorders of Muscle, Ligaemnt, and Fascia	728	M60, M61, M62	All Other			
General Symptoms[4]	7802	R55	All Other			
Fracturs of Rib(s), Sernum, Larynx, and Trachea	807	S22	Injury			
Fracture of Pelvis[2]	808		Injury			
Fracture of Neck and Femur	820	S72	Injury			
Fracture of Tibia and Fibula	823	S820, S821, S822, S823 , S824, S828, S829	Injury			
Fracture of Ankle[5]	824.00, 824.01	S825, S826	Injury			
Injury, Other and Unspecified[2]	959		Injury			
Poisoning by Analgesics, Antipyretics, and Antirheumatics	965	T39, T40	Injury			
Poisoning by Psychotropic Agents[2]	969		Injury			

Notes: [1] This deviates from ICD9 410 [2] Not matched over time [3] This is a subset of ICD9 code 486. [4] This is a subset of ICD9 780 [5] This is a subset of iCD9 824.

C Details on Mechanisms

C.1 Technology Substitution and Adoption

Figure 20: Angioplastic Substitution Patterns

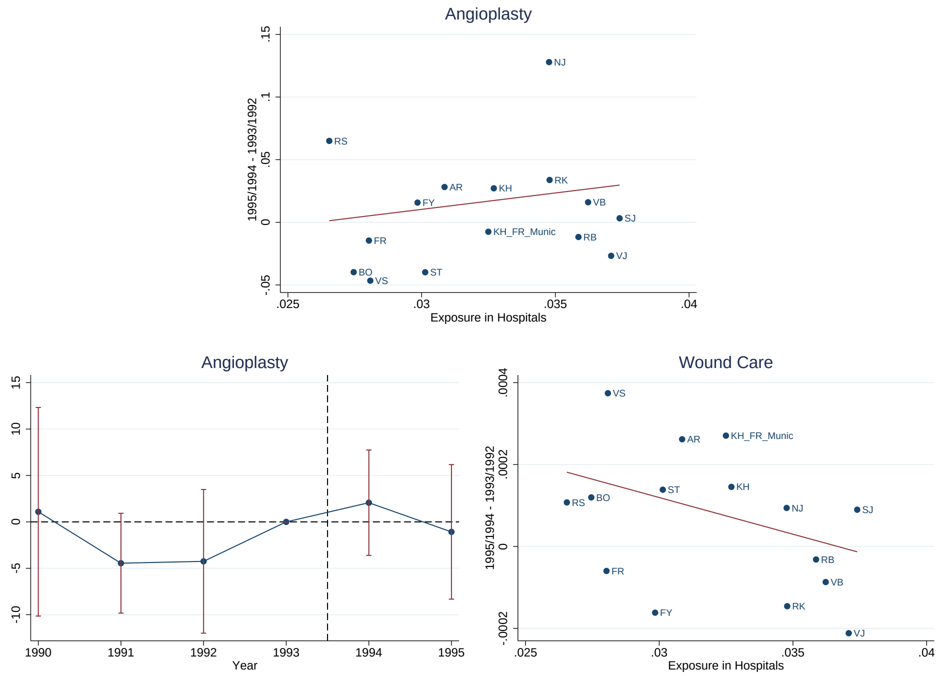
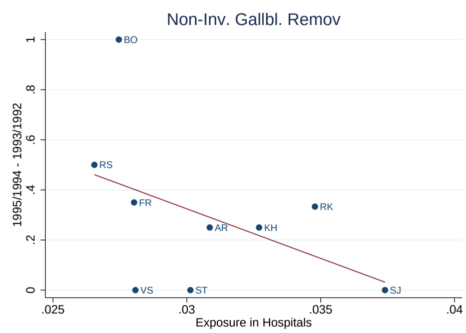
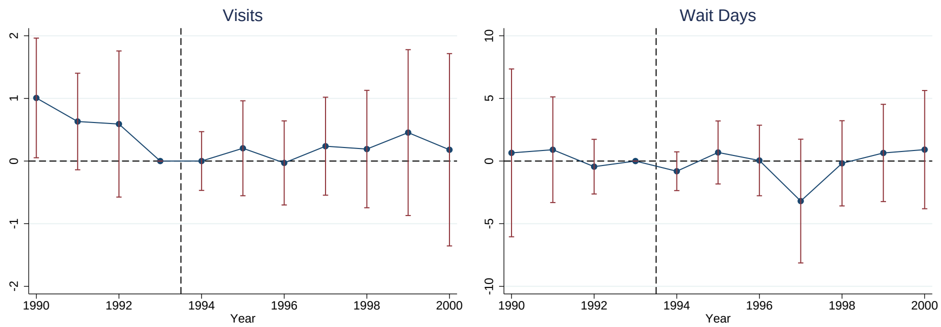


Figure 21: Robustness Technology Adoption



C.2 Access to Care

Figure 22: Access to Hospital Care



C.3 Patient Selection in Nursing Homes

Figure 23: Nursing Home Patients: Entry and Exit Decisions

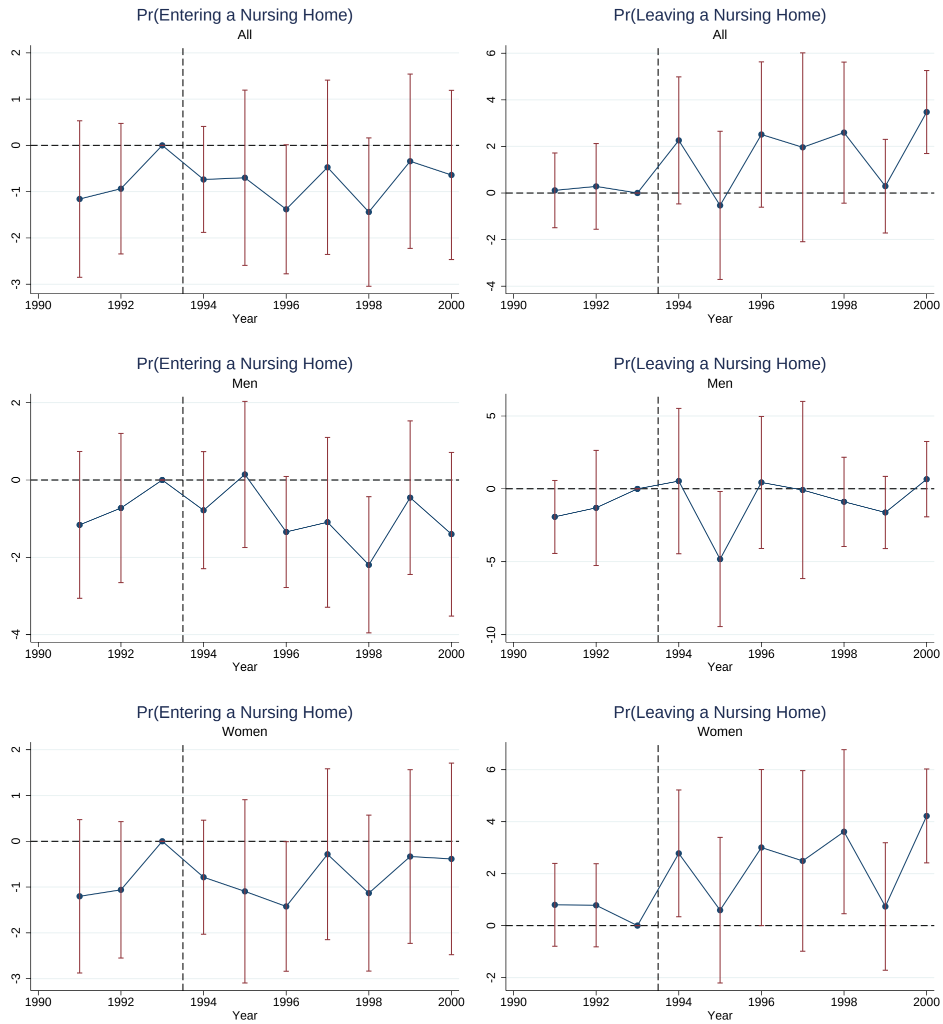


Figure 24: Nursing Home Patients: Entry and Exit Decisions