WILL INCREASED WAGES REDUCE SHORTAGE OF NURSES? A PANEL DATA ANALYSIS OF NURSES' LABOUR SUPPLY

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Abstract

Shortage of nurses is a problem in several countries. It is an unsettled question whether increasing wages constitute a viable policy for extracting more labour supply from nurses. In this paper we use a unique matched panel data set of Norwegian nurses covering the period 1993-1998 to estimate wage elasticities. The data set includes detailed information on 19,638 individuals over 6 years totalling 69,122 observations. The estimated wage elasticity after controlling for individual heterogeneity, sample selection and instrumenting for possible endogeneity is 0.21. Individual and institutional features are statistically significant and important for working hours. Contractual arrangements as represented by shift work are also important for hours of work, and omitting information about this common phenomenon will underestimate the wage effect.

JEL Classification: I10, J22, J44.

Keywords: nurses, labour supply, panel data, selection, semi-parametric models.

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1. INTRODUCTION

The health sector is labour intensive with a continuous demand for highly trained and specialized labour. Several countries suffer to a varying degree from a shortage of key health personnel. This is particularly true for the profession of nursing. Both UK and Scandinavian countries report a scarcity of nurses within the hospital sector as well as in other parts of the public health sector. Remedies are not clear. The nurses' unions claim that wages are too low, making the nurses unwilling to participate or work sufficiently long hours to meet stated demands for nursing. In Norway 40% of the nurses work part-time. Several studies report low wage elasticities for nurses, see Antonazzo et. al (2000) for a survey of US and UK studies. Anecdotal evidence often hints at an unwillingness of nurses to work longer hours, and that several decide to leave nursing altogether. A problem with existing studies is that they are often based on cross sections, and with missing information on variables of importance for the nurses' work decisions. In this paper we use a unique panel data set of Norwegian health care personnel to investigate the labour supply of nurses. We have access to information about individual characteristics, including the health care institution to which the nurse is affiliated, actual working hours, wages and type of contract for each nurse.

Wage policy may be of importance for the health sector if it can reduce the labour scarcity problem. For a work group like nurses, there should be reasons to believe that increased wages may actually contribute to increasing nurses' labour supply. Surprisingly, the evidence seems somewhat to the contrary. The Killingsworth and Heckman (1986) survey indicates that labour supply elasticities for females are positive, i.e., the positive substitution effect outweighs the negative income effect. Since a large percentage of nurses are female, it is expected that such results would carry over to nurses' labour supply. Furthermore, since a large percentage of nurses work part-time, changes in the individual labour supply should be easier for this group than for nurses working full-time. Existing empirical studies, often based on cross sections, reveal quite small, and sometimes even negative, effects of wages on nurses' labour supply (see Link, 1992, Ault and Rutman, 1994, Phillips, 1995). Does this mean that female nurses behave differently from female workers in the general population? Or could it be that low wage elasticities are due to the omission of relevant features of the labour markets for health personnel? These omitted features may be job attributes or contractual arrangements. It could also be that the selection problem is at work in explaining why nurses, when deciding on hours of work, are not very sensitive to wage changes.

There are several econometric issues at hand. First, wages cannot be considered as exogenous in a labour supply equation. In the UK and Scandinavian countries, the market for health personnel is monopsonistic consisting of one or a few large buyers (see e.g. Hirsch and Schumacher (1995, 1998)). This implies that hospitals and other community health institutions consider the marginal incremental cost of increasing wages rather than the wage rate itself. This means that the buyer faces a marginal cost which is steeper than the wage curve. Even though the hospitals claim that they would employ more workers at the going rate, it is not clear that they would be willing to pay the additional cost of increasing the wage for all nurses. This may be of particular relevance in an institutional setting where the demand side of the labour market faces more or less a given budget, which is the case in most public health care systems. We do not attempt to control for monopsony tendencies in the labour market as such. However, by controlling for institution and type of work performed, some effects from a non-competitive labour market may be captured, since the availability and attractiveness of the different institutions may help determine employer selection. Using instrumental variable estimation we take into consideration the simultaneous determination of wages and hours of work, thus singling out demand effects of importance for wage determination.

Second, nurses work under different contractual arrangements. Quite often they work shift hours, which affect contractual working hours as well as hourly pay. Shift hours are generally compensated with an hourly wage premium, and the mandated weekly working hours are shorter for these shift workers. We believe that it is important to correct for shift work, and that the wage effect will be biased if a variable representing such contractual work arrangements is omitted. The reason is twofold; if shift hours are considered burdensome, a wage compensation is required (Moore and Viscusi, 1990) and if this compensation is insufficient, lower labour supply is offered, and the estimated wage effect will be downwardly biased. It may also be the case that shift workers consider it too demanding to work long hours, therefore they respond less to wage changes than those working on ordinary day time contracts. In this case, the derived wage effect underestimates the true effect for some groups, and may give the wrong signals when considering an appropriate wage policy for nurses.

Third, when investigating labour supply, care should be taken to control for selection bias and unobserved heterogeneity. There is likely to be a selection process driving the decision to work or not to work, as well as where to work. Since we only observe nurses holding a job in specific health care institutions, not controlling for selection will result in biased estimates. Similarly, labour market behaviour is also driven by individual characteristics only some of which are observed by the researcher. A panel data set will make it possible to correct for selection bias as well as unobserved heterogeneity.

We have access to a unique panel data set of Norwegian health personnel covering the period 1993-1998. The individualized data with information about wages, working hours and type of work are matched with other data sets which include information about the individual and their household. We can also track trained nurses who are temporarily or permanently employed outside the public sector. For nurses employed by local and regional municipalities, information on wages and working hours are collected by the Norwegian

Association of Local and Regional Authorities (NALRA) for one month (October) during each year. Statistics Norway provides information on background variables for all registered nurses during the relevant period. We have controlled for the type of position held by each individual, and for the fact that nurses on shift contracts have shorter mandated working hours. The variable representing the burden of shift work is highly significant, and contributes to a negative effect on working hours. Thus, the inclusion of variables representing contractual arrangements is warranted, as is the inclusion of individual and institutional controls.

The rest of the paper is organized as follows: The next section provides some background information on the labour market for nurses. The data and sample properties are presented in Section 3. Section 4 derives the empirical specification and discusses some empirical modelling issues. Section 5 presents the empirical results, while Section 6 offers some concluding remarks.

2. INSTITUTIONAL FEATURES OF THE LABOUR MARKET FOR NURSES.

According to OECD Health Data 2000, Norway is one of the countries with the highest density of nurses. In 1996 there were 14.9 registered nurses per 1000 inhabitants[1], outnumbering most other countries. Simultaneously, the Norwegian nurses' union claims there are more than 4000 full time vacancies. The number of nurses includes registered nurses only, i.e. auxiliary nurses are excluded. The difference between registered and auxiliary nurses is length and type of education. Registered nurses receive 3 (4) years of education at college level, whereas auxiliary nurses are trained at the secondary school level. It is worth noting that there is limited capacity in training of nurses, as judged by student applications.

[1] The comparable numbers for 1997 are 9.5 registered nurses per 1000 inhabitants for Norway and Germany, 4.5 for the UK and 5.9 for France.

From the mid eighties a shift in the composition of nursing labour in favour of registered nurses has taken place especially at hospitals. In the rest of this paper we confine ourselves to registered nurses.

In Norway, most nurses are employed by publicly owned institutions. Like the UK and other Scandinavian countries, the public sector is responsible for most of the production of health care services and for its financing[2]. Specialist services were in the period of investigation the responsibility of counties. Somatic and psychiatric hospitals are owned and financed by 19 counties[3]. Exceptions include two national and some private, specialized hospitals. Primary health care is the responsibility of municipalities but a considerable share of general practitioners run private practices. Nurses employed by these private practices are not in our data set, nor are nurses engaged by private specialists. Municipalities are also responsible for general public health services, and institutions for the elderly, including somatic and psychiatric nursing homes. Counties and municipalities are financed from risk adjusted grants from the government using local taxes, and to a minor degree from user charges (co-payment). Owners of somatic hospitals (counties) also receive activity dependent DRG based payment. It is fair to say that the public health institutions are facing periodic (yearly) budget limits, but it is a matter of perception as to how strict these budget restrictions are. This is a fact of some importance when deriving wage effects. Given a fixed budget, institutions may not be willing to let nurses work longer hours following a wage increase, a phenomenon also hinted at in the monopsony theory approach to the nursing labour market.

Wages are bargained by the nurses' union on the one side, and NALRA, representing municipalities and counties, on the other side. Bargaining takes place every year. There may also be bargaining once a year at a local level, and each institution will have some discretion

[2] In 1997, according to OECD Health Data 2000, 82.7% of expenditures on health were public and only 0.1% of hospital beds were in private institutions.

[3] As of 2002, the central government has taken over responsibility of specialist care.

in bargaining individual wages by putting workers into specific wage categories. The bargained tariffs determine wage scales for every position and work category, including shift and overtime compensations. Individual contractual working hours are determined at the specific institution, at which level it is also determined who and how many to employ. Thus, the bargaining process resembles a 'right-to-manage' framework. Bargaining theory predicts wages increasing in union bargaining power, which in the public sector is likely to imply wages increasing in the financial surplus of the relevant health care institution. Commonly, positions are offered as full time or as a share of full time, and as shift work or ordinary day work. Often nurses work shorter hours than full time. Overtime is only paid when weekly hours of work exceed full time, which is 37.5 hours for ordinary work and 35.5 hours for those who work shift. Nurses are not allowed to plan for overtime work but may of course work overtime in cases of particular demand.

3. DATA

The data used in this analysis consist of administrative data for the years 1993-1998 collected from different official data registers. Statistics Norway (SSB) provides detailed background information on all individuals who have completed their nursing education. The data from SSB include information on whether the individual works or not, where the individual works and yearly income. However, this data set does not include information about wage rates or the number of hours worked. Information about the latter is obtained by merging the data from SSB with data from NALRA's personnel register[4]. The NALRA register includes information on all individuals working in the health sector in Norwegian counties and municipalities. An important advantage of this register is that it contains very detailed

[4] Notice that the data in the NALRA register is collected only for the month of October each year. The data for this month is considered representative, since there are no public holidays and it is not a typical holiday month.

individual information on standard wages, overtime, compensation for work outside normal hours, and total number of hours worked. Furthermore, information about the workplace of the nurse (hospital, nursing home, etc), and kind of job, like staff nurse, ward nurse etc., is also included. Using register data should reduce the problems associated with measurement errors which usually plague survey type data[5].

Our sample covers the period 1993-1998. We include female nurses younger than 62 years of age who are registered with a completed nursing qualification and employed by municipalities or counties[6]. Nurses working in institutions which do not provide detailed information for all years were excluded. We will argue below that this limitation of the data set does not seriously affect the representativeness of our analysis. We have detailed wage and contractual information on 19,638 individuals over five years, totalling 69,122 observations. This sample constitutes almost one half of the relevant population of Norwegian nurses. Column 1 of Table 1 reports the total sample of female nurses per year. Column 2 reports the number of nurses out of work. The percentage of nurses out of work is relatively constant over time, at approximately 8%. Column 3 reports the number of nurses employed by institutions covered by the NALRA register. Column 4 includes nurses working in institutions which have provided detailed and consistent wage information.

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[5] Validation studies use administrative data to examine the presence and magnitude of measurement errors in survey data (see for e.g. Poterba and Summers (1986) and Bollinger (1998)).

[6] We have excluded male nurses (4613). Inclusion of male nurses will have a marginal effect on our results. Nurses older than 62 (1400) are excluded since they will have access to different pension schemes. Also nurses registered with more than one job in the health sector are excluded (2743).

Table 1. Number of observations each year.

	Total sample	Out of work	NALRA sample	NALRA sub sample
1993	28734 (14.7)	2343 (8.2)	19399 (14.6)	10152 (14.7)
1994	29996 (15.3)	2497 (8.3)	19878 (14.9)	10888 (15.8)
1995	31534 (16.1)	2593 (8.2)	21297 (16.0)	12422 (18.0)
1996	33396 (17.0)	2596 (7.8)	22969 (17.2)	11280 (16.3)
1997	35243 (18.0)	2873 (8.2)	24437 (18.3)	11825 (17.1)
1998	37161 (19.0)	3055 (8.2)	25358 (19.0)	12555 (18.2)
Total	196064 (100)	15957 (8.1)	133338 (100)	69122 (100)

In Table 2 we report the sample frequencies by the number of years worked. Obviously, nurses who have not been at work in any of the six years cannot be found in the NALRA register, explaining the missing observations in the first row. Comparing the samples, we see that nurses are observed for fewer periods in the NALRA samples than in the total sample of female nurses. The reasons are threefold. First, an individual may work for all years but may temporarily leave a specific institution covered by the NALRA registers. Second, a specific institution may not file adequate reports for all years. This will affect the number of observations in the most restricted sample. Thus, missing observations in the NALRA sub sample are not due to choices of individual nurses but lack of reports from an employer. Third, an individual may leave the labour force for one or more years. As shown below, there seems to be little variation in the characteristics of nurses among the samples.

Table 2. Sample frequencies by number of work years.

No. of years	Total sample	NALRA sample	NALRA sub sample
0	1098 (2.7)	-	-
1	3639 (9.0)	4601 (13.9)	4365 (22.2)
2	3520 (8.7)	4122 (12.4)	2730 (13.9)
3	3639 (9.0)	4243 (12.8)	3051 (15.5)
4	3579 (8.9)	4179 (12.6)	2218 (11.3)
5	4851 (12.0)	4988 (15.1)	2511 (12.8)
6	19990 (49.6)	11018 (33.2)	4763 (24.3)
Total	40316 (100)	33151 (100)	19638 (100)

The variables used in the analysis are defined in Table 3. A more detailed explanation is given in the Appendix.

Table 3. Variable definitions.

Variable name	Definition
Hours per year	Regular hours plus overtime.
Hourly wage	Hourly wage including all bonuses and overtime in NOK.
Shift work	Share of the monthly income that is bonus due to late, night and weekend duties.
Hour_35.5	1 if the individual is on a contract with maximum 35.5 hours per week for full time nurses, 0 otherwise.
Age	Respondent's age.
Age^2	Age squared.
Experience	Number of years working as nurse.
$Experience^2$	Experience squared.
Disable	1 if the individual is more than 50 percent disabled, 0 otherwise.
Number of children	Number of children younger than 18.
Children < 3	1 if the nurse have children aged 2 or younger, 0 otherwise.
Children 3-7	1 if the nurse have children between the ages of 3 and 7, 0 otherwise.
Children > 7	1 if the nurse have children older than 7, 0 otherwise.
Married	1 if the respondent is married or cohabitant with children, and 0 otherwise.
Position	Respondent working as:
	Staff nurse
	Nursing specialist
	Ward nurse
	Senior nurse
Working place	Nurse working in:
	Hospital
	Psychiatric
	Home nursing
	Health service
	Nursing home
	Other
Wage of auxiliary nurses	Mean wage of auxiliary nurses working in the same municipality as the nurse
Municipality net surplus	Net working expenses in the municipality
Hospital in municipality	1 if there is a hospital in the municipality where the nurse lives, 0 otherwise
Availability kindergarten	Number of children aged 2 or younger in kindergarten divided by the total number of children aged 2 or younger in the municipality
Municipality size	Number of inhabitants in the municipality
Participation rate	Number of females working divided by all females in the municipality
Region	Nurse living in:
	East Norway
	South Norway
	West Norway
	Mid Norway
	North Norway
Centrality:	Measures a municipality's geographical position related to the nearest centre with central functions.
	Centrality level 0 (least central)
	Centrality level 1
	Centrality level 2
	Centrality level 3 (most central)

Sample statistics are reported in Table 4. If no figure is reported, it means that there are no observations for that variable in that sample. For the NARLA sub-sample of female nurses, the average age is 37 years with 35% of the nurses being single. The majority of these nurses work in somatic hospitals (62%) or nursing homes (20%) with the remaining nurses engaged in home nursing (10%), at psychiatric institutions (5%), in health services (1%), and others (3%). Senior nurses comprise only 2% of our sample, while 16% are ward nurses, 20% are nursing specialists, and the remaining majority (62%) work as staff nurses. The average years of experience during the sample period was 12.5 years, and the average number of children below 18 years of age was 1.2. Nurses with children below the age of 3 comprise 22% of our sample, while those with children between the ages of 3 and 7 comprise 29% of the sample.

Note that the individual specific variables (age, experience, number of children, etc.) are very similar across the samples. The geographical variables, on the other hand, indicate an under-representation of nurses in central areas in the NALRA samples. In fact, most government owned institutions are situated in the capital and private health care tends to be over-represented in major cities. It is also the case that large hospitals and municipalities are less likely to report the necessary information for all years to the NALRA register. In total, barring a slight geographical misrepresentation, the data in the restricted sample seems representative for the total sample of female nurses.

Table 4. Sample statistics, means and standard deviations (in parentheses).

	Total sample	NALRA sample	NALRA sub-sample
Hours per year	-	-	1382.4 (360.7)
Hourly wage	-	-	129.7 (17.2)
Shift work	-	-	12.0 (8.1)
Hour_35.5	-	0.79 (0.41)	0.86 (0.34)
Disable	0.02 (0.15)	0.01 (0.10)	0.01 (0.1)
Age	37.46 (8.26)	37.30 (8.13)	37.0 (7.9)
Single	0.36 (0.48)	0.36 (0.48)	0.35 (0.48)
Number of children <18	1.19 (1.14)	1.19 (1.12)	1.21 (1.10)
Children < 3	0.22 (0.41)	0.21 (0.41)	0.22 (0.42)
Children 3 – 7	0.28 (0.45)	0.28 (0.45)	0.29 (0.45)
Children > 7	0.31 (0.46)	0.31 (0.46)	0 .32 (0.47)
Hospital	-	0.52 (0.50)	0 .62 (0.49)
Psychiatric	-	0.03 (0.18)	0.05 (0.21)
Home nursing	-	0.12 (0.33)	0.10 (0.30)
Health service	-	0.07 (0.25)	0.01 (0.10)
Nursing home	-	0.21 (0.41)	0.20 (0.40)
Other	-	0.04 (0.20)	0.03 (0.16)
Staff nurse	-	0.57 (0.49)	0.62 (0.49)
Nursing specialist	-	0.21 (0.41)	0.20 (0.40)
Ward nurse	-	0.19 (0.39)	0.16 (0.37)
Senior nurse	-	0.02 (0.12)	0 .02 (0.12)
Experience	-	12.66 (7.77)	12.53 (7.66)
East-Norway	0.48 (0.50)	0.45 (0.50)	0.46 (0.50)
South-Norway	0.13 (0.34)	0.14 (0.35)	0.18 (0.38)
West-Norway	0.18 (0.38)	0.19 (0.39)	0.08 (0.27)
Mid-Norway	0.10 (0.29)	0.10 (0.31)	0.16 (0.36)
North-Norway	0.11 (0.31)	0.13 (0.33)	0.13 (0.34)
Hospital in municipality	0.59 (0.49)	0.58 (0.49)	0.56 (0.50)
Availability kindergarten	0.24 (0.09)	0.24 (0.09)	0.23 (0.08)
Participation rate	0.40 (0.05)	0.40 (0.05)	0.39 (0.04)
Municipality size	92.96 (138.86)	72.08 (115.57)	41.73 (54.51)
Wage auxiliary nurses	86.76 (2.95)	86.76 (2.95)	86.55 (2.71)
Municipality net surplus	1322.74 (1766.41)	1162.35 (1742.78)	972.82 (1626.96)
Centr0	0.12 (0.33)	0.14 (0.35)	0.14 (0.35)
Centr1	0.12 (0.32)	0.13 (0.34)	0.10 (0.30)
Centr2	0.22 (0.41)	0.24 (0.42)	0.35 (0.48)
Centr3	0.54 (0.50)	0.48 (0.50)	0.41 (0.49)
Sample size	196064	133338	69122

4. ECONOMETRIC MODEL

We will consider the following panel data nursing labour supply model with sample selection

$$y_{it}^{*} = x_{it}\beta + \alpha_i + \varepsilon_{it}\,; \quad i = 1,...,N\,; \quad t = 1,...,T\,, \tag{4.1}$$

$$d_{it}^{*} = z_{it}\gamma + \eta_i + u_{it}\,, \tag{4.2}$$

$$d_{it} = 1\left[d_{it}^{*} \geq 0\right] \tag{4.3}$$

Here, y_{it}^{*} is the number of hours supplied by nurse i in period t. Our panel covers 19,638 nurses over maximum 6 years and the total number of observations is 69,122. The unknown parameters we wish to estimate are β (and γ), while x_{it} and z_{it} are vectors of explanatory variables. All variables in z_{it} and x_{it} are assumed to be strictly exogenous[7] and z_{it} and x_{it} might contain common elements. The ε_{it} and u_{it} are unobserved disturbances. The sample selection problem arises because the hours of work variable y_{it}^{*} is only observable for nurses with $d_{it} = 1$, i.e., those who are present in the NALRA sub sample. If α_i and ε_{it} are dependent on d_{it}, the conditional expectation of (4.1) will differ from $x_{it}\beta$. Applying OLS only on the observations for nurses who participate will therefore lead to biased estimates of the β vector. If the sample selection process is constant over all periods a difference estimator eliminates the sample selection bias. In this case both the unobserved individual effect and the sample selection effect are differenced out.

However, in general there is no reason to expect the sample selection process to be time invariant, and to correct for sample selection we use the estimator proposed by Kyriazidou (1997). The individual effects, α_i and η_i are allowed to be correlated with the explanatory variables (x_{it} and z_{it}) and the error terms (ε_{it} and u_{it}). No distributional assumptions are made concerning the error terms. The estimator relies on time differencing

[7] We consider the case where x_{it} is allowed to contain endogenous variables below.

(4.1) for those observations that have $d_{it} = d_{is} = 1,\ t \neq s$ [8]. This strategy will eliminate the individual-specific component but not the sample selection effect, unless the conditional expectation below is equal to zero:

$$
\begin{aligned}
&\mathrm{E}(\varepsilon_{\mathrm{it}} - \varepsilon_{is} \mid d_{it} = d_{is} = 1, \zeta_i) = \\
&\mathrm{E}(\varepsilon_{it} \mid d_{it} = d_{is} = 1, \zeta_i) - \mathrm{E}(\varepsilon_{is} \mid d_{it} = d_{is} = 1, \zeta_i) \equiv \\
&\lambda_{it} - \lambda_{is}
\end{aligned}
\tag{4.4}
$$

Here $\zeta_i = (x_{it}, x_{is}, z_{it}, z_{is}, \alpha_i, \eta_i)$. To see that this may not necessarily equal zero, notice that the sample selection effect in period *t*, may be expressed as

$$
\begin{aligned}
\lambda_{it} &= E(\varepsilon_{it} \mid u_{it} \leq z_{it}\gamma + \eta_i, u_{is} \leq z_{is}\gamma + \eta_i, \zeta_i) \\
&= \Lambda(z_{it}\gamma + \eta_i, z_{is}\gamma + \eta_i; F_{it}(\varepsilon_{it}, u_{it}, u_{is} \mid \zeta_i)).
\end{aligned}
$$

We see that the sample selection effect depends on the conditioning vector ζ_i and the joint conditional distribution of the error terms. Since this distribution may vary over nurses, as well as over time for the same nurse, there is in general no reason to expect the unobserved conditional expectation in (4.4) to equal zero. To ensure the sample selection effect is the same in two periods, it is assumed that Λ is time invariant[9]. If this is the case, λ_{it} and λ_{is} will be equal only if $z_{it}\gamma = z_{is}\gamma$. Thus, applying first-differences in equation (4.1) eliminates both the individual time invariant effect and the selection effect. Notice that since first-differences are taken on an individual basis, the functional form of Λ may vary across nurses.

In most cases $z_{it}\gamma$ and $z_{is}\gamma$ will not be exactly equal. However, differencing across observations when the values of $z_{it}\gamma$ and $z_{is}\gamma$ are close, will also approximately eliminate the unobserved expectation. Thus, to make the estimator operational, Kyriazidou (1997) suggests the following procedure. In the first step, get consistent estimates of the parameters in the selection equation. In this study, we estimate a conditional logit model using only the nurses

[8] Our panel consists of six periods, thus the maximum number of differences is fifteen.
[9] See Kyriazidou for a more detailed discussion on the assumptions needed.

who change status over time. In the second step, these estimates are used for constructing weights which are then included in a weighted least square regression. The estimator is

$$\hat{\beta}_n = \left[\sum_{i=1}^{n} \hat{\psi}_{in} \left(x_{it} - x_{is}\right)' \left(x_{it} - x_{is}\right) d_{it} d_{is} \right]^{-1} \tag{4.5}$$

$$\times \left[\sum_{i=1}^{n} \hat{\psi}_{in} \left(x_{it} - x_{is}\right)' \left(y_{it} - y_{is}\right) d_{it} d_{is} \right],$$

where $\hat{\psi}_{in}$ are "kernel" weights, declining to zero as the difference $| z_{it}\hat{\gamma}_n - z_{it}\hat{\gamma}_n |$ increases:

$$\hat{\psi}_{in} = \frac{1}{h_n} K\left(\frac{\left(z_{it} - z_{is}\right)\hat{\gamma}_n}{h_n} \right). \tag{4.6}$$

K is a "kernel density" function, and h_n is a sequence of "bandwidths" that tends to zero as $n \to \infty$.

So far all variables in x_{it} and z_{it} are assumed to be strictly exogenous. In our application this assumption is likely to be violated since wages cannot be considered as exogenous in the labour supply equation. However, a straightforward generalization by Charlier, Melenberg and Van Soest (1997) allows for endogeneity in the Kyriazidou method using an IV estimator[10]. In particular, they propose the following estimator:

$$\hat{\beta}_{IV} = \left[\sum_{i=1}^{n} \hat{\psi}_{in} \left(\hat{x}_{it} - \hat{x}_{is}\right)' \left(x_{it} - x_{is}\right) d_{it} d_{is} \right]^{-1} \tag{4.7}$$

$$\times \left[\sum_{i=1}^{n} \hat{\psi}_{in} \left(\hat{x}_{it} - \hat{x}_{is}\right)' \left(y_{it} - y_{is}\right) d_{it} d_{is} \right],$$

where $\left(\hat{x}_{it} - \hat{x}_{is}\right)$ are the instruments. This IV estimator may also eliminate a potential endogeneity problem due to measurement errors (see Dustmann and Barrachina, 2000). Notice also that identification of the parameters of interest in this model requires exclusion

[10] Charlier, Melenberg and Van Soest (1997) prove the consistency of this estimator.

restrictions. This is due to the non-parametric nature of the estimator and implies that at least one variable in the selection equation should be excluded from both the labour supply equation and from the set of instruments for wage.

5. RESULTS

Most of our discussion will concentrate on the estimated effect of wages on labour supply. The results are given in Table 5. The first column reports the OLS estimates, the second column the fixed effects (FE) results, while the results from the sample selection model using the Kyriazidou's method (K) is presented in column three. The results from the IV counterpart of these three models are given in column four (2SLS), column five (FE-2SLS) and column six (K-IV).

Table 5. Estimated effects on nurses labour supply.

	OLS	FE	K	2SLS	FE-2SLS	K-IV
Ln wage	0.2543**	-0.0522**	-0.0517**	0.4600**	0.2409	0.2078*
	(0.0105)	(0.0118)	(0.0082)	(0.0353)	(0.1335)	(0.0942)
Shift work	-0.0157**	-0.0094**	-0.0094**	-0.0172**	-0.0114**	-0.0111**
	(0.0004)	(0.0004)	(0.0003)	(0.0004)	(0.0010)	(0.0007)
Shift work 2	0.00002	0.00002*	0.00002*	-0.00000	-0.00000	-0.00000
	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
Hour_35.5	-0.0267**	-0.0260**	-0.0273**	-0.0358**	-0.0405**	-0.0397**
	(0.0034)	(0.0042)	(0.0029)	(0.0038)	(0.0078)	(0.0053)
Disable	-0.3809**	-0.3057**	-0.2588**	-0.3763**	-0.3012**	-0.2581**
	(0.0096)	(0.0194)	(0.0259)	(0.0096)	(0.0197)	(0.0261)
Age	-0.0096**	0.0028	0.0020	-0.0128**	-0.0111	-0.0098*
	(0.0011)	(0.0030)	(0.0022)	(0.0012)	(0.0070)	(0.0048)
Age2	0.00005**	0.0001**	0.0002**	0.0001**	0.0002**	0.0003**
	(0.00001)	(0.00004)	(0.00002)	(0.00001)	(0.00005)	(0.00003)
Single	0.0565**	0.0177**	0.0209**	0.0542**	0.0172**	0.0205**
	(0.0021)	(0.0051)	(0.0035)	(0.0022)	(0.0051)	(0.0035)
Number of children	-0.0423**	-0.1005**	-0.1033**	-0.0449**	-0.0955**	-0.0991**
	(0.0017)	(0.0042)	(0.0032)	(0.0017)	(0.0048)	(0.0035)
Children < 3	-0.0999**	-0.0563**	-0.0478**	-0.0961**	-0.0579**	-0.0495**
	(0.0028)	(0.0038)	(0.0027)	(0.0029)	(0.0038)	(0.0028)
Children 3 - 7	-0.0630**	-0.0230**	-0.0159**	-0.0618**	-0.0250**	-0.0177**
	(0.0027)	(0.0033)	(0.0023)	(0.0027)	(0.0034)	(0.0024)
Children > 7	-0.0480**	-0.0360**	-0.0305**	-0.0449**	-0.0360**	-0.0307**
	(0.0030)	(0.0030)	(0.0021)	(0.0030)	(0.0031)	(0.0021)
Psychiatric	0.0316**	0.0497**	0.0497**	0.0312**	0.0456**	0.0466**
	(0.0045)	(0.0111)	(0.0091)	(0.0045)	(0.0113)	(0.0092)
Home nursing	-0.0352**	-0.0073	-0.0136*	-0.0364**	-0.0162*	-0.0206**
	(0.0033)	(0.0070)	(0.0062)	(0.0033)	(0.0082)	(0.0067)
Health service	-0.0714**	-0.0439**	-0.0543**	-0.0697**	-0.0482**	-0.0567**
	(0.0090)	(0.0174)	(0.0149)	(0.0090)	(0.0176)	(0.0148)
Nursing home	-0.0339**	-0.0079	-0.0101*	-0.0354**	-0.0172*	-0.0177**
	(0.0025)	(0.0060)	(0.0053)	(0.0025)	(0.0074)	(0.0059)
Other	-0.0303**	-0.0127	-0.0095	-0.0300**	0.0051	0.0024
	(0.0059)	(0.0088)	(0.0075)	(0.0059)	(0.0095)	(0.0078)
Nursing specialist	0.0560**	0.0311**	0.0307**	0.0392**	0.0124	0.0144*
	(0.0027)	(0.0048)	(0.0035)	(0.0039)	(0.0098)	(0.0067)
Ward nurse	0.0538**	0.0212**	0.0190**	0.0352**	-0.0013	-0.0004
	(0.0030)	(0.0039)	(0.0029)	(0.0043)	(0.0110)	(0.0076)
Senior nurse	0.0917**	0.0369**	0.0360**	0.0574**	0.0019	0.0057
	(0.0083)	(0.0120)	(0.0065)	(0.0101)	(0.0199)	(0.0123)
East Norway	-0.0850**	-0.0487**	-0.0697**	-0.0801**	-0.0405**	-0.0622**
	(0.0029)	(0.0135)	(0.0131)	(0.0031)	(0.0141)	(0.0131)
South Norway	-0.1277**	-0.0854**	-0.0893**	-0.1214**	-0.0737**	-0.0802**
	(0.0035)	(0.0169)	(0.0170)	(0.0036)	(0.0178)	(0.0170)
West Norway	-0.0892**	-0.1089**	-0.1164**	-0.0823**	-0.0994**	-0.1157**
	(0.0042)	(0.0194)	(0.0218)	(0.0043)	(0.0200)	(0.0218)
Mid Norway	-0.1128**	-0.1084**	-0.1103**	-0.1080**	-0.0985**	-0.1011**
	(0.0037)	(0.0163)	(0.0187)	(0.0038)	(0.0171)	(0.0188)
Municipality size	0.00001	0.00006	0.0002**	0.00001	0.00005	0.0002*
	(0.00001)	(0.00004)	(0.0001)	(0.00001)	(0.00004)	(0.00007)
Constant	6.6072**	7.4675**	0.0065**	5.7145**	6.4896**	-0.0068**
	(0.0498)	(0.0704)	(0.0014)	(0.1546)	(0.4493)	(0.0014)
Number of observations	69122	69122	121622	69122	69122	121622

Standard errors in parentheses. ** and * is statistically different from zero at one and five percent significance level, respectively.

Age has a significant negative effect for the OLS, 2SLS and K-IV estimators. For these estimators the age effect is convex, i.e. the nurses work shorter hours as they become older but to a diminishing degree. The effect of family variables is as expected. Being single has a positive and significant effect on hours of work. The presence of children in the home has a negative impact on hours of work[11]. Nurses working in psychiatric institutions work longer hours compared to the base category somatic hospitals, whereas shorter hours are supplied by nurses engaged in home nursing, as well as in nursing homes. We also note that labour supply is highest in the less densely populated Northern Norway (the base category). This may reflect the fact that hours of work are not allowed to vary as much in these areas. Correcting for sample selection, i.e., applying the K and K-IV estimators yield the result that hours of work increase with the size of municipality.

Compared to a staff nurse, who serves as the base work type category, nursing specialists, ward nurses and senior nurses all work longer hours. The reason for this may be that younger and less experienced nurses are offered work contracts consisting of less working hours, and thus to a larger degree play a role of being residual labour in the sense that short term demand and the institution's financial situation determine how much they may work. Focusing now on wages and contractual arrangements, the OLS estimator in column 1 finds a significant *wage* elasticity of 0.25. Being on *shift work* has a negative effect on hours of work, with a coefficient of -0.016, as is the effect of being on a contract with shorter maximum weekly working hours (*hour_35*, -0.027)). Since we are comparing nurses working on a contract with maximum 35.5 hours per week (full time) with nurses on a contract

[11] Non-labour income including spouse's income and capital income was not available for 1998 and was excluded from our regressions. In regressions using a shorter time span, i.e., excluding 1998, non-labour income had the expected sign of reducing the hours of work with the remaining variables yielding similar results as those reported for Table 5.

stipulating 37.5 hours per week as maximum, the size of this coefficient should be about -0.05. The results indicate that, in addition to wages, the type of contract on which a nurse is engaged, is important for deriving labour supply effects. Omitting these variables will lead to biased estimates. To see this, we estimated the same model without the shift variables, which resulted in a wage elasticity of –0.35. The interpretation of the *shift work* variable is that it represents the degree of burden by working shift, and the compensation is not high enough to have them work longer hours. For the FE and K estimators, the included second order effect, *shift work 2*, is positive and significant, indicating that the burden is decreasing in share of overtime. This result is questionable. We note that when we correct for endogeneity in wage determination, this second order effect is not significant, i.e., the burden is not sensitive to how much shift work is being performed.

The empirical labour market literature draws particular attention to three potential problems that may bias the simple OLS results. These are sample selection problems, unobserved heterogeneity and endogeneity of the wage variable. Another common problem is related to measurement error. By using register data and not survey data, we should be much less exposed to the latter. However, we cannot rule out measurement problems because there still could be mistakes in reporting from health institutions. A priori, we have no reason to assume such mistakes to be systematic in any direction.

We will correct for the above mentioned biases using different estimators. Column 2 of Table 5 shows the results of the FE estimator. Notice that if the individual fixed effects in the hour equation are positively correlated with the wage, then the OLS estimate of the wage effect should be biased upwards. After correcting for unobserved heterogeneity, as expected, we find a reduction in the wage effect as compared to the OLS results. However, the estimated effect of the wage is negative and significant in this model, with a wage elasticity of –0.05. This is possible but not very likely. The variables controlling for shift work have an effect similar to the OLS estimates, and the coefficient for the dummy representing contractual hours of work per week is only marginally smaller than that for the OLS estimate.

Verbeek and Nijman (1992) propose simple tests for sample selection in panel data models. One test is to include variables measuring whether the individual is observed in the previous period (V1), whether the individual is observed in all periods (V2) and the total number of periods the individual is observed (V3). The null hypothesis says that these variables should not be significant in our model if there are no sample selection problems. Another test, a Hausman type test, compares the fixed effects estimator from the balanced sample as opposed to an unbalanced sample. Since both tests reject the null hypothesis of no sample selection[12], we consider a model that explicitly takes sample selection into consideration.

To implement the Kyriazidou (1997) estimator, we first estimated a conditional logit model. This uses only the 11320 individuals who changed status over time. The results are given in table A2. As identifying variables in the regression we use a number of variables characterizing the regions and municipalities where the individuals live (centrality, female work participation rates, availability of kindergarten and whether there is a hospital in the municipality). Job-related variables are excluded since we do not observe this information for those who do not participate. These estimates are then used to construct "kernel weights". We have chosen a normal density function for the kernel, while the bandwidth is set to $h_n = h \cdot n^{-1/5}$ where h = 1. Kyriazidou proposed a plug-in procedure to obtain the optimal kernel bandwidth. However, experimenting with different values of h had very little effect on the estimates in the final regression. Finally, these weights were used in a weighted least square regression. To take account of the weights, we apply the Huber/White estimator for the variance. The results from this model are given in column 3 of table 5. To test for sample selection, we have applied a Hausman test where we compare the weighted model to the same model without weights. This gave a value of the test statistic (chi2(23) = 821.27) that clearly rejected the null hypothesis of no selection. It is therefore somewhat surprising that the results from this model correspond quite closely with the results from the fixed effect model. One explanation for this could be that most of the selection effect works through the individual fixed effects (α_i), so that the unobserved heterogeneity and the selection effect are differenced out in the FE model.

So far we have considered the wage as exogenous. This is probably too restrictive an assumption, and in column 4, 5 and 6 we present IV counterparts of the OLS, FE and K estimators. As instruments for the wage of nurses we have used the financial situation of the municipality, measured by lagged net financial surplus preceding period. Further instruments are lagged mean wage of auxiliary nurses working in the same municipality as the nurse, and each nurse's work experience. These variables are assumed to affect wages of nurses but not their hours of work. Experience will affect wages through seniority rules, and when controlling for age it is reasonable that experience does not have an additional effect on working hours. Both net financial surplus and wages of auxiliary nurses are proxies for the financial strength of administrative units owning and running health care institutions. They are assumed to have a positive effect of union bargaining power, by representing the wage capacity of the health care institutions, but without in itself affecting an individual nurse's willingness to supply work. The instruments pass the Hausman test of overidentifying restrictions[13]. The corresponding results for the wage equations are reported in Table A1.

The effect on the wage elasticity is larger in all three IV models compared to the previous models. Apart from variables representing contracts and type of position held, there are no dramatic changes in sign and size of the estimated coefficients. We note that when

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[12] The estimates of V1, V2 and V3 were; V1: 0.015 (0.004), V2: -0.008 (0.001) and V3: -0.039 (0.003) with

controlling for endogeneity in wage determination, the different types of nurses are now more similar in working hours, and as noted above the burden of shift work no longer seems to be diminishing in magnitude. The negative wage elasticities disappear, and the second order effect of shift work and the size of the 'maximum hours per week' coefficient are more reasonable. Focusing first on the 2SLS estimator, we find that the wage elasticity increases to 0.46, which is higher than what is found in several other studies cited above. The coefficient for the variable representing burden of *shift work* is marginally higher in absolute value than that of OLS, now at –0.017. We also find an estimated coefficient on "Hour_35.5" closer to the expected 5% (0.036).

Similarly, the FE-2SLS wage elasticity estimate of 0.24 is higher than that reported by the FE estimator. However, this estimate is not significant at the ordinary 5% level. The Kyriazidou-IV estimator produces a smaller, and significant, elasticity at 0.21[14]. The variables representing shift work show similar results to what was found in the 2SLS model, i.e., a significantly negative effect, as is expected, but with no clear second order effect. The coefficient for the variable representing contractual (maximum) hours of work per week, "Hour_35.5", is higher than in 2SLS, now at –0.04, and thus better determined given its expected size.

There is little difference in the estimates of the fixed effects 2SLS and the sample selection K-IV estimator. Nevertheless, Column 6 gives our preferred estimates of the nurses' labour supply because it guards against sample selection. Taking into consideration that there is some selection into work, and having controlled for type of contracts, as well as the endogeneity in determination of wages and hours-of-work, we find that wage elasticities are positive and significant and estimated to be around 0.21.

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standard deviations in parentheses. The result of the Hausman type test were: chi2(23) = 60.56 (p-value: 0.00).
[13] A test of overidentifying restrictions gave Chi2(1) = 5.999 (p-value = 0.11) in the FE-2SLS model.

6. CONCLUDING REMARKS

Based on studies of nurses' labour supply in the UK and USA, there is ample evidence indicating that nurses' wage elasticities are small. We have found that this is indeed the case in our panel data set of Norwegian nurses. This result obtained whenever we ignored the endogeneity of wage determination using the OLS estimator. We also obtained a negative and significant wage elasticity when using the fixed effects estimator, i.e., after controlling for nurses' heterogeneity, and similarly after correcting for sample selection using the Kyriazidou estimator. However, we have shown that important effects may relate to the simultaneous determination of wages and hours of work. This may be due to the wage bargaining process and the role played by the demand side in the labour market for nurses, which is represented by hospitals and other institutions that are publicly owned (municipalities and counties), and which are likely to have some degree of market power in their local labour markets. Larger positive and significant wage elasticities were obtained using FE2SLS and the IV counterpart of the Kyriazidou estimator suggested by Charlier et. al (1997).

Another important result from our analysis is that contractual information should be included in the determination of health personnel's labour supply. In particular, omitting information about shift work, which is commonly performed by nurses, will bias the estimates of the wage elasticity. The reason is that the work contract specifies working conditions and payment, including standard hours of work and compensation for work outside of normal working hours.

The magnitude of the wage elasticity depends on the estimator chosen. The wage elasticities are higher when instrumenting for wages, and an elasticity of 0.2, as in the preferred K-IV model, is higher than what is reported in some other studies. The Hausman test performed shows that our estimator is consistent for this choice of instruments.

[14] A Hausman type test rejected the null hypothesis of no sample selection (chi2(23) = 842.70).

A policy implication of the results reported here would be that wages matter for nurses' labour supply but that several institutional aspects play important roles for how many hours of work are performed. In addition to contractual arrangements, the health institutions' financial situation as well as governing structures may be important.

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DATA APPENDIX

The *hourly wage* is calculated by first adding the monthly basic income, overtime pay and all bonuses, and then dividing this total income by the number of hours worked. Bonuses include compensation for shift work on evenings, nights and weekends, and regular bonuses. Regular bonuses are typically compensation for meetings or other work outside normal working hours, mostly paid to ward nurses and leading nurses. Finally the wage is discounted by a price index.

Shift work is calculated as the share of total monthly income that a nurse receives as compensation for shift work. Another possibility would be the proportion of hours worked outside normal hours (shift hours divided by total hours of work). However, we do not have information about the actual number of shift hours, but believe that *shift work* is a close substitute for the exact magnitude of individual shift work. An advantage of calculating the importance of shift work this way, is that it implicitly takes into consideration that shift work of different types may be differently compensated due to variations in the burden of this particular type of work.

Hour_35.5 is a dummy variable taking value 1 if the nurse is on a shift contract, which implies a maximum of 35.5 hours per week for full time nurses, 0 otherwise.

The nurses in our sample are divided into four categories: staff nurse, specialist nurse, ward nurse and leading nurse. *Staff nurses* have 3 (4) years of college education. *Specialist nurses* are nurses with at least one year of specialist training, in e.g. anaesthesia, surgery or intensive care. *Ward nurses* are nurses who are in charge of a ward, whereas *leading nurses* are in charge of a larger unit.

Centrality indicates the geographical position of the municipality in relation to larger urban settlement. The classification is performed by Statistics Norway and it is based on travelling time to a centre where a higher order of central functions is found. “Centrality level

0” consists of the least central municipalities, whereas the most central municipalities are found in “Centrality level 3”.

Table A1. Wage equations.

	OLS	FE	K
Shift work	0.0071** (0.0001)	0.0069** (0.0001)	0.0068** (0.0001)
Shift work 2	0.0001** (0.00003)	0.0001** (0.00004)	0.0001** (0.00003)
Hour_35.5	0.0466** (0.0012)	0.0488** (0.0016)	0.0479** (0.0010)
Disable	-0.0248** (0.0033)	-0.0165* (0.0074)	-0.0056 (0.0154)
Age	0.0092** (0.0004)	0.0377** (0.0013)	0.0363** (0.0009)
Age2	-0.0001** (0.00004)	-0.0002** (0.00001)	-0.0002** (0.00001)
Single	0.0107** (0.0007)	-0.0016 (0.0019)	0.0017 (0.0013)
Number of children	0.0085** (0.0006)	-0.0165** (0.0016)	-0.0155** (0.0011)
Children < 3	-0.0159** (0.0010)	0.0047** (0.0014)	0.0060** (0.0009)
Children 3 - 7	0.0041** (0.0009)	0.0064** (0.0012)	0.0067** (0.0008)
Children > 7	-0.0120** (0.0010)	0.0003 (0.0012)	0.0008 (0.0007)
Psychiatric	0.0053** (0.0016)	0.0144** (0.0042)	0.0131** (0.0029)
Home nursing	0.0152** (0.0011)	0.0308** (0.0028)	0.0273** (0.0018)
Health service	0.0006 (0.0031)	0.0174** (0.0066)	0.0115* (0.0046)
Nursing home	0.0155** (0.0009)	0.0326** (0.0023)	0.0300** (0.0015)
Other	0.0069** (0.0020)	0.0267** (0.0033)	0.0279** (0.0023)
Nursing specialist	0.0732** (0.0009)	0.0641** (0.0018)	0.0627** (0.0012)
Ward nurse	0.0840** (0.0010)	0.0766** (0.0015)	0.0746** (0.0009)
Senior nurse	0.1582** (0.0028)	0.1197** (0.0045)	0.1171** (0.0029)
East Norway	-0.0267** (0.0010)	-0.0275** (0.0051)	-0.0278** (0.0042)
South Norway	-0.0285** (0.0012)	-0.0397** (0.0064)	-0.0333** (0.0052)
West Norway	0.0002 (0.0015)	-0.0328** (0.0074)	-0.0034 (0.0078)
Mid Norway	-0.0158** (0.0013)	-0.0441** (0.0063)	-0.0423** (0.0055)
Size of municipality	0.00003** (0.00001)	0.0002** (0.00002)	0.0002** (0.00002)
Experience	0.0064** (0.0001)	0.0067** (0.0004)	0.0065** (0.0003)
Experience2	-0.00006** (0.000002)	-0.00006** (0.000005)	-0.00006** (0.000003)
Lag of wage auxiliary nurses	0.0078** (0.0001)	0.0008** (0.0001)	0.0005** (0.0001)
Lag of municipality net surplus	-0.00001 (0.00003)	-0.00005** (0.000005)	-0.00001** (0.000003)
Constant	3.7725** (0.0140)	3.4683** (0.0276)	0.0009 (0.0006)
Number of observations	69122	69122	121622

Standard errors in parentheses. ** and * is statistically different from zero at one and five percent significance level, respectively.

Table A2. Participation equation. Conditional logit.

Educated as nursing specialist	0.6155** (0.0685)
Age	0.1125** (0.0340)
Age2	-0.0035** (0.0004)
Single	-0.1256* (0.0550)
Number of children	-0.2640** (0.0457)
Children < 3	-0.1424** (0.0424)
Children 3 – 7	0.0725 (0.0385)
Children > 7	-0.0619 (0.0369)
Disable	-1.2678** (0.2240)
Hospital in municipality	0.6463** (0.0617)
Availability kindergarten	0.3303 (0.2511)
Participation rate	0.0345** (0.0073)
East-Norway	0.5275** (0.1198)
South-Norway	0.8874** (0.1448)
West-Norway	-0.8383** (0.1318)
Mid-Norway	1.4610** (0.1429)
Municipality size	-0.0082** (0.0003)
Centrality level 1	-0.0471 (0.1615)
Centrality level 2	-0.5202** (0.1809)
Centrality level 3	-0.5408** (0.1387)
Log likelihood	-22287.461
Number of observations	61464

Standard errors in parentheses. ** and * is statistically different from zero at one and five percent significance level, respectively.

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