59th Health Economists' Study Group - London, 12-14 September 2001

British nurses' labour supply: an econometric investigation

Diane Skatun[1,2], Emanuela Antonazzo[1], Anthony Scott[1,2], Robert F. Elliott[2,3]

[1] Health Economics Research Unit, University of Aberdeen
[2] Centre for European Labour Market Research, University of Aberdeen
[3] Department of Economics, University of Aberdeen

Abstract

The need to ensure adequate numbers of motivated health professionals is at the forefront of the modernisation of the UK NHS. The aim of the paper is to estimate a classical model of labour supply for British qualified married or co-habiting nurses and midwives. Although recruitment and retention policies are considered a priority area for action, the empirical literature on these issues is almost non-existent. We use a logit model for participation decisions and a selection bias corrected hours of work regression. Data are drawn from the Labour Force Survey by pooling four successive quarters over the years 1999-2000. The sample is made up of 1248 people possessing a nursing qualification, of whom 1043 are working nurses and 205 are currently out of the labour force but could potentially be drawn back into nursing. In the logit model for participation and in the hours equation, own wages, partner wages, non-labour income and number of dependent children all have the expected impact. Interestingly, having a child of nursery age (3-4) is not significantly different from having a school-age child (5-15). Moreover, participation and hours of work are found to be rather inelastic with respect to own wage, partner's wage, and non-labour income. These initial results suggest that increasing the wage would have a moderate effect on attracting back "potential returners". Econometric testing of the model is not complete, and so these initial results should be treated with caution.

Acknowledgements

The Health Economics Research Unit is funded by the Chief Scientist Office of the Scottish Executive Health Department. The views are those of the authors.

1. Introduction

Nurses constitute 45% of the total staff in the NHS Hospital and Community Health Services (Office of Health Economics, 1999), with their salary bill accounting for almost 50% of the NHS salary bill. Recruitment and retention policies are deemed to be a priority area for action, although very few studies have focused attention on the factors that affect labour supply of British nurses. The ageing of the workforce, the reduction of potential "returners", along with the fall in the number of new student nurses due to increased educational qualifications required for entry brought about by the Project 2000 reform, make the current nursing shortage particularly problematic.

The aim of this paper is to estimate a classical model of labour supply for qualified British female married or cohabiting nurses, correcting for sample selection bias. This includes the calculation of up to date elasticities of labour market participation and hours of work. The effects of a change in household composition on the probability of labour participation are also be calculated.

There have been a number of attempts to estimate the participation rate and the size of the pool of nurses (Wilson and Stilwell 1992, Lader 1995, Seccombe & Smith, 1997). The estimates vary according to the source of the data (official statistics such as Census, UKCC data, or survey data, such as LFS) and to the definition of participation rate. Overall, there is common agreement that participation in nursing employment has increased over time, although there is a decline in participation with age.

The paper presents first a brief review of the research on nurses' labour supply, focusing on the British literature. A description of the dataset employed and the methodology follows. Since the methods used are standard, the discussion focuses more on the results and policy implications of the analysis.

2. Review of the literature

Relatively little empirical research has been conducted on the labour market behaviour of nurses[1]. Empirical studies conducted in the US (Link & Settle, 1985; Link 1992; Brewer, 1996) show considerable differences in the sign, size and significance of the relationship between nurse labour force participation and the variables usually included in a classical model of labour supply.

British empirical research on nursing labour supply has been scarce (Antonazzo et al., 2000). Although several studies have focused on the determinants of nursing turnover and the decision to quit (Gray A, Phillips V. L., 1994, 1996; Shields and Ward, 2000) only one study conducted an econometric analysis of labour supply (Phillips, 1995). The estimated model corrects for misspecification and sample selection bias and investigates a wide range of issues, such as the impact of costs associated with married women participators and the possible discountinuities in the labour supply curve. However, the data are now dated (1980) and the sample size was small (312 cases).

3. Data

The source of the sample is the *Labour Force Survey* (LFS), a quarterly nationally sampled dataset produced by the Office of National Statistics (ONS), on the basis of internationally standard concepts and definitions. The LFS is the largest regular household survey in the United Kingdom, containing a wide variety of labour market and personal characteristics. The survey covers approximately 120,000 people aged 16 or over in around 61,000 households per quarter. Each household is interviewed five times at three monthly intervals; the first and the fifth interview also ask about earnings.

We merged the first and fifth wave (the only waves with available income data) of four successive quarters (March-May 1999 up to December-February 2000).

---

[1] For a comprehensive review see Antonazzo et al. (2000)

Our initial sample consisted of 1285 married or co-habiting females with at least one nursing qualification and who reported gross hourly pay. 1076 were currently working as nurses or midwives and the remaining 207 were currently out of the labour force. For those working as nurses we included qualified nurses and midwives regardless of the sector of employment (NHS or private). The nurses considered out of the labour force were the International Labour Office (ILO) unemployed, and those economically inactive. With the aim of identifying the pool of qualified people who could potentially be drawn back into nursing, we excluded those inactive because of being temporarily or long term sick, disabled, students and retired. Instead we included all those who could work, but they were not seeking employment because they were looking after family or believed no job was available.

Before estimation the sample was reduced to 1248 cases (1043 workers, 205 out of the labour force), because of missing values for employment status of the partner and total hours worked. Checks on observed characteristics (highest qualification, ethnicity, number of children) show the excluded cases to be a random sample of married nurses with nursing qualifications. T-test on the age variable show that the sample of married nurses with missing earnings is not significantly different from the sample of married nurses with earnings present (at 10% level of significance).

4. Estimation

Most empirical analyses of labour supply have been based on the neo-classical framework (Killingsworth, 1983). Hours of work are derived from a direct utility function by solving the first order conditions for maximisation. More generally, one can specify a utility function;

$$U = U(G, L, e)$$

Where G is the consumption good, L is the proportion of time spent in leisure ($H=1-L$, where H is hours of work) and e is an unobservable error varying from one person to another. The marginal rate of substitution function M will be:

$$M \equiv \frac{(\partial U / \partial L)}{(\partial U / \partial G)} = M(WH + V, 1 - H, e),$$

where W is the wage rate and V is unearned income. The reservation wage (W_r) is equal to the marginal rate of substitution evaluated at $H = 0$, when the individual will not take part in the labour market:

$$W_r = M_r(V, 1, e)$$

The individual will work if $W > W_r$ or if their reservation wage is lower than the market wage (the wage she/he can command in the labour market). For these individuals, the hours worked function can be derived by imposing W equals M.

Several procedures have been used in the literature to estimate labour supply models[2]. The major problem that confronted researchers in this area was sample selectivity bias and the endogeneity of wages. Given an hours of work function of the form:

$$H_i = X_i b + u_{Hi},$$

where the normally distributed error term u_{Hi} has a population mean of zero and a standard deviation of s, sample selectivity issues arise because we do not observe hours of work for non-workers. Using OLS regression on only working individuals results in a non-random selection of the error term u, since an individual will be included in the estimation sub-sample if and only if $H>0$, that is, if and only if, $u_{Hi} \succ -X_i b$. The estimated parameters will be biased and inconsistent, since u_{Hi} is correlated with X.

Sample selectivity issues began to be addressed using the Heckman procedure (Heckman, 1980). The conditional expectation of hours worked for workers can be written:

[2] For an extensive review see Killingsworth (1983) and Berndt (1991).

$$E(H|H \succ 0) = X_i\, b + s\, l_i,$$

where the second term is non-zero, and can be seen as an omitted variable in the linear hours worked regression equation. Therefore Heckman suggests that l_i (inverse mills ratio) be added as a regressor to such an equation, before carrying out OLS estimation on the working sample individuals.

In this study, we adopt the methodology called by Killingsworth (1983) '*Procedure VIII'*. First, we use a two-step selection-bias corrected Heckman model to predict wages for workers and non-workers. Probit parameter estimates allow us to compute estimates of the inverse mills ratio l_i, and then append l_i as an additional regressor to the wage equation, to obtain selection-bias corrected predicted wages. The complete set of variables, their definitions and means are presented in Table 1.

The wage equation is based on a simple model of human capital, where the remuneration that a qualified nurse can command in the labour market depends upon accumulated work experience and educational qualifications achieved. Unfortunately, the LFS does not contain any information about the precise length of time spent in the profession or indeed, more generally in the labour market. Therefore a variable measuring potential experience (the difference between age and year they left full-time education) has been included to capture the effect of work experience. While this procedure is acceptable for male workers, it overestimates the participation of female workers since it does not consider breaks occurring with marriage and pregnancy.

Four dummy variables for highest qualification were constructed. Having a qualification higher than nursing (teaching, first degree, higher degree or equivalent) is expected to have a positive effect on wages, since it is supposed to give more opportunities on the nursing promotional ladder. Ethnic origin and geographical dummies complete the set of socio-demographic characteristics included.

Participation is modelled with a logit. The participation decision is determined by the comparison between the market wage and the reservation wage. The latter is not observed, so it is frequently proxied by factors such as household composition, which affect the nurse's work/leisure preferences. In our model the total number of dependent children aged less than 16 captures the effect of household composition. Moreover, the age of the youngest child is thought to have a relevant impact on participation over and above the number of children. Therefore, it has been divided into three age categories (0-3; 3-5; 5-15) using three dummy variables.

Having selected married female nurses as the focus of our analysis, variables capturing employment status and wage of the partner have been added. Finally, following the classical literature on modelling female labour supply, we include the level of non-labour income to which the female has access.

Finally a selection-bias corrected hours of work regression for workers is estimated to investigate how wages affect the hours of work decision.

5. Empirical specification and results

In the wage equation, experience has a positive and non-linear impact on wages (Table 2). The educational dummies are all significant and behave as predicted: the higher the educational attainment the higher the wage return to education. Furthermore, living outside London and the south-east of England decreases the wage.

The logit model of participation correctly predicts the participation outcome 84% of the time. Own wages, partner wages and non-labour income are all significant and exhibit the expected impact. The higher the own wage, the more likely the individual is to participate in the labour market. The higher the partner wage and the non-labour income the less likely is the individual to work.

An unemployed partner discourages participation in the labour market, supporting a "discouraged worker hypothesis". According to this view, when unemployment increases, searching for employment becomes so disheartening that some who would ordinarily enter the labour force choose not to do so. The dummy variable indicating the partner wage missing (as opposed to ‘not expected’ due to unemployment) shows a negative and significant coefficient, so it is possible that the subsample of partners who fail to report their wage have high wages.

Increasing the total number of children and having the youngest dependent child aged less than three discourage participation. However, interestingly, having a child of nursery age (3-5) is not significantly different from having a school age child (5-15). This is probably because even for a very young child aged 3-5, there are childcare facilities in existence, which allow the mother to join the labour force. Recent measures to introduce child care vouchers has meant that for the age of 3-5 children are to some extent integrated into the school system in terms of pre-school provision.

Own wage elasticity of participation is positive but low at 0.62. Therefore a 10% increase in wages would give rise to a 6.2% increase in the probability of participation. Participation is also inelastic with respect to the partner’s wage and non-labour income (elasticities at - 0.12 and - 0.009 respectively). The probability of participation decreases at an increasing rate as the number of dependent children increases (Table 3).

In the hours of work equation, the impact of wages, number of children and age of the youngest child mirror the sign and the significance of the participation equation. The term of correction for sample selectivity bias is significant, suggesting the presence of sample selection. The elasticity of hours worked with respect to the own wage is low at 0.48. Furthermore, having an ethnic origin other than white (black, indian, pakistani, Bangladeshi or other) is associated with a higher number of weekly hours worked.

Table 2: OLS wage, logit participation, OLS hours regression

Dependent variables	LN wage	Participation	Hours
Potential experience	0.0160[a]		
Square of potential experience	-0.0003[a]		
Higher degree or equivalent	0.2104[a]		
First degree or equivalent	0.1466[a]		
Teaching or equivalent	0.0757[a]		
Ethnic origin other than white	-0.0586	0.5998	4.0947[a]
North England	-0.1173[a]	0.1979	5.4568[a]
North-East England	-0.0809[a]	0.8493[a]	3.5041[a]
North-West England	-0.0949[a]	0.4264	1.7801
East Midlands	-0.0302	-0.9287[a]	3.2502[b]
West Midlands	-0.0640[b]	0.5158	1.1139
South West England	-0.1128[a]	0.5050	3.2111[a]
Wales	-0.0792[a]	0.3474	2.4770[b]
Strathclyde	-0.0590	0.1150	3.4216[a]
Rest of Scotland	-0.0899[a]	-0.0205	1.4581
Northern Ireland	-0.1983[a]	1.4100[a]	3.5118
Constant	2.0926[a]	-4.5662	3.6175
Predicted Heckman log wage		3.7951[a]	15.3182[a]
Number of dependent children aged less than 16		-0.4310[a]	-3.3556[a]
Age of the youngest kid <3		-0.4429[a]	-1.5708[b]
Age of the youngest kid ≥3 and < 5		-0.5665	-0.9370
Partner wage (£)		-0.1066[a]	-0.1259
Partner not employed		-2.2457[a]	0.9167
Partner wage missing		-1.9054[a]	-1.9513
Non labour income (£)		-0.0001[a]	-0.0001
Lambda (Inverse of Mills ratio)	0.0073		-8.0788[b]
N – sample size	1043	1248	1043
R^2	-	-	0.18
Log likelihood	-	-485.26	-
Pseudo R^2	-	0.13	-

[a] Significant at 5% level [b] Significant at 10% level

The base case is a white married female with just a nursing qualification, living in London or South-East of England, whose youngest dependent is aged between 5 and 15.

Table 3: Joint effect of Number of Children and age of the youngest on probability of participation

	Number of dependent children aged less than 16					
Age of the youngest	*1*	*2*	*3*	*4*	*5*	*6*
0-3	0.85	0.80	0.72	0.63	0.53	0.42
5-11	0.90	0.86	0.80	0.73	0.64	0.54

6. Discussion

In this work we have provided recent estimates of a classical model of labour supply and participation. We used a fairly large sample of 1248 people possessing a nursing qualification from the Labour Force Survey. They are either currently working as nurses or they have chosen to be out of the labour force. In the current study, we have not considered the pool of qualified nurses working outside nursing, and we have not distinguished between public and private sector. These issues could constitute the focus on further research in this area, along with the labour supply behaviour of single nurses.

Furthermore, limitations in the dataset did not allow us to use a correct measure for experience in the wage equation. In particular, female experience might be overestimated leading to potential negative bias on the relative coefficients. However, this can be seen as acceptable as we are not attempting to consider differences between male and female nurses. A final limitation is that the models' specification has yet to be thoroughly tested. The results should therefore be treated with caution.

Working nurses are more than 80% of the total sample, and the participation decision does not appear to be very sensitive to their own wage. Thus the results of the model suggest that increasing the wage may not be the most successful policy tool to attract back those out of the labour force into nursing. Number of children and presence of pre-nursery age children appear to be highly significant predictors of participation (Table 3). This conclusion differs from Phillips (1995). That analysis, however, focused on married and singles, qualified and unqualified nurses in the UK in 1980. Although not specifically reported, the sample split results into these separate groups were found to be very similar. However, the total sample size was very small (312 cases).

An alternative policy angle to deal with recruitment and retention issues might be to try to increase the number of “whole time equivalent” nurses from the stock of actual nurses. The hours of work analysis indicates that wage increases may not prove particularly effective here either. The impact of non-pecuniary job characteristics on participation needs further work (Laing & Rademaker, 1990; Shield & Ward, 2000). In this respect there is agreement with Phillips’ findings, who report an own wage elasticity for hours worked small at 0.15.

However, higher wages along with improved quality of training brought about by Project 2000 may increase the attractiveness of nursing as a career to academically well-qualified school leavers in the long run.

Appendix

Table 1.: Variable names, definitions and means

Variable names	*Definitions*	*Sample means*
LOGWAGE	Log of reported gross hourly wage	2.22
POTEXP	Years of experience in the labour market	23.15
POTEXP2	Square of 'Potexp'	629.47
ED1	Higher degree or equivalent as highest qualification	0.02
ED2	First degree or equivalent as highest qualification	0.09
ED3	Teaching qualification or equivalent as highest qualif.	0.07
ED4	Nursing as highest qualification	0.82
ETNICH	=1 if for ethnic origin other than white	0.04
N_ENG	=1 if living in North England	0.05
NE_ENG	=1 if living in North-East England	0.11
NW_ENG	=1 if living in North-West England	0.08
E_MID	=1 if living in East Midlands	0.06
W_MID	=1 if living in West Midlands	0.07
SW_ENG	=1 if living in South-West England	0.10
WALES	=1 if living in Wales	0.06
STRATH	=1 if living in Strathclyde	0.04
RST_SCOT	=1 if living in the Rest of Scoltand	0.07
NI	=1 if living in Northern Ireland	0.04
LON_SENG	=1 if living in London or in the South-East if England	0.30
PARTIC	=1 if individual is working as nurse or midwive	0.83
HECKWAGE	Imputed log of gross hourly wage	2.22
FDPCH16	Number of dependent children aged less than 16	1.13
KID03	=1 if age of the youngest dependent <3	0.59
KID35	=1 if age of the youngest dependent ≥3 and <5	0.09
KID515	=1 if age of the youngest dependent ≥5 and <16	0.32
PRTWGE	Gross hourly wage of the partner (£)	7.25
PNEMP	=1 if partner is not employed	0.10
PWMISS	=1 if partner is employed but wage is missing	0.24
NONLABINC	Interests and other unearned income of the family (£)	498.82
TOTHOURS	Total weekly hours worked including overtime	31.84
LAM1	Term to correct for sample selection bias (Inverse of Mills ratio)	0.29

Bibliography

Antonazzo E., Scott A., Skatun D., Elliott R.F. 2000, *The labour market for nursing: a review of the labour supply literature,* HERU Discussion Paper 01/00, University of Aberdeen

Ashenfelter O, Card D. 1999, Handbook of Labour Economics. North Holland Elsevier

Berndt E. R.1991, *The Practice of Econometrics: Classic and Contemporary*, Addison-Wesley Publishing Company, Inc.

Brewer, C. S. 1996, "*The Roller Coaster Supply of Registered Nurses: Lessons from the Eighties"*, Research in Nursing & Health, vol. 19, pp. 345-357.

Gray, A. & Phillips, V. L 1994, "*Turnover, Age and length of service: a comparison of nurses and other staff in the National Health Service"*, Journal of Advanced Nursing, vol. 19, pp. 819-827.

Gray, A. & Phillips, V. L. 1996, "*Labour turnover in the British National Health Service: a labour market analysis"*, Health Policy, vol. 36, pp.273-289.

Heckman, James J.1979, *Sample selection bias as a specification error*, Econometrica, 47:1 January, 153-162

Killingsworth MR. 1983, Labour Supply. Cambridge University Press ed.,

Lader D, 1995, *Qualified nurses, Midwives and Health Visitors*, HMSO

Laing, G. P. & Rademaker, A. W. 1990, *"Married Registered Nurses' Labour Force Participation*", The Canadian Journal of Nursing Research, vol. 22,no. 1, pp. 21-38.

Link, C. R. & Settle, R. F. 1985, "*Labor Supply Responses of Licensed Practical Nurses: A Partial Solution to a Nurse Shortage?*", Journal of Economics and Business, vol. 37, pp. 49-57.

Link, C. R. 1992, *"Labor supply behavior of registered nurses: Female Labor supply in the future?*", Research in Labor Economics, vol. 13, pp. 287-320.

Office of Health Economics 1999 *Compendium of Health Statistics*, 11th Edition

Phillips V. L., 1995 *Nurses labour supply: participation, hours of work, and discontinuities in the supply function*, Journal of Health Economics, 14, 567-582

Wilson R. and Stilwell J., 1992, The National Health Service and the Labour Market, Averbury

Seccombe I, Smith G. 1997, Taking Part: Registered Nurses andd the Labour Market in 1997, The Institute for Employment Studies, Report No 338.

Shields, M. & Ward, M. 2000, *Improving nurse retention in the British National Health Service: the impact of job satisfaction on intentions to quit*, University of Leicester, PSERC Discussion Paper n. 00/3.