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Factors affecting the outcome of maternity care

II Neonatal outcomes and resources beyond the hospital of birth*

MIRANDA MUGFORD,[1] ALA SZCZEPURA,[2] ALAN LODWICK,[1] AND JOHN STILWELL[2]

From the National Perinatal Epidemiology Unit,[1] Radcliffe Infirmary, Oxford OX2 6HE; and the Institute of Management Research and Development,[2] University of Warwick, Coventry CV4 7AL

SUMMARY Analysis of data about perinatal mortality and indicators of resources at maternity hospitals in the West Midlands region between 1977 and 1983 showed that paediatric staff ratios were inversely related to in-house mortality rates. In this paper, the outcomes for and resources used by transferred babies are added to those of the hospital of birth for three of the study years—1978, 1980, and 1982. Patterns of transfer differ between units and over time in the region, and a regional neonatal intensive care policy was introduced in 1980. Analysis of the new variables showed that in 1978 paediatric staffing was significantly inversely related to neonatal mortality. In later years, neonatal mortality of births at maternity units is explained entirely by the proportion of low or very low weight births.

In a study of maternity hospitals in the West Midlands covering the years 1977–83, we found a relation between the outcomes of the births and the resources at each consultant maternity unit in the region.[1] Specifically, paediatric staffing ratios were inversely related to in-house perinatal and first week death rates. The units included in the study varied in the proportion of babies transferred elsewhere for further hospital care.

We were aware that perinatal deaths at the hospital of birth did not measure the full extent of mortality. We therefore show here how the results of our first analysis are affected by including in-house deaths up to the end of the first month of life (neonatal deaths) and also neonatal deaths that occurred after transfer to another hospital.

We were also aware that resources available at the place of delivery underestimated the actual resources available to sick newborn infants, while for those units that give care to outborn babies we had overestimated paediatric resources available to babies born at the unit. We therefore adapted our analysis of the relation between mortality and resources for births at each of the hospitals in the study, not only to include deaths after transfer but also to adjust resources available to babies born in the hospitals studied.

This paper describes our second analysis and shows how it affects the conclusion of our previous study.

Methods

The data collection methods for this study have already been described in detail.[1] The main data source of births and subsequent admissions to special care nurseries was the West Midlands Region's Hospital Activity Analysis (HAA). Data concerning staff at each unit were collected directly by us from senior staff at each maternity unit in the region.

DATA ABOUT TRANSFERS

In the West Midlands HAA system for maternity, records for hospital maternity admissions in which a birth occurs also contain details about the babies born. If a baby is transferred to another hospital an HAA record is created for the baby alone.

The West Midlands Regional statistics section provided us with a tape containing data from hospital records for babies included in the obstetric file where the baby was (i) born in the hospital and/or (ii) had been transferred *from* another hospital and/or (iii) had been transferred *to* another hospital.

This should have given us a complete set of data about neonatal transfers, but three hospitals, all of which provide a regional neonatal service, do not contribute to HAA. We could, however, infer use of these hospitals, as records in HAA included destination or source hospital codes. We were also provided with data directly from each of these units about outborn babies treated at that unit.

Linkage of records of transfers in the HAA system was complicated by the fact that babies did not have a unique identifying code which was used at all hospitals. Each record supplied for this study contained encrypted name, date of birth, whether singleton or multiple, and birth order, birthweight, and sex. As long as these details were recorded accurately for every admission we were able to group records into sets with the same identifying details. We then sorted them into chronological order, so that each set of records for one baby started with the birth record and ended with the final discharge, which was usually to home, occasionally death, and sometimes to another Region or to a unit for which we had no record of outcome.

Most of this analysis was done by computer. However, it was easier in some cases to follow certain cases "by hand", where the records could not easily be matched, because of missing hospital codes or dates, for example.

The results of our analysis tell us what hospital records have recorded about neonatal transfers for births in the three years 1978, 1980, and 1982.

We were not able to count in utero transfers, changes in place of booking for delivery, or changes in selection of place of delivery as the HAA records do not contain sufficient information.

RESOURCES USED BY TRANSFERRED BABIES

Our previous analysis assumed that babies born at each hospital had access only to resources at that unit. Thus for units that transfer babies out we were underestimating resources available. Moreover the analysis made no adjustment for units that provide care for babies transferred from elsewhere, and so we were overestimating the resources available to babies born at such units. We separated transfers into those for special or intensive care and those for postnatal recuperation (usually to general practitioner units). We used this information to estimate additional resources available to the births at each unit and calculated weighting factors for each unit's resources as follows:

(a) Use of special or intensive care cots

For each unit we counted transfers in, and by assuming that imported babies stayed in the special care unit as long as in-born babies, we estimated the proportion of resources utilised by the imported group. Babies transferred out were also counted, and the assumption was made that their length of stay at other units was equal to the average length of stay for the type of care offered in the receiving unit. Thus babies transferred to regional referral centres were assumed to use more resources than babies transferred to district hospitals with special care facilities, because the average length of stay in the latter was shorter. A composite weighting factor was constructed for each unit:

$$\frac{A - B + C}{A}$$

where A is all cot days in the unit

B is cot days of care given to outborn babies

C is cot days of care in other units given to babies born in this unit

(b) Other resources in the postnatal/neonatal period

A second weighting factor was calculated to take account of the transfer of mothers and babies to other units for normal postnatal care. It was thought that the proportion of nursing and midwifery time available to babies born in units might be affected by different postnatal care patterns. We therefore calculated the following weighting factor:

$$\frac{D + E - I}{D}$$

where D is the number of admissions in this unit

E is the number of transfers out for postnatal care

I is the number of admissions for postnatal care

These two weighting factors were then used singly or in combination to adjust the values of variables in the statistical analysis. Paediatric staff ratios were weighted by the first factor alone. We assumed that hospital midwifery and nursing staff time in special care, postnatal care, antenatal care, and delivery care in units in our study followed the same pattern as was found in a DHSS study published in 1984.[2] The two weighting factors were applied to the appropriate proportion of the staffing measures concerned. Obstetric workload was assumed to be in proportion to the number of deliveries at the unit and therefore unaffected by neonatal transfer patterns.

REGRESSION ANALYSIS

The linkage of births and transfer records and calculation of weights for resource use resulted in the

Table 1 *Definition of variables used for each regression analysis*

NNMR	Deaths of babies age <28 days at hospital of birth or after transfer per 1000 live births.
NNMRCA	Deaths of babies without malformation age <28 days per 1000 live births without congenital malformation.
TB<15	Per cent of total births weighing 1500 g or less.
TB<25	Per cent of total births weighing 2500 g or less.
PDW	Number of paediatric medical staff weighted to take account of effect on workload of transfers, per 1000 births.
PW/25	As above per 1000 births 2500 g or less.
OB	Number of obstetric medical staff per 1000 births
SCMW	Number of wte qualified midwifery staff per 1000 births weighted to take account of effect on workload of transfers
MNW	Nursing staff not qualified in midwifery. Rate calculated as for SCMW.

Summary of variables included in the regression analyses

Dependent variable	Possible explanatory variables
NNMR	PDW, PW/25, OB, MNW, SCMW, TB<15, TB<25
NNMRCA	PDW, PW/25, OB, MNW, SCMW, TB<15, TB<25

set of variables described in table 1. In the first study we included deaths up to the end of the first week. However, for this analysis we extended the measure of mortality to include all deaths, both in-house and after transfer, occurring in the first month (neonatal mortality). A separate analysis was performed excluding births and deaths where a congenital malformation was recorded. The stepwise regression analysis was initially given seven variables as explanatory factors. There were measures of low weight birth, and of very low weight birth, and weighted staffing ratios. Two measures for paediatric staff were offered: one as a ratio to all births (PDW), the other as a ratio to births weighing 2500 g or less (PW/25). A separate analysis was performed for each of the years 1978, 1980, and 1982. Table 1 also specifies the variables offered in each of the two stepwise procedures.

The null hypotheses that were tested are that neonatal mortality of births at West Midlands maternity units was not, in the years studied, linearly related to: (a) low weight births; (b) weighted indicators of staffing; or (c) a combination of these factors.

Table 2 *Neonatal transfers of babies born in maternity hospitals in West Midlands Region by type of transfer 1978, 1980, 1982*

		1978	*1980*	*1982*
Live births to residents		63809	71186	67892
Transfers:				
All transfers	Number	3372	4331	3662
	% *	5·28	6·08	5·39
Special care†	Number	609	778	483
	%	0·95	1·09	0·71
GP unit	Number	2619	3362	3002
	%	4·1	4·7	4·4
Outside region	Number	144	191	177
	%	0·22	0·27	0·26

* Number of transfers as a percent of livebirths
† Transfers to special and intensive care

Results

NEONATAL TRANSFERS

The three years of our analysis, 1978, 1980, and 1982, show a changing pattern of neonatal transfers within the West Midlands Region. Table 2 shows the number of hospital stays by babies transferred after delivery, subdivided by the highest level of care given at the receiving hospital. Less than 6% of births are transferred to another hospital and, of these, the large majority are transfers to general practitioner units. Only about 1% of all births were transferred to units with special care and intensive care facilities. Of these, between 15 and 20% were recorded on the HAA record as having a congenital anomaly (ICD codes 7400–7599).

There was considerable variation between the units in the study in the proportion of births transferred elsewhere for care in special or intensive units. Figure 1 shows for each unit in 1982 the estimated proportion of the units' workload (special care baby unit cot days) accounted for by outborn babies, by babies born in the unit, and the proportion of the units' potential workload that would have been accounted for by babies transferred to other hospitals. Consultant obstetric units with fewer annual deliveries were more likely to transfer babies to other units for neonatal care.

When transfers of very low birth weight babies are considered, the difference is even more dramatic. The proportion of babies of 1500 g birthweight or less transferred from each unit in 1982 varied from zero to 100% with a mean value of about 15%. (fig 2).

NEONATAL MORTALITY

The linkage of HAA records for delivery and neonatal admissions showed that there were a significant number of deaths after transfer. Of the total of 453 neonatal deaths recorded by HAA in 1982, 86% occurred at the hospital of delivery and 14% after transfer to another hospital in the region. The

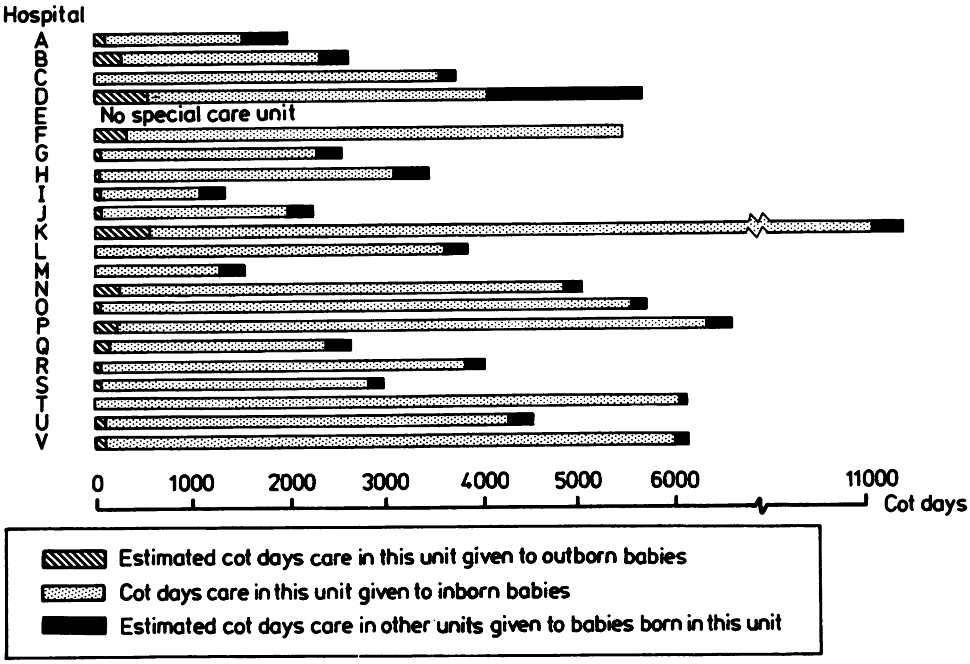

Fig 1 *Estimated special care cot use, West Midlands maternity units, 1982.*

outcome could not be traced for a further 47 babies transferred outside the region, and so the deaths after transfer are likely to be an underestimate. Figure 3 shows that, just as the proportion of live births transferred varied between hospitals, so also the proportion of all neonatal deaths occurring at the hospital of birth varied.

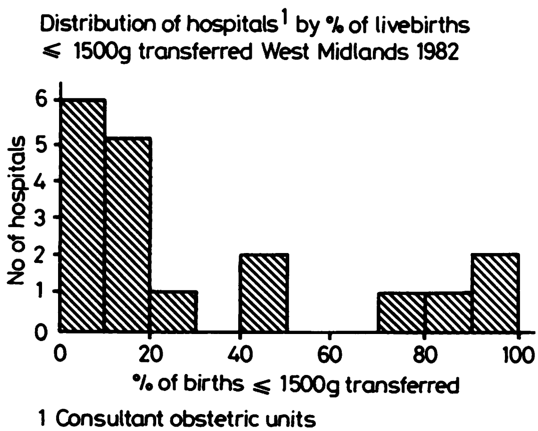

Fig 2 *Percentage of very low weight livebirths transferred, West Midlands maternity units, 1982.*

RELATION BETWEEN RESOURCES AND NEONATAL MORTALITY BEYOND THE HOSPITAL OF BIRTH

The results of the regression analysis for the neonatal mortality variable NNMR showed a significant contribution of one explanatory variable for each of the years studied. In 1978 the weighted paediatric staffing indicator PW/25 was included in the regression equation by the stepwise process. In the other two years, the proportion of very low weight (in 1980) and low weight (in 1982) births are the only explanatory variables included. No other staffing variables are found to be related to neonatal mortality in this analysis.

Where congenital malformations are excluded, a significant result is found only for 1982: in this case the explanatory factor chosen is birth weight of 2500 g or less.

The full results of the analyses are presented in table 3.

Discussion

We have shown, firstly, that those babies born in West Midlands maternity units and not transferred elsewhere had a better chance of surviving the first week of life if born in units with higher paediatric staffing ratios. This relation was consistent over all

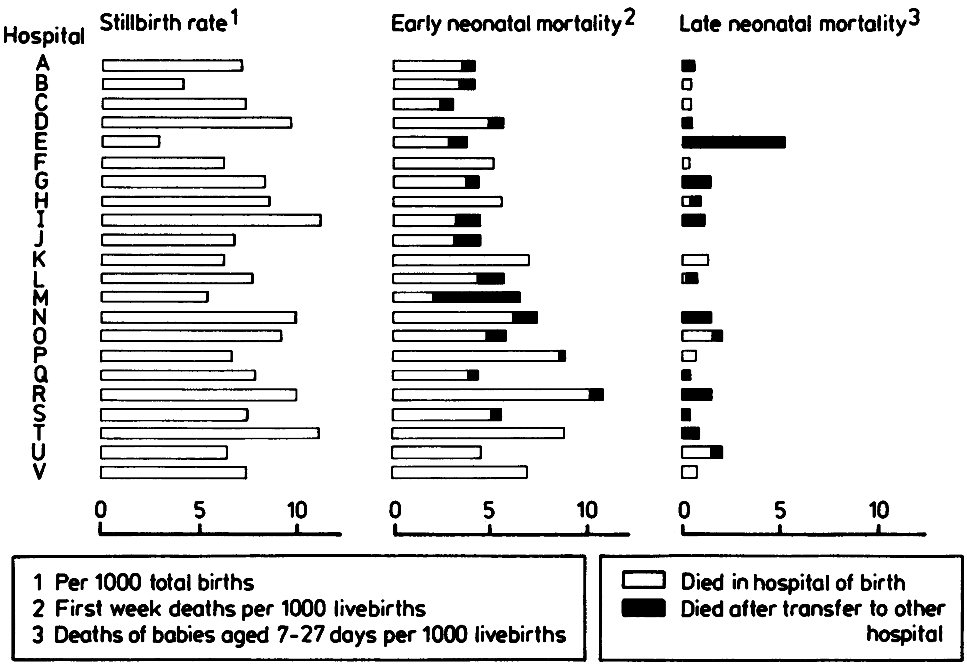

Fig 3 *Stillbirth, early and late neonatal mortality at birth hospital and after transfer, West Midlands maternity unit, 1982*

Table 3 *Results of the regression analysis*

Dependent variable NNMR		
1978	NNMR = 21·8 (± 2) − 193 (± 78) PW/25 R^2 = 0·32 Significance of F statistic: 0·028	N = 15
1980	NNMR = 9·5 (± 2·4) + 0·55 (± 0·2) TB < 15 R^2 = 0·33 Significance of F statistic = 0·013	N = 18
1982	NNMR = 6·1 (± 2·8) + 0·1 (± 0·03) TB < 25 R^2 = 0·39 Significance of F statistic = 0·0095	N = 16
Dependent variable NNMRCA		
1978, 1980	No variables	
1982	NNMRCA = 5·7 (± 3·0) + 0·09 (± 0·04) TB < 25 R^2 = 0·29 Significance of F statistic = 0·033	N = 16

years of the period studied. The relation between paediatric staffing and neonatal mortality was also observed for the year 1978, when the mortality of all births in the unit (including those subsequently transferred) was considered and when paediatric staffing was adjusted to take account of care for transferred babies. In the two subsequent years, 1980 and 1982, this relation between weighted paediatric resources and neonatal mortality was not found to be statistically significant.

One explanation for this change in our findings could lie in the changing pattern and quality of neonatal care during the period studied. Techniques and staff skills have been changing, and this is not necessarily indicated by the number of staff in post at each unit. A regional policy for neonatal intensive care was introduced in the West Midlands in 1980 with clearly designated and funded referral centres. This resulted in an increasing selection and referral before delivery of very high risk infants to the regional centres, which is reflected in increasing divergence in the proportion of very low birthweight deliveries in the units studied, and in the increasing number of in utero transfers to the regional unit. Thus the proportion of very high risk infants likely to require transfer after delivery might be expected to have been correspondingly reduced. Our study did not show a clear trend in the proportion of births transferred neonatally.

It is plausible that, in 1978, units with better paediatric staffing also had better links with referral units for neonatal care. It is also possible that in units with fewer paediatric staff there was less time for advancing knowledge about neonatal care, and that paediatricians and other staff may have had different perceptions about the limits of neonatal viability, correspondingly affecting mortality rates for their unit.

In a survey done in 1978 in Alabama, USA, Goldenberg and colleagues[3] found considerable variation in obstetricians' views about when intervention was likely to be worth while, but these authors did not ask whether this was related to the available neonatal facilities at the hospital where these obstetricians worked.

Some studies conducted in the United States have suggested an overwhelming advantage of regionalisation of neonatal care, either by prenatal referral[4] or by infant transport services.[5] In utero referral in the West Midlands has increased and may have reduced correspondingly the pressure on paediatricians and neonatal nursing staff to resuscitate and support very sick infants at consultant obstetric units without long term neonatal care facilities. Table 4 shows that an increasing number of neonatal deaths occur at the regional referral centre after in utero transfer. In our analysis, these deaths would have been attributed to district maternity hospitals if the births had taken place there.

Table 4 *Neonatal deaths following in utero transfer to the regional neonatal unit. West Midlands, 1978–82*

	Birthweight (g)			
Year	*Up to 1000*	*1001–1500*	*Over 1500*	*Total*
1978	1	0	0	1
1979	1	1	0	2
1980	1	3	1	5
1981	4	4	1	9
1982	8	6	1	15

If the effect of a regional neonatal care policy is to increase access to regional services for relatively less well staffed units, and if the regional unit gives priority to such transfers, this could have the effect of reducing the differential between resources available to the units studied. This in turn would make it less likely that we could detect a statistical relation between resources and mortality, even if it does exist. It seems reasonable to assume that a regional neonatal policy would have the aim of making access to care more rational in this way, and our observations are consistent with this supposition.

Our estimations have been based on the use of relatively crude measures derived from routine statistical systems. In the case of both data derived from HAA and data about staff, it is possible that inaccuracies may have introduced "noise" that hides any underlying relation. This may have affected results more in the later years as the number of deaths fell and the likelihood of variation by chance therefore increased. It is also possible that our assumptions about the way staff workloads are apportioned were wrong. A more detailed study would be required to challenge these assumptions. However, it is to be hoped that the new statistical systems which are being set up in the wake of the Korner recommendations[6] will enable managers of maternity and paediatric services to monitor these aspects of staffing without the need for additional data collection.

Although the cost of care at two English regional centres for neonatal intensive care has been estimated,[7 8] there is no published evidence about the costs of providing neonatal care in district consultant obstetric units in the United Kingdom, with or without adequate access to regional services. English health regions adopt differing policies of balancing funding of central units with providing the resources for more dispersed neonatal intensive care services. There have been doubts about the practicality and desirability of a comprehensive policy of in utero transfer[9] as a high proportion of such transfers take up staff and resources that they are subsequently found not to have needed. If potentially high risk cases are to be cared for outside the regional neonatal centres, then the findings of our analysis support the need for adequate paediatric staff cover at the place of delivery. We might alter the conclusions of our previous study to suggest that, at least, good communication between care-givers in the region and, at best, the presence of more paediatric staff at consultant obstetric units may be a key to efficient transfer policy, and thus to a more effective allocation of neonatal care resources.

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