Perinatal mortality in Scotland: 1970-9

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SUMMARY An examination of the recent decline in perinatal mortality in Scotland during the 1970s showed that despite substantial changes in fertility and the demographic pattern of births, differences in the age, parity, and social class composition of the obstetric population in this decade accounted for just 7% of the overall improvement in perinatal mortality between 1970 and 1979. The general pattern of relative risks associated with maternal age, parity, and social class remained largely unchanged. Marginal changes in the birthweight distribution, however, were sufficient to account for 13% of the reduction in perinatal mortality. The low birthweight infant, especially those weighing under 1500 g, assumed increasing importance as a factor in perinatal mortality owing to a progressive worsening in the relative risk of perinatal mortality associated with low birth weight. Although regional differences in perinatal mortality persisted over this period, there occurred some lessening of the traditional inequality between western and eastern parts of the country. Finally, registered causes of perinatal mortality are reviewed. In the absence of other explanations the results of this analysis, collectively, suggest that much of the recent decline in perinatal mortality was perhaps due to changes in obstetric practice and in the clinical management of neonatal morbidity.

One of the findings of the House of Commons Select Committee on Social Services in its recent inquiry into perinatal and neonatal mortality¹ was that the Scottish perinatal mortality rate in 1979 was likely to be less than that for England and Wales. In fact, beginning in 1978, annual rates of perinatal mortality in Scotland have been slightly lower than those in England and Wales, thus reversing one measure of inequality in public health that had persisted since comparisons became possible in 1939.

Between 1970 and 1980, the Scottish perinatal mortality rate fell from 25 to 13 per 1000 births with most of the improvement occurring after 1975. This period was characterised by three principal developments affecting the reproductive experience of the Scottish population; firstly, there were substantial changes in fertility and in the demographic and social characteristics of the obstetric population. Secondly, the decade was associated with more active obstetric intervention as seen, for example, in rising rates of caesarean section. Thirdly, there was the introduction of increasingly advanced policies for clinical management of neonatal morbidity. As Silverman² has pointed out, however, the collective effect of these different influences is complex, and it is difficult to attribute improvements in perinatal mortality to specific changes in clinical policy. In this paper we estimate

the impact of demographic factors in the decline in Scottish perinatal mortality, examine trends in the distribution of birth weight and weight-specific mortality, review regional differences in perinatal mortality, and report recent changes in the registered causes of perinatal mortality.

Material and methods

Data on all registered births were obtained from the annual reports of the Registrar General for Scotland for 1970-9.³ Information on birth weight and weight-specific mortality was extracted from unpublished tables provided by the information services division of the Scottish Health Service for the years 1970 and 1978. The assessment of regional trends in perinatal mortality was restricted to 1974-9 because data for years before 1974 cannot be assembled for comparable administrative areas. Registered causes of perinatal mortality were classified into six categories, comprising the following codes of the 8th revision of International Classification of Diseases⁴: (1) complications of childbirth (764-773), (2) anoxia, hypoxia, and immaturity (776 and 777), (3) congenital malformations (740-759), (4) maternal conditions (760-763), (5) rhesus incompatibility (774.0 and 775.0), and (6) all other causes.

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The decline in perinatal mortality attributable to changes in the demographic characteristics of the obstetric population and improvements in the birth weight distribution was calculated using the method introduced by Kitagawa,⁵ and recently applied by Kleinman *et al.*,⁶ to analyse the components of a change between two overall mortality rates. The effect of demographic factors on the relative risk of a perinatal death was estimated using the logistic model described in the appendix. Confidence intervals for mortality rates and estimates of relative risk were based on the normal distribution.

Results

MATERNAL AGE AND PARITY

The annual number of births and rates of fertility in Scotland did not change appreciably in the post war years until the late 1960s. Between 1970 and 1979, however, the general fertility rate (births to women aged 15–44) fell from 87 to 64 per 1000. This reduction was not uniform across different age groups but was more pronounced with increasing age with the greatest decline in the age group 35–44 (fig 1). A greater than average reduction in fertility also occurred in women under the age of 20. Beginning in 1978, this downward trend was reversed in all age groups as fertility rates increased slightly in a similar way to comparable changes in England and Wales.

The influence of these changes in the maternal age and parity distribution of legitimate Scottish births is summarised in table 1. In this table the percentage distribution of births in 1979 is expressed as a set of index numbers using the 1970 age and parity distribution as the standard population. The

proportion of births to women aged 25–34 increased slightly and was accompanied by a relative decline in the proportion of births to women aged 16–24 and 35 or more. A proportionate increase in births to women of parities 0 and 1 also occurred, with a progressive decrease in the proportions of births at higher parities. The fall in the proportion of births at higher ages and parities was particularly striking; births to women aged 35–39 and 40 or more fell by 31% and 53% respectively, births to women with three previous births by 44%, and to women with four or more previous births by 67%.

These changes reduced the incidence of births to women in age and parity categories that are associated with a greater than average risk of perinatal mortality. As births in these categories, however, comprised only a relatively small proportion of all legitimate births throughout the 1970s, the collective effect of such changes on perinatal mortality was marginal, accounting for only 6% of the overall improvement between 1970 and 1979. The remaining 94% was due to improvements in the mortality rate which occurred independently of changes in the age and parity structure of the obstetric population. Nor did this general improvement alter the pattern of relative risks that

Table 1 *Percentage distribution of legitimate total births by maternal age and parity: Scotland 1979. (1970 distribution = 100)*

Maternal age	Parity					All parities
	0	1	2	3	≥4	
16–19	87	82	38	30	—	87
20–24	95	93	65	40	20	89
25–29	155	138	90	55	30	120
30–34	158	175	114	66	32	115
35–39	80	103	91	57	38	69
≥40	50	70	57	49	35	47
All ages	111	120	89	56	33	100

Fig 1 *Index numbers of age-specific fertility rates: Scotland 1970–9 (1970 rates = 100).*

have been traditionally associated with age and parity^{7,8} (table 2). With the exception of an increase in the relative risk of perinatal mortality for births to women aged 40 or more, the association between perinatal mortality and maternal age and parity remained virtually unchanged throughout the decade.

SOCIAL CLASS

The broad trends in fertility described above were not the same in each of the Registrar General's social classes. Table 3 presents the 1979 social class distribution of births in various age groups again as index numbers using 1970 births as the standard population. There was a substantial increase in the proportion of births to women in social classes I and

Table 2 *Relative risk of perinatal mortality by maternal age and parity: Scotland 1970 and 1979*

	1970		1979	
	Relative risk	95% confidence interval	Relative risk	95% confidence interval
Age				
16-19	0.89	(0.77-1.03)	0.71	(0.55-0.92)
20-24	0.83	(0.75-0.91)	0.80	(0.68-0.94)
25-29	0.86	(0.78-0.95)	0.95	(0.73-1.00)
30-34	0.88	(0.79-0.98)	0.92	(0.77-1.09)
35-39	1.15	(1.01-1.32)	0.96	(0.73-1.25)
≥40	1.48	(1.20-1.82)	2.05	(1.38-3.05)
Parity				
0	1.09	(1.00-1.18)	1.17	(1.02-1.15)
1	0.83	(0.76-0.91)	0.73	(0.63-0.84)
2	0.90	(0.81-0.99)	1.04	(0.87-1.23)
3	1.01	(0.88-1.15)	0.86	(0.65-1.15)
4	1.28	(1.12-1.45)	1.34	(0.98-1.84)

Notes: (i) Model fits (χ^2 at 18 df) 1970 = 24.37 $p > 0.05$
1979 = 10.12 $p > 0.05$.

(ii) Cells age <20, parity 3 and >4 were omitted from the analysis.

II at all ages, with the exception of births to women aged 16-19. This shift was most pronounced for births to women aged 30 or over and was accompanied by a relative decline in the proportion of births in social classes IV and V.

Taken together, changes in the social class, maternal age, and parity distribution of legitimate births in Scotland between 1970 and 1979 accounted for 7% of the improvement in perinatal mortality. Changes in the social class distribution of births did, however, account for 13% and 17% of the decline in perinatal mortality rates among women aged 30-34 and 35-39 respectively. Despite the overall improvement in perinatal mortality, the approximate relative risk in social classes IV and V changed only slightly from 1.5 in 1970 to 1.3 in 1979, with most of the improvement occurring after 1977.

ILLEGITIMACY

While also declining, the fertility rate for unmarried women aged 15-44 did not fall to the same extent as that for legitimate births. As a consequence, the proportion of illegitimate births increased from 8% in 1970 to 10% in 1979. As the decline in perinatal mortality for these births was less than that for legitimate births, their relative risk of perinatal

mortality increased from 1.4 in 1970 to 1.5 in 1979. The contribution of these changes in incidence and relative risk to the overall decline in perinatal mortality was negligible.

BIRTH WEIGHT

Between 1970 and 1978 the birthweight distribution of Scottish births changed slightly with the proportion of births (both live and still) weighing under 2500 g falling from 6.9% to 6.7% and the proportion weighing under 1500 g falling from 1.1% to 0.9%. Because of the high rates of perinatal mortality in low birthweight infants, however, these very small changes in the incidence of low birth weight were sufficient to account for 13% of the reduction in perinatal mortality between 1970 and 1978.

Although all weight specific rates declined, the greatest reduction (52%) occurred in infants weighing over 2500 g whereas the rate for infants weighing under 1500 g declined by just 16%. The relative risk of perinatal mortality associated with low birth weight thus increased progressively (table 4). In 1970 the average risk of perinatal mortality for infants weighing under 1500 g was 28 times the average risk for all infants and 62 times that for infants with birth weights over 2500 g; comparable figures for 1978 were 41 and 108 respectively. These changing differentials also increased the proportion

Table 4 *Relative risk of perinatal mortality by birthweight categories: Scotland 1970-8. (Numbers in parentheses are 95% confidence intervals)*

Birth weight (g)	1970	1974	1978
<1000	35.24 (33.82-36.66)	42.08 (40.17-44.00)	56.76 (52.90-60.14)
1000-1499	24.18 (22.63-25.73)	26.55 (24.35-28.75)	32.66 (29.21-36.12)
1500-1999	10.26 (9.27-11.25)	11.22 (9.79-12.65)	11.60 (9.80-13.40)
2000-2499	2.99 (2.66-3.32)	3.00 (2.59-3.41)	3.15 (2.63-3.67)
≥2500	0.45 (0.43-0.48)	0.39 (0.35-0.43)	0.37 (0.33-0.41)
<1500	28.07 (26.90-29.24)	31.43 (29.72-33.16)	40.48 (37.68-43.29)
<2500	8.32 (7.91-8.73)	8.37 (7.84-8.90)	9.68 (8.97-10.40)
All births	1.00	1.00	1.00

Table 3 *Percentage distribution of legitimate total births by maternal age and social class: Scotland 1979. (1970 distribution = 100)*

Social class	Maternal age						All ages
	16-19	20-24	25-29	30-34	35-39	40-44	
I and II	82	104	128	161	177	153	137
III	98	109	97	89	88	93	97
IV and V	105	93	77	62	69	79	81
All social classes	100	100	100	100	100	100	100

of perinatal deaths accounted for by infants weighing under 2500 g from 58% in 1970 to 65% in 1978.

REGIONAL DIFFERENCES

The recent decline in Scottish perinatal mortality was also accompanied by a lessening of regional differences in mortality rates. Table 5 compares the perinatal rate in the 12 mainland health boards and suggests that—with exceptions—greater than average improvements between 1974 and 1979 occurred in boards whose mortality rates were above the national rate in 1974. Moreover in contrast to 1974, rates in individual boards were not significantly different from each other in 1979 partly due to the decline in both births and perinatal deaths.

About 80% of all Scottish births occur to women resident in the areas of eight mainland health boards. In 1974 the perinatal mortality rate for the four western boards comprising the Strathclyde local government region was 22% higher than that for the four eastern boards (Lothian, Fife, Tayside, and Grampian). This regional inequality persisted in 1979, but the difference had fallen to 16%. The improvement in the eastern boards was more or less equally distributed between the stillbirth and first-week death rate. Similar changes did not occur in the western boards where the stillbirth rate declined by 49% as compared to a reduction of only 28% in the first-week death rate. In contrast, the first-week death rate in the west was 27% higher in 1974 and 47% higher in 1979.

CAUSES OF PERINATAL MORTALITY

Registered causes of perinatal deaths provide an indication of the events leading to death but may be difficult to interpret in terms of the more basic circumstances causing such an event. As an example, “anoxia” as a cause of death provides little information about the reasons for its occurrence.

Difficulties of this nature are particularly relevant to the coding scheme of the 8th revision of the International Classification of Diseases used in Scotland during the period of review. Our summary of causes should, therefore, be interpreted with caution as indicators of underlying morbidity.

Cause-specific perinatal mortality rates for six categories of deaths are shown in fig 2. A greater than average decline (54%) occurred in the group comprising complications of childbirth and difficult labour where roughly three-quarters of the deaths were stillbirths. The category comprising anoxia, hypoxia, and immaturity declined by only 34%, reflecting perhaps the increasing significance of low birth weight in the overall pattern of perinatal mortality. The mortality rate from rhesus incompatibility, no longer a significant cause of death, fell by 92%.

The mortality rate from all congenital malformations declined by 40%. This improvement was not uniform for all causes: neural tube defect (ICD 740–742) was the cause of 60% of all congenital malformation deaths in 1970 but of only 40% in 1979. The perinatal mortality rate from neural tube defect fell by 60%, seemingly as a consequence of alphafetoprotein screening and subsequent abortion. Although the number of abortions for “risk of abnormality to the fetus” increased by 163% over the decade,^{9 10} when these abortions are added to the number of deaths from these causes the rate for “deaths plus abortions” in 1979 was the same as that in 1970. The effect of this policy on perinatal deaths was more pronounced for stillbirths than for first-week deaths. This observation is consonant with the screening test being a more effective instrument for the diagnosis of anencephaly than for other defects; between 1970 and 1979 the perinatal mortality rate from anencephaly declined from 2.3 to 0.7 per 1000

Table 5 Differences in perinatal mortality rates: Scottish mainland health boards 1974 and 1979

Health board	1974			1979			Average annual change 1974 : 1979* (%)
	Rank	Perinatal mortality rate	Ratio area/Scotland	Rank	Perinatal mortality rate	Ratio area/Scotland	
Grampian	1	17.62	0.77	2	12.72	0.90	-6.31
Dumfries and Galloway	2	18.58	0.82	3	12.77	0.90	-7.22
Lothian	3	19.35	0.85	7	14.26	1.00	-5.92
Highlands	4	20.18	0.89	6	13.71	0.97	-7.43
Tayside	5	21.46	0.94	1	10.04	0.71	-14.10
Argyll and Clyde	6	22.33	0.98	10	16.13	1.14	-6.29
Fife	7	22.80	1.00	8	14.68	1.03	-8.43
Greater Glasgow	8	22.98	1.01	4	13.42	0.95	-10.20
Ayrshire and Arran	9	24.94	1.10	12	18.76	1.32	-5.54
Forth Valley	10	25.92	1.14	5	13.52	0.95	-12.20
Lanarkshire	11	28.72	1.26	9	14.70	1.03	-12.54
Borders	12	29.64	1.30	11	18.15	1.28	-9.34
Scotland		22.79	1.00		14.13	1.00	-9.11

*Average annual percentage changes in perinatal mortality rates were estimated using geometric means.

Fig 2 Perinatal mortality rates by grouped causes of death: Scotland 1970-9.

births—a reduction of 71%. Mortality from congenital malformations other than neural tube defect showed no comparable improvement; the rate for these causes was 2.2 in 1970 and 1.9 in 1979.

Discussion

In seeking explanations for the recent decline in Scottish perinatal mortality it is important to distinguish between improvements arising from demographic or environmental factors affecting the distribution of perinatal risks inherent in the obstetric population and improvements perhaps attributable to more effective therapeutic intervention. Despite recent changes in Scottish fertility,¹¹ shifts in the maternal age and parity distribution of births accounted for just 6% of the decline in perinatal mortality between 1970 and 1979—a proportion that rises to 7% if changes in the social class mix of births are also taken into account. While substantial changes occurred, for example, in the incidence of births to older women at high parities, the numbers of births and perinatal deaths attributable to these higher risk groups were marginal. Moreover, as perinatal mortality is a relatively rare event, differences between “high” and “low” rates are small, thus a shift from one age or parity category to another may have little or no impact on the overall rate.

About 93% of the decline in perinatal mortality in this decade—representing a reduction of nearly 10 deaths per 1000 births—was attributable to improvements in mortality rates per se in the age, parity, and social class categories we have considered. It may be tempting to attribute this improvement to health service intervention, but it is important to emphasise that we offer no direct evidence in support of such a claim: indeed, more subtle social and environmental factors not included

in our analysis may have had important though unknown effects.

The risk of perinatal mortality attributable to the interaction and influence of social and environmental factors has yet to be comprehensively examined in Scotland. None the less, the collective impact of these factors is perhaps indirectly illustrated by the falling incidence of low birthweight infants, which accounted for 13% of the decline in perinatal mortality. Changes in weight-specific survival, however, were the primary determinants of the overall improvement in perinatal mortality. While remaining high and declining less dramatically than the mortality rate for infants weighing 2500 g or more, the rate for infants weighing under 1500 g fell by 100 per 1000 and that for infants weighing 1500–1999 g by 73 per 1000 between 1975 and 1978. Although changes in environmental factors, such as nutrition and smoking, may have influenced their inherent capacity to survive, the enhanced survival of low birthweight infants may provide a measure of more effective perinatal care.

One of the most satisfying aspects of the changes that occurred was the reduction in regional differences in perinatal mortality. The contribution of demographic factors to the diminution of these differences is difficult to estimate but, recalling the small contribution of these factors at the national level, it seems unlikely that they were a major influence. It is, therefore, difficult to escape the tentative conclusion that these changes were again attributable to changes in the provision and effectiveness of health service inputs. The lack of consistency between the east and west in terms of improvements in stillbirth and first-week death rates also adds weight to this view in the light of regional differences in the provision of specialist neonatal services.¹²

The broad categories of causes of perinatal mortality that we use have the defect of not reflecting underlying circumstances leading to the event but are in accord with the results of the clinical surveys of McIlwaine *et al.*¹³ If our categories reflect the consequences of clinical intervention more directly the progressive decline in mortality from what we summarise as “complications of childbirth” may be attributable to more effective obstetric intervention. The less than average decline in the “anoxia, hypoxia, and immaturity” category—of whom 75% are first-week deaths—may, on the other hand, provide a measure of the lack of comparable progress in reducing the perinatal mortality of low birthweight babies.

If the decline in mortality from these two groups of causes provides a measure of the success of obstetric and paediatric intervention, then one must also conclude that there is continuing scope for further improvement. These two categories had a combined perinatal mortality rate of 8.7 per 1000 in 1979. This rate is roughly comparable to recent *overall* rates reported from Scandinavia¹⁴ and from local areas within the United Kingdom.¹⁵ It is also important to recognise that national rates can conceal much higher rates in particular localities. In 1979, for example, the perinatal and neonatal mortality rates in the Ayrshire and Arran Health Board were 86% and 197% greater than those reported in the Tayside Health Board. As the demographic features of the obstetric populations in these two areas are virtually identical, inequalities of this magnitude highlight the unrealised potential for further improvement in both regional and national rates of perinatal mortality in Scotland.

Options for further improvement in perinatal mortality would seem, therefore, to have two main features. At the level of national policy, one might conclude that health service investments did contribute to the reduction in perinatal mortality in the 1970s and that progress of this sort may continue—indeed, the provisional perinatal mortality rate for Scotland in 1981 (at 11.6 per 1000) was 19% below that for 1979.¹⁶ One must recognise, however, that reducing perinatal mortality by the better management of the low birthweight baby is essentially a post hoc solution. Given the influence of maternal age, social class, smoking, nutrition, and other factors on the incidence of low birth weight, perinatal mortality may be increasingly confined to particular high risk groups within the overall obstetric population, thus increasing the need for more effective preventive strategies directed towards reducing the number of low birthweight births in Scotland.

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Appendix

In table 2 the perinatal mortality rate p_{ij} for the i^{th} age and j^{th} parity category is modeled using the logistic function¹⁷:

$$\hat{p}_{ij} = \frac{\mu a_i \beta_j}{1 + \mu a_i \beta_j} \quad (1)$$

As $\hat{p}_{ij}$ is small in most cells, the denominator in (1) is approximately unity.¹⁸ A measure of risk relative to the model mean rate μ is thus given by

$$\frac{\hat{p}_{ij}}{\hat{p}_\mu} \simeq \frac{\mu a_i \beta_j}{\mu} = a_i \beta_j \quad (2)$$

The joint effect of a given age and parity combination on the relative risk of perinatal mortality is therefore approximated by independent multiplicative factors.

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