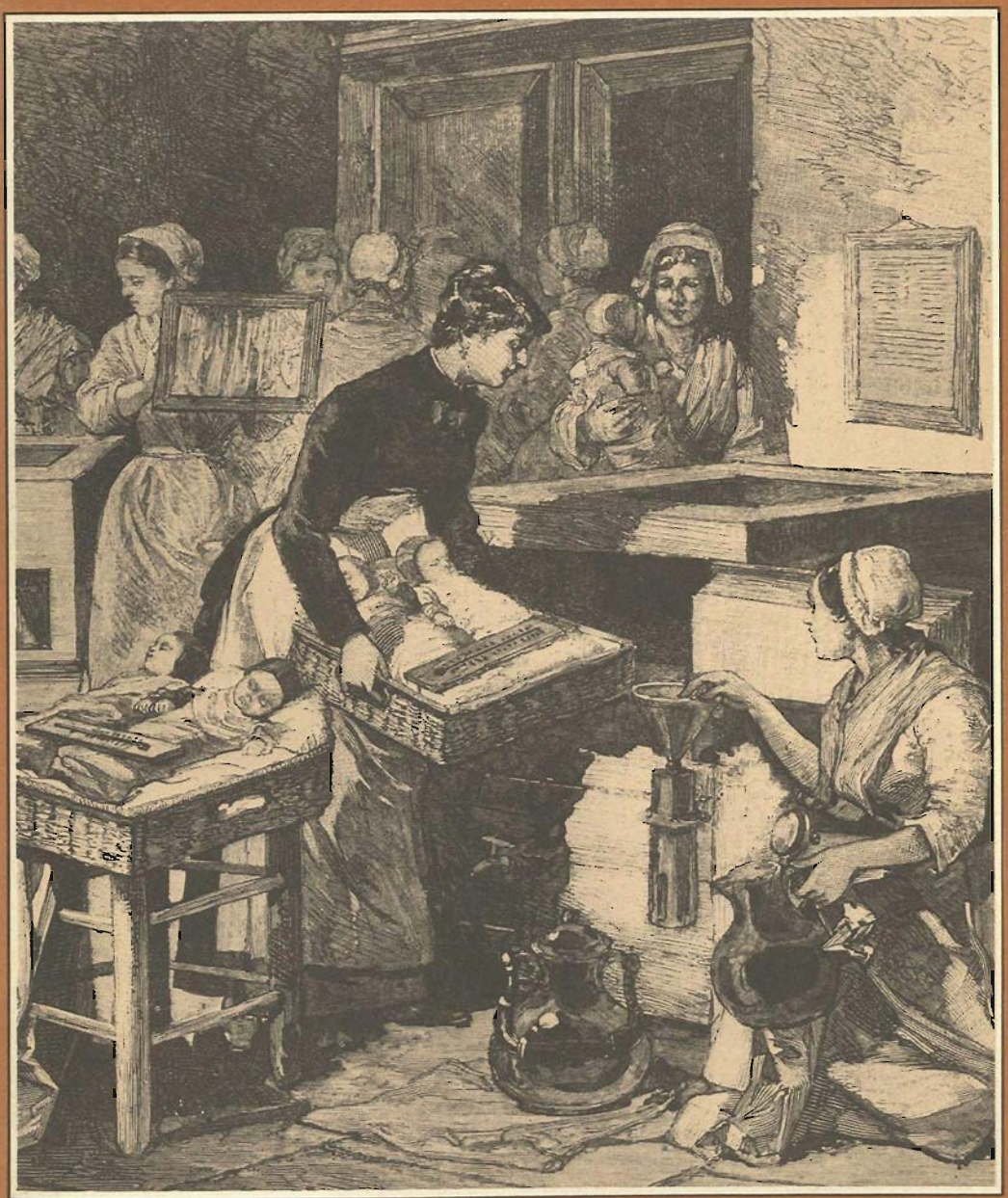
BIRTH IMPAIRMENTS



"INCUBATORS" AT THE MATERNITY HOSPITAL, PORT ROYAL, PARIS

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BIRTH IMPAIRMENTS

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Some of the more commonly occuring birth impairments

Central Nervous System

Anencephalus
Partial or complete absence of cranial vault with or without spina bifida. Brain replaced by a mass of angiomatous and neural tissues covered by thin/incomplete membrane. Invariably fatal.

Spina bifida
Takes two main forms. (a) Spina bifida OCCULTA: defect in posterior wall of spinal wall usually in lumbar region. No deleterious effect unless spinal cord affected. (b) CYSTICA: much more serious. Defect accompanied by protusion of spinal cord: (i) meningocele, in which meninges, containing cerebrospinal fluid, protrude; (ii) meningomyelocele, in which the protruding sac contains spinal cord and nerves. Latter accounts for 90 per cent of cases. Potential for surgical closure of defect varies considerably as does the residual degree of impairment.

Hydrocephalus
Skull enlargement resulting from obstruction to the free flow of cerebrospinal fluid: most often due to abnormalities of the aqueduct of the midbrain. Hydrocephalus frequently accompanies severe cases of spina bifida. Treatment may involve use of unidirectional valves to by-pass cerebrospinal fluid.

Cardiovascular System

Incomplete development or structural abnormalities which may take a variety of forms, such as defects of the valves of the heart, the heart lying on the right side of the thorax instead of the left, patent ductus arteriosus (failure of foetal blood vessel to cease functioning after birth), a defect in the septum separating the chambers of the heart, or coarctation of the aorta (a narrowing of the aorta – the large vessel which opens out of the left ventricle of the heart and carries blood to all the body – in the vicinity of the insertion of the ductus arteriosus). Surgical treatment has become increasingly successful in correcting many heart defects.

Skeletal System

Congenital dislocation of the hip
Hip dislocates at birth. May arise from imbalance between the physical pressure on the foetus and the resistance of the joints to

this force. Short period of splinting during infancy may facilitate development of normal hip later in childhood. When CDH is not recognised until one year after birth, treatment less successful (Harold 1977) with residual limp.

Club foot (talipes equinovarus)
Deformities of the foot. T. equinus (permanent extension of the foot so that only the ball rests on the ground) is commonly combined with t. varus (inversion of the foot, the outer side of the sole only touching the ground) and often associated with t. cavus (an exaggeration of the normal arch of the foot). May be accompanied by dislocation of hip. Fewer than two-thirds are cured without treatment, involving stretching and strapping, splinting, manipulation and serial plaster casts.

Cleft lip and primary palate
Unilateral or bilateral clefts of the lip with or without an associated cleft of the palate. Together account for 60 per cent of all cleft cases. Other congenital malformations in 50 per cent of cases. Boys more commonly affected than girls and the more severe the defect the greater the male preponderance. One-third of cases have clefts of lip only; two-thirds have clefts of lip as well as palate.

Cleft secondary palate
Clefts of palate only. Account for 40 per cent of all cases. Sometimes accompanied by other defects, mental retardation. Lip surgery is usually undertaken at three months of age and palatial closure performed shortly before or after the first birthday.

Down's Syndrome (Mongolism)
Varying degrees of mental handicap resulting from the presence of an extra chromosome. Affected people are often small in stature with small head, nose and mouth and eyes slanting upwards laterally. Increased susceptibility to infections and other malformations, eg heart defects, may be present. Much more common in children born to older women.

Cerebral Palsy
A disorder of movement and posture resulting from damage or failure of normal development in a small part of the brain. Extreme variations in extent to which individuals are affected. Sometimes the damage involves other parts of the brain, leading to deafness and difficulties of perception. Causal factors at work during pregnancy, or brain damage may occur during birth.

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INTRODUCTION

Most of the 600,000 babies born in England and Wales each year are healthy and have before them the prospect of active lives spanning seventy years or more. A proportion of these infants, however, possess impairments, present at or arising during or immediately after delivery which may lead to severe temporary or permanent handicaps. The most frequently occurring of these impairments, involving physical and/or mental disability, are the subject of this paper.

Measuring the incidence of birth defects presents conceptual as well as methodological difficulties but evidence distilled from a large number of epidemiological surveys suggests that between three and four per cent of births are affected each year. Some of the physical deformities are immediately obvious – for example, spina bifida or cleft lip. With other defects detection may be difficult. Certain malformations of the internal organs, such as the heart or kidneys, may show clinical features in the first few days of life but others may remain undiagnosed until discovered by chance during treatment of some ailment, during surgery, or at autopsy. Similarly, conditions resulting from chromosomal abnormalities, of which Down's syndrome is the most common, are not always apparent at birth.

Birth defects have been observed throughout history, attracting hypothetical explanations and generating superstitious beliefs. Teratology, originally the science of investigating monstrosities, flourished in the first half of the nineteenth century concentrating in particular on the occurrence of conjoined twins and severe malformations not compatible with life. However, attention was centred on anatomical details rather than any concern to understand the causes of these abnormalities which is only relatively recent. Scientific interest developed in animal studies in the 1920s and 1930s. It increased markedly and concerned humans in the early 1940s when a link was conclusively demonstrated between maternal rubella and foetal malformations. Further impetus was generated by the thalidomide experience of the late 1950s/early 1960s and the developments subsequent to it. Current intensification of research reflects the relative increase in the contribution of birth defects to childhood morbidity and mortality patterns brought about by improved obstetric management and by control over the infectious diseases with antibiotics. The factors and mechanisms which deflect foetal development from a normal course remain, as yet, unclear.

The scope for preventing the birth of impaired infants is therefore limited in the present state of knowledge. Nevertheless, the adoption of certain general and specific approaches relating to

improved antenatal care and prenatal screening would enhance the possibilities of avoiding at least some of the affected births – in particular those which frequently involve severe handicaps. These measures and the technical, ethical and economic problems to which they give rise form the theme of this paper and are discussed following a study of the incidence and prevalence of birth defects and a brief examination of some of the causes identified so far.

INCIDENCE AND MORTALITY

The derivation of an estimate of the overall incidence of defects in a given cohort of births presents many difficulties. Much epidemiological investigation of the physical and mental impairments present at or arising from birth has concentrated on specific areas of interest. Inevitably, there are important discrepancies in both definition and methodology. Another major limitation stems from variations in sample size. Studies carried out on a relatively small scale may not include sufficient numbers of births to permit an accurate detection of either the very rare forms of impairment or changes in trends.[1] The age at which infants are surveyed is also of critical importance. Immediate postnatal incidence patterns will obviously fail to record those birth impairments which do not become apparent until a later stage of development as is seen in many cases of Down's syndrome and in congenital malformations of the kidney or alimentary system. Later recording may also understate the true level of incidence because some affected infants not detected at birth will have died quite soon afterwards and malformations will have been found only if an autopsy was carried out. On the other hand, it should perhaps be emphasised that straightforward incidence statistics impart little information about the severity of handicap actually experienced by individuals: some congenital malformations can be surgically remedied with little or no residual disability. These points therefore make it clear that incidence figures should be treated with caution and highlight the potential danger in applying overall estimates to such a heterogeneous range of conditions.

Data from the National Children's Bureau 1958 Cohort Study (Davie *et al* 1972) suggests, in broad agreement with other investigations, that between 3 and 4 per cent of live and stillborn infants

1 It has been estimated that 90,000 households would need to be screened in order to pick up a subsample of only 500 very severely handicapped children and that a subsample of this size would only contain small numbers of certain handicapping conditions which in turn would serve limited analytic purpose when broken down by age, sex, class, etc (University of York 1976).

Table 1 *Numbers and incidence of serious defects which were congenital or arose at or shortly after birth (excluding defects of the special senses)*

Congenital disorder	*Number in NCDS*	*Alive at seven years*		*All†*	
		Corrected number†	*Incidence per 1,000*	*Corrected number†*	*Incidence per 1,000*
Anencephalus	—	—	—	32	1·8
Spina bifida and/or Hydrocephalus	15	18‡	1·1	74	4·2
Heart or blood vessels	56	60	3·6	115	6·6
Cleft palate	23	25	1·5	26	1·5
Club feet	48	51	3·1	72	4·1
Dislocated hips	17	18	1·1	19	1·1
Other bones or joints	24	26	1·6	36	2·1
Other malformations	34	37	2·2	155	8·9
Mongolism	11	14‡	0·8	35	2·0
Other 'severe subnormality'	23	25	1·5	25	1·4
Cerebral palsy	36	39	2·3	44	2·5
Cancer, leukaemia or other tumour	4	4	0·2	14	0·8
Other congenital disorders	29	31	1·9	41	2·3
Total children (some have more than one defect)	398	426	25·6	637	36·6
No in Cohort	15,496*	16,606		17,418	

Source Davie *et al* 1972.

*Includes 643 children not matched with perinatal cohort.

†Each total incidence has been corrected to allow for defects estimated to be present in untraced children.

‡For Spina bifida and mongolism the actual number amongst the untraced children is known, because they were diagnosed at birth.

present serious defects (other than those of the special senses) or develop them at or shortly after birth (Table 1). On the basis of this estimate, there were more than 21,000 affected births in England and Wales in 1976. An extremely diverse range of impairments contribute to this total but a substantial proportion is accounted for by the common congenital malformations, such as those of the heart, the neural tube, the face, the gastrointestinal tract and the skeleton. Although there are considerable discrepancies in incidence of specific abnormalities analysed by social, geographical and economic groupings, it has been estimated that approximately 2 per cent of all babies are born with defects of this nature which are either immediately apparent at delivery, detected on examination of the child after birth or discovered at autopsy.

Detailed information on recent trends is available from an Office of Population Censuses and Surveys (OPCS) monitoring programme which concentrates on malformations discovered at or up to seven days following birth. It was introduced in 1964 as a consequence of the thalidomide tragedy which pointed to the need for a means of detecting changes in incidence patterns as rapidly as possible. At the same time the establishment of the monitoring programme reflected an awareness of the increasing importance of congenital abnormalities in infant and child health. Data is collected via Area Medical Officers in England and Wales who return first week notifications of malformed children born in their areas to the OPCS; it is then published on a regular basis.

Between 1964 and 1976 notifications of congenitally abnormal babies and the total number of births in England and Wales both fell, by 15 per cent and 34 per cent respectively (Table 2). However, the notification incidence rate per 1,000 total births increased by 28 per cent over the period, reaching 21 per 1,000 in 1976 (Figure 1). To some extent this increase reflects more efficient reporting and identification at or immediately after birth. This in turn may stem from a heightened awareness of the problem on the part of doctors, stimulated to a large degree by the thalidomide episode and repeated references to it over the years.

It is also likely that recent notifications include a larger proportion of more trivial defects: Figure 2 shows that the rates for the four most frequently occurring impairments (Table 3) have remained fairly constant since 1969 when the currently employed classifications were introduced. Indeed the recorded rate for abnormalities of the central nervous system (CNS) has fallen since 1972.

More specific analysis identifies important differences in the incidence of malformations found in live and still births. The

Table 2 *Live and still births and notifications of births with abnormalities in England and Wales, 1964–76*

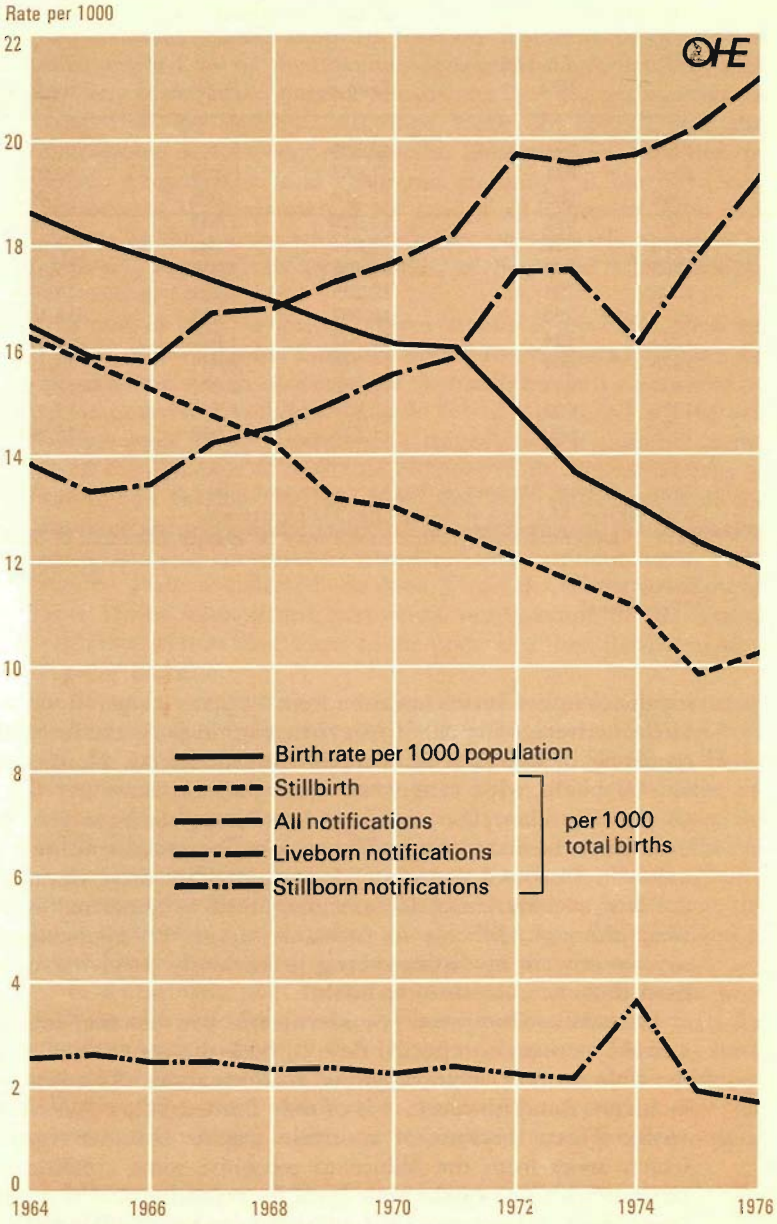
	Total births 000s	*Births with malformation(s)*		*Total notifications*
		Liveborn	*Stillborn*	
1964	891	12,335	2,225	14,631
1965	877	11,687	2,224	13,913
1966	863	11,578	2,086	13,665
1967	845	12,029	2,033	14,062
1968	831	12,071	1,883	13,954
1969	809	12,106	1,853	13,959
1970	794	12,285	1,734	14,019
1971	793	12,567	1,840	14,407
1972	734	12,782	1,629	14,412
1973	684	11,920	1,431	13,353
1974	647	10,382	2,301	12,730
1975	609	10,877	1,175	12,230
1976	590*	11,273	978	12,384

Source Annual Abstract of Statistics 1977 and Office of Population Censuses and Surveys Monitors on Congenital Malformations.
Note Congenital malformations total may be greater than sum of liveborn and stillborn because sex or type of birth may not have been stated or was indeterminate.
*Provisional.

incidence in live births has risen from 13.9 to 19.1 per 1,000 total births between 1964 and 1976, reflecting, in part, the increasing reporting of babies with relatively trivial defects. Notifications of still births with congenital abnormalities, however, fell by 56 per cent over the same period, reducing the rate per 1,000 total births from 2.5 to 1.7. The explanation may lie in improvements in antenatal and obstetric care, perhaps more recently in the late termination of foetuses diagnosed as abnormal *in utero* and, although difficult to substantiate, in the application of stricter criteria in distinguishing precariously surviving infants from those actually dead at birth.

The notification system provides an effective means of detecting a rapid increase in reported defects, both the common ones and the hitherto rare or unrecognised malformations. As a source of incidence data, however, it is of only limited value (Weatherall 1978). This is because of a certain degree of under-reporting which arises from the failure to recognise some conditions at birth or within the strict time limit for reporting and the voluntary nature of the system: in 1975 about 250 fewer still births were

Figure 1 *Notifications of congenital abnormalities, rates per 1,000 total (live and stillborn) births and overall live and still birth rates, England and Wales, 1964–76*



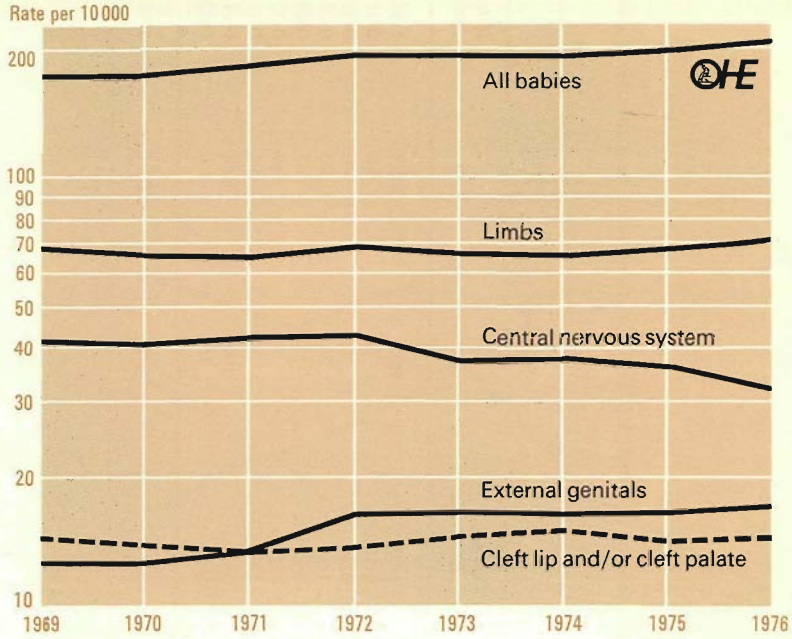
Source Annual Abstract of Statistics 1977 and OPCS Monitors on Congenital Malformations.

Table 3 *Analysis of site of congenital malformations: Notifications of live and still births and expressed as a rate per 1,000 total births. England and Wales, 1976*

	Liveborn			*Stillborn*		
	Number	%	*Rate per 1,000 births*	*Number*	%	*Rate per 1,000 births*
Central nervous system	1,077	9·6	1·83	805	82·3	1·36
Eye	108	1·0	0·18	6	0·6	0·01
Ear	339	3·0	0·57	10	1·0	0·02
Cleft lip or cleft palate	805	7·1	1·36	53	5·4	0·09
Intestines	389	3·5	0·66	17	1·7	0·03
Cardiovascular system	652	5·8	1·11	9	0·9	0·02
External genitals	998	8·9	1·69	4	0·4	0·01
Limbs	4,091	36·3	6·93	100	10·2	0·17
Chromosomes	425	3·8	0·72	16	1·6	0·03
Total	11,273	100	19·11	978	100	1·66

Source OPCS Monitors on Congenital Malformations.

Figure 2 *Malformed infants: major sites, rates per 10,000 live and still births, England and Wales, 1969–76*



Source OPCS Monitors on Congenital Malformations.

notified to the OPCS than were recorded as being due to congenital abnormalities by the Registrar General.[2]

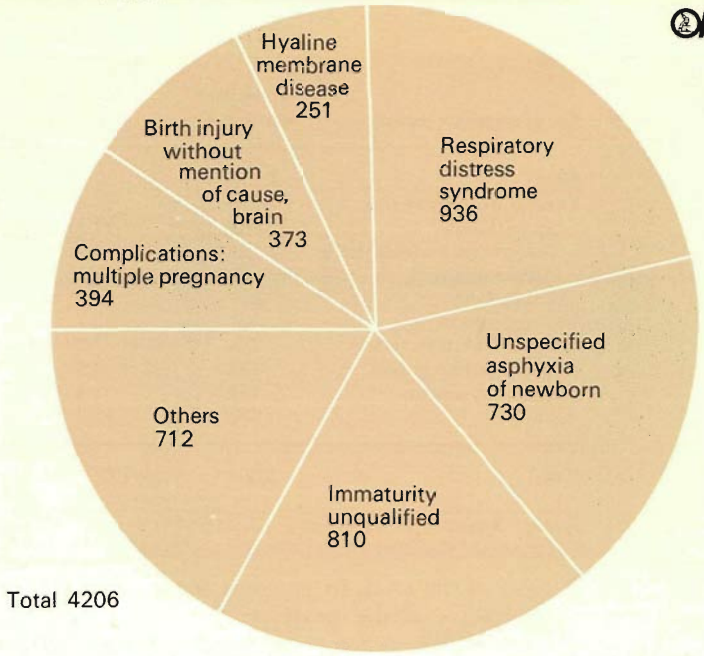
Furthermore, official figures do not register affected pregnancies which undergo early termination by spontaneous abortion nor record dead infants born before the twenty-eighth week of pregnancy. Finally, estimates of incidence based on notification data will inevitably incorporate varying definitions of what constitutes a congenital abnormality.

Mortality

The Registrar General's annual compilation of deaths in England and Wales does not isolate a specific class of mortality which is solely attributable to those conditions associated with serious birth defects. An attempt to derive an overall measurement would require an examination of all the causes entered on a death

2 Such discrepancies can arise in a number of ways. For example, it is possible that the detailed material from a post mortem examination concerning a dead baby may not arrive in time in hospital to allow the baby to be identified at the time of notification.

Figure 3 *Deaths of infants under 1 year classified under 'certain causes of perinatal morbidity and mortality' (ICD 760–779), England and Wales, 1975*



Source Registrar General, 1975.

certificate since for usual mortality analysis only one cause is recorded for each death. This task is beyond the scope of this paper but it is possible to indicate some approximate orders of magnitude. Thus in 1975 nearly 100 deaths were due to cerebral spastic infantile paralysis, 12 per cent of which involved infants under the age of one year and a further 40 per cent among children aged one to fourteen years. In the same year, 4,206 deaths under the age of one year were due to conditions which are largely confined to the perinatal period[3] – a more precise breakdown is given in Figure 3. The most detailed information available is again that relating to congenital malformations (ICD nos 740–759).

In 1975 the Registrar General recorded 1,998 male and 1,806 female deaths from congenital abnormalities in England and

3 The major cause of deaths immediately after birth relate to conditions where the respiration of the child is not securely established. Some are probably due to anoxia during labour. Others are due to immature development of the lung. Yet others may be due to damage of the foetal brain in labour.

Table 4 *Mortality from congenital abnormalities by site, England and Wales, 1975*

Site of congenital anomaly	*Number of deaths*	*Per cent of all abnormality deaths*	*Per cent of these abnormality deaths aged under one year*
Heart	1,419	37·3	51·8
Central nervous system:	1,034	27·2	79·9
Spina Bifida	(667)	(17·5)	87·6
Congenital hydrocephalus	(121)	(3·2)	57·9
Anencephalus	(82)	(2·2)	97·6
Other CNS	(164)	(4·3)	56·1
Urinary system	331	8·7	32·6
Other circulatory system	274	7·2	54·7
Other digestive system	133	3·5	59·4
Respiratory system	131	3·4	56·5
All others	482	12·7	—
Total	3,804	100	60·5

Source Registrar General 1975.

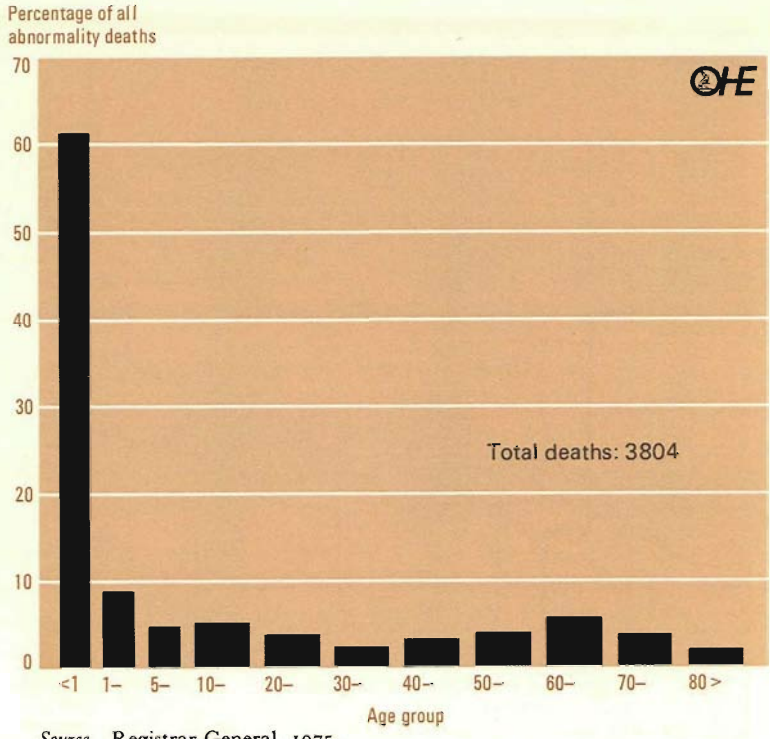
Wales. Of the total, 61 per cent occurred at ages under one year with defects of the heart/circulatory system and those of the central nervous system accounting for 36 and 38 per cent respectively of congenital defect mortality in this age group (Figure 4 and Table 4).

The control gained over the infectious diseases during the last thirty to forty years through medicines, immunisation and improvements in standards of living has raised the relative significance of congenital malformations as a cause of death among the very young. They constitute the largest single cause of perinatal mortality: in 1975 they accounted for 23 per cent of all still births and for 20 per cent of deaths at ages under one week. Among infants aged less than one year, malformations were the cause of one in every four deaths in 1975 (Figure 5). The corresponding ratio was one in seven in 1950 and one in twenty in 1920.

The infant mortality rate associated with these conditions has, nevertheless, remained at a relatively constant level throughout the twentieth century[4] (Figure 6). After a slow rise in the 1920s to the early 1930s, possibly due in part to more precise diagnosis,

4 This contrasts markedly with the 90 per cent fall in the overall infant mortality rate since the turn of the century: in England and Wales there were 138 infant deaths per 1,000 live births in 1901, 30 in 1951, and approximately 16 in 1975.

Figure 4 *Percentage of all congenital abnormality deaths in different age groups, England and Wales, 1975*

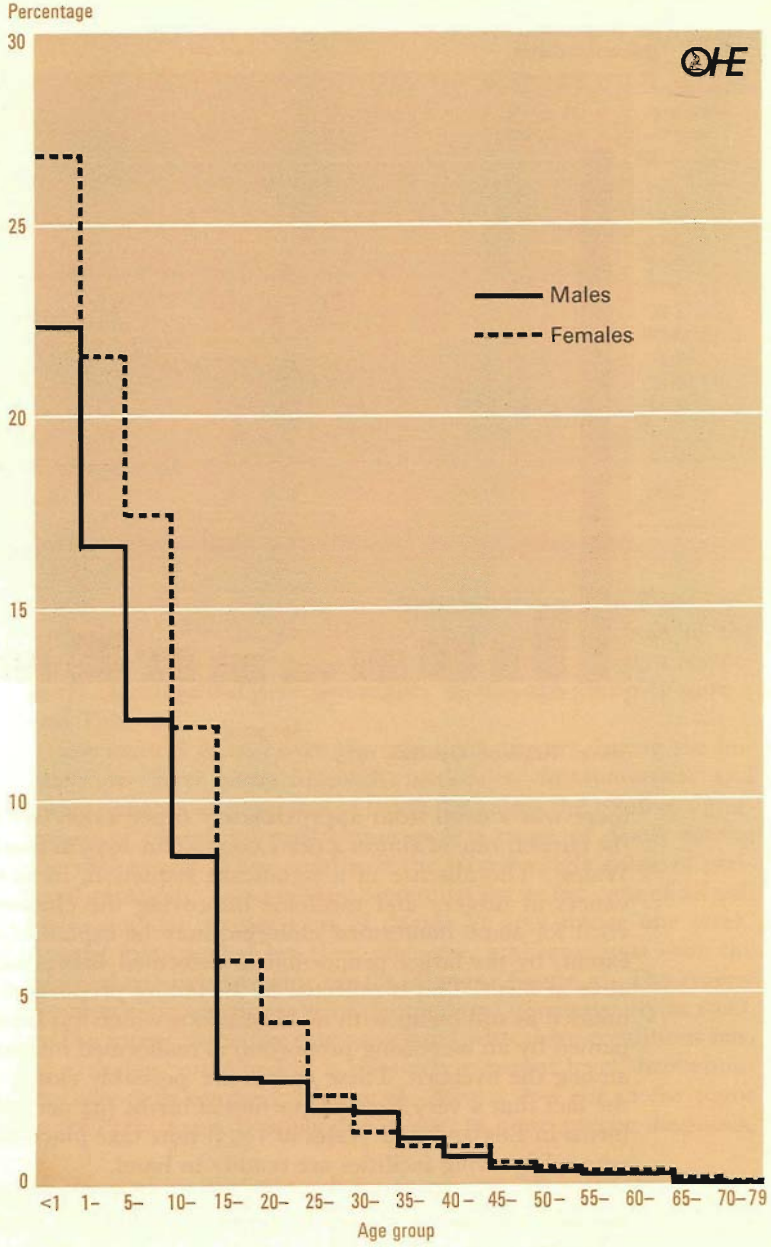


Source Registrar General, 1975.

there was a drop from approximately 6 per 1,000 live births to the current rate of almost 4 per 1,000 (3.8 in 1975 in England and Wales). The absence of a significant reduction, in spite of advances in surgery and medicine improving the chances of survival for some malformed children, may be explained, to some extent, by the larger proportion of deformed babies being kept alive at birth. This is reflected in the falling proportion of births notified as still births with malformations which has been accompanied by an increasing proportion of malformed infants notified among the liveborn. These events are probably closely allied to the fact that a very high proportion of births (94 per cent of live births in England and Wales in 1973) now take place in hospital where life saving facilities are readily to hand.

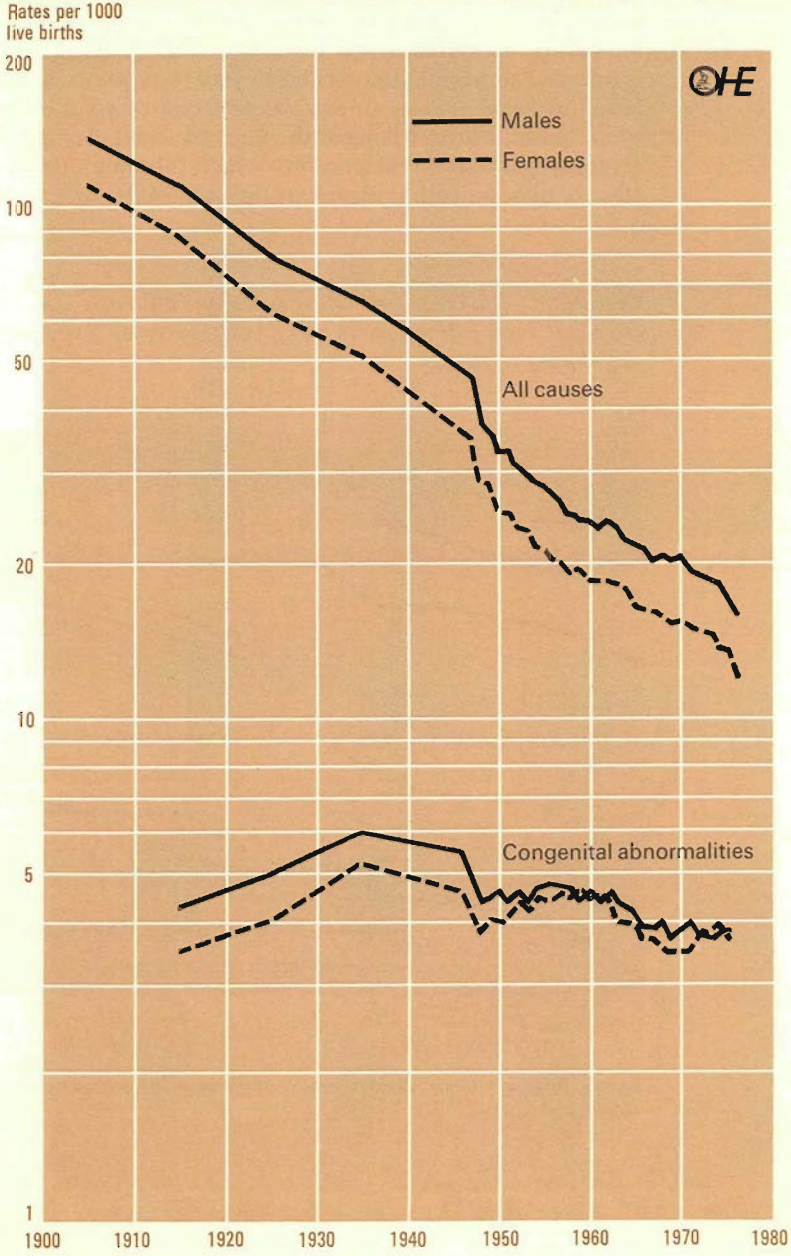
Finally, the persistent and marked differences which exist between the social classes in terms of still birth rates, infant mortality rates and in childhood death rates are also evident in

Figure 5 *Percentage of deaths in each age-group attributable to congenital abnormalities, England and Wales, 1975*



Source Registrar General, 1975.

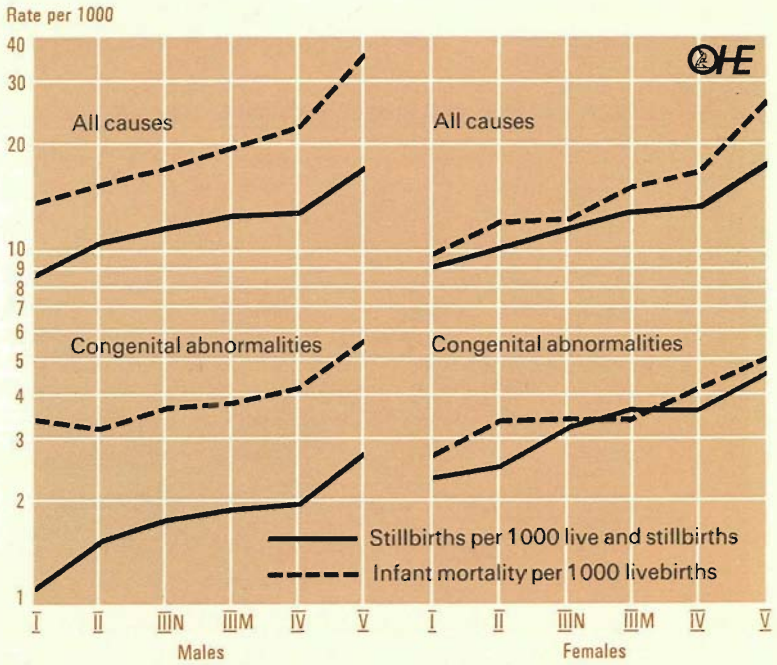
Figure 6 *Infant mortality: rates per 1,000 live births, all causes and congenital abnormalities, England and Wales, 1901–10 to 1975*



Source Registrar General, various years.

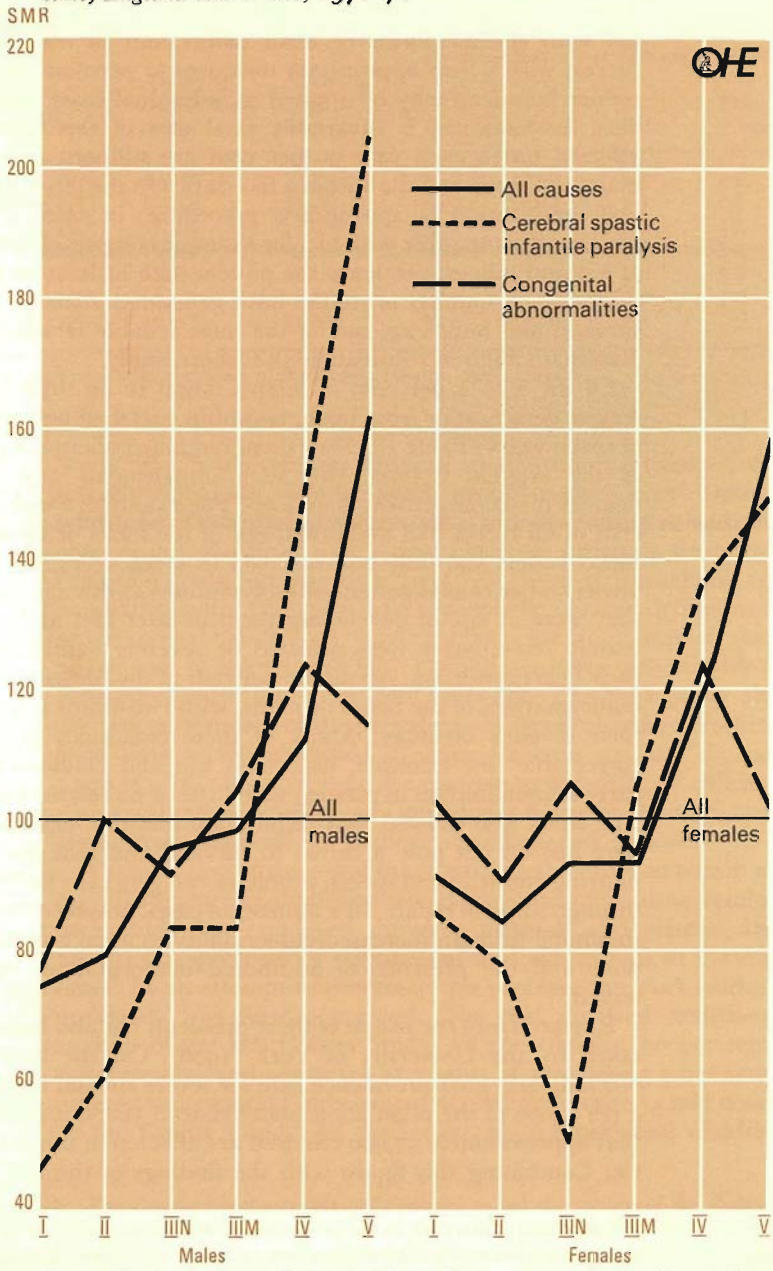
congenital defect mortality patterns (Figures 7 and 8). Once again, however, overall rates such as these obscure the significance of certain component parts of the trends. For example, although for males the standardised mortality ratio in childhood for all congenital abnormalities in social class 5 is just 1.5 times that found in social class 1, an equivalent factor of 4.5 is observed for spina bifida. More striking is the marked social class gradient for cerebral spastic infantile paralysis which (although based on only 165 childhood deaths) is present for both males and females.

Figure 7 *Still births and infant mortality: all causes and congenital abnormalities, males and females, by social class, England and Wales, 1970–72*



Source Registrar General's decennial supplement on occupational mortality, 1970–72.

Figure 8 *Childhood mortality: standard mortality ratios, by social class, England and Wales, 1970–72*



Source Registrar General's decennial supplement on occupational mortality, 1970–72.

SURVIVAL AND HANDICAP

There are dramatic differences both in the survival rates associated with specific forms of birth defect and in the degree of success with which appropriate measures to promote life and to reduce handicap may be applied in individual cases. Anencephalus, for example, is invariably fatal and of the 1,000 or so affected births each year 90 per cent are stillborn and the remaining 10 per cent die within a few days. On the other hand, the swift application of appropriate procedures in cases of defects which are compatible with life, for example congenital dislocation of hip and talipes, can leave the patient with little or no residual disability. A number of studies have generated valuable data on survival and handicap, one of the most reliable of which is the National Children's Bureau 1958 Cohort Study.

Of the 3 to 4 per cent of infants found to be suffering from serious defects at or from birth, two-fifths had died before the age of seven years (Table 1). Thus there remained about 2.6 per cent of the original Cohort with such impairments and varying degrees of accompanying handicap. For example, nearly 0.7 per cent of all births had malformations of the heart or of the great blood vessels and only half survived to seven years. Of the survivors 50 per cent experienced no symptoms at this age (although they were at risk of developing them in later life) and approximately one-quarter were affected or severely handicapped by their heart condition. About 0.7 per cent of the births had serious malformations of the bones or joints, with two-thirds still alive on their seventh birthday. Many of these conditions are largely correctable (for example, dislocated hip and clubfoot through early immobilisation in plaster) with little or no related handicap. The study also showed that facial abnormalities (cleft palate or hare lip) do not pose a threat to survival and that the accompanying cosmetic and speech problems can generally be overcome through surgical repair. In a number of cases, however, handicaps stemming from an increased vulnerability to nasal and ear infections and the presence of additional malformations were observed.[5]

Research into the extent of these problems has also been undertaken by the University of York (1976). On the basis of the officially accepted prevalence rate for severe mental handicap of 4 per 1,000 of the population under sixteen years, it is estimated that approximately 57,000 children are affected in this way in the UK. Combining this figure with the findings of the NCB Cohort

5 OPCS notification data indicates, however, that the majority (84 per cent) of congenitally abnormal infants are not affected by more than one defect (Table 5).

Table 5 *Notified congenital malformations in live and stillborn babies and percentage with one or more malformations, England, 1970–76.*

Year	Number of malformations notified	Number of babies involved	Percentage with one or more malformations			
			One	Two	Three	Four or more
1970	16,464	13,339	82·8	13·2	2·8	1·2
1971	16,784	13,711	83·5	12·4	2·9	1·2
1972	17,127	13,686	82·2	13·0	3·3	1·5
1973	15,641	12,726	83·2	12·7	2·9	1·2
1974	15,254	12,143	81·8	13·4	3·1	1·7
1975	14,592	11,740	82·4	13·3	2·9	1·4
1976	14,615	11,803	83·6	12·0	2·6	1·7

Source On the State of the Public Health, 1976. DHSS.

Study, the York workers estimate that around 14,000 of the severely mentally handicapped group suffer from Down's syndrome. This order of magnitude is broadly consistent with the observation (Griffith 1973) that children suffering from this condition make up approximately one-third of the school age population with IQ's below 50 – a widely recognised definition of severe mental handicap. It further reflects the fact that more than 70 per cent of infants born with Down's syndrome now survive in contrast to only 10 per cent fifty years ago. The York paper also derived an estimate of the prevalence of cerebral palsy. Working from data which identified a range between 2.0 and 2.9 per 1,000 it was calculated that one-quarter to one-third of children with cerebral palsy in the UK (implying a figure of about 16,000) are severely physically or mentally handicapped or both.

A summation of these and other estimates in order to obtain an overall measure of disability would generate misleading results: each study has employed different methods and criteria and surveyed a spectrum of populations and age groups at varying times. In an attempt to overcome this problem the York workers undertook two further projects. The first involved additional analysis of the NCB Cohort Study. Of the 16,606 (100 per cent) children alive and contacted at 7 years of age, 860 (5.2 per cent) suffered some kind of impairment according to criteria laid down by the Family Fund.[6] Of the latter 133 (0.8 per cent) children

6 The Family Fund was originally formed to aid the victims of the thalidomide tragedy and now may help the families of any disabled child under sixteen. The aid it gives is not normally means-tested and claims are decided largely on the basis of a report by a social worker.

were classified as very severely handicapped and in 114 (0.69 per cent) of these cases the cause was judged to be of a congenital nature.[7] Similar orders of magnitude were obtained when this cohort of children was traced at the age of 11 years.[8]

The second study examined a register of disabled children living in the city of York. A prevalence rate for very severe handicap among children under sixteen years of 6.1 per 1,000 was derived from this data. If this estimate is then pooled with that from the NCB Cohort analysis (7.6 per 1,000) a national rate of 6.7 per 1,000 is obtained. This implies that, at the 95 per cent confidence level, there are between 83,000 and 106,000 very severely handicapped children under sixteen years old in the UK, and that less than 15 per cent of these handicaps are non-congenital in origin.

Spina bifida

Spina bifida merits special consideration in the context of the discussion above. In part this stems from the fact that it is one of the most serious congenital defects compatible with continued life after birth. It has been estimated that 20 per cent of very severely handicapped children suffer from the condition. It is also because of the complex ethical issues raised by medical and surgical advance in facilitating an increasing control over the survival of some severely affected babies who would previously have died.

In the wake of suggestions in the first half of the 1960s (Sharrard *et al* 1963) that the early emergency closure of spinal defects was highly beneficial and reduced paralysis, deformity, meningitis and brain damage a universal policy of emergency treatment was adopted. It soon became clear, however, that this strategy was directly responsible for the survival of a large number of severely handicapped children. Lorber (1971) was the first to express publicly misgivings about the routine closure of neural tube defects. A more selective policy has since been followed.

Statistical evidence reflects this change of attitude. Using a sample of the children notified as being born alive with spina bifida between 1965 and 1971, Weatherall (1976) observed that about 40 per cent of these infants born in 1965 were still alive at

7 Of the 114 severely congenitally handicapped children, about 32 per cent suffered from a physical disability only and 39 per cent from both physical and severe mental impairments.

8 The actual rates were 7.65 per 1,000 very severely handicapped of which 6.6 per 1,000 (87 per cent) had an abnormality of birth. Within 95 per cent confidence limits, these rates imply that the prevalence of very severely handicapping impairments in the UK lies between 89,000 and 126,000 of which 76,000 to 110,000 are present at or from birth.

Table 6 *Children born alive with spina bifida. Percentage of children in sample alive at ages 2 to 8, England and Wales*

	Age						
Born	*2 years*	*3 years*	*4 years*	*5 years*	*6 years*	*7 years*	*8 years*
1965							39·6
1966						36·9	
1967					44·6		
1968				45·0			
1969			46·4				
1970		52·3					
1971	40·9						

Source Weatherall 1976.

8 years of age. This contrasted markedly with the experience of the 1971 Cohort in which only 41 per cent of the children were alive in their second year with the clear implication that a smaller proportion would survive to their eighth birthday (Table 6). This fall in the survival rate is consistent with the increased levels of early mortality of children with spina bifida observed since 1970 by Weatherall and White (1976). They found that the number of children in England and Wales whose death in their first year was attributed to spina bifida, hydrocephalus, or both, decreased steadily throughout the 1960s from about 1,000 to 500 but has risen since 1970. Over the same period the incidence of still births due to these CNS abnormalities has followed a similar pattern. Furthermore, hospital data indicates that the number of operations on children with these conditions has been decreasing since 1970 (Table 7).

Considerable debate has surrounded the desirability of actively promoting the survival of infants with severe spina bifida because many of the individuals concerned would be, and indeed have been, exposed to a seriously disabled existence frequently interrupted by sometimes unforeseen medical and social problems of varying degrees of severity.[9] Conflicts stem from, among other things, the social, financial and more immediate resource allocation implications of specific strategies. But ethical questions constitute one of the most intractable aspects of the dilemma. On the one hand, it may be considered that the preservation of life with handicaps so severe as to impose intolerable social, emotional and economic costs on both the individual and those charged with the responsibility for his or her care is unjustified in most circum-

9 About 30 to 40 per cent of all spina bifida children have either other severe malformations or such damage to the central nervous system that operation does not eliminate gross physical disability nor abnormal mental development (Weatherall 1978).

Table 7 *Children treated in hospital with main condition spina bifida and or hydrocephalus, England and Wales, 1970–74*

Year	Number of live and still births with spina bifida	All cases						Cases where surgery undertaken					
		Total number			Deaths in hospital			Total number			Deaths in hospital		
		0–4	5–14	0–14	0–4	5–14	0–14	0–4	5–14	0–14	0–4	5–14	0–14
1970	1,453	5,380	980	6,360	530	(20)	550	2,910	500	3,410	—	—	(180)
1971	1,552	4,510	1,400	5,910	500	(20)	520	2,250	860	3,110	—	—	(130)
1972	1,537	3,930	1,780	5,710	470	(30)	500	1,820	970	2,790	—	—	(120)
1973	1,267	3,950	1,590	5,540	450	(10)	470	1,910	920	2,830	—	—	(80)
1974	1,185	3,750	1,940	5,690	460	(20)	480	1,700	1,100	2,800	—	—	(80)

Source *Hansard*, written answers, 12/12/77, col 43–44.
— Not available.
Bracketed figures are estimates from sample number of 20 or less and are subject to a high degree of sample error.

stances. At the other end of the spectrum there is the view that attempts should always be made to maintain life, to overcome handicaps and to strive for the maximum possible development of the individual's potential. Even after decisions in these areas have been achieved the issue may be further confounded by the fact that surgery does not guarantee life just as non-intervention will not always result in death.[10] Judgements concerning the advisability or otherwise of interventions to promote survival have therefore to be made in the context of a co-ordinated medical and nursing policy which recognises all of the social and ethical problems involved.

AETIOLOGY

Research and epidemiological evidence suggest that a large proportion of the common abnormalities (for example, anencephalus, spina bifida, and cleft lip/palate) may be the result of environmental factors acting on genetically vulnerable individuals. The search for these environmental influences had little scientific grounding before Gregg's discovery of the teratogenic properties of the rubella virus in 1941. Subsequently it has received considerable impetus from the thalidomide episode and current attention is being directed towards a diffuse range of possible hazards which may be present not only in drugs but in food, water and in the general environment.

In spite of the intensification of research efforts over the past two decades, however, understanding of the complex processes which give rise to birth defects has only just begun: many of the relevant intrinsic and environmental factors have yet to be identified clearly and it is uncertain whether they act in isolation or in concert to produce all or just specific defects. At the same time, gaps exist in our knowledge of the causal mechanisms: it is generally unknown if the damage is inflicted directly on the foetus, placenta or uterus or if it is generated indirectly by factors affecting the mother. The stage of pregnancy at which foetal injury occurs is yet another variable factor. Although there clearly are substantial deficiencies in the overall explanation of birth defects, progress has nevertheless been achieved, notably in the identification of certain potent teratogens and in the investigation of genetic material. Furthermore, emphasis has shifted from a predominantly genetically-based approach in the understanding of birth defects to one favouring a multifactorial aetiology.

10 Recent contributions to the debate have highlighted the ethical problems arising from the 'active' and 'passive' encouragement of non-survival of severely impaired spina bifida babies (Zachary 1977).

Intrauterine infections

Intrauterine or foetal infections – those which are contracted between conception and birth as a result of maternal infection – have emerged only relatively recently as a major source of concern. Indeed, a textbook of childhood diseases or of bacteriology published thirty to forty years ago would probably have made no mention of them with the possible exception of congenital syphilis and congenital toxoplasmosis.[11] The reason for this change is of course that their significance is no longer obscured by the overwhelming burdens imposed formerly by communicable diseases such as diphtheria, whooping cough and scarlet fever.

Most maternal infections apparently have no effect on the foetus: the surrounding membranes and separate circulatory system effectively obstruct the passage of infectious agents. But many of those that do succeed in penetrating these barriers multiply rapidly, in the absence of immune responses which develop only postnatally, and thus destroy the foetus. In order therefore to produce defects an infection must interfere with normal development without actually causing death – a balanced sublethal effect as Mims (1976) has described it. As larger microorganisms (bacteria) tend to release toxins and cause more extensive tissue damage often with lethal consequences, it is the viruses which are the more significant infective causes of birth defects (Tables 8a and 8b).

Congenital rubella has probably been the subject of more intensive clinical and laboratory study than any other intrauterine infection and work in this field has led to the development of many of the diagnostic techniques which are currently in more general use. The spectrum of consequences of rubella infection is extremely broad, extending from spontaneous abortion, the birth of infants affected with the active disease, through malformations of varying degrees of severity (frequently involving the eyes, the ears and the heart giving cataracts, deafness and heart disease) to complete absence of problems either at birth or at later ages. Research has also indicated that the mechanisms of foetal damage are probably multifactorial: a depression in the rate of cell division, cytolytic changes, persistence of infection, immunopathological processes and vascular changes. It has been

11 Toxoplasmosis is one of the commonest protozoal infections. Suggested causes include consumption of uncooked meat and contact with cat faeces. Some workers claim it is not a significant cause of abnormality but this may reflect inadequate survey size. Public Health Laboratory Services records, however, show about fifty cases of congenital toxoplasmosis per annum. (It is also likely that there is a group of unrecorded more mildly affected infants). Many of the cases that survive are mentally subnormal, blind or handicapped in other ways.

Table 8a *Intrauterine and perinatal infections*

Protozoal	*Bacterial*	*Viral*
Toxoplasmosis	Syphilis	Rubella
(Malaria)	Listeriosis	Cytomegalic
	Escherichiacoli	inclusion disease
	Proteus	Variola-vaccinia
	Klebsiella	Herpes simplex
	Streptococci	Varicella-zoster
	Staphylococci	Hepatitis B
	Streptococcus faecalis	Poliomyelitis
	Mycoplasma	Influenza
		Mumps
		Coxsackie B, Echo

Table 8b *Incidence of intrauterine and perinatal infections in the United Kingdom*

	Rate per 1,000 live births	*No of cases expected per annum*
Congenital rubella	0·25–0·3	200–250
Congenital cytomegalovirus	0·5 –1·0	400–800
Congenital toxoplasmosis	0·05	40– 50
Congenital syphilis	0·12–0·2	100–150
Perinatal bacterial infections	2·5 –3·5	2,000–3,000

Source Dudgeon 1975.

estimated that the risk for the birth of an infant with defects is about 50 per cent when the mother contracts the illness in the first month of pregnancy, 20 per cent in the second month and 7 to 8 per cent in the following eight weeks (Dudgeon 1967).

Screening at antenatal clinics indicates that about 80 per cent of pregnant women have already acquired immunity to rubella (DHSS 1977). It is hoped that the introduction of a rubella vaccination programme in 1970, which is aimed primarily at girls aged between 11 and 13 years, coupled with appropriate publicity will raise this percentage still higher and thus reduce the number of babies damaged by this particular infection. (See Appendix II.)

Cytomegalovirus (CMV) is another infection now attracting considerable interest as a potentially important cause of mental retardation and microcephaly. It probably accounts for at least twice as many damaged infants as rubella, and Hanshaw *et al* (1973) have estimated that the prevalence of CMV infections at birth is in the range 4–10 infected infants per 1,000 births. It is

generally assumed that most cases of congenital CMV infection result from primary maternal infection during early pregnancy but it is difficult to establish precisely because of the virtual absence of symptomatic disease in the adult.

Pharmaceutical agents

The introduction of the sedative thalidomide in 1958 was accompanied by a marked increase in the incidence of children being born with severe limb defects and other abnormalities. Although only about one-fifth of mothers who took the drug gave birth to deformed children, it has been estimated that worldwide as many as 10,000 infants were adversely affected. The teratogenic action was first suspected in 1961 and confirmed in many countries one year later. The outcome was an intensification of efforts aimed at improving drug safety[12] and a closer examination of medicines suspected of producing a teratogenic effect.

Attention has repeatedly been given to a possible link between anticonvulsant drugs and birth abnormalities. Smithells (1976) has summarised data from several surveys undertaken largely in the first half of the 1970s. The overall incidence of malformations in 2,403 children born to epileptic women was found to be 5.4 per cent compared to rates of between 2.2 and 3.5 per cent for controls. The rate for offspring of epileptics therefore appears to be about twice as high as that expected. If those taking anticonvulsants are separated from those not doing so the malformation rates are respectively 6.0 and 1.4 per cent. Even allowing for possible errors – for example, the latter figure suggests incomplete ascertainment in some studies – it appears that the risk of malformation (particularly oral clefts and congenital heart disease) in infants of epileptics taking these medicines is almost three times that in the rest of the population.

The possibility that synthetic sex hormones might have adverse effects on the foetus has been the subject of recurrent speculation. The developing embryo may be exposed to these preparations either as a means of discouraging spontaneous abortion (usually progestogens) or in the form of oral contraceptives (combinations of progestogen and oestrogen) which may continue to be taken in the early stages of an unrecognised pregnancy. The precise

12 Extensive guidelines and regulations for drug testing procedures have been evolved and official bodies (such as the Committee on Safety of Medicines) now exist to investigate the side effects of medicines and to examine morbidity and mortality data with a view to detecting promptly deviations from normally expected patterns. The voluntary reporting of suspected associations between medicines and defects provides another form of surveillance over drug teratogenicity.

effects, if any, of these drugs have yet to be clarified. Concern about the use of hormone pregnancy tests has, however, intensified in recent years. In 1967, Gal and her colleagues reported that women who had spina bifida babies were more likely than those with normal births to have used these preparations. Evidence for an association has subsequently been strengthened by the findings of an investigation undertaken jointly by the Committee on Safety of Medicines and the Office of Population Censuses and Surveys.

The study was initially set up because it seemed likely that teratogenic effects linked with exposure to certain drugs during child bearing were failing to be detected.[13] It examined those pregnancies which were notified to the OPCS as resulting in the birth of a malformed child in England and Wales during 1971 and 1972.

Details of the maternal drug usage patterns were obtained from general practitioners and each case history was paired with that of a normal baby born to a mother in the same practice within three months of the abnormal birth. Preliminary results (Greenberg *et al* 1975) related to a group of 149 abnormal babies with a wide range of defects other than clefts of the lip or palate. It was found that a total of twenty-three mothers of malformed infants had been exposed during the first trimester of confinement to hormone pregnancy tests (HPT) compared with only eight of the control mothers. A follow-up investigation (Greenberg *et al* 1977) involving 836 case-control pairs which considered all types of malformation also identified a statistically significant discrepancy between the two groups in the use of these preparations. However, the authors concluded that 'the excess use of HPT by case mothers was not great' and that 'the association with malformations was non-specific'. It was also pointed out that the risks could be avoided altogether by employing alternative risk-free methods of pregnancy diagnosis.

As a consequence of the 1975 findings the manufacturers of the hormones concerned were already warning doctors, at the time of the follow-up study, that they should not be used for pregnancy testing[14] or if there were any possibility that the patient may be pregnant. Subsequently, the products in question have been withdrawn from the UK market.

13 Although approximately 13,000 babies with visible malformations were being born each year in England and Wales, only about fifty voluntary reports linking abnormalities with maternal drugs were recorded annually in the Register of Adverse Reactions established in 1964 by the Committee on Safety of Drugs.

14 Pregnancy testing had been excluded from the indications for the two principal products concerned by the end of 1970.

Table 12 *Incidence and recurrence risks of some of the common birth defects*

	Certified still birth rate per 1,000 total births	*Notified liveborn rate per 1,000 total births*	*Total afflicted rate per 1,000 total births*	*Extremes (combined live births*
Anencephalus[4]	1·59	0·22	1·81	2·53 (Wales)
Spina bifida[4]	0·31	1·42	1·74	2·56 (Wales)
Hydrocephalus[4]	0·39	0·24	0·63	0·76 (Wales)

		By maternal age[3]	
	Observed incidence rates	*Maternal age*	*Incidence among liveborn in different age groups (per cent)*
Down's syndrome	1·45–1·8 per 1,000 births	less than 30	0·04
		30–34	0·11
		35–39	0·33
		40–44	1·25
		over 45	3·15

Congenital heart malformations	*Observed incidence rate* 6 per 1,000 births	of these heart defects: 30 per cent are ventricular septal defects; 10–20 per cent are patent ductus arteriosus; 10 per cent are atrial septal defects	*Risks of r* Increase malform apply to

Pyloric stenosis	*Observed incidence rates* Males 5 per 1,000 births. Females 1 per 1,000 births	*Risks*[2] Risk to children of women who have had pyloric s For men who have had pyloric stenosis the risks ar to later sibs of a girl with pyloric stenosis are 1 in sibs of an affected boy are 1 in 14 for brothers and

Cleft lip with or without cleft palate	*Observed incidence rates* 0·6–1·35 per 1,000 births	*Maternal age* Tendency for incidence to rise at high maternal ag thirties and forties

Congenital dislocation of the hip	*Observed incidence rate* 1 per 1,000 births based on late diagnosis at about 1 year. Marked female preponderance of 7 or 8 to 1 boy	Examination in neonatal period identifies four times as many patients as would later prove to have late-diagnosis congenital hip dislocation	*Risks*[2] In terms brothers proportio about 1

Cerebral palsy	*Observed incidence rate* 2·5 per 1,000 births

Notes 1 In all 3 conditions the incidence figures are greatest and approximately equal at the extremes of maternal age.
2 *Source:* Carter 1974

Regional Incidence ll births and notified 1,000 total births)	*Extremes by maternal[1] age (combined still births and notified live births per 1,000 total births)*	*Risk of Recurrence[2] After one affected sib*	*After two affected sibs*	*Risks to child of survivors[2]*
·44 East Anglia) ·13 East Anglia) ·55 South East)	2·20 – 1·63 (20 yrs) (25–34) 2·25 – 1·47 (20 yrs) (25–29) 1·10 – 0·56 (40 yrs) (25–29)	1 in 20	1 in 8	1 in 28
rrence sk in sibs and children of the same type of cardiac on as that in the index patient. The higher risks e more common types of malformation		Between 1 in 25 and 1 in 50	Between 1 in 10 and 1 in 25	Between 1 in 10 and 1 in 25
osis is 1 in 5 for sons and 1 in 15 for daughters. in 20 for sons and 1 in 40 for daughters. The risks for brothers and 1 in 25 for sisters, and for later in 33 for sisters				
– generally by a third or more between early		1 in 25 (varies: from 1 in 33 to 50 when index patient has unilateral cleft; but 1 in 17 to 1 in 20 when bilateral cleft lip and palate)	1 in 7	1 in 25
late diagnosis, with a female index patient 1 in 150 d 1 in 20 sisters are affected and perhaps a similar of sons and daughters. With a male index patient 25 brothers and 1 in 15 sisters are affected				

3 *Source:* Blank 1977
4 *Source:* Rogers and Weatherall 1976. Incidence data based on average for years 1964–72.

Against this background the use of other pharmaceutical preparations during pregnancy has also attracted attention. While some studies have attempted to show an association between specific medicines and foetal malformation others have questioned the extent of medication. Research carried out by the Edinburgh University Department of Child Health, for example, found that 97 per cent of all mothers had taken drugs prescribed by their doctors and 65 per cent had consumed preparations bought 'over the counter' during pregnancy (quoted in Lock and Smith 1976).

Such analyses do not prove causal links[15] and may fail to take account of many related and extraneous variables such as the conditions for which drugs were given. Nevertheless, they have had the desirable effect of focussing attention on the importance of examining critically the benefits of medication employed during confinement against the possible but hitherto unsuspected hazards for the foetus. In this context, pharmaceutical manufacturers now routinely subject new medicines to the best available scientific tests for teratogenicity.

Other environmental influences

Numerous aspects of the environment have undergone investigation having, at one time or another, been considered potentially deleterious to foetal development. At the turn of the last century, for example, a link was detected between malformations and ionising radiation. Subsequent investigation has indicated that the nature of the defects (affecting all systems in animals and frequently microcephaly in man) appears to be related to the stage of embryogenesis at the time of exposure as well as to the magnitude of the latter.

The extent to which nutritional deficiencies, especially of vitamins, have a part to play in the aetiology of birth abnormalities has long been debated. Experimental research has shown that malformations can be produced in many animal species by feeding vitamin deficient diets or vitamin antagonists during pregnancy. Although there is little direct evidence that a deficiency of maternal diet has similar consequences for man, it may prove to be a correctable factor in defects of a multifactorial origin.

More recent contributions in the search for factors which may deflect foetal development from its normal course have included Renwick's (1972) suggestion that anencephalus and spina bifida

15 The effects of drug usage on the foetus are particularly difficult to monitor because retrospective studies are hindered by the time lapse between the administration of a drug and the reporting of a birth defect and because very large sample sizes are required to detect only weak teratogenic activity of drugs not commonly used.

were related to the consumption by pregnant women of 'green' or bad potatoes. But this hypothesis has not been upheld by several independently conducted potato avoidance trials. Similarly, observations that the striking geographical distribution of anencephalus in Britain might be related to some factor in the water supplies have yet to be supported by any conclusive evidence.

In the last few years much concern has focussed on the discovery of an apparently impaired reproductive efficiency in some medical and nursing staff working in operating theatres. The disabilities reported include increased frequencies of involuntary infertility, spontaneous abortion and births of infants with congenital malformations. Further research into the problem is in progress, but current knowledge does seem to indicate that there are grounds for believing that teratogenic agents (stemming perhaps from waste anaesthetic gases, stress or some other unidentified factors) are present in the operating theatre environment. (A synopsis of recent findings is given in *On the State of the Public Health*, 1975.)

THE PREVENTION OF BIRTH DEFECTS

The avoidance of pregnancy in women who are most likely to give birth to infants with defects would clearly provide an efficient means of prevention. But current epidemiological evidence points to only a limited number of factors (for example, advanced reproductive age in Down's syndrome) which are indicative of a raised level of risk; thus few potentially susceptible individuals are readily identifiable. Furthermore, there would of course be immense technical and ethical problems inherent in the manipulation of reproductive patterns in this manner. An alternative approach would be to identify and remove (or modify) all teratogenic agents but at the present level of knowledge this would probably have little effect on the frequency of birth defects (McKeown 1976).

These shortcomings mean that attempts to reduce the numbers of affected births are based on a combination of measures including, in particular, improved antenatal care, genetic counselling and prenatal diagnosis.

Antenatal care

Before the beginning of the twentieth century, obstetric attention was focussed primarily on labour and the actual birth process with little or no consideration given to the importance of the earlier stages of pregnancy. Today, however, it is more widely recognised that the health and nutrition of the mother in the prenatal period is of critical importance to the future health,

growth and development of the child. Good health in pregnancy and the anticipation of potential difficulties which may arise at the time of birth will be more likely to be promoted if mothers are well cared for and supervised throughout their confinements. There is, nevertheless, scope for further improvement both in terms of individual attitudes to childbearing and the provision of health care services. The Spastics Society, for example, has recently estimated that about 40 per cent of all cases of cerebral palsy alone (equivalent to 800 affected infants) could be avoided in Britain each year if present knowledge were fully applied and current practice improved.

Much concern stems from the observation that some mothers-to-be (particularly in social classes 4 and 5) appear to be unaware of the availability and importance of antenatal care. To some extent this is reflected in data relating to attendances at antenatal clinics. It has been estimated that some 20 per cent of women in Britain do not seek assistance and guidance before the end of the first trimester of pregnancy, some fail to keep appointments and a minority remain unknown to the health service until they go into labour. A 1976 survey in Liverpool of a 10 per cent random sample of 3,900 pregnant women showed that 55 per cent, 19 per cent and 17 per cent had not attended an antenatal clinic for the first time at fifteen, nineteen and twenty-three weeks respectively and that the mean length of pregnancy at the time of booking was seventeen weeks (quoted in Loring and Holland 1978). Furthermore, the tendency towards late (first) attendance was greater among younger women and both nulliparous and high parity pregnancies.

A Midlands study found that 8 per cent did not report for antenatal care until twenty-four weeks, or later, and that 24 per cent reported at twenty weeks or more (Wynn and Wynn 1977). Finally, a survey in Leicestershire showed that the mean length of pregnancy at the time of booking was twenty weeks (Heward and Clarke 1976).

In spite of the discrepancies in the individual survey findings it is clear that too many women delay their first antenatal clinic attendance. Yet these consultations can be highly significant for the development of the unborn child: deficiencies in maternal health can be corrected, advice can be given on the avoidance of unnecessary hazards[16] and special problems which may necessitate an appropriate plan of care may also come to light and be provided for. Furthermore, non-attendance may be associated with substantial risks: the 1958 British Perinatal Mortality Survey demonstrated a five-fold increase in perinatal mortality in the offspring of women who did not receive any antenatal care compared with those who did and a four-fold increase in women

attending on only one to four occasions, compared with those attending more than four times. In the light of these considerations the Department of Health and Social Security's (DHSS) Children's Research Liaison Group (1977) has identified the consideration of ways of ensuring booking prior to the sixteenth week of pregnancy as a major research priority. This is also reflected in recent statements of DHSS policy in this area (DHSS 1977).

The limited effectiveness of existing health education measures has led to the suggestion that incentive payments might encourage earlier and regular use of antenatal services. In France and Finland, financial incentives have resulted in 96 per cent attendance before fifteen weeks and 91 per cent before sixteen weeks respectively[17] (Wynn and Wynn 1977). The implementation of similar measures in Britain may be of particular benefit for some less well-educated members of the population who may have special problems in planning for the future and identifying the best interests of their unborn children. However, it is unclear how such schemes could be integrated into the present pattern of benefits which consists of a maternity allowance paid to insured working mothers for eighteen weeks (starting eleven weeks before the baby is due) and a universally available lump sum maternity grant (DHSS 1977).

It may be, however, that more information is required about the fundamental reasons for late and non-attendance before significant progress can be achieved in the take-up of available maternity services. Explanations of the current patterns of service use have tended to emphasise a lack of knowledge and even irresponsibility on the part of some mothers but recent research suggests that a reconsideration of these views may be necessary.

Two studies at York University financed by the Health Education Council – one based on interviews with fifty expectant mothers (1974), the other on interviews with 200 mothers during pregnancy and the first six months after birth (1976–79) –

16 Research has emphasised in particular that good maternal nutrition is an important influence on the baby's weight at birth. The latter also appears to be affected by smoking although the precise mechanism involved is unclear. The findings of a recent study by Davies and his colleagues (1976) suggests that tobacco consumption may only have an indirect effect on foetal weight by lowering the maternal calorie intake. Alternatively, work by Mau (1976) indicates that smoking may have a direct effect on the placenta and foetus. Finally, a study by Kelsey and her colleagues (1978) indicates that women who smoke in excess of twenty cigarettes a day during pregnancy have an increased risk of congenital malformations in their offspring.

17 It should be noted, however, that such payments in France have been available for some twenty-five or more years and are therefore unrelated to recent reductions in French perinatal mortality rates.

suggest that mother's risk-taking behaviour in general, and their underutilisation of the health services in particular, can only be understood in the context of the sense of responsibility that mothers have regarding the health of their family and the failure of the antenatal and postnatal services to take account of and adapt to these responsibilities.

On the basis of the findings so far, Graham (1978) suggests that the failure of some mothers who already have children to attend antenatal clinics can be seen as an attempt to reconcile the commitments felt to the unborn infant with those relating to the marriage partner, the other children and the domestic duties. Among first time mothers risk-taking behaviour stems not from a lack of awareness of the need to protect the infant's health but from a confusion about the means by which this goal can be achieved. Underutilisation of antenatal services, it is argued, can therefore be seen to result from the latter's insensitivity to the uncertainty and conflict of responsibility mothers experience regarding the question of their baby's health. Consequently, the solution may lie firstly in a reorganisation of hospital antenatal services to avoid problems inherent in the timing of clinics, waiting time, clinic location and the provision of facilities for children and other relatives, and secondly in improving the actual content of the check-up. The latter could be given a patient rather than task oriented design which would help to accommodate the mother's needs for privacy, personal attention and advice and continuity of care (Graham 1978).

Other aspects of antenatal and perinatal care

The Court Committee on the Child Health Services, which reported in 1976, emphasised the importance of improving obstetric and neonatal care where standards lag behind the best. Better care would help to reduce perinatal mortality (although unless the care is of a high quality some of those babies who might not otherwise have lived may well survive with handicaps) but it was hoped that its major impact would be in reducing brain damage which may contribute to or cause mental retardation and severe learning difficulties in those who survive.[18] The Committee suggested that progress in these areas could be achieved in a number of ways. It stressed the importance of techniques for monitoring foetal wellbeing both in facilitating the better selection of women for delivery in maternity units which offer

18 The frequency of other congenital defects, it is hoped, may be reduced as a result of the recommended expansion in genetic counselling facilities, the declining birth rate among women over the age of thirty-five years and increased use of prenatal diagnosis.

Table 9 *Current expenditure per head by region on maternity services, hospital and community health services 1975–76*
£ November 1975 prices

Northern	300	Wessex	260†
Yorkshire	300	Oxford	380
Trent	290	South Western	400
East Anglia	290	West Midlands	320
North-West Thames	350	Mersey	360
North-East Thames	440*	North Western	290
South-East Thames	400	England	340
South-West Thames	320		

Source Loring and Holland, 1978.
*Highest
†Lowest

specialised perinatal care and in the management of high risk deliveries. However, many obstetricians regard all deliveries as potentially at high risk as any mother and baby during childbirth may show sudden and unexpected signs of illness which may reach serious dimensions and in this context the growth in the proportion of hospital confinements is seen as a satisfactory development. Another important recommendation concerned the clinical examination of the newborn. The committee stated that there is a need for every newborn baby to be evaluated immediately after delivery and that a full clinical examination is desirable between six and ten days after birth. The latter may help to identify those defects which are not easily recognisable at birth and by facilitating the early instigation of treatment may avert handicaps in later life.

The role of good antenatal and perinatal care in preventing long-term handicaps is again clearly emphasised in a recently published discussion document by the Liaison Committee of the British Paediatric Association and the Royal College of Obstetricians (1978). The report considers as a minimum requirement the universal provision of adequately trained staff to provide a twenty-four hour service for resuscitating the newborn and at least short-term intensive care.[19] It also recommends that adequate facilities and resident paediatric staff should be provided throughout the twenty-four hours in all consultant obstetric units. However, the financial constraints currently confronting the maternity services are likely to pose a formidable obstacle to developments along these lines and to attempts at reducing existing regional inequalities in the provision of care (Table 9).

19 The British Birth Survey of 1970 showed that the onset of respiration was delayed by more than three minures in 4.7 per cent of infants; over half (53 per cent) of all deaths in the first week occurred in this group.

Table 10 *Programmes for perinatal prevention in the French Sixth Plan: Allocation of additional resources 1971*

	Percentage of additional resources
1 Medical education: Twelve new chairs of obstetrics, ten new chairs in neonatal medicine, and consequential staffing.	5·2
2 Records and research: Collection of data on all pregnancies and confinements, introduction of new maternity book.	4·9
3 Inoculation against rubella: All girls by thirteen and all women working with children.	11·2
4 Antenatal care: Increase in number of antenatal visits and establishment of referral centres for women at risk.	58·6
5 Obstetric departments of teaching and district hospitals: Increase in staff and equipment	11·2
6 Enforcement of minimum standards for resuscitation of the newborn: Enforcement by law of standards for construction, size, equipment, and staffing of all maternity units.	3·2
7 Intensive care units for the newborn: Establishment of twenty new major units in teaching hospitals.	5·7

Source Wynn and Wynn, 1976.

In this context it is noteworthy that the cost of caring for a single severely handicapped individual throughout a life of fifty years (about £250,000) has been equated with the annual revenue and expenses needed to pay for optimal perinatal care throughout an NHS district (*British Medical Journal*, 1978).

The French approach

In contrast to the British experience, the French, whose early infant mortality rates showed substantial declines between 1971 and 1974, demonstrated concern for the prevention of handicap at the beginning of the decade. This stemmed from the belief that it was more desirable to spend money helping women to have healthy babies than to incur much larger expenditures later on in caring for handicapped people.[20]

20 The cost of congenital handicap was estimated to be £2,000 million annually at 1976 prices.

Table 11 *Risk estimates for an unfavourable outcome to pregnancy*

Outcome	*1st Incidence*	*After 1 incident*	*After 2 incidents*
Early miscarriage	1 in 6·7	1 in 4	1 in 4[1]
Perinatal death (about one half stillborn)	1 in 50	1 in 25[2]	Probably greater than 1 in 10
Severe congenital abnormality among the liveborn	1 in 50	—	—
Non-specific multiple congenital abnormality	—	1 in 30	1 in 10
Non-specific mental subnormality	—	1 in 30	1 in 8

Source Blank 1977a.

Notes

1 For miscarriage after three months, the risk of two affected pregnancies may be higher.

2 Parity and previous miscarriage may be taken into account. At para four, after two or more miscarriages, risk may approximate 1 in 15.

A plan was introduced which was based on the observation that although 35 per cent of handicap occurs too early in pregnancy to be affected by antenatal care, the remaining 65 per cent is amenable to improvements in this area as well as in delivery, special neonatal care and in other measures taken after the end of the first trimester. It incorporated seven separate programmes (Table 10) and of these antenatal care attracted the largest share of additional resources.

It has, however, proved more difficult to improve standards than was hoped. In particular, there appears to be a lack of awareness of the importance of perinatal medicine. This is reflected, for example, in the finding that many antenatal examinations, particularly the first, are conducted in only a superficial manner, thereby devaluing the achievement of high rates of antenatal clinic attendance. A need also exists for more home visiting as a means of reaching those women who underutilise the antenatal services, notably the poor who are already at higher risk than other members of the community. In spite of these deficiencies, however, the French approach is instructive in the emphasis it places on the avoidance of handicap at the earliest stages of life.

Genetic counselling

Genetic counselling can be defined as the assessment and communication of specified risks in a given pregnancy although its function does, of course, extend considerably beyond this straight-

forward description. Much genetic counselling is retrospective by nature, that is, advice is often sought following the experience of an unfavourable outcome of pregnancy and may relate in particular to the hazards associated with further childbearing (Table 11 and Table 12, centre spead), their acceptability and the potential for reducing them. In recent years the scope and quality of information have improved with the development of better techniques both for detecting the carrier state for some conditions and for diagnosis in the antenatal period. There are now over twenty genetic advisory centres operating in the United Kingdom.

In addition to factors such as the quality of advice and the way it is presented, the response to 'retrospective genetic counselling', and hence the latter's success in limiting the occurrence of birth defects, will be determined in part by parental attitudes to further reproduction following the birth of an infant with an impairment. Available evidence points to a variety of behavioural patterns. Some parents may be so shocked by the event that they may resolve to have no more children in order to avoid any risk of enduring again such a distressing experience. Others may attempt to compensate for the disappointment by deciding to have another child as quickly as possible. A study by Record and Armstrong (1975) of births between 1964 and 1970 in Birmingham found that malformations which resulted in still birth or early death were more frequently followed by another birth and that the interval between these events was shorter than usual. In this respect malformations did not differ in their effect from other causes of still birth and infant death. The birth of children with severe malformations who survived, however, acted as a slight deterrent to further reproduction. This is perhaps to be expected in view of the exacting nature of the task of caring for children with these defects and the anxiety of parents regarding the outcome of another pregnancy.

Genetic counselling might have a greater impact on the incidence of impaired infants if it were possible to identify those high risk parents before they commence reproduction. But apart from the immediate obstacle of not yet knowing the precise causes of most defects a prospective approach would be fraught with many other difficulties. Little is known of the psychological consequences for the person to whom the label 'at risk' is attached nor about the social pressures that may be imposed on such individuals. Nevertheless, the opportunities for prospective genetic counselling are increasing: for example, the hazards associated with advanced reproductive age are now well known and there appears to be a raised level of risk where an epileptic woman is receiving medication. Further progress could perhaps be achieved if a close liaison existed between those concerned with

genetic counselling and those providing family planning. In recent years the latter function has increasingly become a responsibility of the general practitioner. This development in conjunction with a special knowledge of individual medical histories means that the GP is in a good position to identify and alert his patients to high risk situations, even though this information may not have been directly requested. At the same time as the scope for genetic counselling has expanded, its value in allaying fears about certain pregnancies and in assisting individuals to avoid giving birth to impaired children has increased with improvements in the field of antenatal diagnosis.

Antenatal diagnosis

Antenatal diagnosis of foetal abnormality, with the availability of facilities for abortion if necessary, is a central element in the avoidance of births of impaired infants and will continue to be so until substantial progress towards a clearer understanding of the causal mechanisms involved has been achieved.[21] Recent advances have included the development of techniques for analysing amniotic fluid and maternal serum and these are used in conjunction with the more traditional methods of physical examination, radiography and sonography.

Amniocentesis is the aspiration of amniotic fluid from the intrauterine cavity and its subsequent analysis which may take two forms. By culture of foetal cells it is possible to detect metabolic defects caused by the failure of certain enzymes and chromosomal aberrations of which that responsible for Down's syndrome is the most prevalent. Further, alphafetoprotein assay of the fluid may, by establishing high concentrations, indicate the presence of neural tube defects in the unborn infant. The procedure is most appropriately carried out at about sixteen weeks gestation when sufficient amniotic fluid is present to allow some to be removed with relative safety.[22] Investigation at this stage also leaves sufficient time for laboratory work and then termination, if necessary, to be carried out before the twentieth week of pregnancy.

21 It should be emphasised that *post*natal screening can, by indicating a need for early treatment, also reduce the numbers of infants developing certain handicapping complaints. The most obvious example of this is phenylketonuria (PKU) which if left to follow its natural course always leads to mental impairment. It is controlled by the employment of a special dietary regime in the first three years of life. All babies in Britain are screened for PKU which affects one in 10,000 births.

22 Prior to the withdrawal of the fluid, ultrasonography is used to locate the placenta and to exclude the possibility of twins.

A number of hazards are, however, associated with the technique of amniocentesis in terms of the accuracy of the method of assay or cell culture and the potential harm to mother and foetus.[23] Blank (1977c) has suggested that, in testing for Down's syndrome and trisomies, in perhaps one per cent of cases the specimen fluid is contaminated by maternal tissue and that these rather than foetal cells are karyotyped. There is also a possibility of about 5 per cent of the foetal cell cultures being unsuccessful. The maternal risks appear to be minimal but for the foetus they are much more significant. The incidence of induced abortion is estimated at around one per cent (Nadler and Gerbie 1970; Milunsky and Atkins 1974) which would imply a theoretical loss of approximately 6,000 births in England and Wales each year assuming universal application of the technique of amniocentesis.

However, a recent prospective study (NCHD 1976) showed no significant increase in foetal loss among 1,040 women undergoing amniocentesis (3.5 per cent) when compared with the loss among 992 matched controls (3.2 per cent). It has been suggested that if these results are confirmed (an MRC investigation is currently in progress) then the indications for the techniques will have to be re-evaluated (*British Medical Journal*, 1977).

The outcome of the present concern about the hazards involved is that amniocentesis is restricted to those groups known to be at particularly great risk of giving birth to infants with Down's syndrome or neural tube defects. In the case of the former, this is made possible by knowledge of the effect of advanced reproductive age. It has been observed that 14 per cent of all infants with Down's syndrome are born to women of more than forty years of age and 30 per cent of affected individuals to those aged over thirty-five years. It is therefore argued, on the criteria of minimising risk and, less importantly, on economic grounds, that amniocentesis should be offered to all women over thirty-five years of age and to those who have previously had an affected child (DHSS 1977). Yet it has been estimated (Forster 1977) that

23 About 130 diseases are known to be associated with a specific genetic biochemical defect but the actual abnormality in skin fibroblasts obtained at amniocentesis has only been demonstrated for about sixty of them and currently it is only possible to screen pregnancies for some thirty conditions with reliability (Update 1978). The incidence of genetic metabolic disease in the population is small, but since the risk to children or siblings of those affected is high, the use of amniocentesis where possible in these pregnancies may play an important part in reducing associated handicaps without incurring unacceptable screening related risks. In contrast, Down's syndrome is by itself a major cause of handicap. But because most cases are the result of spontaneous accidental fault during the division of germ cells rather than inherited from a previous generation, many mothers at risk are not easily identified and so the employment of amniocentesis is relatively restricted.

only 20 per cent of women over forty years of age are at present being screened for chromosomal disorders. Ferguson-Smith (1978) has reported an even lower figure of 10 per cent for the UK in 1976.

Unfortunately, women who have a relatively greater chance of giving birth to an infant with neural tube defects are not so readily identified: more than 90 per cent are first events which are unlikely to generate any suspicion of an unfavourable outcome to the pregnancy. However, the recent development of a test for assaying alphafetoprotein in the mother's blood has offered a solution to this problem.

Maternal serum analysis for neural tube defects

Following the discovery in 1973 of a diagnostic link between raised maternal serum alphafetoprotein (AFP) and anencephalus (Brock *et al* 1973) a recent nineteen centre study of the former as a method of screening for neural tube defects concluded that it was an effective means of selecting women for further investigation with ultrasonography and amniocentesis (Wald and Cuckle 1977). It was established that the best time to discriminate between normal and abnormal pregnancies is between the sixteenth and eighteenth week and that a maternal serum AFP measurement of 2.5 times the median value for normal pregnancies obtained in individual assay laboratories should be taken as the critical level above which further investigation is warranted.[24] The detection rate is encouragingly high: at the above cut-off level for sixteen to eighteen weeks nearly 90 per cent of anencephalies and almost 80 per cent of spina bifida foetuses could be detected by maternal serum AFP screening. The cost would be that 3 per cent of women with normal pregnancies would be asked to undergo amniocentesis. (See also Table 13).

It should be emphasised that a high maternal serum AFP value is not, by itself, sufficient reason for termination[25] but an indication that further investigation (amniocentesis) is necessary. High levels found by the latter almost always point to neural tube defects. Nevertheless, present evidence (see for example Ferguson-Smith *et al* 1978) suggests that the former technique is sufficiently effective and inexpensive to warrant consideration of a policy of

24 A single cut-off point was not quoted so that regional variations in the incidence of neural tube defects could be taken into account.

25 False positives can arise because of the considerable overlap of AFP values between normal pregnancies and those in which the foetus has neural tube defects. Multiple pregnancy and threatened abortion may also give high values. On the other hand false negatives will arise in that, for example, screening may not help to detect closed neural tube defects, which may represent 5 to 10 per cent of the total. It has been suggested, however, that the majority of these can be repaired surgically and have a good prognosis (Laurence 1974).

Table 13 *The effect of screening by maternal serum* AFP *under different conditions on the generation of 'unnecessary' amniocentesis*

Incidence of neural tube defects/1,000	*Upper limit of normal range (centile)*	*Amniocentesis rate/1,000*	*Detection efficiency per cent*	*Rate of 'unnecessary' to 'necessary' amniocenteses*
10	98	20	50	3:1
6	98	20	50	6:1
10	95	50	70	6:1
6	95	50	70	12:1
4	95	50	50	24:1
2	95	50	50	49:1

Source Blank, 1977b.
For example, where the incidence approaches 10 per 1,000 births, as in South Wales, and the upper limit of normal is taken as the 95th centile, the ratio of unnecessary to necessary amniocenteses would approximate 6:1, with 70 per cent of neural tube abnormalities detected antenatally. But if only those readings above the 98th centile are investigated further, the estimated ratio of unnecessary to necessary amniocenteses falls to 3:1, but the detection efficiency drops to 50 per cent.

general screening and a letter from the DHSS discussing this possibility has been sent to the Regional Health Authorities and various professional bodies.

A number of reservations have been expressed, however, concerning the technique itself, the implied increase in the use of amniocentesis and the desire on the part of some individuals to adopt a universally available scheme as rapidly as possible.[26]

One particular drawback is the short time available for the procedures involved: the determination of maternal serum AFP at sixteen to eighteen weeks, the recall of women for repeat blood sampling, ultrasonography to exclude multiple pregnancy, to correct the gestation and to locate the placenta and amniocentesis all have to be undertaken in time for termination, if indicated, by twenty to twenty-four weeks. The problem is enhanced by the fact (discussed earlier) that some women delay reporting their pregnancy[27] which will of course inhibit the undertaking of antenatal diagnosis.

Some workers are particularly concerned about the potentially greater number of false positives which may be encountered if a universal screening programme is adopted. But the introduction of the testing at the earliest possible stage of pregnancy in order to allow time for checking ambiguous results would help to overcome this problem.[28] It would also permit more opportunity for the family involved to decide about termination before this be-

comes legally and gynaecologically difficult (Walling 1977). In this context, it would be necessary for the currently existing facilities for genetic counselling to be extended in order to meet the inevitable increased demand for information and advice.

The Royal College of Obstetricians and Gynaecologists and some individuals (for example, Harris 1978) have emphasised the dangers of hastily implementing a routine screening policy. In particular it is considered that recent studies may have generated somewhat misleading results in that they have been based on tests carried out by experts in well equipped centres. Given the current level of resources and the numbers of adequately trained staff which should ideally be available it is unlikely that such favourable conditions would prevail equally in all regions in the immediate post-experimental phase. Consequently it is feared that a more extensive use of screening would be accompanied by a raising of the general level of risk by, for example, enhancing the possibilities of misinterpretations of the blood test findings and, by leading to unnecessary amniocenteses, of increasing the frequency of technical mishaps, such as mistaking the location of the placenta or the faulty placement of the needle.[29]

The logistics of a maternal serum screening programme also raise contentious issues which are in many ways closely related to the problems considered above. Organisation in a few laboratories on a central basis would have economic advantages in the current period of resource limitation and need not inhibit the technical capacity necessary for coping with 600,000 or more annual pregnancies. But a screening policy must take account of local variations in the incidence of neural tube defects as well as in the skilled manpower and resources available for the clinical management of patients.

26 For example, around 200 members of Parliament signed a Commons Motion, tabled in January 1978, urging the immediate go-ahead for routine spina bifida screening for all pregnant women.

27 Clark (1977), examining the hypothetical effect of a neural tube defect screening programme in Leicestershire estimated that only 55 per cent of women had visited a hospital antenatal clinic by the eighteenth week of pregnancy. Forster and Davison (1977), in their work on Down's syndrome, found that late hospital antenatal attendance was significantly related to high parity and a mother's country of origin being outside the British Isles. Furthermore, there was no significant association between early attendance and a history of still birth or previous malformed child.

28 Weiss and his colleagues (1978) have drawn attention to the potential value of amniography in clarifying the findings of amniocentesis in certain cases.

29 In this context, Gordon and his colleagues (1978) have emphasised that the availability of an experienced ultrasound unit is essential in reducing the hazards of amniocentesis.

It has been suggested that local laboratories would be more responsive to local needs and, perhaps more significantly, may be able to produce results more rapidly than a centrally organised system. Further, local arrangements may encourage invention and innovation whereas á centralised system, enmeshed in an extensive workload, may have less scope for experimentation which may in turn inhibit the development of superior methods of measuring serum AFP.

Finally, the use of antenatal screening techniques inevitably raises complex ethical issues. Selective abortion is in direct conflict with the beliefs of those who consider that life should be preserved at all costs. Others fear that a rise in the number of abortions of foetuses with genetic or developmental defects may change society's attitude to handicapped children or that the stigmatising effects of impairment may be increased for those infants which escape detection and abortion.

The fact that abortion is the only 'treatment' offered in the event of a positive test result presents few problems for individuals who immutably reject the concept of termination and for those who find no difficulty in contemplating such action. For others who accept abortion as a regrettable necessity only when there seem to be strong reasons for it, however, the problems are much harder. In the past, amniocentesis has mostly been offered to women with strong reasons for wanting to know whether their unborn babies were normal (for example, those of advanced reproductive age or those who have already given birth to an abnormal child) and who are thus likely to have examined carefully the consequences of accepting the test. But if screening is offered to all pregnant women there is a danger that a certain proportion will make use of it without being fully aware of the potential outcome of such action. Some will give positive test results requiring previously unforeseen decisions to be made quickly about further screening and possible abortion. These problems emphasise the need for each individual to be offered as much information and advice as possible so that satisfactory personal choices can be made. They also point to the importance of dispelling any doubts about the voluntary nature of the test (Dunelm 1978).

THE COSTS OF CARE AND PREVENTION

The diverse nature of defects which present at or from birth and the differing levels of accompanying physical and mental impairment imply that the associated economic costs are similarly wide ranging in both nature and magnitude. Thus an overall estimate of the cost of congenital abnormalities (chosen because they are readily identifiable as ICD numbers 740–59) to the hospital services[30] would disguise the fact that much of the expenditure is incurred by infants and children (Table 14) as well as the considerable variations in the length of inpatient stays. Spina bifida patients, for example, experience an average inpatient spell which is double that for all of these conditions together.

Table 14 *Congenital abnormalities: Hospital discharges and deaths of children, England and Wales, 1974*

Age	*Discharges and deaths*	*As a percentage of all abnormality discharges and deaths*	*As a percentage of all discharges for the age group*	*As a percentage of all inpatient days for the age group*
Under 1	15,810	18·8	8·2	14·9
1–4	17,150	20·4	7·5	14·6
5–9	17,980	21·4	6·7	13·3
10–14	13,170	15·7	7·3	9·8
0–14	64,110	76·3	7·4	13·4

Source HIPE 1974.

A large proportion of the overall economic burden stems from the care of affected individuals rather than from readily identifiable therapeutic measures and includes, among others, the costs of accommodation in institutions for the mentally handicapped and expenditure on special education.[31] Imprecise knowledge of the numbers of individuals making demands on the health and welfare services, the extent to which they do so and the availability

30 Congenital defects account for 1.47 per cent of hospital inpatient days in England and Wales implying a cost to the hospital services of approximately £50 million in 1976. The estimated number of discharges and deaths increased by 54 per cent between 1964 and 1974 to 84,050.

31 The cost per inpatient-year in a mental handicap hospital in England was about £3,300 in 1975–76. Glass (1976) has derived the following education costs:

Nursery school	£ 639 per annum
Ordinary primary	£ 287 per annum
Ordinary secondary	£ 436 per annum
Special day school	£1,600 per annum
Special residential school	£3,000 per annum

of only crude estimates of the relevant costs mean that an overall evaluation of the financial implication of birth defects is likely to be inaccurate and misleading. Furthermore, such estimates in relating to a given point in time conceal the possibility that an individual's needs and abilities may alter with a consequent modification of his or her demands on the health and social services.

Progress in antenatal diagnosis, with the possibility of selective termination of affected pregnancies, has drawn attention to the potential financial and emotional savings to be gained by preventing the births of infants with severe physical or mental impairments or both. In particular, this has centred on the employment of cost-benefit techniques to determine the scope, in economic terms, for extending the use of antenatal screening programmes. This means of analysis permits the immediate costs of screening to be compared with the savings resulting from not having to care for severely handicapped children which only accrue over time. The method of comparing current costs with future savings involves the use of a discount rate which reduces the present value of all delayed savings (or expenses).

One example of the use of cost-benefit analysis in this field was the examination, undertaken by Hagard and Carter (1976), of the financial feasibility of providing routine antenatal diagnosis of Down's syndrome with termination of affected pregnancies for older pregnant women resident in the West of Scotland. They found that the potential economic benefits would be greater than the costs for women aged forty or over, probably about equal to costs for those aged thirty-five and over, but less than costs if the service were extended to women under thirty-five. The economically justifiable programme (those aged thirty-five years or more) would however only result in the detection of up to one-third of all cases. The study had the desirable effect of emphasising the importance of examining such problems in the context of long-term perspectives. Nevertheless it is clear that society's response to Down's syndrome cannot rest on consideration of economic costs and benefits alone.

The technique has also been used to evaluate maternal serum screening for neural tube defects. The relative cheapness of the test for spina bifida – less than £3 per head with a detection cost varying from £1,000 to £4,000 per case, depending on regional incidence – superficially appears to indicate that the universal application of a screening programme with termination of affected pregnancies would incur considerably less expense than the care and education of those severely affected children who survive into adulthood. However, a cost benefit study by Hagard, Carter and Milne (1976) concluded that 'on economic grounds,

screening may only be worthwhile in populations in which the incidence of spina bifida is high'. To some extent the explanation for this finding lies in the application of a 10 per cent per annum discount rate to future savings which, although giving a benefit cost index of 1.86 to 1, effectively reduces by two-thirds the present value of the lifetime benefits for an avoided cohort of spina bifida births.[32]

The calculations are also highly sensitive to many other inputs to the analysis. The authors point out, for example, that a more rigorously selective approach than that prevailing at present to identifying spina bifida babies for surgical intervention may, by reducing the number of survivors, produce smaller economic benefits from a screening programme.[33] Similarly, the assumption that 90 per cent of women would attend an antenatal clinic at the appropriate time for screening could prove unrealistic and significantly modify the outcome of the analysis. The effect of a 50 per cent attendance, for example, would be to diminish the value of the benefit cost index from 1.86 to 1.44. Another area of uncertainty concerns public acceptance of antenatal diagnosis and selective pregnancy termination and the extent to which attitudes may change over time. Although experience suggests that only a small percentage of pregnant women at higher risk would not wish amniocentesis and selective abortion, the authors calculated that a refusal by 30 per cent of those screening positive would lower the benefit cost index from 1.86 to 1.37. Finally, the sensitivity of the screening test itself is clearly an important factor in the analysis. A level of 80 per cent would generate a benefit cost index with a value greater than one in all regions of the UK for which reliable spina bifida birth incidence data exist (Figure 9). But if test sensitivity was only 20 per cent then even in those areas where this particular birth defect occurs most frequently the index would not reach unity, implying that society would be economically better-off by not introducing a screening programme.

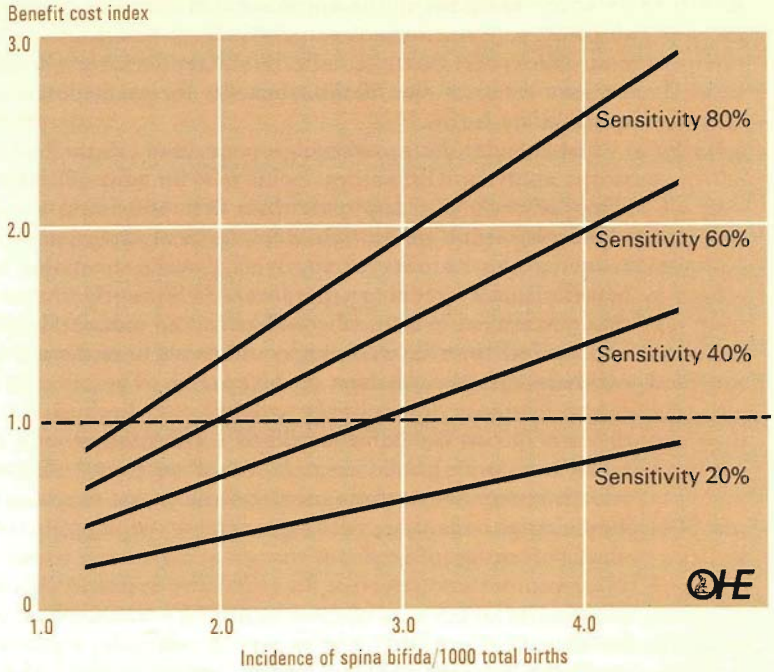
The DHSS (Glass 1976) has undertaken a cost-benefit study along similar lines, although modifying certain assumptions,[34] in order to assess the economic consequences for the public sector of a spina bifida screening programme. It was estimated that where

32 The use of a 5 per cent rate would raise the benefit cost ratio to 3.07 to 1 whereas a 15 per cent rate would lower it to 1.39 to 1.

33 On the other hand, if there were fewer survivors more resources could be devoted to each; the prevention of additional births would thus generate greater resource savings and help to raise the value of the benefit cost index.

34 These related to doubts about Hagard *et al*'s estimates of the recurrent costs of the programme (for example, expenditure on publicity, reagent and antiserum and patient 'inconvenience' costs). Also the Hagard *et al* study was concerned principally with the West of Scotland rather than the country as a whole.

Figure 9 *Variation of benefit – cost index showing screening test sensitivity and incidence of spina bifida*



Source Hagard *et al* 1976.

the test discovers 75 per cent of cases of open spina bifida (and 90 per cent of anencephalus) the public sector costs avoided by preventing the birth of an affected cohort exceed the public sector expenditure on the screening programme within one year. The cost per case discovered would be £800. If the test had a sensitivity of 45 per cent the savings would exceed the costs by the fourth year, with a cost per discovered case of £1,350. Subsequently, Holtermann (1977) has reworked the data assuming a lower level of take-up of the test (66 per cent), a reduction in both total and spina bifida births (to 585,000 and 986 respectively) and that the testing would be undertaken in seventeen instead of five centres. The outcome is that the scheme would cost £1.1 million to set up and £0.6 million annually thereafter to run and would be self-financing by year two and making an overall 'profit' by year five.

It is thus clear that the results of cost-benefit investigations are highly sensitive to the assumptions adopted for the purpose of analysis and that the accuracy and realism of these preconditions

may diminish rapidly over time. In particular it is difficult accurately to forecast future trends in the care for the handicapped and thus the expenditure thereon. Similarly, advances in antenatal diagnosis and in medical and surgical technology, affecting incidence and survival rates, do not lend themselves readily to prediction. But perhaps a more significant shortcoming of such techniques is the tendency to concentrate on the economic effects of selected policy options which may obscure or devalue the social and emotional consequences of, in this instance, the birth of a malformed infant.

For the individuals concerned, physical and/or mental impairment will impose widely varying degrees of handicap. Considerable psychological distress, personal economic hardship, lost or diminished potential for self-achievement and family disruption may also be experienced by those caring for severely handicapped relatives. Tew and his colleagues (1977), for example, examined the matrimonial stability of 142 families in which a child with a neural tube malformation had been born and found that the divorce rate for families with a surviving child was nine times higher than that for the local population and three times higher than for families where the child had died. The omission of these and other factors in the studies described above implies therefore that economic cost-benefit analysis is of limited use in the formulation of policies concerning the introduction of screening programmes. Indeed, Hagard and his colleagues suggest that its value 'in the preparation of that kind of health service planning decision lies in the improvement in sophistication which it brings to the process'.

CONCLUSION

Substantial reductions in the incidence of infants born with physical or mental impairments or both will ultimately be dependent on a clarification of the causes and mechanisms involved in diverting foetal development from its normal course. In the short-term improvements must in the main be sought through the application of a wide range of both general and specific preventive measures. For example, increased public awareness of the extent to which infant and child morbidity and mortality stems from birth defects coupled with an intensification of genetic counselling activities may help to reduce the occurrence and reoccurrence of these conditions by encouraging more people to seek advice about childbearing and to make full use of the available maternity services.

A more direct means of avoiding the birth of infants with certain defects involves the use of antenatal screening with term-

ination of affected pregnancies.[35] The major technique currently available is amniocentesis which facilitates the detection of two of the most handicapping conditions of childhood – Down's syndrome and spina bifida. But persistent doubts about the medical risks inherent in the procedure have served to restrict its use to those cases known to be at greatest risk. However, the development of an initial maternal serum test for selecting those individuals for amniocentesis by showing them to be more likely to give birth to an infant with neural tube defects has provided a partial solution to the problem. It is generally agreed that there is a strong case for a maternal serum screening programme but it has been argued that increased resources, more experience and a greater knowledge of potential problems should be gained before it is introduced on a routine nationwide basis.[36]

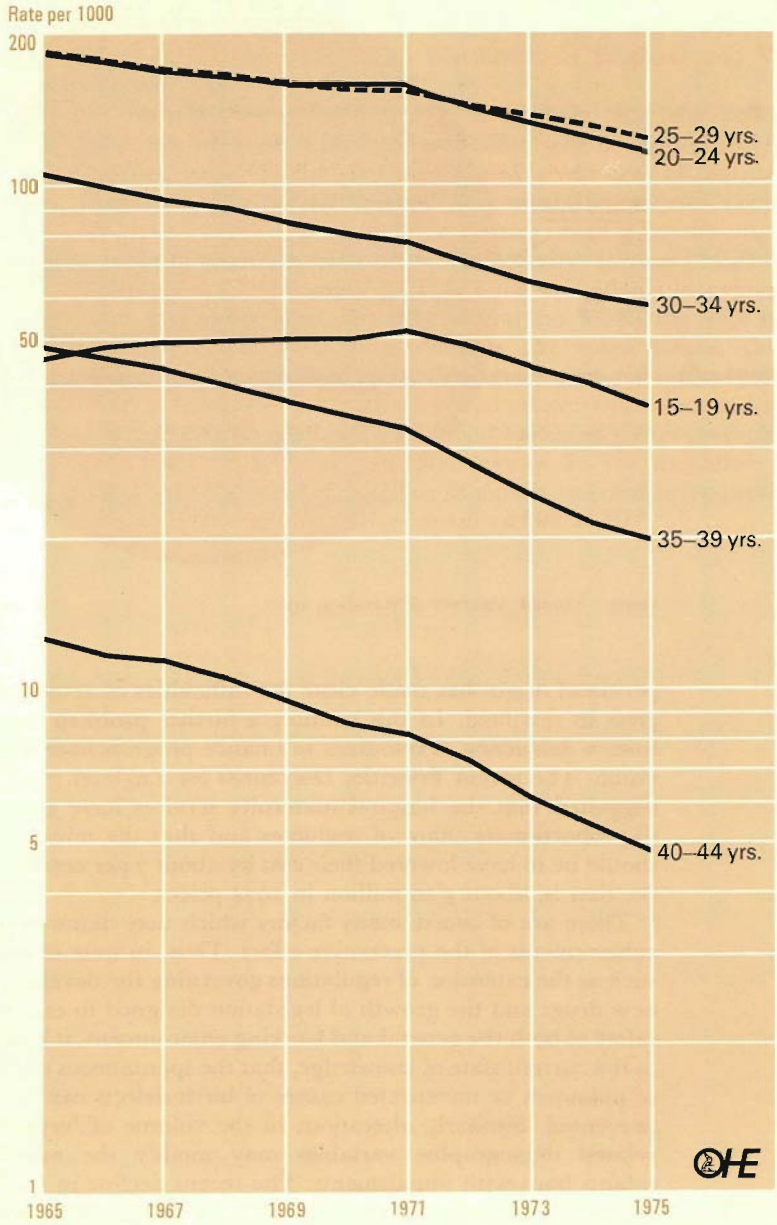
Antenatal screening is a relatively young science and there is still considerable scope for progress, not just in the improvement of the accuracy and safety of existing techniques but in its application to other types of foetal malformation. Developments along these lines (for example, an initial screening technique appropriate to Down's syndrome) and a higher degree of acceptance for the concept of antenatal diagnosis and pregnancy termination may in future reduce the number of births of impaired children. But a preventive approach of this nature is clearly not a complete panacea. Coverage of all pregnancies is unlikely ever to be achieved and tests may on occasions produce erroneous results. Furthermore, the incidence patterns of many birth defects are such that the programme would not be self-limiting – the elimination of a certain proportion of impaired foetuses from a given cohort of pregnancies would not appreciably reduce the incidence of defects in future generations – and would have to continue until all causes are discovered and removed.

Improvements in antenatal care, with particular emphasis on encouraging earlier reporting of pregnancy, have also been considered as a means of reducing the occurrence of birth defects – notably cerebral palsy. But the experience of the French who have developed specific programmes aimed at reducing handicaps of

35 In 1977 in England and Wales approximately 1 per cent of all officially recorded abortions (resident women) were carried out because of a substantial risk of abnormality. A more detailed analysis of these statistics is given in the Appendix.

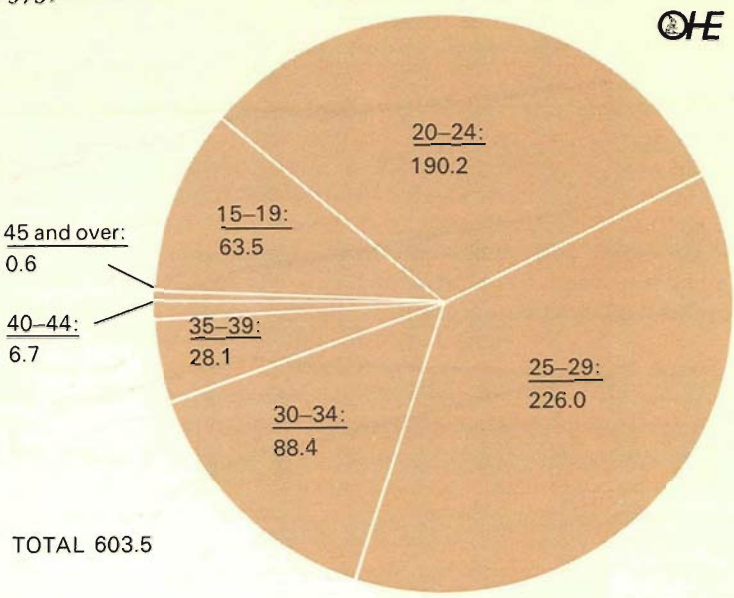
36 Current investigations include a DHSS sponsored feasibility study in Cardiff on incorporating the test into routine antenatal care, a working group set up under the chairmanship of Sir Douglas Black 'to advise on what guidance might be given to health authorities on the introduction into routine antenatal care of a service to detect neural tube defects' and an examination of the ethical problems by a working group chaired by the Bishop of Durham.

Figure 10 *Live births: rates per 1,000 women by age of mother, England and Wales, 1965–75*



Source Annual Abstract of Statistics, 1977.

Figure 11 *Live births by maternal age group, England and Wales, 1975, thousands*



Source Annual Abstract of Statistics, 1977.

perinatal origin has made clear the difficulties of achieving progress in this field. In this country a further problem may stem from a deficiency of resources to finance progress in service provision. The recent Priorities Document for England (DHSS 1976) suggested that the hospital maternity services have attracted a disproportionate share of resources and that the minimum aim should be to have lowered their cost by about 7 per cent by 1979–80, that is, about £10 million in 1974 prices.

There are of course many factors which may detract from the achievements of the preventive effort. Thus, in spite of measures such as the extension of regulations governing the development of new drugs and the growth of legislation designed to enhance the safety of both the general and working environment, it is unlikely, in the current state of knowledge, that the spontaneous occurrence of unknown or unexpected causes of birth defects can be totally prevented. Similarly alterations in the volume of births and in related demographic variables may modify the numbers of infants born with impairments. The recent decline in the former has been accompanied by a fall in OPCS notifications of abnormalities despite slightly increased incidence rates. More significant

will be changes in the age structure of the childbearing population. An encouraging sign, however, has been the sustained reduction in the live birth rate among women aged thirty-five years and over (Figure 10.) In 1975 this age group accounted for less than 6 per cent of all live births in England and Wales (Figure 11).

In the immediate future it is unlikely that the collective balance of these and other variables will be significantly disturbed implying that between 3 and 4 per cent of infants will continue to be born with physical or mental impairments or both. The latter embrace, of course, a diverse range of conditions, each presenting with varying degrees of severity. In many cases treatment is available which permits some individuals to experience full and enjoyable lives with little or no handicap. The major problems are posed by conditions like spina bifida, Down's syndrome and cerebral palsy. The severe personal difficulties they generate for affected individuals and relatives and their combined significance in infant and childhood handicap patterns emphasise the need for research into their causes. In the meantime they highlight the value of resolving as rapidly as possible the problems faced in current preventive measures.

APPENDIX I

Analysis of notified abortions by maternal age and certain grounds, England and Wales, 1977

	All Abortions		*Abortions carried out because of risk of abnormality*			*Abortions carried out because of risk of abnormality combined with risk of injury to health of mother*		
	Number	*Per cent*	*Number*	*Per cent*	*Rate per 1,000 abortions*	*Number*	*Per cent*	*Rate per 1,000 abortions*
Under 16	3,592	3·5	2	0·3	0·56	8	1·1	2·23
16–19	24,371	23·8	49	7·0	2·01	57	7·7	2·34
20–34	57,325	56·1	481	68·2	8·39	342	45·9	5·94
35–44	14,768	14·4	151	21·4	10·22	286	38·4	19·37
45+	528	0·5	10	1·4	18·94	32	4·3	60·60
Not stated	1,653	1·6	12	1·7	7.26	20	2·7	12·10
	102,237	100	705	100	6·90	745	100	7·29

Source OPCS Monitors on Legal Abortions.

APPENDIX II

Analysis by grounds of notified legal abortions carried out under the provisions of the Abortion Act 1967, Single and married women residents, England and Wales, 1977

Grounds for abortion	*Number*	*Per cent of total*
Risk to life of woman	828	0·8
Risk of injury to physical or mental health of woman	85,275	83·4
Risk of injury to physical or mental health of existing child(ren)	2,367	2·3
Substantial risk of child being abnormal	705	0·7
In emergency – to save life of woman	3	—
In emergency – to prevent grave or permanent injury to physical or mental health of woman	9	—
Risk of abnormality and injury to woman's health	745	0·7
Risk to health of existing child combined with other risks	12,305	12·0
	102,237	100

Source OPCS Monitor on legal abortions.

Note In 1976, 253 pregnancies of women resident in England and Wales were terminated for reasons associated with German measles (disease itself 57 per cent, contact 27 per cent and German measles immunisation 16 per cent). These represented 0.25 per cent of all abortions. In 1972 there were 776 (0.72 per cent of the total) terminations for these reasons.

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