DEPARTMENT OF COMMUNITY HEALTH

UNIVERSITY OF CAPE TOWN

BIRTH WEIGHT AND INFANT MORTALITY
IN A WESTERN CAPE METROPOLITAN AREA

by

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ABSTRACT

The nature of the environment, as well as an infants weight at birth, constitute the major risk factors associated with infant death. It is for this reason that the infant mortality rate is universally recognized as an important indicator of the health status of children, the efficacy of the health services, and the level of social and economic progress. An infants birth weight is regarded as the most important single indicator of growth and development during uterine life, and as such is frequently used to indicate maternal nutritional status. The greatest risks of mortality and morbidity exist for those infants who are born with a low birth weight (<2500 grams). Any analysis of infant mortality, therefore, requires a sound understanding of the influences of birth weight on mortality. In this study, birth weight and infant mortality data have been used to characterize maternal and infant health status within a Regional Health Scheme. The cross-linkage of birth and infant death certificates has permitted the identification of those maternal and infant characteristics associated with the greatest risks of death, as well as the calculation of one of the most important infant mortality statistics, namely birth weight-specific death rates. The cross-linkage process has facilitated the identification of certain factors which are effecting the levels of infant mortality. The development of a statistic (ratio) for better describing the birth weight distribution is presented. Such a statistic is shown to be of value for the geographical analysis of maternal health status. Linear regression analysis applied to the birth weight ratio and infant mortality rate is able to compare the 'health status' of mothers and infants in separate geographic units within the region. Birth weight is shown to be an important intervening variable between the circumstances of pregnancy and infant death. This study provides an alternative perspective to the understanding and assessment of infant mortality and its spatial variation, as well as aiding the identification of possible points for future intervention. The technique presented forms a useful epidemiological basis for the implementation of more appropriate strategies for reducing infantile mortality and enhancing the evaluation of interventive programmes. Moreover, the application of medical geographical methods is shown to provide practical advantages to health administrators in that maternal and neonatal health priorities may now be more reliably defined, as well as for the determination of future services in the various geographical areas.

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CHAPTER I

INTRODUCTION

The risk of dying, for infants, is not only closely related to the nature of the environment in which they live, but also to their weight at birth. In order to reduce infant mortality it is necessary to determine points of appropriate intervention in the cycle of morbidity by the maternal and child health care services. To achieve this requires knowledge and understanding of the medical and social components which dictate the levels of infant death. One of the central issues is obtaining the required data necessary so as to appreciate the magnitude and extent of infant mortality. Only then is it possible to develop a health care delivery system which will be able to respond to, and ultimately lower, the infant mortality rate.

For a health care system to be adequate and appropriate to the needs of a community it serves, health care planners should aim at an appropriate distribution of resources, based upon the demand of that community. Obviously the demand is related to its health care needs, which in turn is a function of its health status. Thus if the health status of a community could be evaluated, its needs could be assessed and appropriate action taken. Further, the demand for health care is not static, but dynamic both spatially and temporally. It is thus important that health data be gathered and analysed according to both of these dimensions. For example, health planning programmes in the United States which are directed towards the regionalization of infant health services emphasize the need for 'health' statistics by geographic units (Ryan, 1975; Kleinman et al, 1976).

The provision of health services thus requires a scientific basis for the definition of service priorities. In the light of the limited resources available, it is crucial that health care planning processes are able to identify optimal methods of controlling priority problems while still permitting effective utilization of resources. Epidemiology and geographical techniques of analysis have been shown to be useful in developing a rational basis for optimal health service planning. They have also demonstrated the capacity to incorporate methods of surveillance and evaluation into health care programmes in order to both assess services and to ensure that these very same services remain sensitive to the health needs of the community.

The health needs of infants and young children in developing countries are largely unknown because of the lack of health statistics concerning both infants and pregnant women; the health of the mother being itimately related to that of the child. If we wish to improve the health status of infants and mothers, it is necessary to know the numbers, the whereabouts and the nature of the hazards they encounter in order to determine their priority needs and problems. Maternal and infant health is more often than not measured in the negative terms of morbidity and mortality, because 'positive' measures of health status are difficult to routinely collect and calculate. The use of mortality rates for purposes of health planning and evaluation is at best a difficult exercise and one that needs to be approached with a degree of caution. Yet for the lack of better alternatives, such indicators must often be relied upon.

The Infant mortality rate (IMR) has long been considered one of the most reliable indices of the general health of a population (Todsen, 1980). Infant mortality occupies a special position in vital statistics, not only because of its value as an indicator of loss of life, but also because of its close correaltion with social conditions. The association between infant death, poor housing conditions and other socio-economic factors is widely recognized (Bradshaw et al, 1982. p 11). So strongly does infant mortality affect the crude death rate of a population that they are generally regarded as the most important age-specific death records in a population. Infantile death rates are a reliable reflection of the standard of hygiene and nourishment in a population, as well as its standard of living and health care. Consequently, infant mortality is now accepted as being a sensitive barometer of the availability and effectiveness of certain types of social and medical services (MacMahon, 1974).

The patterns of infant mortality may be important for two reasons. Firstly, mortality is a useful indicator of the major health problems of a community. Unlike morbidity which is difficult to define and measure, mortality is more readily identified and easily counted. Second, an understanding of the epidemiology of mortality is fundamental to effective health planning (Chen et al, 1980).

Many methods are employed for calculating the infant mortality rate. Usually it is based upon the number of infant deaths (under 1 year of age) divided by the number of recorded live births for a given time period (normally a specific one-year period).

It is well known that infant mortality results from a wide variety of influences : congenital causes; availability and quality of medical care; and specific disease entities; as well as a wide range of socio-economic and environmental causes (Patel, 1980). The major factors considered by demographers to have a significant environmental effect on infantile mortality are access to food (nutrition), medical care, sanitation, and housing.

DEFINITION OF THE INFANT MORTALITY RATE

As previously stated, infant mortality comprises deaths of children under 1 year (<365 days) of age, and is usually expressed as a rate of 1000 live births during the same period.

Ordinarily infant mortality is defined as :-

$$\text{Infant mortality rate (IMR) (per 1000 live births)} = \frac{\text{Deaths under 1 year of age}}{\text{Live births}} \times 1000$$

However, because this study is concerned largely with the influence of birth weight on infant death, only live singleton births are considered in the anlaysis process for reasons enunciated in Chapter III. The IMR is re-defined as follows : -

$$\text{Infant Mortality Rate (per 1000 live singleton births)} = \frac{\text{Deaths under 1 year of age}}{\text{Live singleton births}} \times 1000$$

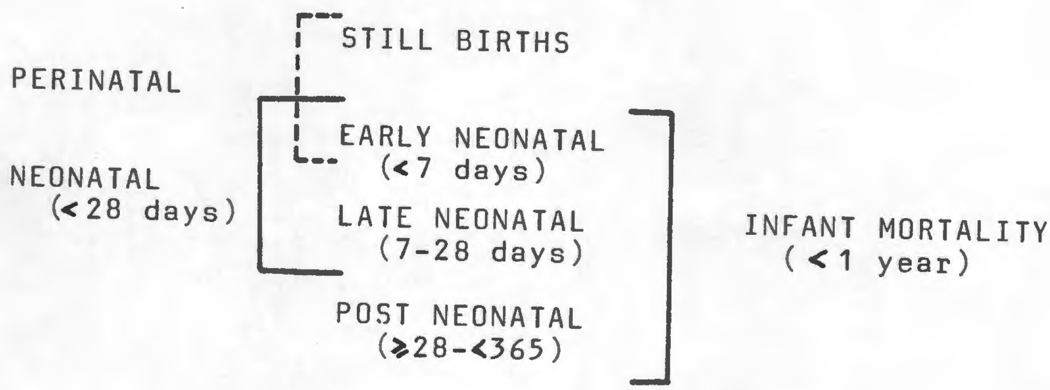
The difference made to the denominator (and hence the IMR) by excluding multiple deliveries is negligible.

One major problem bedeviling the comparison of IMR's on a national or local level is the question of reporting (notification) and the accuracy of the reporting itself. The level of reporting may also vary quite considerably from one area to another, thereby making some IMR statistics less accurate than others.

THE COMPONENTS OF INFANT MORTALITY

Comparisons between IMR's from different areas are made even more meaningful if the data is divided into two primary categories based on period-of-survival. The major componenets of infant mortality being (i) Neonatal, and (ii) Post-neonatal (Table 1). Neonatal deaths are those which occur during the first 4 weeks (<28 days) after birth, whereas post-neonatal mortality is defined as deaths occurring between the ages of 4 weeks and 1 year (28 - <365 days). These two compnents are equally significant criteria reflecting general living standards, particularly standards of health and health care in a population.

TABLE 1. COMPONENTS OF INFANT MORTALITY



The distinction between neonatal and post-neonatal mortality is also primarily a distinction of causality.

They are resonably realiable indicators of the roles played by endogenous or (congenital) and exogenous factors in causing infantile death. So-called endogenous deaths are those deaths which principally occur during the early-neonatal period (< 7 days), but also refers to those deaths taking place throughout the neonatal period (28 days). Such deaths are due to mostly non-preventable causes, and are primarily from the following causes :

- congenital malformations
- postnatal asphyxia and pulmonary atelectasis and
- nutritional maladjustment in early infancy

In Sweden, more than 80% of all infant deaths occur within the neonatal peiod, almost exlusively from such endogenous causes (O'Neill, 1980. p113).

By comparison, the New Zealand proportion is closer to 60% (ibid. p 114), with a corresponding larger proportion falling within the exogenous, or more easily prevented range of causes of infant death.

In less technologically advanced areas, infections of the newborn (particularly septicaemia and tetanus), birth trauma and low birth weight (associated with maternal malnutrition and infection) are mainly responsible for neonatal mortality (Harfouche, 1979. p 394)

On the other hand, exogeneous deaths are mainly due to external factors which are more likely to occur in the post neo-natal period, and are predominately caused by "environmental" or preventable factors, particularly infections and casualties after birth. The following represent the major causes of post-neonatal mortality:

- pneumonia
- diarrhoeal diseases
- accidents and
- infective and parasitic diseases

These types of infant mortality are undoubtedly a reflection of the medical and sanitary amenities and socio-economic conditions of a population (Todsen, 1980. p 380.)

Health supervision for an infant needs to be comprehensive during the first year of life. This factor is thought to be one of the most significant in the control of post-neonatal mortality in industrialized nations (McNickle, 1976). Ideally, health services and socio-economic conditions should be such that deaths in this (post-neonatal) period are minimal. The hazards of delivery and the postpartum period are past and unavoidable causes of death, should in general pertain.

In the United States it has been shown (Hunt and Huyck, 1966) that insufficient medical and health services, along with the under-utilization of existing services contribute to excessive infant mortality rates. On the other had, Patel (1980. p76) has recently demonstrated in Sri Lanka that the observed regional variation in infant mortality rates were strongly associated with regional variations in environmental determinants of mortality, rather than with regional variations in public health expenditure.

THE IMPORTANCE OF BIRTH WEIGHT

The weight of an infant at birth is probably the most important determinant of infant survival, as well as being a valuable indicator of growth and development during uterine life (Harfouche, 1979).

Indeed, it is also considered to represent an important developmental milestone and as such should be recorded on the birth notification form of every neonate.

Low birth weight (<2500 grams) neonates are probably one of the most challenging global health problems (Ibid; and Miller, 1983 . p 323), because they are associated with high rates of mortality and morbidity. Further, low birth weight also tends to give rise to a pool of children with malnutrition who are likely to be of small adult stature, thus perpetuating the problem, at least until 11 years of age (Illingworth,1979).

There is a paucity of vital statistics data in South Africa concerning birth weights of newborn infants. Information supplied when births are notified to a Local Authority provide an extremely useful, if not complete, body of analysable data when these notification forms include a birth weight measurement.

The physical maturity of a newborn infant can be judged by its weight at birth, or its gestational age (or both). Birth weight has been used more widely because it is accurately and completely reported. The accuracy of gestational age, however, depends on the mothers correct recall of the date of the last mentrual period. Because estimation of gestational length is subject to, potentially, large errors, birth weight is more often used to characterize the physical maturity of the infants.

There are two components to the influence of birth weight on infant mortality; that of the frequency distribution of birth weight; and the pattern of birth weight-specific mortality. The birth weight distribution is obtainable from elimentary analysis of the birth notification forms, whereas the derivation of the birth weight-specific mortality rates is a far more complicated procedure necessitating the cross-linkage of both birth notification and infant death certificates.

CROSS LINKAGE OF INFANT BIRTH AND DEATH RECORDS

The value of bringing together medical information about the individual was recognized by Farr (Editorial, 1969. p 203) more than 100 years ago and has been vigorously stressed since. A system of linked records, based on the individual, is of great importance to all who are professionally concerned with epidemiology and genetic research and the organization and efficiency of the health services. Among the more important subjects of immediate value that such a system would introduce will be to identify groups of subjects at special risk and requiring surveillance, and to create the opportunity for large-scale investigations of the inter-relationship between diseases (Ibid. p 204).

The cross-linking philosophy has been put into operation, for example by the State Vital Records Division of the State of Georgia (U.S.A.), as recently as October, 1976. All infant birth and death certificates are now cross-matched in an effort to identify the maternal and infant characteristics associated with the highest risks of death (McCarthy et al, 1980. p 977).

Birth weight-specific mortality curves exhibit features common to all human populations which have been investigated (Wilcox and Russell, 1983. p 319). Mortality is very high at the lowest birth weights but falls sharply as birth weight increases. It is at its lowest within the range of the most frequent birth weights and rises again for the heaviest birth weights. The distribution, which has been recognized for many years, can be best described as essentially Gaussian, but slightly peaked and with additional births in the lower tail.

The matching of birth and death certificates has provided an efficient means for producing the necessary information for health planning programmes directed towards the regionalization of perinatal and infant health services in California (Williams et al, 1980. p 559).

The recent growth of regional child health networks have increased the need for surveillance and monitoring the trends and variations in birth weight-specific infant mortality rates. Ideally, this type of system requires local, regional, and national systems of linked birth and death certificates.

GLOBAL INFANT MORTALITY

Table 2 shows the infant mortality rates per 1000 live births for developed and underdeveloped countries. It is a commentary on social and health progress that for the less developed countries the IMR's are often 10 times that for developed (First World) Countries.

On a regional scale (Table 3), a similar situation is observable with so-called developed regions having IMR's between 15 to 25% that of the less-developed areas.

TABLE 2. COMPARATIVE INFANT MORTALITY STATISTICS FROM VARIOUS COUNTRIES

COUNTRY	IMR+	
Bangladesh	132	
Upper Volta	160	"Underdeveloped"
Pakistan	200	
Sweden	10	
France	16	"Developed"
U.S.A.	18	

+ Rate per 1000 live births.

Source: U.S. and World Dev. Agenda for Action (1975) Overseas Dev. Council.

TABEL 3. INFANT MORTALITY RATES BY REGION (1982)

REGION	IMR+
Africa	121
Asia	91
Global IMR	85
Latin America	67
Developed Countries	20

+ Rate per 1000 live births.

Source: Draper Fund Report (1982)
Children : The right to be wanted.
No. 11. p 4.

Turning to the situation of infant mortality on a local scale, one finds that the overall IMR for the Greater Cape Town area during 1981 was about 25 per 1000 live births. This compares with the lower levels of IMR's reported in Table 3. However, if IMR's were to be calculated at the suburb level of spatial definition the rates may perhaps then appear to be less favourable, with possible large area variations being observable as well.

ADMINISTRATION OF HEALTH CARE IN THE GREATER CAPE TWON AREA

Health services within the Greater Cape Town area are administered by two Local Authorities, namely the Cape Town City Council (C.C.C.) and the Divisional Council of the Cape (D.C.C.) The former authority provides health care services to an area which is confined to the City of Cape Town (Fig. 1). The D.C.C., on the other hand, has been the controlling authority in a regionalized health scheme which is much larger in spatial dimension and composed of rural, peri-urban and urban residential areas. This constitutes what is known as the Combined Health Control Scheme (CHECS) region. The scheme is comprised of eight member (or partner) municipalities; two State Administration Board (SAB) controlled areas; and a large area under the administration of the D.C.C. The municipal areas embraced by the scheme are Bellville, Parow, Milnerton, Durbanville, Pinelands, Goodwood, Fish Hoek, and Simonstown, while the two SAB areas are the Nyanga Black Township and the Cross Roads "Squatter" area. The remaining area of the scheme, namely that of the entire D.C.C., has been partitioned according to the "suburb" boundaries as designated by the Technical Management Services Division of the C.C.C. (Table 4). For the purpose of clarity and ease of useage this geographic region will now be referred to as the CHECS region.

The Nyanga Black Township and the Cross Roads "squatter" area were originally under the control of the D.C.C. Since 1980, however, the State Administration Board has assumed control but the D.C.C. continues to provide health services in the area. The D.C.C. has, since 1977, also rendered health services in the area under the control of the Mamre Management Board. In effect the scheme now embraces the entire Cape Division with the exception of the C.C.C.

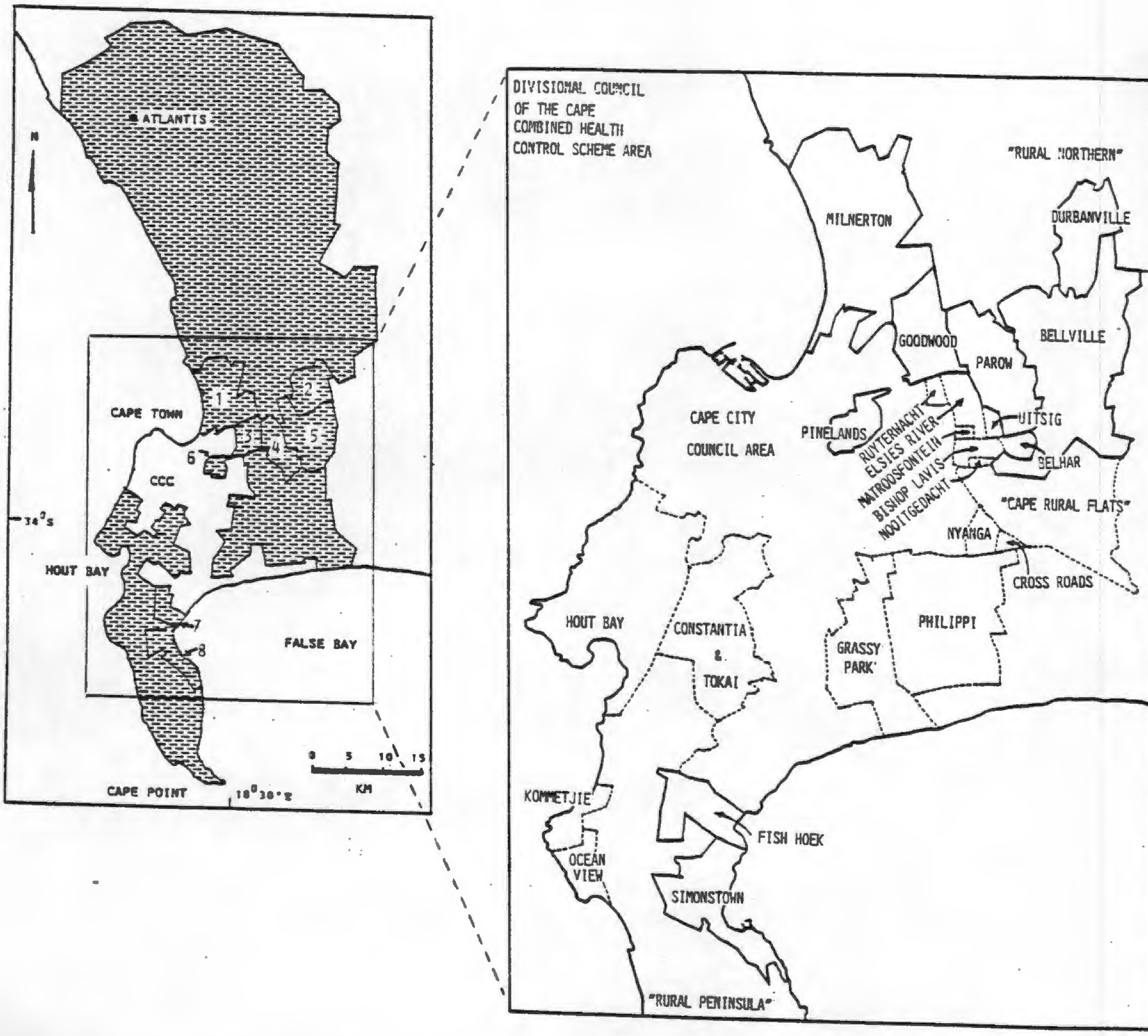


FIG. 1. THE COMBINED HEALTH CONTROL SCHEME REGION

The map on the left shows the locality and extent of the Combined Health Control Scheme (CHECS) region. The numbered areas refer to the member municipalities; 1 = Milnerton; 2 = Durbanville; 3 = Goodwood; 4 = Parow; 5 = Bellville; 6 = Pinelands; 7 = Fish Hoek; and 8 = Simonstown. CCC indicates the Cape Town City Council area which is not included in the scheme. The enlarged portion of the CHECS region (right) shows the member municipalities (solid lines) and "suburbs" (dotted lines) in more detail.

TABLE 4. LIST OF OVERALL AREAS WITHIN THE CHECS REGION

AREA NAME	
Milnerton	Municipalities
Bellville	Municipalities
Parow	Municipalities
Goodwood	Municipalities
Durbanville	Municipalities
Pinelands	Municipalities
Fish Hoek - including Sun Valley	Municipalities
Simonstown	Municipalities
Nyanga	State Administration Board
Cross Roads	State Administration Board
Atlantis	Divisional Council of the Cape
Mamre - includes Pella and Philladelphia	Divisional Council of the Cape
Melkbosstrand - includes Bloubergstrand	Divisional Council of the Cape
Rural Northern	Divisional Council of the Cape
Elsies River	Divisional Council of the Cape
Uitsig	Divisional Council of the Cape
Belhar	Divisional Council of the Cape
Nooitgedacht	Divisional Council of the Cape
Ruyterwacht	Divisional Council of the Cape
Matroosfontein	Divisional Council of the Cape
Bishop Lavis	Divisional Council of the Cape
Grassy Park - includes Zeekoevlei	Divisional Council of the Cape
Constantia	Divisional Council of the Cape
Hout Bay - includes Llandudno	Divisional Council of the Cape
Kommetjie - includes Ocean View and Scarborough	Divisional Council of the Cape
Rural Cape Flats - includes Lourdes Farm and Phillipi	Divisional Council of the Cape
Rural Peninsula	Divisional Council of the Cape

The CHECS region has an estimated total population of 602 000 (as at December, 1981), comprising 201 000 Whites; 337 000 Coloureds; and 64 000 Blacks.

In 1981 the gross cost of running the Combined Health Scheme was R 3 281 187. The Child health clinics recorded 367 331 attendances during the same period.

The lack of appropriate and timely 'health' information, especially on an area by area basis, in the CHECS region is preventing the development and assessment of appropriate (child) health services. (An example of this is the availability of birth weight measurements which were only routinely collected from the beginning of 1982). The result is that very little is quantitatively known regarding the distribution, influence, and effect which birth weight is contributing to the overall infant mortality pattern within the CHECS region, and more importantly, according to individual geographic units within this region.

THE DATA ANALYSED

The data used in this study are based upon information contained on the certificate of birth and infant death filed with the D.C.C. Local Health Authority. The data consist of all resident infant deaths reported during 1981, as well as all deliveries reported during the two-year period 1981-1982. The reason for collecting two years birth data is that some of the infants who died in 1982 would have been born not in that year but in the previous year (1981). This means therefore, that the numerator and denominator of all of the mortality rates do not quite correspond. Fortunately, the error introduced is quite trivial because the birth rates for this period are practically constant (see Medical Officer of Health, D.C.C. Annual Reports, 1981 and 1982). By matching the infant death record with the corresponding birth record it is possible to analyze infant mortality in terms of the detailed characteristics on either the birth or death certificate.

SOCIO-ECONOMIC STATUS INDICES

Research workers, for example Miller (1983), have drawn attention to the poor relationship between the occurrence of low birth weight infants and socio-economic status (SES).

Efforts to determine the specific socio-economic factors responsible for this poor relationship have been unrewarding. The limited role that SES has in the occurrence of low birth weight infants has been elegantly demonstrated by Miller (ibid). On the other hand, a significant relationship is known to exist between infant mortality and SES (Antonovsky and Bernstein, 1977). Although it is recognized that it would have been beneficial to a study of this type to have analysed the data in terms of SES variables, the 1980 census data were unfortunately unavailable at the time of this research. Consequently, no SES indices/ scores were available for the Greater Cape Town area. The 1970 indices were considered to be completely out-of-date to have made a meaningful contribution and were therefore ignored.

SUMMARY OF OBJECTIVES OF THESIS

It is the aim of this thesis to consider the major factors which influence infant mortality by characterizing maternal and infant health status through the medium of birth weight and infant death. An appreciation of the health status of pregnant women and infants may aid in the better planning (and assessment) of the health care services and possibly lead to a reduction in the infantile mortality rate within the CHECS region.

This study was undertaken with the object of showing that, while a separate analysis of birth weights and/or infant mortality is of academic and practical value, it is the analysis of both of these variables together which will be of considerably more value to the health care planner and community physician. This may be achieved through the process of cross-linking infant birth and death records, thereby identifying both maternal and infant characteristics associated with the highest risks of infant death. Further, it is not only individual characteristics which require elucidation, but residential areas need to be identified also. In order to achieve this, a technique needs to be developed to adequately assess the combined influence of birth weight and infant mortality. Thus a final objective of this study is an attempt to contruct such a technique in the hope that its application will permit the ready evaluation of priority "at-risk" areas, thereby facilitating the provision of appropriate preventive and promotive maternal and infant health care services to the affected areas.

The specific objectives addressed in this study include:

- An analysis of birth weight and infant mortality data (in the traditional way), as well as a presentation of these data according to medical geographic methods of spatial representation;
- A cross-linkage of infant birth and death records in order to derive birth weight-specific mortality rates for the CHECS region as a whole, so as to quantify the effect of birth weight on infant death;
- The development of a technique which will permit the definition and spatial analysis of different birth weight distributions; and finally
- An application of this technique in an attempt to assess the combined effects of birth weight and infant mortality for each geographic unit within the study area.

An assessment of the results of international research into the effects of birth weight on infant mortality, as well as the longer term sequelae resulting from low birth weight to the survivors, are presented in the following Chapter.

CHAPTER II

BIRTH WEIGHT AS A DETERMINANT OF INFANT MORBIDITY AND MORTALITY

Over the last decade, increasing attention within the field of infant health research, has been focused upon the role which the pre-natal environment and the outcome of pregnancy has on the subsequent health of an infant (Ashford, 1973; Puffer and Serrano, 1975; McNickle, 1976; Kleinman et al, 1978; Harfouche, 1979; Shapiro et al, 1980; OPCS, 1981; Gosh, 1982; Miller, 1983).

It is recognized that low birth weight is a major determinant of infant death and, to a lesser extent, ill-health. Moreover, the risk factors which increase the probability of infant mortality and morbidity, as well as the observed patterns of infant death and disease, must be understood for appropriate intervention to occur.

BIRTH WEIGHT DEFINED

A birth weight of less than 2500 grams is regarded as falling within the low birth weight category, according to the International Classification of Diseases (ICD - 9th revision), and is often used to identify infants of elevated risk. Low birth weight is thus an important guide to the level of health care needed by individual neonates.

It has been pointed out by the National Institute of Health (1972. p15) that with regard to postnatal care for the infant, the distinction is of paramount importance, since the care appropriate for low birth weight infants who are preterm may be inappropriate or even contraindicated for the full-term low birth weight infant.

Any infant who weights less than 2500 grams used to be called "premature". This term only considered the baby's weight, taking no account of whether the infant arrived before the end of the normal forty weeks of pregnancy, or why it weighed less than average.

As a term of general use, low birth weight infant ("small-fór-dates") has replaced the term premature infant, since the former includes all infants with a birth weight of less than 2500 grams, regardless of the duration of gestation. Preterm is now used to indicate a period of gestation of 37 weeks or less (Lowrey, 1978. p 115). There is some evidence to suggest that most low birth weight neonates in the developing countries are small-for-dates rather than preterm (Morley. 1973).

In some developed countries, the proportion of neonates with low birth weight is 2 - 3%, as compared with 7 - 10% in many developing countries, and 25 - 30% in many areas of the latter group of countries (Harfouche, 1979. p 391)

FACTORS CAUSING LOW BIRTH WEIGHT

Many of the factors that have been associated with infant mortality operate through their effect on the birth weight of infants, which in turn adversely affects the overall birth weight distribution.

As early as 1961, Warkany et al (1961. p 249) discussed the significance of what was termed "intrauterine growth retardation"(IGR). Low birth weight is a function of intruterine growth retardation and duration of pregnancy. An infant who has experienced IGR is small-for-dates because it was starved by receiving insufficient nutrients whilst in the womb. Known causes of intrauterine growth retardation include genetic factors, malnutrition, multiple pregnancy, short birth intervals, smoking, alcohol consumption during pregnancy, high altitude, infections, congential anomalies, drug-taking and irradiation (Illingworth, 1979. p 49)
A number of recent reports (e.g. Armstrong, 1972; and Shapiro et al, 1980 have identified further characteristics which tend to lower an infants' weight at birth and increase the risk of death. These factors include; population group, age-birth order, previous foetal or infant loss, legitimacy status, level of education, and most importantly, the timing and frequency of prenatal care (Eisner, 1979). Other (maternal) characteristics which have been shown (Hemminski and Starfield, 1978) to inhibit the intrauterine growth potential of foetuses, and ultimately elevate the incidence of low birth weight infants, are maternal stature, pre-pregnant weight, weight-gain during pregnancy, poor nutrition during pregnancy, and various maternal diseases such as anemia.
A poor maternal weight-height ratio has also been shown (Moodie, 1970) to be associated with low mean birth weight.

The most important aspect of low maternal weight relates to pregnancy outcome. American studies (e.g. Edwards et al, 1979) have shown that underweight women have an increased incidence of premature rupture of membranes, endometritis, premature infants and growth retarded (low birth weight) infants, hence there is considerable value in a women entering pregnancy in a sound nutritional state (Van der Spuy and Jacobs, 1983. p 4).

More recently, increasing attention is being focused on the role played by maternal nutrition (Prentice et al; 1983); moderate alcohol consumption (Little; 1977 and Olsen et al; 1983 maternal work load (Chamberlain and Garcia, 1983); and cigarette smoking (Wainwright. 1983) during pregnancy in lowering infantile birth weight. Saugstad;(1981.p118) in a comprehensive analysis, identified further factors which were adversely affecting the birth weight distribution in North America and Europe. Elective delivery, use of diuretics, and the restriction of diet during pregnancy appear to have shifted the birth weight distribution to the left in these countries, and Saugstad suggests (ibid, p185) that his may have counterbalanced the possible beneficial effects of these practices.

EFFECT ON MORTALITY

In a study of various factors influencing neonatal and post-neonatal mortality, Shah and Abbey;(1975. p. 10) concluded that birth weight was the most important factor in infant mortality and the adjustment for other factors did not modify the effect of birth weight. Analysis of linked birth and death records from the 1960 United States live birth cohort (the most recent year that linked records are available), shows that mortality rates are highest for infants weighing 1000 grams or less and then declines steadily with increasing birth weight up to 4000 grams (Fig.2) (Foster and Kleinman, 1982). This relationship between birth weight and infant mortality is also observed for neonatal and post-neonatal mortality separately, although birth weight is more closely associated with the risk of dying within the first 28 days of life. The vast majority of children weighed over 2500 grams at birth, only 7.8% weighing less than 2500 grams. However, 59% of all infant deaths were contributed by this small group of low birth weight infants. Most interestingly, Kleinman et al (1978) have demonstrated that the decline among low birth weight infants in six States in the United States between 1969 and 1973 accounted for over 50% of the overall decline in neonatal mortality.

More recently (Centre for Disease Control, 1983. p567), a study conducted in South Georgia (U.S.A.) during 1979 - 1980 drew attention to the fact that although infants with birth weights less than 2500 grams represented only 7.8% of births, they possessed the highest mortality rates and constituted 62.3% of infant deaths.

Returning to Fig 2, the probability of a fatal outcome declined steadily as birth weight increased, reaching a low for infants between 3001 to 4500 grams (about 4/1000), and then rising slightly for infants who were exceptionally heavy at birth .

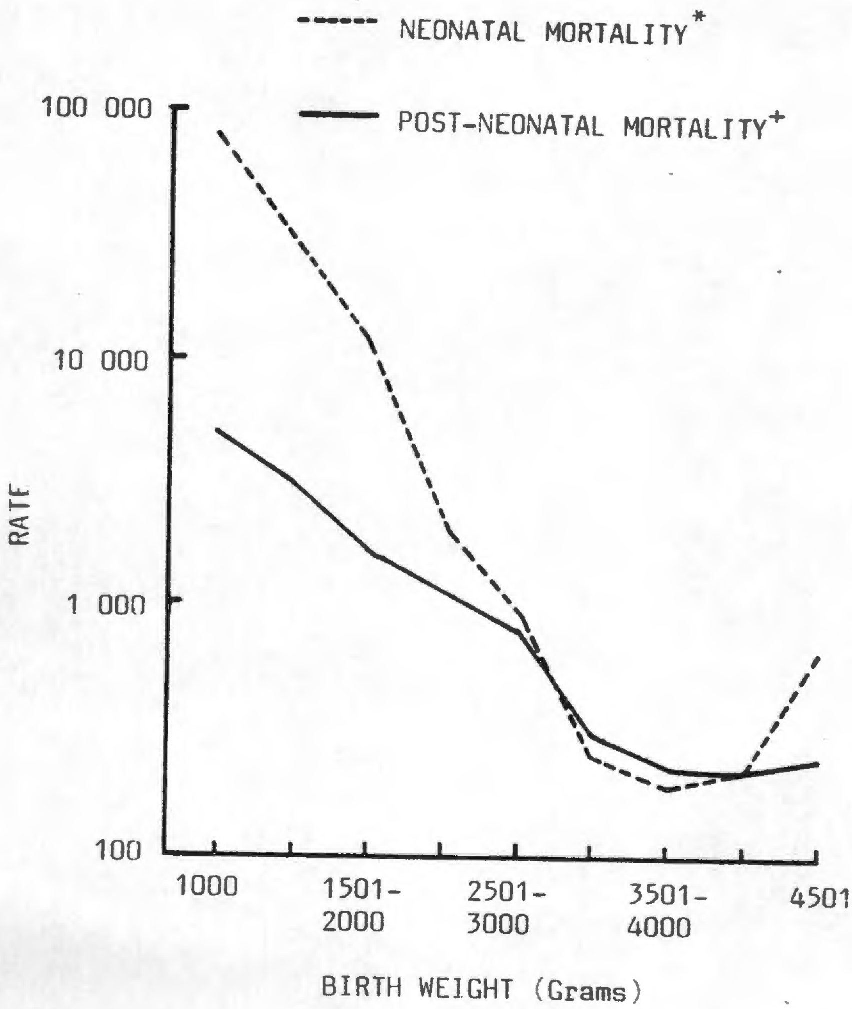


FIG. 2 NEONATAL AND POST-NEONATAL MORALITY RATES BY BIRTH WEIGHT (UNITED STATES, 1960)

* Deaths under 28 days per 1000 live births.

+ Deaths 28 days - 11 months per 1000 survivors of neonatal period.

Source: Foster and Kleinman, 1982

The lowest infant mortality rates recorded in industrialised nations are for infants with a birth weight of more than 3500 grams (Saugstad, 1981). Such a relationship has also been demonstrated from areas throughout the world (e.g. Armstrong, 1972; and Gosh, 1982).

EFFECT ON MORBIDITY

Low birth weight children show inadequate rates of growth, with evidence of delayed neurological development (Leading article, 1980. p 1154; and Harvey et al, 1982).

Illingworth (1979. p 50) has shown in Sheffield (U.K.) that the birth weight was strongly correlated with subsequent weight and height: the smaller the baby was at birth, the smaller it was likely to be in later years before puberty. Most anthropometric measurements of older children have been found to be related to the infants size at birth (Sinclair and Coldiron, 1969) These include the sitting height, pelvic girth, chest and calf circumference, standing height and weight. This has also been confirmed by Singer et al (1968).

Fancourt et al (1976; in an extremely comprehensive study, followed 93 full-term small-for-dates infants. It was observed that those infants whose skull growth had begun to slow in utero before 34 weeks were more likely to have a weight and height below the 10th centile. Moreover, if the onset of growth failure had occurred before the 26th week, the child was associated with a lower developmental quotient* (ibid). It would therefore appear that prolonged slow growth in utero is likely to be followed by slow growth and development after birth (Neligan et al, 1976). In the immediate neonatal period, the effect of low birth weight on the pre-term and small for dates infant may be similar, but the long-range outcome is quite different. A recent review of the literature (see Harfouche, 1979. p392) suggests that the cause of low birth weight does have an effect on postnatal growth. Other studies have indicated that there are two fairly distinct patterns of growth found in

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Footnote: * Developmental quotient - The Griffiths extended scales were Used to assess development in six areas: locomotion; personal-social; hearing and speech; eye and hand co-ordination; performance; and practical reasoning (See Griffiths, R. (1970) The Abilities of Young Children. Chard, Somerset Young and Son, London).

the low birth weight infant (Lubchenco, 1976 and Drillien, 1972). If the infant is premature, but appropriate weight for gestational age, then after a period of adjustment following birth, the infant will exhibit some "catch-up" or accelerated growth followed by a rate that parallels that of full-term infants. However, if the infant has low birth weight for gestational age, it does not show evidence of this "catch-up" phase of growth exhibited by the former type of infant (Lowrey, 1978 p 125).

Milner et al (1974) has also shown that this period of slowed development can be extended to the age of, at least, 22 years, where there was still a correlation between birth weight and height.

A number of studies have indicated that a low birth weight is a liability to intellectual development. Knobloch et al (1956. p 583) found that only half of the infants who weighed less than 1500 grams, would be considered normal at one year of age. A quarter of the infants had demonstrable moderate-to-severe neurologic abnormality. This was in contrast to the finding that 7% of similar abnormalities were found in infants with birth weights between 1500 and 2500 grams. Children weighing more than 2500 grams at birth had an incidence of less than 2% of abnormalities.

A more recent study quoted in the British Medical Journal (Leading Article, 1980. p 1154) estimated that as many as 33% of low birth weight survivors have significant mental or motor handicaps. There does not appear to be a clear-cut difference in the prognosis of mental performance of the premature, as compared to the small-for-dates infant of the same birth weight (Towbin, 1970. p 529). Both types of infants appear to experience an increased incidence of learning and reading difficulties in the orthodox school situation (Rubin et al, 1973. p 352). Further, a number of investigators have reported an increased incidence of behavioural disorders in children of low birth weight (Drillien, 1972). Drillien (ibid) also observed that when children reached school age, behavioural problems increased at a much higher rate in low birth weight children, especially in males.

SPATIAL VARIATIONS

There has been a perceptible shift in medical research in recent years away from clinical and laboratory research towards an investigation of environmental determinants of disease and death. It suggests a significant shift from an emphasis on "cure" to one of "prevention". One of the benefits of this change has been the growing number of researchers interested in the spatial distribution of morbidity and motrtality rates.

Considerable spatial variations between infant mortality and birth weight have been noted over the years. Early studies, such as those undertaken by Brimblecombe et al (1968) and Ashford et al (1969), clearly showed the benefits of analyzing and presenting infant and maternity data according to geographic area. More recently, this approach has been developed further. For example, Ashford et al (1973) studied perinatal mortality and birth weight variations amongst Local Authorities in England and Wales and concluded that, because of the substantial local variation found in the organization and resources of the maternity services, the only feasible way of successfully determining the appropriate maternity resource allocation was by assessing the data by local authority regions. Similar work has been presented by Williams et al (1980) and Foster and Kleinman (1982), except that these two groups of workers progressed a stage further in their respective analyses. The former calculated an index based upon the indirect adjustment technique for assessing perinatal mortality in each of 57 Californian counties in order to facilitate better health care planning, while the latter group of researchers, in a seminal piece of work, have produced an elegant method for standardizing and geographically comparing birth weight distributions and neonatal mortality among the small Health Service Areas in the U.S.A., which are areas designated for health planning purposes.

The CHECS region, because of its heterogeneous nature, would be an ideal study area in which to illustrate the spatial variation of the influence of birth weight on infant mortality. Notwithstanding the techniques used for spatial analyses, the data that would be used for such a study in the CHECS region is complicated by the fact that their derivation is from different reporting systems.

CHAPTER III

SOURCES AND CHARACTERISTICS OF THE DATA

This study requires the input of two sets of vital statistics in the form of births (and weights) and infant deaths. These sets of data are notified via independent routes of reporting.

A. BIRTH AND BIRTH WEIGHT DATA

One of the sources of data for this study were the "notification of birth" forms submitted to the D.C.C. by the institutions where the birth occurred and also by the registered midwives for home births. Key variables contained on each form, such as surname and initial, date of birth, birth weight (g), population group, sex, mothers age, parity, live birth or still birth, residential address and geocode were computer coded.

Each birth is geocoded according to local area as defined by the 1980 census. Birth weight reporting during 1982 was 97.7%, when only 580 births lacked a birth weight measurement. *

Non-reporting of birth weight by area within the study region (Table 5) is noticeably higher in the more "rural", and in most "Coloured" residential areas.

All birth notifications received during 1982 were collated and utilized for this study. A total of 16029 births were recorded, of which 97.7% (15653) were live singleton deliveries. All live births notified by area within the CHECS region is provided in Appendix A. The occurrence of all live singleton births in each population group is tabled below (Table 6).

Footnote * This level of birth weight reporting compares favourably with that in England and Wales where in the first quarter of 1981 approximately 96% of birth draft entries contained birth weight data (OPCS. 1981).

TABLE 5. OVERALL TABULATION OF BIRTHS

AREA NAME	LIVE BIRTHS	LIVE SINGLETON BIRTHS	BIRTH WEIGHTS NOT STATED (N)	(%)+
Milnerton	390	382	4	1.0
Bellville	1411	1393	19	1.3
Parow	1473	1435	35	2.4
Goodwood	673	657	9	1.3
Durbanville	280	278	6	2.1
Pinelands	111	109	1	0.9
Fish Hoek	104	104	7	6.7
Simonstown	65	65	5	7.7
Nyanga	798	764	10	1.3
Cross Roads	1889	1793	20	1.1
Atlantis	921	911	15	1.6
Mamre	119	119	5	4.2
Melkbosstrand	95	95	1	1.1
Rural Northern	303	295	3	1.0
Elsies River	2326	2288	75	3.2
Uitsig	321	317	10	3.1
Belhar	750	726	17	2.3
Nooitgedacht	100	98	2	2.0
Ruyterwacht	112	108	2	1.8
Matroosfontein	138	138	3	2.2
Bishop Lavis	889	873	48	5.4
Grassy Park	1452	1416	24	1.7
Constantia	354	348	4	1.1
Hout Bay	234	228	2	0.9
Kommetjie	255	253	21	8.3
Rural Cape Flats	364	362	10	2.8
Rural Peninsula	86	84	8	9.5
D.C.C. (CHECS REGION)	16029	15653	366	2.3

+ Percentage of all live singleton births only.

TABLE 6. PROPORTION OF ALL LIVE SINGLETON BIRTHS BY POPULATION GROUP

POPULATION GROUP	BIRTHS N	BIRTHS %	ESTIMATED POPULATION (1982) N	ESTIMATED POPULATION (1982) %
WHITE	3297	21.1	201 000	33.4
COLOURED	9504	60.7	337 000	56.0
BLACK	2852	18.2	64 000	10.6
TOTAL	15653	100.0	602 000	100.0

The distribution of all live, and live singleton births according to maternal residence address is listed in Table 5.

Because of the fact that the majority of multiple pregnancies often produce neonates with widely differing birth weights which are not representative of their potential intrauterine growth, this study excludes such pregnancies and the analysis of birth weight data is concerned solely with live singleton births. A total of 188 multiple deliveries were notified during 1982, representing 1.17% of the total live births notified.

Of the 15653 live singleton births notified, 2.3% (366) did not contain a birth weight figure. In order to derive the correct birth weight-specific distribution for all live singleton deliveries, it is necessary to distribute the 366 unknown birth weight births according to the percentage occurrence of those births with known birth weights. The resulting total live singleton birth weight-specific distribution is given in Table 7.

In this study the base population is represented by all live singleton births delivered within the CHECS region during 1982. These births were, as mentioned previously, geocoded according to maternal residential address. The spatial units which comprise the study region are delineated according to health administrative boundaries (Fig. 1). However, although the use of such a geographic base map is valuable in indicating where births occur, it is nonetheless severely deficient in providing information regarding the size of the population at-risk in the areas concerned (Foster in McGlashan. 1972). As a result, the correct spatial weighting cannot be given to a large urban population occupying small areas, whereas small rural populations which may be sparsely distributed over large areas are often over-represented (Foster,

TABLE 7. REDISTRIBUTION OF NON-STATED LIVE SINGLETON BIRTH WEIGHTS ACCORDING TO THE KNOWN PERCENTAGE DISTRIBUTION OF REPORTED LIVE SINGLETON BIRTH WEIGHTS

BIRTH WEIGHT GROUP (g)	LIVE SINGLETON BIRTHS +		LIVE SINGLETON BIRTHS	TOTAL LIVE SINGLETON BIRTHS
	(N)	(%)	(N) *	(N)
500-999	62	0.4	1	63
1000-1499	173	1.1	4	177
1500-1999	417	2.7	11	428
2000-2499	1175	7.7	28	1203
2500-2999	3817	25.0	92	3909
3000-3499	5723	37.4	137	5860
3500-3999	3096	20.3	74	3170
≥4000	823	5.4	20	843
TOTAL	15287	100.0	366	15653

\+ With known birth weights only.

* With unknown birth weights

ibid). Thus a base map which represents both the size of the "populations at-risk" (in this case all live singleton births for 1982), and their geographical location is required for the optimum spatial representation of these data. The development of a demographic based map in which the area of each spatial unit was constructed proportional to its population size, whilst contiguity of geographic boundaries and the relative geographical positions are maintained as far as possible appears to fulfill this need most closely at present (McGlashan. 1975; and Foster in McGlashan. 1972). In this study, a demographic base map is constructed (similar to that outlined above) where each (administrative) unit within the CHECS region is portrayed as a square area being proportional to the number of live births notified in each (Fig. 3) Such a map allows for easy visual comparisons of base population size to be made between the various areas. Unfortunately, the layout of this demographic base map has resulted in the loss of precise geographic location of each mapping unit. However, the inherent advantages of readily comparible "population" sizes outweigh any geographic distortions.

B. INFANT MORTALITY DATA

All infant death certificates possessing a maternal residential address within the CHECS region for 1981 and 1982 were collected, encoded and stored on computer file. A total of 455 infant deaths were reported during 1982. The percentage composition according to population is listed below (Table 8).

TABLE 8. INFANT MORTALITY - 1982

POPULATION GROUP	INFANT MORTALITY (N)	(%)
White	25	5.5
Coloured	311	68.4
Black	119	26.1
Total	455	100.0

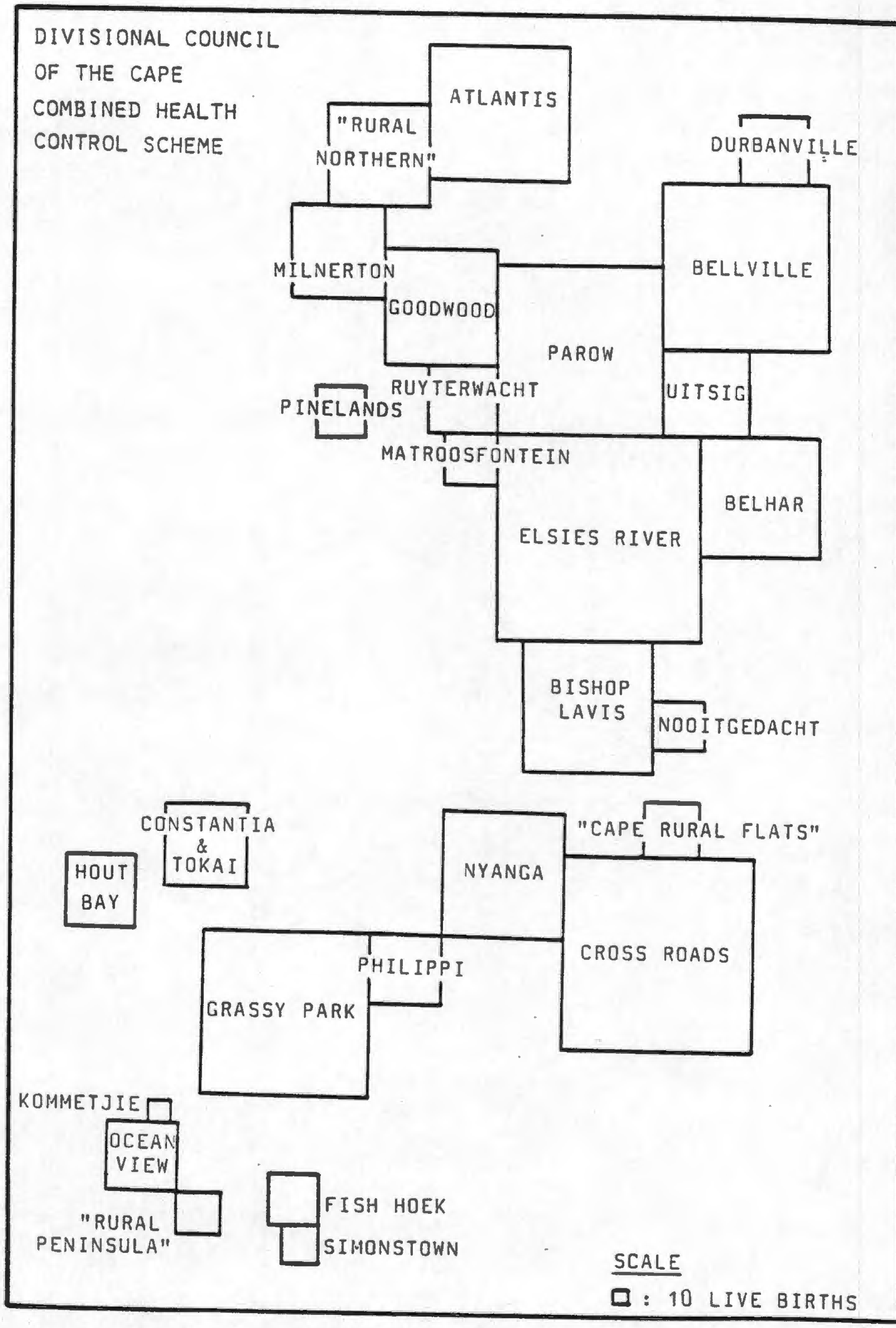


FIG. 3. DEMOGRAPHIC BASE MAP.

Each square area in this schematic map of the DCC Combined Health Control Scheme region represents a discrete municipality or suburb which is scaled according to the number of live births notified in each.

The data collected contained the infant's surname and initial, population group, sex, age (in days), date of birth, date of death, cause-of-death (coded to the ICD-9), and residential address of mother. All of these deaths are classified according to 25-sub areas which coincide with municipal or suburb boundaries (refer to Chapter I and Fig. 1).

Within the CHECS region, three areas are suspected of having unreliable infant death statistics on the basis of their neonatal and post-neonatal rates which are significantly at variance with the same rates observed for other areas (refer to Tables 17 and 18). Those concerned are the three "rural" areas to the North; the East; (Cape Flats); and South (Peninsula) of the study area (Fig 1). What proportion of infant deaths the reported figures represent is unknown.

Another factor which, potentially, influences the accuracy of infant mortality rates, even where accurate figures are kept, is the interpretation of "liveborn". The lower the minimal weight limit accepted, the larger the number of premature (preterm and low birth weight) infants included in the total live births will be, and consequently the greater the number of deaths that will be recorded. Dogramaci (1981. p53) has eloquently raised the issue of "viable" minimum birth weight. There are numerous complications to this idea (ibid. p54), and minimum weight is regarded as a poor criterion on which to depend, although it is easily determined. Certain developed European countries, however, consider liveborn to mean those neonates weighing 1000 grams or more at birth (Harfouche, 1979. p 393). This is obviously an area for fairly significant inaccuracies to develop, specifically in peri-natal and early neo-natal mortality rate calculations. The procedure adopted for the D.C.C. region is one which accepts the conventional definition of still born and that regards liveborn as those infants who have breathed, regardless of for how long, and what their birth weight was.

CROSS-LINKAGE OF ALL LIVE BIRTHS AND INFANT DEATHS

Of the 3740 deaths certified in the CHECS region during 1982, a total of 455 infant death certificates were applicable. Two years of birth notif-ications were collated, representing a total of 31474 births, of which 15445 and 16029 occurred during 1981 and 1982, respectively.

An attempt was made to cross-match these births and death records by computer. This, however proved not to be possible, particularly for the Blacks, because of an extremely poor correlation between the spelling of surnames within each record file. Consequently, all cross-matching was performed manually. Matching was accomplished using the following criteria: surname, date of birth, sex, population group, and age.

This will be discussed in greater detail in the following chapter.

CHAPTER IV

ANALYSIS AND DISCUSSION

This chapter presents the results of an analysis of the birth weights and infant mortality data, as well as the cross-linkage of both of these variables. Included is a spatial analysis according to medical geographic principles, and the more important findings are discussed.

AN ANALYSIS OF BIRTH WEIGHTS

OVERALL ANALYSIS

Descriptive birth weight statistics for the study area are outlined in Table 9. It is readily apparent that substantial differences exist in mean birth weight between the different population groups.

Babson *et al* (1979) showed that the mean birth weight of foetuses in the U.S.A., during the last week of pregnancy were relatively large - being 3462 grams. The corresponding value for whites in the CHECS region is very similar (3335g), with Blacks and Coloureds haveing somewhat lesser values; 3175 g and 3022 g, respectively. The mean birth weight for Coloured infants in 313 g below the mean birth weight of their White counterparts and 153 g below that for Black neonates.

It is of interest to note that for the Coloured birth population (Fig 4), with a standard deviation of 613 g, a negative shift of one standard deviation represents a birth weight value of 2519 g, which is marginally (19 g) above the ICD-9 low birth weight limit of 2500 grams. Moreover, it appears that this situation is also predominant for each maternal age group.

The distribution of all live singleton birth weights according to 500 g birth weight categories, as defined by the ICD-9, is presented in Appendix B. The birth weight distributions are graphically portrayed in Fig 5. Of interest is the relatively large occurrence of low birth weight infants in the Coloured community, as well as the negatively skewed birth weights of both the Coloured and Black groups, whereas that for the Whites is shifted to the right (positive). This leftward displacement of birth weights in each of the birth weight groups, as well as the mean birth weight is illustrated in detail in Figure 6. The empirical birth weight distributions for each population group shown in Fig.6 also clearly depicts the substantial difference in the proportion of low birth weight neonates for each

TABLE 9. SUMMARY TABLE OF BIRTH WEIGHT MEANS AND STANDARD DEVIATIONS (IN GRAMS) ACCORDING TO POPULATION GROUP

POPULATION GROUP	SUMMARY STATISTICS n	%	$\bar{x}$	σ
White	3198	21.2	3335	515
Coloured	9117	60.4	3022	613
Black	2758	18.4	3175	559
Total	15073	100.0	3116	597

Non-useable records : 580

population group: the coloured group displaying the largest number of low birth weight infants and a strongly skewed mean birth weight. The percentage distribution of birth weights occurring in each area of the study region is listed in Appendix C.

Statistics presented for the CHECS region make no distinction between low birth weight infants born prematurely (before 37 weeks) and those born at term, but small-for-dates, as no data pertaining to gestational length is available on the birth notification forms.*

Footnote:

It has been noted (Professor A. Malan, pers comm) that for infants born at the Groote Scuur Hospital during 1982, the proportion of infants being preterm and low birth weight was estimated to be 60% and 40% respectively. Whether these values reflect the position within the CHECS region is unknown.

In the United States, based on the clinical evaluation of newborn infants (Lubchenco, 1976), between 25 and 35% of low birth weight babies are small-for-gestational age.

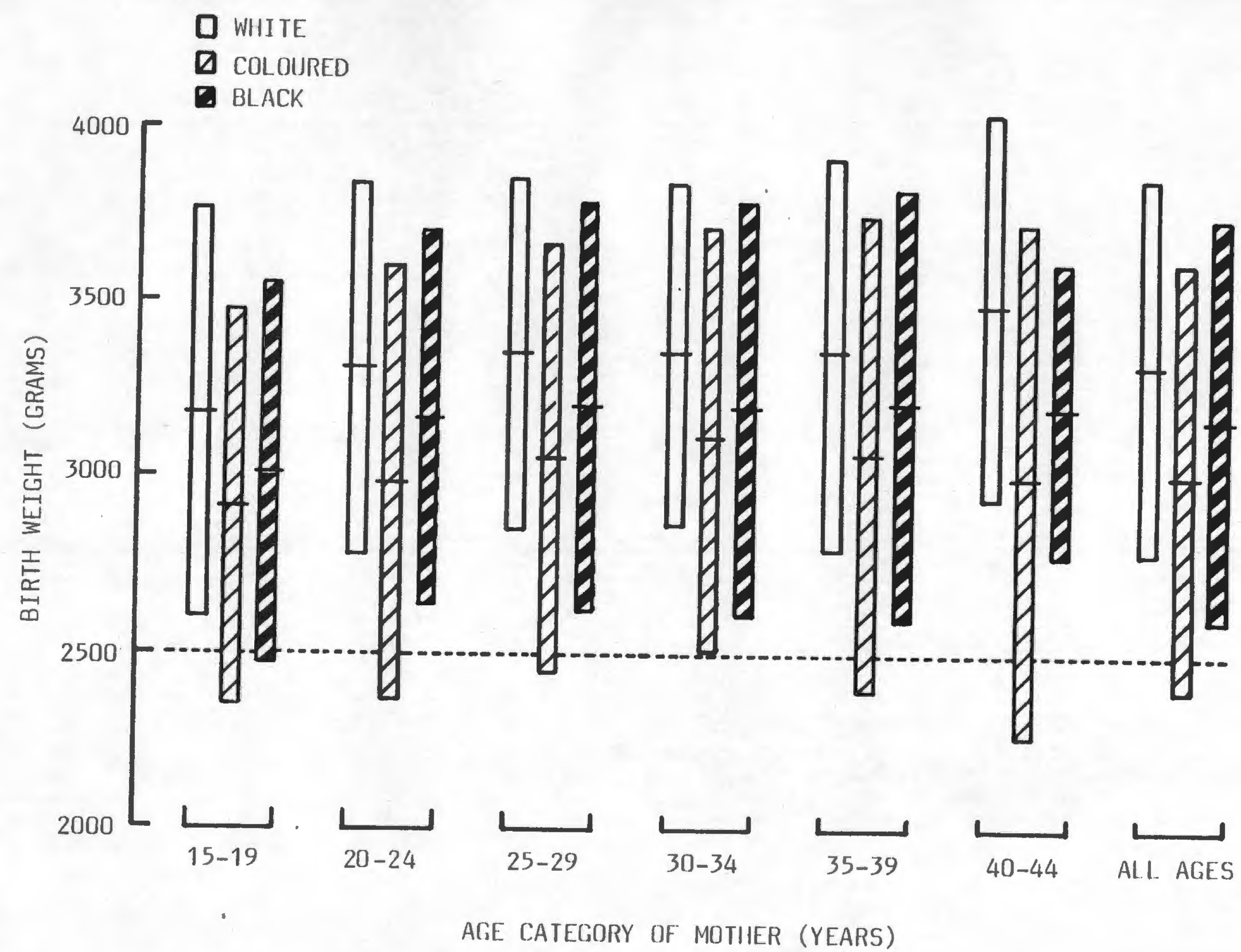


FIG. 4. MEAN AND STANDARD DEVIATION OF BIRTH WEIGHT ACCORDING TO MATERNAL AGE AND POPULATION GROUP

The mean birth weight for each population group is indicated by the short horizontal line. Vertical bars depict one standard deviation of birth weight around the mean. Low birth weight threshold (<2500 grams) is shown as a dotted line.

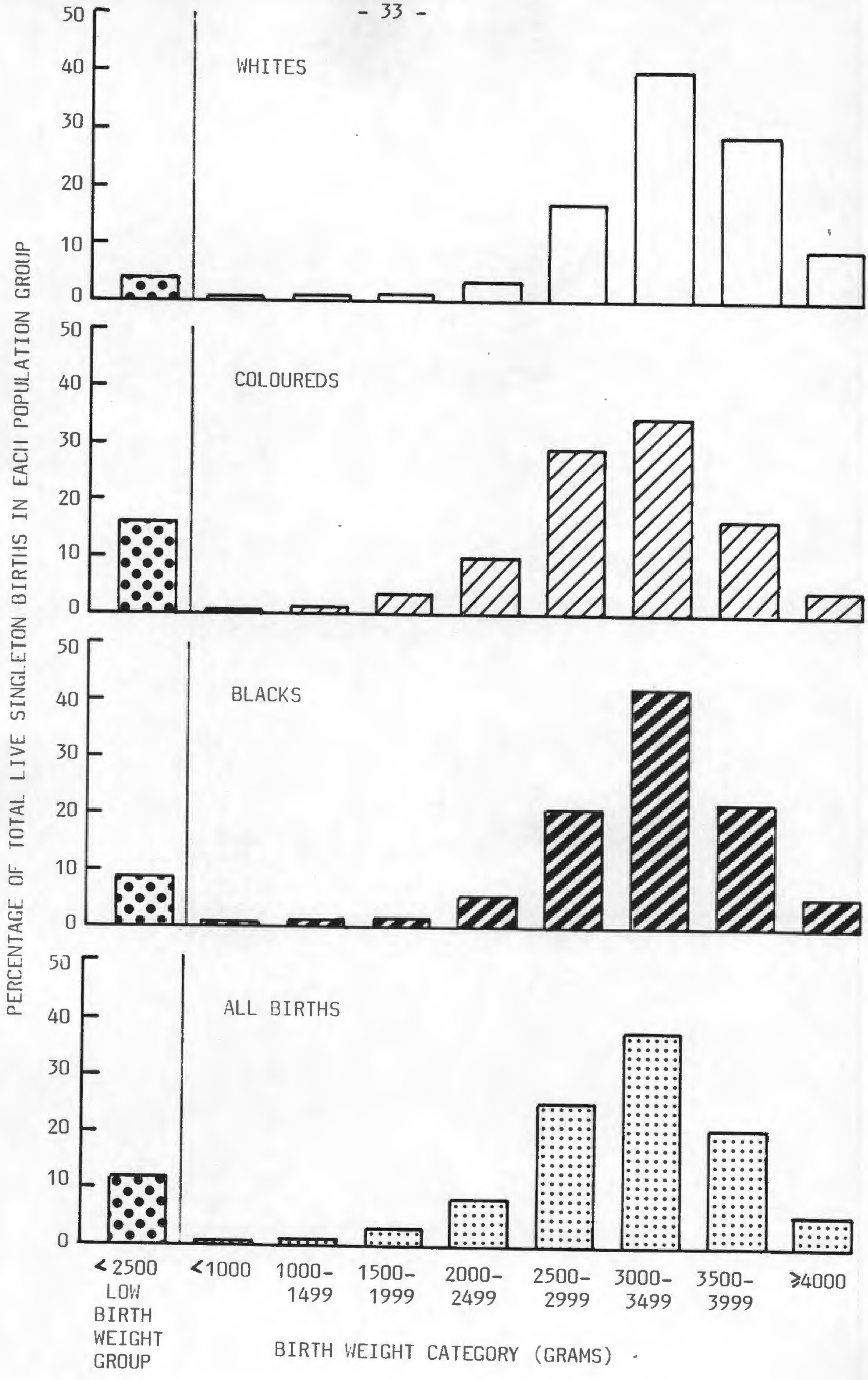


FIG. 5. PERCENTAGE DISTRIBUTION OF ALL LIVE SINGLETON BIRTH WEIGHTS

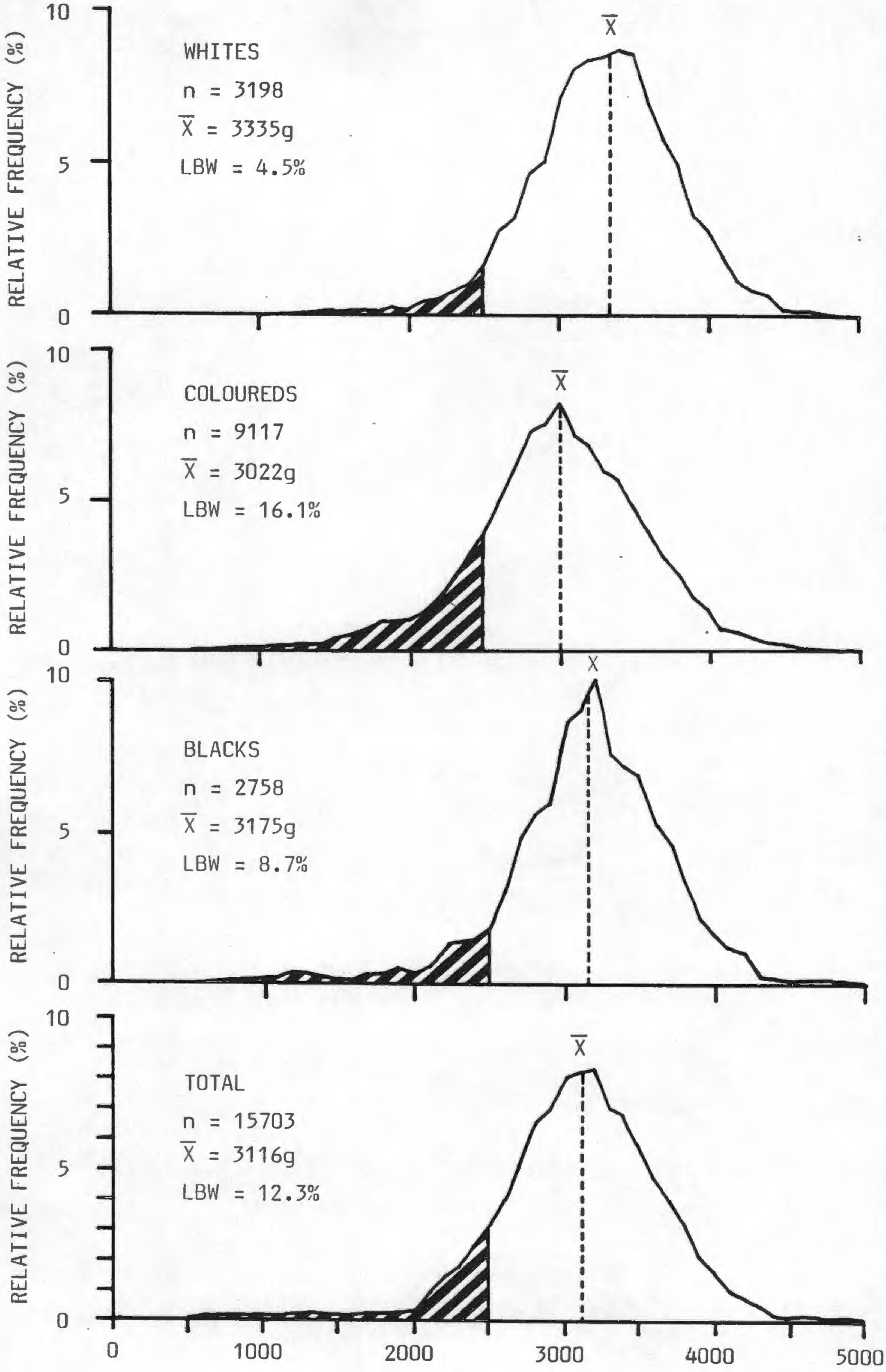


FIG. 6. EMPIRICAL (1982) BIRTH WEIGHT DISTRIBUTIONS FOR EACH POPULATION GROUP WITHIN THE DIVISIONAL COUNCIL OF THE CAPE COMBINED HEALTH CONTROL SCHEME REGION
The shaded area represents the low birth weight (LBW : < 2500g) group.

LOW BIRTH WEIGHTS

The lower tails of the empirical (Gaussian) birth weight distribution of all live singleton birth weights for each population group is shown in Figure 7. The Coloured population group has a marked excess of low birth weight infants, the majority (63.6%) possessing a birth weight between 2000-2499g, and hence a prenatal strategy which leads to even a relatively small increase in the birth weights of this group will significantly decrease this proportion of "at-risk" neonates. Corresponding figures for the White and Black birth populations are 73.9% and 62.8%, respectively.

When the low birth weight rates for each area within the CHECS region are ranked in descending order of magnitude (Table 10), nearly half of the areas have low birth weight rates below the overall regional mean. The so-called "rural" areas appear at the top of the list with rates approximately double the regional mean. Further, almost without exception, all of the predominantly Coloured areas are represented in the upper group. What is even more interesting is the fact that the Black Townships of Nyanga and the Cross Roads "squatter" camp have low birth weight rates which are well below the regional mean. Cross Roads actually having a low birth weight rate (79.0/1000) almost identical with that of the U.S.A. (1982) of 70.0 per 1000. The Cross Roads rate is also substantially lower than that recorded from the more "settled" Township of Nyanga (79.0/1000 versus 106.1/1000), as well as being somewhat lower than the municipalities of Durbanville (95.6/1000) and Bellville (85.1/1000). Figure 8 illustrates the spatial distribution of low birth weight rates within the study area.

"OPTIMAL" BIRTH WEIGHTS

Birth weights of greater than or equal to 3500 grams ('high' birth weights) have been for some time regarded (particularly by Saugstad, 1981) as representing "optimalty" of a birth population. The CHECS region experiences an overall "high" (≥3500 g) weight rate of 256.4 per 1000 live singleton births. A ranking of the areas in the study region, in descending order according to "optimal" birth weight rate (Table 11) is the inverse of the previous Table (10) which ranked the areas by low birth weight rate. In Table 11, it is clear that all of the municipalities possess "optimal" rates far superior to those of the remaining areas. Moreover, the Black areas of Nyanga and

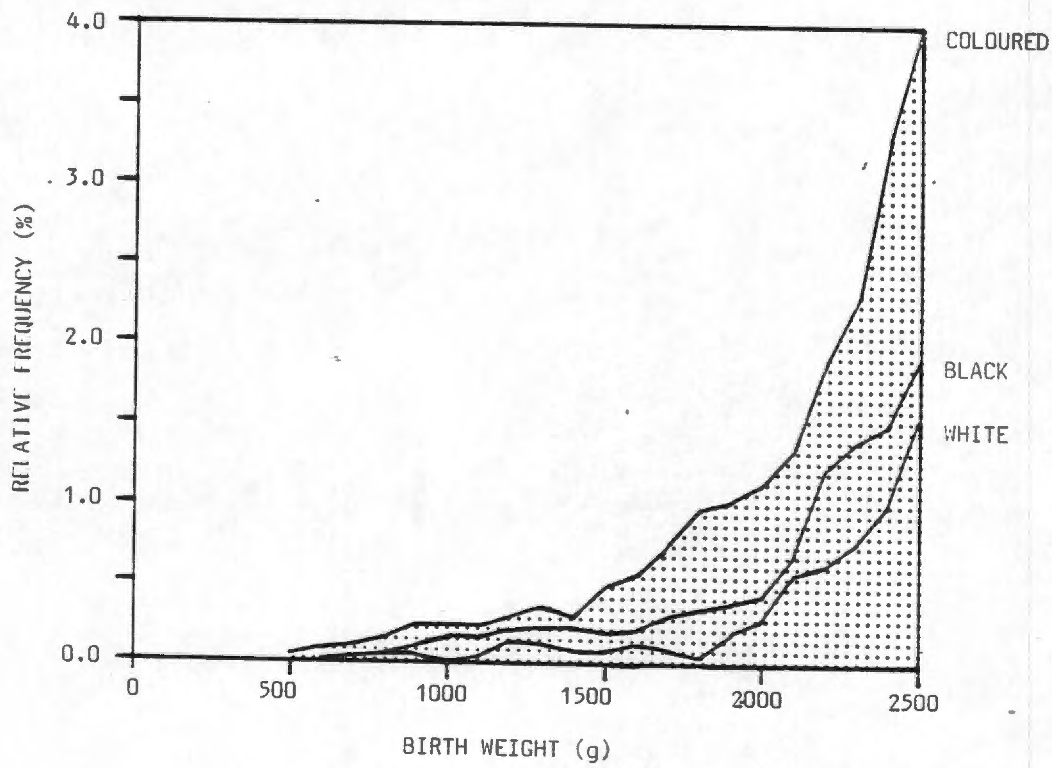


FIG. 7. LOWER TAILS (< 2500g) OF THE BIRTH WEIGHT DISTRIBUTION FOR EACH POPULATION GROUP

TABLE 10. EACH AREA WITHIN THE STUDY REGION RANKED IN DESCENDING ORDER ACCORDING TO LOW BIRTH WEIGHT RATE (LBW :< 2500g)

RANK	AREA NAME	LIVE SINGLETON BIRTHS*	LOW BIRTH WEIGHT (N)	LOW BIRTH WEIGHT (Rate)+	
1	Rural Northern	292	66	226.0	
2	Cape Rural Flats	352	71	201.7	
3	Nooitgedacht	96	18	187.5	
4	Kommetjie	232	43	185.3	
5	Rural Peninsula	76	14	184.2	
6	Atlantis	896	157	175.2	
7	Mamre/Pella	112	19	169.6	
8	Elsies River	2213	365	164.9	
9	Uitsig	307	50	162.9	
10	Bishop Lavis	825	133	161.2	
11	Simonstown	60	9	150.0	
11	Belhar	709	106	150.0	
13	Hout Bay	226	28	123.8	
					— D.C.C. ave.
14	Parow	1400	169	120.7	
15	Grassy Park	1392	160	114.9	
16	Matroosfontein	135	15	111.1	
17	Nyanga	754	80	106.1	
18	Durbanville	272	26	95.6	
19	Bellville	1374	118	85.1	
20	Cross Roads	1773	140	79.0	
21	Constantia	344	23	66.9	
22	Ruyterwacht	106	7	66.0	
23	Melkbosstrand	94	5	53.2	
24	Milnerton	378	20	52.3	
25	Goodwood	648	31	47.8	
26	Fish Hoek	104	4	40.8	
27	Pinelands	108	3	27.8	
	D.C.C. CHECS REGION	15287	1881	123.1	

Not included : Phillipi (N=2)

* Only births with recorded birth weights.

\+ Rate per 1000 live singleton births with recorded birth weights.

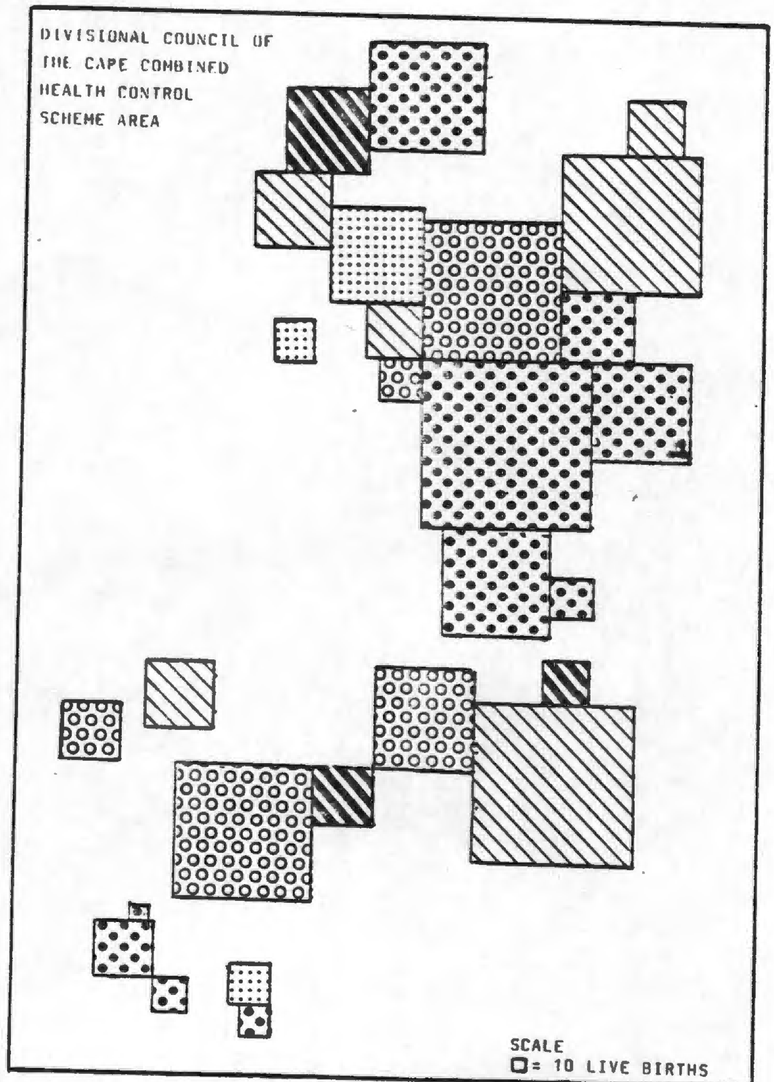


FIG. 8. LOW BIRTH WEIGHT (<2500 g) RATES
(per 1000 live singleton births)

≥ 200	
150 - 199	
100 - 149	
50 - 99	
< 50	

TABLE 11. "OPTIMAL" BIRTH WEIGHT (≥3500g) RANKED IN ASCENDING ORDER FOR EACH AREA WITHIN THE STUDY REGION

RANK	AREA NAME	LIVE SINGLETON BIRTHS*	"HIGH" BIRTH WEIGHT (N)	"HIGH" BIRTH WEIGHT (Rate)+	
1	Matroosfontein	135	9	65.2	
2	Rural Northern	292	49	167.8	
3	Uitsig	307	54	175.9	
4	Nooitgedacht	96	18	187.5	
5	Bishop Lavis	825	157	190.3	
6	Belhar	709	139	196.0	
7	Cape Rural Flats	352	72	204.5	
8	Elsies River	471	471	212.8	
9	Atlantis	896	191	213.2	
10	Mamre/Pella	112	25	223.2	
11	Rural Peninsula	76	17	223.7	
12	Kommetjie	232	53	228.4	
13	Grassy Park	1392	328	235.6	
14	Ruyterwacht	106	25	235.8	
15	Hout Bay	226	59	261.1	—— D.C.C. ave.
16	Parow	1400	377	269.3	
17	Cross Roads	1773	500	282.0	
18	Nyanga	754	217	287.8	
19	Durbanville	272	85	312.5	
20	Milnerton	378	120	317.5	
21	Bellville	1374	438	318.8	
22	Constantia	344	112	321.8	
23	Goodwood	648	234	361.1	
24	Simonstown	60	24	400.0	
25	Melkbosstrand	94	27	404.3	
26	Pinelands	108	44	407.4	
27	Fish Hoek	104	41	418.4	
	D.C.C.	15287	3920	256.4	

Not included : Phillipi (N=2)

* Only births with recorded birth weights.

\+ Rate per 1000 live singleton births with recorded birth weights.

Cross Roads also form part of a group of areas which have "optimal" birth-weight rates above the average for the entire region. The spatial patterning of these rates is presented in Fig. 9. The situation is such that all of the municipalities and the Administration Board areas have "high" birth-weight rates which are well above the regional mean, whilst, without exception, all of the Coloured areas constitute a group which are below the average rate. In other words, the areas constitute a group which are below the average rate. In other words, the areas which contain predominantly Coloured people exhibit a birth-weight distribution which is sub-optimal in character.

BIRTH ORDER

It is well recognized that birth weight is affected, to some extent, by birth order. The percentage occurrence of all live singleton births by parity is tabled below (Table 12)

There is a definite trend for inclusion of more first births, the percentage occurrence declining with increasing parity. However, the mean birth-weight for each parity remains compartively constant (Fig 10). It would, therefore, appear that for the CHECS region the mean birth weight is not significantly affected by parity. A similar situation exists when low birth weight infants are considered separately. The percentage occurrence of low birth weight infants by pairty is listed in Table 13; being essentially uniform for each parity. . This conforms to the mean birth weight by parity pattern for all birth weight groups presented above.

It would appear that there is no relationship between parity, the occurrence of low birth weight babies, and mean birth weight. This is at variance with the well known observation and the mean birth weight of primiparae is lower (on average by 180 g) than that of children of multiparae (WHO. 1972).

Since this study is concerned with all live singleton births, it makes no distinction between primiparae or multiparae births. Because multiparae infant birth weights are slighly (on average) higher than primiparae ones and are included in the analysis of birth weights, the results obtained will, in actual fact, represent slightly conservative estimates.

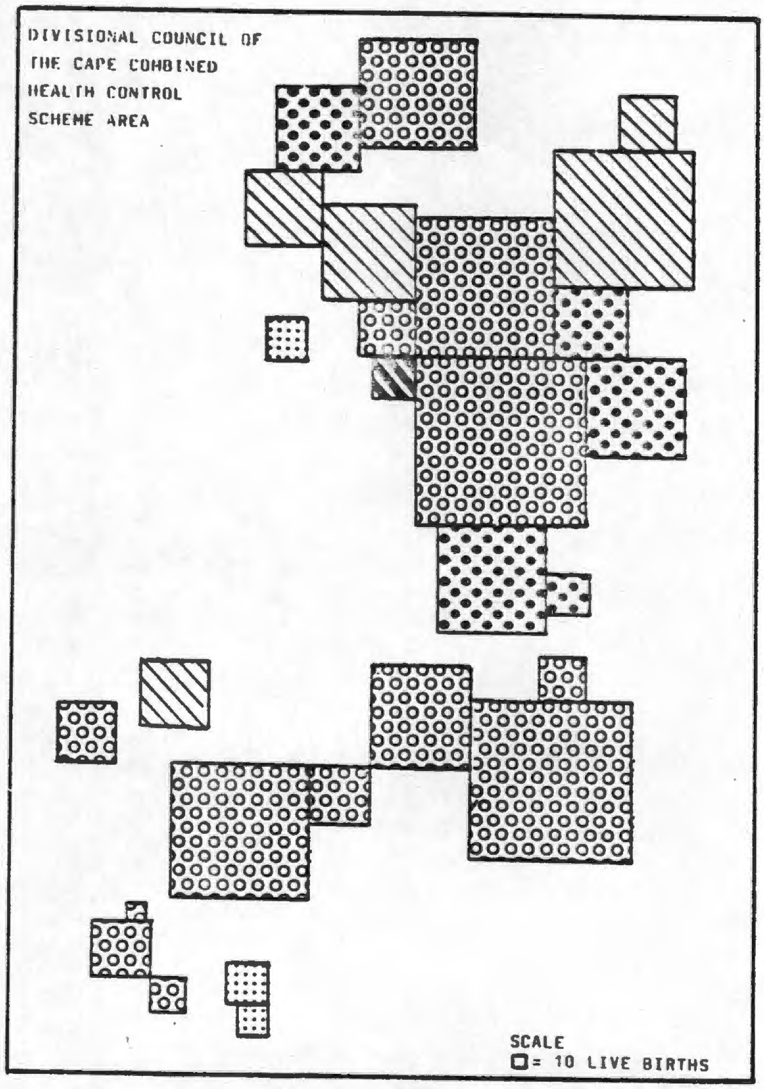


FIG. 9. "OPTIMAL" BIRTH WEIGHT (≥3500 g) RATES (per 1000 live singleton births)

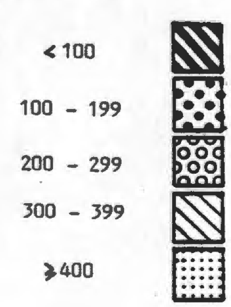


TABLE 12. PERCENTAGE DISTRIBUTION OF ALL LIVE SINGLETON BIRTHS ACCORDING TO PARITY AND MEAN BIRTH WEIGHT

PARITY	%	MEAN BIRTH WEIGHT (g)
1	35.1	3062
2	28.9	3142
3	17.2	3161
4	9.0	3137
5	4.7	3153
6	2.6	3106
ALL	100.0	3151

TABLE 13. PERCENTAGE OCCURRENCE OF LOW BIRTH WEIGHT INFANTS ACCORDING TO PARITY

PARITY	% LOW BIRTH WEIGHT
1	13.0
2	10.5
3	11.2
4	12.0
5	12.8
ALL	12.0

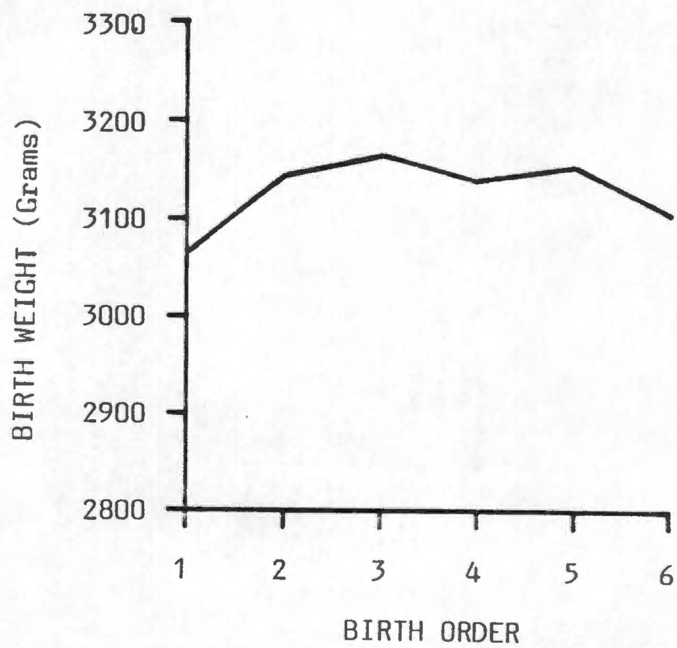


FIG. 10. MEAN BIRTH WEIGHT AND BIRTH ORDER

MATERNAL AGE

Age of the mother is also known to affect birth weight. Table 14 and Fig. 11 show a gradual rise in birth weight, from teenage pregnancies with a (low) mean birth weight of 2962 g to a peak (3209g) for the 35 - 39 year age group, representing a range of 247 grams.

TABLE 14. MEAN BIRTH WEIGHT FOR ALL BIRTH ORDERS ACCORDING TO MATERNAL AGE GROUP

AGE GROUP (Yrs)	MEAN BIRTH WEIGHT (g)	% BIRTHS
< 20	2962	14.5
20 - 24	3080	32.8
25 - 29	3169	28.9
30 - 34	3209	16.2
35 - 39	3185	5.9
40 - 44	3154	1.6
≥ 45	----	0.1
TOTAL	3151	100.0

---- $n < 30$

Although maternal age is an influencing factor of the overall birth weight distribution, the situation in the CHECS region is such that 76.2% of all live singleton births occur to women below the age of 30 years with a mean birth weight for this group of 3092 grams; being marginally lower (59 grams) than the overall regional mean of 3151 grams. It would seem, therefore, that infants born to women younger than 30 years of age have an age-specific mean birth weight which is almost identical to the mean for the region, and that the relatively few births to women older than 30 years do not significantly alter the birth weight statistics. Further, it is clear that maternal age (see Fig. 11) effects birth weight somewhat more strongly than does birth order (Fig. 10).

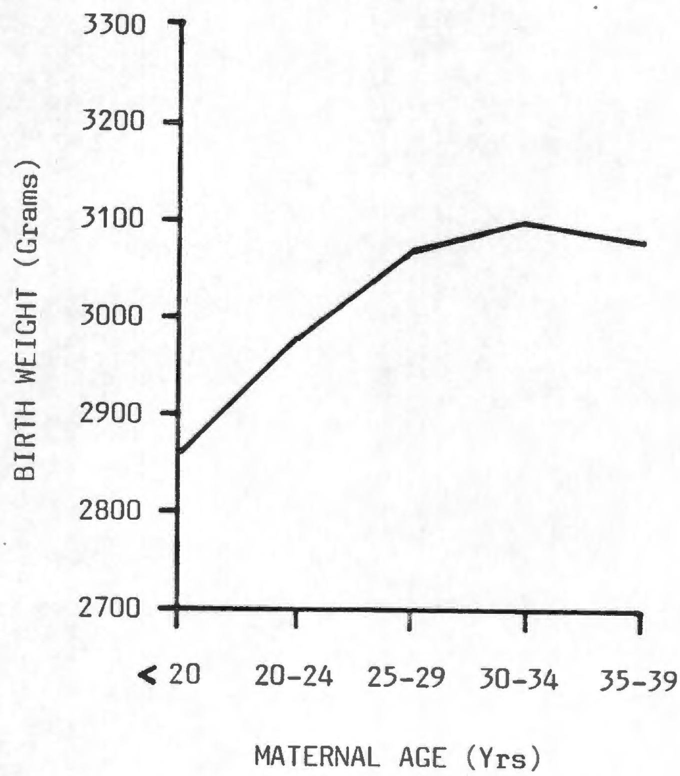


FIG. 11 . MEAN BIRTH WEIGHT AND MATERNAL AGE

ANALYSIS OF INFANT MORTALITY

OVERALL ANALYSIS

The D.C.C. Health Authority has observed a consistant decline in the overall IMR for its region (Table 15). However, this trend appears to be flattening out in the most recent years. Moreover, while the IMR for the Black Population group has declined the most dramatically, that for the Coloured group is increasing (from 26/1000 in 1981 to 32/1000 in 1982); being marginally less than that recorded in 1979 (32.2 versus 33.0). The IMR for Whites (7.4/1000) is comparable with the most developed nations of the world (refer to Table 2)*

Infant deaths in the neonatal period were slightly more frequent than in the later post-neonatal period (52.3% versus 47.7%), for the region as a whole (Table 16). Post-neonatal mortality amongst the Black communities however, (Table 15) is much larger than the neonatal component: 26.7/1000 as opposed to 13.0/1000, respectively. The effects of the extrauterine environment are clearly reflected through these rates.

Contained in Appendices D and E are detailed analysis of infant mortality according to Period of Survival (D) and Causes-of-Death (E) for each population group within the CHECS region.

INFANT MORTALITY BY AREA

Table 17 presents the 1982 infant mortality rates for each area within the study region according to neonatal and post-neonatal components. An important feature in the Table is the manner in which the post-neonatal rate is determined. The method used is one suggested by the Centre for Disease Control (CDC) (CDC, 1983. p 68). Usually this rate is calculated per 1000 live births, but it is more precise to define the post-neonatal

---

Footnote: *

Unfortunately, D.C.C. mortality data have only recently (1981) been computerised and hence no spatial / temporal analysis is possible at present. However, it is possible that with the economic recession over the last few years and its accompanying redunancies in the labour force the IMR in certain areas within the CHECS region may possibly have risen, as has been observed in certain States in North America (Editors, Sci. Am., 1983. p 65), even though the regional average is declining. If this hypothesis is proven correct in the future, it will have far reaching implications for health resource distribution and health delivery to the effected areas.

TABLE 15. DIVISIONAL COUNCIL OF THE CAPE
COMBINED HEALTH CONTROL SCHEME REGION

Infant Mortality Rates (per 1000) : 1979 - 1982

YEAR	POPULATION GROUP	STILL BIRTHS	PERI-NATAL	NEONATAL EARLY	NEONATAL LATE	NEONATAL TOTAL	POST-NEONATAL	INFANT
1979 :	Whites	3.8	-	-	-	4.1	10.3	14.4
	Coloureds	17.7	-	-	-	7.3	25.7	33.0
	Blacks	20.2	-	-	-	10.1	52.5	62.6
	Total	-	-	-	-	-	-	33.1
1980 :	Whites	6.1	11.9	5.8	3.2	9.1	2.9	12.0
	Coloureds	19.0	27.4	8.6	4.2	12.7	15.2	27.9
	Blacks	12.9	22.1	9.4	4.9	14.3	42.0	56.3
	Total	15.5	23.2	8.1	4.1	12.2	17.1	29.4
1981 :	Whites	5.1	12.7	7.7	1.0	8.6	3.8	12.5
	Coloureds	14.1	24.6	10.6	3.6	14.2	12.3	26.5
	Blacks	18.5	25.5	7.1	5.0	12.1	40.9	53.0
	Total	13.1	22.4	9.4	3.3	12.7	15.8	28.5
1982 :	Whites	5.0	9.5	4.5	1.2	5.6	1.8	7.4
	Coloureds	13.7	25.6	12.1	6.4	18.5	13.7	32.2
	Blacks	17.1	27.6	10.7	2.3	13.0	26.7	39.7
	Total	12.5	22.6	10.2	4.6	14.8	13.6	28.4

Source: D.C.C. Annual Reports, 1979-1982.

TABLE 16. PERCENTAGE COMPOSITION OF INFANT MORTALITY

MORTALITY	N	%
NEONATAL	238	52.3
POST-NEONATAL	217	47.7
TOTAL	455	100.0

mortality rate as including only those infant deaths occurring between 28 days to 1 year of age per 1000 neonatal survivors.

Infant mortality rates ranked in descending order of magnitude (Table 18) and plotted spatially (Fig. 12) reveals a valuable amount of information. The squatter community located in Cross Roads exhibits an IMR, high as it is (48.5/1000), which is significantly lower than the two settled (permanent) Coloured suburbs of Matroosfontein and Nooitgedacht. The municipality of Durbanville with an IMR of 46.8/1000 is the only municipal area to perform so poorly, being substantially higher than the IMR for the Black Township of Nyanga (28.8/1000). Overall, it can be said that the predominantely Black and Coloured areas possess high IMR's, whereas, by and large, the municipalities have lower ones.

TABLE 17. INFANT MORTALITY RATES BY AREA

AREA NAME	NEONATAL (N)	NEONATAL (Rate)+	POST-NEONATAL (N)	POST-NEONATAL (Rate)*	No. OF NEONATAL SURVIVORS	INFANT MORTALITY (N)	INFANT MORTALITY (Rate)+
Milnerton	9	23.6	2	5.4	373	11	28.8
Durbanville	7	25.2	6	22.1	271	13	46.8
Goodwood	4	6.1	3	4.6	653	7	10.7
Parow	27	18.8	12	8.5	1408	39	27.2
Bellville	19	13.6	7	5.1	1374	26	18.7
Pinelands	0	-	0	-	0	0	-
Fish Hoek	0	-	0	-	0	0	-
Simonstown	0	-	0	-	0	0	-
Nyanga	8	10.5	14	18.5	756	22	28.8
Cross Roads	24	13.4	63	35.6	1769	87	48.5
Atlantis	7	7.7	9	10.0	904	16	17.6
Rural Northern++	5	9.5	0	-	520	5	9.5
Elsies River	45	19.7	39	17.4	2243	84	36.7
Uitsig	11	34.7	4	13.1	306	15	47.3
Belhar	14	19.3	16	22.5	712	30	41.3
Nooitgedacht	2	20.4	4	5.6	96	6	61.2
Ruyterwacht	1	9.3	0	-	107	1	9.3
Matroosfontein	7	50.7	2	15.3	131	9	65.2
Bishop Lavis	24	27.5	9	10.6	849	33	37.8
Rural Cape Flats	5	13.8	10	28.0	357	15	13.8
Grassy Park	14	9.9	10	7.1	1402	24	16.9
Constantia	1	2.9	1	2.9	347	2	5.7
Hout Bay	2	8.8	4	17.7	226	6	26.3
Kommetjie	2	7.9	1	4.0	251	3	11.9
Rural Peninsula	1	11.9	0	-	83	1	11.9
Total	237	15.1	218	14.1	15416	455	29.1

\+ Rate per 1000 live singleton births

* Rate per 1000 neonatal survivors (≥28 days/neonatal survivors X 1000)

++ Area includes: Pella; Mamre; Rural Northern; Philadelphia; Melkbosstrand and Bloubergstrand

TABLE 18. INFANT MORTALITY RATES RANKED IN DECENDING ORDER

AREA NAME	RANK	INFANT MORTALITY (Rate)+	
Matroosfontein	1	65.2	
Nooitgedacht	2	61.2	
Cross Roads	3	48.5	
Uitsig	4	47.3	
Durbanville	5	46.8	
Belhar	6	41.3	
Bishop Lavis	7	37.8	
Elsies River	8	36.7	D.C.C.
Nyanga	9	28.8	Ave. IMR (29.1)
Parow	10	27.2	
Hout Bay	11	26.3	
Bellville	12	18.7	
Atlantis	13	17.6	
Grassy Park	14	16.9	
Rural Cape Flats*	15	13.8	
Kommetjie	16	11.9	
Rural Peninsula*	17	11.9	
Goodwood	18	10.7	
Rural Northern*	19	9.5	
Ruyterwacht	20	9.3	
Constantia	21	5.7	
Pinelands	22	0.0	
Fish Hoek	22	0.0	
Simonstown	22	0.0	

+ Rate per 1000 live singleton births

* Areas which possess IMR's of questionable accuracy

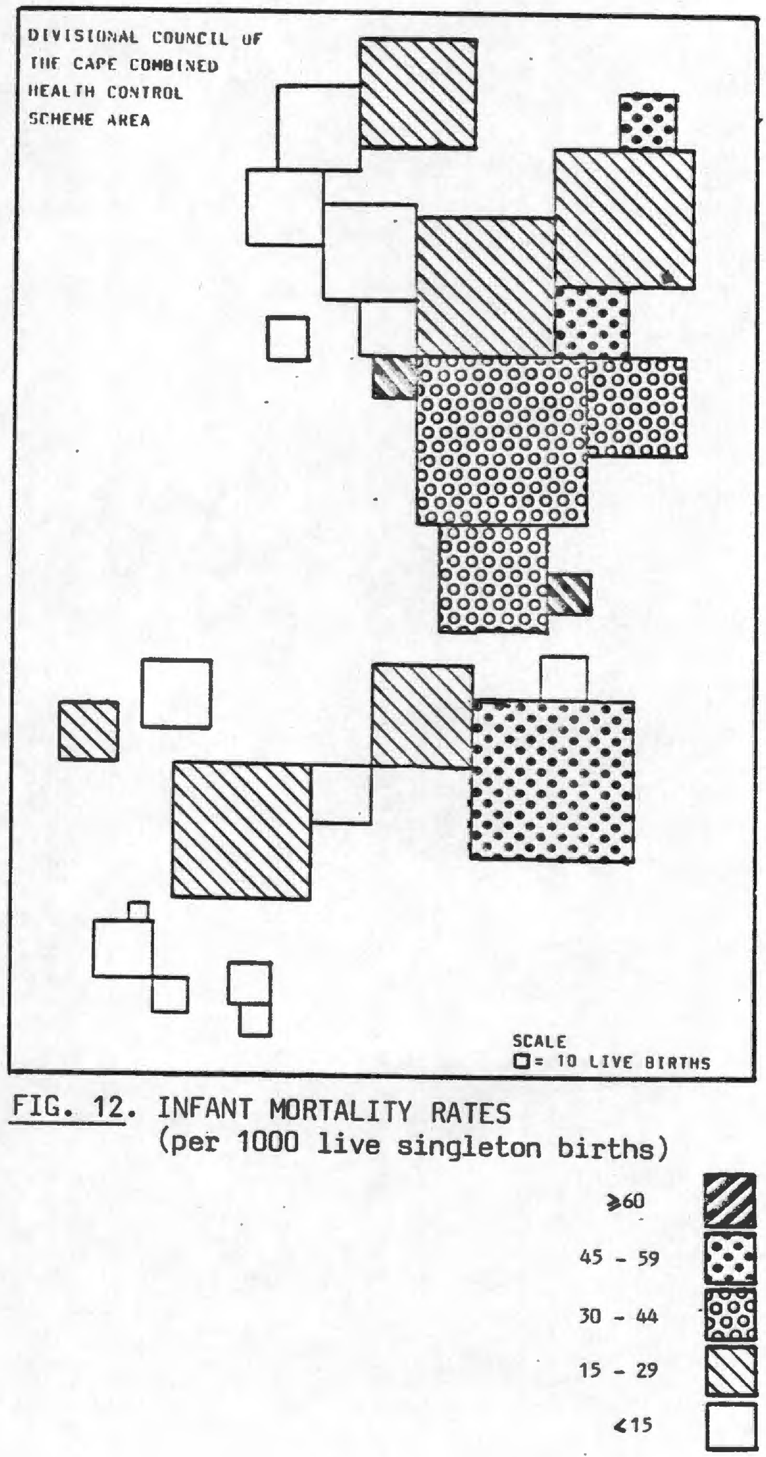


FIG. 12. INFANT MORTALITY RATES
(per 1000 live singleton births)

NEONATAL MORTALITY (NNM) BY AREA

Neonatal mortality rates by area are given in Table 19 and portrayed spatially in Fig 13. The suburb of Matroosfontein has the largest NNM rate (50.7/1000); being about five times that for the Black Township of Nyanga (10.5/1000). It is interesting to note that both of the Administration Board areas (Cross Roads (13.4/1000) and Nyanga (10.5/1000) not only have have NNM rates below the overall regional mean of 15.1/1000, but are also significantly lower than the municipalities of Durbanville and Milnerton, and to a lesser degree that of Parow. These two municipalities have NNM rates of between two to three times greater than those of the other member municipalities. The Bellville municipality, interestingly enough, has a NNM rate (13.6/1000) of the same magnitude as the Black squatter community of Cross Roads (13.4/1000). These NNM figures suggest an anomaly in the community and require further consideration by the respective authorities.

POST-NEONATAL MORTALITY (PNM) BY AREA

The effects of the extrauterine environment are patently obvious from Table 20. The black squatter area of Cross Roads, having a respectable NNM rate of 13.4/1000, is now seen to be severly disadvantaged with a post-neonatal mortality (PNM) rate of 35.6/1000; being about two-and-a-half times greater than the regional average rate of 14.1 per 1000 neonatal survivors. This is also nearly seven times as great as the mean for the municipal areas.

Again, the municipality of Durbanville is strongly associated with areas having high PNM rates. An interesting feature is the suburb of Matroosfontein which hasd the highest infant and neonatal mortality rates, has a marginally above average PNM rate of 15.3/1000; being slightly less than half that of Cross Roads. The two rural areas to the north and to the south (Peninsula of the study area with PNM rates of zero (0.0/1000) are regarded to be extremely unreliable. The spatial distribution of the PNM rates is detailed in Fig. 14.

TABLE 19. NEONATAL MORTALITY RATES RANKED IN DECENDING ORDER

AREA NAME	RANK	NEONATAL MORTALITY (Rate)+	
Metroosfontein	1	50.7	
Uitsig	2	34.7	
Bishop Lavis	3	27.5	
Durbanville	4	25.2	
Milnerton	5	23.6	
Nooitgedacht	6	20.4	
Elsies River	7	19.7	
Belhar	8	19.3	
Parow	9	18.8	D.C.C.
Rural Cape Flats*	10	13.8	—— Ave. rate (15.1)
Bellville	11	13.6	
Cross Roads	12	13.4	
Rural Peninsula*	13	11.9	
Nyanga	14	10.5	
Grassy Park	15	9.9	
Rural Northern*	16	9.5	
Ruyterwacht	17	9.3	
Hout Bay	18	8.8	
Kommetjie	19	7.9	
Atlantis	20	7.7	
Goodwood	21	6.1	
Constantia	22	2.9	
Pinelands	23	0.0	
Simonstown	23	0.0	
Total		15.1	

\+ Rate per 1000 live singleton births

* Areas which have questionable rates

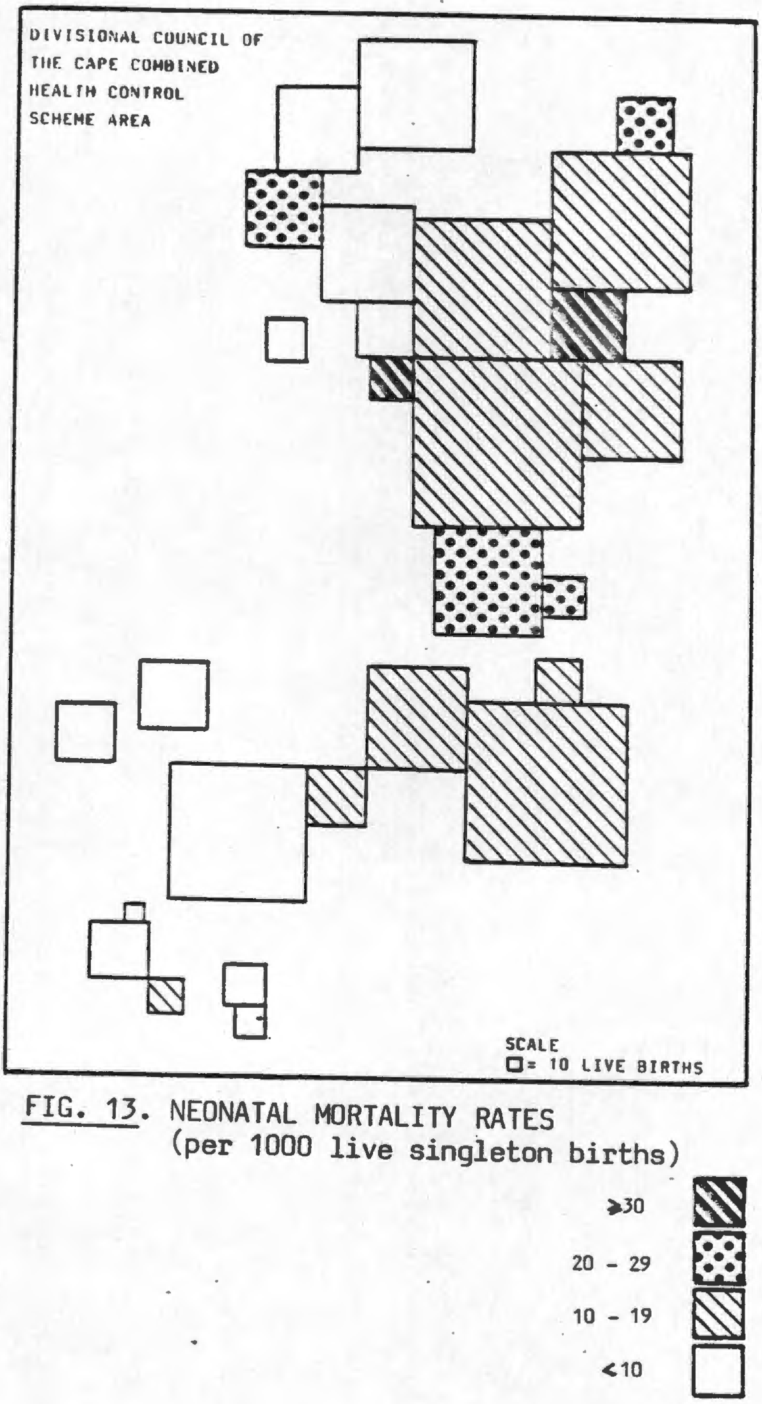


FIG. 13. NEONATAL MORTALITY RATES
(per 1000 live singleton births)

TABLE 20. POST-NEONATAL MORTALITY RATES RANKED IN DECENDING ORDER

AREA NAME	RANK	POST-NEONATAL MORTALITY (Rate)+
Cross Roads	1	35.6
Rural Cape Flats*	2	28.0
Belhar	3	22.5
Durbanville	4	22.1
Nyanga	5	18.5
Hout Bay	6	17.7
Elsies River	7	17.4
Matroosfontein	8	15.3
Uitsig	9	13.1
Bishop Lavis	10	10.6
Atlantis	11	10.0
Parow	12	8.5
Grassy Park	13	7.1
Nooitdedacht	14	5.6
Milnerton	15	5.4
Bellville	16	5.1
Goodwood	17	4.6
Kommetjie	18	4.0
Constantia	19	2.9
Ruyterwacht	20	0.0
Pinelands	20	0.0
Fish Hoek	20	0.0
Simonstown	20	0.0
Rural Northern*	20	0.0
Rural Peninsula*	20	0.0
Total		14.1

—— D.C.C. Ave. rate (14.1) (marked between 15.3 and 13.1)

\+ Rate : Post-neonatal deaths (>28 days) divided by neonatal survivors X 1000

* Areas which possess PNMR's of questionable accuracy

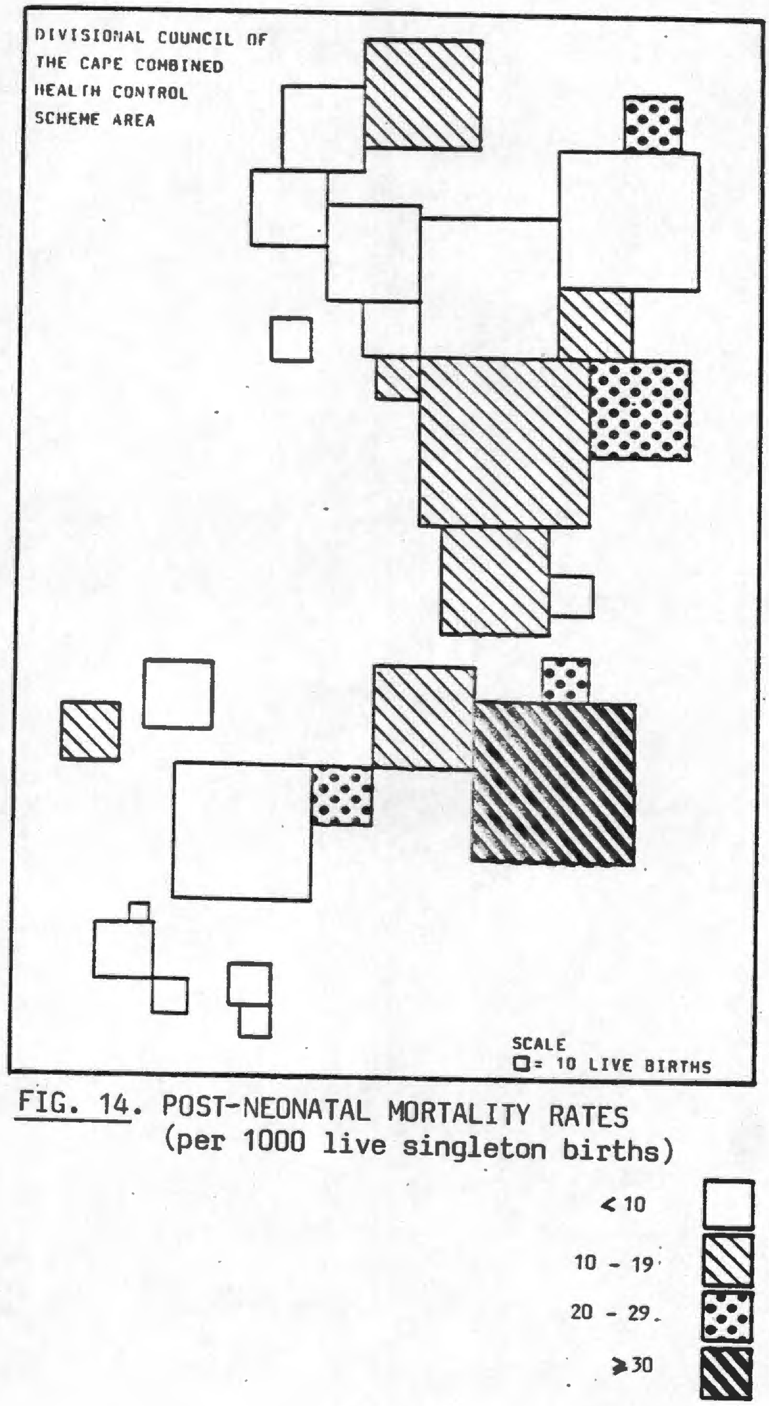


FIG. 14. POST-NEONATAL MORTALITY RATES (per 1000 live singleton births)

CROSS-LINKAGE

Of the 455 infant deaths reported during 1982, 291 (64%) had a cross-matching birth weight measurement and only 18 (3.9%) were without a birth weight figure. Cross-linkage was therefore successfully performed on 67.9% of the total infant deaths reported, leaving 146 (32.1%) infants for whom no matching birth notification form could be located. Table 21 represents a detailed summary of the cross-linkage procedure, whilst the cross-matching process is illustrated schematically in Figure 15.

STILL BIRTHS

Through a nuance in the overall birth and death reporting system operating in the Greater Cape Town Area, still births appear to be reported via both birth and death certificates. This observation led to a detailed analysis of the records in an attempt to assess the potential impact this practice may be having on the determination of perinatal statistics.

It is quite evident that some considerable confusion surrounds the reporting of late foetal deaths. Figure 15 shows that 203 still births were notified via the death certificates, whereas only 163 were reported from birth notification forms.

By checking these two sets of data it was discovered that only 110 records were able to be cross-linked, and that 146 still births were not. More importantly, however, is the fact that none of these 146(93 + 53) still birth records are common. The only deduction that can be made from this is that there is a significant amount of under-reporting of late foetal deaths. It would seem that a more reliable estimate of the CHECS region still birth population for 1982 is 256 (110 + 146) (Refer to Fig. 15).

The number of still births reported, obviously depends on which so-called source of still birth reporting is being used. Birth notification will provide only 163 (63.7%) and death certificates 203 (79.3%) of all (?) still births. It should be remembered that whilst some degree of migration (as yet un[redacted]determined) will influence the degree of cross-matching of infant death and birth records, this will not apply to the still birth data as there is no temporal delay between birth and (death) reporting.

TABLE 21. SUMMARY OF CROSS-LINKAGE OF INFANT MORTALITY WITH BIRTH WEIGHT

SUMMARY

TOTAL INFANT DEATHS (DCC CHCS REGION : 1982) :		455
INFANT DEATHS CROSS-MATCHED WITH BIRTH WEIGHT :	291	
INFANT DEATHS CROSS-MATCHED WITHOUT BIRTH WEIGHT :	18	
TOTAL INFANT DEATHS CROSS-LINKED :		309
INFANT DEATHS NOT CROSS-MATCHED/MISSING :		146

INFANT DEATHS (CROSS-LINKED)

EARLY NEONATAL (< 7 days)	=	128	(41.4%)
LATE NEONATAL (7-27 days)	=	58	(18.8%)
NEONATAL (<28 days)	=	186	(60.2%)
POST-NEONATAL (28-<365 days)	=	123	(39.8%)
TOTAL INFANT (<1 yr)	=	309	(100.0%)

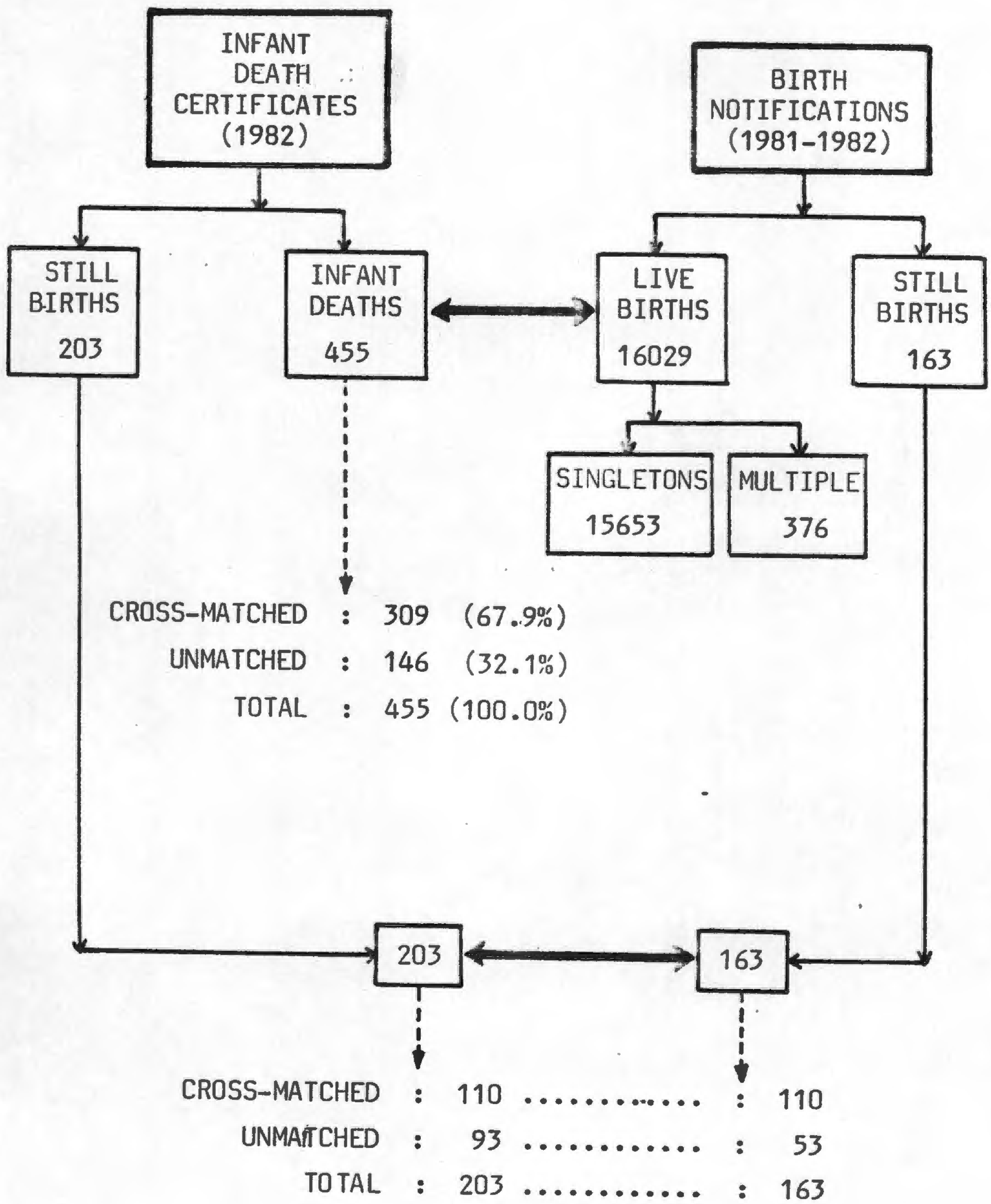
INFANT DEATHS (CROSS-LINKED WITH A BIRTH WEIGHT)

EARLY NEONATAL	=	113	(38.8%)
LATE NEONATAL	=	56	(19.2%)
NEONATAL	=	169	(58.1%)
POST-NEONATAL	=	122	(41.9%)
TOTAL INFANT	=	291	(100.0%)

INFANT DEATHS (CROSS-LINKED BUT NO BIRTH WEIGHT)

EARLY NEONATAL	=	15	(83.3%)
LATE NEONATAL	=	2	(11.1%)
NEONATAL	=	17	(94.4%)
POST-NEONATAL	=	1	(5.6%)
TOTAL INFANT	=	18	(100.0%)

FIG. 15. DETAILED ASSESSMENT OF THE CROSS-LINKAGE PROCESS OF INFANT DEATHS AND STILL BIRTHS WITH ALL BIRTHS



Possible Total STILL BIRTHS = 110 + 93 + 53

= 256

BIRTH WEIGHT-SPECIFIC MORTALITY

OVERALL ANALYSIS

Analysis of linked birth and infant death records for the 1982 live birth cohort (Table 22) shows that the infant mortality rates are highest for infants who weighed less than 1000 grams at birth (761.9 per 1000), and then decline steadily with increasing birth weight up to 4000 grams (16.6/1000) (Fig. 16). There is a very slight upturn in mortality for the heaviest births. In the lowest weight group (<1000g), nearly three out of every four infants die, whereas the infant mortality rate reaches a low level of 12.8/1000 at 3000-3499 grams.

TABLE 22. BIRTH WEIGHT-SPECIFIC INFANT MORTALITY RATES FOR THE ENTIRE CHECS REGION - 1982

BIRTH WEIGHT GROUP (g)	BIRTHS+	INFANT MORTALITY CROSS-LINKED (N)[A]	(%)	NOT CROSS-LINKED* (N)[B]	TOTAL INFANT DEATHS (N) [A+B]	INFANT MORTALITY RATE **
500-999	63	31	10.7	17	48	761.9
1000-1499	177	52	17.9	28	80	452.0
1500-1999	428	34	11.7	18	52	121.5
2000-2499	1203	31	10.7	17	48	39.9
2500-2999	3909	52	17.9	27	79	20.2
3000-3499	5860	50	17.2	25	75	12.8
3500-3999	3170	32	11.0	17	49	15.5
≥4000	843	9	3.1	5	14	16.6
TOTAL	15653	291	100.0	154	455	28.4

+ Refer to Table 7. (Live singletons only).

* Infant deaths which could not be cross-matched, or contained a missing birth weight - redistributed according to the known [A] percentage live singleton birth weight-specific distribution.

** Rate per 1000 live singleton births.

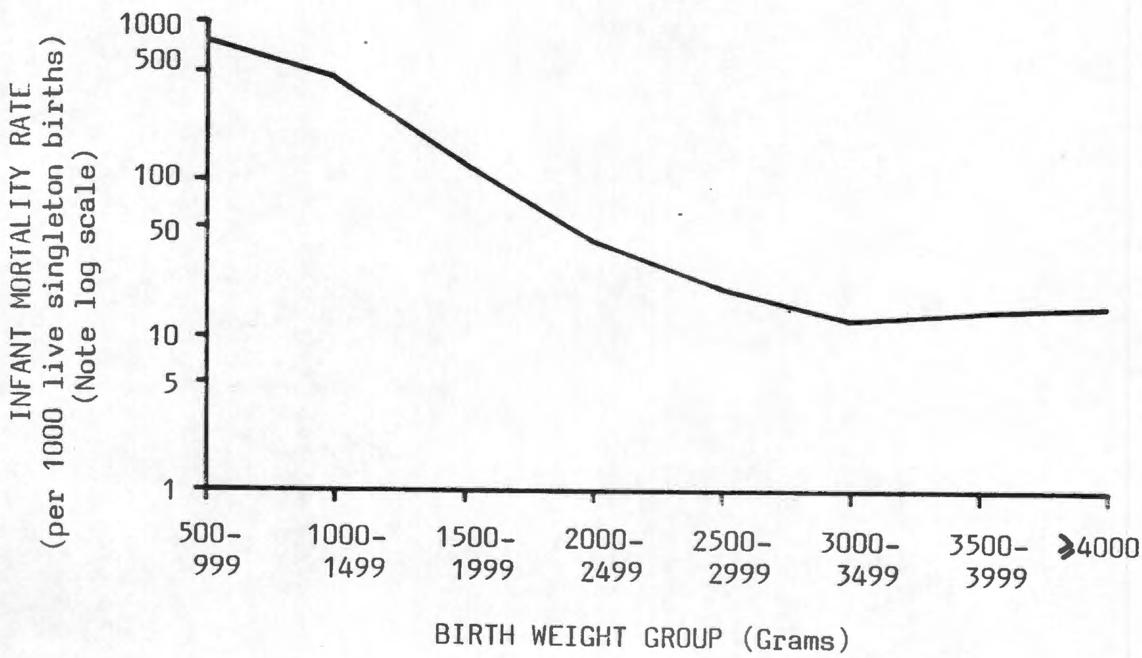


FIG. 16. BIRTH WEIGHT-SPECIFIC INFANT MORTALITY CURVE FOR THE ENTIRE CHECS REGION - 1982.

Table 23 shows the importance of birth weight as a discriminating variable for infant mortality. The concern over low birth weight infants is re-inforced, since these infants are much more likely to die in the first year of life. This weight group represents the majority of infant deaths having an overall low birth weight-specific mortality rate of 121.9 per 1000. Further, these infants form 52.3% of all infant mortality, yet arise from out of only 12.0% of the birth cohort.

TABLE 23. BIRTH WEIGHT-SPECIFIC INFANT MORTALITY RATES

BIRTH WEIGHT GROUP (g)	BIRTHS+ (N)	(%)	INFANT DEATHS (N)	(%)	INFANT MORTALITY* (Rate)
< 1500	240	1.5	128	28.8	533.3
< 2500	1871	12.0	238	52.3	121.9
≥ 2500	13782	88.0	217	47.7	15.7
TOTAL	15653	100.0	455	100.0	28.4

\+ Live singleton births only.

* Rate per 1000 live singleton births.

NEONATAL BIRTH WEIGHT-SPECIFIC MORTALITY

Table 24 and Fig. 17 indicate again, the well-known relationship between birth weight and infant death. This relationship is also observed for neonatal and post-neonatal mortality individually, although birth weight is more closely associated with the risk of dying within the first month of life. It will be noted that the relationship falls into two distinct parts. For infants weighing more than 2500 grams at birth, the neonatal mortality rate is uniformly low. Amongst the lower weight groups, however, neonatal mortality rises very steeply with decreasing birth weight, reaching 619.0/1000 live singleton births in the 500-999 gram weight group. This sub-division of the range of birth weights coincides with the point at which neonatal mortality falls to a uniform level.

TABLE 24. BIRTH WEIGHT-SPECIFIC NEONATAL MORTALITY RATES (<28 Days) FOR THE ENTIRE CHECS REGION - 1982

BIRTH WEIGHT GROUP (g)	BIRTHS	NEONATAL MORTALITY CROSS-LINKED (N) [A]	(%)	NOT CROSS-LINKED* (N) [B]	TOTAL INFANT DEATHS (N) [A+B]	NEONATAL MORTALITY RATE **
500-999	63	28	16.6	11	39	619.0
1000-1499	177	47	27.8	19	66	372.9
1500-1999	428	23	13.6	9	32	74.8
2000-2499	1203	19	11.2	8	27	22.4
2500-2999	3909	20	11.8	8	28	7.2
3000-3499	5868	16	9.5	6	22	3.8
3500-3999	3170	12	7.1	5	17	5.4
≥4000	843	4	2.4	2	6	7.1
TOTAL	15653	169	100.0	68	237	15.1

* Neonatal deaths which could not be cross-matched, or contained a missing-birth weight, distributed according to the known [A] percentage distribution of live singleton birth weight-specific distribution.

** Rate per 1000 live singleton births.

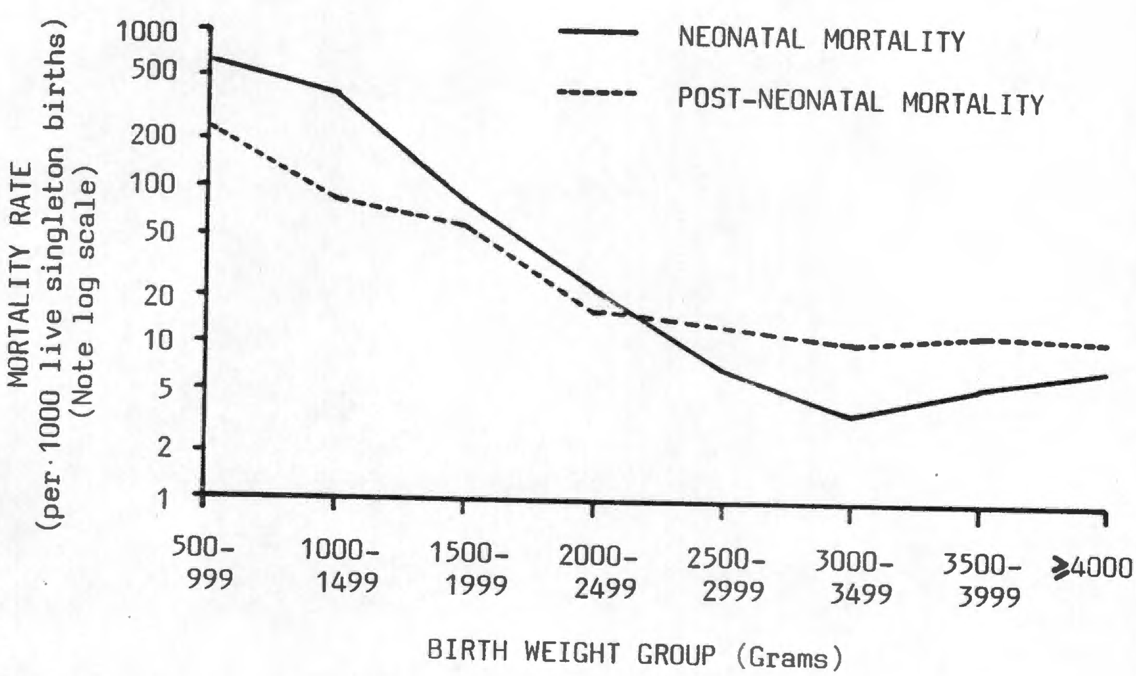


FIG. 17 . NEONATAL AND POST-NEONATAL BIRTH WEIGHT-SPECIFIC MORTALITY CURVES FOR THE CHECS REGION - 1982

The dependence of neonatal mortality on birth weight is clearly observable as nearly half (44.3%) of neonates weighing less than 1500 grams at birth, die during the first four weeks of life, compared with 24.9% of infants weighing between 1500 and 2499 grams, 11.8% of those between 2500 and 2999 grams, and approximately only one in every thousand (9.7%) of those weighing more than 3500 grams (Table 24).

POST-NEONATAL BIRTH WEIGHT-SPECIFIC MORTALITY

Post-neonatal mortality rates among the survivors of the neonatal period (Table 25) are elevated in the lower birth weight groups, but the gradient is less steep than with the neonatal rates (Fig. 17). Overall, a similar relationship between birth weight and infant mortality pertains for the post-neonatal period as it does in the neonatal period.

TABLE 25. POST-NEONATAL BIRTH WEIGHT-SPECIFIC MORTALITY RATES FOR THE ENTIRE CHECS REGION - 1982

BIRTH WEIGHT GROUP (g)	BIRTHS	NEONATAL SURVIVORS (A)	POST-NEONATAL MORTALITY (B)	POST-NEONATAL MORTALITY RATE * (B/A 1000)
500-999	63	24	5	208.3
1000-1499	177	111	9	81.1
1500-1999	428	396	20	50.5
2000-2499	1203	1176	21	17.9
2500-2999	3909	3881	57	14.7
3000-3499	5849	5827	61	10.5
3500-3999	3170	3153	36	11.4
≥4000	843	837	9	10.8
TOTAL	15653	15416	218	14.1

* Rate defined as the number of deaths in infants ≥28 days to <365 days of age per 1000 neonatal survivors.
Refer to CDC (1983) Morbidity and Mortality Weekly Report (MMWR) 32(43): 567-570.

PERIOD -OF-SURVIVAL AND BIRTH WEIGHT

Mortality rates for the less than 2500 grams and greater than 2500 gram categories, according to period-of-survival are shown in Table 26. As would be anticipated, the rates for the low birth weight group are highest in the neonatal period (87.7/1000) than in the post-neonatal period (29.4/1000).

TABLE 26. INFANT MORTALITY RATES (per 1000 live singleton births) BY BIRTH WEIGHT GROUP AND PERIOD-OF-SURVIVAL

BIRTH WEIGHT GROUP (g)	EARLY NEONATAL	TOTAL NEONATAL	POST-NEONATAL	TOTAL INFANT	BIRTHS
< 2500	57.7	87.7	29.4	121.9	1871
≥ 2500	4.1	5.3	11.8	15.7	13782
TOTAL	10.5	15.1	14.1	29.1	15653

There is an interesting shift in mortality rate for these two periods in the higher weight group ($\geq$2500 g), where neonatal mortality (5.3/1000) is less than half the post-neonatal rate of 11.8/1000. This implies that a significant number of "viable" births (weighing more than 2500 g) are perishing in the post-neonatal period.

A similar observation is made when considering the proportional infant mortality rates (Table 27), where 69.2% of the neonatal deaths are derived from the low birth weight group, while the remainder account for less than a third (30.8%). During the post-neonatal period, the pattern is significantly reversed, where only a quarter (25.2%) of these deaths occur in the low birth weight group. Again suggesting strongly elevated (74.8%) mortalities in the more viable birth weight groups. The overall percentage distribution of proportional infant mortality rates change marginally when presented accoring to birth weight and period-of-survival (Table 28).

TABLE 27. PROPORTIONAL INFANT MORTALITY RATES (%) ACCORDING TO PERIOD-OF-SURVIVAL AND BIRTH WEIGHT GROUP

BIRTH WEIGHT GROUP (g)	EARLY NEONATAL	TOTAL NEONATAL	POST-NEONATAL	TOTAL INFANT
< 2500	65.9	69.2	25.2	52.3
≥ 2500	34.1	30.8	74.8	47.7
TOTAL	100.0	100.0	100.0	100.0

TABLE 28. PROPORTIONAL INFANT MORTALITY RATES (%) ACCORDING TO BIRTH WEIGHT GROUP AND PERIOD-OF-SURVIVAL

BIRTH WEIGHT GROUP (g)	EARLY NEONATAL	TOTAL NEONATAL	POST-NEONATAL	TOTAL INFANT
< 2500	47.4 (108)	71.9 (164)	24.1 (55)	100.0 (228)
≥ 2500	25.8 (56)	33.6 (73)	75.1(163)	100.0 (217)
TOTAL	36.9 (164)	52. (237)	47. (218)	100.0 (455)

The low birth weight group account for 71.9% and 24.1% of neonatal and post-neonatal deaths, respectively. Alternatively, for the greater than 2500 gram group, the neonatal period now only represents 33.6% of infant deaths and the post-neonatal period 75.1%, thereby reinforcing the general pattern illustrated in the previous two tables (Tables 26 and 27).

CROSS-LINKAGE ACCORDING TO AREA

When considering the percentage of births and infant deaths which were, or were not cross-linked according to area of residence (Table 29), the overall success rate is 67.9%. Very few of the areas have a cross-matching of under 60%. Those that do, however, deserve careful scrutiny. The municipalities of Durbanville (58.3%) and Goodwood (57.1%) are marginally below this figure. Nooitgedacht and the rural area of the Peninsula have distorted cross-linkage percentages due to few occurrences ($n<5$). The two Black residential areas of Nyanga and Cross Roads have an approximately 50% successful cross-matching rate. Statistically this is certainly a large enough "sample" from which statements may be made about birth and infant death occurrences in these areas. With roughly 50% of the Black infant deaths unable to be cross-linked with their respective birth certificate, the question arises; what has happened to the other half of the infant birth records?

A valid criticism may be leveled concerning the representativeness of these birth weight measurements. It is possible that a substantial portion of the "at-risk" (low birth weight) infants are somehow being missed by the reporting system. It is also recognized that a large number of infants of poor health are brought to Cape Town from such regions as the Ciskei and Transkei where they possibly die, thereby adding to the infant mortality figures locally. This would certainly account for the larger number of Black infant deaths without corresponding birth certificates. The important question is, were these infants born in Cape Town, the births never being reported possibly because mothers feared deportation back to the "homelands" (if they happened to be classified as illegal), or were the infants imported , so to speak, from the aforementioned independent Black States and perished locally? The problem mentioned previously, concerning the spelling of Black surnames is of particular importance. It is probable that a number of unmatched infant death records are due to this source of error within both of the data files, and that the records are in actual fact present.

TABLE 29. CROSS-LINKAGE OF BIRTH AND INFANT DEATHS BY AREA

AREA NAME	% MATCHED	% UN-MATCHED
Milnerton	63.6	36.4
Bellville	71.4	28.6
Parow	95.0	5.0
Goodwood	57.1	42.9
Durbanville	58.3	41.7
Pinelands	-	-
Fish Hoek	-	-
Simonstown	-	-
Nyanga	50.0	50.0
Cross Roads	50.5	49.5
Atlantis	68.8	31.2
Mamre	100.0	0.0
Melkbosstrand	100.0	0.0
Rural Northern	66.7	33.3
Elsies River	80.9	19.1
Uitsig	80.0	20.0
Belhar	71.4	28.6
Nooitgedacht+	25.0	75.0
Ruyterwacht	100.0	0.0
Matroosfontein	71.4	28.6
Bishop Lavis	72.7	27.3
Grassy Park	68.0	32.0
Constantia	100.0	0.0
Hout Bay	60.0	40.0
Kommetjie	100.0	0.0
Rural Cape Flats	85.7	14.3
Rural Peninsula	0.0	100.0
Total	67.9	32.1

+ Small numbers ($n < 5$)

The exact extent of such a source of error is unknown and requires careful consideration in the future. At present, it would appear this issue could be argued from either direction in the absence of appropriate quantitative data. For the purposes of this study, it is assumed that factors influencing the cross-matching rates are not significantly biasing the observed weight-specific distributions.

There appears to be no cause-specific preference of the non-reporting of birth weight. Table 30 shows that the most common causes of infant mortality contain the largest numbers of non-reported birth weight records. In 1980, Frost and Kirkwood (1980. p 975) reported considerable racial differences between linked birth and infant death records in Washington State (U.S.A.). However, negligible errors relating to the incorrect reporting of population group, sex, and period-of-survival were detected in this study.

TABLE 30. CROSS-LINKED INFANT DEATHS WHICH DID NOT POSSESS A BIRTH WEIGHT RANKED IN DECENDING ORDER ACCORDING TO CAUSE-OF-DEATH

RANK	ICD-9 B.T.L. CODE+	INFANT DEATHS (N)	INFANT DEATHS (%)
1	32	40	27.4
2	45	38	26.0
3	1	29	19.9
4	46	10	6.8
5	3	5	3.4
6	28	4	2.7
6	44	4	2.7
8	22	3	2.1
8	Unknown	3	2.1
10	29	2	1.4
11	11	1	0.7
11	20	1	0.7
11	31	1	0.7
11	33	1	0.7
11	48	1	0.7
11	50	1	0.7
11	51	1	0.7
11	56	1	0.7
TOTAL		146	100.0

\+ Cause-of-death coded according to the International Cause of Death (ICD - 9th revision) Basic Tabulation List code. (Refer to Table 54 for a detailed explanation of the codes).

LOCAL VS. INTERNATIONAL FINDINGS

Substantial differences between infants of the three major population groups in weight at birth are evident within the CHECS region (Appendix B and Fig. 5). There is a considerably higher incidence of low birth weight among Coloured infants than among White ones (16.1% compared with 4.4%). Some investigators, noteably Penchaszadeh _et al_ (1972) and Niswander _et al_ (1969), have noted the persistence of this racial differential even after adjustments were made for differences in such maternal characteristics as age and parity, socio-economic status, cigarette smoking, and pre-pregnant weight. Failure to eliminate the racial difference observed after standardizing out these factors which are known to be associated with birth weight variations, suggests that genetic factors may be affecting the observed birth weight differences. To what extent genetic factors are influencing the birth weight distributions of the various population groups in the D.C.C. has yet to be quantified. However, two recent studies (Molteno _et al_, 1980; and Keet _et al_, 1971) conducted in Cape Town have incriminated the environment for much of the sub-optimal growth amongst underprivilaeged children.

The CHECS region experienced a 12.3% low birth weight occurrence during 1982 (Table 31). The low birth weight rate for Whites (44.95/1000) compares favourably to that recorded in developed countries, while that for Blacks (87.06/1000) is similar to developing countries and the Coloured rate (161.44/1000) tending to be strongly associated with so-called Third World countries. Further comparing low birth weight rates (Table 32) with those recorded from other parts of the world, it is of particular interest to observe that the overall low birth weight rate for the CHECS region (123.1/1000), and more particularly that for the Coloured community (161.4/1000), tend to be more similar to Oregon State (U.S.A.) with a low birth weight rate of 136.5 per 1000 births for women who had no prenatal care, rather than with an area such as Michigan State (1978) where, on average the women had greater than five prenatal visits and experienced a low birth weight rate of 57.0 per 1000 births (Scientific American, 1983. p 65).

TABLE 31 : PERCENTAGE LOW BIRTH WEIGHTS (< 2500 g) ACCORDING TO POPULATION GROUP

POPULATION GROUP	% LOW BIRTH WEIGHT (<2500 g) (LIVE SINGLETONS)
White	4.5
Coloured	16.1
Black	8.7
Total	12.3

TABLE 32. LOW BIRTH WEIGHT RATES FOR VARIOUS AREAS OF THE WORLD

AREA	YEAR	LOW BIRTH WEIGHT RATE
U.S.A.	(1982)	70.0 (estimated)
Oregon State	(1979-1982)+	136.5
Michigan State	(1971)**	203.0
Michigan State	(1978)++	57.0
Japan	(1982)	53.0
Sweden	(1982)	41.0
D.C.C. Region	(1982)*	123.1
England & Wales	(1980)	67.0
U.S.A. (Negro)	(1976)	127.0

\+ Females with no prenatal care.

* Live singleton births only.

** Females who had < 6 prenatal visits.

++ Women who had > 5 prenatal visits.

Source: Sci. Am. (1983). 249(3):65 and Suagstad (1981).

The White population group within the CHECS region has essentially a low low birth weight rate (44.95/1000) which compares with those rates for Sweden and Japan; two of the most developed nations of the world (see Table 32). On the other hand, the low birth weight rate of 87.06 per 1000 for Blacks is close to that of the estimated 1982 rate for the entire U.S.A.

From the above it may be tentatively suggested that the prenatal services for the Coloured female are either inadequate or not utilized correctly. Obviously considerable research will be required in the future for such a question to be adequately resolved.

One question raised by the mean birth weight pattern is; does the birth weight distribution truly relect the intruterine growth potential of the mother and child? The Table below shows the increase that can be expected with increased parity (Table 33). For developed countries such as Denmark and Norway, the mean birth weight increases by about 140 - 150 g between parity 1 and 2, and then by about 50 g for subsequent pregnancies.

TABLE 33. MEAN INCREASE IN BIRTH WEIGHT (g) WITH PARITY IN SELECTED COUNTRIES

COUNTRY	YEAR	PARITY: 1	2-3	3-4	MEAN BIRTH WEIGHT (g)
Norway	1967	140	40	40	3470
Denmark	1970	150	50	50	3370
USA+	1973	50	10	10	3350
New York State+	1967	50	23	22	3344
D.C.C.	1982	80	19	-24	3116

Source: Saugstad (1981, p 187).
+ White births only

Saugstad (1981) postulated such an increase might indicate that the majority of pregnancies are allowed to reach term. In the U.S.A., the increase between parity 1 & 2 is only 50 g and is negligible for later pregnancies. This reduced increase in birth weight with parity was first noted by Selvin and Janerich (Br.J.prev.soc.Med., 1971). It was suggested by these authors that American mothers were not premitted to develop their full uterine growth potential. On comparing the D.C.C. figures (Table 33) it would appear that the situation is even more severe locally than with the

American example. The pattern presented in the CHECS region is one which is characterized by a rapid decline in the mean increase in birth weight with increasing parity. What variable(s) are acting so strongly to inhibit the intrauterine growth potential of mothers in the region has yet to be elucidated. Infants weighing more than the low birth weight division of 2500 grams represent the outcome of 88.0% of all deliveries during 1982, yet contribute 47.7% of infant deaths and experience a weight-specific mortality rate of 15.7 per 1000. By comparison (Table 34), although Georgia State (U.S.A.) experienced lowest mortality rates in the greater than 2500 gram birth weight group, they represented 45% of infant deaths in 1974-1978 and 38% in 1979-1980 (CDC, 1983. p 567). The CHECS region does not compare very favourably (47.7% in 1982) with these figures and it would appear that the region is lagging approximately ten years behind the United States.

TABLE 34. COMPARISON OF BIRTH WEIGHT-SPECIFIC INFANT MORTALITY IN GEORGIA STATE (U.S.A.) AND THE D.C.C. CHECS REGION

BIRTH WEIGHT GROUP (g)	GEORGIA STATE INFANT MORTALITY+ (1974-1978) (%)	(1979-1980) (%)	D.C.C. CHCS REGION INFANT MORTALITY (1982) (%)
< 2500	55	62	52.3
≥2500	45	38	47.7
TOTAL	100	100	100.0

+ Source: CDC (1983) 32(43):567-570.

Figure 18 illustrates the steeper birth weight-specific mortality curve associated with neonatal as opposed to post-neonatal mortality for the United States during 1960 (Foster and Kleinman, 1982. p3). Notwithstanding the difference in X- and Y- axes scales of Figures 17 and 18, the relationship between birth weight-specific neonatal and post-neonatal mortality curves for both the United States and the CHECS region are strongly correlated. However, it is of interest to detect a subtle shift to lower birth weights of the point where the neonatal crosses the post-neonatal weight-specific mortality curve for the CHECS region as compared with that for the U.S.A. The birth weight category where mortality rates intersect is 2500-3000 grams, whereas it is approximately 500 grams less (2000-2499g) in the CHECS region. The factors responsible for this are at present debateable, but may be related to the elevated (more unfavourable) post-neonatal mortality rates observed in the study area.

There is a much greater probability of heavier post-neonatal infants dying locally than in the United States, although neonatal weight-specific mortality rates compare favourable.

Recently, Wilcox and Russell (1983) have developed new models for the distribution of birth weight and for the curve of weight-specific mortality in an attempt to further investigate the influence of birth weight on infant mortality, and how it might be better anlaysed. Unfortunately their technique requires computerized data sets containing more than 20 000, and preferably hundreds of thousands of births.

Recent advances in neonatal medicine are known to have led to a decline in mortality among North American infants (Foster and Kleinman, 1982). To what extent these advances have lowered the mortality of low birth weight infants in the CHECS region has been alluded to in this Chapter. For example during 1960 the birth weight-specific neonatal mortality rate for White American infants weighing less than 1000 grams was 948.7 per 1000 live births (Foster and Kleinman, 1982). Today the rate is in the order of 700/1000, and locally it is 619/1000. Quite clearly, the last two decades have seen a dramatic decrease in particularly the low birth weight-specific infant mortality rates. These advances, together with an increase in infant health services within the CHECS region have raised the need for surveillance and monitoring of trends and areal variations in birth weight-specific mortality rates.

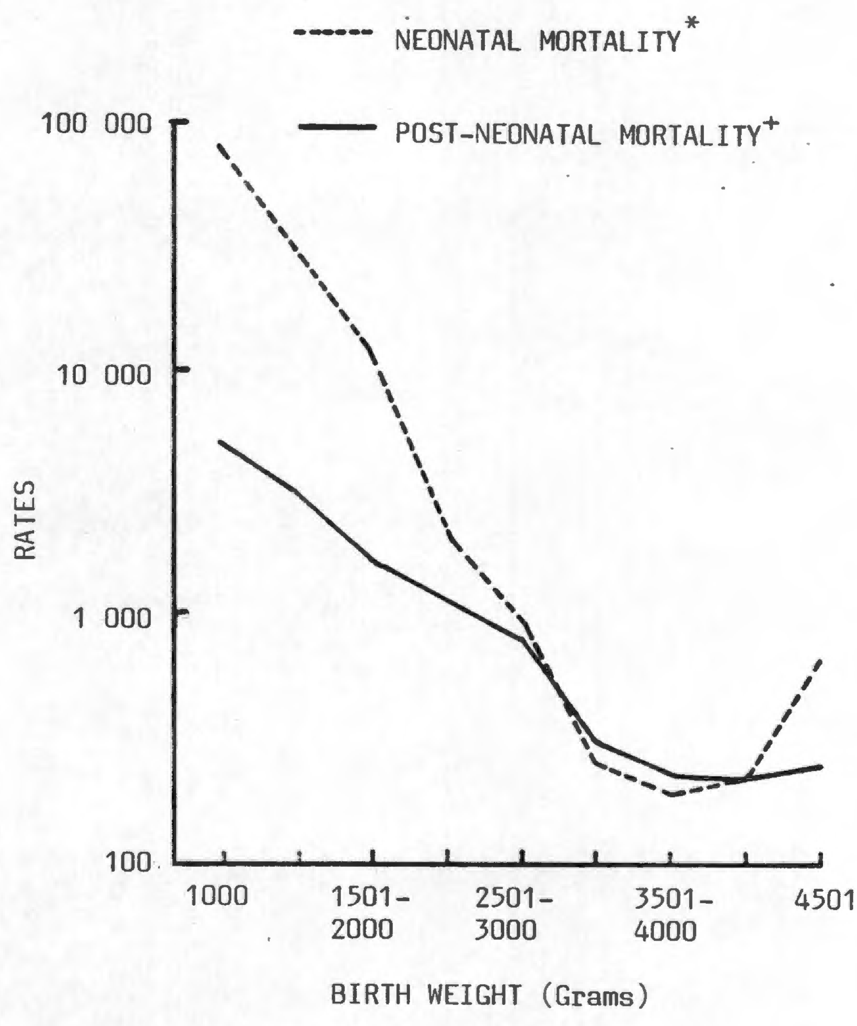


FIG. 18 . NEONATAL AND POST-NEONATAL MORTALITY RATES BY BIRTH WEIGHT (UNITED STATES, 1960)

* Deaths under 28 days per 1000 live births.

\+ Deaths 28 days - 11 months per 1000 survivors of neonatal period.

Source: Foster and Kleinman (1982).

It is now clear that the study of neonatal and post-neonatal mortality requires a sound understanding of the influences of birth weight on mortality. Neonatal mortality for a geographic area is viewed as the outcome of two separate processes; the distribution of birth weight in a population and the probabilities of death within each birth weight group. Birth weight-specific neonatal mortality rates for the State of North Carolina for 1973-74 (the most recent available) (Foster and Kleinman, 1982) and similar rates for the study area (1982) are presented in Table 35 and illustrated graphically in Fig. 19, in an attempt to assess the local rates in the light of those recorded from a developed country.

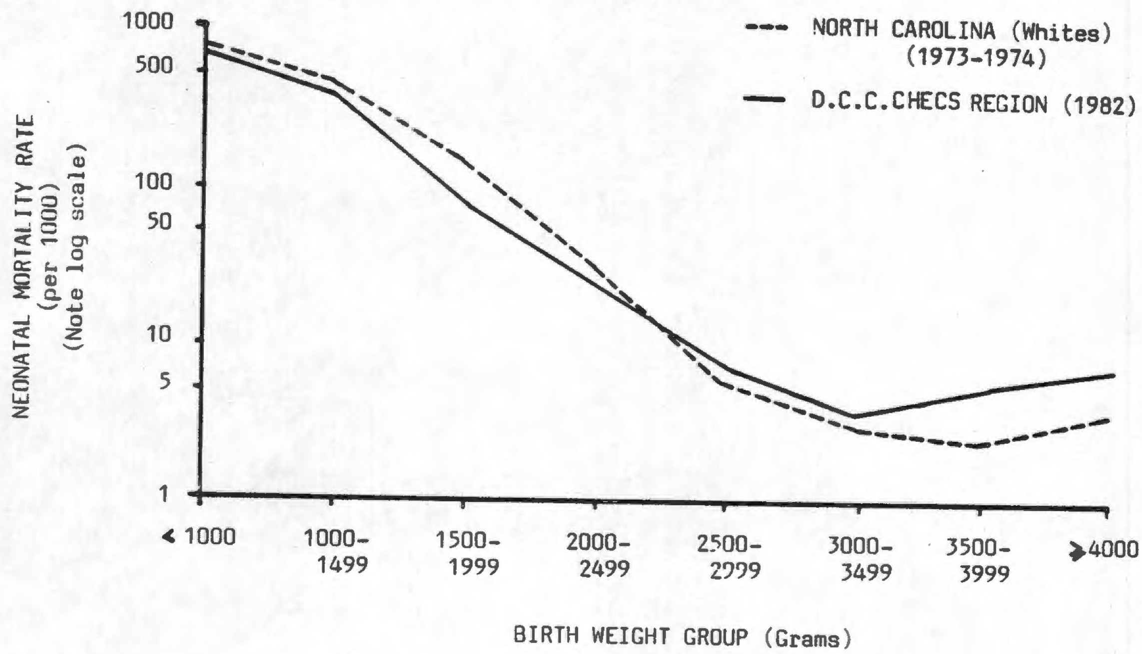
TABLE 35 . WEIGHT-SPECIFIC NEONATAL MORTALITY RATES FOR NORTH CAROLINA AND THE D.C.C. COMBINED HEALTH CONTROL SCHEME REGION

BIRTH WEIGHT GROUP (Grams)	NORTH CAROLINA NEONATAL MORTALITY RATE+	D.C.C. CHECS REGION NEONATAL MORTALITY RATE*	BIRTH WEIGHT GROUP (Grams)
500-1000	897.46	619.00	500-999
1001-1500	464.66	372.90	1000-1499
1501-2000	151.83	74.80	1500-1999
2001-2500	31.91	22.40	2000-2499
2501-3000	5.95	7.20	2500-2999
3001-3500	3.24	3.80	3000-3499
3501-4000	2.53	5.40	3500-3999
≥4000	3.82	7.10	≥4000

+ Rate per 1000 live births (Whites only).
(Source: Foster and Kleinman, 1982.)

* Rate per 1000 live singletons only.

FIG. 19. BIRTH WEIGHT-SPECIFIC NEONATAL MORTALITY RATE CURVES FOR NORTH CAROLINA (1973-1974) AND THE D.C.C. CHECS REGION (1982)



Two features relating to the mortality rate curves in Fig.19 are noteworthy. Firstly, at lower birth weights, the CHECS region experiences somewhat lower birth weight-specific neonatal mortality rates than did the State of North Caroline in 1973-74. Secondly, the study area is characterized by elevated mortality rates for birth weights greater than 3000 grams and to a lesser extent those between 2200 grams and 2999 grams, indicating that more 'viable' neonates perish locally than was the case of North Carolina more than ten years ago.

There is no regional (or local) data set which can be used to develop estimates of weight-specific mortality rates for the study area. Birth weights were only rountinely collected as recently as 1981/82. The birth weight-specific mortality rates presented represent a first attempt to construct such curves. Unfortunately, due to the lack of data spanning a number of years, birth weight-specific mortality rates can only be determined for the entire study area at present. Ideally this needs to be undertaken for each of the defined geographical units within the region.

Since the CHECS region has no formal system of linked birth and infant death records at present, it is realistic to anticipate a long delay before birth weight-specific infant mortality rates for small geographic units will become available for use by the health administrators in determining and monitoring appropriate infant health care strategies.

In the light of the sub-optimal birth weight distribution (particularly) among the Coloured community) and relatively high neonatal and post-neonatal mortality rates, an alternative measure needs to be developed locally. An alternative technique must be developed in order to adequately analyse the spatial variation of the combined effects of birth weight and infant mortality.

CHAPTER V

THE BIRTH WEIGHT RATIO - TECHNIQUE, UTILITY AND INTERPRETATION

A number of indices have already been used in various countries, noteably western Europe, attempting to describe the effects of birth weight on infant mortality. Some of these indices have also been used in a geographical context in an attempt to highlight areas which may be considered "at-risk" on the basis of their poor index values.

INDICES FOR SPATIAL ANALYSIS

Such indices include - the IMR; summary measures of birth weight and gestational age; and indices which describe the birth weight distribution (or part thereof), such as mean birth weight, as well as the proportion of low birth weight neonates or the proportion of optimal birth weight infants.

THE INFANT MORTALITY RATE

The IMR has withstood the test of time and is regarded by the WHO as one, if not the primary, measure by which the health (and health care) of different countries (or areas) may be compared. It is a useful indicator of the health status not only of infants but also of the whole population and of the socio-economic conditions under which they live. However, underpinning most measures of health status is the explicit supposition that measures based solely on mortality are inadequate (Goldsmith. 1973).

BIRTH WEIGHT AND GESTIONAL AGE

The strength of the association between birth weight and infant death becomes increasingly more pronounced with decreasing age of the infant. Susser _et al_ noted that birth weight " ... is indeed a good predictor of perinatal mortality" (1972. p203).

Although a combined measure of gestational age and birth weight would be the most appropriate indicator of prematurity, there is considerable rationale for focusing on birth weight alone as a single outcome measure. Analysis of linked birth and death records indicates that mortality is more strongly influenced by birth weight than by gestational duration

(Armstrong (1972); and Kleinman, 1982. p1). That is, although infants with shorter gestations generally experience greater mortality at a given birth weight, mortality varies more strongly by birth weight when gestational age is controlled (Susser et al, 1972; amd Armstrong et al, 1972).

Ganguly et al (1972. p166) have also accurately pointed out that the length of gestation cannot be considered as a predicative factor of birth weight because, although this factor is significantly associated with birth weight, it is itself an outcome, rather than a precursor, of pregnancy.

In their review of the literature on prematurity, Hemminski and Starfield (1978. p 343) presented additional evidence that birth weight alone explains the variance in infant (predominantly perinatal) mortality almost as well as a combined index of gestational age and birth weight. Furthermore, the vital statistics data on gestational age (that is derived from the date of the mother's last mentrual period) have very limited reliability, particularly in underdeveloped countries, and even in the United States (20% in 1977) (Querec, 1980).

Gosh (1982.p 315)in a recent letter, has highlighed the experience in Delhi concerning birth weight and gestational age on infant mortality. Birth weight and gestation were important factors which influenced the outcome of pregnancy. It was discovered that when gestation was included along with birth weight, remarkable differences in mortality within the same birth weight group were observable (ibid. p315). It is unfortunate that Gosh does not present data relating to the accuracy of reporting and non-response of the gestation variable to substantiate its reliability. In the light of previous work (i.e. Querec, 1980; and Hemminski and Starfield, 1978), it is not unlikely that these gestation data from an urban cohort in India are of questionable accuracy and might explain the remarkable differences in mortality observed, and therefore, only the birth weight figures are of practical significance.

MEASURES OF THE BIRTH WEIGHT DISTRIBUTION

The distribution of birth weight is usually summarized by a single statistic, either the mean or the proportion of babies weighing less than 2500 grams (5.5 pounds). This has been critized by Rooth (1980), who suggested that this approach may lead to an oversimplification of the relationship between birth weight and infant mortality, not least because different communities may have different frequency distributions of birth weight. However, the use of a fixed critical weight has recently been supported on empirical grounds by Goldstein (1981). Since birth weight serves as an intermediate outcome for many variables associated with infant mortality, birth weight can be viewed as a summary measure of the effect of social and demographic risk factors (Foster and Kleinman, 1982. p7).

Birth weight has also been used as an important (positive) health indicator of community nutrition (WHO, 1981). More importantly, however, is the fact that low birth weight has been frequently used as an indicator of maternal and newborn nutritional status (WHO, 1981) and ill-health, mainly because low birth weight is one of the most readily recognizable risk factors for the survival of an infant and can be easily measured.

Ashford et al (1973. p31) have demonstrated in England and Wales that maternity services do not bear a close relationship to birth weight distribution , which appears to be determined largely by the characteristics of the population and general environment. This finding confirms the view that birth weight describes, not obstetric services, but rather antenatal care and maternal nutrition.

MEAN BIRTH WEIGHT

The mean birth weight has been long regarded as one of the indices of the health of a country; underdeveloped countries, in which malnutrition is common, (i.e. poor maternal nutrition) have a lower mean birth weight than the countries with a high standard of (maternal) nutrition (Illingworth, 1979. p5). Moreover, the mean birth weight tends to be higher in the higher socio-economic classes than in the lower ones. In Sweden and Denmark the mean birth weight is regarded as one of the indices of the general health of each country (Saugstad, 1981; and Illingworth, 1979 p 48). It is important to note that research conducted in the United States has found little or no association between large birth weights and the duration of pregnancy (Ounsted, 1969. p 693; and USDHEW, 1978).

LOW BIRTH WEIGHT

The proportion of low birth weight infants is frequently used as a single birth weight statistic in identifying "at-risk" neonates.

Saugstad (1981) has argued that because the higher neonatal (and infant) mortality rates are to be found in infants weighing less than 2500 grams, any discussion on how to reduce infant mortality should centre upon the reduction of the proportion of infants with a low birth weight.

"OPTIMUM" BIRTH WEIGHT

Karn and Penrose (1951)were the first to note that the "optimum" birth weight (i.e. the weight at which the mortality curve reaches a minimum) is several hundred grams heavier than the mean, being (for England and Wales) of the order of 3750 g. Other workers, noteably Saugstad (1981) have more recently put forward the suggestion that the proportion of infants greater than 3500 grams may be regarded as a possible measure of optimality of the birth population as a whole, the reason being that the lowest mortality rates are recorded among newborn infants weighing 3500 grams or more. There is an inverse relationship between the proportion of heavy newborn infants in a çountry (or area) and its infant mortality rate.

THE BIRTH WEIGHT RATIO (BWR)

The use of mean birth weight as a summary measure of the birth weight distribution has considerable appeal, despite a number of fairly significant statistical limitations. After due consideration of the birth weight data (refer to Chapter IV), it is clear that the mean birth weight is not appropriate for application in the CHECS region, because of the skewed birth weight distributions of the different population groups. It is now known that the proportion of low birth weight infants is highly correlated with areas presenting with high infant mortality rates (refer to Chapter IV). The percentage occurrence of low birth weight infants for various countries is shown in Table 36.

The concept of birth weight "optimally" put forward by Saugstad (1981), was noted with interest. Table 37 shows, for the same localities listed in the aforementioned Table 36, the proportion of optimal births occurring in these countries.

Both of these 'measures', the proportion of low and optimal birth weights respectively, are representative of the so-called tails of somewhat skewed Gaussian (birth weight) distributions observed in the study area (Fig. 6).

By taking the ratio of the two measures (low birth weight and optimal birth weight) it might be possible to arrive at a superior (synthesized) index which could summarize the birth weight distribution, but more importantly, point to whether an area may be considered more "at-risk" on the basis of

TABLE 36. PERCENTAGE OF LOW BIRTH WEIGHTS (<2500g) FOR VARIOUS COUTRIES COMPARED WITH THE D.C.C. COMBINED HEALTH CONTROL SCHEME (CHECS) REGION

COUNTRY/AREA	YEAR	< 2500g (%)
Faeroes Is.	1973	3.7
Iceland	1972	4.3
Norway	1972-74	4.4
Sweden	1973	4.6
Japan+	1974	5.1
Czechoslovakia+	1973	6.1
U.S.A. (Whites)	1973	6.5
Germany GFR+	1973	6.7
Denmark	1973-74	6.8
United Kingdom	1970	6.8
Canada+	1973	7.0
U.S.A.	1973	7.6
Poland+	1974	8.0
Hungary+	1974	11.7
D.C.C. CHECS Region*	1982	12.3
U.S.A. (Non-Whites)	1973	13.3

\+ Live births only

* Live singleton births only

Source: After Saugstad (1981. p 186)

TABLE 37. PERCENTAGE OF "OPTIMAL" BIRTH WEIGHTS ($\geq$3500g) FOR VARIOUS COUNTRIES COMPARED WITH THAT IN THE D.C.C. CHECS REGION

COUNTRY	PROPORTION OF BIRTH WEIGHTS $\geq$3500g (%)	D.C.C. CHECS REGION	
FAEROES IS. (1973)	61.4		
ICELAND (1972)	58.8		
NORWAY (1972-74)	51.0		
SWEDEN (1973)	49.5		
GERMANY GFR (1973)*	40.4		
U.S.A. (Whites) (1973)	38.8		
DENMARK (1973-74)	38.5		
CZECHOLOVAKIA (1973)*	37.8		
U.S.A. (1973)	36.0	— D.C.C. (Whites) (1982)**	37.4
CANADA (1973)*	35.2		
UNITED KINGDOM (1970)	35.1		
POLAND (1974)*	35.0		
HUNGARY (1974)*	26.9	— D.C.C. (Blacks) (1982)**	27.5
JAPAN (1974)*	23.3	— D.C.C.CHECS Region** (1982)	25.1
U.S.A. (Non-Whites) (1973)	22.6	— D.C.C. (Coloureds)** (1982)	20.1

* Live births only.

** Live singleton births only.

Source: Saugstad, 1981.

that distribution. This is of some considerable importance in the light of workers such as Mallet and Knox (1979. p 6), as well as King (1979), having indicated the need for epidemiological data to be considered in terms of geographical area. Indeed, Knox et al (1980) have found that the variation in birth weight distribution between English health areas was by far the most powerful determinant (up to 60%) of area variation in perinatal and neonatal mortality rates.

The birth weight ratio is illustrated schematically in Figure 20 and is defined as follows;

$$BWR = \frac{\text{Proportion infants weighing} < 2500 \text{ grams}}{\text{Proportion infants weighing} \geq 3500 \text{ grams}}$$

If the BWR has a value of greater than 1.0, this would indicate that the numerator is larger than the denominator; the conclusion being that the proportion of low birth weight infants is greater that that of the "optimal" birth weight infants, and the particular geographic unit is characterized by a negatively skewed birth weight distribution. Furthermore, it is hypothesized that the infant mortality rate will be larger than that of an area which possesses a BWR value of less than 1.0.

SPATIAL VARIATION

With this hypotheseis in mind, Table 38 was constructed showing the calculated BWR's for the group of countries listed in Tables 36 and 37. The BWR is viewed as an indicator (index) of maternal nutritional status and level of health care.

Similar BWR's were then calculated for each area within the CHECS region (Table 39), and the spatial distribution of the BWR's is shown in Fig. 21. Table 40 provides the legend and mapping class intervals for Fig 21. Figure 21 represents an improved depection of the birth weight distribution, especially for the "at-risk" areas, than does the low birth weight rate (Fig. 8), or the 'optimal' birth weight rate (Fig.9) maps. For example, in Fig. 8, the suburb of Matroosfontein has a low low birth weight rate being in mapping class 3 which represents the range 100 to 149 per 1000. However, when this single summary measure is compared with the BWR (Fig.21), Matroosfontein is shown to be the highest "at-risk" area, having a BWR value of 1.67 (mapping class 1. Matroosfontein may be thought of as possessing 1.67 times more.

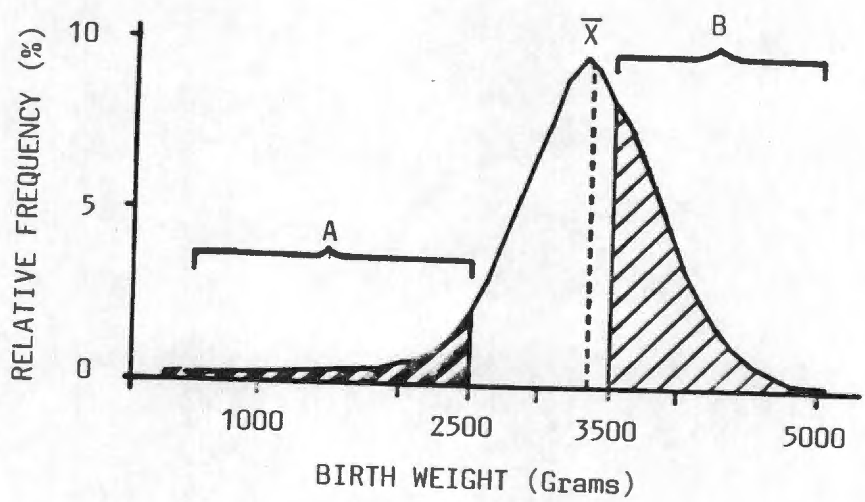


FIG. 20 . COMPONENTS OF THE BIRTH WEIGHT RATIO (BWR) (Emperical birth weight distribution based upon Wilcox and Russell, 1983).

A : Proportion of low birth weight (LBW) infants (<2500g).

B : Proportion of "optimal" (≥3500g) birth weight infants (After Saugstad, 1981).

$\overline{X}$: Mean birth weight.

$$\text{BWR} = \frac{\text{COMPONENT A}}{\text{COMPONENT B}} = \frac{< 2500\text{g}}{\geq 3500\text{g}}$$

TABLE 38. BIRTH WEIGHT RATIOS (BWR) FOR VARIOUS COUNTRIES

COUNTRY	YEAR	BIRTH WEIGHT <2500g (%)	BIRTH WEIGHT ≥3500g (%)	CALCULATED BIRTH WEIGHT RATIO
Denmark	1973/74	6.8	38.5	0.18
Sweden	1973	4.6	49.5	0.08
Norway	1972/74	4.4	51.0	0.09
Faeros Is.	1973	3.7	61.4	0.06
Iceland	1972	4.3	58.8	0.07
Canada+	1973	7.0	35.2	0.19
U.S.A.	1973	7.6	36.0	0.21
U.K.	1970	6.8	35.1	0.19
Japan+	1974	5.1	23.3	o.22
Germany GFR+	1973	6.7	40.4	0.17
Hungary+	1974	11.7	26.9	0.43
Poland+	1974	8.0	35.0	0.23
Czecholovakia+	1973	6.1	37.8	0.16

+ Live births only

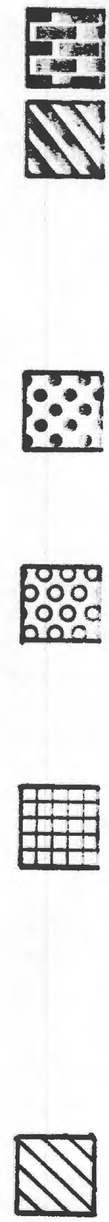
Source: Saugstad, 1981.

TABLE 39. COMPONENTS OF THE BIRTH WEIGHT RATIO FOR EACH AREA WITHIN THE STUDY REGION

AREA NAME	BIRTH WEIGHT <2500g (N)	(%)	≥3500g (N)	(%)	BIRTH WEIGHT RATIO (<2500g/≥3500g)
Milnerton	20	5.3	120	31.8	0.17
Bellville	118	8.6	438	31.9	0.27
Parow	169	12.1	377	26.9	0.45
Goodwood	31	4.8	234	36.1	0.13
Durbanville	26	9.6	85	31.3	0.30
Pinelands	3	2.8	44	40.7	0.07
Fish Hoek	4	4.1	41	41.8	0.10
Simonstown	9	15.0	24	40.0	0.38
Nyanga	80	10.6	217	28.8	0.37
Cross Roads	140	7.9	500	28.2	0.28
Atlantis	157	17.5	191	21.3	0.82
Mamre/Pella	19	17.0	25	22.3	0.76
Rural Northern	66	22.6	49	16.8	1.35
Elsies River	365	16.5	471	21.3	0.77
Uitsig	50	16.3	54	17.6	0.93
Belhar	106	15.0	139	19.6	0.76
Nooitgedacht	18	18.8	18	18.8	1.00
Ruyterwacht	7	6.6	25	23.6	0.28
Matroosfontein	15	11.1	9	6.6	1.67
Bishop Lavis	133	16.1	157	19.0	0.85
Grassy Park	160	11.5	328	23.6	0.49
Constantia	23	6.7	112	32.2	0.21
Hout Bay	28	12.4	59	26.1	0.47
Kommetjie	43	18.5	53	22.8	0.81
Cape Rural Flats	71	20.2	72	20.5	0.99
Rural Peninsula	14	18.4	17	22.4	0.82
D.C.C. CHECS REGION	1881	12.3	3920	25.6	0.48

TABLE 40. AREAS WITHIN THE STUDY REGION RANKED IN DECENDING ORDER ACCORDING TO BIRTH WEIGHT RATIO

AREA NAME	RANK	BIRTH WEIGHT RATIO	MAPPING END POINTS	CLASS
			1.68	
Matroosfontein	1	1.67		7
Rural Northern	2	1.35	1.44	
Nooitgedacht	3	1.00	1.20	6
Rural Cape Flats	4	0.99		5
Uitsig	5	0.93	0.96	
Bishop Lavis	6	0.85		
Atlantis	7	0.82		
Rural Peninsula	7	0.82		
Kommetjie	9	0.81		4
Elsies River	10	0.77		
Belhar	11	0.76		
Mamre/Pella	11	0.76		
Grassy Park	13	0.49	0.72	
Hout Bay	14	0.47	0.48	3
Parow	15	0.45		
Simonstown	16	0.38		
Nyanga	17	0.37		
Durbanville	18	0.30		2
Cross Roads	19	0.28		
Ruyterwacht	19	0.28		
Bellville	21	0.27		
Constantia	22	0.21	0.24	
Milnerton	23	0.17		
Goodwood	24	0.13		
Melkbosstrand	24	0.13		1
Fish Hoek	26	0.10		
Pinelands	27	0.07		
			0.00	
D.C.C. CHECS REGION		0.48		



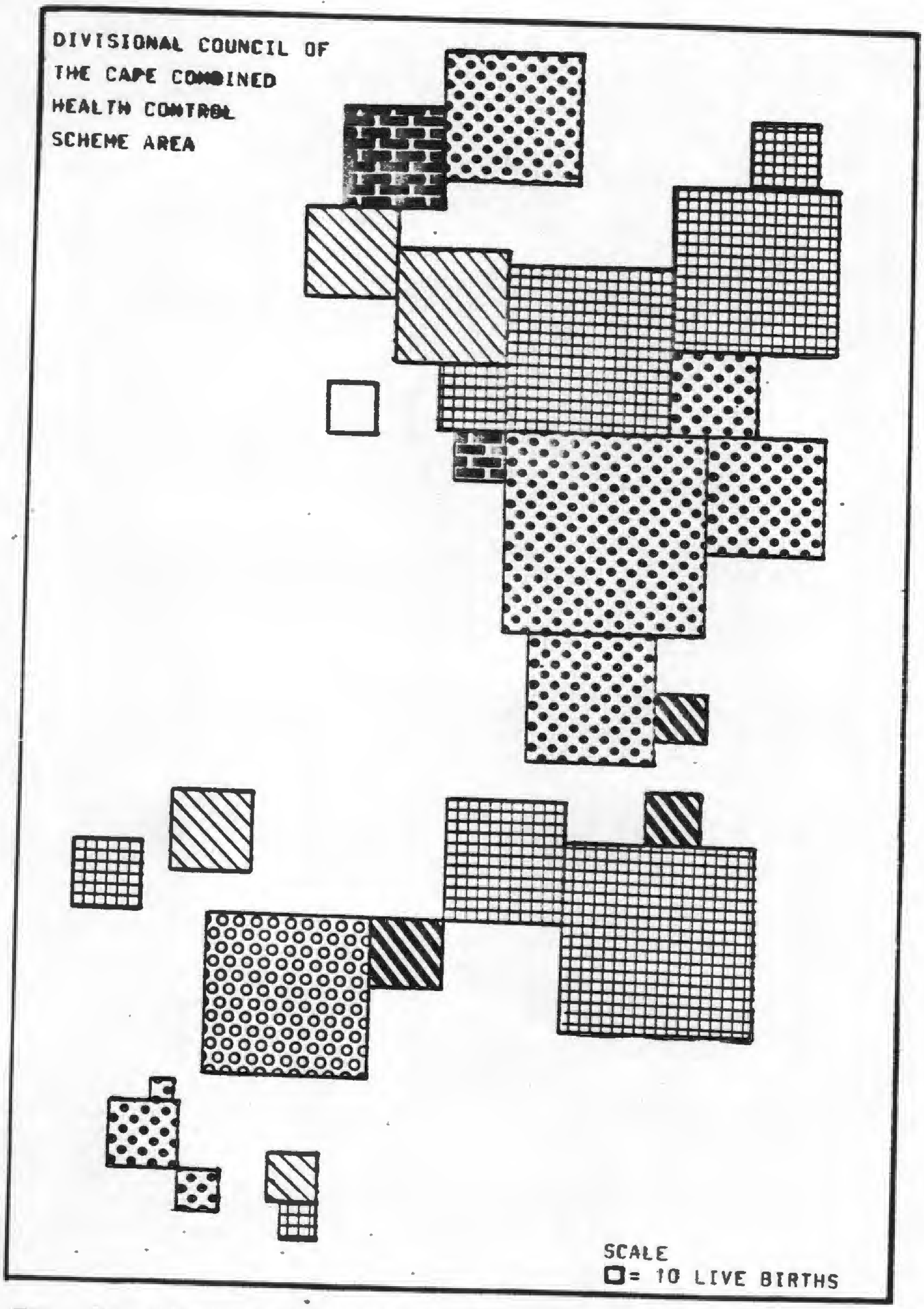


FIG. 21. DISTRIBUTION OF BIRTH WEIGHT RATIOS
Refer to Table 52)

low birth weight infants than infants weighing over 3500 grams. This implies that the women residing in this subsurb have a propensity to produce more "at-risk" low birth weight neonates than 'optimal' ones.

DETERMINING GEOGRAPHCIAL VARIATIONS IN MATERNAL AND INFANT HEALTH STATUS

With the previously enunciated hypothesis regarding a possible relationship between the BWR and IMR in mind, it was further noted that when the BWR is considered jointly with its attendant infant mortality rate, a strong association appears to exist between these two 'measures' (Table 41). The infant mortality rate reflecting infant health status and socio-economic advancement.

BWR AND IMR RELATIONSHIP - INTERNATIONAL

Both of these variables (BWR and IMR) for the group of countries listed in the previous Table (41) were subjected to linear regression analysis in an attempt to establish the strength of the association (correlation). The resultant scatter diagram is presented in Figure 22, and the accompanying regression statistics and significance tests are outlined in Table 42. The outcome was noted with great interest; the regression being statistically significant at the 95% confidence level (R=0.825). The null hypothesis was rejected in favour of the alternative hypothesis (H_1) that a significant relationship between BWR and IMR does exist and is not related to chance or random processes.

The case of Japan (country No.9 in Fig.22) is used as an example of the predictive nature of the regression (scatter) diagram. Japan falls marginally above the upper 95% confidence limit. In other words, this country experiences an IMR (10.8/1000) which is lower than would have been anticipated given its birth weight distribution measure (BWR) value of 0.22, on the basis of the BWR/IMR experience of its international peers. Japan would have been expected to have an IMR ranging between 12/1000 to 28/1000 (at 95% confidence) on the basis of the birth weight distribution of its newborn. The interpretation of Figure 22 is revealing in that it elegantly illustrates not only the relationship (and strength of this association) between BWR and IMR, but more importantly it provides one with a rational

TABLE 41 . BIRTH WEIGHT RATIOS AND INFANT MORTALITY RATES FOR VARIOUS COUNTRIES.

NO.	COUNTRY	BIRTH WEIGHT <2500g (%)	BIRTH WEIGHT ≥3500g (%)	BIRTH WEIGHT RATIO	IMR (per 1000 live births)
1	DENMARK (1973/4)	6.8	38.5	0.18	10.7
2	SWEDEN (1973)	4.6	49.5	0.08	8.6
3	NORWAY (1972-74)	4.4	51.0	0.09	10.4
4	FAEROES IS. (1973)	3.7	61.4	0.06	12.8
5	ICELAND (1972)	4.3	58.8	0.07	10.1
6	CANADA (1973)*	7.0	35.2	0.19	15.0
7	U.S.A. (1973)	7.6	36.0	0.21	17.7
8	U.K. (1970)	6.8	35.1	0.19	16.4
9	JAPAN (1974)*	5.1	23.3	0.22	10.8
10	GERMANY GFR (1973)*	6.7	40.4	0.17	21.1
11	HUNGARY (1974)*	11.7	26.9	0.43	34.3
12	POLAND (1974)*	8.0	35.0	0.23	23.5
13	CZECHOSLOVAKIA (1973)*	6.1	37.8	0.16	20.4

* Live births only.

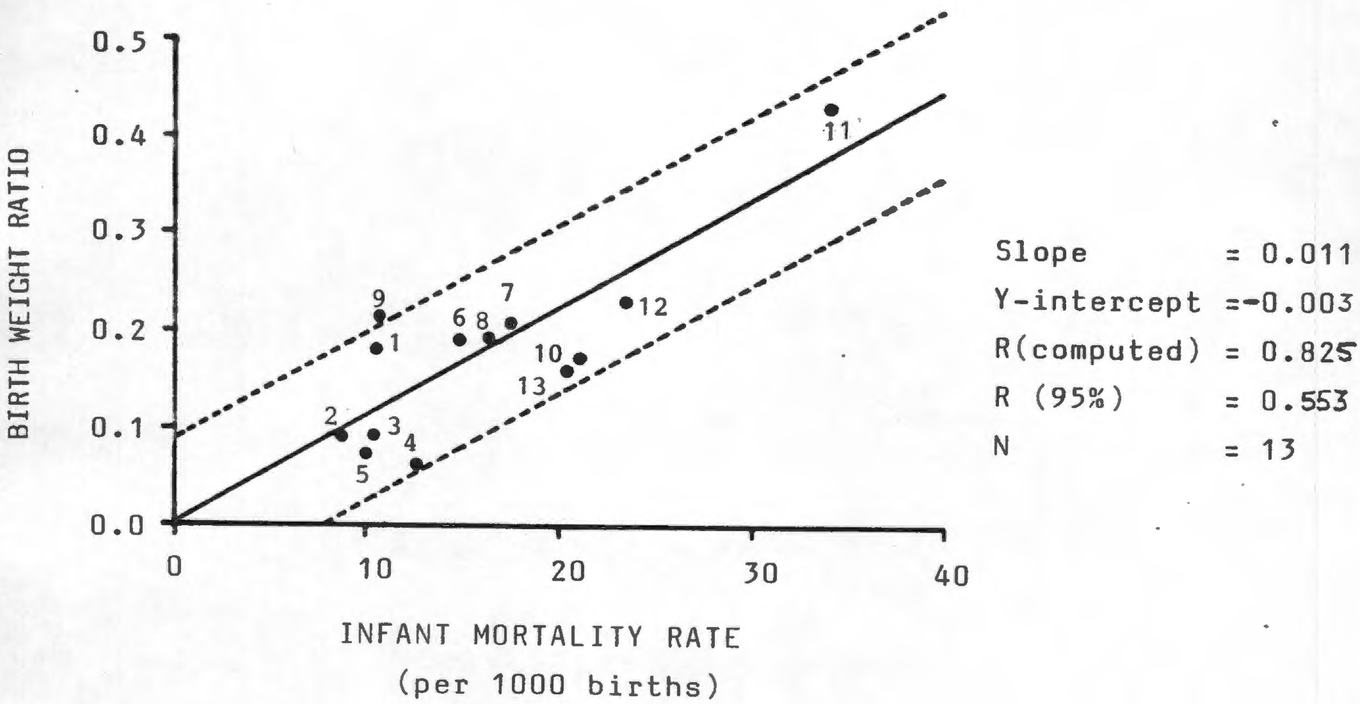


FIG. 22 SCATTER DIAGRAM SHOWING THE RELATIONSHIP BETWEEN BIRTH WEIGHT RATIO AND INTERNATIONAL INFANT MORTALITY RATES. LINEAR REGRESSION LINE AND 95% CONFIDENCE LIMITS ARE ALSO SHOWN.

KEY:

No.	Country
1	Denmark
2	Sweden
3	Norway
4	Faeroes Is.
5	Iceland
6	Canada
7	U.S.A.
8	United Kingdom
9	Japan
10	Germany GFR
11	Hungary
12	Poland
13	Czechoslovakia

TABLE 42. LINEAR REGRESSION ANALYSIS OF BIRTH WEIGHT RATIOS AND INFANT MORTALITY RATES FOR VARIOUS COUNTRIES.

Null Hypothesis (H_0) : There is no significant relationship between birth weight ratios and infant mortality rates.

Significance Test : T-value for 95% confidence = 2.228
Calculated T-value with 11 degrees of freedom = 4.840

Calculated t-value greater than tabled value hence H_0 rejected.

Descriptive Statistics : Y-intercept = - 0.002
Slope = 0.011
R (95%) = 0.553
R (computed) = 0.824
N = 13

Regression Equation : Y = - 0.00262 + 0.0109718 X

where Y = Birth Weight Ratio (BWR)
X = IMR

method of being able to predict one of the variables, given the other parameter. This is of some considerable interest to the health care planner. It is evident from the scatter diagram (Fig.22) that most of the countries lie within the 95% confidence limits, except Japan. This means that the vast majority of these developed countries have recorded appropriate infant mortality rates, given their respective birth weight distributions (as summarized by the BWR); which is known to exert the greatest influence on infant death. Because Japan possesses an IMR lower than expected it might be reasoned that either the level of infant health care and/or the socio-economic status of the country is operating to depress the IMR in defience, so to speak, of the marginally adverse birth weight distribution.

BWR AND IMR RELATIONSHIP - THE CHECS REGION

With this international situation in mind, it was decided to attempt to apply the technique to the CHECS region in order to rationally derive a strategy for assessing each geographical unit on the basis of its BWR and IMR relationship.

Table 43 shows the birth weight ratios and neonatal and infant mortality rates for each area within the region. After visual scrutiny, it was decided to omit two of the rual areas (Rural Northern and Rural Cape Flats) from the analysis, on the grounds that their mortality rates are of questionable accuracy.

Initially, the BWR's and IMR's of each area were subjected to linear regression analysis and the statistics (Table 44) proved a significant relationship (R=0.633) to exist, albeit somewhat lower than that for the international countries (R=0.825). Figure 23 portrays the resultant scatter diagram for BWR and IMR, while each area's expected infant mortality rates for the upper and lower 95% confidence intervals are shown in Table 45. It is clear from Fig. 23 and Table 45 that the CHECS region conforms to the established pattern of IMR and BWR association, with the majority of areas being represented within the 95% confidence limits.

TABLE 43 . BIRTH WEIGHT RATIOS, NEONATAL AND INFANT MORTALITY RATES FOR EACH AREA WITHIN THE STUDY REGION.

AREA NAME	BIRTH WEIGHT (%) <2500g (A)	BIRTH WEIGHT (%) ≥3500g (B)	BIRTH WEIGHT RATIO (A/B)	NEONATAL MORTALITY RATE* (< 28 d)	INFANT MORTALITY RATE* (< 1 Yr)
Milnerton	5.3	31.8	0.17	23.6	28.8
Durbanville	9.6	31.3	0.30	25.2	46.8
Goodwood	4.8	36.1	0.13	6.1	10.7
Parow	12.1	26.9	0.45	18.8	27.2
Bellville	8.6	31.9	0.27	13.6	18.7
Pinelands	2.8	40.7	0.07	0.0	0.0
Fish Hoek	4.1	41.8	0.10	0.0	0.0
Simonstown	15.0	40.0	0.38	0.0	0.0
Nyanga	10.6	28.8	0.37	10.5	28.8
Cross Roads	7.9	28.2	0.28	13.4	48.5
Atlantis	17.5	21.3	0.82	7.7	17.6
Rural Northern	22.6	16.8	1.35	9.5**	9.5**
Elsies River	16.5	21.3	0.77	19.7	36.7
Uitsig	16.3	17.6	0.93	34.7	47.3
Belhar	15.0	19.6	0.76	19.3	41.3
Nooitgedacht	18.8	18.8	1.00	20.4	61.2
Ruyterwacht	6.6	23.6	0.28	9.3	9.3
Matroosfontein	11.1	6.6	1.67	50.7	65.2
Bishop Lavis	16.1	19.0	0.85	27.5	37.8
Rural Cape Flats	20.2	20.5	0.99	13.8**	13.8**
Grassy Park	11.5	23.6	0.49	9.9	16.9
Constantia	6.7	32.2	0.21	2.9	5.7
Hout Bay	12.4	26.1	0.47	8.8	26.3
Kommetjie	18.5	22.8	0.81	7.9	11.9
Rural Peninsula	18.4	22.4	0.82	11.9	11.9
D.C.C. CHECS REGION	12.3	25.6	0.48	15.1	29.1

* per 1000 live singleton births.

** denotes areas which were considered to have duboius IMR and Neonatal mortality rates.

TABLE 44. LINEAR REGRESSION ANALYSIS OF BIRTH WEIGHT RATIOS AND INFANT MORTALITY RATES FOR THE D.C.C. COMBINED HEALTH CONTROL SCHEME REGION.

Null Hypothesis (H_0) : There is no significant relationship between birth weight ratios and infant mortality rates

Significance Test : T-value for 95% confidence = 2.228
T-value (calculated) = 3.478
with 21 degrees of freedom

Calculeted T-value greater than tabled vale, hece H_0 rejected.

Descriptive Statistics : Y-intercept = 0.212
Slope = 0.012
R (95%) = 0.413
R(computed) = 0.633
N = 23

Regression Equation : Y = 0.212642 + 0.0125447 X

where X = IMR
Y = Birth Weight Ratio

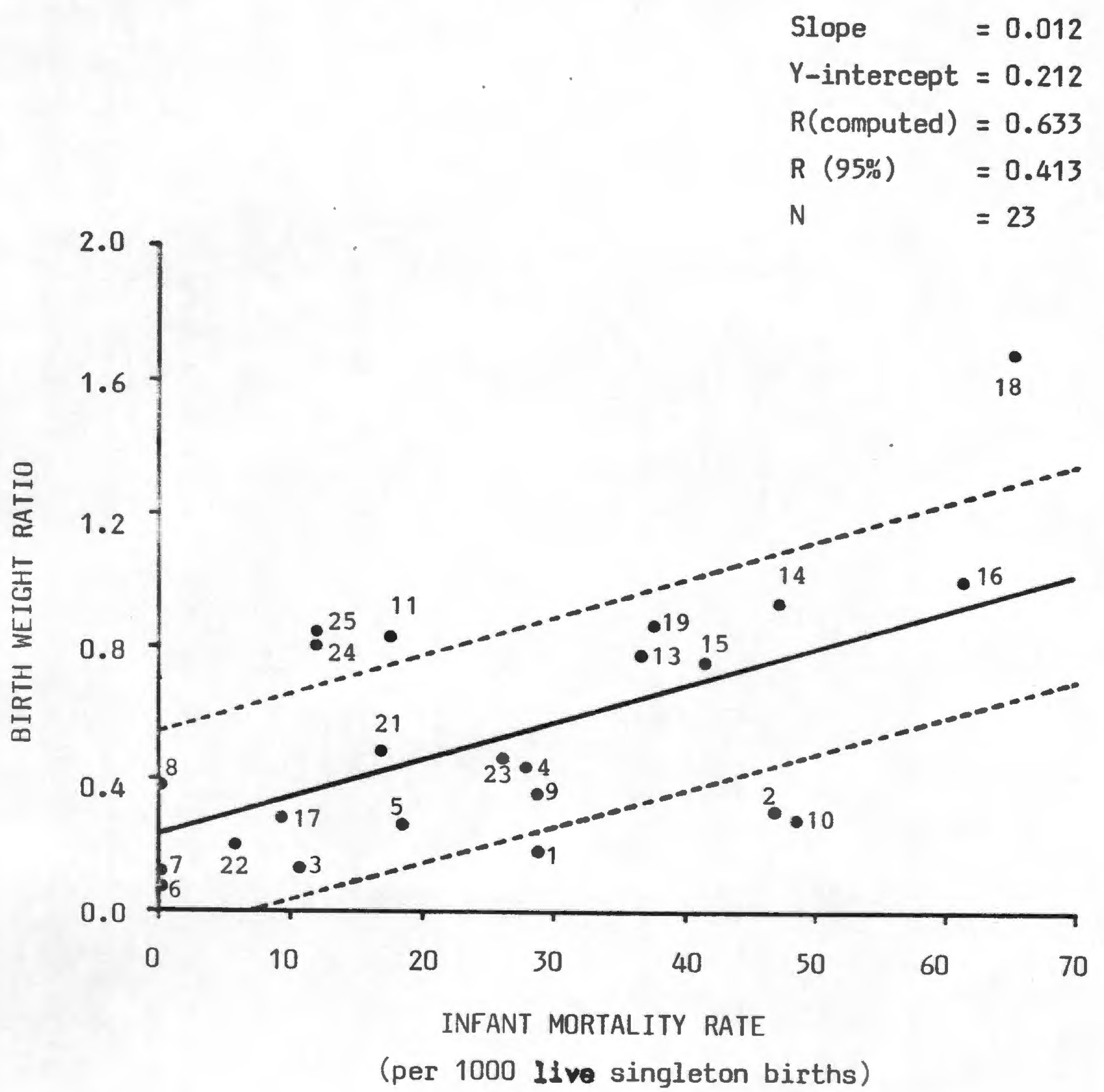


FIG. 23. SCATTER DIAGRAM SHOWING THE RELATIONSHIP BETWEEN BIRTH WEIGHT RATIO AND INFANT MORTALITY RATES WITHIN THE D.C.C. COMBINED HEALTH CONTROL SCHEME REGION. LINEAR REGRESSION LINE AND 95% CONFIDENCE LIMITS ARE ILLUSTRATED.

KEY:

AREA No.	AREA NAME	AREA No.	AREA NAME	AREA No.	AREA NAME
1	Milnerton	9	Nyanga	17	Ruyterwacht
2	Durbanville	10	Cross Roads	18	Matroosfontein
3	Goodwood	11	Atlantis	19	Bishop Lavis
4	Parow	12	Rural Northern*	20	Rural Cape Flats
5	Bellville	13	Elsies River	21	Grassy Park
6	Pinelands	14	Uitsig	22	Constantia
7	Fish Hoek	15	Belhar	23	Hout Bay
8	Simonstown	16	Nooitgedacht	24	Kommetjie
				25	Rural Peninsula

* Areas not included in the analysis.

TABLE 45. DETERMINATION OF ANTICIPATED INFANT MORTALITY RATES ACCORDING TO CALCULATED REGRESSION STATISTICS FOR 95% CONFIDENCE INTERVAL FOR AREAS WITHIN THE STUDY REGION.

No.	AREA NAME	BIRTH WEIGHT RATIO	CALCULATED IMR AT 95% CONFIDENCE LIMIT (LOWER)	IMR	CALCULATED IMR AT 95% CONFIDENCE LIMIT (UPPER)	
1	Milnerton	0.17	23.2	28.8	-	X
2	Durbanville	0.30	34.4	46.8	-	X
3	Goodwood	0.13	18.1	10.7	-	
4	Parow	0.45	45.3	27.2	-	
5	Bellville	0.27	30.3	18.7	-	
6	Pinelands	0.07	13.7	0.0	-	
7	Fish Hoek	0.10	16.0	0.0	-	
8	Simonstown	0.38	40.9	0.0	-	
9	Nyanga	0.37	39.0	28.8	-	
10	Cross Roads	0.28	31.8	48.5	-	X
11	Atlantis	0.82	80.6	17.6	24.1	**
12	Rural Northern	1.35	+	9.5	+	+
13	Elsies River	0.77	75.9	36.7	20.0	
14	Uitsig	0.93	89.5	47.3	33.8	
15	Belhar	0.76	73.1	41.3	17.6	
16	Nooitgedacht	1.00	95.8	61.2	39.5	
17	Ruyterwacht	0.28	31.6	9.3	-	
18	Matroosfontein	1.67	166.5	65.2	98.4	**
19	Bishop Lavis	0.85	83.3	37.8	27.2	
20	Rural Cape Flats	0.99	+	13.8	+	+
21	Grassy Park	0.49	50.4	16.9	-	
22	Constantia	0.21	25.0	5.7	-	
23	Hout Bay	0.47	48.4	26.3	-	
24	Kommetjie	0.81	78.5	11.9	22.7	**
25	Rural Peninsula	0.82	81.4	11.9	25.7	**

Note

X denotes those areas which fall below the calculated 95% lower confidence limit for IMR

** indicates those areas wich fall above the calculated 95% upper confidence limit for IMR

\+ indicates area omitted from the regression analysis

However, a few of the areas fall either above (area no's. 11; 18; 24; and 25), or below (numbers 1;2; and 10) the 95% confidence limits (Fig.23 and refer to Table 45). Those areas which lie above the upper 95% confidence limit display lower IMR's than would otherwise be expected, whereas those areas falling below the lower 95% confidence limit may be reagrded as being sub-optimal by possessing higher IMR's than their respective birth weight distributions would suggest.

It will be remembered that the suburb of Matroosfontein was concluded to be highly "at-risk" on the basis of its BWR (Fig. 21), and less so when considering solely the low birth weight rate (Fig.8).

Figure 24 affords an altogether differecnt interpretation. That the area of Matroosfontein is"at-risk" is not being questioned, but more importantly it will be noted that this area falls distinctly above the upper 95% confidence interval. Further, from Table 45 it is clear that the observed IMR (65.2 per 1000) is substantially less than the expected range allowed for by the 95% confidence intervals (98.4 to 166.5/1000). The BWR (1.67) indicates that maternal health and nutrition is probably the poorest of all the areas within the CHECS region. What factor, or group of factors, is responsible for lowering the IMR so significantly is unknown, but it may by hypothesized that the neonatal services provided to this area are playing a role in depressing the IMR. Conversely, it might also be suggested that the level of prenatal care is inadequate, thereby giving rise to the excess of low birth weight infants, and hence a high BWR figure. A similar situation pertains for the areas of Atlantis; Kommetjie (including Ocean View), and the rural area of the Peninsula.

At the other end of the spectrum of the BWR and IMR relationship are the municipal areas of Milnerton and Durbanville, as well as the Black "squatter" area of Cross Roads (Fig. 24) These areas all reside below the lower 95% confidence limit for the region. Their observed IMR's are higher than their respective BWR values indicate. Cross Roads for instance has an IMR of 48.5/1000 whereas its BWR (0.28) suggests that a more realistic (potential) rate should be in the range of between 0.0 and 31.8 per 1000 (at 95% confidence) (Table 45). This may imply that all three of these areas (no's. 1; 2; and 10) are characterized by 'healthy', positively skewed birth weight distributions, but experience a rate of infant mortality greater than can be explained by the birth weights alone. The level of infant care and/or socio-economic variables are, therefore, seen to be responsible for this disparity. It would, on the other hand, superficially appear that

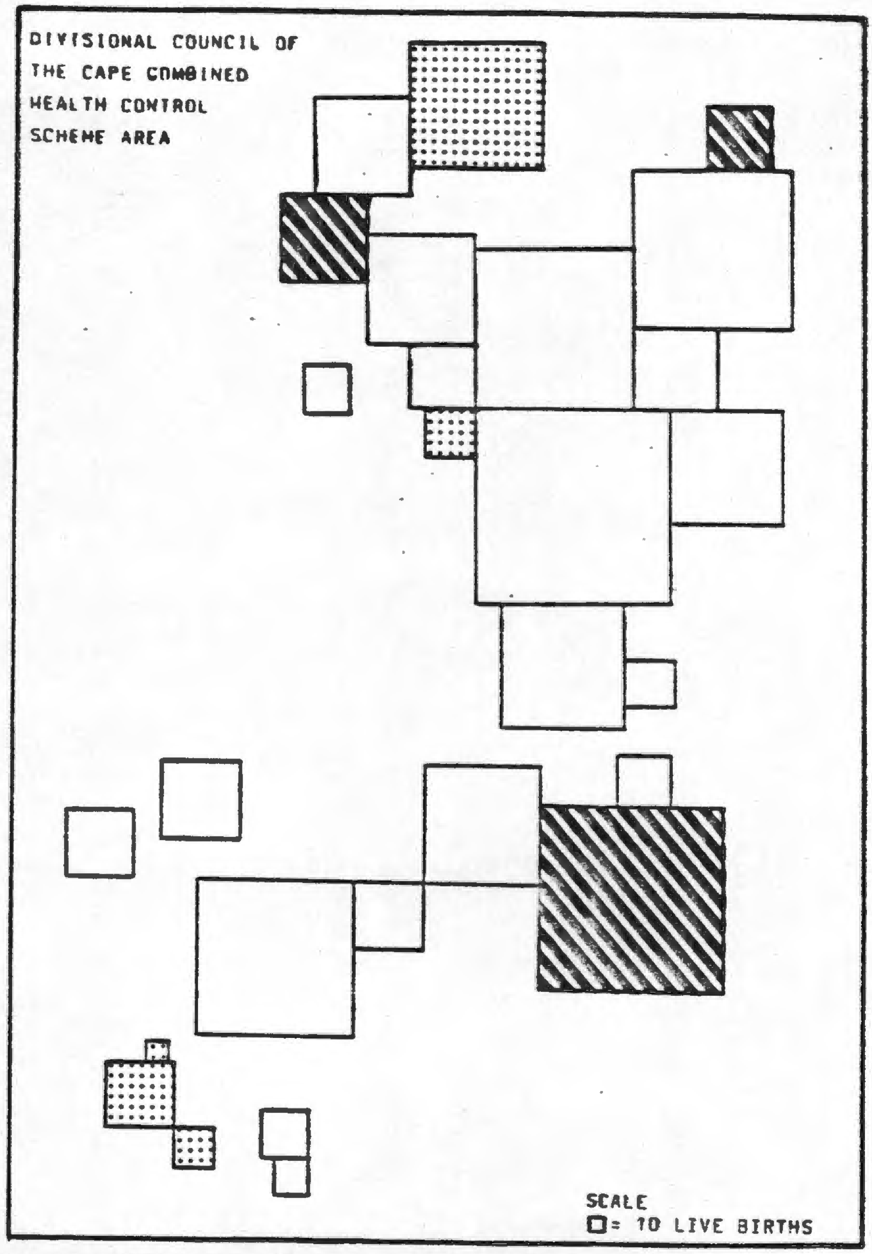


FIG. 24. MAP BASED ON THE INFANT MORTALITY RATE (IMR) AND BIRTH WEIGHT RATIO (BWR) LINEAR REGRESSION STATISTICS (Refer to Table 45 and Fig. 23)

Areas above the upper 95% confidence limit

Areas within the 95% confidence limits

Areas below the lower 95% confidence limit the level of prenatal services and overall maternal health and nutrition is adequate.

A further feature of the regression scatter diagrams for the international countries and the CHECS region (Figs. 22 and 23) which warrants comment is a comparison of the statistics themselves (Table 46). Interestingly, the slopes of both of the regression lines is extremely similar (0.011 versus 0.012), indicating that the relationship between the BWR and IMR, both locally and internationally, are almost identical. Further, the Y-axis intercept is -0.002 for the developed countries, whereas it is substantially elevated (0.212) for the D.C.C. region; suggesting the negative character of the overall birth weight distribution. Both sets of regression analyses are statistically significant at the 95% level according to the R value, as well as the t-value (Tables 42 and 44)

Foster and Kleinman (1982) drew attention to the fact that birth weight is more closely associated with the risk of dying during the neonatal period (< 28 days), than within either the post-neonatal period or the first year of life. Table 43 depicts the BWR and neonatal mortality rate for each geographical unit within the study area. Again a visual association is observable. The results of the regression analysis is presented in Table 47 and the accompanying scatter diagram is presented in Figure 25. The computed regression coefficient is significant at the 95% level (R=0.716); being somewhat higher than for the IMR correlation (R=0.633). This result is consistent with the findings of Kleinman (1978) and Foster and Kleinman (1982) who have demonstrated higher neonatal birth weight-specific mortality than for any other period-of-survival.

The scatter diagram (Fig. 25) shows the relative NMR and BWR associations. Areas 11; 16; 18; 24; and 25 (Atlantis; Nooitgedacht; Matroosfontein; Kommetjie; and the Rural Peninsula, respectively) have NMR's greater than the upper 95% confidence limit, whilst areas 1 and 2 (Milnerton and Durbanville municipalities) fall below the lower 95% confidence limit (Fig. 25 and Table 48). Two important changes between Figures 23 and 25 are observable. Firstly, the suburb of Nooitgedacht, which possesses an IMR compatible with its birth weight distribution (Fig.23) has an observed NMR of 20.4/1000 which is considerably lower than expected (29.0 to 49.2 per 1000). One explanation might be that neonatal services are making significant inroads into this area and are suppressing the 'expected' NMR. Matroosfontein, on the other hand, is again present with a mortality rate lower than expected (50.7/1000 versus a range of 60.1 - 80.6/1000).

TABLE 46. COMPARISON OF INTERNATIONAL AND D.C.C. BIRTH WEIGHT RATIO AND INFANT MORTALITY RATE LINEAR REGRESSION CORRELATIONS.

SUMMARY STATISTICS	INTERNATIONAL*	D.C.C. (CHCS REGION)
Y-intercept	- 0.003	0.212
Slope	0.011	0.012
R (computed)	0.825	0.633
R (95%)	0.553	0.413
N	13	25

* Refer to Table 42.

TABLE 47. LINEAR REGRESSION ANALYSIS OF BIRTH WEIGHT RATIOS AND NEONATAL MORTALITY RATES FOR THE D.C.C. COMBINED HEALTH CONTROL SCHEME REGION

Null Hypothesis : (H_0) There is no significant association between birth weight ratio and neonatal mortality.rate.

Descriptive Statistics :

Y-intercept	= 0.202
Slope	= 0.023
R (computed)	= 0.716
R (95%)	= 0.413
N	= 23

Significance Test : T-value at 95% confidence = 2.228
Calculated T-value = 4.704
with 21 degrees of freedom

Calculated t-val greater than tabled value, hence H_0 rejected.

Regression Equation : Y = 0.201598 + 0.0227062 X

where X = Neonatal mortality rate
Y = Birth weight ratio

Slope	= 0.023
Y-intercept	= 0.202
R (computed)	= 0.716
R (95%)	= 0.413
N	= 23

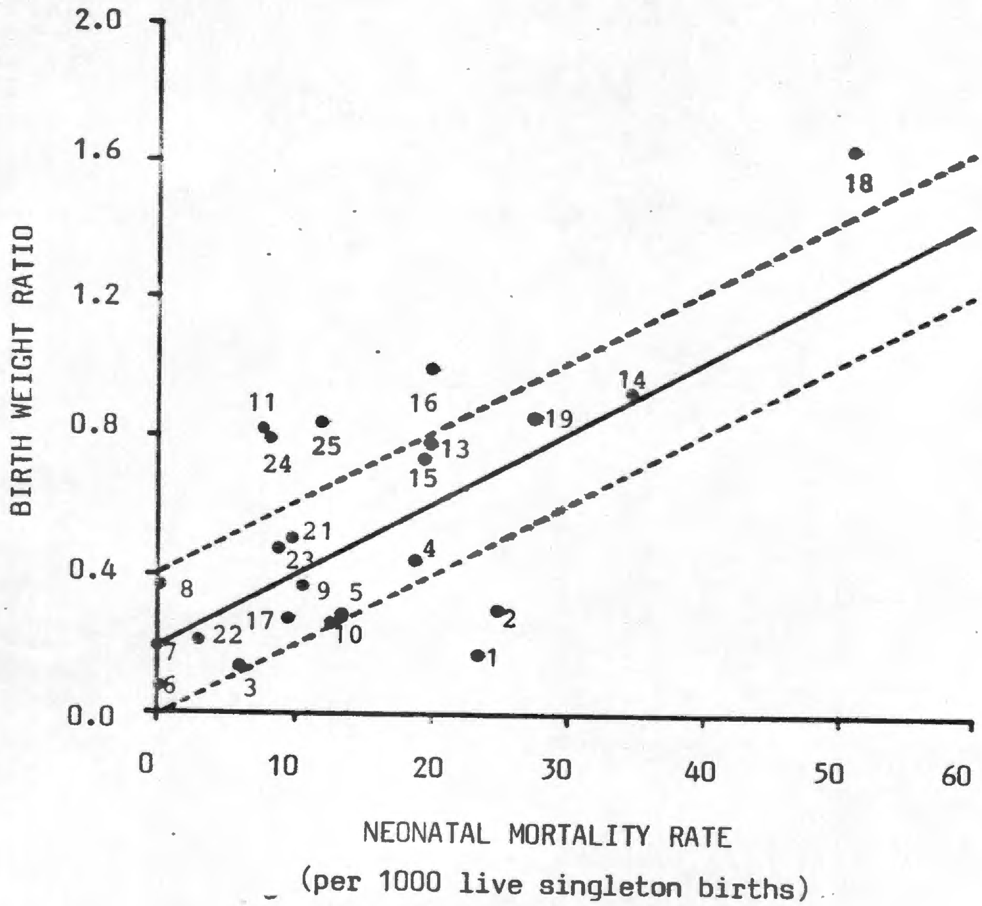


FIG. 25. SCATTER DIAGRAM SHOWING THE RELATIONSHIP BETWEEN BIRTH WEIGHT RATIO AND NEONATAL MORTALITY RATES FOR AREAS WITHIN THE D.C.C. COMBINED HEALTH CONTROL SCHEME REGION. LINEAR REGRESSION LINE AND 95% CONFIDENCE LIMITS ARE ILLUSTRATED.
(Refer to Figure 23 on page 98 for the appropriate area names and numbers)

TABLE 48 . DETERMINATION OF ANTICIPATED NEONATAL MORTALITY RATES (NNMR) ACCORDING TO CALCULATED REGRESSION STATISTICS AT 95% CONFIDENCE LIMITS FOR AREAS WITHIN THE STUDY REGION.

No.	AREA NAME	BIRTH WEIGHT RATIO	CALCULATED NNMR AT 95% CONFIDENCE LIMIT (LOWER)	NNMR	CALCULATED NNMR AT 95% CONFIDENCE LIMIT (UPPER)	
1	Milnerton	0.17	8.2	23.6	-	X
2	Durbanville	0.30	15.5	25.2	-	X
3	Goodwood	0.13	6.2	6.1	-	
4	Parow	0.45	22.0	18.8	1.9	
5	Bellville	0.27	14.0	13.6	-	
6	Pinelands	0.07	4.0	0.0	-	
7	Fish Hoek	0.10	10.1	0.0	-	
8	Simonstown	0.38	18.4	0.0	-	
9	Nyanga	0.37	18.2	10.5	-	
10	Cross Roads	0.28	13.4	13.4	3.6	
11	Atlantis	0.82	40.4	7.7	19.9	**
12	Rural Northern	1.35	+	+	+	+
13	Elsies River	0.77	38.2	19.7	18.1	
14	Uitsig	0.93	45.6	34.7	25.1	
15	Belhar	0.76	37.4	19.3	17.2	
16	Nooitgedacht	1.00	49.2	20.4	29.0	*
17	Ruyterwacht	0.28	14.9	9.3	-	
18	Matroosfontein	1.67	80.6	50.7	60.1	**
19	Bishop Lavis	0.85	42.1	27.5	21.5	
20	Rural Cape Flats	0.99	+	+	+	+
21	Grassy Park	0.49	25.1	9.9	5.0	
22	Constantia	0.21	11.6	2.9	-	
23	Hout Bay	0.47	24.0	8.8	3.5	
24	Kommetjie	0.81	39.3	7.9	19.2	**
25	Rural Peninsula	0.82	41.6	11.9	21.2	**

X Denotes those areas which fall below the calculated lower 95% confidence limit for NNMR's

** Denotes those areas which lie above the calculated upper 95% confidence limit for NNMR's

\+ Indicates those areas not included in the regression analysis because of poor data

What is clear is that Matroosfontein has an observed infant mortality experience (NMR and IMR) which is uniformally better than its birth weight distribution would belie. However, Nooitgedacht is seen to have a NMR higher than expected, but has an IMR appropriate with its birth weight distribution, Secondly, Cross Roads (area no. 10) is no longer below the lower 95% confidence limit; with a NMR of 13.4/1000. Whereas the municipalities of Milnerton and Durbanville remain below this limit. Figure 26 shows those areas which lie above or below the 95% confidence intervals. Of some considerable importance is the fact that the NMR experienced by neonates from Cross Roads conforms to the birth weight/ neonatal mortality norm for the CHECS region as a whole. This is not so as far as its IMR is concerned (refer to Fig. 23). Post-neonatal mortality rates presented in Chapter IV explain the reasons underpinning this shift, where Cross Roads has the highest PNMR (Table 20) in the study region. Moreover, it is now evident that infants from Cross Roads are being produced by mothers who may be said (on the basis of the BWR index) to be 'healthy', in that they are able to deliver neonates whose weight at birth is comparable to that of any other local area, as well as being of an above average nutritional state.

Alternatively, the situation for an area such as Matroosfontein will necessitate a concommitant effort in antenatal/prenatal and infant health care services in order to attempt to reduce infant mortality yet further, and to positively skew the birth weight distribution (by uplifting maternal health status).

An important attribute of this technique is the capability of identifying which component (maternal or infant) demands attention. A significant logistical consideration is that it does not require a system of linked birth and infant death records, although this is regarded as being of considerable importance. The data is easily quantifiable, the measures are simple to calculate and residential areas requiring attention may be rapidly pinpointed through the application of this technique. Moreover, this method for describing and quantifying the spatial variation of the birth weight distribution (by the Birth Weight Ratio) and infant health (through the Infant Mortality Rate) together, will enable health care planners to monitor and assess any interventive programme aimed at improving maternal and infant health status and to determine whether such intervention is responsible for reducing the infant mortality rate.

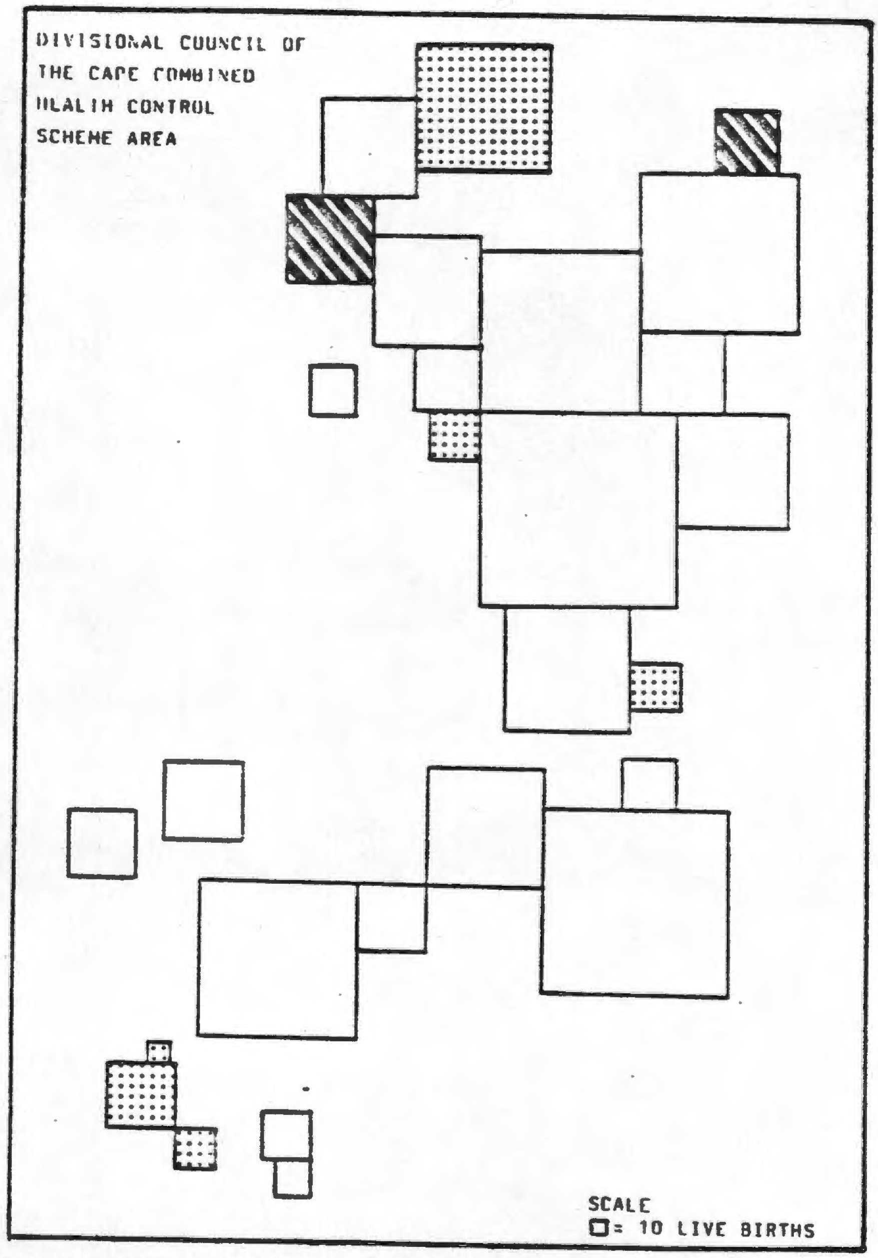


FIG. 26. MAP BASED ON THE NEONATAL MORTALITY RATE (NMR) AND BIRTH WEIGHT RATIO (BWR) LINEAR REGRESSION STATISTICS (Refer to Table 48 and Fig. 25)

Areas above the upper 95% confidence limit

Areas within the 95% confidence limits

Areas below the lower 95% confidence limit

Overall it would appear that the geography of the inter-relationship between birth weight and infant mortality within the CHECS region, tends in part, to mirror long-standing gradients in socio-economic status, particularly for area with elevated IMR's. But other factors might be contributing significantly to the observed spatial variations in the quality and quantity of antenatal care, obstetric, neonatal and infant health care. Future studies would be necessary in order for the importance of these factors to be reliably determined.

CHAPTER VI

CONCLUSIONS

The spatial analysis of birth weights and infant mortality data for a heterogeneous region such as the Western Cape has revealed a number of significant factors about the general "health" of the population and about the operative infant and maternal health care services in existence. While it is recognized that although 16029 births and 455 infant deaths comprise the data sets, the data only effectively applied to 1 year (1982). Obvious limitations prevented the analysis of the data on a finer spatial resolution - ideally to each 'suburb' or local area (as defined by the 1980 census). Moreover, these constraints prevented the determination of the birth weight distributions for each population group in each of the geographic units used. Nevertheless, this study has been able to characterize maternal and infant 'health status' both spatially and statistically and thereby reveal areas where more appropriate intervention of health care services are required. The following are the most significant conclusions to emerge from this study:

1. The necessity for birth data (including weight) and infant mortality data to be analysed, not just in terms of rates, but also according to spatial variation.

2. Further investigation is required of the factors which cause a high incidence of low birth weight Coloured neonates, while a low rate appears to apply to the Black population group.
   This research has shown that the majority of Coloured residential areas are characterized by:
   (a) high rates of low birth weight infants
   (b) very low 'optimal'birth weight rates
   (c) elevated neonatal mortality rates; and
   (d) above average post-neonatal death rates.

3. Compared to observations made in other parts of the world, the full intrauterine growth potential of mothers in the study area appears to be inhibited. This warrants further research.

4. The role that maternal undernutrition, moderate alcohol consumption, cigarette smoking and drug use during pregnancy plays in reducing birth weight in the CHECS region should also be the subject of future research.

5. Birth weight-specific infant mortality rates should be calculated for each population group and individual geographic units; this would be of considerable importance to the health care authorities.

6. The birth weight ratio can be used for assessing the spatial variations of birth weight distributions and also comparing individual geographic units within a health region.

7. The technique of correlating the birth weight ratio and infant mortality rate enable:
   (a) The determination of possible intervention points and;
   (b) The assessment of the magnitude and influence that each variable has within its specific geographical area.

8. The results suggest that certain issues pertaining to the data are in need of attention or modification. These include:
   (a) The reporting system for births and deaths, particularly for Blacks, needs to be carefully audited in order to determine the completeness and accuracy of reporting.
   (b) The accurate recording of the surnames of Black mothers and infants is necessary for the cross-matching of birth and infant death records.
   (c) The use of a separate still birth notification form needs to be implemented as soon as possible, so as to remove the major cause of underreporting of still births. As a result of this, all perinatal statistics from the CHECS region should be viewed with caution.
   (d) Studies directed towards assessing the health care requirements of any area need access to readily retrievable data. Local Health Authorities should consider the computerization of all recorded vital statistics.

9. Antenatal, maternal and infant health care should be considered as a continuum, rather than be delivered as two discrete services. A joint strategy involving both the local Health Authorities (providing maternal and infant care) and the Cape Provincial Hospital Services (providing antenatal care) is required for a reduction of infant mortality.

10. Reductions in the occurrence of Coloured infant deaths can be brought about by:
    (a) reducing the proportion of low birth weight neonates; which will have the effect of positively skewing the birth weight distribution; and
    (b) improving the survival rates within each birth weight category.

    Any interventive strategy aimed at reducing Coloured infant mortality must focus upon these two aspects. Programmes should include improvements in maternal nutrition, access to anenatal care (including ideally a minimum of five visits), and maternal education. This will have the effect of improving the birth weight distribution. Increased survival rates could be achieved by improved health care facilities for sick neonates.

11. This study has shown that the occurrence of low birth weight infants is financially demanding. (The full financial implications of this are detailed in Appendix F). Consequently, it is apparent that it would be more cost effective to invest in maternal health care, and thereby reduce the occurrence of "at-risk" (low birth weight) infants.

While this study has produced an understanding and assessment of the variations of birth weight and infant mortality from one Local Health Authority, the techniques used and the conclusions drawn have implications for most other Health Authories in South Africa.

It has also provided justification for more spatially-sensitive programmes for the provision of maternal and infant health care services.

Finally, these results support the hypothesis that birth weight may be a crucial intervening variable between the circumstances of pregnancy and infant mortality.

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APPENDIX A.

APPENDIX A.

NOTIFICATION OF BIRTHS IN THE DIVISIONAL COUNCIL OF THE CAPE COMBINED HEALTH CONTROL SCHEME REGION - 1982

Number of live (LB) births notified

AREA NAME	WHITE LB	ASIAN LB	COLOURED LB	BLACK LB	TOTAL LB	BIRTH RATE+
BELLVILLE	788	0	595	28	1411	19.05
DURBANVILLE	193	0	69	18	280	20.41
GOODWOOD	633	0	38	2	673	20.17
MILNERTON	312	0	33	45	390	16.98
PAROW	566	1	897	9	1473	23.00
PINELANDS	106	0	3	2	111	8.53
FISH HOEK	46	0	4	4	54	6.56
SUN VALLEY	49	0	1	0	54	27.93
SIMONSTOWN	57	0	5	3	65	10.85
NYANGA	0	0	16	782	798	31.54
CROSS ROADS	0	0	11	1878	1889	56.20
ATLANTIS	0	1	919	1	921	30.50
MAMRE	0	0	87	0	87	19.77
BELHAR	0	0	745	5	750	34.84
CONSTANTIA	232	0	79	43	354	23.92
PELLA	0	0	30	0	30	18.63
BISHOP LAVIS	0	0	889	0	889	29.09
ELSIES RIVER	2	1	2287	36	2326	28.50
UITSIG	0	0	313	8	321	31.94
GRASSY PARK	1	1	1425	5	1432	27.32
OCEAN VIEW	0	0	239	0	239	24.84
NOOITGEDACHT	0	0	100	0	100	20.41
RUYTERWACHT	106	0	3	3	112	14.14
HOUT BAY	69	0	140	18	227	24.73
MELKBOSSTRAND	64	0	3	3	70	16.95
RURAL PENINSULA	38	0	38	10	86	29.76
RURAL CAPE FLATS	18	1	309	33	361	16.28
PHILADELPHIA	0	0	2	0	2	10.00
RURAL NORTHERN	14	0	236	53	303	31.40
LOURDES FARM	0	0	3	0	3	-
ZEEKOEVLEI	18	0	0	2	20	21.74
KOMMETJIE	12	0	1	1	14	15.56
SCARBOROUGH	2	0	0	0	2	-
LLANDUDNO	6	0	0	1	7	-
NOORDHOEK	10	0	6	0	16	-
BLOUBERGSTRAND	22	0	0	3	25	24.75
MATROOSFONTEIN	0	0	138	0	138	18.83
TOTAL	3364	5	9664	2996	16029	25.67

APPENDIX B.

APPENDIX B.

DISTRIBUTION OF ALL LIVE SINGLETON BIRTHS ACCORDING TO BIRTH WEIGHT CATEGORY

POPULATION GROUP		BIRTH WEIGHT CATEGORY (grams) : <2500	<1000	1000-1499	1500-1999	2000-2499	2500-2999	3000-3499	3500-3999	≥4000	NOT STATED	TOTAL
WHITE	n	142	5	13	19	105	561	1312	951	282	49	3297
	%	4.4	0.2	0.4	0.6	3.2	17.0	39.8	28.8	8.6	1.5	100.0
COLOURED	n	1443	46	122	357	918	2669	3209	1514	388	281	9504
	%	15.2	0.5	1.3	3.8	9.7	28.1	33.8	15.9	4.2	3.0	100.0
BLACK	n	242	11	38	41	152	587	1201	631	153	38	2852
	%	8.5	0.4	1.3	1.4	5.3	20.6	42.1	22.1	5.4	1.3	100.0
TOTAL	n	1827	62	173	417	1175	3817	5723	3096	823	368	15653
	%	12.0	0.4	1.1	2.7	7.5	24.4	36.6	19.8	5.3	2.4	100.0

APPENDIX C.

APPENDIX C.

PERCENTAGE DISTRIBUTION OF ALL LIVE SINGLETON BIRTH WEIGHTS ACCORDING TO INDIVIDUAL AREAS WITHIN THE D.C.C. COMBINED HEALTH CONTROL SCHEME REGION

AREA NAME	BIRTH WEIGHT GROUP (g) 500-999	1000-1499	1500-1999	2000-2499	2500-2999	3000-3499	3500-3999	≥4000	BIRTH WEIGHT NOT STATED	TOTAL (N)	(%)
MILNERTON	0.8	0.3	1.8	2.4	18.3	44.0	25.4	6.0	1.0	382	100.0
DURBANVILLE	0.4	1.4	2.2	5.0	21.9	36.3	25.2	5.4	2.2	278	100.0
GOODWOOD	0.0	0.6	0.8	3.2	17.8	40.6	27.2	8.4	1.4	657	100.0
PAROW	0.5	1.2	2.0	7.8	23.0	36.9	21.2	5.1	2.4	1435	100.0
BELLVILLE	0.4	0.6	1.4	6.0	23.2	35.5	24.8	6.7	1.4	1393	100.0
PINELANDS	0.0	0.9	0.9	0.9	16.5	39.4	28.4	11.9	0.9	109	100.0
FISH HOEK	0.0	0.0	1.0	2.9	12.5	37.5	32.7	6.7	6.7	104	100.0
SIMONSTOWN	0.0	1.5	0.0	9.2	13.8	30.8	21.5	15.3	7.7	65	100.0
NYANGA	0.3	1.6	1.7	6.9	21.5	38.4	23.2	5.2	1.3	764	100.0
CROSS ROADS	0.3	1.2	1.6	4.6	20.0	43.3	22.4	5.5	1.1	1793	100.0
ATLANTIS	0.5	0.8	5.3	10.4	28.9	31.5	16.9	4.1	1.6	911	100.0
RURAL NORTHERN*	0.4	1.3	3.8	13.4	31.5	30.7	17.1	6.3	1.9	479	100.0
ELSIES RIVER	0.5	1.5	3.5	10.1	27.4	33.1	16.2	4.4	3.3	2288	100.0
UITSIG	0.0	2.5	3.2	9.1	31.9	33.1	14.5	2.5	3.2	317	100.0
BELHAR	0.1	1.2	3.4	9.4	27.8	36.5	14.2	5.0	2.3	726	100.0
NOOITGEDACHT	0.0	0.0	9.2	9.2	31.6	29.6	12.2	6.1	2.0	98	100.0
RUYTERWACHT	0.0	0.9	0.0	5.6	23.1	45.4	17.6	5.6	1.9	108	100.0
MATROOSFONTEIN	0.7	0.0	2.2	8.0	28.3	37.7	16.7	4.3	2.2	138	100.0
BISHOP LAVIS	0.6	1.1	3.8	8.6	27.3	35.2	14.1	3.9	5.6	873	100.0
RURAL CAPE FLATS	0.6	1.9	5.8	10.5	26.5	32.0	16.9	3.0	2.8	362	100.0
GRASSY PARK	0.7	0.9	2.8	6.8	26.6	37.3	18.0	5.2	1.7	1416	100.0
CONSTANTIA	0.0	0.6	1.1	4.9	17.8	42.2	25.6	6.6	1.1	348	100.0
HOUT BAY	0.4	0.9	2.6	8.3	21.9	39.0	22.8	3.1	0.9	228	100.0
KOMMETJIE	0.0	1.2	2.8	8.4	26.3	31.9	17.5	3.6	8.4	253	100.0
RURAL PENINSULA	0.0	0.0	4.8	10.7	23.8	30.9	9.5	10.7	9.5	84	100.0
D.C.C. CHECS REGION	0.4	1.1	2.7	7.5	24.4	36.6	19.8	5.3	2.4	15653	100.0

* Includes the following areas; Mamre; Pella; Philladelphia; Bloubergstrand; and Melkbosstrand.

APPENDIX D

APPENDIX D.

INFANT MORTALITY ANALYSIS - Period-of-Survival

The pattern of infant deaths assumes a new meaning when analysed according to period-of-survival. In the introduction to this thesis, the reasons for this importance were outlined. There are considerable community health and socio-economic implications depending upon when an infantile death occurred. The overall situation for each population group is presented in Table 53. A few important details to emerge are :-

- nearly a quarter (24.6%) of all infant mortality takes place within 72 hours of birth (<3 days). 44% of White infantile mortality occurs during this period, while only 25.4% and 18.5% of Coloured and Black neonates, respectively, perish during this period.

- more than a third (36.0%) of all infant deaths occur before the first week. The startling fact is, whereas 60.0% of White infant deaths take place in this time period, 37.6% of Coloured and only 26.9% of Black infant deaths occur within the first week of life.

- slightly more than one half (52.1%) of infantile mortality occurs within the neonatal period (<4 weeks). Figure 27 clearly shows the predominance of neonatal mortality. During this time period, more than three quarters (76%) of white infant deaths, and more than one half (57.6%) of Coloured infant deaths have occured. Of some considerable significance is the fact that roughly one third (32.8%) of Black infants who perished did so during the neonatal period. Consequently, it must be deduced that 67.2% of Black neonates who died within the first year of life did so within the post-neonatal period. Moreover, of these infants, most probably died from conditions related to environmental (extruterine) causes which are considered to be mostly preventable.

- over three quarters (77.7%) of all infant deaths took place within the first four months, and 84.8% died before six months

- Whereas 76.0% of White infant deaths occurred during the first four weeks (neonatal period), 76.3% of Coloured infant deaths took place before twelve weeks (<3 months), and for approximately the same proportion of Black infant deaths to occur (74.8%) took up until the first six months (<24 weeks).

TABLE 53. INFANT MORTALITY ACCORDING TO PERIOD-OF-SURVIVAL AND POPULATION GROUP

TIME PERIOD	WHITE (N)	WHITE (%)	COLOURED (N)	COLOURED (%)	BLACK (N)	BLACK (%)	TOTAL (N)	TOTAL (%)
Days :								
0	0		2		2		4	
1	4	44.0	62	25.4	9	18.5	75	24.6
2	7		15		11		33	
3	2		8		4		14	
4	0		14		3		17	
5	1		12		1		14	
6	1		4		2		7	
Weeks :								
0	15	60.0	117	37.6	32	26.9	164	36.0
1	2		37		3		42	
2	1		19		1		21	
3	1		6		3		10	
Months :								
0	19	76.0	179	57.6	39	32.8	237	52.1
1	2		35		7		44	
2	0		23		15		38	
3	0		21		13		34	
4	2		12		9		23	
5	0		3		6		9	
6	0		8		11		19	
7	0		11		7		18	
8	1		7		8		16	
9	0		6		2		8	
10	0		2		0		2	
11	1		4		2		7	
TOTAL :	25	100.0	311	100.0	119	100.0	455	100.0

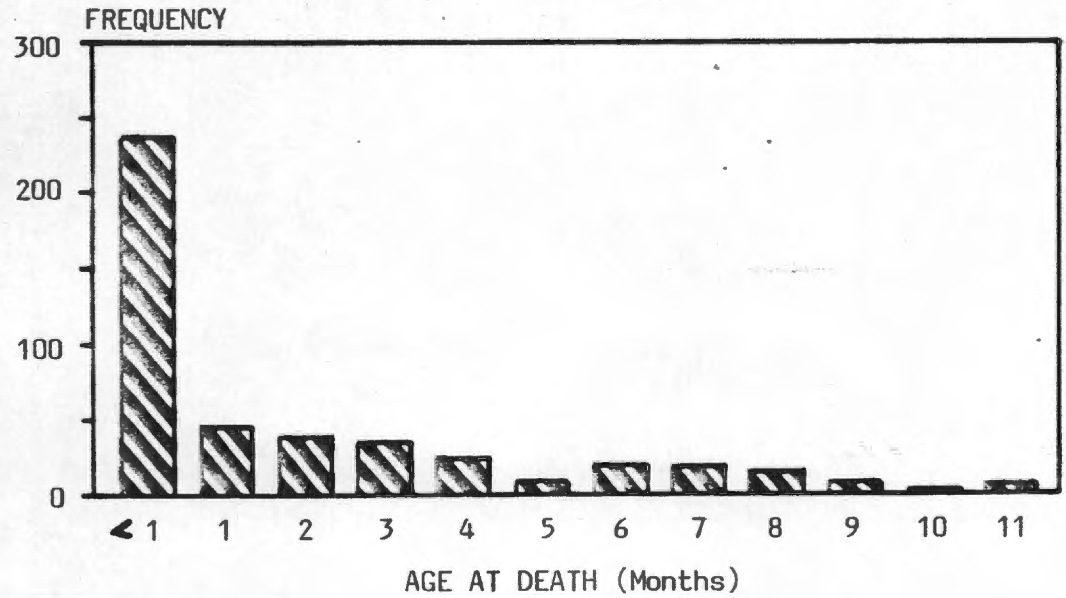

FIG. 27 . INFANT MORTALITY BY AGE (IN MONTHS)
D.C.C. CHECS REGION - 1982

APPENDIX E

APPENDIX E.

INFANT MORTALITY ANALYSIS - Cause-of-Death

The leading causes of overall infantile mortality according to the ICD-9 Basic Tabulation List (BTL), as well as for the comprehensive three-digit codes is presented in Tables 54 and 55. Slightly under half (42.0%) of all infant mortality is reported to be due to conditions originating in the perinatal period (Table 54) with diseases of the respiratory system (21.3%) being a distant second. The only other dominant cause of death (BTL code no.1) is that caused by intestinal infectious diseases (13.2%). Together, these three major causes account for no less than 76.2% of all infant deaths.

The detailed ICD-9 cause-specific infant death statistics (Table 55) shows that diarrhoeal diseases, respiratory diseases and pheumonia are responsible for 38.5% of all infantile mortality. At the foot of Table 55 is a percentage breakdown of infant death by ICD-9 code for the period-of-survival. Of the 60 infants who died from ICD-9 code number 9 (III-defined intestinal infections), 96.7% did so in the post-neonatal period, whereas for the second leading cause of infant death (code no. 769 : Respiratory Distress Syndrome), 85.0% died in the early-neonatal period.

The leading causes of infant deaths in the different population groups is listed in Tables 56, 57 and 58. The dominant cause of White infantile mortality (Table 56) is Respiratory Distress Syndrome (36.0%). 88.9% of those perishing during the early-neonatal period.

As far as the Coloured community is concerned (Table 57), the two leading causes of infant death (perinatal Disorders and Respiratory Disease) together account for 28.9% of deaths and occur predominantely during the neonatal period (see foot of Table 57). The next two leading causes of death (Bronchopneumonia and ill-defined Intestinal Infections) occur almost exclusively within the post-neonatal period (21.2%), whereas unspecified low birth weight was the cause of 5.8% of deaths occuring almost exclusively in the early-neonatal period.

The cause-specific pattern observed among Black infant deaths is at considerable variance to the pattern of White and Coloured infants (Table 58). Here the trend is for diarrhoeal diseases (25.2%) to dominate, while two forms of pneumonia account for another 27.7% of the infant deaths. Most noteable is the fact that the first three leading causes induce, almost exclusively, Black infantile deaths to occur during the post-neonatal period.

TABLE 54 . LEADING CAUSES OF INFANT MORTALITY ACCORDING TO THE I.C.D.-9 BASIC TABULATION LIST

RANK	ICD-9 B.T.L. CODE	CAUSE	INFANT DEATHS (N)	INFANT DEATHS (%)
1	45	Certain conditions originating in the perinatal period.	191	42.0
2	32	Other diseases of the respiratory system.	97	21.3
3	1	Intestinal infectious diseases	60	13.2
4	44	Congenital anomalies	29	6.4
5	46	Signs, symptoms and ill-defined conditions.	28	6.2
6	28	Diseases of the pulmonary circulation and other forms of heart disease.	10	2.2
7	3	Other bacterial diseases	9	2.0
8	22	Diseases of the nervous system.	5	1.1
TOTAL		All Causes.	455	100.0

TABLE 55. LEADING CAUSES OF INFANT MORTALITY ACCORDING TO THE I.C.D.-9 (3-DIGIT) CODES

RANK	ICD-9 CODE	CAUSE	INFANT DEATHS (N)	(%)
1	9	Ill-defined intestinal infections.	60	13.2
1	769	Respiratory distress syndrome.	60	13.2
3	485	Bronchopneumonia, organism, unspecified.	55	12.1
4	777	Perinatal disorders of digestive system.	54	11.9
5	486	Pneumonia, organism, unspecified.	33	7.3
6	765	Disorders relating to short gestation and unspecified low birth weight.	25	5.5
7	768	Intra-uterine hypoxia and birth asphyxia.	14	3.1
7	798	Sudden death, cause unknown.	14	3.1
9	799	Other ill-defined and unknown causes of morbidity and mortality.	13	2.9
10	770	Other respiratory conditions of fetus and newborn.	10	2.2
10	772	Fetal and neonatal haemorrhage.	10	2.2
Total		All causes.	455	100.0

NOTES:

For code :
9 ...... 96.7% died in the post-neonatal period.
769 ...... 85.0% died in the early neonatal period.
485 ...... 83.6% died in the post-neonatal period.
777 ...... 72.2% died in the neonatal period.
486 ...... 66.7% died in the post-neonatal period.
765 ...... 96.0% died in the early neonatal period.

TABLE 56 . LEADING CAUSES OF INFANT MORTALITY FOR WHITES ACCORDING TO THE I.C.D.-9 (3-DIGIT) CODES

RANK	ICD-9 CODE	CAUSE	INFANT DEATHS (N)	(%)
1	769	Respiratory distress syndrome.	9	36.0
2	485	Bronchopneumonia, organism, unspecified.	3	12.0
2	799	Other ill-defined and unknown causes of morbidity and mortality.	3	12.0
4	765	Disorders relating to short gestation and unspecified low birth weight.	2	8.0
Total		All causes	25	100.0

NOTES:

For codes : 769 ..... 88.9% died in the early-neonatal period.
485 ..... 100.0% died in the post-neonatal period.

TABLE 57. LEADING CAUSES OF INFANT DEATHS FOR COLOUREDS ACCORDING TO THE I.C.D.-9 (3-DIGIT) CODES

RANK	ICD-9 CODE	CAUSE	INFANT DEATHS (N)	INFANT DEATHS (%)
1	777	Perinatal disorders of the digestive system.	51	16.4
2	769	Respiratory distress syndrome.	39	12.5
3	485	Bronchopneumonia, organism, unspecified.	36	11.6
4	9	Ill-defined intestinal infections.	30	9.6
5	765	Disorders relating to short gestation and unspecified low birth weight.	18	5.8
6	486	Pneumonia, organism, unspecified.	16	5.1
Total		All causes	311	100.0

NOTES:

For code :

777 ...... 74.5% died in the neonatal period.
769 ...... 82.1% died in the early-neonatal period.
485 ...... 80.6% died in the post-neonatal period.
9 ...... 93.3% died in the post-neonatal period.
765 ...... 94.4% died in the early-neonatal period.

TABLE 58 . LEADING CAUSES OF INFANT DEATHS FOR BLACKS ACCORDING TO THE I.C.D.-9 (3-DIGIT) CODES

RANK	ICD-9 CODE	CAUSE	INFANT DEATHS (N)	INFANT DEATHS (%)
1	9	Ill-defined intestinal infections.	30	25.2
2	486	Pneumonia, organism, unspecified.	17	14.3
3	485	Bronchopneumonia, organism, unspecified.	16	13.4
4	769	Respiratory distress syndrome.	12	10.1
5	765	Disorders relating to short gestation and unspecified low birth weight.	5	4.2
Total		All causes.	119	100.0

NOTES:

For code :
9 ..... 100.0% died in the post-neonatal period.
486 ..... 88.2% died in the post-neonatal period.
485 ..... 87.5% died in the post-neonatal period.
769 ..... 91.7% died in the early neonatal period.

APPENDIX F.

APPENDIX F.

FINANCIAL IMPLICATIONS OF LOW BIRTH WEIGHT INFANTS.

A significant implication arising out of this study concerns the health economics , or financial implications, of the occurence (delivery) of low birth weight infants from the CHECS region.

During 1982, the Combined Health Scheme spent a total of R 6.4 million in providing health care services to the region. Of this, R 1.2 million was devoted to Child Health Services (Medical Officer of Health, D.C.C., Annual Report 1982). In attempting to determine the financial burden to the health services, the following approach was adopted. While, it is recognized that the total monetary costs involved are impossible to derive accurately, it is nevertheless feasible to arrive at a relaible estimation which may be used as an indication of the overall financial burden created by the occurrence of low birth weight infants at the time of birth. To date, no health institution within the Greater Cape Town area has attempted to establish such costs.

The method conceived takes no account of infants delivered who weigh more than 2500 grams at birth; the assumption being that these neonates will not require specialized care (except in the rare case) and be returned to their mother in the ward. Infants who require further treatment after their normal discharge (with their mother) from hospital are also not considered. In other words, only infants who are born with a low birth weight and require admission to either a neonatal intensive care unit (NICU) or nursery are used to calculate as estimation of costs.

Low birth weight infants born within the CHECS region during 1982 (n=1871) were divided into two groups: those who perished (N=228) and those who survived (N=1643)*. The mean hospital days figures are based on 42249 deliveries to the Peninsula Maternity and Neonatal Service institutions during the two year period 1981 - 1982. The average length of stay (mean hospital days), according to infant birth weight group and life status (alive or died) is shown in Table 49.

Footnote: * This data was kindly supplied by Professor A. Malan (Department of Paediatrics and Child Health, Groote Schuur Hospital), as was the data pertaining to the average number of days which infants remained in hospital.

In order to appraise the approximate financial costs which these infants imply, it is necessary to establish the cost to the health services of supporting an infant in an NICU or nursery on a daily basis. A conservative estimate again based upon the 1981-1982 period, is R150.00 per day (Prof. A. Malan, pers comm), although a more realistic value is in the region of R220.00 per day. The costing procedure is detailed in Table 50.

Infants who weighed less than 1500 grams at birth (n=240) stayed, on average, a total of 5341 days in hospital (NICU/Nursery) which resulted in an estimated expenditure of R0.80 million (Table 51). On the other hand, the 1500-1999 gram birth weight group (n=385) accounted for a total of 6042 mean hospital days with a concommitant expenditure of R=.91 million, and the final birth weight group (2000-2499 g) was represented by 60 neonates and a total of 329 mean hospital days being responsible for R0.05 million. Consequently, on the basis of the approximate accounting procedure outlined above, the occurrence (at time of delivery) of low birth weight infants in the CHECS region during 1982 necessitated an expenditure by the Peninsula Maternity and Neonatal Services of R1.76 million alone.

Table 52 lists the differential monetary costs per low birth weight infant according to whether it survived or perished during hospitalization. For infants who died, the lower their birth wieghts the less was their average cost to the institution. This is not surprising because very low birth weight neonates (<1500 g) tend to die within an average of only 3.2 days (see Table 49). Conversely, the mean cost for each low birth weight infant who survived decreases with increasing weight at birth, from R6422 for the less than 1500 gram group to R825 for the 2000-2499 gram group.

TABLE 49 AVERAGE LENGH OF STAY IN HOSPITAL (DAYS) OF LOW BIRTH WEIGHT INFANTS FROM TIME OF DELIVERY ACCORDING TO BIRTH WEIGHT GROUP

		DIED		ALIVE	
BIRTH WEIGHT GROUP (g)	BIRTHS	(N)	MEAN HOSP DAYS*	(N)	MEAN HOSP DAYS*
500-999	63	48	3.2	15	61.0
1000-1499	177	80	4.9	97	40.0
< 1500	240	128		112	
1500-1999	428	52	2.7	376	17.5
2000-2499	1203	48	4.9	1155	5.5
< 2500	1871	228		1643	

* Source: Prof. A. Malan (Groote Schuur Hospital, pers comm) Based upon 1981-1982 Peninsula Maternity and Neonatal Services (PMNS) data embracing 42249 deliveries.

Summaries are provided in the Table(49) for three predominant birth weight categories, namely the less than 1500 gram group (very low birth weight group), the 1500-1999 gram group, and the 2000-2499 gram group. The reason for this distinction is that the admission criteria for the Neonatal Unit at Groote Schuur Hospital varies according to birth weight. All infants weighing less than 1500 grams at birth are automatically admitted to the NICU or Nursery, whereas approximately only 90% are admitted from the 1500-1999 gram group and only 5% from the 2000-2499 gram group.

The lower an infants birth weight the longer the infant remains in hospital. For example surviving neonates weighing between 500-999 grams spent on average, 61.0 days in an NICU or nursery. Conversely, the mean length of stay figure declines dramatically to 5.5 days for neonates weighing between 2000 and 2499 grams at birth.

TABLE 50. DETERMINATION OF MCNETARY COSTS INVOLVED WITH THE OCCURRENCE OF LOW BIRTH WEIGHT INFANTS

- Estimated average cost per infant day in Intensive Care Unit or Nursary = R150.00 *

Infants weighing <1500g -

- 100% admittance to ICU or Nursary
- 128 infants died ; with a total of 545.6 mean hospital days
- 112 infants survived ; with a total of 4795.0 mean hospital days
- TOTAL = 240 infants ; with a total of 5340.6 mean hospital days
- Estimated total cost @ R150.00 per ICU/Nursary day = R0.80 m

Infants weighing 1500-1999g -

- 428 infants delivered
- Estimated 90% admittance (385 infants)
- A total of 52 infants died (90% = 47 infants); with a total of 126.9 mhd+
- A total of 376 infants survived (90% = 338 infants); with a total of 5915.0 mhd
- TOTAL mean hospital days = 6041.9
- Estimated cost @ R150.00 per ICU/Nursary day = R0.91 m

Infants weighing 2000-2499 g -

- 1203 infants delivered
- Estimated 5% admittance
- A total of 48 infants died (5% = 2 infants); with a total of 9.8 mhd
- A total of 1155 infants survived (5% = 58 infants); with a total of 319.0 mhd
- TOTAL mean hospital days = 328.8
- Estimated cost @ R150.00 per ICU/Nursary day = R0.05 m

* Applies to the Peninsula Maternity and Neonatal Services for 1981-82
Source : Prof. A. Malan (Groote Schuur Hospital, *pers comm*)

\+ Mean hospital days (mhd).

TABLE 51. CALCULATED AVERAGE COSTS FOR LOW BIRTH WEIGHT INFANTS

Estimated total annual costs for 1982 -

Birth Weight Group (g)	Number Deliveries+	Costs
500-1499	240	R 801 090.00
1500-1999	385	R 906 285.00
2000-2499	60	R 49 320.00
TOTAL	685	R 1 756 695.00

+ Estimated number of deliveries admitted to ICU or Nursary.

TABLE 52. CALCULATED AVERAGE COSTS FOR EACH LOW BIRTH WEIGHT INFANT

Birth Weight Group (g)	Number Deliveries+	INFANTS			
		Survived	Cost‡	Died	Cost‡
500-1499	240	112	R 6421.90	128	R 639.40
1500-1999	385	338	R 2625.00	47	R 405.00
2000-2499	60	58	R 825.00	2	R 735.00
TOTAL	685	508		177	

+ Estimated number of deliveries admitted to ICU or Nursary.

‡ Average cost per infant.

ERRATA

Page 22 - Death certificates were collected during 1982 only, and birth notification forms during 1981 and 1982.

Page 26 & 28 - Death certificates collected for 1982 only.