BIRTH NOTIFICATION DATA AS A SOURCE OF BASIC DEMOGRAPHIC MEASURES; ILLUSTRATED BY SPECIFIC APPLICATION TO THE STUDY OF CHILDHOOD MORTALITY IN THE SOLOMON ISLANDS

SHEILA MARY MACRAE

A THESIS
Presented for the Degree of Doctor of Philosophy
in the Faculty of Medicine
University of London

London School of Hygiene and Tropical Medicine
1979

Nothing to see but the palmtrees one way
And the sea the other way,
Nothing to hear but the sound of the surf.
Nothing at all but three things

What things?

Birth, and copulation, and death.
That's all, that's all, that's all, that's all,

....

Birth, and copulation, and death.
That's all the facts when you come to brass tacks.

T.S. Eliot
Sweeney Agonistes:
Fragment of an Agon

ACKNOWLEDGEMENTS

All concerned with this thesis, however indirectly, probably regard it as thanks enough that it is now actually completed. Nevertheless, a few individuals must be singled out for special mention.

Of course, thanks are due primarily to my supervisor, Professor William Brass, whose inspiration and constructive comments have guided the direction of this work. Other staff of the Centre for Population Studies have on occasions given me advice, and the secretarial staff have been particularly helpful and long-suffering - as have the School library staff.

Many people have been most generous in providing me with information. Of these, I should like especially to thank: Dr. Gordon Avery (ex-Government Malariologist, Solomon Islands) for his M.D. thesis while still in press; Dr. Jimmy Macgregor (ex-Director of Medical Services, Solomon Islands) for his M.D. thesis and some unpublished documents; Mr. Charles MacFadden (Government Statistician, Solomon Islands) for preliminary results and basic tabulations of the 1976 Census; Mr. Patrick Macdonald (Archivist, Fiji) for information gleaned from long hours of research in the Western Pacific Archives; and two friends, Saba and David Potten, for studying the birth registers on my behalf, while visiting Honiara.

The text and tables were typed by Mrs. Lorna Vickerstaff, and I cannot adequately express my thanks to her for all her willing assistance. Her hard work made the production of this manuscript less painful for me than it would otherwise have been.

Essential moral support throughout the period of this work has come from my family and from many friends, one of whom in particular has suffered my variable moods with patient understanding. Without such continual encouragement from them all, I could never have finished this thesis.

The collection and processing of the data was funded by the Ministry of Overseas Development, which also gave me personal financial support for the final few months of work. The Medical Research Council supported me financially for the majority of the period of study. The support from both agencies is gratefully acknowledged.

ABSTRACT OF THESIS

The collection of maternity history data at the time of registration of a current birth would seem to be a profitable use of the existence of registration. However, such data present unique problems which have not previously been recognised. These problems relate to the biases caused by the sample not being a random one of all women but one of proven fecund women only, all of whom are at the end of a birth interval.

The present work is based on birth notification data collected in the Solomon Islands over a period of nine years. The thesis develops techniques which can be applied to such data to derive conventional demographic indices of fertility and childhood mortality. Established techniques are adapted to take account of the nature of the sample and innovative techniques introduced in this study. The value of each technique developed is discussed and the results compared, where appropriate, both with those from the other techniques applied and also with census results.

The birth notification data also provide a rare opportunity to monitor, in a demographic manner, the progress of the concurrent malaria eradication programme in the Solomon Islands. With the islands grouped according to their malarial status, birth characteristics and childhood mortality indices are compared in malarious and non-malarious areas. The effect of malaria eradication is reflected, sometimes dramatically, in some of these indices.

With the successful derivation of demographic indices from such data as shown in this thesis, the collection of maternity history data at the time of registration of a current birth is found to be a valuable and viable method of data collection. In addition, for the Solomon Islands, malaria eradication could be monitored with these data.

TABLE OF CONTENTS

LIST OF TABLES

a) Text Tables

a) Text Tables(contd)

a) Text Tables(contd)

b) Appendix Tables

b) Appendix Tables(contd)

LIST OF FIGURES

List of Figures(contd)

LIST OF APPENDICES

CHAPTER 1 INTRODUCTION

The birth notification data collected in the Solomon Islands and on which this thesis is founded present unique problems. The idea that past fertility characteristics of the mother recorded at the time of registration of a birth might be used for the estimation of demographic indices is not new, as El-Badry (1967) studied such information in Bombay but derived indices which were unconventional and therefore of limited value. The idea that the maternity history of the mother should be recorded for this purpose is also not new, as Jain (1965) first proposed it for the registration programme in India. However, the problems associated with the collection of maternity history data at the time of registration of a birth have not been recognised hitherto. These relate to the biases caused by the sample being of proven fertile women only, all of whom are at the end of a birth interval and not randomly distributed within it. These women are therefore not comparable with a random sample of the general population of women. No previous attempt to apply to such data the techniques necessary to take account of these biases has been published. The main hypothesis of this thesis is that such a method of data collection can be used to derive conventional demographic indices and is therefore both valuable and viable.

Since registration of births is seriously incomplete in many countries, "the attempt to obtain as much profit as possible from the existence of registration is well justified" (Brass, 1969). The opportunity for this arose in the Solomon Islands in 1966. The Director of Medical Services wished to find a demographic method of monitoring the progress of the malaria eradication programme recently begun there. It was hoped that the collection of data on the maternity history of the mother at the time of registration of a birth would provide conventional demographic indices of childhood mortality by which this progress could be assessed. Good evidence of the demographic effects of the eradication of malaria is uncommon, as the effects frequently cannot be isolated from those of confounding factors. It was therefore considered worthwhile to have as a subsidiary hypothesis to this thesis that malaria eradication can be monitored using birth notification data.

The birth notification scheme existed concurrently with the malaria eradication programme affording a total of nine years of data for study. The approach to this study is outlined by a description of the contents of the ensuing chapters.

Chapter 2 contains essential background information concerning the Solomon Islands. A general description of the Islands and a study of available population data is followed by an outline of the stages of the malaria eradication programme.

The birth notification data are described in Chapter 3. The questionnaires used and the procedure for their processing are discussed in detail. However, the greater part of the chapter is devoted to a study of the practical and methodological problems raised by such a form of data collection.

Chapter 4 begins the analysis related to the first hypothesis of this thesis. Methods for deriving conventional fertility indices from the birth notification data are studied. In particular, the derivation of mean completed family size is discussed in detail, and total fertility rates are used to determine the proportion of births notified. Mean parities, mean age at first birth and sex ratio at birth are also studied, while important and unusual information emerges from the studies of infertility.

Chapter 5 is the core of the thesis. In it, is discussed the derivation of childhood mortality indices from the birth notification data. Established techniques are adapted for application with these data and the results compared with those from the Solomon Islands' censuses where appropriate. New techniques are also presented and the results compared with those from the adapted established techniques. The value of birth notification data in providing conventional indices of childhood mortality is discussed.

Chapter 6 is the first of the two chapters in which is discussed the second hypothesis of the thesis and in this chapter the effect of malaria eradication on birth characteristics is studied. Most attention is paid to the somewhat unusual index of birth weights, while stillbirths and mean parities are also considered.

In Chapter 7 are discussed the childhood mortality levels found over the years in different areas of the Solomon Islands. Explanations are sought for the initial differences in mortality levels between the so-called 'malarious' and 'non-malarious' areas. The decline in mortality levels is studied and the contribution of malaria eradication to this decline is considered. The value of monitoring malaria eradication by this method using these data is discussed.

Chapter 8 concludes the thesis. The hypotheses are reiterated and the results of the analyses summarised. The value and viability of birth notification data in the derivation of fertility and childhood mortality indices is discussed, along with the side benefit, in this instance, of their role in the monitoring of malaria eradication. The potential future use of such forms of data collection is assessed.

CHAPTER 2 THE SOLOMON ISLANDS

INTRODUCTION

A description of the Solomon Islands is an essential prerequisite to an understanding of the analyses of the country's birth notification data which are described in the following chapters. Only the Islands as a whole are discussed in this chapter; relevant inter-island comparisons are made elsewhere. Where appropriate, comparisons are made with other Pacific island groups.

DESCRIPTION OF THE ISLANDS*

a) *TOPOGRAPHY*

The Solomon Islands consist of a segment of the arc of islands lying to the northeast of Australia in the Western Pacific. The scattered archipelago, situated between latitudes 5°S and 12°S and longitudes 155°E and 170°E, stretches for over 1,000 miles in a south-easterly direction from Papua and New Guinea (see Figures 1 and 2). The six main islands - Choiseul, New Georgia, Santa Isabel, Malaita, Guadalcanal and Makira - form a rugged and mountainous double chain. The numerous other islands are mostly volcanic or are coral atolls. The total land area is approximately 11,500 square miles, ranging from Guadalcanal of approximately 2,000 square miles to lagoon islands of a few square yards. More than 90% of the land is of foothills and mountain ranges covered with rain forests; the remainder being the flat coastal region and the lagoon islands and atolls.

---

*Much of the material for this section has been taken from Avery (1977), Brookfield and Hart (1971) and the Annual Reports and Annual Medical Reports of the Solomon Islands. Research among the holdings of the Western Pacific Archives in Suva, Fiji, was conducted on the author's behalf by Mr. P. D. Macdonald, to whom grateful acknowledgement is made.

FIGURE 1 MAP SHOWING THE LOCATION OF THE SOLOMON ISLANDS IN THE PACIFIC OCEAN

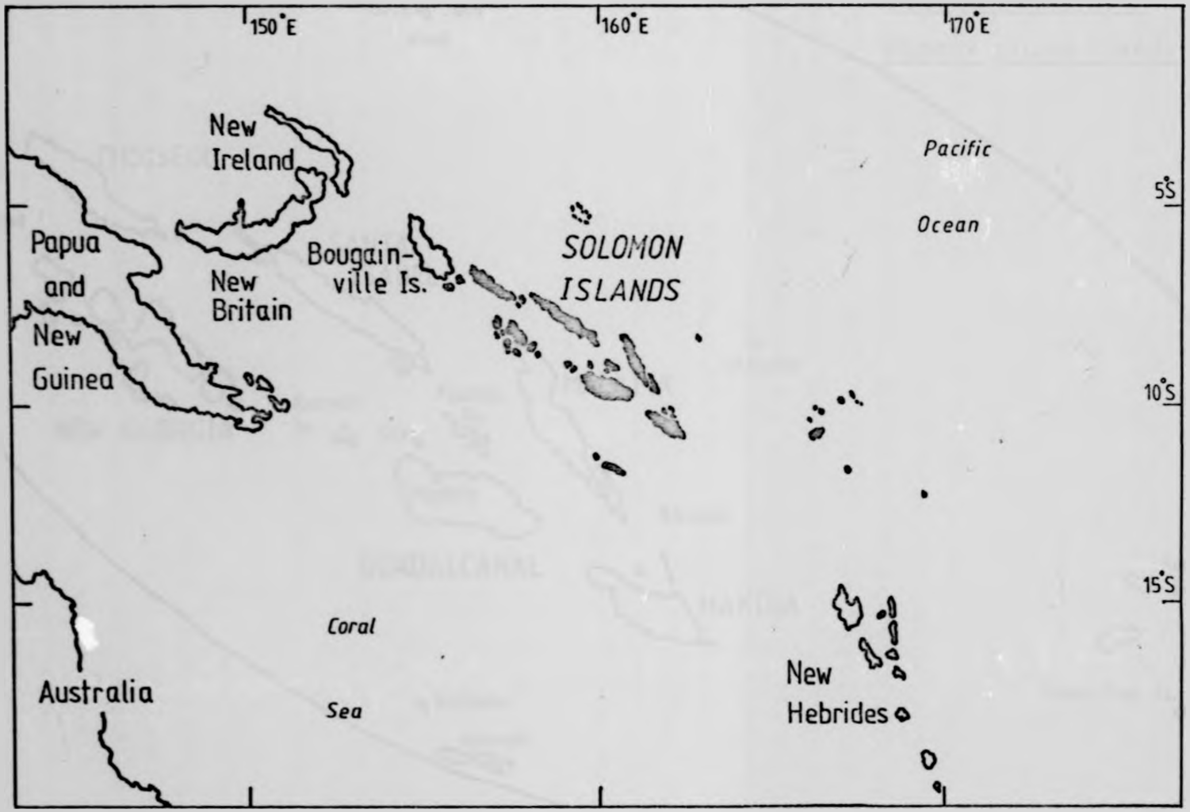
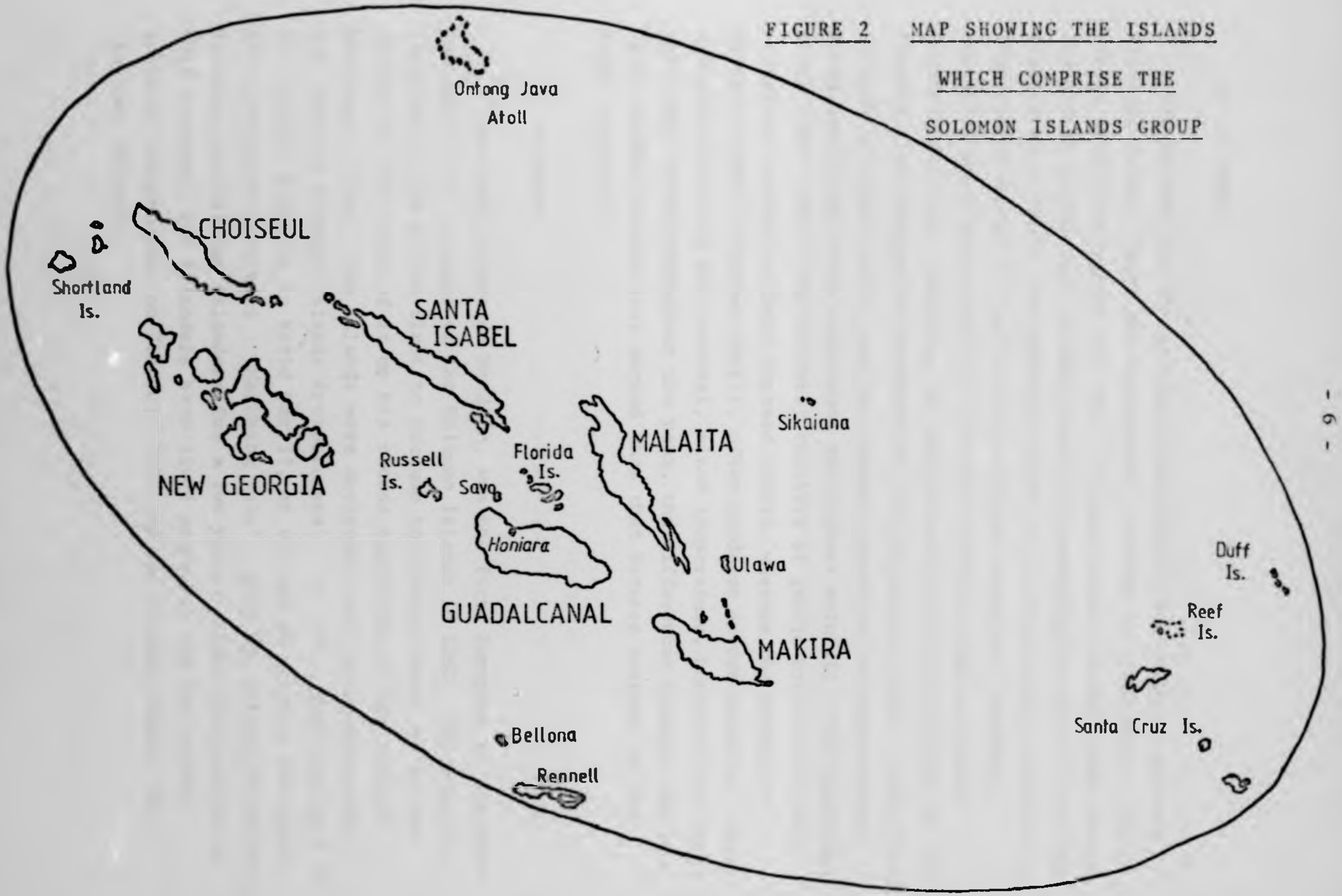


FIGURE 2 MAP SHOWING THE ISLANDS WHICH COMPRISE THE SOLOMON ISLANDS GROUP



b) *CLIMATE*

The islands lie in the equatorial oceanic and tropical oceanic climatic zones. There are no seasonal patterns to temperature, which varies little throughout the year. In many areas, monthly mean maxima and minima seldom vary by more than 1°C, averaging around 27°C for the islands as a whole. In addition, there is little diurnal variation in temperature except in the vicinity of high mountains. However, humidity, which also changes little over the year, has a greater diurnal variation. Rainfall is also seasonally uniform in most of the islands with averages of between 200 and 500 cms per annum. Rain falls everywhere almost daily, but the coasts exposed to the rain-bearing south east trade winds experience the highest rainfall. The south east trade winds season (May-October) consists of gentle breezes and only occasional storms on these exposed coasts, whereas the northwest monsoon season (November-April), often produces severe squalls. Thus, although the winds are seasonal, since temperature, humidity and rainfall vary little throughout the year, the differences between the two wind seasons is much less marked than that between seasons in many other countries.

c) *HISTORY*

A Spaniard, Alvaro de Mendaña, was the first European to discover and record the presence of the Solomon Islands in 1568. (He was also, ironically, one of the first to succumb to malaria there, as he was thought to have died of it on his second expedition to the Islands - Macgregor, 1966.) The Islands were declared a British Protectorate - the 'British Solomon Islands Protectorate' - in 1893. They saw much of the Pacific fighting in World War II, at the end of which a nativistic anti-government movement - 'Marching Rule' - grew up, mainly on Malaita, dividing the Solomon Islanders for a few years. Since the decline of this movement, the Islanders have lived peaceably and the country achieved independence on 7th July 1978 and was renamed simply the 'Solomon Islands'.

d) *THE PEOPLE*

The present Islanders are descendents of people who migrated from south-east Asia some 10,000 years ago, although some migrations from other areas occurred subsequently. Of the total population of the Solomon Islands, 93% are Melanesians (Census Report, 1970). These are the people of the ethnic region of Melanesia* which covers the whole tropical area from New Guinea to Fiji and New Caledonia. In the Solomons, the Melanesians inhabit all the large islands whereas the outlying coral atolls and volcanic islands are mainly peopled by Polynesians (3.9% of the population). A small group (1.5% of the total population of the Solomon Islands) of Micronesians from the over-populated Gilbert and Ellice Islands settled in the Western Solomons in the 1950's. (The remaining 1.6% of the population are mostly European, Fijian or Chinese.) There is considerable linguistic diversity among the Islanders, and among the Melanesians alone there are approximately 40 languages and as many dialects - the largest language group (Kwara'ae) being spoken by a mere 9% of the populace (Asiaweek, 1978). Pidgin English is the *lingua franca*.

The people are mainly Christian, living in the coastal villages with only a few pagan communities (approximately 5% of the population) living in the remote hilly bush areas of the large islands, notably Malaita. Both Christian and pagan festivals are celebrated, usually with feasts. Traditional beliefs and customs are slowly dying out in most areas in the face of Western influence.

Most islanders in the rural areas engage in subsistence agriculture, with some supplementary fishing and hunting. They cultivate mixed gardens of several root vegetables. Some of these crops, *e.g.* yams, are seasonal, but some, *e.g.* taro, can be planted and harvested

---

*Melanésie was the term advanced by the navigator Dumont d'Urville (1832) to describe those parts of the Pacific inhabited by black men (Brookfield and Hart, 1971, *ibid*).

continuously. There are thus no periods in the year when all islanders are either harvesting their one staple crop or experiencing a lean period of food intake. In fact, the ease of cultivation of several root crops, and the additional adequate supply of various fruits and nuts, and occasionally fish, pigs and poultry, means that most people have a well-balanced and sufficient diet continuously throughout the year.

Few islanders (though the number is increasing) therefore see the economic necessity of wage-earning employment since, when tax dues or material needs demand, they merely cut a few bags of copra and sell some cattle from their smallholdings. However, some islanders, particularly the young men, now migrate to work on the copra plantations or in the commercial industries centred around the capital, Honiara, on Guadalcanal. Improved inter-island communications in recent years have enabled this labour migration to increase. As a result, the overall export economy of the Solomon Islands, based primarily on copra but including timber, fish, palm oil, and possibly soon bauxite and copper ore extraction, has improved to a stage where exports exceeded imports in value for the first time in 1974.

Government services to the people are increasing and improving all the time. The education services expanded rapidly during the 1970's and at 31st March, 1974 approximately 50% of children in the school age group were attending primary or secondary schools. Although formal social services have only begun to take shape in the last decade, health services have evolved steadily over many years, although their distribution has been dictated by both the topography and the extent of communications. Missionaries established the first clinics and hospitals (previously treatment for ills had traditionally been provided by the local medicine man). The Government then established a hospital on each main island, with the principal and referral hospital being at Honiara. Primary health care is provided outwith the main centres by the Rural Health Clinics as well as by Mission and commercial clinics. Current curative and preventive health services are relatively extensively distributed throughout the Solomon Islands. The main health campaign to be launched in the islands, the malaria eradication campaign, will be discussed below.

POPULATION DATA

a) *AVAILABLE RECORDS*

There is no registration of deaths in the Solomon Islands and (although there was theoretically registration of births by Local Councils) the only registration of births is that established in 1966 under the Birth Notification Scheme; there is therefore no national record of vital statistics. There have been a very few academically-sponsored population surveys (the largest of which was that of the Weather Coast of Guadalcanal conducted by Chapman and Pirie, 1974), but all of these have been of selected sub-groups of the population. Hospital records on morbidity and mortality exist, but incompletely and for varying time periods. Hence, the only sources of data for the entire population are the censuses.

b) *HISTORY*

In the early part of this century, population statistics of the Solomon Islands were still hardly more than rough estimates. It was widely believed that the Islands, in common with other island groups in the Pacific (McArthur, 1967), had been actively depopulated by internecine warfare, labour emigration and infectious diseases. However, this is now considered unlikely and it is probable that periods of decline, caused by, *e.g.* epidemics, alternated with periods of growth.

The first 'census' of the Solomon Islands was carried out over a period of several months in 1931. The information sought was the population by sex and three broad age groups (<6, 6-16, >16 years), but in some areas only a head count was made and in other islands not even that. The census results for the territory as a whole were therefore probably seriously in error. The proposed census of 1949 was finally abandoned due to the opposition of the members of the "Marching Rule" (see above). There was no other attempt at a census until the sample census of November 9th, 1959 - the sampling frame for which was based on the population data from the anti-yaws campaign (since these, although collected over a two year period, 1956-58, were the only data available). This census collected the "minimum information about the population necessary to plan its development" (Census Report, 1959). The first full census of the population was conducted on February 1st, 1970 and the next (the most recent) on February 8th, 1976. Only the preliminary results of the 1976 Census had been published by February 1979, although some basic tabulations were made available to the author for use in this study.*

c) *POPULATION GROWTH*

The figures for population size determined at each census and two of the inter-censal growth rates are given in Table 1. The growth rate between 1931 and 1959 should be regarded with much scepticism owing to the undoubted inaccuracy of the figures for the population in 1931. That for the period 1959-70 is also necessarily the best estimate of a range of rates of increase due to the different nature of the censuses, the 1959 census being a *de jure* sample census and the 1970 being a *de facto* census. Indications are that the growth rate in the 1970-76 inter-censal period will be higher than in the previous inter-censal period. Calculation of the annual rate of natural increase in the 1959-70 inter-censal period is further encumbered by the inaccuracy of the migration statistics. It is known, however, that external migration was mainly restricted to non-Solomon Islanders, with little international migration by Melanesians and Polynesians. Their rate of natural increase was therefore close to the overall rate of increase in that period and the best estimate of this was taken as 2.3% p.a.

---

*by courtesy of the Government Statistician, Mr. C. A. MacFadden, to whom grateful acknowledgement is made.

TABLE 1

POPULATION SIZE AND GROWTH RATES; ALL ETHNIC COMPONENTS OF THE POPULATION

Census	Males	Females	Total	Average Annual Intercensal Growth in Total Population
1931	-	-	94,066	-
1959	65,532	58,544	124,076	0.97%
1970	85,179	75,819	160,998	2.58%
1976†	102,808	94,015	196,823	*

† Preliminary figures

* Not available

However, internal movement between the islands is quite common and, at the 1970 Census, 13% of all Melanesians were enumerated outwith their area of birth. Among the adult males this figure reached 23%. The Polynesians showed slightly higher levels of movement. The census figures for Melanesians suggest that each of the four Administrative Districts had a different migration pattern; Western District had high levels of both inward and outward movement; Malaita District had high outward movement and virtually no inward movement; Central District had very little outward movement but a high influx of people (predominantly adult males); Eastern District had comparatively few departures and arrivals. Most of the movement in the territory was to the capital, Honiara, on Guadalcanal.

d) *POPULATION STRUCTURE*

(i) *Sex*

The proportion of males in the Melanesian population in the 1970 Census was 530 per thousand population. Similar high sex ratios were also found in the 1966 Census of Papua and New Guinea (521/1000 in the indigenous population - Van der Kaa, 1969) and in the 1967 Census of the New Hebrides (528 males per 1,000 population - New Hebrides Census Report, 1967). As the influence of migration can be excluded there are three possible causes: a high sex ratio at birth, an unusual sex-specific mortality risk, and sex-specific inaccuracies in enumeration. The sex ratio at birth (see Chapter 4) was found to be high in the Solomon Islands (as it is, for example, in parts of Papua and New Guinea - Groenewegen and Van der Kaa, 1967). Mortality risks for females in the Solomon Islands may be higher than for males as *e.g.* in Ceylon, India and Pakistan (El-Badry, 1969) and in Papua and New Guinea (Van der Kaa, 1971) but the evidence was inconclusive. The 1970 Census data do not provide sufficient detail to establish which of these causes are responsible for the excess of males in the Melanesian population.

(ii) *Age*

The age pyramid in five year age groups of the Melanesian component of the population in 1970 (Census Report, 1970, *ibid*), with approximately 45% of the population under 15, is typical of many developing countries. Females in the reproductive age group 15-49 were 46% of the total female population (both for the Melanesians only and also for all components of the population).

e) *FERTILITY*

The fertility of Melanesian women appeared to be higher than that of Polynesians, though such an observation has to be treated with caution as it is based on indices which are notoriously unreliable and subject to under-reporting by the older women. At the 1970 Census, Melanesian women at the end of their reproductive period (*i.e.* aged 45-49) reported a mean number of 6.1 ever born children, whereas Polynesian women of the same age reported a mean of only 4.9 children. However, there was little difference between the two ethnic groups in the mean number of children born per mother. It is thought that there was little change in the fertility level in the 1959-70 inter-censal period. (Mean parities of women aged 45-49 in other Melanesian islands varied from 4.42 for the total indigenous population of Papua and New Guinea in 1966 to 6.28 for the indigenous population of the New Hebrides in 1967 (South Pacific Commission, 1975). Adjusted age-specific fertility rates give a total fertility rate of 6.5 for Melanesian women and a lower rate of 5.4 for Polynesian women. These estimates must all be regarded with some caution as they are based on very indirect methods of varying degrees of validity. The adjusted crude birth rates (strongly influenced of course by the age and sex compositions of the component populations) were 42 per 1,000 and 37 per 1,000 for Melanesians and Polynesians respectively.

f) *MORTALITY*

Infant mortality rates vary widely throughout the world from a rate of approximately 10 per 1,000 livebirths in Scandinavia to one of approximately 300 per 1,000 in parts of tropical Africa (Vallin, 1976;

Page, 1971). The infant mortality rate at the time of the 1970 Census was approximately 75, which was half that estimated from the 1959 Census data. It is still higher than that in the more developed islands of Fiji (37 per 1,000 for Fijians (from average of births 1968-72) - World Fertility Survey, 1974) but comparable with that of 85 per 1,000 for the indigenous of the New Hebrides in 1967 (Tsubouchi, 1969). However, despite their wide use, infant mortality rates calculated indirectly are subject to several errors and these figures should also be regarded with some caution. An average crude death rate (like the crude birth rate heavily dependent on the age structure of the population) over the 1959-70 inter-censal period of 13.4 per 1,000 had seemingly declined to 11 per 1,000 at the 1970 Census.

Since the crude birth rate of the Melanesian and Polynesian population in the year preceding the 1970 Census was approximately 41 per 1,000, their rate of natural increase has reached approximately 3% per annum. On present evidence, this rate of natural increase will continue to grow since the Solomon Islands in common with many other developing countries, have reached a stage in their demographic transition of declining mortality but continuing high fertility.

MALARIA ERADICATION PROGRAMME*

a) *BACKGROUND*

Malaria had been frequently mentioned in historical records and in the Annual Medical Reports as a major cause of the ill-health of the community and as one of the leading causes of admission to hospital. The disease, sometimes reaching epidemic proportions, was one of the greatest hazards experienced by the armed forces in Guadalcanal in World War II. At the South Pacific Commission in 1950, it was noted

---

*Most of the material for this section has been taken from Macgregor (1966, *ibid*), Avery (1977, *ibid*), and Saint-Yves (1975).

that malaria was a serious disease and that steps should be taken to control it. As a start, several malaria surveys were conducted (*e.g.* Black, 1952) and the islands were mostly classified as having mesoendemic malaria (according to the Kampala classification - WHO, 1951). Black (1955) indicated that the administration should waken up to the seriousness of the malaria situation, though he admitted that a malaria eradication programme would be both difficult and expensive due to the small but scattered population. Proposals for such a programme were initially discussed in 1956 and formulated into a World Health Organisation/Solomon Islands joint agreement in 1961.

b) *PROGRAMME*

Malaria eradication was tackled in three main phases: the Pilot Project (1962-64); the Pre-eradication Programme (1965-69); and the Eradication Programme (1970-). During the Pilot Project, the islands where malaria was first attacked (using DDT residual spraying on the walls of buildings as the means of attack on the anopheline vector*) were Guadalcanal (1962), Savo (1963) and the New Georgia group (1963). During the period of the Pre-eradication Programme, Choisseul came under spray cover in 1968, so that the entire Western District was by then in the programme (the Shortland Islands having first been sprayed by the Papua and New Guinea administration in 1959). The objective of the third phase, the national Malaria Eradication Programme, was to "eradicate malaria from the whole of the Solomon Islands within a reasonable period of time commensurate with the resources available". While all proven cases of malaria were treated with drugs, DDT spraying was gradually extended to cover the remaining islands. The rest of the Central District (Santa Isabel, Florida Islands and the Russell Islands),

---

*The vectors were:
Anopheles farauti - widely distributed in coastal and riverine areas in many islands.
A. koliensis and A. punctulatus - mostly on larger islands.

all of Malaita District and Ulawa in Eastern District were first sprayed in 1970 and the rest of Eastern District in 1971 (Makira and Ndende) and in 1972 (the Reef Main Islands).

c) *RESULTS*

The Malaria Eradication Programme was evaluated by studying both the anopheline vector and also the parasite* in man before and after spraying operations. Serveillance was established to discover and to control any residual foci of malaria. However, despite this, resurgence of malaria did occur in several 'problem areas'. The majority of the Solomon Islands provide the ideal physical environment in which anopheline mosquitoes flourish, and it was therefore probably inevitable that small pockets of malaria would persist or redevelop. Reasons for this were varied: spray rounds taking several weeks; re-spraying being required at regular intervals; occasional interruption in DDT supplies; changes in the biting habits of the anopheline mosquitoes (Slooff, 1969); inter-island migration (Prothero, 1965); increasing refusal rates in some areas; and changes in the financial support of what may become a malaria control rather than a malaria eradication programme. Nevertheless, the Malaria Eradication Programme has made a major impact on malaria (and, indirectly, on a number of other diseases) and if eradication is not finally achieved, then good control certainly has been.

---

*The parasites in man were:

Plasmodium vivax	- most common parasite
P. falciparum	- common parasite
P. malariae	- uncommon parasite

CHAPTER 3 BIRTH NOTIFICATION DATA

ORIGIN AND HISTORY OF THE SCHEME

Since there was no registration of births (or deaths) in the Solomon Islands, in 1965 the then Director of Medical Services, Dr. J. D. Macgregor, decided to establish a 'Birth Notification Scheme'. Financial assistance for the printing and computer processing of the questionnaire forms was provided after the inception of the scheme by the Ministry of Overseas Development in the form of a Scientific, Technical and Medical Department Research Grant No. R2681A. Professional advice on the design of the questionnaire and the tabulations required for analysis was given by Professor Brass of the London School of Hygiene and Tropical Medicine.

The scheme did not begin until mid-1966 and analysis has only been made of the data collected in 1967 *et seq*. Notification of births under this scheme has continued to date, but the financial support from the Ministry of Overseas Development terminated with the analysis of the 1975 data. Further analysis on subsequent years' data will be an internal matter for the Solomon Islands' Government.

DATA COLLECTED, QUESTIONNAIRES USED, AND POPULATION SURVEYED

This scheme afforded an opportunity to extend the questions beyond those relating to the current birth to ones relating to the mother's maternity history. The questionnaire used was designed under the guidance of Professor Brass. The format and content of the questionnaire form changed slightly on a reprinting in 1968, but remained the same thereafter (see Appendix 1).

All women, regardless of their marital status, were interviewed either at the time of a current birth by the nurse attending the birth or soon after the baby was born. (In some areas, where there was an active nurse, the women gave their maternity histories at ante-natal clinics.) The nurse recorded details of the current birth, of the parents, and of the mother's maternity history. A second form was used if the woman had had more than six previous children. Women were interviewed when giving birth in hospital, in a clinic or at home.

PROCEDURE

The completed questionnaires were sent to the Ministry of Health (originally the Medical Department) in Honiara. There the clerks in the medical statistics office recorded the details of each current birth in a Birth Register, which was retained in the office. Details recorded were the date of the birth, the name (if known at birth) and sex of the child and the location of the birth. (Before 1968, the area related to the location of the mother's usual place of residence.) The clerks also inspected the questionnaire forms for obvious errors or omissions, *e.g.* sex of child not recorded, and, if necessary, returned the forms to the nurses concerned for correction. Although the form was, in the main, pre-coded, the clerks had to code the occupation or business of the father of the child (though this was not subsequently used in analysis). The questionnaires were then parcelled up by month of birth and sent by sea-mail to the London University Computer Services for computer processing. The whole procedure from the birth of the child to receipt of the questionnaire in London took fifteen months, on average. In London, the forms were first verified and those with errors that could not be corrected, *e.g.* age of mother not recorded, were eliminated. The remaining questionnaires were then translated onto punch-cards and magnetic tape and processed to produce the tabulations determined by Professor Brass in 1966. Copies of the tabular output were sent each year both to him and also to the Director of Medical Services in Honiara. After processing, all questionnaires were eventually destroyed due to limitations of space.

PROBLEMS

a) *PRACTICAL*

Problems of management and administration, inevitably associated with the instigation of a new scheme, were hopefully overcome or at least reduced to a minimum during the first few months of the scheme. Analysis only began on the records collected from January 1967 *et seq.*, thereby avoiding the initial, uncertain months of data collection.

Initially, the survey covered only current live-births but was extended to include stillbirths in 1968 - hence the re-printing of the questionnaire form. This change of policy occurred between March and June 1968 and its effect on biasing the 1967 data is considered small.

The nurses attending the births were requested to send the completed questionnaires to the Ministry of Health. There was no financial or other incentive given to the nurses to encourage them to record *all* births, and the questionnaire therefore merely represented extra work for them. It is likely therefore that, even when a nurse did attend a birth, occasionally the details were either not recorded or not sent to Honiara. If they were sent, some forms were possibly lost en route. The number of these losses is indeterminate. Checking of the forms at receipt by relatively untrained staff in the medical statistics office was an arbitrary procedure, judging from the number of forms still containing errors and omissions which were received in London. It is uncertain whether those with errors detected by the clerks and which were returned to the nurses for correction were ever returned to Honiara for inclusion in the analysis, and it must be presumed that some of these forms were never seen again. It can only be hoped, since it cannot be estimated, that there was no bias created by this particular group of forms.

However, the posting of unique data halfway round the world for processing in London was a much more hazardous procedure. The number of births recorded in the Birth Registers in Honiara were counted* and compared with the number of questionnaires finally analysed in London (see Table 2). It can be seen that, in the main, approximately 5% of the forms received in London each year were rejected before processing. The reasons for rejection are listed in Appendix 2. The numbers rejected in 1975, for example, (when the processing was the most closely monitored of all the years') was known to be 365 - the discrepancy of 2 can presumably be attributed to an error in the manual counting of the notified births. This would indicate that the 5% loss of forms in most of the years is due solely to the verification and rejection procedures. However, for the years 1971, 1973 and 1974, the proportion of notified births analysed is much lower, particularly in 1974 where the discrepancy is disturbingly large. No explanation can be confirmed for the years 1971 and 1973 and it can only be supposed that whole parcels of forms either arrived too late to be included in the analysis or simply went astray. This supposition is strengthened by an analyis of births by month (unfortunately only possible for the years 1974 and 1975) which demonstrated that whole months of data for 1974 were missing in London (see Table 3). Intensive searching in LUCS and Honiara did not bring them to light and it can only be concluded that they were lost at sea (1). A 50% loss of forms in 1974 seriously undermines the validity of the analysis of the data for that year. However, from tabulations by area, it is known that forms for all areas of the Solomon Islands for the months of May, July, September, October and December went astray, rather than forms for a few specific areas. It is therefore hoped that the sample, albeit much reduced, is still representative of all births occurring in the Solomon Islands in 1974.

The findings of the 1967 survey were, in part, studied by Professor Brass (1969, *ibid*). However, apart from an analysis of the birth weight data (see Chapter 6) by Macgregor and Avery (1974), the

---

*by Saba and David Potten, to whom grateful acknowledgement is made.

TABLE 2

PERCENTAGE OF NOTIFIED BIRTHS AVAILABLE FOR ANALYSIS

Year of Birth	Births Notified in Honiara	Questionnaires Analysed in London	Percentage of Notified Births Analysed %
1967	1841	1753	95.2
1968	2591	2504	96.6
1969	3387	3232	95.4
1970	3879	3720	95.9
1971	4634	4055	87.5
1972	5183	5025	97.0
1973	5299	4465	84.3
1974	6406	3243	50.6
1975	6370	6007	94.3

TABLE 3

NUMBER OF BIRTHS PER MONTH IN 1974 AND 1975

		Notified*	Analysed**
1974	January	396	364
	February	410	369
	March	453	374
	April	551	315
	May	570	67
	June	553	505
	July	594	17
	August	619	587
	September	576	39
	October	557	41
	November	582	564
	December	545	1
1975	January	519	497
	February	452	442
	March	532	513
	April	545	516
	May	547	507
	June	515	481
	July	575	534
	August	563	528
	September	572	543
	October	549	506
	November	510	480
	December	491	459

*Notified in Honiara **Analysed in London tabulations produced thereafter have not been studied - for errors and omissions as well as for content - prior to this study. The data for the years 1967-1972 were already processed by the time the author became involved in this study in August 1976. The processing of the 1973 data was completed in December 1976 and that of the 1974 and 1975 data in September 1977. With only some monitoring of the processing of the data for the years 1967 and 1968 and a total lack of such monitoring for the years 1969-1972, unchecked errors inevitably occurred. Examples of these are rows of zeros in tables, discrepancies between the totals of different tables, uncertainties over the definition and derivation of some variables, *etc.* No amount of 'intuitive juggling' can now correct these programming errors, all punch-cards and magnetic tapes for the years 1967-1972 having been destroyed by LUCS. Since only the tabular output was available, the possibility of producing any further tables deemed necessary by the direction of the analysis (*e.g.* number of births per month by area) was precluded. In addition, some information recorded on the forms which might have been of use was inextricably lost.

Perhaps the most serious problem related to the coding given to the different islands in the Solomon's group. The error arose due to an initial misunderstanding, but was perpetuated since no analysis of the results was done during the early years of the survey. As stated, one of the objectives of this survey was to monitor, if possible, the effects of the malaria eradication programme on fertility and mortality. Therefore, when the codings for the different islands were devised at the start of the survey, the malaria situation existing on each island *at that time* was taken into consideration, particularly when combining certain islands together under one code. The processing of the data was then done for each coded area separately. However, for 1968 and 1969, although the island code numbers remained the same, they were combined according to their *current* malaria situation and processed only as 'malarious' and 'non-malarious' areas and, separately, the island of Malaita. Grouped processing occurred again in 1970 and 1971, but this time the combination of islands which formed the 'malarious' and 'non-malarious' areas was different from that in previous years. They had been re-coded to take account of the *current* malaria situation. The islands' codes were again changed for 1972 *et seq.* to take account of further changes in the malaria situation, and different islands combined under one code. However, at least the new individual groupings were processed separately and not further amalgamated into 'malarious' and 'non-malarious' areas. The data from the island of Malaita have been the only ones to be uniquely processed over the whole period of the survey and hence can be analysed separately. Since anti-malarial spraying operations began on the island only during the course of the survey, Malaita could act as its own control on any change resulting from the eradication of malaria. The coding changes can be seen in Table 4 and in Figures 3-6. It can be seen, in summary, that over time the islands have been re-coded (*re:* numbers used), re-grouped (*re:* islands combined to form one code area) and re-classified (*re:* malarious or non-malarious state according to anti-malarial spraying the preceding year). Of course, the islands should have been given codes initially and these left *unaltered* during the progress of the survey. Apart from the errors introduced by frequent changes in the code number of an island, a mass of important data has been inextricably subsumed by this processing technique. Some solution had to be devised in order to salvage at least a modicum of information from these valuable data. The approach taken was to study the 1970 Census to try and find a compromise combination of the data, suffering minimal distortion over the time period, since,as the data stood, no island other than Malaita could be studied over the whole time period. From the population figures and from the dates given for the first anti-malarial spraying for each island, the islands were re-grouped for this macro study as in Table 5. The final groupings derived were really very acceptable and homogenous. Although obviously it was not ideal to have over time even slight changes in the combinations of islands, these changes were relatively unimportant since only a very small proportion of the total population was affected by each one. Hence, the data finally available for analysis were for the Solomon Islands as a whole, for malarious and non-malarious areas separately, and also for the individual island of Malaita.

TABLE 4

CLASSIFICATION OF EACH ISLAND OVER THE PERIOD OF THE SURVEY

ISLAND	POPULATION all components (1970 Census)	FIRST ANTI-MALARIAL SPRAYING	ISLAND CODES 1967	68-69	70-71	72-75
CENTRAL DISTRICT						
Honiara Township	11,200	pre-1965	1	1	1	1
Guadalcanal, Savo	25,300	pre-1965	1	1	3	2
Santa Isabel, Florida, Russells	16,700	1970	4	4	3	2
Rennell, Belona	1,500	1970	6	6	3	2
EASTERN DISTRICT						
Ulawa, Santa Cruz Makira	15,800	1970-2	3	3	4	3
Reefs, other R.O.I.	6,700	1971	6	6	2	3
MALAITA DISTRICT	50,700	1970	5	5	5	4
WESTERN DISTRICT						
New Georgia Shortlands	24,200	pre-1965	2	2	6	5
Choiseul	8,000	1968	4	4	6	5

Note: The islands whose codes are underlined were classified as 'non-malarious' in the various periods. For 1968-69 and 1970-71 the underlined islands were processed together only as 'non-malarious' areas - the remainder in those years being grouped as 'malarious areas.' Malaita was processed separately throughout (thereby appearing both separately and in the data for 'malarious areas' in the years 1968-71). Individual islands were processed for 1967 and 1972-75.

FIGURE 3 MAP SHOWING ISLAND GROUPINGS FOR CODING IN 1967

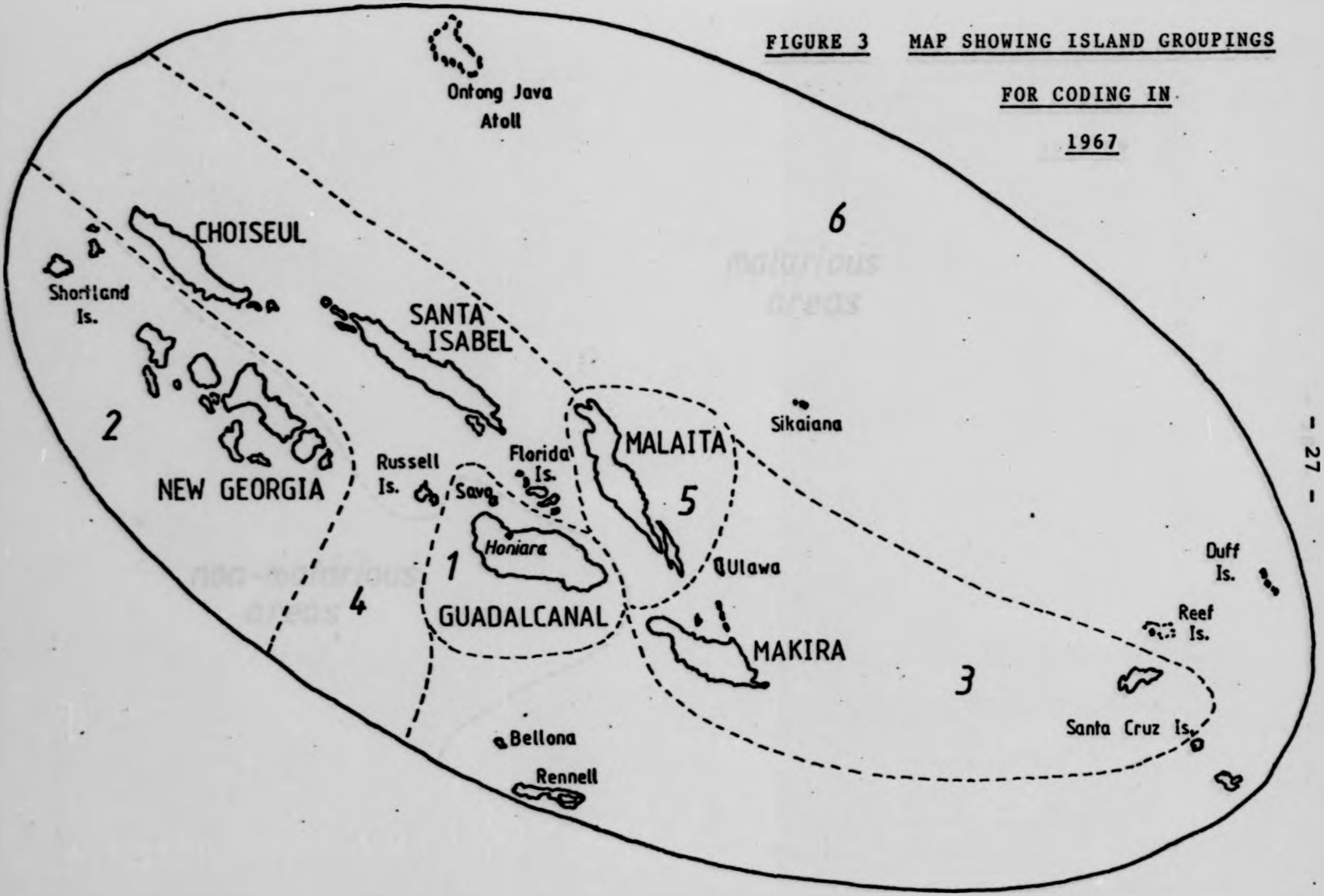


FIGURE 4 MAP SHOWING ISLAND GROUPINGS FOR CODING IN 1968-69

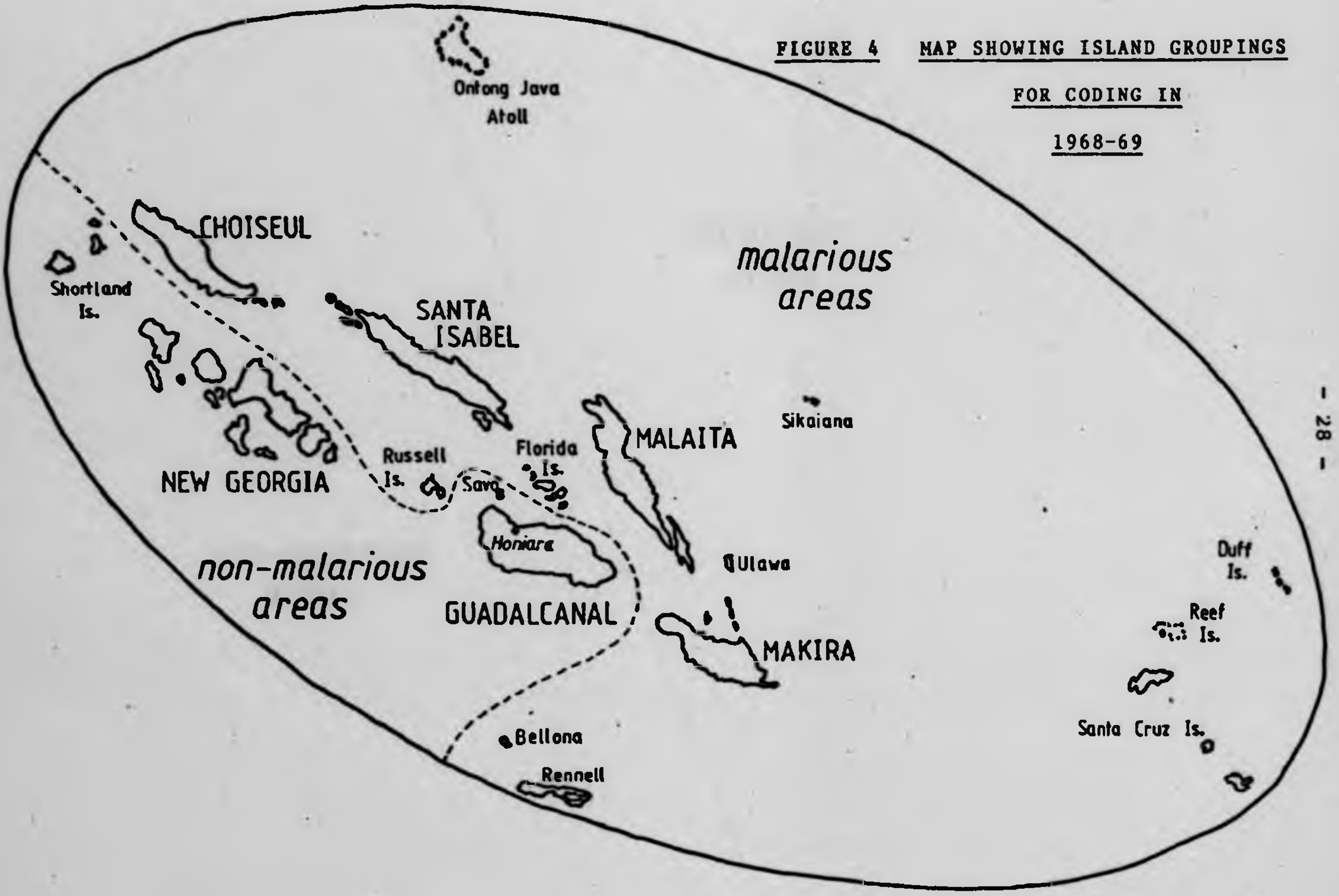


FIGURE 5 MAP SHOWING ISLAND GROUPINGS FOR CODING IN 1970-71

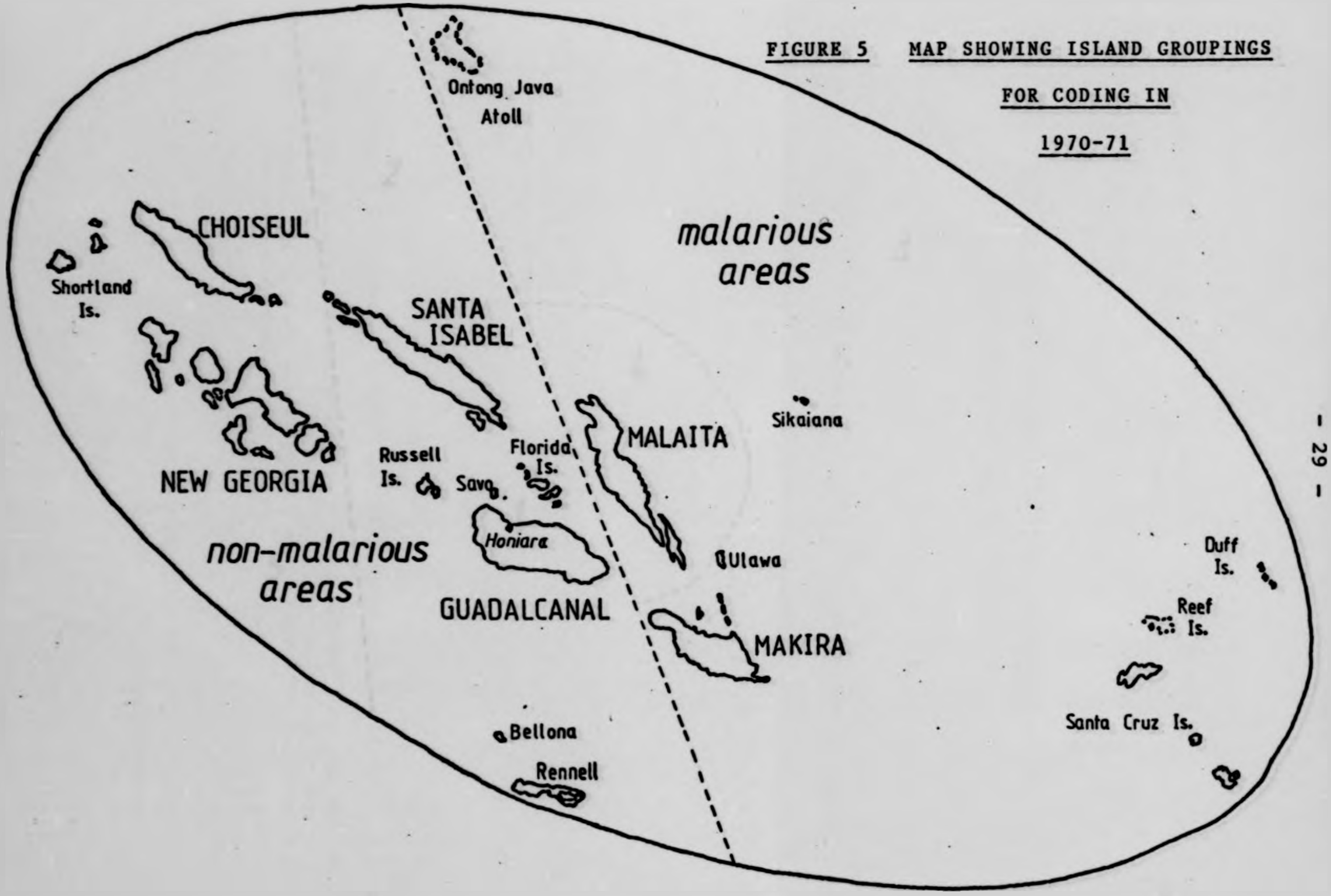


FIGURE 6 MAP SHOWING ISLAND GROUPINGS FOR CODING IN 1972-75

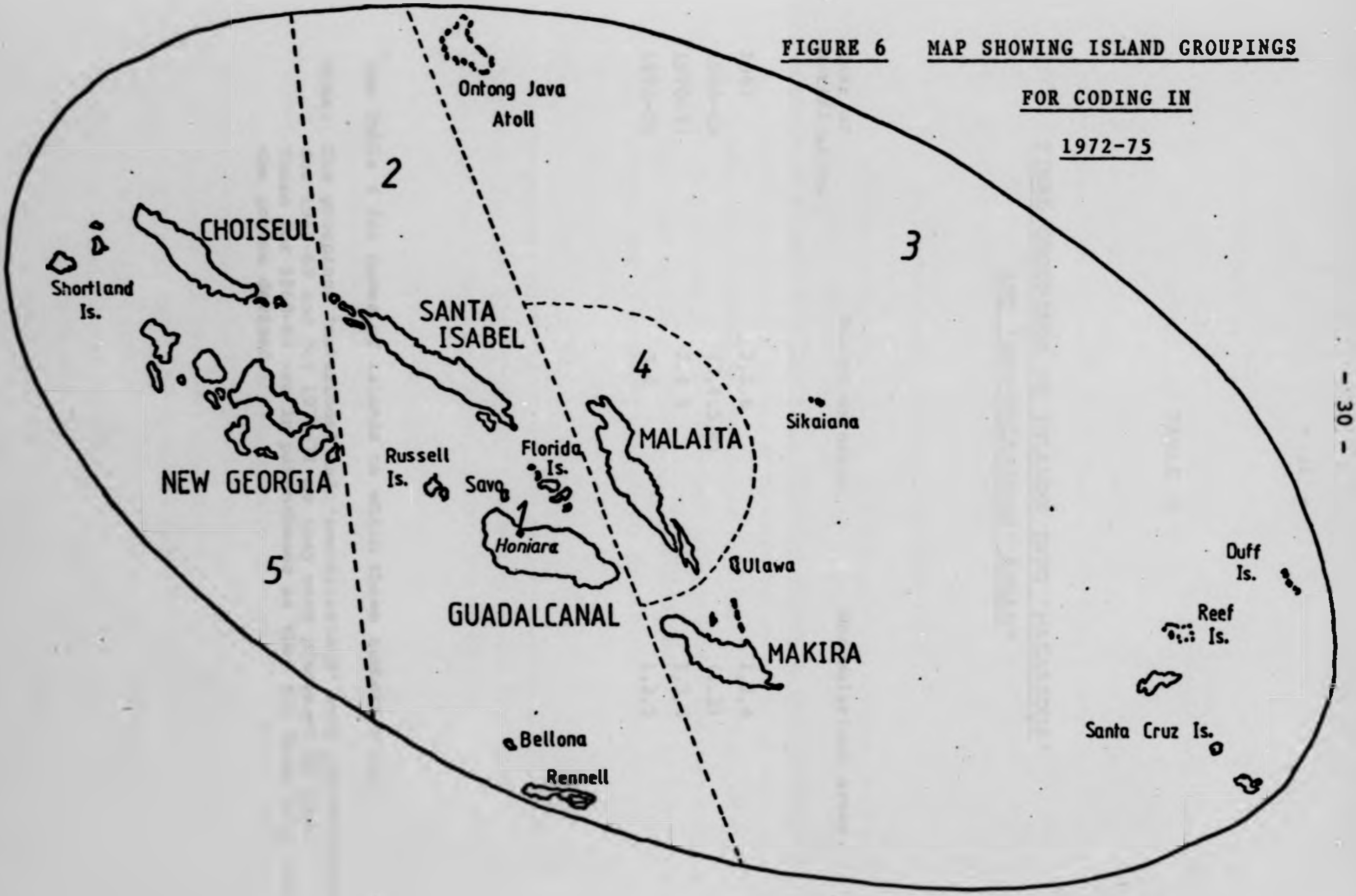


TABLE 5

FINAL GROUPINGS OF ISLANDS INTO 'MALARIOUS' AND 'NON-MALARIOUS' AREAS*

Year of Notification	Malarious areas	Non-Malarious Areas
1967	3,5,6	1,2,4
1968-69	(3,4,5,6)	(1,2)
1970-71	2,4,5	1,3,6
1972-75	3,4	1,2,5

---

*See Table 4 for names of islands to which these numbers refer.

Note: The groupings 'malarious' and 'non-malarious' were pre-determined for 1968-69 and for 1970-71 as they were processed as such. Those for 1968-69 are in parentheses as they fit least well into the scheme devised.

b) *METHODOLOGICAL*

(i) *Nature of Data*

Although this study covers a period of nine years, there are no longitudinal data as such. Each year's data form a discrete cross-sectional entity, and the separate years then form a series of discrete observations. Obviously, many of the women will be sampled repeatedly, but there is no means of measuring this.

(ii) *Percentage of All Births Notified*

As the survey progressed, the percentage of all births notified in a year increased from approximately 29% in 1967 to 81% in 1975 for the islands as a whole (see Table 6). These percentages were calculated (see Chapter 4) from the number of questionnaires received and analysed in London, and it should be remembered that (as shown above) some were thought to have been lost in the years 1971 and 1973 and some were definitely lost in 1974. These figures should therefore be interpreted with caution, and the overall increasing percentage notified per annum merely noted.

The problem arises as to whether this increasing proportion notified each year has meant that the nature of the sample has changed in any way which may bias the findings; for example:-

1. Rural-Urban Bias

The survey was initiated in and conducted from the Ministry of Health in Honiara. Although the scheme deliberately intended to 'start as it meant to continue' covering all areas of the Solomon Islands equally and with no bias towards hospitals and the urban areas, it seems intuitively inevitable, if only because of the distribution of health personnel and the inaccessibility of some areas, that the majority of births initially notified were those occurring in the hospitals and health centres. Because of the area coding errors referred to above, it was impossible to study the proportions of births notified over the whole time period of the survey in, for example, the urban area of Honiara or a small rural area such as the Outer Reef

TABLE 6

PERCENTAGE OF ALL BIRTHS NOTIFIED DURING EACH YEAR OF THE SURVEY

Year of Notification	All Solomon Islands %	Malaita %
1967	28.7	27.4
1968	37.5	41.4
1969	49.3	48.9
1970	56.0	50.8
1971	60.2	55.2
1972	75.1	65.5
1973	64.8	57.6
1974	44.9	47.2
1975	80.7	87.2

Islands to prove or disprove this theory. All that can be studied are summarised in Table 7. The findings should again be interpreted with caution since the coding of, for example, births as being in Honiara and not merely on Guadalcanal was variable (judging from observations of the entries in the 1968 Birth Register). It is apparent that the proportions registered in Honiara have increased and those in Guadalcanal and the closely surrounding islands have decreased. The difference is probably genuine and due to an increase in the total population of Honiara as a result of in-migration, but may possibly be an artefact due to poor coding. If the Honiara and Guadalcanal figures are combined, the resulting proportions are virtually constant over time. For Malaita, after the first two years, the proportion of all notified births which have come from the island has remained virtually constant, as for Guadalcanal. However, for the small islands of the Eastern District there is an indication that the births notified there, as a proportion of all births notified throughout the Solomon Islands, have increased between 1967-8 and 1972-5, but the figures involved are too small to permit firm conclusions to be drawn.

From these limited data, it is erroneous to conclude definitively anything about possible changes over time in the urban-rural ratio of births notified. However, the data do indicate a probable stability in the ratio, and hence there is unlikely to be a large bias caused by this particular form of differential notification; but whatever the bias, it cannot be quantified for these data.

2. Percentage of First Births Notified

It can be seen from Table 8 that the percentage of first births notified has remained virtually constant over the years. No pattern or trend to these figures could be detected, even after standardisation to equal numbers of women in each age group (see Chapter 4). Variations in these percentages reflect either real demographic changes or changes in the nature of the sample and coverage of the survey. There has obviously been no significant change in either of these factors over the period of the survey. However, these percentages (even allowing

TABLE 7

PERCENTAGE OF ALL BIRTHS NOTIFIED WHICH ARE FROM EACH REGION

Region	Year of Notification								
	1967	68	69	70	71	72	73	74	75
Honiara		15*				17	17	20	22
						}34	}32	}33	}3
Guadalcanal & rest of Central District						17	15	13	11
Malaita	36	36	31	29	29	29	29	31	31
Eastern District, R.O.I., *etc.*	5					13	15	11	13
Western District						25	24	25	23
TOTAL BIRTHS	1753	2504	3232	3720	4055	5025	4465	3243	6007

*Figure obtained from birth register: 390/2591 = 15.1%

TABLE 8

PERCENTAGE OF CURRENT BIRTHS NOTIFIED WHICH ARE FIRST BIRTHS

Year of Notification	All Solomon Islands	Non-Malarious Areas	Malarious Areas	Malaita
	%	%	%	%
1967	24	24	25	25
1968	22	23	22	21
1969	24	25	22	20
1970	23	23	22	22
1971	24	24	23	23
1972	21	21	22	23
1973	23	23	23	25
1974	25	25	25	26
1975	24	23	25	25
Census 1970	17	Data not available		

Note: See Tables A 1,A2,A3 & A4 for figures from which these proportions were derived.

for the different methods of data collection) are consistently higher than the percentages of births which were first births recorded as occurring in the twelve months preceding the 1970 Census, for the Solomon Islands as a whole.

3. Bias Towards Younger Women

Simple percentages of women notifying their current births by age group of women for both the Solomon Islands as a whole and Malaita separately, indicated that the percentages of younger women in this survey did not change appreciably over time (see Table 9). However, (although comparisons with census data need to be made with caution owing to the different methods of age recording used in the survey and census), when the births notified in the survey were compared with the 1970 Census data on births occurring in the preceding twelve months, it was found that they were to women distributed differently over the age range 15-49 years (see Table 9). In the survey, there was a higher percentage of younger women recorded as having a current birth than there was in the 1970 Census. This is probably because younger women are more educated and enlightened and therefore more likely to have their births attended by a recognised nurse than older women who may prefer to have their births at home attended only by a relative. Births to older women are therefore less likely to be notified. A higher percentage of younger women in the survey probably explains why there is also a higher percentage of first births recorded in the survey than in the 1970 Census.

4. Proportions Notified in Malarious and Non-Malarious Areas

If the ratio of the births notified in malarious and non-malarious areas varies with time, the findings for the whole of the Solomon Islands combined may be artificially affected by this and erroneous conclusions drawn. However, it can be seen from Table 10 that, with the exception of 1968 and 1969, the ratio of births recorded in malarious:non-malarious areas is approximately similar over time, averaging 0.72. These areas were created as a result of the problems over coding (see above). The groupings were least acceptable for the

TABLE 9

PERCENTAGE OF WOMEN IN EACH OF THE 3 YOUNGEST AGE GROUPS HAVING A CURRENT BIRTH*

		%WOMEN				TOTAL NO.
ALL SOLOMON ISLANDS	Year	15-19	20-24	25-29	15-29	15-49
Birth Notification Data	1967	8	29	32	69	1753
	1968	10	26	33	69	2504
	1969	10	28	31	69	3232
	1970	9	29	28	66	3720
	1971	10	30	30	70	4055
	1972	9	28	30	67	5025
	1973	10	29	29	68	4465
	1974	11	30	29	70	3243
	1975	10	30	28	68	6007
Census 1970		6	22	28	56	5713
MALAITA						
Birth Notification Data	1967	6	30	32	68	625
	1968	8	27	33	68	899
	1969	7	26	32	65	998
	1970	6	28	29	63	1083
	1971	7	27	34	68	1186
	1972	7	26	33	66	1472
	1973	9	27	32	68	1276
	1974	10	25	33	68	1003
	1975	8	26	33	67	1853
Census 1970		5	19	29	53	1639

*See Tables A.1 and A.4 for figures from which these percentages were derived.

TABLE 10

NUMBER OF BIRTHS ANALYSED FROM MALARIOUS AND NON-MALARIOUS AREAS

Year of Notification	Malarious Areas	Non-Malarious Areas	Ratio Malarious: Non-Malarious
1967	719	1034	.70
1968	1356	1148	1.18
1969	1713	1519	1.13
1970	1418	2302	.62
1971	1635	2420	.68
1972	2100	2925	.72
1973	1938	2527	.77
1974	1367	1876	.73
1975	2641	3366	.78
TOTAL BIRTHS 1967-75 (Excluding 1968 & 1969)	11818	16454	.72

years 1968-69 and therefore nothing more significant should be read into the discrepancy. Despite the fact that the 1969 groupings fitted least well into the general scheme employed for the entire survey analysis, and despite there inevitably being errors in the numbers of births reported at the 1970 Census as occurring in the preceding year, it was still considered worthwhile comparing 1969 survey data with 1970 Census data (see Table 11). The comparison indicates a lower percentage of births notified in the malarious areas than occurred in the general population. It was likely therefore that mortality rates determined from the survey data compared with findings from census data would, at any one point in time, have a slight downward bias (assuming that mortality in non-malarious areas was found to be lower than in malarious areas), though the extent of this bias varied little over time.

In summary, the problems caused by differential coverage of the survey, assessed by these criteria, seem to have been minimal and no over-riding bias was found.

(iii) *Sampling Biases*

There are certain unavoidable methodological problems inherent in all cross-sectional surveys where the subjects are chosen when a demographical event (marriage, first birth, *etc.*) has occurred (Pool, 1978). These problems refer to the effects of the intervention of data collection, which then excludes those women who have not yet achieved the event under observation. For example, if the women are studied by age group, the younger women have obviously not yet been as exposed to the risk of the event occurring as older women. Thus the younger women who are in the sample are a selected group biased against the 'late starters'. In the present study, such effects are clearly in operation. In addition, the older women still in the sample are the hyper-fertile ones, since those with early sterility will be excluded from the sample. This bias is substantial, but the proportion of current births in this group is small. Even within a cohort, there is a bias towards the more fecund women who, having experienced certain events at a younger age, move on to the next event more quickly than the

TABLE 11

NUMBER OF BIRTHS IN MALARIOUS AND NON-MALARIOUS AREAS; A COMPARISON OF 1969 SURVEY DATA WITH 1970 CENSUS DATA

YEAR	NUMBER OF BIRTHS			
	Malarious Areas	Non-Malarious Areas	Total	Percentage Malarious
1969 Survey	1713	1519	3232	53%
1970 Census	3372	2341	5713	59%
Percentage notified	51%	65%	57%	

less fecund women in the same cohort. Although in this sample the intervention is actually the event of a birth, these particular problems still apply and have to be remembered when comparisons are made between age groups.

This particular sample presents even more acute problems because of the nature of its selection by the occurrence of a birth. The women are all sampled at the end of a birth interval (or the interval between marriage and first birth) and are not randomly distributed within it, as in a random sample. In addition, they are all women of proven fertility and therefore, in this respect also, are not comparable with a random sample of all women. These 'analysis problems' necessitate the development of the specialised analytical techniques described in ensuing chapters.

CHAPTER 4 THE USE OF BIRTH NOTIFICATION DATA TO DERIVE FERTILITY INDICES

INTRODUCTION

There is no suggestion from census or other data that the age at marriage or the proportions married have changed in recent years, nor is there any indication of the beginning of family limitation practices. In one respect, therefore, it is possible that the detail of nine years' of birth notification data is rather unnecessary in the study of fertility. On the other hand, there is great methodological value in having a consistent series of data over a period of time. There has previously been little empirical study; methods have been established theoretically and applied mostly to vital registration data. Application to these birth notification data is therefore of great value and interest.

MEAN COMPLETED FAMILY SIZE

Brass (1969, *ibid*) devised this method and applied it to the 1967 data from this survey. The opportunity is taken here to apply it to all subsequent years of survey data, to study the value of the data and the method as well as of the results. The following description of the method is based on that given in his paper.

The principle is as follows: if the data have been standardised to a population with equal numbers of women in each five year age group of the reproductive period, the ratio of all:first births in the year is equal to the total fertility rate (TFR) divided by the proportion of women who become mothers at the current rates (F_1). If the rates remain constant, this ratio also corresponds to the mean completed family size of mothers (F_m), *i.e.* -

$$\frac{\text{Standardised All Births}}{\text{Standardised First Births}} = \frac{\text{TFR}}{F_1} = F_m$$

The proportion of women who bear at least one child in the reproductive period (F_1) can usually be estimated relatively accurately (probably from census data) and its use as a multiplier of the ratio of all:first births gives the total fertility rate.

However, the disadvantage of the method is that it is heavily dependent on the number of first births recorded and these are particularly vulnerable to differential reporting (see Chapter 3). The information on the full birth order obtained in the birth notification scheme can be utilised to counter this problem. If a suitable curve can be fitted to the numbers by birth order, more reasonable values for the proportion of first births can be estimated from it. Although this can be done theoretically, Brass has devised a simpler approach, more in keeping with the nature and quality of the data, whereby the proportions of current births of each birth order are compared with the proportions of the corresponding birth orders of a reference birth distribution.

To do this, several stages of preliminary calculations are required:-

1) The mid-year populations of all women by five year age groups between 15 and 50 years in the Solomon Islands for each year of the survey data (see Table 3(i)) are calculated using the 1959 and 1970 Censuses. The details of the method can be found in Appendix 3.

2) The factors necessary to raise the numbers of women in older age groups to the numbers in the age group 15-19 are calculated from these and the appropriate factors then applied to the number of births by order for each age group of mother for each year of data (see Table A.1) to obtain the number of current births standardised by age of women (*i.e.* where the numbers of women in each five year age group are the same as for the 15-19 years group). The birth performance in a single year by a cross-section of women can now be interpreted as that of an 'artificial' cohort over the reproductive period.

3) The births by order are then summed across all ages of the reproductive period to obtain figures for the number of women who will have had 1, 2, 3, *etc.*, children by the end of childbearing. It

should be noted that the counting in cohort terms is of the reaching of a birth order and does not imply that no further births occur to the woman.

4) If these total figures are expressed as proportions of the total adjusted births born to this 'artificial' cohort based on women aged 15-19, the resulting values represent the proportions of women who have had births of the given order and above (see Table 3(ii)(b)). These are the adjusted observed proportions of births which need to be compared with a reference distribution of births by order.

5) The construction of such a reference distribution is done from the reports of women aged 40-49 (*i.e.* at the end of their childbearing period) at the 1959 and 1970 Censuses of the total number of children born alive to them. Cumulation gives the numbers of women with one or more, two or more, *etc.*, children (*i.e.* the number of children of first birth order, second birth order, *etc.*). Division by the total number of children gives the proportion of all births which are first order, second order, *etc.* In a manner analagous to the derivation of the proportions of women in each age group in each year (see Appendix 3), the proportions of births of each birth order to women aged 40-49 years are calculated for each year of the survey and these form the terms of the empirical reference distribution (see Table 3(ii)(a)).

The standardised birth order distributions are plotted against the corresponding empirical reference distributions for each year of survey data (see Figures 7 and 8 for sample graphs from two years' data). Regression lines were calculated and drawn on each graph. These were based only on parities 4-10 inclusive, as parities 1-3 were under study potentially and parities 11-13 were based on very small numbers and so both groups were omitted.

It can be seen that the point for first order births (and to a lesser extent the points for 2nd and 3rd order births too) shows a large discrepancy from the consistent trend shown by births of higher orders. There is no basic reason why this trend should be a straight line. A slight curvature would, however, make little difference to the estimating of values for 1st, 2nd and 3rd order births which are the

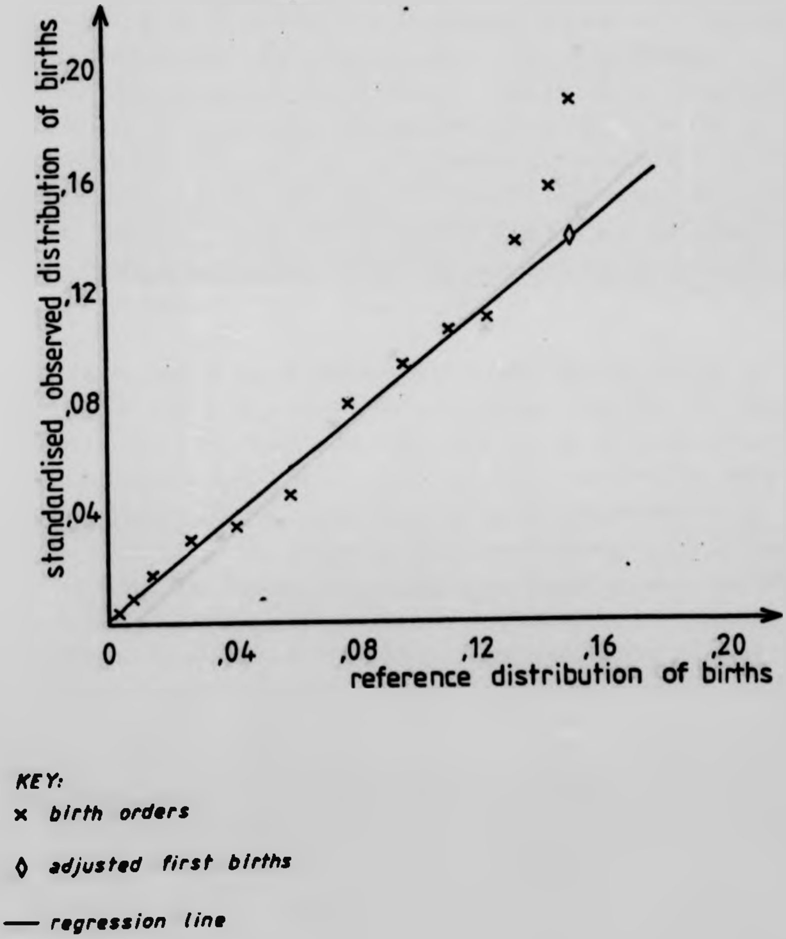
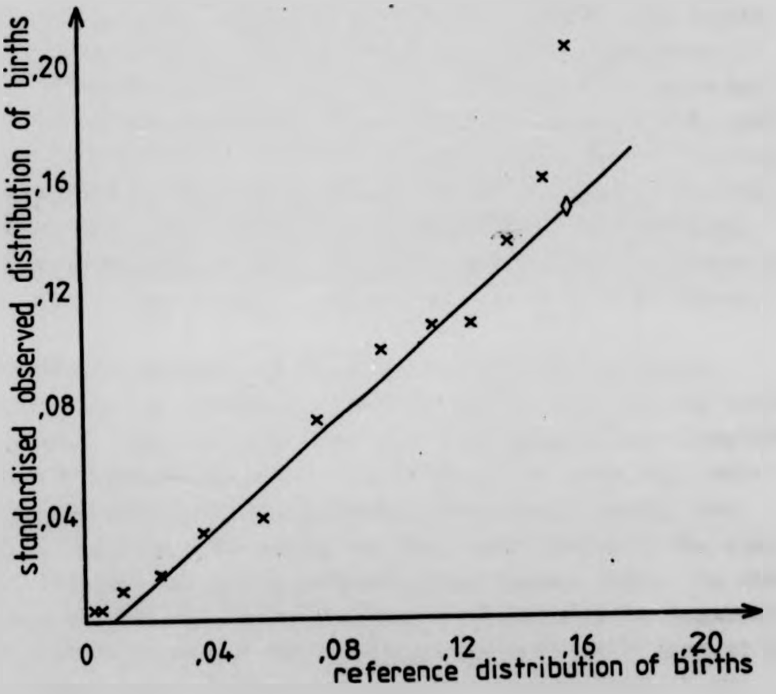


FIGURE 7 COMPARISON OF BIRTH ORDER DISTRIBUTION WITH REFERENCE DISTRIBUTION IN 1968

FIGURE 8 COMPARISON OF BIRTH ORDER DISTRIBUTION WITH REFERENCE DISTRIBUTION IN 1975



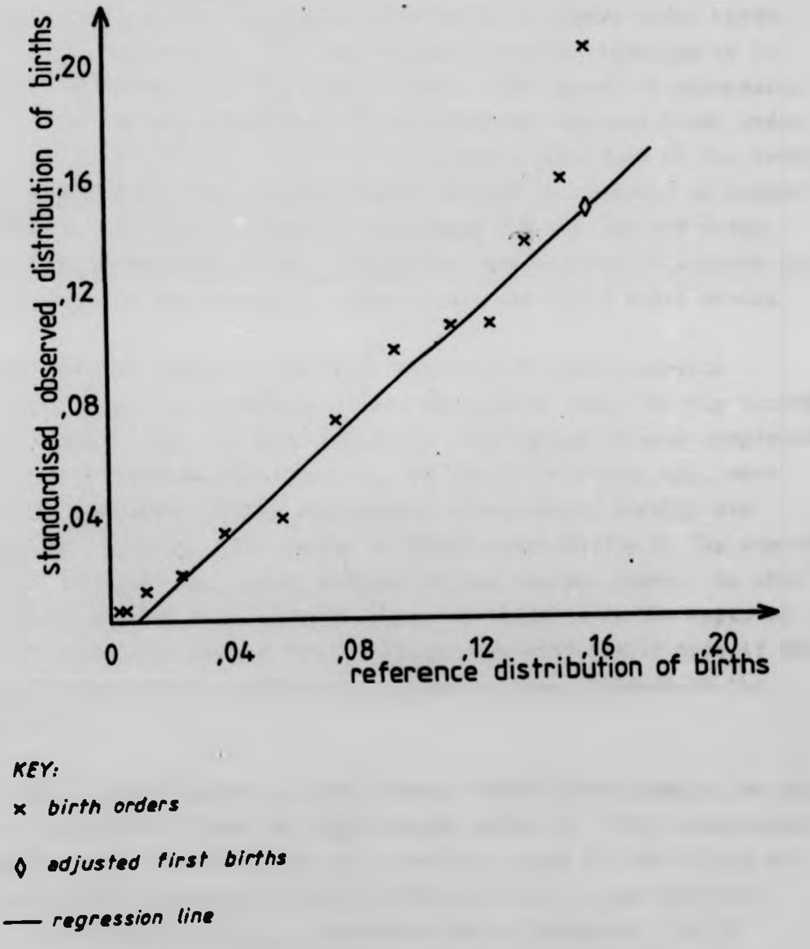
KEY:

× *birth orders*

◊ *adjusted first births*

— *regression line*

FIGURE 8 COMPARISON OF BIRTH ORDER DISTRIBUTION WITH REFERENCE DISTRIBUTION IN 1975



only ones which appear not to follow the trend of higher order births. The most likely explanation for this discrepancy is that it is due to the relatively more complete reporting of 1st (and possibly 2nd and 3rd) order births compared with that of higher order births. However, the value for first order births can be made more consistent by adjusting the point to lie on the regression line based on higher order births. In effect, it then suffers the same degree of under-reporting as is presumably suffered by higher order births. The amount of adjustment necessary and the new proportion of standardised observed first order births were both recorded. In view of possible curvature of the trend line, sample errors, and possible small changes in coverage at higher birth orders, the small correction necessary for 2nd and 3rd order births seems of doubtful value. Since the main aim was to achieve true comparability, it was decided to adjust only the first order births.

The ultimate objective of these calculations and graphical adjustments - *i.e.* to determine a more acceptable level for the numbers of first births - has now been achieved. The values of mean completed family size determined from the ratio of all:first births (or, more accurately, the ratio of the proportions of all:first births) are tabulated in Table 12. The number of first order births is the same as the number of women who become mothers at the current rates. So this ratio merely divides the expected number of children by the expected number of mothers to obtain their average completed family size if they continue through their reproductive period to have children at the current rates.

Another point of note is that seventh order births always lie well above the regression line and eighth order below it. It is postulated that this is merely an artefact of reporting caused by the design of the questionnaire form which only had space on it for six previous births. For higher parities, a second form was required. It is thought that sometimes a second form was not employed for use when there were seven previous children (*i.e.* only one to be recorded on the second form) but the information omitted and only one form completed.

TABLE 12

CALCULATION OF MEAN COMPLETED FAMILY SIZE FROM GRAPHS

PROPORTIONS	YEAR OF NOTIFICATION								
	1967	1968	1969	1970	1971	1972	1973	1974	1975
Observed proportion of 1st births	.210	.187	.201	.192	.203	.180	.194	.214	.207
Corrected proportion of 1st births	.144	.138	.143	.143	.147	.155	.154	.149	.149
Amount of adjustment	.066	.049	.058	.049	.056	.025	.040	.065	.058
B/B_1	$\frac{1-.066}{.144}$	$\frac{1-.049}{.138}$	$\frac{1-.058}{.143}$	$\frac{1-.049}{.143}$	$\frac{1-.056}{.147}$	$\frac{1-.025}{.155}$	$\frac{1-.040}{.154}$	$\frac{1-.065}{.149}$	$\frac{1-.058}{.149}$
F_m	6.486	6.891	6.587	6.650	6.422	6.290	6.234	6.275	6.322

NOTE: Since proportions always sum to 1, the proportion of total births must be reduced by the amount of the adjustment made to first births.

Hence, there was a disproportionately large number of women with six previous children (*i.e.* having their seventh child) and a corresponding deficit in the number having their eighth child.

The values of mean completed family size derived from each year's data (see Table 12) are quite reasonable and show little trend with time but merely fluctuate. The fluctuations are probably mainly due to inadequacies of the data, although real variations are not ruled out. It is possible that the data collection has improved in the last four years of the survey (and, of course, a higher proportion of births was recorded) since there are very similar values for mean completed family size in these years. It is not thought that any decline in fertility can be deduced from these results, partly because of the relatively short time period involved and partly because of the problems of interpretation of results from such data. This is a method to derive the mean completed family size of mothers (F_m) which is independent of the extent of coverage of the survey, but which assumes that F_m is the same for all birth orders. In the calculations of F_m the absolute numbers of women in each age group is not needed, but only relative numbers, since any factor will cancel out in the ratio of all:first births. In view of the stringency of the assumptions, the limitations of the data and the crudeness of the calculations, the estimates are encouragingly consistent.

It is not an essential part of the technique to base the standardisation by age and construction of a reference distribution on census data. It will usually be possible to estimate age standardisation factors sufficiently accurately from an approximate model and the reference scale can be derived from any reasonably comparable distribution of women of completed fertility by numbers of live-births. The aim is simply to obtain a graphical relationship which tends towards the linear in order that anomalies can be seen clearly and adjusted by simple means. (In some circumstances, transformation (*e.g.* by the logit) may be useful for examining higher birth orders whose proportions are small.) The search is only for notable first birth discrepancies which appear quite clearly for high fertility countries, since the proportion of women who go on from a first to a second birth is so high.

TOTAL FERTILITY RATES AND PROPORTIONS OF BIRTHS NOTIFIED

The values for mean completed family size refer to mothers, but they can be converted into indices for all women if the proportions of women who become mothers by the end of the reproductive period (F_1) is known. This proportion can be calculated from data in the 1959 and 1970 censuses, and since it does not vary very much within a population, an average of the two census proportions at ages 40-49 years was taken, and it was assumed that 0.9056 of all women in the Solomon Islands became mothers. If this proportion is multiplied by the values obtained for mean completed family size, an estimate of the total fertility rate is obtained from each year's data (see Table 13(b)).

However, total fertility is normally calculated from the sum of the age-specific fertility rates. The latter can be calculated from survey data by dividing the number of current births to women in each age group (see Table A.1) by the total number of women in that age group in the population (see Table 3(i)). Five times the sum of these gives the observed total fertility rate for each year of survey data (see Table 13(a)). It can be seen from this table that these total fertility rates are lower than can reasonably be expected, confirming previous indications (see Chapter 3) of considerable under-notification of current births.

The extent of this under-notification can be measured by comparing the total fertility rates derived from the age-specific fertility rates based on survey births with those derived from the product of mean completed family size values and the census proportions of women who become mothers. The ratios of these two results give, for each year of data, the proportions of births notified (or, more correctly, the

TABLE 13

TOTAL FERTILITY RATES AND PROPORTIONS OF BIRTHS NOTIFIED

Year	(a) Observed TFR†	(b) Estimated TFR* from F_1m	(c) Proportion of Births Notified (a)/(b)
1967	1.688	5.874	.287
1968	2.339	6.240	.375
1969	2.941	5.965	.493
1970	3.375	6.022	.560
1971	3.500	5.816	.602
1972	4.275	5.696	.751
1973	3.659	5.646	.648
1974	2.552	5.683	.449
1975	4.622	5.725	.807

† - TFR calculated from sum of age-specific fertility rates

* - TFR calculated from $F_1 . F_m$, where:-

F_1 - proportion of women who become mothers by the end of the reproductive period = 0.9056

F_m - mean completed family size (see Table 12).

proportions of births notified and analysed in London) (see Table 13(c)). These are the proportions discussed in Chapter 3.

MEAN PARITIES

Brass (1969, *ibid*) discussed the value of mean parity indices when studying the 1967 birth notification data. El-Badry (1967, *ibid*) had previously recognised this value and studied such indices from data recorded at the registration of births in Bombay. However, the 'standardised mean parity measure' that he derived, being an unconventional index, was suitable only for internal comparisons of sub-groups of a population (see Chapter 6) or for a study of one population over time (see Appendix 4).

Mean parities are conventional indices of fertility and therefore it seemed reasonable to consider that the birth order of the notified current births would be a possible index of fertility. The mean number of previous children to mothers giving birth in a particular period does not depend directly on completeness of notification. However, the non-random nature of the sample and the biases this creates (see Chapter 3) has to be remembered when comparing mean parities of women in this survey with mean parities of women recorded in the census. Surprisingly, these biases, at least for a high fertility country such as the Solomon Islands, seem to have comparatively little effect and the mean number of previous live-births (at the time of the current birth, but excluding it -see Table A.5(a)), seem to be similar, at least at younger ages, to the corresponding values for women in the population. At older ages, the bias due to the survey being only of proven fertile women (and therefore excluding the infertile women who are included in the figures for the general population) is substantial, but the proportion of current births in the group is small.

As discussed previously, women sampled at the time of a current birth are a non-random sample of fertile women. However, the sample becomes very close to a random one when an event in the past is being studied, because of the variations in timing of births in the past.

Therefore, the mean parities of these women, say, five and ten years previously (see Table A.5(b) and (c)) may not differ very much from the values of mean births per fertile woman (although there may still be some time scale bias). To convert these mean parities into estimates of mean parities of all women, they merely need to be multiplied by the proportion of women who eventually become mothers. The indications are that the resulting mean parities are roughly equivalent to those of all women in the population.

INFERTILITY

The mean parity of women aged 45-49 in the survey is much higher than is observed in the whole population as the sample is only of known fertile women who are still exposed to risk. It would seem reasonable to use these data to obtain a measure of the age at which women become infertile. The method employed is an adaptation of one by Henry (1965).

Age-specific fertility rates had previously been calculated and summed to give a measure of the total fertility rate based on survey data (see Table 13(a)). The total fertility rate had also been calculated by a method independent of the number of women reporting a birth - *i.e.* as the product of the value of the mean completed family size and the proportion of women in the population who became mothers (see Table 13(b)). This latter value for the total fertility rate can be regarded as the 'true' value.

Alternatively, the age-specific fertility rates of observed survey births can be raised to the value they should have been if there had been complete notification of births. This is done merely by multiplying the individual age-specific fertility rates by the ratio:-

$$\frac{TFR_{(F_1 . F_m)}}{TFR_{OBS}}$$

where:- $TFR_{(F_1.F_m)}$ - TFR determined from mean completed family size calculations

TFR_{obs} - observed TFR based on age-specific fertility rates of notified current births

The age-specific fertility rates so adjusted are then cumulated to give cumulated fertility to exact ages 20, 25, 30, *etc.* (see Table A.6(a)).

Observed mean parities (see Table A.5(a)) refer to the mid-point of each five year age group of women (17.5, 22.5 years, *etc.*). Before comparison with cumulated fertility is possible, it is necessary to derive values for mean parities cumulated to ages 20, 25 years, *etc.* In addition, some allowance has to be made for the non-randomness of the survey in relation to the births before the adjusted mean parities can be calculated. Since the women are all at the end of a birth interval and not on average all at a point half-way through it, their previous births are half a birth interval further in the past, on average, than those of a random sample, so that the mid-points of the age groups are now in effect 16.25, 21.25 years, *etc.* (with a birth interval of 2.5 years - see Chapter 5). If graphs are plotted with observed mean parities for each age group located at ages 16.25, 21.25, *etc.* mean parities 3.75 years later (*i.e.* at ages 20, 25 years *etc.*) can be read from the curve. The results (see Table A.6(b)) can then be compared directly with values of cumulated fertility.

In a population experiencing little change in its level of fertility, there is likewise little change in its level of infertility. Hence, the figures for both cumulated fertility (F) and mean parity (P) can be averaged for each age group over all years of the survey (see Table A.6). Further graphical smoothing of the resulting average values is found to be unnecessary.

To determine the change in fertility between successive age groups, the differences between the values of cumulated fertility for each age group (D_F) are calculated, as are the differences between successive values of mean parities (D_P) (see Table 14). The former

TABLE 14

ESTIMATION OF PERCENTAGE OF MARRIED WOMEN WHO ARE INFERTILE

Age of women cumulated to:-	Differences in F between age groups	Differences in P between age groups	$R = D_F/D_P$	Proportions of women currently married*	Proportions of married women who are fertile	Percentage of married women infertile
	D_F	D_P		M	R/M	%
20	-	-	-	.1527	-	
25	1.5085	-	-	.5721	-	
30	1.5664	1.686	.9291	.7839	1.1852	
35	1.2123	1.652	.7338	.8458	.8676	13
40	.8183	1.509	.5423	.8646	.6272	37
45	.2665	.814	.3274	.8362	.3915	61
50	.0544	1.038	.0524	.7967	.0615	94

---

[*] 1970 Census data.

is an estimate of the fertility rate of all women and the latter of that for women still bearing children. The ratios of these differences (D_F/D_P) are then calculated. These ratios give estimates of the proportions of women who are fertile in the whole population in age groups (27.5-32.5), (32.5-37.5), *etc.* If they are further divided by the proportion of women in each age group in the population who are married, then the result is an estimate of the 'exposed to risk' women who are fertile and hence the percentage infertile in each age group is easily deduced (see Table 14).

This method is really studying a cohort of known fertile 'exposed to risk' women as they pass through the reproductive period. However, women are still entering the cohort in the two youngest age groups when they first marry (mate), and the cohort is effectively not 'closed' to distorting influences until later ages. The newly-married women entering the cohort will have a lower fertility than women who were in the cohort at the beginning of the five year age group as they will not have had the chance to have had as many children in the period. The effect of these late entrants is therefore to lower the previous parity to a level below that which it would have been if the cohort were closed from the beginning of the reproductive period (see Table A.6(b) - mean parities cumulated to ages 20 and 25). The proportions married in these age groups are very low. The method is therefore only applicable to age groups where the proportions of women married in the population is reasonably stable at its maximum level, that is for the age groups 30-34 *et seq.* The age group 25-29 can be regarded as a 'transitional' group, where the proportion of women married is high but has not yet reached the maximum level. The effect of new entrants into the group of known fecund women on their level of mean parity is therefore small but still distorts the figure for proportions of married women in this age group who are fertile (see Table 14).

There are certain assumptions which also have to be remembered when interpreting the results, although they refer to biases which are inherent in the method. Infertility has been ascribed to the women and related to their ages, but it is really 'couple infertility' that is being assessed. It has also been assumed that the level of fecundability is the same for all women (variations in this could bias the results though probably not greatly at this level of approximation) and that the probability of becoming infertile is the same for all parities.

However, the derived percentages of infertile women in each age group are reasonable, despite these limitations, and are also comparable with those calculated by Henry (1965, *ibid*), when allowance has been made for the displacement of age groups by half a group - *i.e.* 2.5 years. So, by capitalising on the nature of the data (since the women in the survey are the 'known fecund women' of Henry's method) reasonable figures of infertility have been successfully derived. There is a great lack of knowledge of infertility even at the crude level, and what methods there are available for its estimation all have limitations. Such indices derived from these birth notification data therefore have additional value in that errors can be expected largely to cancel out in the internal comparisons. However, at the same time, the nature and quality of the data impose limitations on the number of methods by which the data may be studied. Extensive and elaborate methods of study such as computer simulation models, were not applied to the data for these reasons.

MEAN AGE AT FIRST BIRTH

This was calculated for all women in the survey, married or not, from the data on current first births (see Table A.1). The results are tabulated in Table 15. It is seen that the mean age at first birth has remained reasonably constant over the period of the survey. This indication of stability in terms of fertility is encouraging, since changes in mean age at first birth could have affected the studies on mean parities. With no detectable trend to these values, the mean age at first birth averaged over the period of the survey was calculated and the resulting value of 21.8 years compared favourably with the value of 22.5 years calculated from the 1970 Census. It has to be remembered that the census values are cohort ones while the survey values are time period ones and these latter would be expected to be lower.

TABLE 15

MEAN AGE AT FIRST BIRTH

Year of Notification	Age of Women
1967	22.7
1968	21.4
1969	21.9
1970	22.1
1971	22.0
1972	21.9
1973	21.6
1974	21.5
1975	21.8
Mean 1967-75	21.8
1970 Census	22.5

SEX RATIO AT BIRTH

The ratios are tabulated in Table 16 and can be seen to be untenably high, the 'normal' sex ratio being taken as 105 males per 100 female births. Such a high proportion of male births is usually only seen in a population practising female infanticide, but this is not the current situation in the Solomon Islands, even if some infanticide were practised in the past. The male bias could have been caused by discrepancies in data collection. If births were sometimes notified only when mothers presented their young babies for medical care, this bias could have arisen if mothers took male children for treatment more readily than they took female children. Additionally, the bias may have been caused by careless completion of the questionnaire as, under the question concerning the sex of the current birth, the first box was for 'male' child. However, poor data collection may not account for all of this excess of male births, although no other explanation can be found.

TABLE 16

SEX RATIO OF CURRENT BIRTHS

Year of Notification	Male Births	Female Births	Sex Ratio: males/100 females
1967		Data not available	
1968	1294	1210	107
1969	1670	1477	113
1970	1964	1728	114
1971	2106	1823	116
1972	2597	2428	107
1973	2380	2085	114
1974	1718	1525	113
1975	3131	2876	109
1967-75	16860	15152	111

CHAPTER 5 THE USE OF BIRTH NOTIFICATION DATA TO DERIVE CHILDHOOD MORTALITY INDICES

INTRODUCTION

The value of reliable information on childhood mortality, as an indicator both of the health situation in a country and also of the growth of a population, has always been recognised.' However, such information has rarely been available in developing countries. In the absence of full registration and good statistics on births and deaths, techniques for estimating levels of childhood mortality from limited and defective data were originated many years ago (Brass *et al*, 1968) and have subsequently been extended and adapted (Sullivan, 1972; Trussell, 1975). All these techniques utilise data collected in cross-sectional surveys where the samples are random.

Other than in this scheme in the Solomon Islands, any data previously collected on a woman's maternity history at the time of her current birth were not fully investigated and exploited, and so there was no precedent for determining mortality indices from such data. It was therefore considered important to determine methods of converting these readily-obtainable data into standard mortality indices.

Several methods for the derivation of such indices from these data are investigated in the present work. The principles and limitations are discussed, and the results studied for their validity and reasonableness before being compared with results from censuses, where appropriate.

MULTIPLYING FACTOR TECHNIQUE

Since the most widely available data on childhood mortality are from reports of children born and surviving to certain age groups of mothers, and since the most widely used technique of estimating lifetable probabilities of non-survivorship from such data is the so-called 'Brass multiplying factor technique' (Brass *et al*, 1968, *ibid*), it was obvious that most effort should be put into an attempt to adapt this method for use with non-random samples.

The multiplying factor technique for converting the reported proportions of children dead (D_i) by recorded age group of mothers into lifetable probabilities of dying by specific ages, q(a), is now well established and has been widely used. It is based on the principle that, if there has been an unchanging schedule of mortality such that the proportion of children dying before age a is q(a) and if there has been a constant fertility schedule in recent years, the proportion dead, Q, among children ever born (which depends on their age distribution and on q(a)) can be expressed for each age group of women as:-

$$Q = \int_0^\infty q(a) \quad C(a)da$$

where : C(a)da denotes the proportion of children born a to a + da years prior to the survey.

Thus the proportion of non-surviving children is a weighted average of the lifetable q(a) values, the weights being determined by the distribution in time of the birth dates of all children ever born. The function C(a) - where $a \geqslant 0$ - may be referred to as the 'time distribution of children ever born'. The difficulty of having an infinite number of solutions to the above equation is overcome by introducing empirical demographic reasoning in the form of model lifetables, when the equation may be re-written as:-

$$Q = \int_0^\infty q(a,\omega) \; C(a)da$$

where $q(a,\omega)$ denotes the probability of death between birth and exact age a in the model lifetable corresponding to the level of mortality represented by ω. This equation may be solved for ω, thus identifying a particular model lifetable which, in turn, provides the desired mortality estimates.

However, Brass circumvented the need for the calculation of the basic equation for each individual estimation by concentrating on the 'weights' required to convert proportions of non-surviving children, D_i, into lifetable probabilities of dying by specified ages, q(a). The method employed depended on the approximate equality of D_1 and q(1), D_2 and q(2), *etc.*, and a set of multipliers (*i.e.* 'weights') was calculated by which values of D_i could be converted into estimates of q(a). The multipliers did not alter for different patterns of mortality, but did do so for different fertility functions as designated by the fertility location parameter P_2/P_3 (*i.e.* the ratio of the number of children born to women aged 20-24 to the number born to women aged 25-29). This single parameter is now preferred to the original two parameters of P_1/P_2 (the ratio of the number of children born to women aged 15-19 to the number born to women aged 20-24) used for the estimates from the reports of younger women, and $\bar{m}$ (the mean age of the age-specific fertility distribution) used for the estimates from older women (Brass, 1976). This is because P_1 is sensitive to age-reporting errors at the start of child-bearing and also sample fluctuations due to the small number of births to women aged 15-19 years. The reports from older women, subject as they are to memory error biases, give unreliable results and hence the method is no longer used to obtain estimates of probabilities of dying beyond age five. It has been found that P_2/P_3 is a particularly satisfactory fertility location parameter for the estimates of q(2), q(3) and q(5) which are the most reliable obtained by the procedure.

There are several reasons why levels of infant mortality, q(1), derived by this method are unreliable. In a small sample, the total number of dead children to women aged 15-19 (on which figure the derivation of q(1) is based) is small and therefore subject to large sampling variability. Secondly, in many populations, infant mortality among children born to very young mothers (who are, in the main, having their first child) is not representative of general infant mortality. In addition, this method is based on the assumptions that fertility and mortality have remained constant. If fertility has been falling, the effect, nevertheless, is likely to be unimportant since most fertility trends are very gradual. The multiplying factors for the estimation of q(2), q(3) and q(5) are not sensitive to small changes in P_2/P_3. However, the estimates of q(1) are much more sensitive to small changes in P_2/P_3 as there can be significantly different age distributions of children born to women aged 15-19 with even very small changes in P_2/P_3. If mortality has been falling, the method is more directly affected, since the conversion of D_i into q(a) is derived by the use of values from a lifetable expressing the mortality risks to which young children are exposed, and since q(a) can be identified with the lifetable prevailing at the time of the survey only if mortality has been constant during the preceding years (as q(a) represents the mortality of a cohort born _a_ years ago). However, when mortality has been falling (as is postulated is the case in the Solomon Islands), the largest change is in infant mortality, and the method still gives results for q(2), q(3) and q(5) representative of the average mortality of the few years preceding the survey.

In addition to the problems specifically associated with the reliability of the estimate of q(1), there are other problems associated with the nature of the data, irrespective of the method of analysis. Older women or women with several children tend to forget some of their children, particularly those who have died. The bias is minimal for the estimates of q(1), q(2) and q(3), as these are from reports from younger women who have had their children in the recent past. Likewise the proportions dead of children to women of a certain age group are probably not representative of the proportions dead of all children born to mothers in that age group at that time, since there is probably lower mortality among children whose mothers survived than among those whose mothers died. However, this bias is less important for younger women and, again, has minimal effect on the estimates of q(1), q(2) and q(3). Finally, biases which potentially affect all age groups of women and hence all values of q(a) are those caused by the omission of children who have died soon after birth, and also by the inclusion of stillbirths as live-births which have subsequently died.

In summary, estimates of q(1) - infant mortality - are unacceptable for the reasons outlined. The probabilities of dying q(10), q(15) *et seq.* are unreliable because of the memory errors mentioned. Of the three remaining values (q(2), q(3) and q(5)), q(2) is the most acceptable as it refers to mortality in the most recent past and is therefore minimally subject to the biases of time and possible changing mortality mentioned above. The probability of dying by age two, q(2), will therefore be the value derived in all calculations.

Prior to this study, the multiplying factor technique had only ever been applied to cross-sectional surveys of random samples, in which the women were distributed randomly at all stages over the birth interval. However, the technique could not be applied directly to the data from this birth notification scheme, since they were collected at the time a woman gave birth to her current child, and hence the women in the sample were not distributed randomly over the birth interval but all located at the end of it. Nevertheless, it was considered that the proportions dead among children born to women in this sample could be converted into lifetable probabilities of dying by specified ages by this method, if allowance was made for the non-random nature of the data.

In a random sample, the distribution of previous births back from the date of the interview is a continuous function, with previous births being distributed evenly, continuously and randomly from the present levels back to a point in time where they are zero - for each age group of women and also for all ages combined (see Figure 9). However, this situation does not hold for a sample where the women are interviewed *at* the time of a current birth. Current births occur at a *point* in time. The distribution of first preceding births is fairly narrow around the mean birth interval - and it is known that the birth immediately prior to the current one is unlikely to have occurred less than one year previously. Distribution of second preceding births around the mean, also determined by the mean birth interval, is wider and that for third preceding births still wider, *etc*. In other words, the distributions of births around the means widen the further back in time they are from the current births (see Figure 10). This semi-discrete, as opposed to continuous, function could be ignored if mortality with age (*i.e.* ℓ_x of the lifetable survivors) were a linear function, but, due to the sharp

FIGURE 9

DISTRIBUTION OF PREVIOUS BIRTHS TO A RANDOM SAMPLE OF WOMEN

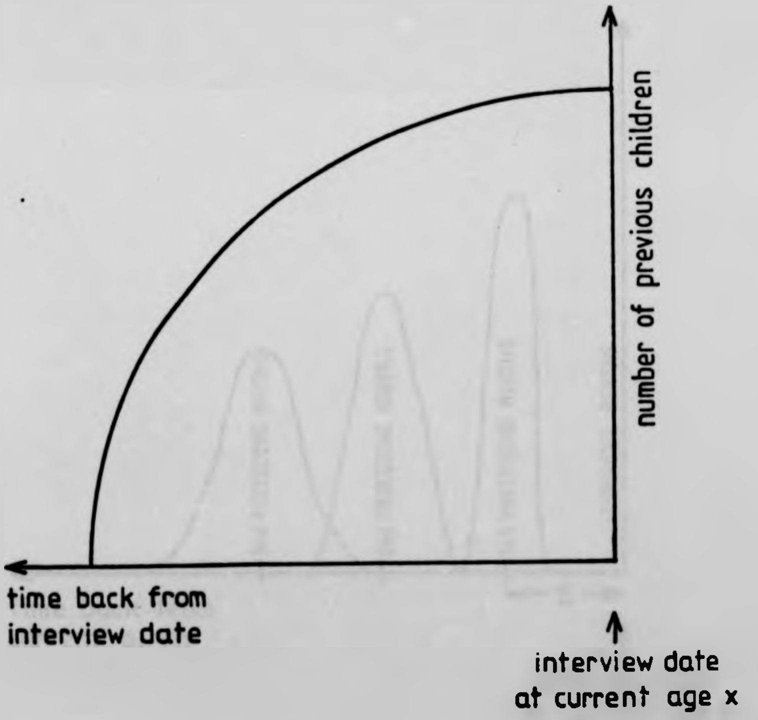
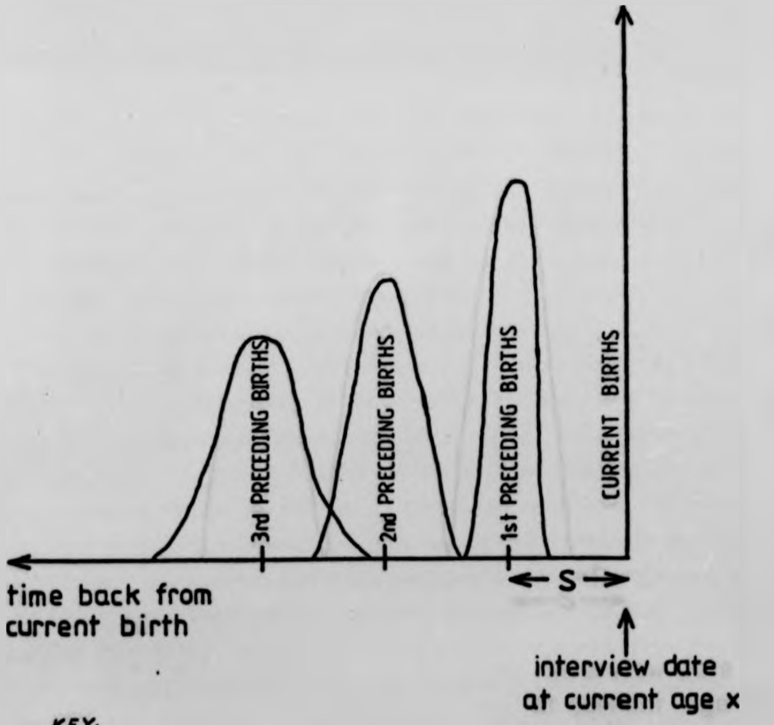


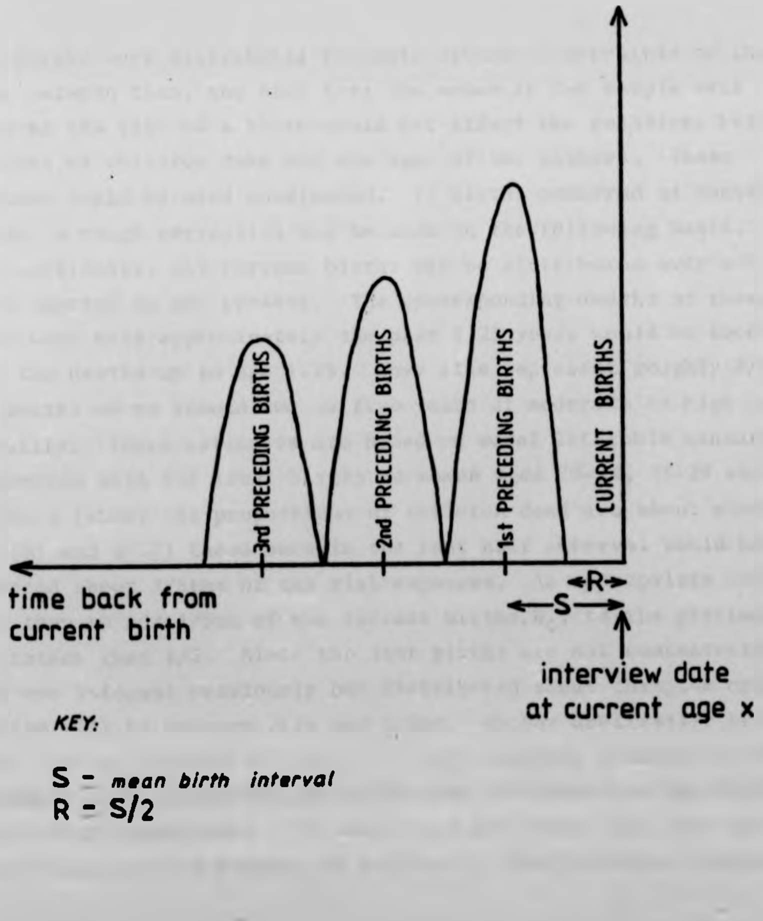
FIGURE 10 DISTRIBUTION OF PREVIOUS BIRTHS TO A NON-RANDOM SAMPLE OF WOMEN



KEY:

S *mean birth interval*

FIGURE 11 IDEALISED DISTRIBUTION OF PREVIOUS BIRTHS TO A NON-RANDOM SAMPLE OF WOMEN



changes in mortality in the first two years of life, it is not and this causes appreciable biases. It can be visualised that, in order to approximate the existing semi-discrete function into a continuous one, each order of preceding births in the past is distributed exactly over a whole birth interval (rather than over less than a birth interval for the first preceding birth and more than a birth interval for births further in the past) centred around the position of mean birth interval (see Figure 11). The current births are distributed with no spread around time zero because of the nature of the sample. Continuity has otherwise been simulated by spreading the 'clumps' over the birth intervals.

If births were distributed randomly without constraints on the interval between them, the fact that the women in the sample were selected at the time of a birth would not affect the relations between proportions of children dead and the ages of the mothers. These proportions could be used unadjusted. If births occurred at constant intervals, a rough correction may be made on the following basis. To achieve continuity, the current births can be distributed over a birth interval centred on the present. The corresponding deaths of these children born over approximately the past 1.25 years would be about 0.60 of the deaths up to age 1.25. They also represent roughly 2/5ths of the deaths up to around two to five years at moderate to high levels of mortality. These estimates are based on model lifetable measures. In comparison with the total births to women aged 20-24, 25-29 and 30-34 years (where the proportions of children dead are about equal to q(2), q(3) and q(5)) those born in the last half interval would have experienced about 2/5ths of the risk exposure. An appropriate adjustment is then to add 1/5th of the current births, B_c, to the previous births rather than 1/2. Since the last births are not concentrated exactly one interval previously but distributed about this, the optimum correction will be between zero and 1/5Bc. Rather arbitrarily it has been set mid-way between at $1/10B_c$. A more accurate calculation would be extremely complicated and depend on such influences as the length of post-partum amenorrhoea. It would also of course vary with age group of women and the pattern of fertility. The correction adopted clearly improves the estimates and the residual error must be small. For older women the correction should be reduced because the previous births have had an increasingly long exposure but current births are then becoming a small fraction of the total and the effects of any such change would be negligible compared with the other uncertainties.

Having determined this as the most appropriate correction factor, the multiplying factor technique could then be applied in the conventional manner. Instead of studying the proportions of previous children dead by age group of mother (as in a random sample), the proportions dead of (previous children + 1/10 current births) were used. In the calculation of the fertility location parameter, P_2/P_3, some allowance had likewise to be made for the non-randomness of the data. However, the correction factor of $1/10B_c$ applied to the mortality indices was not suitable for use with this parameter as no allowance for deaths need be made when considering only fertility. On the basis of the reasoning above, it was therefore adequate merely to add, to the previous number of births, half the number of current births, for each age group of mother. Hence, in this instance, P_2 is the number of (previous births + 1/2 current births) to women aged 20-24, and P_3 is the number of (previous births + 1/2 current births) to women aged 25-29. The appropriate multiplying factors from published tables (Brass *et al*, 1968, *ibid*) were selected on the basis of this ratio, P_2/P_3, and applied in the usual manner to the proportions of children dead to women aged 20-24 to obtain values of q(2) (see Table A.7 and Table 17). Graduation of these results by the Brass logit lifetable system (Brass, 1971) was considered in order to reduce errors caused by age mis-statement and errors of timing, but was not applied since it was thought preferable to retain the unadulterated q(2) values.

The derived proportions of children dead by age two, q(2), were plotted (see Figure 12), according to the year of notification. The results from the 1967 notification records seemed unacceptably low and were not plotted. It is thought that these low levels were due to a misunderstanding connected with the collection of data. Initially, only current *live*-births were required to be recorded and it is

TABLE 17

ESTIMATION OF q(2) BY THE MULTIPLYING FACTOR TECHNIQUE

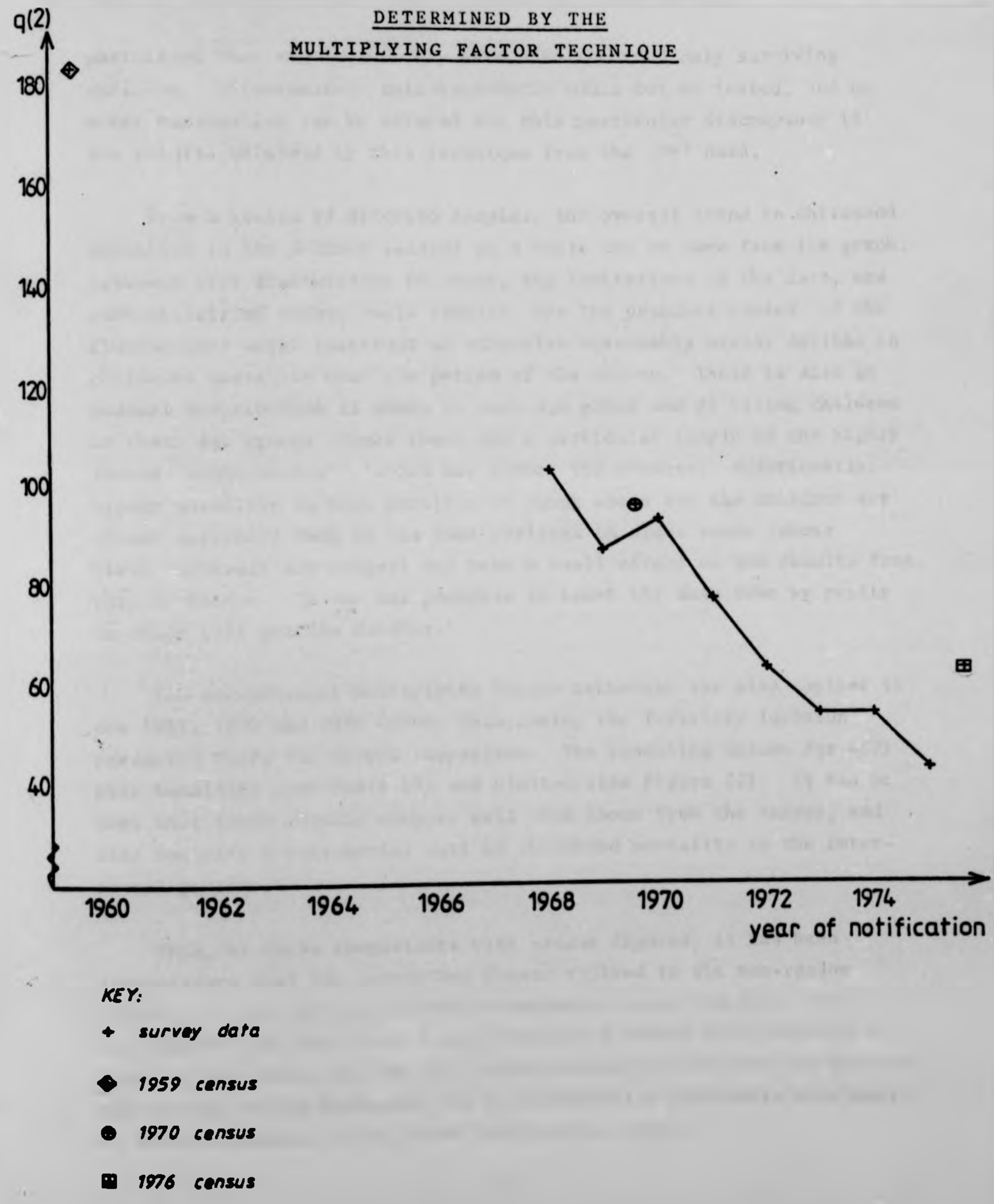
Year of Notification	Proportion of Children Dead, D_2 to Women Aged 20-24	P_2/P_3	Multiplying Factor, k_2	Adjusted Proportion Died by Age 2 $q(2) = D_2k_2$
1967	.0689	.495	1.007	.069
1968	.1013	.481	1.016	.103
1969	.0857	.482	1.015	.087
1970	.0936	.520	0.992	.093
1971	.0778	.516	0.994	.077
1972	.0636	.524	0.990	.063
1973	.0544	.509	0.999	.054
1974	.0531	.488	1.011	.054
1975	.0431	.501	1.003	.043
Censuses				
1959[*]	.1761	P_1/P_2 = .125	1.056	.186[¶]
		P_2/P_3 = .447	1.039	.183
1970[*]	.0872	P_1/P_2 = .114	1.064	.093[¶]
		P_2/P_3 = .396	1.097	.096
1976[†]	.0619	P_1/P_2 = .207	1.009	.062
		P_2/P_3 = .479	1.017	.063

[*] refers to Melanesians and Polynesians only

[¶] published values

[†] derived from basic tables.

FIGURE 12 DEATHS BY AGE 2 PER 1000 LIVEBIRTHS DETERMINED BY THE MULTIPLYING FACTOR TECHNIQUE



postulated that some nurses may have also recorded only surviving children. Unfortunately this hypothesis could not be tested, and no other explanation can be offered for this particular discrepancy in the results obtained by this technique from the 1967 data.

From a series of discrete samples, the overall trend in childhood mortality in the Solomon Islands as a whole can be seen from the graph. Although real fluctuations do occur, the limitations of the data, and particularly of rather small samples, are the probable causes of the fluctuations which interrupt an otherwise reasonably steady decline in childhood mortality over the period of the survey. There is also an unusual distribution of women in each age group and of having children in these age groups (since these are a particular sample of the highly fecund 'rapid-movers'), which may affect the results. Additionally, higher mortality in high parities of young women (as the children are closer together) than in the same parities in older women (whose birth intervals are longer) may have a small effect on the results from this technique. It was not possible to break the data down by parity to study this problem further.

The conventional multiplying factor technique was also applied to the 1959, 1970 and 1976 Census data, using the fertility location parameter P_2/P_3 for direct comparison. The resulting values for q(2) were tabulated (see Table 17) and plotted (see Figure 12). It can be seen that these results compare well with those from the survey, and also indicate a substantial fall in childhood mortality in the intercensal periods.

Thus, by these comparisons with census figures, it has been demonstrated that the correction factor applied to the non-random sample is valid and has provided reasonable values for q(2). Its application has shown that a very simple and rather crude correction does in fact allow well for the non-randomness of the data and that the multiplying factor technique can be successfully applied to data such as those collected in the birth notification scheme.

(The methods developed by Sullivan (1972, *ibid*) and Trussell (1975, *ibid*) were not applied to these data, since the results from these methods have been shown to parallel closely those from the multiplying factor technique.)

GRIFFITH FEENEY TECHNIQUE

One of the assumptions made in the multiplying factor technique, on which the Griffith Feeney technique (Feeney, 1975, 1976) is based, is that mortality has been constant during the years preceding the survey. For older mothers, whose children have been born further in the past than the children of younger mothers, any changes in mortality which have occurred over time are confounded with the mortality pattern by age. If these time changes are large, however, then it is apparent from the multiplying factor technique that survivorship to different ages cannot be made consistent with a lifetable pattern of mortality and therefore changes in mortality over time can be deduced. The Griffith Feeney technique attempts to quantify these time changes in mortality. In this technique, it is assumed that the mortality pattern by age is fixed and hence deviations from it implied by the proportions of children surviving by age group of mother are taken to represent the time changes in mortality.

Consider a population in which mortality has been declining, but in which the period lifetable applicable at any given time conforms to a particular model lifetable. If the level of mortality at the time of a particular population survey is denoted by ω_0, and if this level has been declining at the rate of $\underline{r}$ units per annum, these assumptions determine a complete series of lifetables for each year preceding the survey. From this series of lifetables, it is possible to calculate the probability that a child born $\underline{a}$ years prior to the survey will die by the time of the survey. This probability will depend on both ω_0 and $\underline{r}$, as well as on $\underline{a}$, and will accordingly be denoted by $q(a;\ \omega_0,r)$. Brass' equation (see page 63) may then be re-written:-

$$Q = \int_0^\infty q(a;\, \omega_0,\, r)\, C(a)da$$

where (as in Brass' equation):-

Q - proportion of non-surviving children among all children ever born to women in a particular age group

C(a)da - proportion of these children born a to a+da years prior to the survey, *i.e.* "the time distribution of children ever born".

The only difference between this equation and Brass' original equation is that the probabilities of death by the time of the survey for children born at various times preceding the survey no longer depend on only one quantity (the assumed constant mortality level) but on two (the level of mortality at the time of the survey and its annual rate of decline in preceding years).

One such equation is available for each age group of women; each equation is 'solved' for the unknown values of ω_0 and r and these values then determine the trend of mortality in the years preceding the survey. Of several strategies available for solving this equation, Feeney chose to develop the one based on a consideration of the equations for each group individually. There is an infinite number of combinations of ω_0 and r values which satisfy the equation for a given group, and Feeney determined a finite but large number of these and then considered the family of mortality level trajectories defined by these combinations. Any two of these trajectories must intersect, but it emerged that *all* trajectories of mortality level consistent with a given child survivorship figure intersected at approximately the same point. The co-ordinates of this point gave the estimated infant mortality rate and years-prior-to-survey values. With increasing age group of women, the intersection of trends occurred at an increasing number of years prior to the survey.

Feeney re-expressed the equation above as:-

$$Q = 1 - \Sigma_j c_j p_j(\omega,r)$$

where Q - proportion of dead children among all children born to women in a particular age group (as before)

c_j - proportion of this group of children who were born in the j-th year prior to the survey

$p_j(\omega,r)$ - proportion of children born during the j-th year prior to the survey who would survive to the time of the survey if:-

(i) Infant mortality was ω at the time of the survey and had been declining at a constant rate $\underline{r}$ in the years prior to the survey;
(ii) there was no differential mortality by age of mother;
(iii) the lifetable representing the mortality experience each year prior to the survey is included in a known one-parameter model lifetable family.

The values of c_j may be estimated from M, the mean age at child-bearing, hence this equation may be re-written:-

$$Q = 1 - \Sigma_j c_j(M) p_j(\omega,r)$$

This combination of values of ω and $\underline{r}$ for specified values of Q and M may be determined. Feeney first tabulated the co-ordinates corresponding to a range of values of Q and M and then fitted the tabular values by a mathematical formula to derive simple formulae for each age group of women from which unique values of ω and $\underline{r}$ for specific values of Q and M could be determined (see Table 18). These formulae obviated the need for much long and tedious computation directly from the basic equation. However, they are necessarily approximations of the basic equation and as such only detect overall linear trends of mortality and are not sensitive to small fluctuations in mortality, since each child survivorship figure represents an average over a period.

TABLE 18

ESTIMATION OF INFANT MORTALITY RATES FROM PROPORTIONS OF DECEASED CHILDREN (Q) AMONG CHILDREN BORN TO WOMEN IN FIVE YEAR AGE GROUPS, GIVEN THE MEAN AGE AT CHILDBEARING (M)*

Age Group of Women	Infant Mortality Rate	Years Prior to Survey
20-24	(-44.7+30.5M)Q - 2.6	11.8 - 0.325M - 0.17Q
25-29	(294+14.9M)Q - 2.9	16.5 - 0.424M + 0.16Q
30-34	(357+10.4M)Q - 2.8	20.6 - 0.494M + 0.77Q
35-39	(362+9.77M)Q - 7.8	24.9 - 0.556M + 0.80Q
40-44	(282+11.0M)Q - 8.5	30.1 - 0.633M + 0.87Q
45-49	(216+11.1M)Q - 7.5	33.4 - 0.641M + 1.58Q

*after Feeney (1976)

There are other problems inherent in the assumptions made. The effect of differential mortality by age of mother cannot be estimated but can be minimised by using data from the reports of the younger women only - this also circumvents problems of memory error biases. In addition, the model lifetable chosen may not accurately reflect the mortality pattern in the population of the Solomon Islands. However, the estimates themselves indicate how much the linearity assumption is valid by the extent to which they deviate from a straight line (although errors in the data and fluctuations due to small samples also contribute to this).

The Feeney formulae were applied directly to the birth notification data, after allowance for the non-randomness of the sample. It was considered that the correction factor determined for the multiplying factor technique and applied to the number of previous children by age group of mother should be applied in this instance. The values of Q were therefore those used in the multiplying factor technique. The values of M were determined using a method of Feeney's and a 'ranking chart' (see Table 19). In this method, the ratio of the mean parities, P_2/P_3, was calculated, as before after allowance for the non-random nature of the data, and located in the chart to estimate the displacement of M from the interface age of the two age groups in the ratio. The procedure was repeated for the ratio P_3/P_4. The displacements determined were then added to the interface ages and the two averaged to obtain an estimate of the mean age of childbearing based on the reports from the three least unreliable age groups of women.

It was considered preferable, to facilitate comparison with the optimal results determined from other methods, to convert the values of infant mortality derived by this method (see Table A.8) into q(2) values (*i.e.* proportions of children dead by age 2). This was possible since Feeney based his calculations on the logit system with one parameter α and the 'General Standard lifetable'. Hence, conversions of q(1) values into q(2) values could be done, since:-

TABLE 19

ESTIMATION OF THE MEAN AGE AT CHILDBEARING FROM MEAN PARITY RATIOS FOR SUCCESSIVE FIVE YEAR AGE GROUPS*

$\frac{\text{Mean Parity for Women Aged (x-5) to x}}{\text{Mean Parity for Women Aged x to (x+5)}} \times 1000$	Displacement of Mean Age at Childbearing from x
063-110	+10
111-167	+ 9
168-230	+ 8
231-293	+ 7
294-353	+ 6
354-409	+ 5
410-461	+ 4
462-508	+ 3
509-552	+ 2
553-593	+ 1
594-630	0
631-665	- 1
666-697	- 2
698-728	- 3

*after Feeney (1976).

$$\text{logit}\,(1 - \ell_x) = \alpha + \text{logit}\,(1 - \ell_x{}^s)$$

where ℓ_x - proportion surviving from birth to age x in lifetable of population under study

$\ell_x{}^s$ - proportion surviving from birth to age x in standard lifetable

But: $\text{logit}\,(1 - \ell_1) = \text{logit}(q(1)) = \alpha + \text{logit}(q(1)^s)$

and $\text{logit}(q(2)) = \alpha + \text{logit}(q(2)^s)$

where $q(x)$ - proportion dying by age x in lifetable of population under study

$q(x)^s$- proportion dying by age x in standard lifetable.

Eliminating α

$$\begin{aligned}\text{logit}(q(2)) &= \text{logit}(q(1)) + \text{logit}(q(2)^s) - \text{logit}(q(1)^s)\\ &= \text{logit}(q(1)) + (-.7152) \quad - (-.8670)\\ &= \text{logit}(q(1)) + .1518\end{aligned}$$

The results (see Table 20) were plotted as separate series of trends of q(2) values in Figure 13.

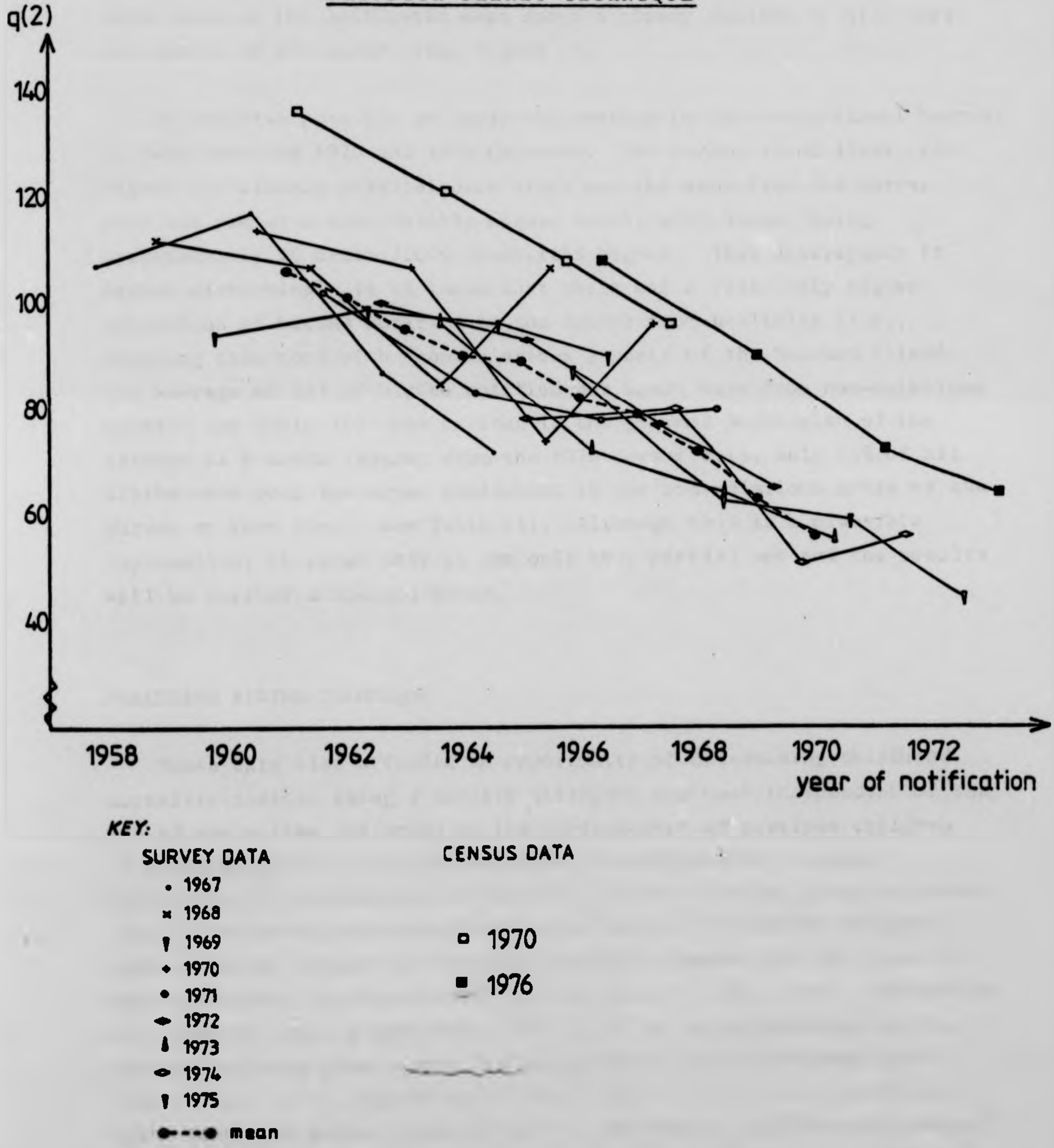
The data collected in the birth notification scheme in the Solomon Islands offered a unique opportunity to apply this method to consecutive years' data, so obtaining several series of trends in q(2). If the data were good, with minimal error, and if the assumptions inherent in the method held reasonably well for this population, the trend lines should have been very close. Thus there was available an internal consistency check on a method which is still not well established. However, it can be seen that many of the trend lines show erratic fluctuations, indicative of the inevitable discrepancies in the data, particularly the errors associated with small samples. The trend lines derived from all years' notification data are neither linear nor coincident. In view of these fluctuations, it was decided to summarise the mass of results into a single trend line merely by taking the arithmetic mean of the values at each year's midpoint on the graph. Although it might have been preferable to have determined a single trend line from the average of reports from younger women, since these

TABLE 20

ESTIMATION OF q(2) BY THE GRIFFITH FEENEY TECHNIQUE

Year of Notification	Proportion of Children Dead by Age 2 q(2)	No. of Years Prior to Survey
1967	.072	2.5
	.087	4.4
	.117	6.6
	.107	9.2
1968	.107	2.5
	.085	4.4
	.107	6.6
	.112	9.2
1969	.090	2.5
	.096	4.4
	.099	6.6
	.094	9.2
1970	.096	2.7
	.074	4.6
	.107	6.9
	.114	9.5
1971	.080	2.7
	.078	4.6
	.083	6.8
	.102	9.4
1972	.065	2.7
	.077	4.6
	.093	6.9
	.100	9.4
1973	.055	2.7
	.064	4.6
	.072	6.8
	.096	9.4
1974	.056	2.4
	.051	4.2
	.080	6.3
	.078	8.9
1975	.044	2.5
	.059	4.4
	.063	6.6
	.087	9.1

FIGURE 13 DEATHS BY AGE 2 PER 1000 LIVEBIRTHS DETERMINED BY THE GRIFFITH FEENEY TECHNIQUE



are the least unreliable, (as Feeney did for his two years of data (1976, *ibid*)), the result was too erratic to be of use. The trend line calculated as the arithmetic mean shows a steady decline in q(2) over the period of the survey (see Figure 13).

It was also possible to apply this method in the conventional manner to data from the 1970 and 1976 Censuses. The census trend lines (see Figure 13) closely parallel each other and the mean from the survey data but are at a considerably higher level, q(2) values being approximately 20 deaths/1000 livebirths higher. This discrepancy is rather disturbing. It is known that there was a relatively higher proportion of births notified in the scheme from healthier (*i.e.*, equating this term with 'non-malarious') parts of the Solomon Islands (an average of 58% of births notified per annum were from non-malarious areas - see Table 10) than existed in the general population of the islands as a whole (where, from the 1970 Census data, only 41% of all births were from the areas equivalent to the non-malarious areas of the survey at that time - see Table 11). Although this is a plausible explanation, it seems that it can only be a partial one and the results will be further discussed below.

PRECEDING BIRTHS TECHNIQUE

These data also afforded an opportunity of determining childhood mortality indices using a totally different approach independent of the age of the mother reporting on the survivorship of previous children. It was made possible by the fact that, in addition to the usual tabulations of proportions of children dead to each age group of mother, tabulations were produced of births and deaths of previous children ordered by the number of intervals preceding the current one, *i.e.* for the immediately previous birth, the one prior to that, *etc.* Tabulations of births by rank of preceding birth (*i.e.* by first preceding birth, second preceding birth, *etc.*) rather than by the conventional birth order (first birth, second birth, *etc.*) give births in an approximately equivalent time period (though this is admittedly less true with higher orders of parity), since women are entering the survey at the time of a current birth and the distribution of previous births is semi-discrete.

The mean time between each of these categories of births is known approximately from the birth interval. A birth interval of 3.1 years calculated from the 1970 Census data on all women and all parities was too uncertain for use, since it was based on the interval between a woman's first and last child (Census Report, 1970). Calculations made during the processing of the 1973 survey data gave a mean birth interval between the immediately preceding birth and the current birth of a gratifyingly exact 2.50 years. (The intervals calculated from the 1974 and 1975 data processed subsequently were 2.47 and 2.61 years, respectively. No birth interval calculations were made during the processing of earlier years' data.) A mean birth interval of 2.50 years was therefore used in all calculations. This interval was very close to the age of 2.47 years reached by the survivors of the first preceding births at the time of the current birth, which was calculated by Brass (1969, *ibid)* from model birth intervals representing the Solomon Islands' features. This interval is derived from and therefore refers to the interval between the immediately preceding birth and the current birth and refers to all ages of women and all parities up to 12 (the limit of the questionnaire). For the purpose of analysis, it was assumed that the interval, based on 1973 data, remained constant over the period of the survey.

For all years except 1967, the data were tabulated according to proportions dead of first preceding, second preceding ..... fifth preceding births. In 1967, the data were tabulated by birth order and these had to be transformed into a format as similar as possible to that of subsequent years' before they could be studied. The period of survivorship of the most recent child from birth to the time of the current birth is known from the birth interval and the proportions dead of the first preceding birth can be considered as proportions dead by age 2.5 years, *i.e.* $q(2.5)$. These values are then converted into the conventional $q(2)$ values for comparison with results from other methods by use of the African Standard lifetable and the Brass logit lifetable system, in which the equation to link two lifetables is:-

$$Y(x) = \alpha + \beta Y_s(x)$$

where $Y(x)$ - logit function $\frac{1}{2}\log_e\left(\frac{q(x)}{1-q(x)}\right)$

α, β - constants (with β usually taking its central value of 1)

$Y_s(x)$ - logit function of $q(x)$ values in African Standard lifetable.

The $q(2.5)$ values calculated simply as proportions dead of all first preceding births are converted into logits, which are then compared with the corresponding logit value (*i.e.* logit $q(2.5)$) in the African Standard. The difference between them was taken as the value of α required to be added to the logits of the conventional q values of the African Standard lifetable. The derived values were anti-logited to give the graduated q values for the Solomon Islands' data and the results for all parities combined were tabulated (see Table 21). If only $q(2)$ is considered, there is minimal dependence on the standard lifetable chosen, since standard lifetables differ little in this value. The use of a particular standard lifetable presupposes the existence of a similar mortality pattern in the population under study, since the pattern of the standard is to a certain extent superimposed on that of the study population in this technique. By using only the data concerning the first preceding birth, only the most recent mortality is being studied and only the minimum adjustment is necessary to derive $q(2)$ values which can be compared with those derived by other techniques. In addition, as one goes further back to second, third, fourth and fifth preceding births, both the sample size decreases and hence the sampling errors increase, and also time and memory errors increase, thus combining to reduce the validity of conclusions drawn from the data.

The results from all years' notification data, with the exception of those from 1967, were plotted (see Figure 14). The results from 1967 data were not plotted as re-tabulation of the original format gave a format similar to but not identical with that of later years so that the results were not strictly comparable. (Another contributory factor may have been the possibly erroneous data collection - see p71.) The results show a reasonably steady decline in childhood mortality

$$Y(x) = \alpha + \beta Y_s(x)$$

where $Y(x)$ - logit function $\frac{1}{2}\log_e\left(\frac{q(x)}{1-q(x)}\right)$

α,β - constants (with β usually taking its central value of 1)

$Y_s(x)$ - logit function of $q(x)$ values in African Standard lifetable.

The q(2.5) values calculated simply as proportions dead of all first preceding births are converted into logits, which are then compared with the corresponding logit value (*i.e.* logit q(2.5)) in the African Standard. The difference between them was taken as the value of α required to be added to the logits of the conventional q values of the African Standard lifetable. The derived values were anti-logited to give the graduated q values for the Solomon Islands' data and the results for all parities combined were tabulated (see Table 21). If only q(2) is considered, there is minimal dependence on the standard lifetable chosen, since standard lifetables differ little in this value. The use of a particular standard lifetable presupposes the existence of a similar mortality pattern in the population under study, since the pattern of the standard is to a certain extent superimposed on that of the study population in this technique. By using only the data concerning the first preceding birth, only the most recent mortality is being studied and only the minimum adjustment is necessary to derive q(2) values which can be compared with those derived by other techniques. In addition, as one goes further back to second, third, fourth and fifth preceding births, both the sample size decreases and hence the sampling errors increase, and also time and memory errors increase, thus combining to reduce the validity of conclusions drawn from the data.

The results from all years' notification data, with the exception of those from 1967, were plotted (see Figure 14). The results from 1967 data were not plotted as re-tabulation of the original format gave a format similar to but not identical with that of later years so that the results were not strictly comparable. (Another contributory factor may have been the possibly erroneous data collection - see p 71.) The results show a reasonably steady decline in childhood mortality

TABLE 21

ESTIMATION OF q(2) BY THE PRECEDING BIRTHS TECHNIQUE

FIRST PRECEDING BIRTHS (ALL PARITIES)

Year of Notification	First Preceding Birth Born	Died	Proportion Died D	Logit D	Graduated Observed Logits	q(2)
1967	993	60	.0604	-1.3722	-1.4122	.056
1968	1769	209	.1181	-1.0053	-1.0453	.110
1969	2400	255	.1063	-1.0646	-1.1046	.099
1970	2796	331	.1184	-1.0038	-1.0438	.110
1971	3030	281	.0927	-1.1406	-1.1806	.086
1972	3861	333	.0862	-1.1805	-1.2205	.080
1973	3369	228	.0677	-1.3113	-1.3513	.063
1974	2390	159	.0665	-1.3209	-1.3609	.062
1975	4472	264	.0590	-1.3847	-1.4247	.055

Note: Birth Interval = 2.5 years
African Standard Logit for q(2) = -.8052
African Standard Logit for q(2.5) = -.7652

FIGURE 14 DEATHS BY AGE 2 PER 1000 LIVEBIRTHS DETERMINED BY THE PRECEDING BIRTHS TECHNIQUE

over the period of the survey, with the exception of the value derived from the 1970 notification data, which (although real fluctuations do occur) seems spuriously high. (It is postulated that, in the processing of this year's data, stillbirths were included as livebirths which had died, so inflating the proportions of preceding births which had died, but this could not be checked.)

The Solomon Islands' censuses did not produce data tabulated in this format, since they were standard cross-sectional surveys. Hence, there was no comparison possible with results from the censuses.

This method raises certain conceptual problems which need discussing. Although, in theory, when looking at first preceding births for all parities, one is studying the first born of a parity 1 woman, the second born of a parity 2 woman, *etc.* (parity referring to her status immediately prior to the birth of her current child), over theoretically the same time period, in practice the birth interval can be quite different depending on a woman's parity and age.

Since survivorship by parity is a J-shaped curve (Heady and Morris, 1959) with the highest mortality occurring with the first child, decreasing to the third child approximately and rising steadily with increasing parity, it was considered worthwhile also studying the data on preceding births by parity to see if this differential mortality became apparent. The first preceding birth of a parity 1 woman is her first born child and so data on survivorship of first births can be studied. Similarly, the first preceding birth for a parity 2 woman is her second born child, for a parity 3 woman her third born, *etc.* Since the lowest level of mortality is approximately related to parity 3, the data were studied merely for first born, (2nd & 3rd) born and (4th-12th) born, since further sub-division would render already small samples unuseably smaller. In theory, births are still being studied over the same time period, and the survivorship of, for example, first born children born at different times in the past is *not* being studied. As with all parities combined, the birth interval between first preceding and current births is taken as 2.5 years, so that the proportions dead, q(2.5), in the interval can be converted to q(2) as before.
The results were tabulated in Table 22 and plotted in Figure 15.

TABLE 22

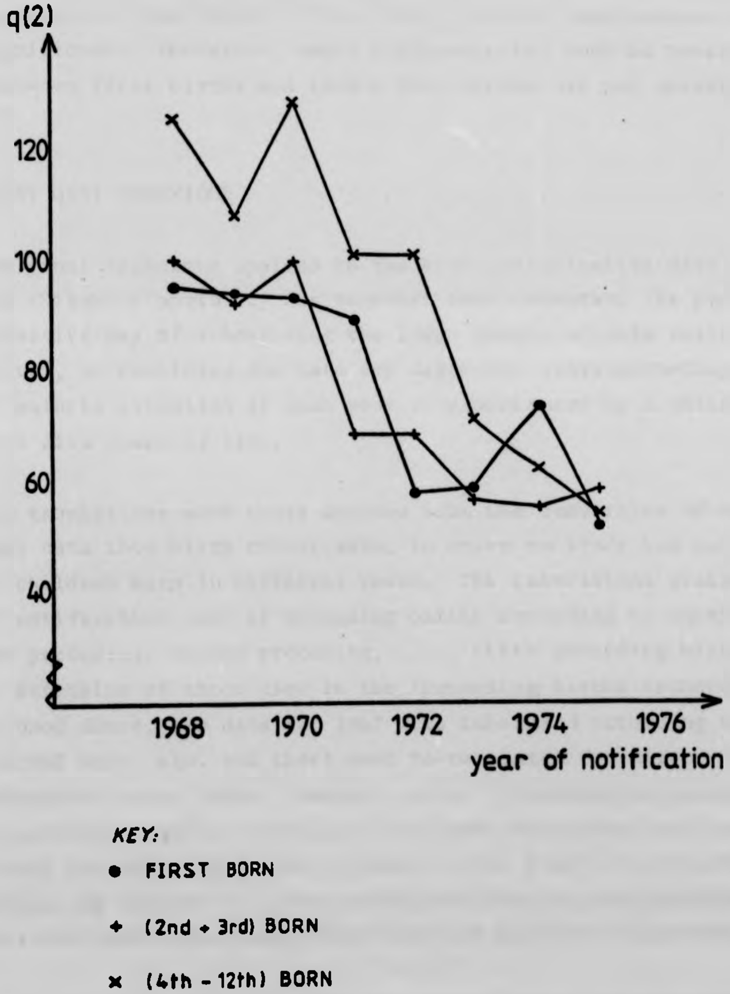
ESTIMATION OF q(2) BY THE PRECEDING BIRTHS TECHNIQUE

FIRST PRECEDING BIRTHS BROKEN DOWN BY BIRTH ORDER

Birth Order	Year of Notification	No. of Live Births	No. Died	Proportion Died	q(2)*
FIRST BORN	1967	262	15	.0573	.053
	1968	400	41	.1025	.095
	1969	576	58	.1007	.094
	1970	632	63	.0997	.093
	1971	683	65	.0952	.089
	1972	810	50	.0617	.057
	1973	715	45	.0629	.058
	1974	521	41	.0787	.073
	1975	1034	57	.0551	.051
2nd & 3rd BORN	1967	430	26	.0605	.056
	1968	584	63	.1079	.100
	1969	840	83	.0988	.092
	1970	973	105	.1079	.100
	1971	1097	80	.0729	.068
	1972	1353	99	.0732	.068
	1973	1196	72	.0602	.056
	1974	846	50	.0591	.055
	1975	1483	93	.0627	.058
4th - 12th BORN	1967	Data not available			
	1968	785	105	.1338	.125
	1969	984	114	.1158	.108
	1970	1191	163	.1369	.128
	1971	1250	136	.1088	.101
	1972	1698	184	.1084	.101
	1973	1458	111	.0761	.071
	1974	1023	68	.0665	.062
	1975	1955	114	.0583	.054

*These values calculated using logits as in the method for first preceding births (all parities).

FIGURE 15 DEATHS BY AGE 2 PER 1000 LIVEBIRTHS
DETERMINED BY THE
PRECEDING BIRTHS TECHNIQUE
BROKEN DOWN BY PARITY



The results were interesting, with different patterns and levels of mortality for first births, (2nd & 3rd) births and subsequent births. The results may be spurious and due merely to sampling errors caused by small samples. However, it should be noted that around age 2.5 years (*i.e* an age equivalent to the birth interval) childhood mortality is quite low and errors in the length of the birth interval selected are not very significant. Therefore, small differentials, such as possibly exist between first births and (2nd & 3rd) births are not detectable.

EQUIVALENT q(5) TECHNIQUE

The final technique applied to the birth notification data in the study of childhood mortality was somewhat less orthodox. It provided an alternative way of summarising the large amount of data collected in this survey, by combining the data for different years according to the overall malaria situation of each year as experienced by a child during its first five years of life.

The tabulations were those derived from the conversion of cross-sectional data into birth cohort data, in order to study the survivorship of children born in different years. The tabulations available per year of notification were of preceding births according to survivorship of first preceding, second preceding, ... fifth preceding birth, and were an extension of those used in the 'Preceding births technique'. As mentioned above, the data for 1967 were tabulated according to first born, second born, *etc.* and these were re-tabulated for direct comparison with subsequent years' data. However, since re-tabulation produced tables similar to but not identical with those from subsequent years, and since there was also a programming error in the years 1968-71, various permutations of data were studied before deciding to use groupings of all available data even though these were not strictly comparable.

Conversion of cross-sectional into cohort data requires a knowledge of the birth interval. This was taken to be 2.5 years, as before, and was used in the conversion of cross-sectional data on survivorship of preceding births (for all ages of mother and all parities - see Table

A.9) into birth cohort data for single calendar years (see Table A.10). Cross-sectional data from two successive years of the survey were averaged where necessary to provide the required cohort data. For each cohort and for each order of preceding birth, the proportions of births which had died were calculated. Because the birth interval had been taken as 2.5 years, the proportions of the first preceding births which had died by the date of the current birth were the proportions which had died by age 2.5, *i.e.* q(2.5). Similarly, the proportions of the second preceding birth could be considered as those dying by an age equivalent to twice the birth interval, *i.e.* q(5). So, in summary, the proportions of children dead for each preceding birth could be regarded, respectively, as q(2.5), q(5), q(7.5), q(10), q(12.5) (see Table 23).

The effects of malaria on levels of childhood mortality are much greater at younger ages than at ages above five years. Hence, in considering the environment experienced by a child, only the first five years of its life were taken into account. During the period of this survey, malaria eradication efforts progressively covered the islands. Over time, the environment has changed from totally malarious to totally non-malarious, and some children have been born into an already totally malaria-free environment. Since the non-malarious areas of the survey were regarded as having had malaria eradicated by/on 1.1.65. (several years before eradication occurred in other areas), the largest amount of data on experience in a wholly non-malarious environment was available from the malaria-free period in these areas.

To determine the 'normal' least-disturbed pattern of mortality which existed in the absence of malaria, the number of livebirths and subsequent deaths occurring in the non-malarious areas since 1.1.65. were summed for each q(x) value and the proportions of children dead calculated. The survey lifetable so derived (although for both sexes combined) agreed most closely with the pattern of mortality in the Coale and Demeny Regional Model lifetable for East females level 19 ($\mathring{e}_o$ = 65) (see Table 24). It indicated a generally low level of mortality in the Solomon Islands.

TABLE 23

EQUIVALENT q(5) TECHNIQUE
PROPORTIONS OF CHILDREN DEAD, q(x), IN BIRTH COHORTS

Year of Birth of Cohort	Proportions of children dead by age x, q(x)				
	q(2.5)	q(5)	q(7.5)	q(10)	q(12.5)
1957				.150	.196
1958				.173	.186
1959				.158	.174
1960			.152	.160	.165
1961			.147	.149	.137
1962		.089	.133	.145	.136
1963		.126	.130	.128	
1964		.111	.127	.122	
1965	.097	.118	.116	.120	
1966	.111	.108	.100		
1967	.113	.107	.089		
1968	.105	.085			
1969	.089	.079			
1970	.078	.077			
1971	.067				
1972	.062				

TABLE 24

COMPARISON OF 'NORMAL' MALARIA-FREE MORTALITY PATTERN IN THE SOLOMON ISLANDS WITH THE CORRESPONDING MODEL LIFETABLE

Solomon Islands 'Non-malarious' Environment	Coale & Demeny Model Lifetable East, Female, level 19
.0754	.0746
.0798	.0810
.0801	.0837
.1120*	.0865
-	.0885

---

*Based on only one observation.

The selected East model lifetable was taken to represent the mortality pattern of the Solomon Islands in the absence of malaria. Thus in one simple technique, a good estimate of the malaria-free mortality pattern of the Solomon Islands as a whole has been determined. This model lifetable was then used to compare the mortality of different individual cohorts. It was decided to compare them on one survivorship ratio, q(5) (chosen since this was the only conventional one of the series of q(2.5), q(5), *etc.*), but some cohorts did not have information for this particular ratio. To overcome this, and also to smoothe out the errors caused by small samples and memory biases (evidenced by the disappointing fluctuations in the q values which should have formed a single lifetable for each birth cohort), the observed ratios were compared with the model ratios and a value for a so-called 'equivalent q(5)' derived. (This value of q(5) was not sensitive to the weightings given by the model lifetable selected.) The calculations involved use of as many of the components of the following equation as were available in the observed data:-

$$\text{Equivalent } q(5) = \frac{1}{n}\left[\left(\frac{q(5)_M}{q(2.5)_M} \times q(2.5)_O\right) + \left(\frac{q(5)_M}{q(7.5)_M} \times q(7.5)_O\right) + q(5)_O + \left(\frac{q(5)_M}{q(10)_M} \times q(10)_O\right) + \left(\frac{q(5)_M}{q(12.5)_M} \times q(12.5)_O\right)\right]$$

where: $q(x)_M$ - model lifetable values of q

$q(x)_O$ - observed values of q

$1/n$ - values of n range between 1 and 5 depending on the number of components in the equation.

The derived equivalent q(5) values were tabulated (see Table 25) and plotted (see Figure 16) according to year of birth of the cohort, since this method determined the proportion of children born in each cohort which would have died by age five.

TABLE 25

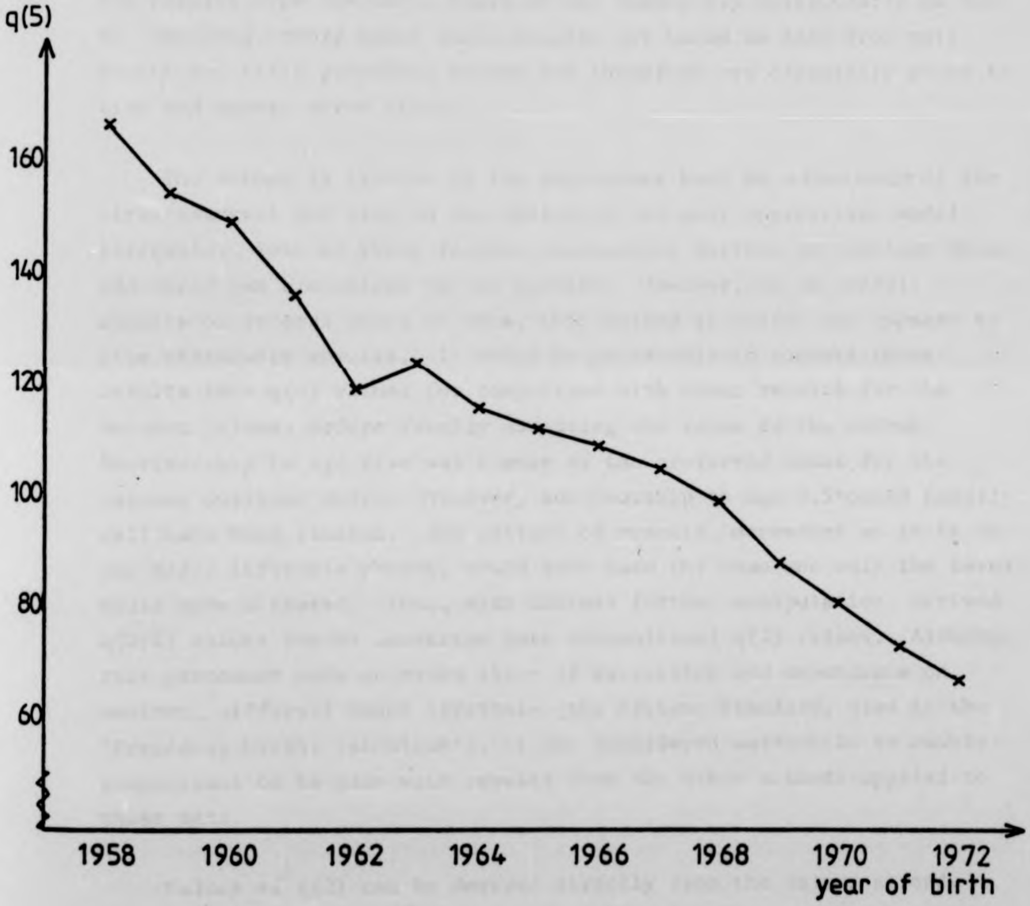
EQUIVALENT q(5) TECHNIQUE
CONVERSION OF EQUIVALENT q(5) VALUES INTO q(2) VALUES

Year of Birth of Cohort	Equivalent q(5)	Logit* (.9210)(=q(5)	Graduated Observed Logit	q(2)
1957	.160	-.8788	-.9188	.137
1958	.166	-.8552	-.8952	.143
1959	.154	-.9019	-.9419	.132
1960	.149	-.9194	-.9594	.128
1961	.136	-.9739	-1.0139	.116
1962	.119	-1.0469	-1.0869	.102
1963	.124	-1.0263	-1.0663	.106
1964	.116	-1.0625	-1.0989	.100
1965	.112	-1.0822	-1.1222	.096
1966	.109	-1.0986	-1.1386	.093
1967	.105	-1.1155	-1.1555	.090
1968	.099	-1.1477	-1.1877	.085
1969	.088	-1.2151	-1.2551	.075
1970	.081	-1.2619	-1.3019	.069
1971	.073	-1.3161	-1.3561	.062
1972	.067	-1.3618	-1.4018	.057

Note: * See text

African Standard Logits: q(2) = -.8052
q(2.5) = -.7652

FIGURE 16 DEATHS BY AGE 5 PER 1000 LIVEBIRTHS DETERMINED BY THE EQUIVALENT $q(5)$ TECHNIQUE



The graph shows a reasonably steady decline in mortality of children under five years,with one or two fluctuations. These fluctuations may be real or due to sampling errors. The fluctuations in the results from the early years of the survey may particularly be due to sampling errors since these results are based on data from only fourth and fifth preceding births and therefore are especially prone to time and memory error biases.

The method is limited by its dependence both on a knowledge of the birth interval and also on the choice of the most appropriate model lifetable. Both of these factors incorporate further assumptions which add their own dimensions to the problem. However, as an overall summary of several years of data, this method is useful and appears to give reasonable results. It would be preferable to convert these results into q(2) values for comparison with other results for the Solomon Islands before finally assessing the value of the method. Survivorship to age five was chosen as the preferred index for the reasons outlined above. However, survivorship to age 2.5 could equally well have been studied. The pattern of results, dependent as it is on the model lifetable chosen, would have been the same and only the level would have differed. Thus, with minimal further manipulation, derived q(2.5) values can be converted into conventional q(2) values. Although this procedure adds an extra stage of correction and dependence on another, different model lifetable (the African Standard, used in the 'Preceding births technique'), it was considered worthwhile to enable comparisons to be made with results from the other methods applied to these data.

Values of q(2) can be derived directly from the values already derived for the equivalent q(5). The latter are converted into equivalent q(2.5) values simply by multiplying them by the ratio* $q(2.5)_M/q(5)_M$. In the model lifetable employed, these values are

---

*The simple ratio relationship, $q(n) = cq^*(n)$, has also been used elsewhere (*e.g.* Palloni, 1978).

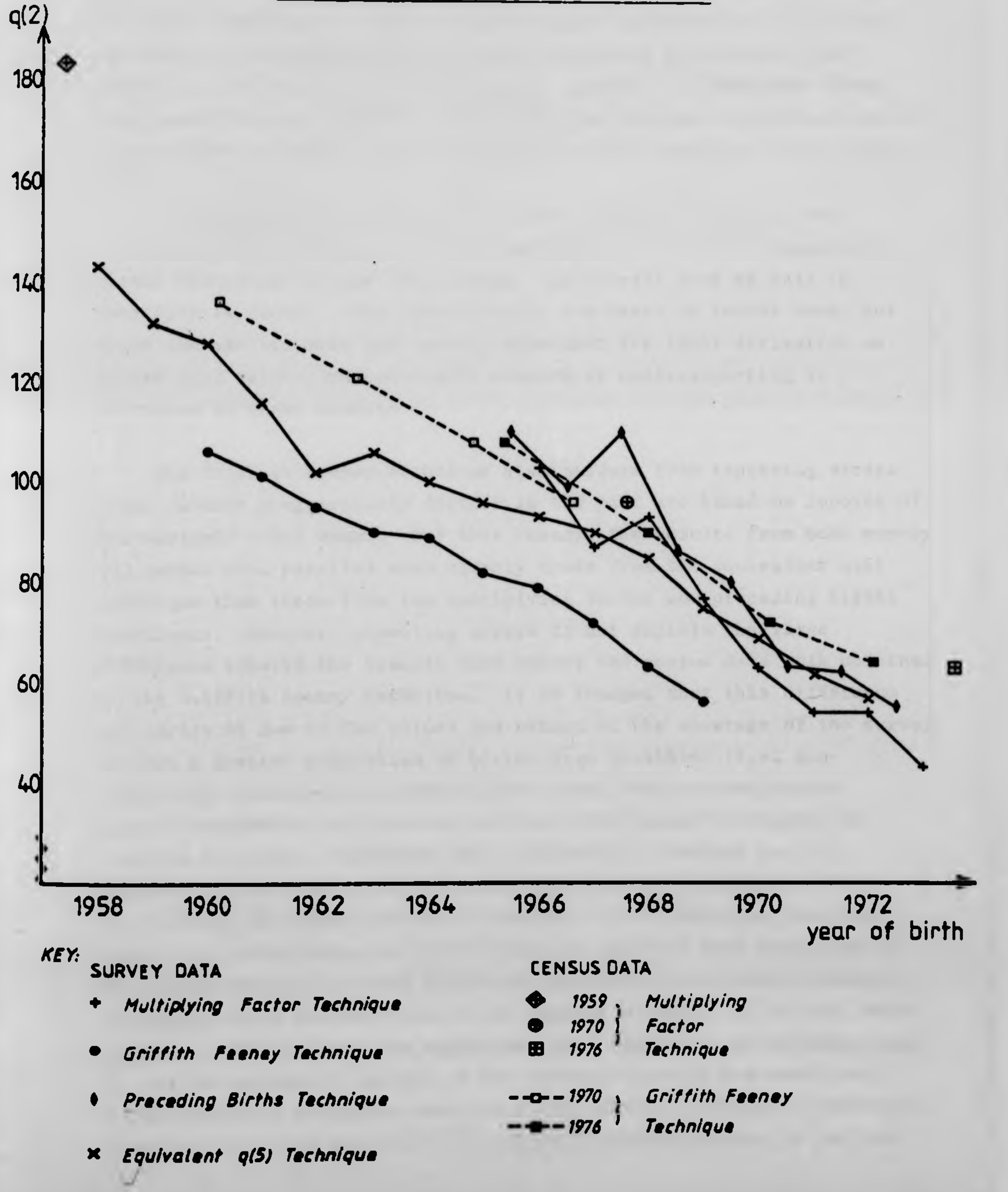
.0746/.0810 = 0.9210. If the equivalent q(5) values are all multiplied by 0.9210, the resulting values (*i.e.* equivalent q(2.5) can be converted into q(2) values by using the African Standard and the logit system (see Table 25). As to be expected, the results were similar in pattern to, but lower in level than, those for the equivalent q(5).

COMPARISON OF THE TECHNIQUES USED

Before such a comparison can be made, there are certain problems of the location in calendar time of the results from the four techniques which have to be considered. The values of childhood mortality obtained from the multiplying factor technique for, say, year n of the birth notification scheme are not formally allocated to any specific year but for convenience they can be regarded as referring to a cohort of births in year (n-2). The preceding births technique was based on the assumption that (with a birth interval of 2.5 years) the derived q(2) values referred to a cohort born 2.5 years prior to the year of notification n, *i.e.* in year (n-2.5). In the equivalent q(5) technique, cohorts of births were created from the cross-sectional notification data and the results therefore refer directly to the year of birth of the cohort. The results of these three methods, which all provide cohort values of q(2), can therefore be plotted in the year of birth of the cohort. The Griffith Feeney technique, however, provides time period results and these, for comparability with the other methods, should be located in the middle of the period over which the cohort values for q(2) refer. This, graphically, implies a displacement of one year back from the year of notification n, *i.e.* to year (n-1), which is equivalent to (cohort birth year + 1), before the number of 'years-prior-to-the-survey' can be located. The census values obtained from the multiplying factor and Griffith Feeney techniques were likewise suitably located. Having referred all results to a common abscissa of cohort birth year, it was possible to plot them together (see Figure 17).

A number of interesting features are apparent from this graph. The first point to note is that the results from the multiplying factor and preceding births techniques are generally very similar and are also

FIGURE 17 COMPARISON OF VALUES OF q(2) DETERMINED BY DIFFERENT METHODS



close to the results from the multiplying factor technique applied to the 1970 Census data. The fall in mortality indicated by the results of these two methods parallels closely the trend indicated by the census results for the two inter-censal periods. It therefore seems that survey results based on recent data are the ones which most closely compare with the results from the censuses (also based on recent data).

Although the results from the equivalent q(5) technique are reasonably close to those from the multiplying factor and preceding births techniques in the later years, the overall rate of fall in mortality is slower. The later results are based on recent data, but since the earlier ones are heavily dependent for their derivation on higher q(x) values, an inevitable element of under-reporting is contained in these results.

The Griffith Feeney technique also suffers from reporting errors since results progressively further in the past are based on reports of increasingly older women. For this reason, the results from both survey and census data parallel more closely those from the equivalent q(5) technique than those from the multiplying factor and preceding births techniques. However, reporting errors do not explain the large difference between the results from survey and census data both obtained by the Griffith Feeney technique. It is thought that this difference may partly be due to the nature and extent of the coverage of the survey in that a greater proportion of births from healthier (*i.e.* non-malarious) areas were recorded in the survey than existed in the general population and hence a lower mortality could reasonably be expected to prevail (although this differential coverage was not apparent in the results of the multiplying factor technique). More importantly, the lower levels of results by this technique from both census and survey data are probably due to the fact that Feeney based his calculations on a model pattern of mortality (the General Standard lifetable) which was not that of the Solomon Islands. If an East model lifetable (thought from the equivalent q(5) technique to represent more closely the mortality pattern of the Solomon Islands) had been used, higher mortality estimates would have been obtained from this technique, since in this model the falls in mortality between the age of two and later ages of childhood is substantially smaller than in the General Standard lifetable. (Access to Feeney's original calculations was not possible, so this could not be investigated.) Use of the East model lifetable would have significantly reduced the gap between the results from this and the equivalent q(5) techniques, but not that between the survey and census results, since the latter would also have increased. Hence, the Griffith Feeney technique appears not to be very successful for countries with different mortality patterns from those on which he based his calcualtions. It is useful merely as an indicator of trends rather than of levels of mortality.

Thus it has been shown that non-random data can be used in a variety of techniques to produce acceptable values of childhood mortality. The two techniques which give values for q(2) far into the past are particularly vulnerable to reporting errors and are therefore liable to under-estimate both the trend and the level of mortality. The conclusion is that the best evidence on childhood mortality is obtained from the methods which utilise the most recent data, *i.e.* the multiplying factor and preceding births techniques. Of these the multiplying factor technique is considered the more robust and reliable; it is based on data in a format usually collected in surveys, it is independent of any model lifetable, it is minimally dependent on the precision of the birth interval and it provides reasonable results irrespective of the proportion of births notified. It is thus this technique which is specifically recommended for the estimation of childhood mortality indices from non-random samples.

CHAPTER 6 MALARIA AND BIRTH CHARACTERISTICS

INTRODUCTION

Malaria may cause interruption of pregnancy by precipitating abortion or premature labour. It may also interfere with the growth of the foetus or even cause it to die *in utero*. In addition, the breakdown of malarial immunity is most marked in first pregnancies and so the phenomena for which malaria can be responsible are more obvious in primigravidae women. These phenomena do also occur in multigravidae women, but with progressively lessening severity with increase in parity (Lawson and Stewart, 1967).

Two such phenomena for which data concerning current births were collected in this survey are birth weights and stillbirths. Indirect evidence of the possible effect of malaria on pregnancy was also obtained from retrospective data collected at the time of notification concerning mean parities. These are the indices discussed below. For ease of reference, and as background data to this chapter, the current births notified each year in the non-malarious and malarious areas and in the malarious island of Malaita are tabulated in Tables A.2, A.3 and A.4. All indices have been studied by these sub-group areas.

BIRTH WEIGHTS

The birth weight data collected in the early years of the survey have been studied in detail by Macgregor and Avery (1974, *ibid*). Their findings are reiterated here and the final years of data added to complete and confirm the picture. They found a significant difference ($p < 0.05$) between the birth weights of babies born on Malaita Island in 1968 and 1969 (when malaria was endemic) and of those born in areas of the Solomon Islands which had been subjected to anti-malarial spraying for several years - the non-malarious areas. The difference was most noticeable in babies born to primigravidae women. The survey data confirmed these findings (see Table 26 and Figure 18) as did hospital data collected on Guadalcanal, Savo and Malaita by Jansen (1973).

The first round of anti-malarial spraying in Malaita was completed by January 1st, 1971. It can be seen from Figure 18 that the recorded birth weights rose steadily to that date to the mean weights already pertaining in the non-malarious areas. Subsequent years of data indicate that these improvements have been maintained and that the mean birth weights are approximately similar throughout the Solomon Islands - although first births weigh, on average, five ounces less than later births. The percentage of births which are premature, (*i.e.* less than 88ozs/2500gms) after being initially significantly higher in the malarious areas and Malaita than in the non-malarious areas ($p < 0.05$) (confirmed by Jansen, 1973, *ibid*), have also stabilised at a uniform level for both primigravidae and all women (see Table 27 and Figure 19). Comparable with the findings on mean birth weights, the percentage of births which are premature are higher among primigravidae women than among all women.

The particular susceptibility of primigravidae women to malarial infection has been commented on by Bruce-Chwatt (1952) who also recognised the connection between malarial infection and low birth weight. This comparison of birth weights in an endemic area both within the area before and after interruption of malaria transmission and also with non-malarious areas in the same group of islands demonstrates the quantitative effects of placental malaria.

Social customs may also have had some effect on the birth weights of babies. Willmott (1969) observed (with particular reference to Malaita) that "the women are expected to carry heavy loads ..... right up to the last weeks of pregnancy. .... Heavy work may cause the baby to be born early at a lower birth weight (this will lessen its chances of survival) ..... The mother may not be having sufficient calories to cater for the work she is doing and the production of fat in the foetus. Fat is usually accumulated by the foetus late in pregnancy; thus the child will be slightly smaller at birth". However, it is considered that (since any change in them would be gradual) such

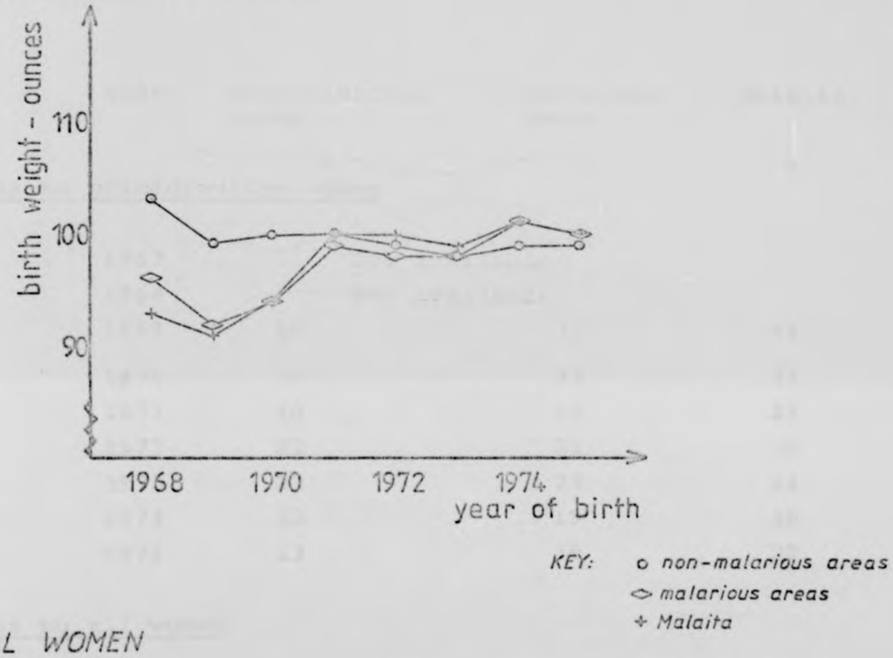
TABLE 26

MEAN BIRTH WEIGHTS (OZS)

Year	Non-Malarious Areas	Malarious Areas	Malaita
Births to primigravidae women			
1967	Not available		
1968	103	96	93
1969	99	92	91
1970	100	94	94
1971	100	99	100
1972	99	98	100
1973	98	98	99
1974	99	101	101
1975	99	100	100
Births to all women			
1967	Not available		
1968	109	102	102
1969	107	101	101
1970	106	102	103
1971	106	105	107
1972	106	104	106
1973	105	104	106
1974	105	106	106
1975	105	105	106

FIGURE 18 MEAN BIRTH WEIGHTS OF CURRENT BIRTHS TO a)PRIMIGRAVIDAE AND b)ALL WOMEN

a) PRIMIGRAVIDAE WOMEN



b) ALL WOMEN

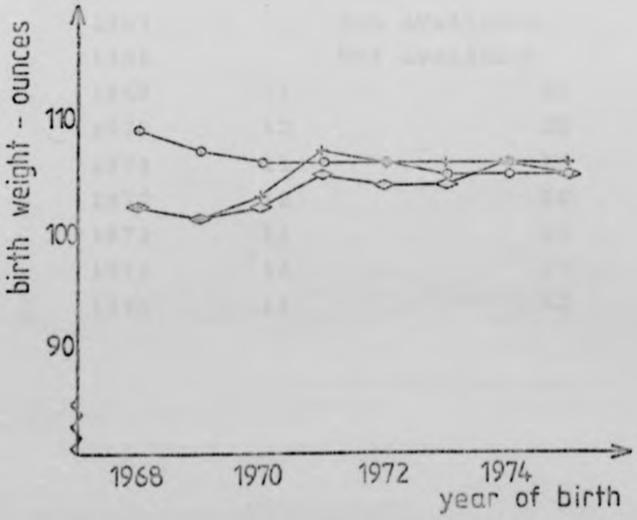


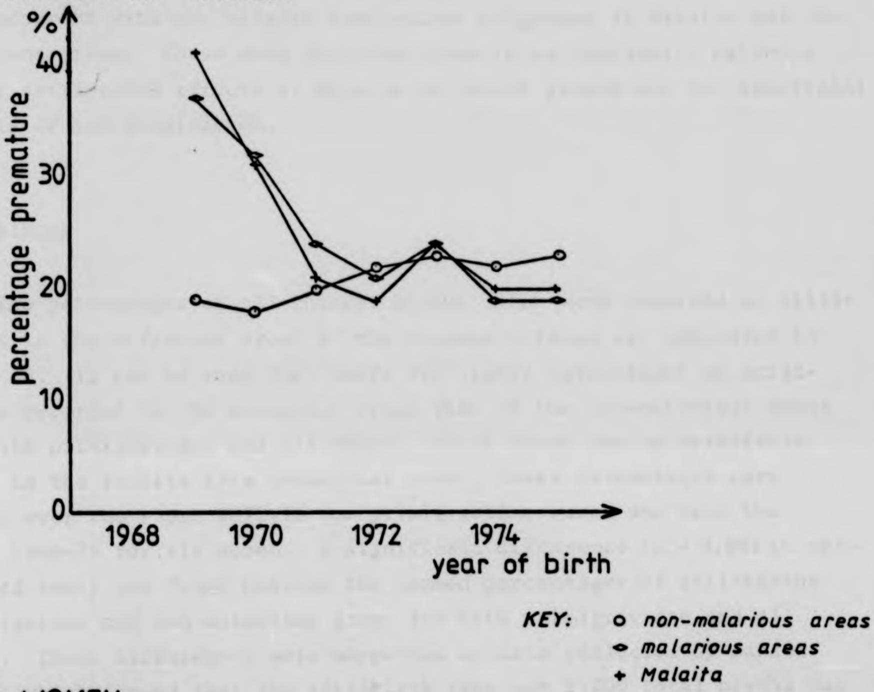
TABLE 27

PERCENTAGE OF ALL BIRTHS WHICH WERE PREMATURE

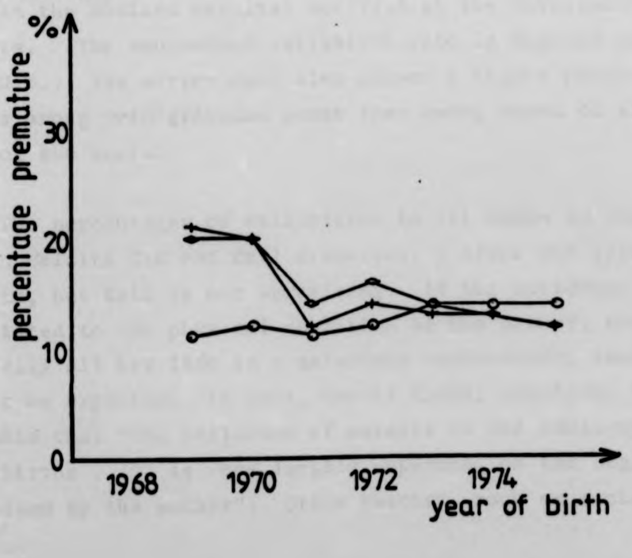
Year	Non-Malarious Areas	Malarious Areas	Malaita
	%	%	%
Births to primigravidae women			
1967	Not available		
1968	Not available		
1969	19	37	41
1970	18	32	31
1971	20	24	21
1972	22	21	19
1973	23	24	24
1974	22	19	20
1975	23	19	20
Births to all women			
1967	Not available		
1968	Not available		
1969	11	20	21
1970	12	20	20
1971	11	14	12
1972	12	16	14
1973	14	14	13
1974	14	13	13
1975	14	12	12

FIGURE 19 PERCENTAGE OF PREMATURE CURRENT BIRTHS TO a) PRIMIGRAVIDAE AND b) ALL WOMEN

a) PRIMIGRAVIDAE WOMEN



b) ALL WOMEN



customs cannot explain the dramatic rise in birth weights observed to be concurrent with the malaria eradication programme in Malaita and the malarious areas. These data therefore seem to be conclusive evidence of the detrimental effects of malaria on foetal growth and the beneficial effects of its eradication.

STILLBIRTHS

The percentages of all current births which were recorded as stillbirths in the different areas of the Solomon Islands are tabulated in Table 28. It can be seen that there are higher percentages of stillbirths recorded in the malarious areas than in the non-malarious areas for both primigravidae and all women. Since there was no detectable trend in the results from individual years, these percentages were summed over the years 1972-75 for primigravidae women and over the years 1969-75 for all women. A significant difference ($p < 0.001$ in chi-squared test) was found between the summed percentages of stillbirths in malarious and non-malarious areas for both primigravidae and all women. These differences were supported by data collected by Jansen (1969) which showed that the stillbirth rate per 1,000 total births was 18.9 at the Honiara hospital but 72.5 at the Government hospital on Malaita. (The equivalent stillbirth rate in England and Wales in 1960 was 19.8.) The survey data also showed a higher percentage of stillbirths among primigravidae women than among women of all parities in each of the areas.

The percentages of stillbirths to all women in the malarious areas and in Malaita did not fall dramatically after the eradication of malaria, but this is not surprising. If the incidence of stillbirths is related to the physical condition of the mother, who has lived virtually all her life in a malarious environment, immediate change cannot be expected. In fact, Covell (1950) concluded that it seemed probable that "the influence of malaria on the incidence of ..... stillbirths ..... is very largely dependent on the degree of tolerance possessed by the mother". Other factors, such as social and cultural

Table 28

PERCENTAGE OF ALL BIRTHS WHICH WERE STILLBIRTHS

Year	Non-Malarious Areas %	Malarious Areas %	Malaita %
Births to primigravidae women			
1967	Not available		
1968	Not available		
1969	Not available		
1970	Not available		
1971	Not available		
1972	1.6	2.4	2.4
1973	1.6	2.0	2.6
1974	1.3	2.4	1.9
1975	0.9	2.6	2.4
Σ1972-5	1.3	2.4	2.3
Births to all women			
1967	Not available		
1968	Not available		
1969	1.6	2.1	2.6
1970	1.3	1.9	2.2
1971	1.5	1.9	2.1
1972	1.2	1.5	1.8
1973	1.0	1.7	2.1
1974	1.3	2.0	2.2
1975	0.9	1.6	1.5
Σ1969-75	1.2	1.8	2.0

customs and availability of health services (particularly ante-natal facilities) may also have some effect on the incidence of stillbirths. (They are discussed in Chapter 7 in connection with their effect on child mortality.)

In the past, researchers have been divided over the effect of malaria on stillbirths. Although Blacklock and Gordon (1925) believed that stillbirth rates were much higher among mothers with malaria than among those without the infection, Garnham (1949) found only two cases of stillbirth among 111 pregnancies with malaria. Likewise, Kortmann (1972) could find no correlation between malaria and his observed 2.2% stillbirth rate (similar to the summary percentages found in this survey). However, the findings from this survey indicate that malaria may indeed have some influence on the incidence of stillbirths.

MEAN PARITIES

The mean parities per woman in each five year age group at the time of notification of her current birth (but excluding it) were summarised for the calculation of standardised mean parities by the El-Badry technique (see Appendix 4). The standardised mean parities of women living in non-malarious areas are seen (Table 29) to be higher for every year of the survey (except in 1967 where the data collection was in question, see p 71) than those of women living in the malarious areas. The 1970 Census also found lower mean parities among women living in Malaita District than among women in other districts, and a survey by Chapman and Pirie (1974, *ibid*) of the 8,000 people of the Weather Coast of Guadalcanal found mean parities among women in this non-malarious area similar to the results of comparable areas observed in both the census and this survey.

The lower mean parities in Malaita District are attributed, in the census report, to the proportion of childless women being greatest in this district. However, this cannot be the explanation for the differences found in the survey since the sample is entirely of proven

TABLE 29

STANDARDISED MEAN PARITIES FOR WOMEN AGED 15-39
(El-Badry Technique)

Year	Non-Malarious Areas	Malarious Areas	Malaita
1967	2.21	2.27	2.33
1968	2.49	2.29	2.34
1969	2.45	2.25	2.29
1970	2.44	2.20	2.17
1971	2.49	2.22	2.24
1972	2.54	2.41	2.38
1973	2.47	2.37	2.28
1974	2.56	2.34	2.31
1975	2.52	2.29	2.22

fecund women. It seems plausible therefore that the differences, albeit small, are due in part to the influence of malaria. (Newman (1970) claimed that fertility increased substantially after eradication of Malaria in Ceylon, and Pringle and Matola (1967) observed an increase in fertility rates possibly due to the eradication of malaria in the Pare-Taveta area of Tanzania). As noted above, malaria may precipitate foetal wastage. The lower level of mean parity in the malarious areas is an indirect indicator that there has been a higher level of abortions, miscarriages and stillbirths in the past in these areas than in non-malarious areas, and this may be due to the effects of malaria. (The data on current stillbirths serve to confirm this impression.) However, malaria eradication only began in the Solomon Islands in 1962. Prior to that date, the endemicity of malaria was approximately similar throughout the islands (see Chapter 7). Hence, women conceiving before 1962 (data on these births contribute substantially to the mean parity figures) were each exposed to the same potential effect of malaria on the foetus. Nevertheless, the Solomon Islanders themselves seemed to notice the difference before and after malaria eradication, if the comment of one is typical: "More people are born about (*i.e. as a result of*) the malaria spraying. Our population are more high" (Marcus Pipisi of Duidui village on Guadalcanal, quoted by Chapman, 1969).

However, many factors determine the level of fertility in a society. In particular, there are large variations in natural fertility among societies where no family planning practices are observed due to differences in social and cultural customs, especially those concerned with the length and nature of breast-feeding and with cohabitation. Hence, too much emphasis should not be placed on the effect of malaria on fertility.

CHAPTER 7

MALARIA AND CHILDHOOD MORTALITY

INTRODUCTION

Malaria is probably still the leading cause of morbidity and mortality in the tropics, despite the fact that at the end of 1974 some 1572 million (81.3%) out of 1935 million people in formerly malarious countries were largely free from the ravages of the disease as a result of the World Health Organisation's global malaria eradication strategy initiated in 1955 (WHO, 1975).

The process of malaria control appears to have caused substantial changes in the relevant rates of population growth. For example, in Ceylon, Gray (1974) claimed that the eradication of malaria contributed approximately 23.4% to the total decline in the post-war crude death rate. For many reasons, however, the measurement of such induced changes encounters serious conceptual problems, the most important of which arise from the well-established fact that malaria tends to reduce greatly the general health and resistance to disease of any affected population (Newman, 1977). Other problems exist due to the difficulties of determining cause of death as being due to malaria in a country such as the Solomon Islands where medical facilities for the determination of the cause of death are poor (Pampana, 1954). It is therefore usually appropriate merely to study overall death rates.

The higher the malaria mortality, the greater will be the proportion of malaria deaths in all deaths, and the greater will be the reduction in the death rate after malaria has been controlled. But if malaria mortality was low before malaria control (other factors being equal or if no other important variations have intervened) it will be difficult to ascribe to the latter any reduction of the general death rates (Pampana, 1954, *ibid*). Even if there was previously a high malaria mortality, it is still difficult to attribute this decrease to the disappearance of malaria, since DDT spraying often also controls other insect-borne diseases, antibiotics have been introduced and the repeated visits of health personnel may have had some health educational value. There may also be other factors of a social or economic nature which may have had an influence on vital statistics.

The malaria eradication programme in the Solomon Islands proceeded through several stages, beginning in the first area in October 1962 (see Chapter 2). The concurrence of the birth notification scheme with the main part of this programme afforded a potential opportunity of quantifying the contribution of malaria eradication to the reduction in levels of childhood mortality. Data on infant and childhood mortality were particularly valuable, both because malaria tends to become a childhood disease in endemic areas where immunity increases with age (Pampana, 1954, *ibid*), and also because the only data previously available were hospital statistics, theoretically for the Islands as a whole, but in practice selective and of dubious worth and for all ages and both sexes combined. Census data were the only other source of information on mortality, since no registration data existed.

The birth notification data were therefore studied by sub-groups according to their malarial status (see Chapter 3). It was thereby possible to study effects of malaria eradication on the levels of childhood mortality by making comparisons both between areas and also within areas over time.

ESTIMATION OF CHILDHOOD MORTALITY IN THE NON-MALARIOUS AND MALARIOUS AREAS AND IN MALAITA

All the techniques for the estimation of childhood mortality described in Chapter 5 were applied to the data from these areas. The necessary basic data can be found in Tables A.11, A.12, A.13 and the results are graphed* in Figures 20, 21, 22. It can be seen that within

---

*The results from the preceding births technique broken down by parity were not graphed since they were unuseably erratic, probably due to the very small sample sizes.

FIGURE 20 VALUES OF q(2) DETERMINED FOR THE NON-MALARIOUS AREAS

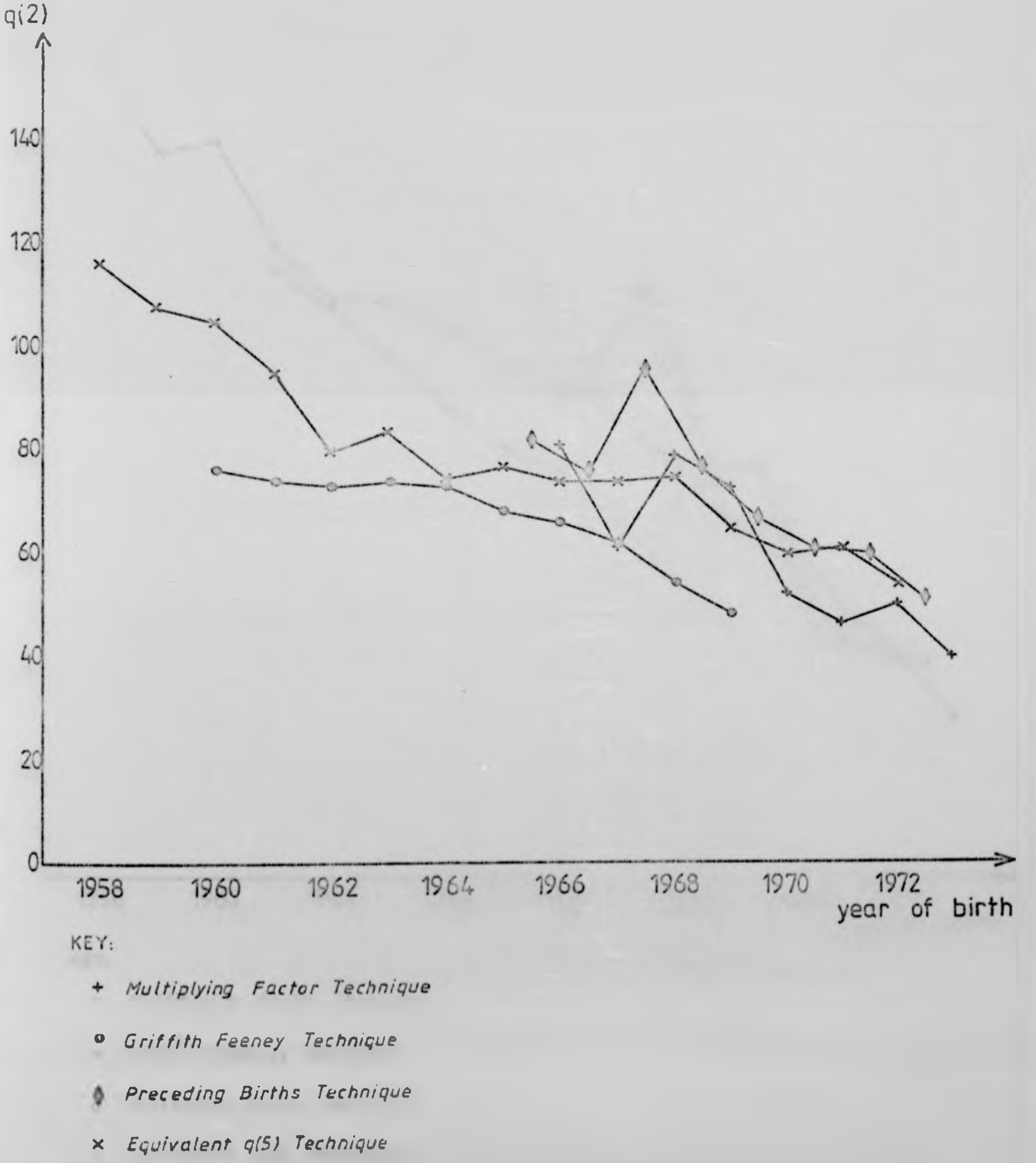


FIGURE 21 VALUES OF q(2) DETERMINED FOR THE MALARIOUS AREAS

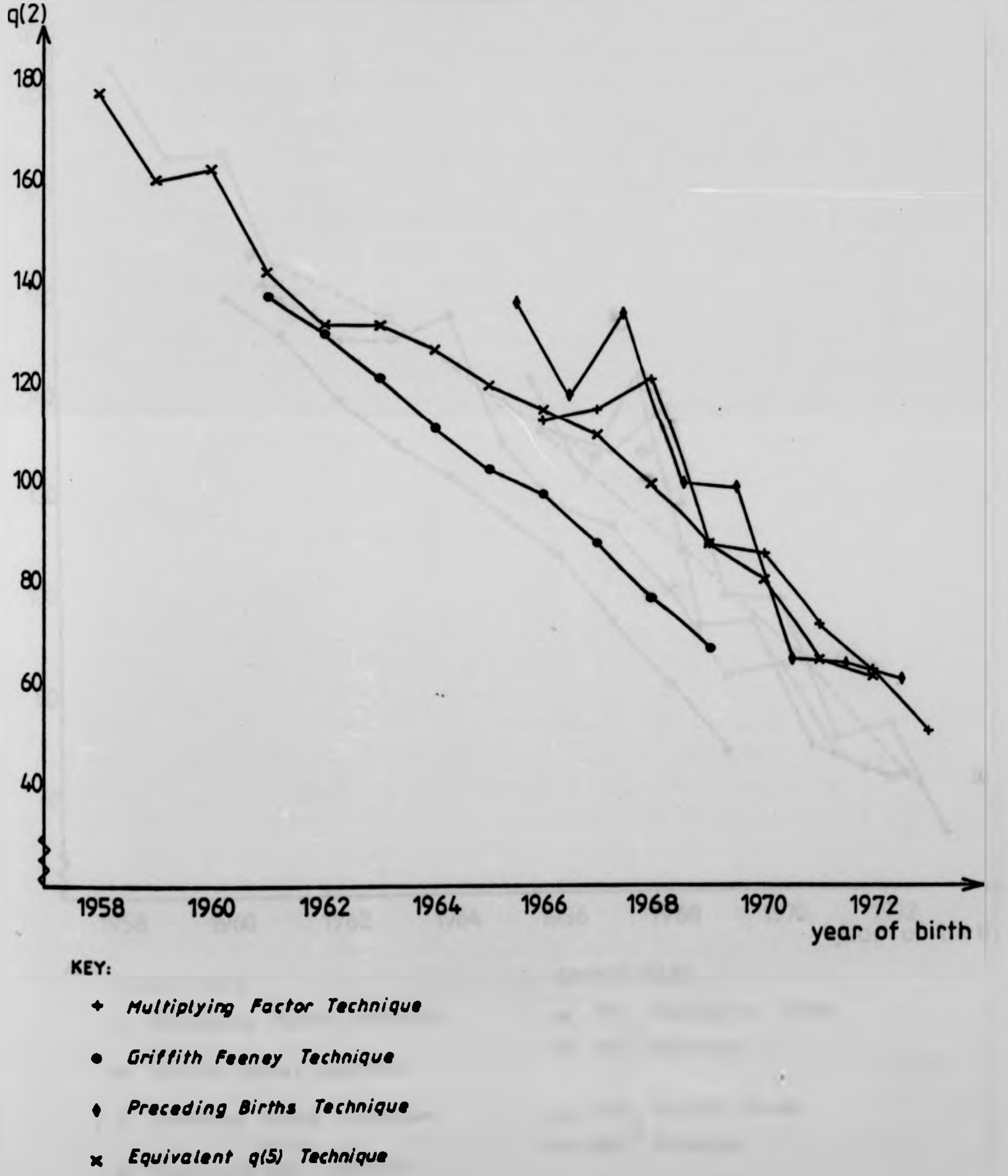
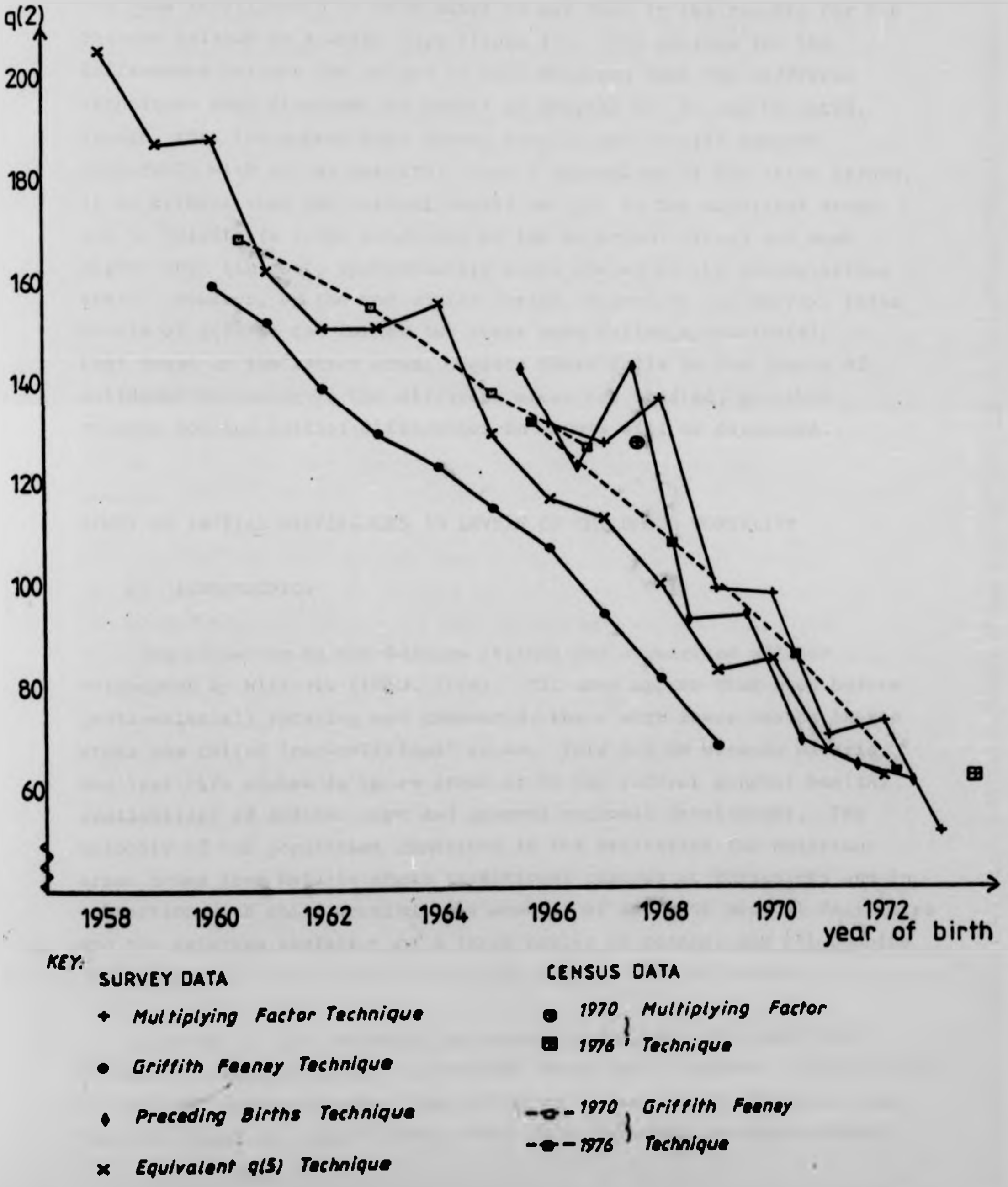


FIGURE 22 VALUES OF q(2) DETERMINED FOR MALAITA



each area the values of q(2) obtained by the different techniques show the same relationship to each other as was seen in the results for the Solomon Islands as a whole (see Figure 17). The reasons for the differences between the values of q(2) obtained from the different techniques were discussed in detail in Chapter 5. It can be noted, though, that the appropriate survey results for Malaita compare favourably with census results. From a comparison of the three graphs, it is evident that the initial levels of q(2) in the malarious areas and in Malaita (a large component of the malarious areas) are much higher than (in fact, approximately twice those) in the non-malarious areas. However, by the end of the period covered by the survey, these levels of q(2) in the former two areas have fallen approximately to that found in the latter area. Before these falls in the levels of childhood mortality in the different areas are studied, possible reasons for the initial differences in levels will be discussed.

STUDY OF INITIAL DIFFERENCES IN LEVELS OF CHILDHOOD MORTALITY

a) *INTRODUCTION*

The situation in the Solomon Islands was summarised well in retrospect by Willmott (1969, *ibid*). "It does appear that even before (anti-malarial) spraying was commenced, there were fewer deaths in the areas now called 'non-malarious' areas. This may be because malaria was less rife anyhow in these areas or it may reflect general health, availability of medical care and general economic development. The majority of the population contained in the statistics for malarious areas comes from Malaita where traditional customs at childbirth and in connection with child weaning, the absence of adequate medical facilities and the relative isolation of a large number of people, may all combine to increase the death rate of children irrespective of malaria.

However, it has been well documented throughout the world that malaria is responsible for many deaths among small children, particularly if they are under-nourished, and likewise diseases such as measles and whooping cough can also be fatal when those infected are malnourished.

Infectious diseases of childhood, tuberculosis and repeated attacks of malaria conversely also increase the likelihood of a sick child becoming malnourished, so that a vicious circle is created."

The factors which may possibly have contributed to a different child mortality level in Malaita and the other malarious areas from that in non-malarious areas, and which have been mentioned by Willmott, will now be discussed.

b) *MALARIA ENDEMICITY*

Malaria is described as 'endemic' when there is a measurable incidence of infection due to natural transmission over a succession of years (Bruce-Chwatt, 1970). The WHO classification of endemic malaria is based on either the spleen rate or the parasite rate and grades endemicity from the lowest level of hypoendemic through mesoendemic and hyperendemic to holoendemic.

In the Solomon Islands, from pre-spraying parasite surveys, the endemicity of malaria on each of the main islands was classified as shown in Table 30. It can be seen that unlike Ceylon, where the districts were grouped for study according to the endemicity of malaria (Gray, 1974, *ibid*), no such differentials in endemicity exist in the Solomon Islands, where most islands are seen to have experienced mesoendemicity. In some of the small outer islands and in small areas of some of the larger islands hyperendemicity was found, while other outer islands, *e.g.* Bellona and Tikopia, experienced only hypoendemicity (Avery, 1973-74). The populations experiencing other than mesoendemicity of malaria are very small and so, for the purposes of this study, it is reasonable to regard the overall endemicity of malaria as being approximately similar throughout the Solomon Islands. Although the definitions of endemicity are clearly very approximate, it is unlikely that this could have contributed much to the initially different levels of childhood mortality observed between areas.

TABLE 30

PRE-SPRAYING MASS BLOOD SURVEYS

	Island	First Sprayed	Date of pre-spray parasite survey	Age Group	Parasite Rate* %	Classification
NM	Guadalcanal[1]	Oct. 62	1962	All ages	30.0	
				1 - 9	44.8	high mesoendemic
NM	New Georgia Group[1]	Feb.63	1962	All ages	28.9	mesoendemic
NM	Savo[1]	July 63	1963	All ages	39.1	holoendemic
NM	Santa Isabel[2]	Dec. 69	1968	2 - 9	42.7	high mesoendemic
M	Makira[2]	Oct.71	1971	2 - 9	45.4	high mesoendemic
M	Malaita Island[2]	July 70	1967	2 - 9	44.3	mesoendemic
			1969	2 - 9	29.7	
NM	Choiseul[2]	Sept. 68	1968	2 - 9	37.7	mesoendemic

*The parasite rate is the percentage of sample blood films examined which are positive for malaria parasites. If the sample sizes are adequate, the parasite rate is the best available index of the decrease in malaria transmission over time. It should fall to a level of 16% and not more than 22% of the original rate in the 2-9 age group within one year, if malaria transmission has been adequately interrupted.

Sources: 1 Macgregor
2 Avery

c) *OTHER FACTORS*

(i) *Education*

Information on educational status was not given for each district in the Annual Reports, nor was it determined at the 1959 Census but only at the 1970 Census. It was postulated therein that one of the factors contributing to the differentials in child mortality observed between districts may have been the comparatively high level of education in the Western District (part of the non-malarious areas). Grouping the districts approximately into the survey non-malarious and malarious areas and Malaita shown a substantial difference between the proportions of both men and women who had reached Standard 7 education in the different areas (see Table 31). The women aged 30-44 at the 1970 Census are those who would have been at the peak of their child-bearing in the period prior to any anti-malarial spraying. It is quite possible that a higher level of education is linked with a higher standard of child care and a lower level of child mortality. Similarly, the census report considered that, "on the grounds that conservatism and lack of development in an area would be displayed by small literacy ratios and by high proportions of the people retaining their traditional beliefs, one would expect a close inverse relationship between these two characteristics". However, when the sub-districts of Malaita were studied in the census, this was not clearly borne out by the calculation of a coefficient of correlation, probably because of the presence of distorting factors such as out-migration. Certainly the proportions of people with Standard 7 education in Central District were distorted by in-migration to Honiara. However, this affected predominantly males aged 15-29 (in 1970) and it is considered that migration did not greatly affect the conclusions regarding the women of the districts. It is reasonable therefore to postulate that the differences in education contributed to the initial differences in child mortality levels (although these conclusions are based on 1970 Census data of the whole population). (The educational status of the women in the birth notification survey was not recorded, so comparisons based on survey data could not be made.)

TABLE 31

PERCENTAGE OF MALES AND FEMALES WHO REACHED STANDARD 7 AT SCHOOL*

Age in 1970	Non-Malarious Areas %	Malarious Areas %	Malaita %
Males			
15-29	25.3	13.3	13.5
30-44	13.7	5.2	4.9
Females			
15-29	12.0	3.9	3.9
30-44	1.9	0.5	0.4

*derived from 1970 Census data.

(ii) *Economic Development and Communications*

Unfortunately there are no data available concerning the economic development of each individual island at a time prior to anti-malarial spraying. (Economic development of the Solomon Islands as a whole is discussed in Chapter 2.) However, the impression given by writers familiar with the islands (Brookfield and Hart, 1971, *ibid*; Avery, 1977, *ibid*; Macgregor, 1966, *ibid*) leads one to conclude that any small differences in economic development which may exist between islands would not by themselves account for the observed differences in child mortality levels.

Economic development is closely linked to the level of communications which exists within and between islands, and the communications relevant to this comparative study are the intra-island ones. In fact, in all the islands, communication between coastal villages is reasonable but that with villages in the interior away from the coastal regions is limited by the hilly terrain. Communications are worst on Malaita where approximately 7,000 people live in remote bush villages which are particularly difficult of access, and can only be reached on foot along rough mountain tracks (Avery, 1977, *ibid*; Emanuel and Biddulph, 1969). Poor communications may therefore be a factor in the differential mortality observed between areas, although probably only a small factor since these data are from a survey of notified births so, by definition, the communications could not have been so bad as to have prevented notification.

(iii) *Social and Cultural Customs*

Communications and economic development are closely linked to living conditions, social and cultural customs, and traditions. Living conditions on Malaita, the most densely populated of all the islands, were considerably poorer than elsewhere. Although in 1949 (Annual Report, 1949) the people of the Western Solomons were reported to be making a definite attempt to improve their living standards, general living conditions were still poor on Malaita a few years later and it was suggested that the incidence of disease would not fall there until these were improved (Annual Report, 1952).

However, they had not improved by 1958, when Zoleveke - the Solomon Islander in charge of the anti-yaws team there - remarked with reference to the Koio district of Malaita (Annual Report of the Medical Department, 1958): "People, especially the inland dwellers, are typically primitive. Many of them are still wanderers. They have no places to live permanently and they get their [illegible] by way of stealing pigs and root crops ....

Their sanitary conditions are very poor indeed. Neglect of cleanliness is commonly seen among the people. Love of pigs supercedes that of their parents and relatives, for the animals are well cared for and much time is spent on them. The type of houses in the bush are not up to standard and are built very low without ventilation for the purpose of sharing with pigs.

..... heathen taboos also come into this, and we left all the women who were giving birth in the bush but not in the houses, those who were menstruating and in early pregnancies, and the worshippers of dirty devils at that time without injections."

This situation was confirmed by Emanuel and Biddulph (1969, *ibid*) who, during a paediatric survey of the Kwaio of Malaita, commented that "because of the inaccessible terrain, inadequate census, and menstrual taboos, many people undoubtedly missed (*anti-yaws*) treatment".

As observed by Zoleveke, in addition to enduring poor social conditions, many of the people of Malaita are pagans and still practise their traditional customs, although most people in other areas of the Solomon Islands (and parts of Malaita) have succumbed to the influence of Christian missionaries and have, in the main, discarded their traditional beliefs. This change is probably also closely linked to levels of education (even though this could not be proved statistically in the 1970 Census - see above). Several of the customs relating to childbirth and infant care - which had prevented many women on Malaita from receiving anti-yaws injections of penicillin - were almost inevitably also contributory factors in the observed higher levels of child mortality in Malaita. Emanuel and Biddalph (1969, *ibid*) observed these customs in the Kwaio, and Willmott (1969, *ibid*) commented that: "In some pagan areas on Malaita, the mother moves into a special hut for the birth of the child and she and the hut are considered unclean for 30 days after the baby's birth. Food may be brought by the mother-in-law and left outside the hut, or else the woman ...... fends for herself. Whether or not she is allowed the physical help of a midwife varies from place to place. Sometimes instructions are given by the midwife placed at a 'safe' distance away from the hut.

In some areas the child is breast-fed by a nurse until the mother's colostrum has finished .... and the child may not be given back for several days. In other places, no child can be sucked by another woman unless it is an orphan. This means that if the mother has no breast milk, the child's life is in jeopardy, unless tinned milk is available.

These customs may be dying out (*in 1969*), but are still strongly adhered to in many parts of Malaita." They serve as an indication that social and cultural customs have had a stronger influence on the survivorship of the child in Malaita than elsewhere, and that these customs are probably a contributory factor to the higher child mortality levels observed there.

(iv) *Nutrition*

The only comprehensive survey of nutrition undertaken prior to any anti-malarial spraying was that of Holmes (1952), who conducted an intensive nutrition study of six villages. Those villages - two on Malaita, one on Savo, one on Santa Isabel, two on Guadalcanal - were chosen as being representative of the different living conditions of the islands. Detailed information on the diets of each village is given but the nutritive value of the dietary components is not, so quantitative comparisons cannot be made between, say, the villages on Malaita and those on Guadalcanal. Although a few cases of malnutrition were found in children 0-9 years old, there were no significant differences in the proportions found in each village. In all the observed cases of malnutrition, it appeared that they had been precipitated by a severe attack of yaws, tropical ulcer or malaria. However, no evidence of widespread symptoms of malnutrition was found. Although nutrition could have been improved by an increased intake of protein and riboflavin-containing food, it was concluded that villagers in all areas visited could obtain an adequate diet. It was also noted that most babies 6-18 months suffered from intermittent malaria attacks, and it was thought that probably dehydration, lack of hygiene, malaria and dysentry had more significant effects on infant health than had the nature of the diet.

Hence, although no quantitative comparisons are possible, it can be concluded from this early nutrition survey that there were no important differences in nutrition between the islands of Malaita and the non-malarious areas which could account for the large differences in childhood mortality which existed prior to any attempts at malaria control. Subsequent nutrition surveys (Willmott, 1969, *ibid*; Jansen and Willmott, 1970; Jansen, 1973, *ibid*) confirmed these early findings.

(v) *Health Campaigns Against Endemic Diseases*

The Annual Report of the Medical Department (1956) stated that "it is the endemic diseases of malaria, yaws, pulmonary tuberculosis and leprosy that are the main causes of mortality and morbidity in all districts of the Protectorate".

However, lack of co-operation and resistence to outside influences have had a long history among the islanders of Malaita and these attitudes were exacerbated by the formation of the anti-Government Marching Rule movement (see Chapter 2) which prevented the people (and also the people of Makira Island) from deriving optimum benefit from the medical services (Annual Report, 1949, *ibid*). In contrast, at the same time, the people of the Western Solomons were reported to be both more advanced and also more receptive to medical propaganda.

These attitudes of the people in some areas of the Solomon Islands did not help the campaigns undertaken to try and tackle some of the endemic diseases. For example, although no trouble was experienced in assembling the villagers in part of Guadalcanal for the trial yaws campaign (Annual Report, 1953), the people of Malaita remained completely indifferent to injections even when these were brought to the door. Lack of parental control of children made the process even more difficult. A year later Malaitans were still un-coperative with surveys and investigations but more willing to take advantage of quick-acting injections (Annual Report, 1954), and the eradication of yaws was successfully achieved in 1958. Reduction in clinically active yaws was particularly dramatic in those areas such as Small Malaita where the initial incidence had been high. It was thought that the yaws campaign greatly improved the health of the people, and may therefore have had a great effect on child mortality levels and been an important contributory factor in the mortality decline everywhere. However, "a result which is probably of as great importance to the health of the people of the Solomons as the actual decrease in yaws, is a less measurable one, namely the greatly increased confidence of the people in the activities of the Medical Department" (Annual Report of the Medical Department, 1958, *ibid*). Since the lack of co-operation and degree of mistrust in the Government had been greatest in Malaita, any improvement would have been most noticeable there.

Pulmonary tuberculosis is another endemic disease against which there has been a concerted attack, though not to the same extent as with yaws. In a preliminary survey of tuberculosis in Malaita, the results were disappointing as "the people were less co-operative than in most other parts of the Protectorate" (Annual Report of the Medical Department, 1954). An extensive whole population BCG campaign was started in the Eastern and Western Solomons in 1956 and later extended to the Central Solomons and then to Malaita (Avery, 1977, *ibid*). Thus, again, Malaita was later in being reached by medical facilities than were the Western Solomons (part of the non-malarious areas). The disease is currently under good control in the Western Solomons generally and is rare in the Shortland Islands and Santa Isabel (where most of the houses are large, light and airy - Avery, 1977, *ibid*) but is still a serious problem elsewhere, especially on Malaita (where the houses are often one-roomed and windowless (Zoleveke, 1958, *ibid*; Emanuel and Biddulph, 1969, *ibid*).

Leprosy has also been extensively studied and its sufferers are now mainly under treatment. The majority of cases occur in Guadalcanal and Malaita but it is not thought that leprosy has had any significant effect on the levels of childhood mortality.

In addition to these endemic diseases, the poliomyelitis epidemic of 1951 had a devastating effect on the health of the Solomon Islands, not least on the people of Malaita (Cross, 1977). There the epidemic reached 'monstrous proportions' and was concurrent with a severe drought which, in turn, was followed by both the coldest weather in living memory and also a severe outbreak of influenza which may well have caused the deaths of many of the badly paralysed, and may also have affected childhood mortality at the time.

(vi) *Health Facilities and Services*

All records indicate that there was a considerable discrepancy between the health services in different districts of the Solomon Islands in the 1950's and early 1960's. The distribution of Government health services, as assessed in one pre-spraying year (1962) only by the number of expatriate medical officers is shown in Table 32. Comparison of the number of hospital beds in Government and Mission hospitals was not made both because it was difficult to determine from the Annual Reports of the Medical Department exactly the number of beds which conformed to the U.N. definition of a hospital bed, and also because many of the hospitals had a large and sometimes changing proportion of their beds exclusively for leprosy or tuberculosis patients. Likewise, the nature and number of both Government and Mission rural health institutions (rural health clinics, maternal and child health centres, dispensaries and dressing stations) were indeterminate, so these could not be compared between areas. Thus the difference between the numbers of people per Government expatriate medical officer in non-malarious areas and in Malaita (or in the combined malarious areas) is the only quantitative result available to support the reports

TABLE 32

GOVERNMENT HEALTH SERVICES PRIOR TO ANTI-MALARIAL SPRAYING 1962

	Non-Malarious Areas	Malarious Areas	Malaita
Total Population*	71535	60184	42531
Expatriate Government Doctors†	5	2	1
Population/ Doctor	14307	30092	42531

---

*derived from 1970 Census data and annual growth rate

†Annual Report of the Medical Department, 1962.

of the time that there was a large discrepancy in health services between different areas of the Solomon Islands (Malaita Island being by far the least well served) which undoubtedly had a considerable effect on the levels of childhood mortality.

d) *SUMMARY*

The impression is therefore gained from the above descriptions that various factors together combined to make the level of childhood mortality in Malaita approximately twice that of the non-malarious areas even before any anti-malarial spraying had occurred. Differences in education, living conditions and social and cultural customs (and particularly attitudes to health services and campaigns), health facilities and possible differences in the endemicity of yaws all contributed to this. It is possible that because of these factors, malaria (though its actual endemicity was no greater on Malaita than elsewhere) also took a greater toll.

STUDY OF THE DECLINE IN CHILDHOOD MORTALITY LEVELS

a) *INTRODUCTION*

The virtual disappearance of inter-area differentials in childhood mortality by the end of the period of the survey (see Figures 20, 21, 22) may well be associated with the eradication of malaria, as in Ceylon (Gray, 1974, *ibid*). It is hoped that the ensuing discussion will demonstrate this. Firstly, though, the reduction in endemicity of malaria must be demonstrated.

b) *MALARIA ENDEMICITY*

Decline in the parasite rate during and after a malaria eradication campaign is the best available index of the decrease in malaria transmission over time. Obviously the aim is to achieve a parasite rate of zero before it can be claimed that malaria has been eradicated.

The endemicity of malaria after the spraying operations in the Solomon Islands is shown in Table 33. It can be seen that, although the incidence of malaria has been greatly reduced (*cf.* Table 30) it has not been totally eradicated. There were pockets of resurgence of malaria (see Chapter 2) but these were not confined to Malaita and so it could be considered that the endemicity of malaria had reached a level which was generally similar throughout the islands and which was extremely low. However, the timing of these falls naturally varied between islands according to the dates of spraying and this will be discussed below in connection with the falls in childhood mortality levels.

c) *OTHER FACTORS*

Factors other than malaria endemicity, which were assessed above in connection with the initial differences in levels of childhood mortality between areas, also need to be studied in connection with the decline in mortality, and assessed for their possible contribution to this decline and to the reduction in inter-island differentials in mortality.

(i) *Education*

Unfortunately, improvements in educational standards attained in the separate areas cannot be assessed further without the 1976 Census report.

(ii) *Economic Development and Communications*

No comment can be made on any economic development in each island, since the Annual Reports do not give this information. The economy of the whole country has developed in the last decade (see Chapter 2) but if there has been differential economic growth in the islands, this has probably favoured Guadalcanal in the non-malarious areas, since it is the capital (Honiara) which has developed most rapidly. Communications are improving all the time on all the islands.

TABLE 33

MALARIA ENDEMICITY - POST-SPRAYING

AREA	DATE OF LATEST POST-SPRAYING PARASITE SURVEY	AGE GROUP	PARASITE RATE %
Guadalcanal[1]	Jan. 64	1 - 9	6.3
	Jan. 71	All	0.6
New Georgia group[1]	Nov. 64	All	2.7
Savo[1]	May 64	All	0
Santa Isabel[2]	May 72	2 - 9	0.9
Makira[2]	April 74	2 - 9	4.8
Malaita[2]	March 73	2 - 9	5.0
Choiseul[2]	Feb. 71	2 - 9	8.8

Sources: 1 Macgregor (1966)
2 Avery (1977)

(iii) *Social and Cultural Customs*

It is thought that social conditions on Malaita may have improved in the last decade and that the cultural customs may have begun to have less influence. Certainly the attitude of the people seems to have improved a little, judging from a comment by the Government Malariologist: "The Malaita anti-malarial spraying operations were regarded as being potentially the most difficult .... The island was well known for the truculent nature of its indigenes and the strict adherence to custom by the pagan bush people. These were expected to make spraying and blood-taking difficult. However, the first DDT spray round started in July 1970 with excellent public co-operation all round. This remained good for the first two years but then deteriorated during 1973-75 " (Avery, 1977, *ibid*).

(iv) *Nutrition*

The diets of the Solomon Islanders continue to be adequate throughout the Islands, according to the results of the most recent nutrition survey conducted (in 1970) in the Solomon Islands: "The data on dietary intakes would suggest that diets of most households in urban and rural areas are fairly satisfactory when compared with the WHO recommended levels" (Jansen, 1973, *ibid*). However, this was at a time when malaria had still not been eradicated from some areas and Jansen concluded, from a survey of the nutritional status of people in the malaria-infected small island of Nggela-Sandfly and in other areas already free of malaria, that "the nutritional status was best on Savo (virtually malaria-free) but on Nggela-Sandfly, where the malaria control programme had just started its activities, the overall nutritional status of the population was inferior. As the nutrient intake on Nggela-Sandfly compared fairly well, in general, with the interim WHO recommended allowances for the Western Pacific ....., it seems reasonable to conclude that the poor nutritional status of the people was mainly caused by malaria" (Jansen, 1973, *ibid*). In fact, one of the objectives of the Nutritional, Dietary and Budgetary Survey (Jansen and Willmott, 1970, *ibid*) was "to form a baseline of information against which can be measured the effects of the malaria eradication campaign on nutritional status, growth, *etc.*, and general health".

(v) *Health Campaigns Against Endemic Diseases*

The only health campaign to be actively pursued in the period under study was the malaria eradication campaign itself.

(vi) *Health Facilities and Services*

These steadily improved over the years (see Table 34; *cf.* Table 32) as judged from the improved ratio of population per Government expatriate medical officer. There was proportionally a greater improvement in Malaita and the malarious areas than in the non-malarious areas.

d) *SUMMARY*

The islands have continued to develop and progress. It is reasonable to assume that the effects on the levels of childhood mortality of improved social and cultural customs, of extended educational facilities and health services, and of general development have been favourable but gradual. The effects of these developments have probably been greater on Malaita where there was more room for improvement than in the non-malarious areas. Thus, during the period of the malaria eradication campaign, there have been no influences, other than malaria eradication itself, which are likely to have had an immediate impact on child mortality levels.

CONTRIBUTION OF MALARIA ERADICATION TO THE FALLS IN THE LEVELS OF CHILDHOOD MORTALITY

It is considered preferable to study the falls in the levels of q(2) by one technique only, so that any deficiencies in the technique (although present in the results from each area) will cancel out since

TABLE 34

GOVERNMENT HEALTH SERVICES AFTER ANTI-MALARIAL SPRAYING: 1972

	Non-Malarious	Malarious	Malaita
Total Population*	94443	79457	56151
Expatriate Government Doctors†	12	7	4
Population/doctor	7870	11351	14038

*derived from 1970 Census data and annual growth rate

†Annual Report of the Medical Department, 1972.

only internal comparisons are being made. The technique which gives values of q(2) over the longest period of time is the equivalent q(5) technique. In this, all the data on preceding births are used to derive an equivalent q(5) value and hence a q(2) value by use of a model lifetable. This approach tends to smooth any fluctuations in mortality levels so that only an overall trend emerges. In the study of mortality differentials between areas, it was decided to use this technique with only the most recent data available in an attempt to demonstrate the detailed changes in q(2) levels over time. Therefore, for recent years, only q(2.5) values were used, but q(5) and sometimes q(7.5) values had to be employed for earlier years.* This internal variation in the data base over time may contribute slightly to the pattern of results since there is likely to be a greater element of under-reporting of second and third preceding births than of first preceding births and this lowers slightly the levels of q(2) found in the earlier years. Appropriate birth cohorts (from some of the basic data in Table A.13) were created as before (see Chapter 5) and the q(x) values so obtained (see Table A.14) converted into q(2) values using logits (averaging these where necessary) and the African Standard lifetable. The resulting q(2) values for each area are tabulated in Table 35 and graphed in Figure 23. The levels and trends of childhood mortality in the non-malarious and malarious areas and in Malaita can now be seen more clearly in Figure 23 than previously in Figures 20, 21, and 22.

In the malarious areas and in Malaita there are considerable falls in q(2) values over the period covered by the survey data, by the end of which time the values have fallen approximately to that in the non-malarious areas. There is a distinctive pattern to these falls over time. This pattern is more clearly seen in Malaita, probably because the grouping of islands which formed the malarious area was not truly homogeneous but changed slightly over time. This lack of homogeneity

---

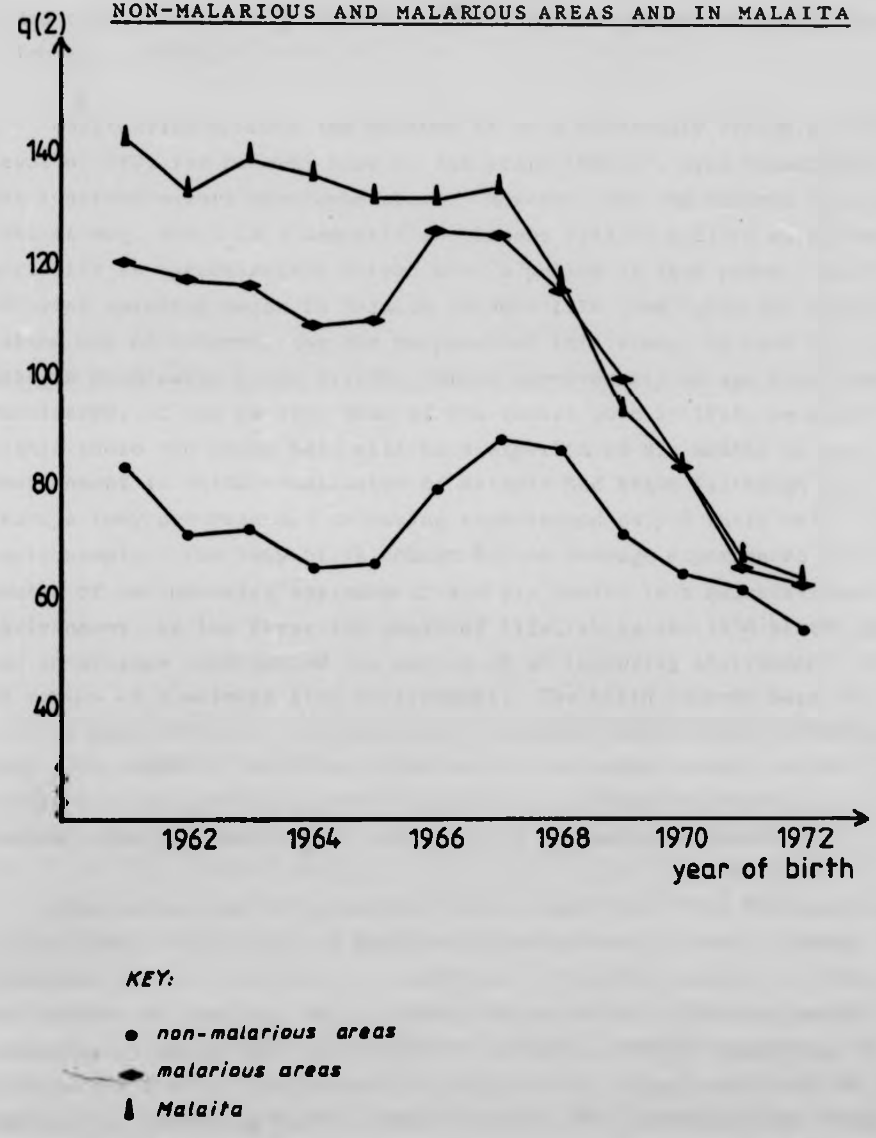
*Data from fourth and fifth preceding births were not used, nor were the suspect data from the notification records of 1967.

TABLE 35

CHILDHOOD MORTALITY BY AGE 2, q(2), IN EACH AREA, AS DERIVED BY THE ADAPTED EQUIVALENT q(5) TECHNIQUE

Year of Birth	Non-Malarious Areas	Malarious Areas	Malaita
1961	.083	.120	.142
1962	.071	.117	.133
1963	.072	.116	.139
1964	.065	.109	.136
1965	.066	.110	.132
1966	.079	.126	.132
1967	.088	.125	.134
1968	.086	.115	.117
1969	.071	.099	.093
1970	.064	.083	.083
1971	.061	.065	.067
1972	.054	.062	.063

FIGURE 23 COMPARISON OF THE NUMBER OF DEATHS BY AGE 2 PER 1000 LIVEBIRTHS IN THE NON-MALARIOUS AND MALARIOUS AREAS AND IN MALAITA



also applied to the non-malarious areas and it is only to be regretted that no non-malarious island, such as Guadalcanal, had been uniquely coded over the entire period of the survey, for comparison with Malaita which had so been.

Considering Malaita the picture is of a reasonably steady but high level of q(2) for cohorts born in the years 1961-67, even remembering the inherent errors mentioned above. However, for the cohorts born in 1968 *et seq*. there is a dramatic continuous fall in q(2) in which the mortality is approximately halved over a period of five years. Anti-malarial spraying began in Malaita in July 1970 (see Table 30) and the island was considered, for the purposes of this study, to have had malaria eradicated by/on 1.1.71. Since survivorship to age two is being considered, it can be seen that of the cohort born in 1968, in practice, within those two years half will have experienced six months in an environment in which eradication of malaria had begun (although on average they are regarded as having experienced only a fully malarious environment). The 1969 birth cohort has on average experienced six months of an improving environment and six months in a malaria-free environment, in the first two years of life, while the 1970 birth cohort has on average experienced six months of an improving environment and 18 months of a malaria-free environment. The birth cohorts born in 1971 *et seq*. have all been born into a totally malaria-free environment. This progressively improving situation is reflected clearly in the values for childhood mortality in Malaita, and this situation is, of course, also apparent in the results from the malarious areas.

Considering the non-malarious areas, there have been fluctuations in the level of q(2) and in particular an apparently sharp increase from 1965 to 1967 followed by a decrease. The lower values for 1965 and before are possibly due to errors of two kinds - firstly, under-reporting of deaths of these children compared with the reporting of more recent deaths (the values for 1966 *et seq*. being based only on the immediately preceding birth), and, secondly, the translation of mortality at ages 5 and 7.5 to mortality up to age 2 (which is dependent on the choice of model lifetable). For these reasons, the mortality in this earlier period is likely to have been higher than estimated. Nevertheless, the peaking is supported by the 1966 estimate which is strictly comparable with those from 1967 *et seq*. There is therefore good support for the view that a real fluctuation did occur. Fluctuations in childhood mortality in conditions such as exist in the Solomon Islands are to be expected from experience in other countries (*e.g.* Ceylon - Gray, 1974, *ibid*). Taking these factors into account, there has been a slight downward trend in the level of mortality over the period. The initial level of mortality was already low prior to eradication, and it is therefore difficult to ascribe any reduction in the death rates to malaria eradication (Pampana, 1954, *ibid*). It is probable that the whole of the change in these areas was due to improvements in living conditions (see above) prior to eradication and so there was little further change possible or detectable subsequent to malaria eradication. General improvements in living conditions probably also influenced the falls in childhood mortality observed in the malarious areas and in Malaita. However, the extent of the fall in these areas and the fact that the levels fall finally to those existing in the non-malarious areas are strong indications that the eradication of malaria was the main reason for these dramatic falls in childhood mortality.

These results support the impressions gained by many researchers about the effect of malaria eradication on childhood mortality. Macgregor (1966, *ibid*) commented that "village authorities on the southern coast of Guadalcanal stated that no baby died from malaria in the area after spraying began". Avery (1977, *ibid*) also asserted that "we knew from clinic records and reports of nursing staff that many more babies and toddlers were surviving once spraying started". Perhaps the eradication of malaria may also have led the people of Malaita to believe that the devil had been disposed of since they thought "C'est le 'devil' qui envoie la malaria en utilisant le moustique comme messager. Le moustique n'a pas de pouvoir en soi, la véritable cause est le devil" (Petit, 1968).

SUMMARY

Despite the limitations of the data and of the technique employed, it is still clear that the birth notification data have been valuable in monitoring the progress of the malaria eradication programme by a study of childhood mortality. By including data on the survivorship of previous children when recording a current birth and by tabulating these data according to the order of the preceding birth, a wealth of information over an extended period of time has emerged with which to study the effects of malaria eradication. Although the effects of several factors on the levels of childhood mortality are apparent in the different areas, there is still strong evidence that the most important influence has been that of malaria.

CHAPTER 8 CONCLUSIONS

The opportunity afforded by the availability of nine years of birth notification data was unprecedented. In addition, the problems associated with the analysis of maternity history data collected at the time of notification of a current birth had not been recognised prior to this study of such data. These relate to the sample being of proven fertile women only, all of whom are at the end of a birth interval. All existing methods for the derivation of conventional demographic indices from limited and defective data are based on the assumption that the sample is of all women distributed randomly over a birth interval. It was therefore the hypothesis of this thesis that such a form of data collection can be utilised to derive these conventional indices of childhood mortality and fertility. It has been shown that much has been achieved from these data to substantiate this hypothesis. The supposition rested on whether techniques could be developed which either took account of the biases inherent in the data or else capitalised on the nature of the data. The techniques developed in this thesis are assessed in an attempt to determine their overall value and whether this method of data collection has a place in the field of demographic data collection.

Most effort was put into the study of childhood mortality in which a variety of approaches was taken in order to derive reasonable values for survivorship to age two, q(2). Data on the survivorship of previous children are conventionally collected by age group of mother, and the most commonly used technique for their analysis is the Brass multiplying factor technique. The problem with these data was therefore to determine a suitable correction factor which would take account of the non-random nature of the data and which, when applied to the data, would then permit the technique to be used in the conventional manner. The determination and application of such a correction factor in the multiplying factor technique gave values of q(2) which compared very favourably with those derived from the Solomon Islands' censuses.

Use of this correction factor enabled the Griffith Feeney technique to be applied to these data in the usual way; the results were interesting. Accounting for an element of under-reporting, it was still evident that there were internal deficiencies in the technique, judging from the similar trends but different levels of q(2) values obtained from survey and census data. These deficiencies related partly to the nature and extent of coverage of the survey, but more probably to the suitability of the model used by Feeney with data from a country which appears to have a different mortality pattern from that of the model. Thus from these data it was possible also to offer a critique of a reasonably well-established technique and to conclude that the technique is more a useful indicator of trends rather than of levels of mortality.

By virtue of the fact that the women in the sample were all giving birth and therefore all at the end of a birth interval, the previous births could be located in time at semi-discrete intervals, rather than over a continuous period as in a random sample. These previous births could therefore be grouped according to the order of the preceding birth at multiples of the birth interval prior to the current birth. One innovative technique was based on a study of the survivorship of the cohort of births born immediately prior to the current births - the so-called first preceding births. The values of q(2) derived from these data closely paralleled those from the multiplying factor technique. Both these techniques use the most recent data available (although the latter technique is regarded as being the more useful and robust) and therefore suffer minimally from errors of under-reporting.

However, such errors were more evident in the results of the technique developed utilizing all the data on preceding births, in which birth cohorts were created from cross-sectional data and a knowledge of the birth interval. Such cohorts, of differing orders of preceding births, were all converted to an equivalent q(5) value using the appropriate model lifetable chosen on the basis of the 'normal' mortality pattern in the Solomon Islands. Further manipulation of these results produced q(2) values which could be compared with the results from the other methods. In addition to the memory errors already mentioned, it was found that the use of the model lifetable tended to smooth the fluctuations in q(2) values so that only overall trends in mortality were evident. Despite the problems both of the under-reporting of deaths which occurred sometime in the past and also of possible biases from the choice of a wrong model lifetable in translating the measures to a common age of survivorship, it has nevertheless been shown that reasonable estimates of trends over quite a long time period can be obtained by this method.

These several techniques have amply demonstrated the value of birth notification data in the derivation of childhood mortality indices which are reasonable and acceptable and which compare favourably with values obtained by conventional means, such as censuses. They have proved that the biases and problems created by the nature of the sample can be overcome and indeed turned to advantage. Deficiencies in data collection, reflected in the proportions of births notified, are also overcome with these techniques. This is therefore seen to be a viable method of data collection and is obviously valuable in terms of estimating levels of childhood mortality.

The Solomon Islands are not a good test of the value of the fertility methods for looking at trends in fertility, since there is no evidence that any falls in fertility are taking place. The occurrence of such falls is extremely unlikely. Hence the value of a method which studies trends in fertility cannot be tested on these data. Nevertheless, the reasonable consistency of the results for mean completed family size suggests that if there had been trends in fertility these might well have been detected.

The 1970 Census indicated approximately 6.4 children born to mothers at the end of childbearing (i.e. aged 40-44 years). Although estimates derived from this survey are of the same order, experience of parity data from other comparable populations suggests that the census result is likely to be an under-estimate. This strongly suggests the possibility that the technique adopted here is also subject to downward biases, most probably because the sample of notified births is over-weighted by the lower birth orders. Even if this is the case, it is reasonable to surmise that trends would be more reliably estimated than levels.

The results for mean completed family size were useful for the derivation of total fertility rates. Comparison of these with total fertility rates derived from age-specific fertility rates in the conventional manner gave the proportions of births notified. These proportions were an interesting observation on the progress and improvement of the data collection as the proportions steadily increased each year. Mean parity data yielded little useful information (except in as much as the mean parities for five and ten years prior to the survey could be regarded as being approximately equivalent to those of a random sample of fertile women). Since there was no trend with time to these values, they could be averaged over the nine years of survey data to smooth out small sample fluctuations and be used, by comparison with a comparably averaged value for cumulated fertility, to estimate the level of infertility. This innovative technique capitalised on the sample being of proven fertile women only but, being an exploratory method, the estimation procedure used was relatively crude. Despite this, the results were promisingly consistent and sensible. There is scope for further research into the best methods for measuring infertility based on the ideas introduced here.

The second hypothesis of this thesis concerns the possibility of monitoring the eradication of malaria by the use of these data. This potential side-benefit arose because a malaria eradication programme was being conducted in the Solomon Islands during the period in which birth notification data were being collected. There had previously been considerable controversy in the literature as to the contribution of malaria eradication to the reduction in levels of childhood mortality. With these data grouped according to the malarial status of the islands, an adaptation of the equivalent q(5) technique, which utilised only recent data, gave values of q(2) over the longest time period possible. Any deficiencies in the technique were cancelled out by the internal comparisons of q(2) values found in the non-malarious and malarious areas and the island of Malaita. Clearly different patterns of mortality were seen in the non-malarious and malarious areas. The initial differences which existed prior to any anti-malarial spraying were obviously due to causes other than malaria (*e.g.* health services, social and cultural customs), and these continued to have some progressive effect over the period of the malaria eradication programme. However, the childhood mortality levels in the malarious areas and in Malaita (also included in the figures for the malarious areas), which had previously been approximately constant, fell dramatically to that existing in the non-malarious areas at the end of the survey period. There seems no other explanation but that this fall was due to malaria eradication.

The effects of malaria eradication were also seen dramatically in some birth characteristics, notably in birth weights. These rose immediately malaria was eradicated to those birth weights already existing in the non-malarious areas. Correspondingly, there was a fall in the proportions of premature births. Collection of data on birth weights was an unusual addition to the demographic data collected, but was obviously very valuable precisely for monitoring of the malaria eradication programme. Data on stillbirths and on standardised mean parities also indicated better health of the mother and child in the non-malarious areas than in the malarious areas and this may in part be due to the removal of the influence of malaria.

It can be seen that these birth notification data, because they had been coded according to the malarial status of the island of birth of the current birth, have played an important monitoring role with respect to the malaria eradication programme. The derived q(2) values are as clear indicators as one can hope to obtain from such data of the effect of an external factor on childhood mortality. The concurrence of this birth notification scheme with the malaria eradication programme was a unique opportunity which may rarely be repeated, and it is considered that maximum advantage has been taken of the situation. Good demographic evidence of the effects of malaria eradication is uncommon, and these results add considerably to the limited body of knowledge already available.

In addition to the substantiation of the two hypotheses, the actual method of data collection is to be commended. It is extremely simple and inexpensive involving no special survey as the questionnaire is completed during routine work and visits. As a result of this study it is suggested that, with no loss of information, the data collection could be simplified even further by streamlining the questionnaire. For example, it has been shown that full details of the entire maternity history are not required. Only details of, say, the last two births immediately preceding the current birth, and merely the total number of previous children born and still alive need [illegible] recorded. Based on a refined questionnaire, simple routine tabulations could be developed to facilitate the utilisation of the data.

Hence in conclusion, this work has contributed to the use of a system which is extremely simple and which evaluates trends in childhood mortality easily and successfully. The potential of this method of data collection, regarded, *q.e.d.*, as reliable and valuable, should not be under-estimated and it is recommended that it be widely employed in the interim before full vital registration exists in developing countries.

APPENDIX

TABLES

TABLE A .1 SOLOMON ISLANDS

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE GROUP OF WOMEN

AGE GROUP OF WOMEN

1967

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
Parity 0	119	205	80	19	4	1		428
1	19	147	86	17	7	1		277
2	2	87	110	28	12	2	1	242
3	2	48	108	30	18	1		207
4		11	84	48	21	4	1	169
5		1	57	54	34	3	3	152
6			19	33	41	11	2	106
7			9	30	23	3		65
8		1	4	14	30	7		56
9			2	7	11	5		25
10				2	4	2	1	9
11				1	3	4		8
12				2		6	1	9
TOTAL	142	500	559	285	208	50	9	1753

1968

Parity 0	221	253	75	9	2			560
1	34	231	142	21	3	1		432
2	2	120	182	43	12		2	361
3		40	161	61	14	2		278
4		14	132	71	29	3	1	250
5		2	76	79	42	5	1	205
6		4	36	72	46	6	1	165
7			9	21	47	9	1	87
8			4	16	39	6		65
9				9	28	11	5	53
10				2	14	11	1	28
11					6	6	2	14
12			1		2	2	1	6
TOTAL	257	664	818	404	284	62	15	2504

TABLE A.1(contd) SOLOMON ISLANDS

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE GROUP OF WOMEN

AGE GROUP OF WOMEN

1969

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
Parity 0	259	367	115	18	3			762
1	57	317	173	28	11	4		590
2	7	157	222	71	13			470
3	3	66	222	67	31	3		392
4		9	125	109	22	2	1	268
5		2	91	107	53	4	1	258
6			31	100	78	15	1	225
7			4	37	46	10	1	98
8	1		3	18	39	19	2	82
9			2	6	23	7	1	39
10				1	16	10	1	28
11				2	5	5		12
12					5	3		8
TOTAL	327	918	988	564	345	82	8	3232

1970

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
Parity 0	283	395	132	29	5	2		846
1	48	376	159	53	8	4		648
2	6	210	249	58	15	5	1	544
3	3	71	239	103	30	2		448
4		22	145	123	47	7	1	345
5	1	6	73	117	65	18	2	282
6			22	115	99	16	4	256
7			11	46	45	9	1	112
8		1	2	17	62	22	1	105
9				8	32	17	2	59
10				8	17	17	2	44
11				1	15	5		21
12					3	5	2	10
TOTAL	341	1081	1032	678	443	129	16	3720

TABLE A.1(contd) SOLOMON ISLANDS

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE GROUP OF WOMEN

AGE GROUP OF WOMEN

1971

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
Parity 0	324	458	136	26	7	3	1	955
1	69	380	202	27	14	3	3	698
2	15	234	281	64	31	1		626
3	6	88	268	108	22	2	1	495
4	2	25	189	104	55	1		376
5	1	4	75	131	74	8	1	294
6	2	4	42	104	115	15	1	283
7		1	10	47	45	13	1	117
8		1	3	18	43	15	2	82
9			1	5	34	17	2	59
10	1		1	5	25	7	3	42
11				1	9	4	1	15
12				1	6	6		13
TOTAL	420	1195	1208	641	480	95	16	4055

1972

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
Parity 0	372	513	146	31	5	3		1070
1	63	461	253	41	9			827
2	8	260	337	81	20	1		707
3	2	139	346	135	34	8	2	666
4	1	47	202	164	58	4	2	478
5	2	8	113	166	83	15	3	390
6		2	60	157	128	23	8	378
7			17	70	82	24	2	195
8			9	28	49	18	2	106
9			4	15	45	23	3	90
10				3	31	10	6	50
11			1		18	9	4	32
12				3	13	14	6	36
TOTAL	448	1430	1488	894	575	152	38	5025

TABLE A.1(contd) SOLOMON ISLANDS

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE GROUP OF WOMEN

AGE GROUP OF WOMEN

1973

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
Parity 0	385	484	108	26	11	3		1017
1	60	409	223	36	6	2		736
2	16	258	300	77	25		1	677
3	1	104	278	123	31	7	1	545
4		33	232	154	56	7		482
5		10	97	131	69	13	1	321
6		1	38	133	85	17	2	276
7			12	58	73	9	4	156
8				27	53	10	5	95
9			2	14	36	18	5	75
10				3	23	21	3	50
11				1	7	14	3	25
12				1	3	5	1	10
TOTAL	462	1299	1290	784	478	126	26	4465

1974

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
Parity 0	307	385	91	18	4	2		807
1	57	300	146	26	7	1		537
2	7	162	229	49	13		1	461
3	2	81	212	66	36	2		399
4		23	144	107	35	4	1	314
5		4	73	90	52	4	1	224
6		1	35	77	67	10	1	191
7			6	49	56	12	4	127
8			4	15	46	12	2	79
9				8	30	5	4	47
10				7	7	9	2	25
11					8	6	2	16
12				1	8	5	2	16
TOTAL	373	956	940	513	369	72	20	3243

TABLE A. 1(contd) SOLOMON ISLANDS

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE GROUP OF WOMEN

AGE GROUP OF WOMEN

1975

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
Parity 0	520	690	182	38	16	2		1448
1	93	580	300	68	12			1053
2	18	324	365	110	36	2		855
3	3	140	332	125	46	3		649
4	1	34	261	209	81	9	1	596
5	1	13	153	222	102	20	1	512
6		3	58	144	128	31	2	366
7		1	15	74	84	12	1	187
8			9	33	92	22	3	159
9			2	14	43	18	7	84
10				8	27	16	4	55
11				1	10	8	1	20
12					10	12	1	23
TOTAL	636	1785	1677	1046	687	155	21	6007

TABLE.A.2

NON-MALARIOUS AREAS

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE GROUP OF WOMEN

	AGE OF WOMEN							
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
1967								
PARA 0	77	98	55	11	3	1		245
1	17	80	50	10	7	1		165
2	2	56	68	20	6	1	1	154
3	2	30	63	22	11	1		129
4		7	45	31	12	1	1	97
5			33	30	21	2		86
6			14	17	23	5	1	60
7			5	16	13	2		36
8		1	3	10	20	4		38
9			2	2	4	3		11
10				1	2	1		4
11				1	1	1		3
12						4	1	5
TOTAL	98	272	338	171	123	27	4	1033
1968								
PARA 0	118	105	34	1	1			259
1	21	110	51	9	1			192
2	1	55	74	20	6			156
3		23	79	24	6			132
4		7	66	27	9	1		110
5		1	42	40	14	2	1	100
6		2	20	31	18	5		76
7			6	13	17	6	1	43
8			4	6	17	3		30
9				5	12	5	2	24
10				1	6	10	1	18
11					2	4	1	7
12							1	1
TOTAL	140	303	376	177	109	36	7	1148
1969								
PARA 0	138	187	51	9				385
1	37	146	77	13	1	2		276
2	6	82	99	25	3			215
3		34	93	29	12	1		169
4		7	57	46	11	1	1	123
5		2	42	43	21	1		109
6			18	49	30	6		103
7			1	21	26	4		52
8	1			11	18	12	1	43
9				4	12	2	1	19
10				1	8	7		16
11				2	1	4		7
12					1	1		2
TOTAL	182	458	438	253	144	41	3	1519

TABLE A.2(contd)

NON-MALARIOUS AREAS

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE GROUP OF WOMEN

	AGE OF WOMEN							
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
1970								
PARA 0	200	242	79	15	2	1		539
1	38	240	89	27	3	2		399
2	6	137	141	29	9	3		325
3	3	47	139	58	15	2		264
4		20	91	71	30	6		218
5	1	5	50	74	41	8	1	180
6			14	63	63	9	2	151
7			7	38	23	7	1	76
8			2	13	36	15		66
9				7	16	9	1	33
10				7	12	8	1	28
11				1	13	4		18
12					2	3		5
TOTAL	248	691	612	403	265	77	6	2302
1971								
PARA 0	210	270	76	15	4	3	1	579
1	51	243	104	17	7	3		425
2	14	161	150	37	12	1		375
3	6	64	139	65	8			282
4	2	16	116	61	26	1		222
5	1	3	53	84	40	4		185
6	2	1	28	60	61	8	1	161
7		1	8	27	30	10		76
8		1	2	10	20	5	2	40
9			1	5	14	11	2	33
10	1		1	3	12	5	2	24
11					6	2		8
12				1	4	5		10
TOTAL	287	760	678	385	244	58	8	2420
1972								
PARA 0	244	282	65	20	3	3		617
1	50	294	139	28	7			518
2	8	174	170	40	13	1		406
3	1	98	181	75	18	3	1	377
4	1	35	115	73	33	2	1	260
5	2	6	71	88	50	11	2	230
6		1	42	83	85	16	5	232
7			12	39	47	11	1	110
8			6	16	20	13	1	56
9			2	9	27	12	3	53
10				2	13	8	5	28
11					10	6	3	19
12				2	7	8	2	19
TOTAL	306	890	803	475	333	94	24	2925

TABLE A.2(contd)

NON-MALARIOUS AREAS

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE GROUP OF WOMEN

	AGE OF WOMEN							
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
1973								
PARA 0	233	259	57	14	8	3		574
1	46	226	120	22	5	2		421
2	16	177	149	47	13			402
3	1	80	146	68	14	5	1	315
4		22	115	92	28	5		262
5		9	57	68	41	10		185
6		1	23	75	51	9		159
7			9	32	31	6		78
8				18	25	4	5	52
9			2	11	12	11	5	41
10				1	11	7	2	21
11				1	5	5	1	12
12				1	2	2		5
TOTAL	296	774	678	450	246	69	14	2527
1974								
PARA 0	202	214	37	11	2	2		468
1	42	192	78	13	5			330
2	5	116	114	23	3		1	262
3	2	57	116	38	22	1		236
4		19	78	55	17	4	1	174
5		2	47	53	21	3	1	127
6		1	25	50	35	5	1	117
7			4	30	29	7	1	71
8			3	7	21	6	1	38
9				7	11	1	2	21
10				3	4	5	1	13
11					5	2	1	8
12				1	6	3	1	11
TOTAL	251	601	502	291	181	39	11	1876
1975								
PARA 0	324	370	67	16	5	2		784
1	70	365	146	39	8			625
2	12	215	175	54	17	1		474
3	3	100	187	67	25	3		385
4	1	21	134	110	44	7		317
5	1	13	77	121	61	14		287
6		3	27	84	63	21	2	200
7		1	10	48	43	7	1	110
8			4	23	41	14		82
9			2	9	24	10	6	51
10				5	15	10	3	33
11				1	4	3		8
12					5	4	1	10
TOTAL	411	1088	829	577	352	96	13	3366

TABLE A.3

MALARIOUS AREAS

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE GROUP OF WOMEN

	AGE OF WOMEN							
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
1967								
PARA 0	42	107	25	8	1			183
1	2	67	36	7				112
2		31	42	8	6	1		88
3		18	45	8	7			78
4		4	39	17	9	3		72
5		1	24	24	13	1	3	66
6			5	16	18	6	1	46
7			4	14	10	1		29
8			1	4	10	3		18
9				5	7	2		14
10				1	2	1	1	5
11					2	3		5
12				2		2		4
TOTAL	44	228	221	114	85	23	5	720
1968								
PARA 0	103	147	41	8	1	1		301
1	13	121	91	12	2	1		240
2	1	65	108	23	6		2	205
3		18	82	37	8	1		146
4		7	66	44	20	2	1	140
5		1	34	39	28	3		105
6		2	16	41	28	1	1	89
7			3	8	30	3		44
8				10	22	3		35
9				4	16	6	3	29
10				1	8	1		10
11					4	2	1	7
12			1		2	2		5
TOTAL	117	361	442	227	175	26	8	1356
1969								
PARA 0	121	180	64	9	3			377
1	20	171	96	15	10	2		314
2	1	75	123	46	10			255
3	3	32	129	38	19	2		223
4		2	68	63	11	1		145
5			49	64	32	3	1	149
6			13	51	48	9	1	122
7			3	16	20	6	1	46
8			3	7	21	7	1	39
9			2	2	11	5		20
10					8	3	1	12
11					4	1		5
12					4	2		6
TOTAL	145	460	550	311	201	41	5	1713

TABLE A.3 (contd)

MALARIOUS AREAS

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE GROUP OF WOMEN

	AGE OF WOMEN							
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
1970								
PARA 0	83	153	53	14	3	1		307
1	10	136	70	26	5	2		249
2		73	108	29	6	2	1	219
3		24	100	45	15			184
4		2	54	52	17	1	1	127
5		1	23	43	24	10	1	102
6			8	52	36	7	2	105
7			4	8	22	2		36
8		1		4	26	7	1	39
9				1	16	8	1	26
10				1	5	9	1	16
11					2	1		3
12					1	2	2	5
TOTAL	93	390	420	275	178	52	10	1418
1971								
PARA 0	114	188	60	11	3			376
1	18	137	98	10	7		3	273
2	1	73	131	27	19			251
3		24	129	43	14	2	1	213
4		9	73	43	29			154
5		1	22	47	34	4	1	109
6		3	14	44	54	7		122
7			2	20	15	3	1	41
8			1	8	23	10		42
9					20	6		26
10				2	13	2	1	18
11				1	3	2	1	7
12					2	1		3
TOTAL	133	435	530	256	236	37	8	1635
1972								
PARA 0	128	231	81	11	2			453
1	13	167	114	13	2			309
2		86	167	41	7			301
3	1	41	165	60	16	5	1	289
4		12	87	91	25	2	1	218
5		2	42	78	33	4	1	160
6		1	18	74	43	7	3	146
7			5	31	35	13	1	85
8			3	12	29	5	1	50
9			2	6	18	11		37
10				1	18	2	1	22
11			1		8	3	1	13
12				1	6	6	4	17
TOTAL	142	540	685	419	242	58	14	2100

TABLE A.3 (contd)

MALARIOUS AREAS

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE GROUP OF WOMEN

	AGE OF WOMEN							
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
1973								
PARA 0	152	225	51	12	3			443
1	14	183	103	14	1			315
2		81	151	30	12		1	275
3		24	132	55	17	2		230
4		11	117	62	28	2		220
5		1	40	63	28	3	1	136
6			15	58	34	8	2	117
7			3	26	42	3	4	78
8				9	28	6		43
9				3	24	7		34
10				2	12	14	1	29
11					2	9	2	13
12					1	3	1	5
TOTAL	166	525	612	334	232	57	12	1938
1974								
PARA 0	105	171	54	7	2			339
1	15	108	68	13	2	1		207
2	2	46	115	26	10			199
3		24	96	28	14	1		163
4		4	66	52	18			140
5		2	26	37	31	1		97
6			10	27	32	5		74
7			2	19	27	5	3	56
8			1	8	25	6	1	41
9				1	19	4	2	26
10				4	3	4	1	12
11					3	4	1	8
12					2	2	1	5
TOTAL	122	355	438	222	183	33	9	1367
1975								
PARA 0	196	320	115	22	11			664
1	23	215	154	29	7			428
2	6	109	190	56	19	1		381
3		40	145	58	21			264
4		13	127	99	37	2	1	279
5			76	101	41	6	1	225
6			31	60	65	10		166
7			5	26	41	5		77
8			5	10	51	8	3	77
9				5	19	8	1	33
10				3	12	6	1	22
11					6	5	1	12
12					5	8		13
TOTAL	225	697	848	469	335	59	8	2641

TABLE A.4

MALAITA

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE GROUP OF WOMEN

	AGE OF WOMEN							
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
1967								
PARA 0	37	90	21	7	1			156
1	2	57	34	5				98
2		24	37	7	4	1		73
3		16	40	5	4			65
4		2	34	14	8	3		61
5		1	22	22	10		2	57
6			5	16	16	6		43
7			4	14	10	1		29
8				4	9	3		16
9				5	6	2		13
10				1	2	1	1	5
11					2	3		5
12				2		2		4
TOTAL	39	190	197	102	72	22	3	625
1968								
PARA 0	59	95	26	4	1			185
1	9	85	66	8	2	1		171
2		45	70	14	4		1	134
3		10	56	26	3			95
4		5	43	32	8	2		90
5		1	23	27	17	2		70
6		2	13	32	15			62
7			2	6	20	3		31
8				6	13	2		21
9				3	13	5	1	22
10				1	7	1		9
11					3	2	1	6
12			1		2	1		3
TOTAL	68	243	299	159	108	19	3	899
1969								
PARA 0	64	95	33	3	1			196
1	9	95	55	11	5	2		177
2		48	70	33	6			157
3	3	19	64	26	13	2		127
4		1	45	40	7	1		94
5			36	44	15	3	1	99
6			8	27	24	2		61
7			3	12	12	3		30
8			3	6	16	3	1	29
9			1	2	6	5		14
10					6	2	1	9
11					2			2
12					1	2		3
TOTAL	76	258	318	.204	114	25	3	998

TABLE A.4 (contd)

MALAITA

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE

	AGE OF WOMEN							
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
1970								
PARA 0	59	120	40	13	1			233
1	4	101	54	20	5	2		186
2		59	81	25	4	2	1	172
3		15	72	31	14			132
4		2	39	39	13	1		94
5		1	20	35	21	9		86
6			6	36	28	5	1	76
7			4	7	20	2		33
8		1		1	19	7		28
9				1	13	8	1	23
10				1	5	7	1	14
11					1	1		2
12					1	1	2	4
TOTAL	63	299	316	209	145	45	6	1083
1971								
PARA 0	69	147	46	9	2			273
1	13	98	81	10	7		3	212
2	1	46	93	19	17			176
3		18	93	31	7	2	1	152
4		8	55	28	18			109
5		1	18	33	25	3	1	81
6		3	10	34	33	5		85
7			2	16	12	2		32
8			1	4	18	6		29
9					14	2		16
10				2	10	2		14
11				1	2	2	1	6
12					1			1
TOTAL	83	321	399	187	166	24	6	1186
1972								
PARA 0	95	172	60	9	2			338
1	7	114	83	11	1			216
2		62	122	30	6			220
3	1	31	113	44	9	4	1	203
4		5	59	52	19	2	1	138
5		2	26	48	28	2	1	107
6		1	14	48	32	2	2	99
7			3	23	28	7		61
8			3	8	17			28
9			2	4	14	9		29
10					14	1		15
11			1		7	2	1	11
12					3	3	1	7
TOTAL	103	387	486	277	180	32	7	1472

TABLE A.4(contd)

MALAITA

NUMBER OF CURRENT BIRTHS BY PARITY AND AGE GROUP OF WOMEN

	AGE OF WOMEN							
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	TOTAL
1973								
PARA 0	105	154	42	9	3			313
1	9	116	78	10	1			214
2		50	99	19	9			177
3		15	83	46	11	1		156
4		5	71	40	21	1		138
5		1	21	36	20	2	1	81
6			8	33	27	5	2	75
7			2	17	27	1	4	51
8				5	18			23
9				2	18	1		21
10				2	8	8		18
11					2	4		6
12					1	1	1	3
TOTAL	114	341	404	219	166	24	8	1276
1974								
PARA 0	89	120	44	6	2			261
1	12	79	45	11	2	1		150
2		34	92	17	8			151
3		19	65	21	9	1		115
4		1	53	42	13			109
5		2	19	25	18	1		65
6			7	22	17	4		50
7			2	15	20	5	2	44
8			1	6	16	5		28
9					12	2	1	15
10				4	3	2		9
11					1	2	1	4
12					1	1		2
TOTAL	101	255	328	169	122	24	4	1003
1975								
PARA 0	124	215	100	20	9			468
1	17	147	120	25	7			316
2	4	78	128	48	13			271
3		30	92	42	13			177
4		10	87	70	31	2		200
5			49	64	32	5		150
6			23	42	46	4		115
7			4	16	30	3		53
8			3	8	30	8	2	51
9				1	12	7		20
10				1	10	4		15
11					5	4	1	10
12					3	4		7
TOTAL	145	480	606	337	241	41	3	1853

TABLE A.5

MEAN PARITIES 0, 5 AND 10 YEARS PRIOR TO SURVEY

Years Prior to Survey	Age of Women	1967	1968	1969	1970	1971	1972	1973	1974	1975	Mean Σ67-75
(a) 0*	15-19	.190	.140	.260	.214	.355	.221	.204	.201	.226	.223
	20-24	.974	1.000	.930	1.017	1.040	1.121	1.075	1.004	1.030	1.021
	25-29	2.478	2.617	2.467	2.416	2.483	2.591	2.593	2.580	2.558	2.531
	30-34	4.218	4.198	4.195	4.114	4.218	4.305	4.282	4.390	4.193	4.235
	35-39	5.303	6.070	5.826	5.941	5.698	6.130	5.805	5.951	5.735	5.829
	40-44	6.880	7.742	7.281	6.861	7.105	7.355	7.333	7.444	7.252	7.250
	45-49	5.444	7.600	7.000	7.125	6.188	7.895	7.962	8.100	8.286	7.289
(b) 5	15-19	.126	.327	.171	.092	.103	.182	.183	.155	.143	.165
	20-24	1.036	1.582	1.202	.900	.560	1.140	1.103	1.045	1.047	1.068
	25-29	2.779	3.109	2.894	2.432	2.161	2.740	2.858	2.630	2.306	2.657
	30-34	3.851	4.778	4.548	4.395	2.998	4.652	4.530	4.187	3.857	4.200
	35-39	5.680	6.726	6.293	5.566	5.337	6.059	5.921	5.750	5.439	5.863
	40-44	4.000	6.400	6.250	5.938	5.125	6.974	6.846	6.750	6.381	6.074
(c) 10	15-19	.149	.317	.201	.108	.165	.237	.177	.172	.155	.187
	20-24	1.119	1.374	1.207	.919	.715	1.080	1.116	.957	.860	1.039
	25-29	2.168	2.965	2.733	2.542	1.296	2.715	2.564	2.388	2.169	2.393
	30-34	3.900	5.371	4.549	3.946	3.400	4.118	4.167	3.889	3.729	4.119
	35-39	2.444	4.667	5.000	4.500	4.000	5.184	5.269	4.800	4.810	4.519

---

*Mean parities at the time of the current birth, but excluding it.

TABLE A. 6

INFERTILITY ESTIMATION: BASIC INFORMATION ON AGE-SPECIFIC FERTILITY RATES, F, AND MEAN PARITIES, P.

	Age of Women	1967	1968	1969	1970	1971	1972	1973	1974	1975	Mean 1967-75
(a) Age-specific fertility rates cumulated to specified ages (F)	20	.3395	.4630	.4400	.3970	.4435	.3705	.4315	.4900	.4535	.4254
	25	1.8360	1.9555	1.9705	1.9495	1.9945	1.8115	1.9030	2.0055	1.9795	1.9339
	30	3.4905	3.7790	3.6095	3.4280	3.5625	3.3165	3.3750	3.5100	3.4315	3.5003
	35	4.5920	4.9660	4.8560	4.7370	4.6940	4.5615	4.6195	4.6660	4.7215	4.7126
	40	5.5210	5.8955	5.6745	5.6210	5.5415	5.3330	5.3245	5.4120	5.4555	5.5309
	45	5.8150	6.1665	5.9370	5.9725	5.7725	5.6170	5.5860	5.6180	5.6925	5.7974
	50	5.8740	6.2400	5.9655	6.0215	5.8155	5.6965	5.6460	5.6825	5.7245	5.8518
(b) Mean parities (with adjustment of ½BI) at specified ages (P)	20	.74	.73	.70	.75	.82	.82	.75	.72	.77	.756
	25	2.05	2.20	2.00	2.03	2.05	2.17	2.22	2.14	2.13	2.110
	30	3.56	3.80	3.76	3.72	3.80	3.90	3.87	3.96	3.79	3.796
	35	5.03	5.65	5.48	5.45	5.38	5.62	5.40	5.62	5.40	5.448
	40	6.57	7.36	7.00	6.70	6.80	7.13	6.98	7.15	6.92	6.957
	45	7.45	8.43	7.70	7.08	7.57	7.80	7.88	7.98	8.05	7.771
	50	7.80	8.75	7.90	7.25	7.85	8.05	8.08	8.25	8.67	8.067

TABLE A.7

BASIC DATA AND CALCULATIONS USED IN THE MULTIPLYING FACTOR TECHNIQUE

(a) Year of Notification	(b) Age of Women	(c) No. of Women $\equiv B_c$	(d) No. of Previous Births	(e)* Previous Births + $\frac{1}{2}B_c$ $(d)+\frac{(c)}{2}$	(f)* Previous Births $+1/10B_c$ $(d)+\frac{(c)}{10}$	(g) No. Died	(h) Parity (e)/(c)	(i) Parity Ratios	(j) Proportions Died (g)/(f)
1967	15-19	142	27	98	41	3	0.6901		.0728
	20-24	500	487	737	537	37	1.4740	$P_2/P_3=.495$	.0689
	25-29	559	1385	1665	1441	138	2.9785	$P_3/P_4=.631$	.0958
	30-34	285	1202	1345	1231	172	4.7193		.1398
	35-39	208	1103	1207	1124	156	5.8029		.1388
1968	15-19	257	36	165	62	1	0.6420		.0162
	20-24	664	664	996	730	74	1.5000	$P_2/P_3=.481$	.1013
	25-29	818	2141	2550	2223	207	3.1174	$P_3/P_4=.664$	.0931
	30-34	404	1696	1898	1746	223	4.6980		.1284
	35-39	284	1724	1866	1752	254	6.5704		.1449
1969	15-19	327	85	249	118	18	0.7615		.1529
	20-24	918	853	1312	945	81	1.4292	$P_2/P_3=.482$	.0857
	25-29	988	2437	2931	2536	268	2.9666	$P_3/P_4=.632$	.1057
	30-34	564	2366	2648	2422	288	4.6950		.1189
	35-39	345	2010	2183	2045	250	6.3275		.1223

TABLE A.7(contd)

BASIC DATA AND CALCULATIONS USED IN THE

(a)	(b)	(c)	(d)	(e)	(f)
1970	15-19	341	73	244	107
	20-24	1081	1099	1640	1207
	25-29	1032	2493	3009	2596
	30-34	678	2789	3128	2857
	35-39	443	2632	2854	2676
1971	15-19	420	149	359	191
	20-24	1195	1243	1841	1363
	25-29	1208	3000	3604	3121
	30-34	641	2704	3025	2768
	35-39	480	2735	2975	2783
1972	15-19	448	99	323	144
	20-24	1430	1603	2318	1746
	25-29	1488	3855	4599	4004
	30-34	894	3849	4296	3938
	35-39	575	3525	3813	3583
1973	15-19	462	94	325	140
	20-24	1299	1396	2046	1526
	25-29	1290	3345	3990	3474
	30-34	784	3357	3749	3435
	35-39	478	2775	3014	2823

MULTIPLYING FACTOR TECHNIQUE

(g)	(h)	(i)	(j)
6	0.7155		.0560
113	1.5171	P_2/P_3=.520	.0936
215	2.9157	P_3/P_4=.632	.0828
370	4.6136		.1295
399	6.4424		.1491
13	0.8548		.0681
106	1.5406	P_2/P_3=.516	.0778
272	2.9834	P_3/P_4=.632	.0872
281	4.7192		.1015
373	6.1979		.1340
7	0.7210		.0487
111	1.6210	P_2/P_3=.524	.0636
343	3.0907	P_3/P_4=.643	.0857
442	4.8054		.1122
475	6.6313		.1326
4	0.7035		.0285
83	1.5751	P_2/P_3=.509	.0544
248	3.0390	P_3/P_4=.647	.0714
302	4.7819		.0879
359	6.3054		.1272

TABLE A.7(contd)

BASIC DATA AND CALCULATIONS USED IN THE MULTIPLYING FACTOR TECHNIQUE

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
1974	15-19	373	75	262	112	6	0.7024		.0534
	20-24	956	960	1438	1056	56	1.5042	$P_2/P_3=.488$	.0531
	25-29	940	2425	2895	2519	142	3.0798	$P_3/P_4=.630$	.0564
	30-34	513	2252	2509	2303	221	4.8908		.0959
	35-39	369	2196	2381	2233	273	6.4526		.1223
1975	15-19	636	144	462	208	9	0.7264		.0434
	20-24	1785	1839	2732	2018	87	1.5305	$P_2/P_3=.501$	.0431
	25-29	1677	4289	5128	4457	291	3.0578	$P_3/P_4=.652$	.0653
	30-34	1046	4386	4909	4491	341	4.6931		.0759
	35-39	687	3940	4284	4009	462	6.2358		.1152

TABLE A.8

GRIFFITH FEENEY TECHNIQUE FOR ESTIMATION OF INFANT MORTALITY RATES

Year of Notification	Age of Women	Proportion of Children Dead	Parity Ratios	Factor to be added (see table)	- to Age	Mean Age of Childbearing, M	Infant Mortality Rates	No. of Years Prior to Survey
1967	20-24	.0689	P_2/P_3=.495	+3	25	28, 28.5	54	2.5
	25-29	.0958	P_3/P_4=.631	-1	30	29	66	4.4
	30-34	.1398					89	6.6
	35-39						81	9.2
1968	20-24	.1013	P_2/P_3=.481	+3	25	28, 28.5	81	2.5
	25-29	.0931	P_3/P_4=.664	-1	30	29	64	4.4
	30-34	.1284					81	6.6
	35-39	.1449					85	9.2
1969	20-24	.0857	P_2/P_3=.482	+3	25	28, 28.5	68	2.5
	25-29	.1057	P_3/P_4=.632	-1	30	29	73	4.4
	30-34	.1189					75	6.6
	35-39	.1223					71	9.2
1970	20-24	.0936	P_2/P_3=.520	+2	25	27, 28	73	2.7
	25-29	.0828	P_3/P_4=.632	-1	30	29	56	4.6
	30-34	.1295					81	6.9
	35-39	.1491					87	9.5
1971	20-24	.0778	P_2/P_3=.516	+2	25	27, 28	60	2.7
	25-29	.0872	P_3/P_4=.632	-1	30	29	59	4.6
	30-34	.1015					63	6.8
	35-39	.1340					77	9.4

TABLE A.8(contd)

Year of Notification	Age of Women	Proportion of Children Dead	Parity Ratios
1972	20-24	.0636	P_2/P_3=.524
	25-29	.0857	P_3/P_4=.643
	30-34	.1122	
	35-39	.1326	
1973	20-24	.0544	P_2/P_3=.509
	25-29	.0714	P_3/P_4=.647
	30-34	.0879	
	35-39	.1272	
1974	20-24	.0531	P_2/P_3=.488
	25-29	.0564	P_3/P_4=.630
	30-34	.0959	
	35-39	.1223	
1975	20-24	.0431	P_2/P_3=.501
	25-29	.0653	P_3/P_4=.652
	30-34	.0759	
	35-39	.1152	

Factor to be added (see table)	- to Age	Mean Age of Childbearing,M	Infant Mortality Rates	No. of Years Prior to Survey
+2	25	27, 28	49	2.7
-1	30	29)	58	4.6
			70	6.9
			76	9.4
+2	25	27, 28	41	2.7
-1	30	29)	48	4.6
			54	6.8
			73	9.4
+3	25	28, 29	42	2.4
0	30	30)	38	4.2
			60	6.3
			71	8.9
+3	25	28, 28.5	33	2.5
-1	30	29)	44	4.4
			47	6.6
			66	9.1

TABLE A.9

CROSS-SECTIONAL DATA: NUMBER OF LIVEBIRTHS AND SUBSEQUENT DEATHS (ALL AGES OF WOMEN) BY ORDER OF PRECEDING BIRTH

YEAR OF NOTIFICATION

	1967		1968		1969		1970		1971		1972		1973		1974		1975	
PRECEDING BIRTHS	LB*	D*	LB	D	LB	D	LB	D	LB	D	LB	D	LB	D	LB	D	LB	D
1st	993	60	1769	209	2400	255	2796	331	3030	281	3861	333	3369	228	2390	159	4472	264
2nd	732	65	1384	174	1835	203	2170	255	2352	254	3066	328	2670	226	1866	147	3429	264
3rd	587	72	1040	175	1377	180	1641	220	1736	218	2366	301	1999	205	1421	138	2604	222
4th	460	69	791	137	994	157	1210	193	1256	187	1722	249	1460	187	1021	125	1962	235
5th	358	51	385	56	482	85	591	125	595	96	1253	226	990	144	719	90	1385	196

*LB - Livebirths

D - Subsequent deaths

TABLE A.10 **FORMATION OF BIRTH COHORTS FROM CROSS-SECTIONAL DATA***

		Year of Birth of Cohort															
From Preceding Births:		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1st	Born									1381	2085	2598	2913	3446	3615	2880	3431
	Died									135	232	293	306	307	281	194	212
2nd	Born						732	1384	1835	2170	2352	3066	2670	1866	3429		
	Died						65	174	203	255	254	328	226	147	264		
3rd	Born				814	1209	1509	1689	2051	2183	1710	2013					
	Died				124	178	200	219	260	253	172	180					
4th	Born	460	791	994	1210	1256	1722	1460	1021	1962							
	Died	69	137	157	193	187	249	187	125	235							
5th	Born	537	593	924	1122	855	1052										
	Died	105	111	161	185	117	143										

* assuming a birth interval of 2.5 years, and averaging two successive years' data where necessary.

TABLE A.11

BASIC DATA REQUIRED FOR THE MULTIPLYING FACTOR AND/OR GRIFFITH FEENEY TECHNIQUES

NUMBER OF PREVIOUS LIVEBIRTHS† AND SUBSEQUENT DEATHS (ALL PARITIES)

YEAR OF NOTIFICATION

	Age of	1967		1968		1969		1970		1971		1972		1973		1974		1975	
	Women	LB*	D*	LB	D	LB	D	LB	D	LB	D	LB	D	LB	D	LB	D	LB	D
NON-MALARIOUS AREAS																			
	15-19	25	3	22	0	57	12	63	5	129	11	83	5	80	40	56	4	110	6
	20-24	292	17	325	28	437	29	734	64	841	67	1086	62	942	48	670	36	1242	54
	25-29	834	60	1076	80	1090	89	1518	107	1768	150	2193	142	1785	136	1388	66	2224	129
	30-34	691	67	782	72	1120	108	1759	194	1639	141	2049	206	1945	142	1312	102	2517	192
	35-39	622	69	663	79	884	81	1603	183	1422	148	2011	210	1392	143	1087	123	2043	199
MALARIOUS AREAS																			
	15-19	2	0	14	1	28	6	10	1	2	2	16	2	14	0	19	2	34	3
	20-24	195	20	339	42	416	52	365	49	402	39	517	49	454	35	290	20	597	33
	25-29	551	78	1065	177	1347	179	975	108	1232	122	1662	201	1560	112	1037	76	2065	162
	30-34	511	105	914	151	1246	180	1030	176	1065	140	1800	236	1412	160	940	119	1869	149
	35-39	481	87	1061	175	1126	169	1029	216	1313	225	1514	265	1383	216	1109	150	1897	263
MALAITA	15-19	2	0	9	1	15	5	4	0	15	1	10	2	9	0	12	2	24	2
	20-24	159	17	234	34	246	34	277	42	291	32	361	39	277	21	214	17	426	24
	25-29	488	73	715	97	814	123	736	95	920	104	1166	156	961	77	776	57	1393	112
	30-34	477	102	650	125	819	138	763	152	772	112	1157	173	896	103	716	94	1264	98
	35-39	421	82	682	131	640	120	838	184	918	162	1121	210	977	176	702	103	1330	192

† - Number of previous livebirths without correction of $1/10B_c$

* - LB - Livebirths
D - Subsequent deaths

TABLE A.12

BASIC DATA REQUIRED FOR PRECEDING BIRTHS TECHNIQUE: FIRST PRECEDING BIRTH ONLY

NUMBER OF LIVEBIRTHS AND SUBSEQUENT DEATHS (ALL AGES OF WOMEN)

	YEAR OF NOTIFICATION																	
	1967		1968		1969		1970		1971		1972		1973		1974		1975	
Non-Malarious Areas	LB*	D*	LB	D	LB	D	LB	D	LB	D	LB	D	LB	D	LB	D	LB	D
All Parities	601	23	846	75	1109	91	1719	177	1800	149	2261	163	1909	125	1382	90	2539	137
1st Born	155	3	183	17	269	27	392	37	414	36	508	25	408	19	321	27	614	32
2nd & 3rd Born	274	13	274	17	381	24	578	56	641	43	769	54	702	45	488	27	849	47
4th - 12th Born	N/A		389	41	459	40	749	84	745	70	984	84	799	61	573	36	1076	58
Malarious Areas																		
All Parities	392	37	923	134	1291	164	1077	154	1230	132	1600	170	1460	103	1008	69	1933	127
1st Born	107	12	217	24	307	31	240	26	269	29	302	25	307	26	200	14	420	25
2nd & 3rd Born	156	13	310	46	459	59	395	49	456	37	584	45	494	27	358	23	634	46
4th - 12th Born	N/A		396	64	525	74	442	79	505	66	714	100	659	50	450	32	879	56
Malaita																		
All Parities	332	34	609	93	766	101	824	126	891	89	1101	111	936	70	729	50	1349	89
1st Born	94	12	154	15	172	18	179	21	209	23	210	20	208	19	147	11	309	18
2nd & 3rd Born	128	12	197	31	268	36	297	41	322	25	419	25	323	15	263	17	439	31
4th - 12th Born	N/A		258	47	326	47	348	64	360	41	472	66	405	36	319	22	601	40

* LB - Livebirths
D - Subsequent deaths

TABLE A.13

BASIC DATA REQUIRED FOR EQUIVALENT q(5) TECHNIQUE

NUMBER OF LIVEBIRTHS AND SUBSEQUENT DEATHS (ALL AGES OF WOMEN)

	YEAR OF NOTIFICATION																	
	1967		1968		1969		1970		1971		1972		1973		1974		1975	
	LB*	D*	LB	D	LB	D	LB	D	LB	D	LB	D	LB	D	LB	D	LB	D
NON-MALARIOUS AREAS																		
PRECEDING BIRTHS																		
1st	601	23	846	75	1109	91	1719	177	1800	149	2261	163	1909	125	1382	90	2539	137
2nd	445	35	668	62	839	68	1325	127	1393	130	1761	150	1508	111	1062	74	1922	124
3rd	346	29	512	81	633	56	1012	115	1021	107	1357	131	1118	90	811	56	1463	112
4th	260	31	391	55	463	62	760	94	747	90	988	103	803	82	571	52	1080	121
5th	208	21	192	19	239	37	366	62	343	45	732	104	543	71	403	38	774	85
MALARIOUS AREAS																		
PRECEDING BIRTHS																		
1st	392	37	923	134	1291	164	1077	154	1230	132	1600	170	1460	103	1008	69	1933	127
2nd	287	30	716	112	996	135	845	128	959	124	1305	178	1162	115	804	73	1507	140
3rd	241	43	528	94	744	124	629	105	715	111	1009	170	881	115	610	82	1141	110
4th	200	38	400	82	531	95	450	99	509	97	734	146	657	105	450	73	882	114
5th	150	30	193	37	243	48	225	63	252	51	521	122	447	73	316	52	611	111
MALAITA																		
PRECEDING BIRTHS																		
1st	332	34	609	93	766	101	824	126	891	89	1101	111	936	70	729	50	1349	89
2nd	241	28	458	88	604	108	647	113	682	90	897	123	739	71	579	49	1037	105
3rd	206	37	336	73	452	84	480	92	511	91	677	135	556	72	430	55	779	72
4th	177	35	256	60	331	70	352	90	363	76	484	115	406	67	318	61	606	79
5th	137	29	131	31	144	32	175	55	177	43	350	93	272	54	214	40	409	83

* LB - Livebirths D - Subsequent Deaths

TABLE A.14

BIRTH COHORT VALUES OF q(x) DERIVED FROM CROSS-SECTIONAL DATA FOR USE IN THE ADAPTED EQUIVALENT q(5) TECHNIQUE

	YEAR OF BIRTH COHORT											
q(x)	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Non-Malarious Areas												
q(2.5)						.0849	.0948	.0926	.0768	.0691	.0656	.0581
q(5)			.0928	.0810	.0958							
q(7.5)	.1204	.1045	.1091	.1001	.0897							
Malarious Areas												
q(2.5)						.1346	.1343	.1239	.1067	.0895	.0697	.0666
q(5)			.1564	.1355	.1515							
q(7.5)	.1714	.1674	.1607	.1636	.1513							
Malaita												
q(2.5)						.1410	.1434	.1259	.1004	.0893	.0720	.0674
q(5)			.1921	.1788	.1747							
q(7.5)	.2005	.1888	.1855	.1902	.1831							

APPENDICES

APPENDIX 1

CONFIDENTIAL

SOLOMON ISLANDS
MEDICAL DEPARTMENT

Med/93 (Rev. 1968)

NOTIFICATION OF LIVE/STILL BIRTH

This certificate must be completed within seven days of the date of birth and sent to the Registrar of Births, Medical Headquarters, P. O. Box G 9, Honiara.

PLACE OF BIRTH

AREA No. 1 ☐ SERIAL No. 2 3 4 5 6 7 8 9 ☐☐☐☐☐☐☐☐ D D M M Y Y FORM No. 10 ☐

at (House, Village or Institution) .... Island or Sub-district ....

District .... on (date) .... at (time) .... a. m. /p. m.

CHILD

NAME ....
(two names if possible underline last or surname)

SEX: 11/1 Male ☐ 11/2 Female ☐ | THIS BIRTH: 12/1 Single ☐ 12/2 Twin ☐ 12/3 Triplet ☐ | IF TWIN OR TRIPLET: 13/1 First ☐ 13/2 Second ☐ 13/3 Third ☐

LENGTH OF PREGNANCY: 14 15 Completed weeks ☐☐ | WEIGHT AT BIRTH: 16 17 lb. ☐☐ 18 19 oz. ☐☐ | LEGITIMATE: 20/1 Yes ☐ 20/2 No ☐

FATHER

NAME ....
(two names if possible; underline last or surname)

AGE (at the time of this birth): 21 22 Years ☐☐ | BIRTHPLACE: 23/1 B. S. I. P. ☐ 23/2 Foreign Country ☐ | OCCUPATION: 24 25 ☐☐ | BUSINESS OR INDUSTRY: 26 27 ☐☐

MOTHER

MAIDEN NAME ....
(two names if possible; underline last or surname)

AGE (at time of this Birth): 28 29 Years ☐☐ | AGE (at first marriage): 30 31 Years ☐☐ | BIRTHPLACE: 32/1 B. S. I. P. ☐ 32/2 Foreign Country ☐

USUAL ADDRESS (in full) ....

OTHER CHILDREN

BIRTH ORDER	SEX M	SEX F	Date of Birth or Best Estimate of Month	Year	Born Alive	Still Born	Now Alive	Now Dead
First	33/1 ☐	33/2 ☐	34 35 ☐☐	36 37 ☐☐	38/1 ☐	38/2 ☐	39/1 ☐	39/2 ☐
Second	40/1 ☐	40/2 ☐	41 42 ☐☐	43 44 ☐☐	45/1 ☐	45/2 ☐	46/1 ☐	46/2 ☐
Third	47/1 ☐	47/2 ☐	48 49 ☐☐	50 51 ☐☐	52/1 ☐	52/2 ☐	53/1 ☐	53/2 ☐
Fourth	54/1 ☐	54/2 ☐	55 56 ☐☐	57 58 ☐☐	59/1 ☐	59/2 ☐	60/1 ☐	60/2 ☐
Fifth	61/1 ☐	61/2 ☐	62 63 ☐☐	64 65 ☐☐	66/1 ☐	66/2 ☐	67/1 ☐	67/2 ☐
Sixth	68/1 ☐	68/2 ☐	69 70 ☐☐	71 72 ☐☐	73/1 ☐	73/2 ☐	74/1 ☐	74/2 ☐

(Use a second form if more than six previous children born)

INFORMANT

NAME .... QUALIFICATIONS ....

ADDRESS .... DATE SIGNED ....

I hereby certify that the child named above was born.... Alive ☐ 75/1 Stillborn ☐ 75/2 on the date stated

Signature ....

REGISTRAR

Date Received .... Date on which child's name added .... by ....
(Registrar)

Registrar's Signature ....

Other Data

This baby is to be immunised at ....(name of clinic) in .... District, and the mother has been advised accordingly.

ALL ENTRIES EXCEPT SIGNATURES MUST BE TYPED OR CLEARLY PRINTED

CONFIDENTIAL

212-68

APPENDIX 2 REASONS FOR REJECTION OF QUESTIONNAIRES

(based on processing of 1975 data)

Error No.	Reason
1	Not a number 1 form
2	Area code: non-existent
3	Sex: non-existent
4	No. of children at birth - not filled in
5	No 'alive or stillborn'
6	Day of birth GT 31
7	Month of birth GT 12
10	Year incorrect
11	Birth weight too big in metric (GT 6000)
12	Metric weight EQ 0
13	lb oz weight too large
14	Over 15 oz should be 1lb
15	Weight too large (GT 176) in ozs
19	Mother not of childbearing age LT 12 or GT 50
20	For other children - (stillborn/born alive) (now alive/dead) not filled in
21	2 births occurred in less than 9 months
22	Other children - months GT 12
23	(Children now alive and children dead) not filled in ≠ children born alive
30	Should be a no. 2 form but isn't
40	Dates of birth wrong - previous child born after new child
41	Age of mother at birth of other children was less than 12 years

Questionnaires: 697 initially rejected
332 then accepted
365 errors

APPENDIX 3 MEAN COMPLETED FAMILY SIZE: CALCULATION OF MID-YEAR POPULATIONS OF ALL WOMEN AGED 15-49 IN THE SOLOMON ISLANDS

The number of women in each age group of the reproductive period enumerated in the 1959 and 1970 Censuses as proportions of the total number of women of all ages were calculated, as were the number of months from the 1959 Census to the mid-point of each year of the survey. The mid-year population of women of all ages was calculated using the formula (Barclay, 1958)

$$P_2 = P_1 e^{rn}$$

where:- P_2 - required population at mid-point of each year

n - number of years between census and mid-point of year in question

(P_1 - female population in 1959 Census = 58542

(r - annual rate of growth between 1959 and 1970 Census = 0.0256

or (P_1 - female population in 1970 Census = 75819

(r^* - annual rate of growth between 1970 and 1976 Census = 0.0340

The proportion of women in each age group were calculated using the formula:-

---

[*] From preliminary results of 1976 Census.

$$N_i = P_{59} + f_n(P_{70} - P_{59})$$

where:- N_i - required proportion of women in age group i

P_{59} - proportion of women in age group i enumerated in 1959 Census

P_{70} - proportion of women in age group i enumerated in 1970 Census

f_n - $\dfrac{\text{number of months between 1959 Census and midpoint of year n}}{\text{number of months between 1959 and 1970 Censuses}}$

Hence, having calculated the proportion of women in each age group and the total number of women in the whole population for each year of the survey, the numbers of women in each age group of the reproductive period were easily calculated (see Table 3(i)). These are then used in the calculations (see Chapter 4) of the standardised distribution of births and the empirical reference distribution of births (see Table 3(ii)).

TABLE 3(i)

MID-YEAR POPULATIONS OF ALL WOMEN OF REPRODUCTIVE AGE IN THE SOLOMON ISLANDS

	YEAR								
Age of Women	1967	1968	1969	1970	1971	1972	1973	1974	1975
15-19	7281	7402	7537	7659	7858	8061	8259	8475	8685
20-24	5814	5935	6082	6214	6402	6612	6812	7022	7245
25-29	5878	5986	6112	6229	6402	6587	6761	6960	7154
30-34	4503	4541	4590	4630	4708	4784	4862	4943	5021
35-39	3897	4074	4275	4468	4708	4965	5228	5506	5796
40-44	2964	3059	3172	3276	3420	3565	3721	3885	4046
45-49	2636	2730	2827	2922	3054	3187	3321	3471	3618
TOTAL ALL AGES	71246	73002	74992	76902	79534	82339	85145	88102	91134

TABLE 3(ii)

COMPONENTS OF THE GRAPHS USED IN THE

	Birth Order	1967	1968
a) Abscissa:Empirical Reference Distribution of Births	1st	.152	.153
	2nd	.145	.146
	3rd	.135	.135
	4th	.124	.125
	5th	.112	.112
	6th	.097	.097
	7th	.079	.079
	8th	.061	.060
	9th	.043	.042
	10th	.027	.027
	11th	.014	.014
	12th	.008	.008
	13th	.004	.003
b) Ordinate:Standardised Observed Distribution of Births	1st	.210	.187
	2nd	.143	.156
	3rd	.131	.137
	4th	.114	.109
	5th	.101	.104
	6th	.097	.092
	7th	.076	.078
	8th	.045	.045
	9th	.042	.034
	10th	.019	.030
	11th	.007	.017
	12th	.007	.009
	13th	.009	.004

CALCULATION OF MEAN COMPLETED FAMILY SIZE

YEAR OF NOTIFICATION						
1969	1970	1971	1972	1973	1974	1975
.154	.154	.155	.156	.157	.158	.159
.146	.147	.148	.148	.149	.150	.151
.136	.137	.137	.138	.138	.139	.139
.125	.125	.125	.127	.126	.126	.126
.112	.112	.112	.113	.113	.113	.113
.097	.097	.096	.096	.096	.096	.096
.079	.078	.078	.077	.077	.076	.076
.060	.060	.059	.059	.059	.058	.058
.042	.041	.041	.040	.040	.040	.039
.026	.026	.026	.025	.025	.024	.024
.014	.013	.013	.013	.012	.012	.012
.007	.007	.007	.006	.006	.006	.005
.003	.003	.003	.003	.003	.003	.003
.201	.192	.203	.180	.194	.214	.207
.166	.158	.158	.148	.149	.152	.160
.139	.137	.147	.132	.144	.136	.137
.120	.118	.121	.131	.123	.123	.108
.088	.098	.097	.100	.114	.104	.107
.089	.087	.084	.088	.082	.078	.098
.085	.084	.084	.090	.074	.070	.073
.039	.037	.036	.048	.043	.049	.038
.034	.037	.027	.027	.027	.031	.033
.017	.022	.020	.024	.022	.019	.018
.013	.017	.014	.014	.016	.011	.012
.005	.008	.005	.009	.008	.007	.005
.004	.004	.005	.011	.004	.007	.005

APPENDIX 4 THE EL-BADRY TECHNIQUE FOR THE STUDY OF MEAN PARITY DATA

This method was devised to summarise a series of parity data by five year age groups of mothers into a single index of fertility. El-Badry (1967, *ibid*) calculated the mean parity of mothers in each five year age group of women registering a birth in Bombay City, and then used these mean parities as multiplicands of the total number of mothers in each five year age group to determine the total number of children which would have been born to all mothers at the rates of those registering births. He restricted his calculations to mothers aged 15-39 due to the very small numbers of mothers aged 40 and over. The total number of children born to women aged 15-39 in the standard population was divided by the number of these women to obtain a standardised mean parity for the whole age group. Since this is a fairly crude method to devise only an unconventional index of fertility, it can only be used for internal comparisons between sub-groups (see Chapter 6) or over time, as here.

The standard population of mothers in the Solomon Islands is not known except in census years. The total population of all women aged 15-39, in five year age groups (see Table 3(i)), was therefore taken as the standard in this instance and multiplied by the mean parities of the women in the survey (see Table A.5) to derive the standardised number of births and hence standardised mean parities (see Table 4(i)). Little can be concluded from the results, except to note the fluctuations of the value over time and the absence of any trend - a conclusion similar to the one based on mean parities and mean completed family size values (see Chapter 4). The results are not directly comparable with El-Badry's figures since the standard population used in this study (all women) differed from the one used in the Bombay study (mothers).

TABLE 4(i)

EL-BADRY TECHNIQUE TO DERIVE STANDARDISED MEAN PARITIES

		YEAR OF NOTIFICATION								
	Age of Women	1967	1968	1969	1970	1971	1972	1973	1974	1975
Standardised Number of births	15-19	1384	1037	1959	1640	2788	1781	1681	1704	1966
	20-24	5663	5935	5656	6318	6659	7412	7321	7051	7465
	25-29	14563	15668	15076	15047	15899	17065	17531	17955	18296
	30-34	18991	19063	19255	19046	19860	20597	20819	21699	21054
	35-39	20666	24729	24906	26544	26826	30435	30349	32766	33240
	15-39	61267	66432	66852	68595	72032	77290	77701	81175	82021
Standardised Mean Parity Per Woman	15-39	2.24	2.38	2.34	2.35	2.39	2.49	2.43	2.47	2.42

B I B L I O G R A P H Y

BIBLIOGRAPHY

Note: All Government publications of the Solomon Islands are listed under 'Solomon Islands' rather than under 'British Solomon Islands Protectorate' or under the author's name.

ANON (1978) Solomon Islands: a nation is born. *Asiaweek,* July 7th, 4, 26, pp 40-45.

AVERY, J.G. (1973-74) A review of the Malaria Eradication Programme in the British Solomon Islands 1970-72. *Papua New Guinea Med.J.,* 17, 1, pp 50-60.

(1977) *Epidemiology of Disappearing Malaria in the Solomon Islands.* M.D. thesis, University of Sheffield.

BARCLAY, G. (1958) *Techniques of Population Analysis.* John Wiley and Sons Inc., New York.

BLACK, R.H. (1952) A survey of malaria in the British Solomon Islands Protectorate. *South Pacific Commission, Noumea, Technical Paper no. 33.*

(1955) Malaria in the South-west Pacific. *South Pacific Commission, Noumea, Technical Paper no. 81.*

BLACKLOCK, D.B. & GORDON, R.M. (1925) Malaria infection as it occurs in late pregnancy; its relation to labour and early infancy. *Ann.trop.Med.Parasit.,* 19, pp 327-364.

BRASS, W. (1969) Disciplining demographic data. *IUSSP Conference London, Proceedings,* 1, pp 183-203.

(1971) On the scale of mortality. *In: Biological Aspects of Demography,* Ed. W. Brass. Taylor and Francis, London.

(1976) Indirect methods of estimating mortality: illustrated by application to Middle East and North African data. *Population Bulletin of the United Nations Economic Commission for Western Asia,* nos. 10 & 11.

BRASS *et al.* (1968) *The Demography of Tropical Africa.* Princeton University Press, Princeton, New Jersey.

BROOKFIELD, H.C. & HART, D. (1971) *Melanesia: A Geographical Interpretation of an Island World.* Methuen, London.

BRUCE-CHWATT, L.J. (1952) Malaria in African infants and children in Southern Nigeria. *Ann.trop.Med.Parasit.*, 46, pp 173-200.

(1970) The 39 steps; a primer on quantitative epidemiology of malaria. *London School of Hygiene & Tropical Medicine, Ross Institute mimeo.*

CHAPMAN, M. (1969) A population study in South Guadalcanal: some results and implications. *Oceania*, XL, 2, pp 119-147.

& PIRIE, P. (1974) *Tasi Mauru; a report on population and resources of the Guadalcanal Weather Coast.* East-West Population Institute Draft Mimeo.

COVELL, G. (1950) Congenital malaria. *Trop.Dis.Bull.*, 47, pp 1147-1167.

CROSS, A.B. (1977) The Solomon Islands tragedy - a tale of epidemic poliomyelitis. *Medical History*, 21, pp 137-155.

EL-BADRY, M.A. (1967) Some aspects of differential fertility in Bombay as assessed from registration data. *IUSSP Conference Sydney, Proceedings*, pp 309-318.

(1969) Higher female than male mortality in some countries of South Asia: a digest. *IUSSP Conference London, Proceedings*, II, pp 863-876.

EMANUEL, I.& BIDDULPH, J. (1969) Paediatric field survey of the Nasioi and Kwaio of the Solomon Islands. *J.Trop.Paed.*, 15, pp 56-69.

FEENEY, G. (1975) Estimation of mortality trends from child survivorship data. *East-West Population Institute Mimeo.*

(1976) Estimating infant mortality rates from child survivorship data by age of mother. *East-West Population Institute Mimeo.*

GARNHAM, P.C.C. (1949) Malarial immunity in Africans: effects in infancy and early childhood. *Ann.trop.Med.Parasit.*, 43, pp 47-61.

GRAY, R.H. (1974) The decline of mortality in Ceylon and the demographic effect of malaria control. *Population Studies,* 28, 2, pp 205-229.

GROENEWEGEN, K. & VAN DER KAA, D.J. (1967) *Resultaten van het demografisch onderzoek Westelijk Nieuw-Guinea.* Government Printing and Publishing Office,. The Hague.

HEADY, J.A. & MORRIS, J.N. (1959) Social and biological factors in infant mortality; no. 7: Variation of mortality with mother's age and parity. *J.Obstet.Gync.Br.Emp.,* 66, pp 577-593.

HENRY, L. (1965) French statistical research in natural fertility. *In: Public Health and Population Change.* Ed. Sheps, M.C. and Ridley, J.C., University of Pittsburgh.

HOLMES, S. (1952) *A nutrition survey - British Solomon Islands Protectorate.* South Pacific Health Service, Suva, mimeo.

JAIN, S.P. (1965) The Indian programme for improving basic registration. *World Population Conference,* III, pp 145-149.

JANSEN, A.A.J. (1969) Report on a visit to the British Solomon Islands Protectorate, November 1968. *World Health Organisation Document No. WPRO 0148/FR/4.*

(1973) Report on a nutrition survey in the British Solomon Islands Protectorate, 1970. *World Health Organisation Document No. WPRO 5601 (BSIP).*

& WILLMOTT, J.V. (1970) Nutrition, Dietary and Budgetary Survey-BSIP; WHO-SPHS Survey III, April-July 1970. *WHO, WPRO mimeo.*

KORTMAN, H.F.C.M. (1972) *Malaria and Pregnancy.* Drukkerij Elinkwijk, Utrecht.

LAWSON, J.B. & STEWART, D.B. (1967) *Obstetrics and Gynaecology in the Tropics and Developing Countries.* Edward Arnold Ltd., London.

McARTHUR, N. (1967) *Island Populations of the Pacific.* Australia National University Press, Canberra.

MACGREGOR, J.D. (1966) *Malaria in the Island Territories of the South-west Pacific.* M.D. Thesis, University of St. Andrews.

MACGREGOR, J.D. & AVERY, J.G. (1974) Malaria transmission and fetal growth. *Brit.Med.J.*, 3, pp 433-436.

NEW HEBRIDES, Condominium of (1968) *A Report on the First Census of the Population, 1967,* by McArthur, N. and Yaxley, J.F. Government Printer, New South Wales, Australia.

NEWMAN, P. (1970) Malaria control and population growth. *J.Development Studies,* 6, 2, pp 133-158.

(1977) Malaria and mortality. *J.Amer.Stats.Assoc.,* 72, 358, pp 257-263.

PAGE, H.J. (1971) Infant and child mortality. *IUSSP Conference Accra 'Population in African Development',* pp 85-100.

PALLONI, A. (1978) *Estimating infant and childhood mortality under conditions of changing mortality.* Paper presented at the Population Association of America meeting, Atlanta, Georgia.

PAMPANA, E.J. (1954) Effect of malaria control on birth and death rates. *World Population Conference, Rome. UN publication no. UN E/Conf 13/413,* pp 497-509.

PETIT, S. (1968) Rapport d'une visite au Protectorat Britannique des Iles Salomon, Octobre-Decembre 1968. *South Pacific Commission, Noumea, Mimeo.*

POOL, J.E. Sceats (1978) Family-building in a Canadian city: an analysis of the timing and spacing of pregnancies. *Population Studies,* 32, 3, pp 583-592.

PRINGLE, G. & MATOLA, Y.G. (1967) Report on the Pare-Taveta vital statistics survey 1962-66. *East African Common Services Organisation, Nairobi.*

PROTHERO, M.R. (1965) *Migrants and Malaria.* Longmans, London.

SAINT-YVES, I.F.M. (1975) *The Malaria Eradication Programme and Population Dynamics in the British Solomon Islands Protectorate 1970-76.* M.D. Thesis, University of Glasgow.

SLOOFF, R. (1969) Assignment Report. March 18th 1964 - September 30th 1968. Unpublished document, *World Health Organisation, WPR/47/69.*

SOLOMON ISLANDS (1949-76) *Annual Reports of the British Solomon Islands Protectorate.* Government Printer, Honiara.

(1950-72) *Annual Reports of the Medical Department of the British Solomon Islands Protectorate.* Government Printer, Honiara.

(1961) *Report on the Population Census of the British Solomon Islands Protectorate, 1959* by McArthur, N., Central Statistical Office, Honiara.

(1970) *Report on the Census of the Population of the British Solomon Islands Protectorate, 1970* by Groenewegen, K., Central Statistical Office, Honiara.

(?1979) *Report on the Census of the Population of the Solomon Islands, 1976,* by MacFadden, C. and Dudley, G., Central Statistical Office, Honiara; in press.

SOUTH PACIFIC COMMISSION (1975) Population 1974. *South Pacific Commission, Noumea, Statistical Bulletin no. 7.*

SULLIVAN, J.M. (1972) Models for the estimation of the probability of dying between birth and exact ages of early childhood. *Population Studies,* 26, 1, pp 79-97.

TRUSSELL, T.J. (1975) A re-estimation of the multiplying factors for the Brass technique for determining childhood survivorship rates. *Population Studies,* 29, 1, pp 97-107.

TSUBOUCHI, Y. (1969) Estimation of child mortality, the birth rate, the death rate and total fertility in the New Hebrides. *The Southeast Asian Studies,* 7, 2, pp 191-197.

VALLIN, J. (1976) La mortalité infantile dans le monde; évolution depuis 1950. *Population,* 4-5, pp 801-838.

VAN DER KAA, D.J. (1969) The vital rates of Papua and New Guinea's indigenous population. *IUSSP Conference London, Proceedings,* I, pp 419-426.

(1971) *The Demography of Papua and New Guinea's Indigenous Population.* PhD. Thesis, Australia National University.

WILLMOTT, J.V. (1969) Nutrition in the British Solomon Islands - a general report following a visit. *South Pacific Health Service, Suva, mimeo.*

WORLD FERTILITY SURVEY (1974) *Fiji Fertility Survey, Principal Report.* Bureau of Statistics, Suva.

WORLD HEALTH ORGANISATION (1951) Report of the malaria conference in Equatorial Africa. *World Health Organisation, Geneva, Technical Report Series no. 38.*

(1975) The malaria Situation in 1974. *WHO Chronicle,* 29, pp 474-481.

SUPPLEMENTARY APPENDIX

FURTHER JUSTIFICATION FOR THE ADOPTION OF THE CORRECTION FACTOR USED IN THE MULTIPLYING FACTOR AND GRIFFITH FEENEY TECHNIQUES

Having visualised the previous births as being distributed as shown in Figure 11 on page 69, two general approaches to the problem of the non-random nature of the data were made before the particular correction factor used was selected. These approaches are outlined and discussed below.

"PREVIOUS LIVE-BIRTHS + ½BIRTH INTERVAL"

The previous children (excluding the current births) have all, on average, lived half a birth interval longer than those of a random sample (since the women sampled are all at the end of a birth interval and not, on average, halfway through it). A logical approach, initially taken by Brass (1969, *ibid*), was therefore to consider that the ages by which proportions of these children had died referred to ages half a birth interval older than the conventional ages of 1, 2, 3, 5, *etc*. Since the mean birth interval was found to be 2.5 years, the age to which the most reliable index of mortality generally derived (q(2)) now refers is (2 + 1.25) years, *i.e.* q(3.25). The multiplying factor technique was applied in the usual manner to the proportions dead of previous births only, and the q(3.25) values so obtained converted to the conventional q(2) values by use of the logit lifetable system and the African Standard. However, those graduated observed estimates of q(2) were higher than might reasonably have been expected. In a random sample, a substantial number of births would have occurred over the whole period of the half birth interval. In this sample, use of the half birth interval has given biased results because of the very high mortality in the first few weeks of life. Virtually all the births have experienced this high mortality fully (because of their relative concentration around one birth interval before the survey) rather than only a proportion of the births as in the random situation. The method is also dependent on a knowledge of the length of the birth interval and on the model used for the translation of mortality up to ages such as 3.25 into the conventional measures.

"PREVIOUS LIVE-BIRTHS + CURRENT BIRTHS"

As an alternative to studying the situation from the point of view of time (*i.e.* the birth interval), the actual numbers of current births were considered. Inclusion of a proportion of the current births with the previous livebirths was thought to be a means of compensating for the longer-than-average exposure of the previous children relative to a random sample, even though the current births would not yet have been exposed to the risk of dying. In the multiplying factor technique, addition to the previous births of *all* current births (which clearly biases the results downwards) gave unrealistically low values of q(2). Likewise, addition of half the number of current births (a natural consequence of the first idea and in keeping with the concept of adding half a birth interval) gave values of q(2) which were still too low. The reason is that no account is taken of the non-linearity of mortality in the early months of life. If the current births had actually been spread so that half of them fitted in the open part to the last birth, the deaths would have been correspondingly higher than those which occurred, because of the longer exposure (compared with the random situation) of the last birth. This arises of course because the death incidence in the first months of life is so high. The alternative of no correction factor (rather than one based on somewhat arbitrary considerations of mortality effects) was briefly studied; calculations from previous births only did then give more acceptable levels of q(2).

DISCUSSION

These studies had produced a number of alternative ways of modifying the standard multiplying factor technique. On theoretical grounds and from model calculations some could be shown to be biased upwards and some downwards. It was decided that the fairly arbitrary averaging of the results from an 'upward' and a 'downward' biased method would be the best solution.

For convenience, it seemed best to formalise this as the addition of a fraction of the current births to the previous ones for the denominator in the calculation of the proportion of children died. The lower limit for the fraction was taken as zero, giving a clear over-estimate of mortality, as noted previously. To determine an upper limit, it was assumed that the current births were redistributed evenly over a birth interval around the mean point. One half of the current births would then have to be added to the previous ones for the denominator. The deaths which would have occurred among these one half current births would also have to be added to the numerator. More simply, the half could be multiplied by a factor which expressed the fact that the births over the previous half interval would have had a lower exposure to risk than had the total births to the women as a whole. (This is a standard procedure when allowing for losses from follow-up in the calculation of a lifetable.) This factor varies with total exposure of children (and therefore by age of woman) and the pattern of death rates by age in childhood. However, calculations from model lifetables show that a value of two-fifths is a reasonable estimate for the significant age groups of mothers. The low level of deaths of children from age three onwards ensures that the change in the true factor with age group of mother is small. Half the births at a two-fifths exposure compared with the remainder gives a correction of one-fifth of the current births. But this correction is too high, in general, since the previous births (particularly the most recent) are concentrated too closely at points rather than spread over a full interval. The effect of this is to make the observed deaths of previous children rather larger than they would have been in the random case (exactly as argued for Brass' half interval described earlier). With an upper limit correction of one-fifth of the current births and a lower of zero, the compromise is the mid-point of one-tenth of the current births, and this is what is added to the previous births in the calculation of children dead.

Despite the procedure being somewhat arbitrary, it is believed that the resulting estimates are less biased than the alternatives. Any more precise development of methodology would require extremely complex models of the timing of births to mothers, and this is dependent on bio-social factors such as post-partum amenorrhoea and abstinence, foetal mortality, and fecundability.