The Demographic Impact of Malaria and The National Impregnated Bed Net Programme in The Gambia.

Dissertation presented for MSc in

Applied Population Analysis by

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CHAPTER ONE.

INTRODUCTION.

1.0 INTRODUCTION.

Malaria is one of the world's most significant killers. The parasitic disease, transmitted to humans by the biting of mosquitoes, is estimated to cause one to two million deaths a year world wide. Around half of these deaths occur in sub-Saharan Africa, where most of the population is frequently infected. Most people in endemic regions over the age of five have developed some natural immunity to malaria and therefore usually survive infection. It is in the under five years age group that the vast majority of deaths occur.

Many of the more developed countries in malarial regions have achieved eradication of the disease, such as Singapore and Taiwan (Turley 1990). Global eradication has not occurred since methods of controlling the disease are expensive and need to be applied indefinitely. The majority of those countries affected by malaria are poor and therefore unable to afford the indefinite costs. Additional problems include the growing resistance of the parasite to drugs and the reluctance of the developed nations to aid the countries which are affected.

Malaria is a very significant cause of death amongst Gambian children under the age of five. Around one in twenty five rural children die from the disease. Effective malaria control has not been achieved through the use of preventative or curative drugs mostly due to economic constraints. Recent research by the Medical Research Council (MRC) in The Gambia has concluded that the use of insecticide impregnated bed nets (mosquito nets) is not only the most effective method of controlling malaria, but also the most economically viable option. This research will examine a government backed programme, the National Impregnated Bed Net Programme (NIBP), aimed at the universal impregnation of bed nets within the Gambian Primary Heath Care (PHC) programme.

There is clearly considerable scope for research into the demographic impact that this programme will have on the Gambian population. This study will focus on the impact of the programme on population growth and will consider the benefits in terms of malarial deaths averted.

Chapter one of this dissertation will consider the aims and objectives of this study as well as the limitations.

Background and literature will be reviewed in chapter two. Firstly background on The Gambia pertinent to this research will be considered, such as a review of population, health and economic characteristics of the country.

Secondly, the distribution of malaria world wide and its demographic impact will be examined. Particular attention will be paid to the epidemiology of malaria within sub-Saharan Africa before focusing on malaria in The Gambia.

Thirdly, malaria control will be reviewed in terms of the options available and progress made. Trials intended to establish the optimum method of controlling malaria in rural Gambia will be examined as a background to the inception of the universal bed net programme.

Finally, this chapter will put the study into context in the health and development debate. Additionally, the changing philosophy of health care in the developing world will be reviewed.

Chapter three will focus on the spatial characteristics of malaria in The Gambia. It will suggest that malaria is enormously varied locally and that factors resulting in large mosquito populations may often not be associated with high levels of malaria transmission.

The focus of this study is presented in chapter four. The impact of the bed net programme on the rural population will be explored. The results of the study will show how the programme will affect population growth rates and absolute population increase. In addition, under fifteen years old population growth will be examined as well as under five years old mortality.

1.1 AIMS AND OBJECTIVES OF THE STUDY.

The aim of this research is to appraise the demographic impact of a malaria control programme in The Gambia.

The first question to be asked is how significant is malaria on a world scale as well as within The Gambia? The demographic significance is of interest, in terms of mortality and which groups are most vulnerable. The

geographical patterns and determinants of malaria will also be considered.

The second major question is, what can be done to control or eradicate malaria? What progress has been made and what are the future prospects for the elimination of the disease?

Finally, what is the demographic impact of a malaria control programme? How would an 'intervention' affect mortality, how many lives would be saved and would population growth be affected?

Considerable work has been done to assess the effectiveness of malaria control programmes world wide in terms of how effective a particular method is in reducing mortality amongst infants and children. Trials have recently been carried out in The Gambia by the Medical Research Council (MRC) which concluded that insecticide impregnated bed nets (mosquito nets) are highly effective as a malaria control method and viable on a community scale. Results of the trials convinced the Gambian government to initiate the National Impregnated Bed Net Programme. (NIBP) aimed at universal impregnation of bed nets within the Primary Health Care (PHC) programme.

The MRC is responsible for the monitoring and evaluation of the progress of the programme. This research hopes to use the results of the evaluation, which is being carried out in five ecologically diverse study sites, to establish how effective the programme is in reducing mortality.

As yet no research has been carried out to evaluate the demographic impact, on a national scale, of a malaria control programme, or the NIBP in particular. Using the multi-study site results, it is hoped to examine the impact of the programme in different regions within The Gambia.

Projections will be carried out to 'map' the growth of the population from the year 1993, in which the latest population census was carried out, to the year 2003. The projections will be limited by availability and quality data as well as the assumptions made. However, it is hoped that they will provide a useful indication of possible future population trends and a comparison between those settlements which receive the programme and those which do not. The principal advantage that these projections will have over previous ones is that they are based on the 1993 census.

Previous projections, such as those carried out by the United Nations (Zachariah and Vu 1988) and the Secretariat of the National Population Commission, The Gambia (Population Data Bank 1993), have been based on the preceding census in 1983. Estimates of the 1993 population have fallen short of the population enumerated in that year. Additionally it is hoped that the projections carried out in this study will prove to be meaningful since they account for what is considered significant interventions on the population.

Life tables will be used to project the population since mortality is the principal component being examined. It is aimed to consider the appropriateness of the technique as a method of evaluating the impact of a health care intervention.

It is also intended to examine a number of additional 'scenarios', such as the hypothetical possibility of the eradication of malaria, for example, by the implementation of a vaccine programme. A range of scenarios will be investigated by projecting the population to the year 2003.

The aims of the visit to The Gambia included obtaining the 1993 Population and Housing Census and other population data not available in the UK. In addition, I intended to speak to the people who are monitoring the NIBP to obtain details and results of the programme. It was also hoped to observe the implementation and evaluation activities of the programme in the field.

1.2 LIMITATIONS OF THE STUDY.

This research is based on secondary data. Data quality and availability therefore affect the comprehensiveness of the study. Despite the full 1993 Gambian Population and Housing Census Report currently being in preparation, a Provisional Report was obtained. In isolation, this report is limited in as much as it does not present details such as the age distribution of the population. Other population data sources are available such as the full 1983 census and demographic material in the Report on the 1992 Priority Survey (Wadda and Craig 1993). In addition, a 1993 'Population Data Bank' augments the 1993 census report by

providing current data on a wide range of population issues. These reports together provide an adequate base of population data for this research.

Despite problems associated with census data in developing countries, the Gambian full 1983 report is very comprehensive. The undertaking of a census every ten years is an 'institution' set up by the British and has been running since 1901. The continuity has allowed the administrative structure to become effective and there is a good deal of awareness and co-operation amongst the Gambian people. Each settlement is enumerated separately by five year age cohorts making the report very detailed. Data is aggregated into administrative areas and on a national level. Additional sections include population break downs by ethnic group, marital status and educational attainment.

This study is limited by the data available regarding malaria mortality before and after malaria control interventions. It was hoped to use results of the NIBP multi-site evaluation to augment the spatial dimensions of this study. These results are currently in preparation and are therefore unavailable. The analysis in this study will therefore be based on the results of a single site survey carried out by the MRC. It was this survey that prompted the Gambian government to endorse the NIBP.

It was hoped to observe the execution and monitoring of the NIBP in the field to provide a qualitative aspect to this research. This proved not to be possible, although it was possible to speak to many of the MRC staff who were involved.

CHAPTER TWO.

BACKGROUND AND LITERATURE REVIEW.

2.0 INTRODUCTION.

Chapter two will provide background information and literature on which the remainder of the dissertation is built.

First, a brief introduction to The Gambia in order to provide a context for the specific studies on malaria and population. Aspects of The Gambia to be covered include population, health and the economy.

Secondly, this chapter will examine the background to malaria. An overview of the distribution and impact of malaria on the world scale will be covered, focusing on sub- Saharan Africa. The demographic impact on the local scale, that is in The Gambia, will also be considered. Additionally, progress in controlling malaria will be reviewed including an examination of malaria control trials in The Gambia.

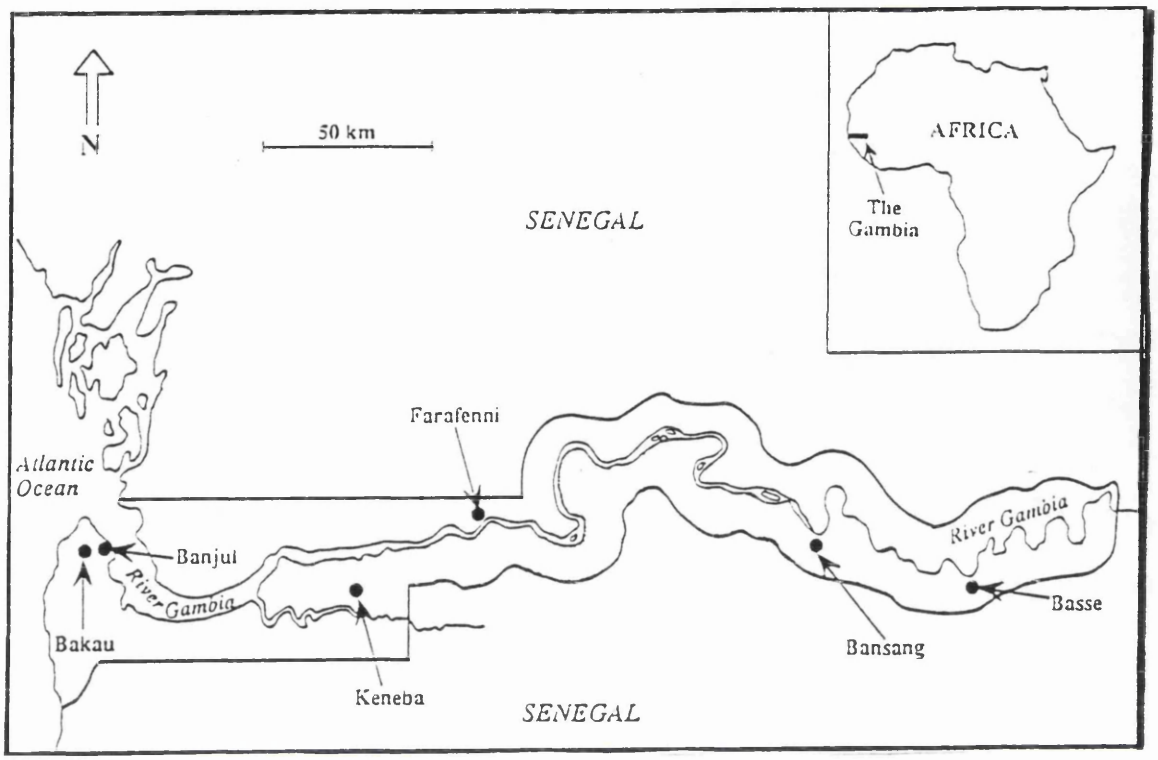
Finally, the study will be put into the broader context of health and health care provision in the third world. The relationship between development and health will be considered as well as the changing philosophy of health care provision in the third world.

2.1 THE GAMBIA.

The Gambia is a former British colony on the coast of west Africa. The country extends eastwards around 325km on either side of the River Gambia. The Gambia, only 50km wide at most, is surrounded by its larger neighbour, Senegal. Figure 2.1 shows the position and some of the major settlements.

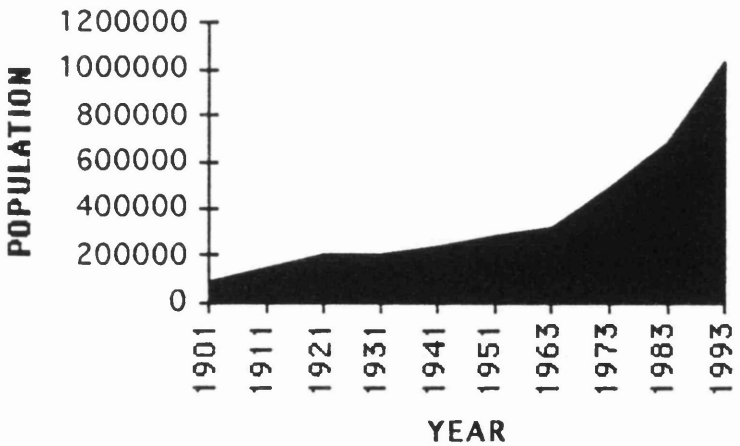
The population of The Gambia has grown from 90,404 at the beginning of the century to 1,025,867 in 1993. The growth of the population is illustrated in Figure 2.2.

FIGURE 2.1. MAP OF THE GAMBIA.



Source: Greenwood et al. 1993.

FIGURE 2.2 POPULATION OF THE GAMBIA 1909 TO 1993.



Source: Population and Housing Census 1993.

The rate of population growth have remained high over the period; 3.9% per annum between 1973 and 1983 increasing to 4.9% per annum between 1983 and 1993. One factor effecting the rate of growth is high fertility; the total fertility rate was 6.5 children per woman in 1991 (World Population Data Sheet 1991). Crude birth rates (CBR) have shown little decline over the last twenty years. The CBR was 49.5 births per 1000 population in 1973 and 48 in 1993 (Population Data Bank 1993). Zachariah and Vu (1988) predict a significant future decline in the CBR to 45.3 per 1000 between 1990 and 1995, to 41.7 between 1995 and 2000.

Another factor influencing growth rates is the high level of international immigration. The non-Gambian population living in The Gambia, mainly of Senegal origin, grew by 113.5% between 1983 and 1993 compared to an indigenous growth of 49% over the period (Population and Housing Census 1993). There is no significant difference in natural increase between the two populations, therefore the considerable growth of the non-Gambian population is accounted for by high levels of immigration.

A decline in the crude death rate (CDR), from 29.5 deaths per 1000 population in 1973 to 21 per 1000 in 1993, shows that mortality is experiencing a downward trend (Population Data Bank 1993). An increase in life expectancy at birth, from 33 years in 1973 to 42 years in 1983 confirms the declining trend of mortality. Infant and child mortality improvements account for most of this change. Zachariah and Vu (1988) estimate a significant reduction in infant mortality from 161.1 under one year old deaths per 1000 live births between 1985 and 1990 to 130.7 per 1000 between 1995 and 2000.

The proportion of Gambian population living in rural areas declined from 77.17% in 1973 to 62.29% in 1993 (Population and Housing Census 1993), suggesting that significant rural/ urban migration is taking place. Population growth is highest in the coastal 'core' urban area, that is the Banjul/ Kanifing/ Brikama area as identified in Figure 2.3. Kanifing Local Government Area had a particularly high population growth rate of 12.5% per annum between 1983 and 1993. Not only is it receiving unplanned 'overspill' population from the spatially constrained capital, Banjul, but also high levels of rural/ urban male labour migration.

The Gambian population comprises of nine major ethnic groups. The three most significant are the Mandinka (37% of the Gambian population), Fula (17%) and Wollof (13%) groups. Different groups have different languages and traditions. The majority (85%) of the Gambian population follow the Islamic faith.

The most significant health problems in The Gambia are those relating to infectious and parasitic diseases, which have most impact on infants and children (Greenwood *et al.* 1990). Therefore, since high infant and child mortality are the major causes of low overall mortality and low life expectancy, these diseases have considerable demographic significance. Furthermore, it is these diseases which could be reduced with simple low technology treatments and preventative methods and could be eradicated if sufficient resources were available.

Other major health considerations include the prevalence of malnutrition, which has a significant impact on infant and child health. Around 15% of the Gambian population aged under five years suffers from malnutrition during the wet season when minimum food resources are available (Population Data Bank 1993). Non-sanitised water also creates a health risk, especially amongst infants and children, and is a major contributing factor to infectious and parasitic disease. Access to clean water is limited and in 1981 it was estimated that 1200 new water points, such as proper wells, would be needed to fulfil requirements (World Bank 1981). The population has risen significantly since then and it is unlikely that the provision of water has kept pace with the increase in demand. In addition, the lack of awareness of the significance of using contaminated water containers as a health risk needs to be addressed

The Gambia has an underdeveloped economy which has experienced poor economic growth recently. In 1991 the estimated GNP per capita was US$230 (World Population Data Sheet 1991). The economy is dominated by agriculture, primarily the production of groundnuts for export and rice, millet and sorghum as subsistence crops. The majority of the population are subsistence farmers. Reliance on one dominant agricultural crop renders the economy vulnerable to climatic influences and world market prices. However, the tourism industry is becoming more important, which has lead to an expansion in employment in hotels and restaurants (Statistical Abstract 1992).

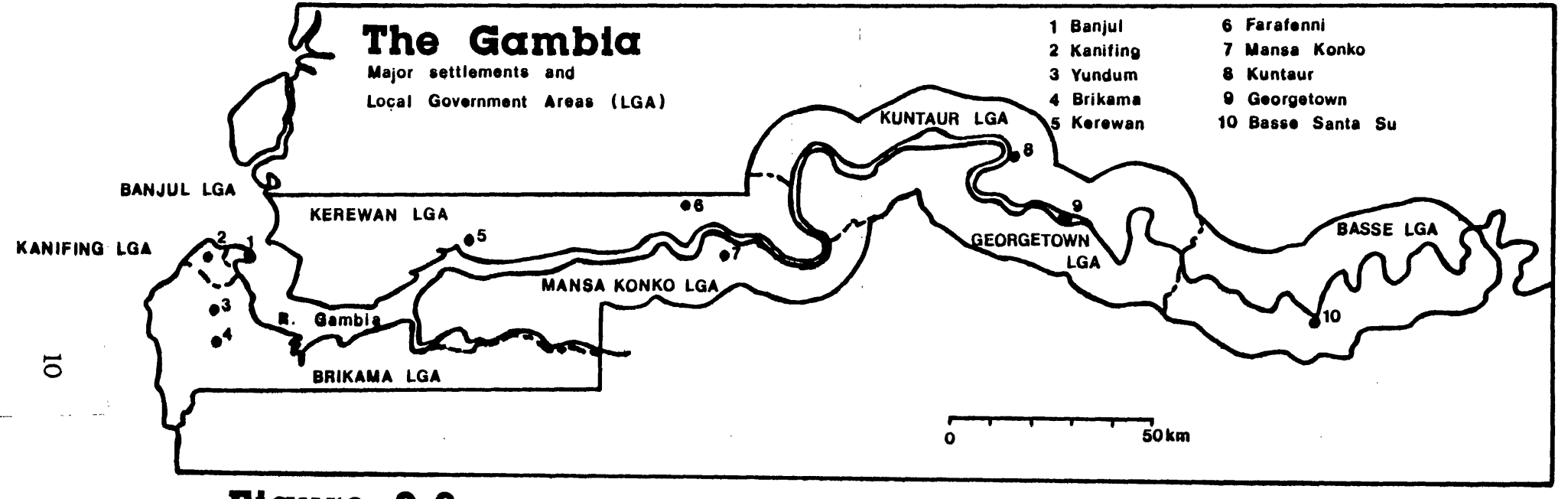

The Gambia
Major settlements and
Local Government Areas (LGA)
1 Banjul
2 Kanifing
3 Yundum
4 Brikama
5 Kerewan
6 Farafenni
7 Mansa Konko
8 Kuntaur
9 Georgetown
10 Basse Santa Su
BANJUL LGA
KANIFING LGA
KEREWAN LGA
KUNTAUR LGA
MANSA KONKO LGA
GEORGETOWN LGA
BASSE LGA
BRIKAMA LGA
R. Gambia
0
50km

Figure 2.3

2.2 MALARIA.

2.2.1 Malaria Biology.

Malaria is a parasitic disease which is transmitted to man by mosquitoes. In sub-Saharan Africa, the female *Anopheles* species mosquito is the main malaria vector. Mosquitoes require a sufficiently warm temperature to survive and sufficient shallow, still fresh water in which to lay eggs. The first activity of the male mosquito after emerging from the pupa stage is to mate. Therefore mosquito breeding takes place in the vicinity of water (Knell 1991).

Mosquitoes infect humans with the malaria parasite whilst feeding on blood which takes place close to breeding sites. Once the human blood has been infected, parasites travel to the liver where they multiply to huge numbers. Thousands of parasites erupt from the liver and invade red blood cells. After three to four days, even greater numbers are released from the red blood cells. At this stage, the victim experiences symptoms such as fever, headache, nausea and abdominal pains. The fever has three distinct stages, the cold stage, the hot stage and the sweating stage. The period between the outbreak of the symptoms in serious malaria and fatality is often very short.

Of the malaria parasites which infect man, there are four species. *Plasmodium ovale*, *P. vivax* and *P. malariae* are all rarely fatal, often remaining dormant in the liver for years. *P. falciparum* is the most dangerous species, often infecting up to 80% of an individuals red blood cells. Complications include cerebral malaria which often results in a coma. Infection with the *P. falciparum* parasite frequently results in death, particularly amongst younger children.

2.2.1 World Scale.

i) Demographic impact.

Table 2.1 and Figure 2.4 show the proportion of the world's population which lived in malarial and non-malarial regions in 1982. It is likely that

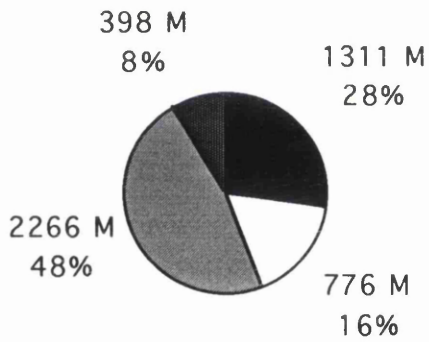
since population growth is generally greater in those regions where malaria is endemic than elsewhere, the numbers and proportion of the world affected by malaria has increased since then.

TABLE 2.1.

		POPULATION	% TOTAL
PROPORTION OF THE WORLD POPULATION SUBJECT TO DIFFERENT MALARIA THREATS	Total world population 1982	4751 M	100
	Areas where malaria has never existed or disappeared without intervention	1311 M	28
	Areas where malaria has been eradicated in the last 50 years	776 M	16
	Areas where interventions continue	2266 M	48
	Areas where malaria is endemic with no interventions	398 M	8

Source: Knell 1991

FIGURE 2.4. PROPORTION OF THE WORLD POPULATION SUBJECT TO DIFFERENT MALARIA THREATS.



Source: Knell 1991. Refer to Table 2.1.

World Health Organisation (WHO) estimates suggest that world-wide there are over 100 million cases of malaria annually. Knell (1991) suggests that this is likely to be a massive under estimation since many cases go unreported due to lack of organisation and health care facilities in less developed countries.

Additionally, the period between serious infection and death can be very short, an average of 2.8 days was suggested in studies in The Gambia

(Greenwood *et al.* 1993). This exacerbates the recording difficulties since the majority of cases are unlikely to be referred to any formal health care. In The Gambia, 92% of malaria deaths occurred in the home and it is therefore unlikely that the disease will be reported in the normal course of events.

The total number of deaths from malaria is also difficult to determine, but is likely to be around one to two million world wide per year. The majority of these deaths are amongst children under five years old. Knell (1991), suggests that malaria is one of the worlds biggest killers.

ii) World wide distribution.

Figure 2.5 shows the regions of the world in which malaria is endemic. The major regions include sub-Saharan Africa, Northern Latin America and southern Asia. Malaria transmission requires an average temperature exceeding fifteen degrees centigrade for at least one month of the year. Therefore the countries significantly to the north and south of the equatorial endemic regions have low or no malaria transmission. Mountainous regions are also free from malaria, especially those above 3000m, due to cooler temperatures.

Due to the requirement of water for breeding and egg laying by mosquitoes, dry and desert areas are usually free from malaria transmission. Greenwood *et al.* (1993) indicate that there is downward trend in rainfall in The Gambia. This has lead to the tentative suggestion than climatic changes may play an important part in reducing malaria prevalence in addition to human factors. The southward encroachment of the Sahara is related to this climatic change.

Malaria has been eradicated from some regions of the world, particularly those which have undergone significant development, (Turley 1990). Table 2.1 suggests that around 16% of the world population now lives in areas which malaria eradication has occurred in the last fifty years. Examples of countries in previously endemic areas which have recently experienced the eradication of malaria include Singapore and Taiwan.

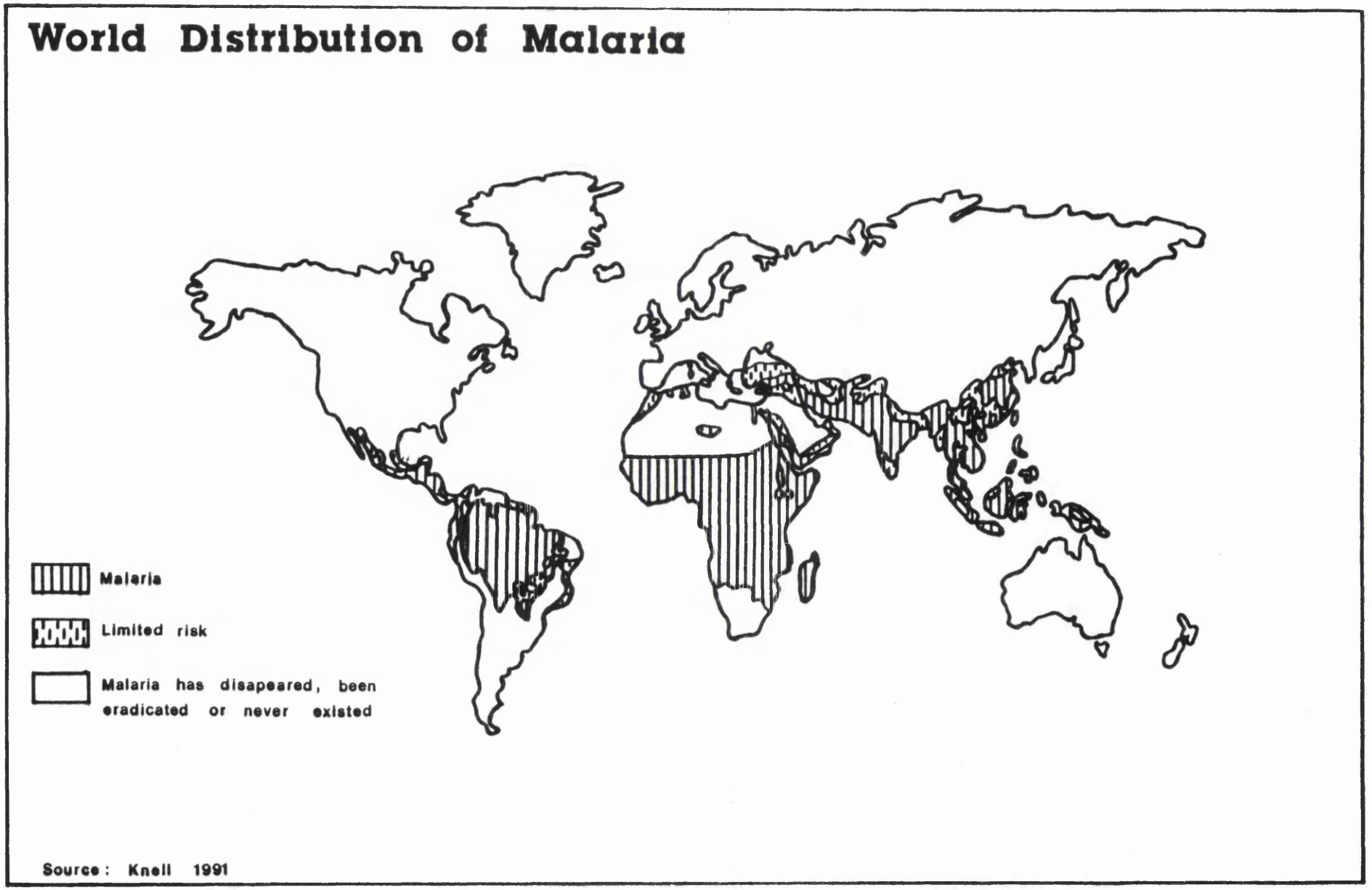

World Distribution of Malaria
Malaria
Limited risk
Malaria has disapeared, been eradicated or never existed
Source: Knell 1991

Figure 2.5

iii) Sub-Saharan Africa.

Sub-Saharan Africa is the world's most significant malaria region. It is useful to use this region as an example to illustrate the significance of environmental and human factors as influences on malaria epidemiology.

Levels of malaria transmission vary significantly spatially within Africa, often with great diversity within a local area. However, there are four broad ecological zones, each characterised by very different levels of malaria prevalence.

a) The forested areas of Africa correspond to the highest levels of malaria transmission. Malaria is prevalent all year round since water is abundant and temperatures are suitable for the survival and breeding of mosquitoes. Despite having the highest transmission of malaria, the forest regions do not have the highest levels of malaria mortality. This is due to high levels of natural immunity being gained quickly by children who experience high malaria transmission rates.

b) The savannah areas are drier than the forests, but suffer the greatest malaria mortality. Rainfall is highly seasonal, often a short wet season occurs in the summer months with no rain outside this period. The seasonal characteristics of malaria transmission result in children acquiring later natural immunity. Therefore when the annual wet season 'epidemic' occurs, mortality is particularly severe. The Gambia falls within this broad region.

c) The Saharan desert area of north Africa is unaffected by malaria due to its aridity. However, transmission does occur in the semi-arid Sahel region bordering the Sahara where short wet seasons result in short periods of malaria transmission. Less immunity is acquired, but malaria transmission is relatively light resulting in low levels of malaria mortality.

d) Areas of high altitude are usually beyond the malaria transmission zones or have light transmission due to lower temperatures. Immunity is generally not acquired by populations in these regions. If an epidemic does occur, for example during an abnormally hot period, malaria mortality may be very severe in the margins of the highlands.

Numerous other factors affect malaria transmission. For example, Bradley (1991) suggests that in coastal regions where the water is brackish, most varieties of Anopheles mosquito cannot survive. Transmission is normally lower in cities due to factors such as the lack of suitable open water for mosquito breeding and egg laying. Irrigated areas for agriculture may extend transmission both in terms of area and seasonality.

2.2.3 Local Scale: The Gambia.

Around one in twenty five Gambian children under five years of age die from malaria. Mortality rates found in a study in The Gambia are estimated as being 19.5/1000 for infants and 20.6/1000 for children between one and four years.

The MRC has carried out research into causes of infant and child mortality in The Gambia. Findings by the MRC suggest that malaria is an extremely significant cause of death, accounting for some 25% of mortality amongst infants and children. Acute Lower Respiratory Infection (ALRI) is the second most prolific illness in this age group (14% of deaths). Other significant causes of under five mortality include gastro-enteritis (10%), malnutrition (17%) and meningitis (8%). The pattern is different amongst infants considered in isolation from other children under five years old. For example malaria accounts for only 5% of deaths amongst one to five month old infants, ALRI accounts for 22% in this group.

Infants are more likely to receive breast milk than children, which provides some immune protection already acquired by the mother and accounts for the particularly low levels of malaria mortality amongst infants. The most vulnerable group are those children who have stopped breast feeding. By the time the age of five has been reached, children are likely to have acquired their own natural immunity to malaria and are physically stronger, therefore have very low levels of vulnerability.

Malaria is also highly seasonal in The Gambia. Greenwood *et al.* (1993) indicate that most malarial deaths occur during a short period at the end of the wet season, which lasts from July to October. 81% of malaria

deaths amongst children aged one to four occurred in the period July to December in The Gambia. 35% of these occurred in the month of October.

2.2.4 Review of Malaria Control.

i) The options.

Many attempts have been made to control malaria. One solution has been to leave a layer of oil on the surface of mosquito breeding sites in an attempt at stopping the larva/ pupa stage of the mosquito breathing. However, increasing levels of irrigation world-wide has expanded areas of water which need to be covered. The importance of rice in many areas of the world, including The Gambia, which cannot be sprayed with oil since this ruins the crop, provides huge man made areas for mosquito breeding.

Another vector control method is the use of insecticides to reduce the population of mosquitoes in a given area. The continuation of this method is important as was demonstrated from the 1950s onwards in Madagascar (Turley 1990). The French embarked on a costly insecticide and drug aid programme with the view to irradicating malaria from Madagascar. The programme had been long running and has resulted in levels of natural immunity in individuals dropping dramatically. When the French withdrew their aid, the Malagasy government discontinued the programme due to lack of funding. Thus in the 1980s the mosquito population, and therefore levels of malaria transmission, began to build up. Malaria mortality reached epidemic proportions in 1988, with around 100,000 deaths.

Recent developments in the use of insecticide include smaller scale house by house measures and the targeting of particular mosquito breeding sites (Targett 1991). A number of chemicals have been used as insecticides. One notable example, DDT, is no longer used due to the particularly detrimental effects this chemical has on the environment.

Increasing the use and availability of treatment drugs (chemotherapy) is not without problems. Originally quinine has been used, later chloroquine and other drugs. Greenwood *et al.* (1993) indicate the problem is that the parasite *P. falciparum* is becoming increasingly resistant to

drugs, and in some cases, for example in Thailand, multi-resistant. Ad hoc use of drugs as well as limited availability in many areas leading to treatment at often sub-curative levels has allowed the parasite population to evolve resistant characteristics (Bradley 1991).

Preventative drugs (chemoprophylaxis) have been found to be more effective than chemotherapy alone. The loss of natural immunity is a foreseeable problem, particularly amongst younger children, but, as yet has not become significant. The use of drugs, which do not completely stop the development of parasites in the blood and allow an individual to gain natural immunity through some contact, is one solution. Finding the balance between this and potential drug resistance of the parasite needs to be considered. The prolonged use of chemoprophylaxis can also create problems for the individual, such as side effects. Newer drugs, such as fansidar are more effective than, for example, chloroquine since there is limited resistance amongst parasite populations. However, the side effects have been found to be more serious.

Recent developments in the search for effective control methods have opted for a switch from complex technical solutions to simple community based ones (Targett 1991). One solution which is gaining recognition as being effective and workable is the use of bed nets (mosquito nets) as protection to individuals whilst they sleep. This method is effective since much insect activity occurs in the evening and at night. Trials, such as those in Tanzania and The Gambia has suggested that particular benefits occur when the nets are treated with insecticide. The use of nets has advantages in that they are relatively cheap, low technology, durable and therefore rapidly assimilated within a community. Many groups protect themselves against the nuisance caused by those insects which bite at night, for example many mosqito species in many areas, by using bed nets, unaware that they are also protecting themselves from malaria.

A vaccine would be the ideal solution since one injection would take the place of prolonged chemoprophylaxis dispensing. However, no vaccine is available at the moment or is likely to be in the next few years. There are, however, several contenders for the development of a vaccine such as Dr. Manuel Patarroyo's Colombian team. Patarroyo's vaccine has been shown to be effective in protecting monkeys against human malaria, but only partially effective on humans. This vaccine and other possibilities are

currently under going trials in various parts of the world, including the Upper River Division of The Gambia.

Although malaria has been eradicated in some areas and controlled to a certain extent in others, a world wide solution is not likely in the near future. Some of the reasons for the lack of world wide success are as follows:

a) Some aid schemes have been very successful in controlling malaria, but the huge cost has lead to a lack of continuation, rendering the schemes counter-productive.

b) Resistance of the parasite to anti-malarial drugs (often multi-resistance) perpetuated by low doses administered in an ad hoc fashion.

c) Some resistance amongst mosquitoes to insecticides is becoming evident. Additionally, care must be taken in selecting chemicals which are not harmful to non-mosquito populations and the environment.

d) Some large development projects have changed the environment, for example dam projects, providing mosquitoes with additional still water for breeding sites. Increasing levels of irrigation for crops has also provided breeding sites.

e) An increase in the levels of inter-regional and international travel has lead to re-infection in some previously eradicated areas.

f) Migration of people from non-malarial areas, for example from high altitude to lower altitude areas of high transmission is a problem since those people with no previous contact do not develop natural immunity.

g) Migration from rural areas to urban areas and the creation of large non-sanitised slum settlements provide ideal breeding grounds for mosquitoes in open shallow pools of water. Informal settlements are often on the poorest land in a city, such as swampy areas, which are also major breeding sites.

h) The *Anopheles* species of mosquito, unlike many other species, favours clean water sources. However, recent studies have suggested that some *Anopheles* populations are adapting to dirty water areas.

i) There is a lack of investment in measures to control malaria and further inability of those countries most affected by malaria to pay for programmes as foreign debts become more onerous. The developed world has proved to be highly erratic in supplying aid for control programmes.

ii) Malaria Control Trials. Phase I: North bank of the River Gambia.

A series of surveys and malaria control trials were carried out by the MRC between 1982 and 1987 in the Farafenni area, 100km from the coast on the north bank of the River Gambia as shown in Figure 2.6. Greenwood *et al.* (1988) discuss the methodology of the trials. Initially, the study sought to determine levels of mortality and morbidity attributed to malaria amongst rural children. Aspects considered included, which age groups were most affected, the seasonality of malaria prevalence, severity of attack and reliability of methods used to determine the cause of death or illness. Once the epidemiological character of malaria in the study area was established, malaria control strategies were considered under three broad types; chemotherapy, chemoprophylaxis and bed nets (either insecticide impregnated or not). The purpose of the study was to determine which method, or combination of methods is most effective in reducing mortality and morbidity.

Mortality and morbidity surveys were carried out in 1982-3, considering deaths amongst those under seven years. The main method of determining cause of death was interviewing the relatives of the child (*post-mortem* questionnaire technique). This proved to be reliable since the symptoms of malaria are not similar to other diseases. It is also the most feasible since most deaths occur in the home and few received any medical treatment before death. Poor accessibility to health care is a major contributory factor.

Surveys show similar seasonal patterns of morbidity. For example, 56% of observed episodes of fever caused by malaria occurred in the September to October period. Parasite infection is very common amongst children, each child experiencing an average of 0.31 episodes of clinical malaria per year. Episodes are most frequent amongst children aged one to two years, who experience an average of 0.73 episodes per year.

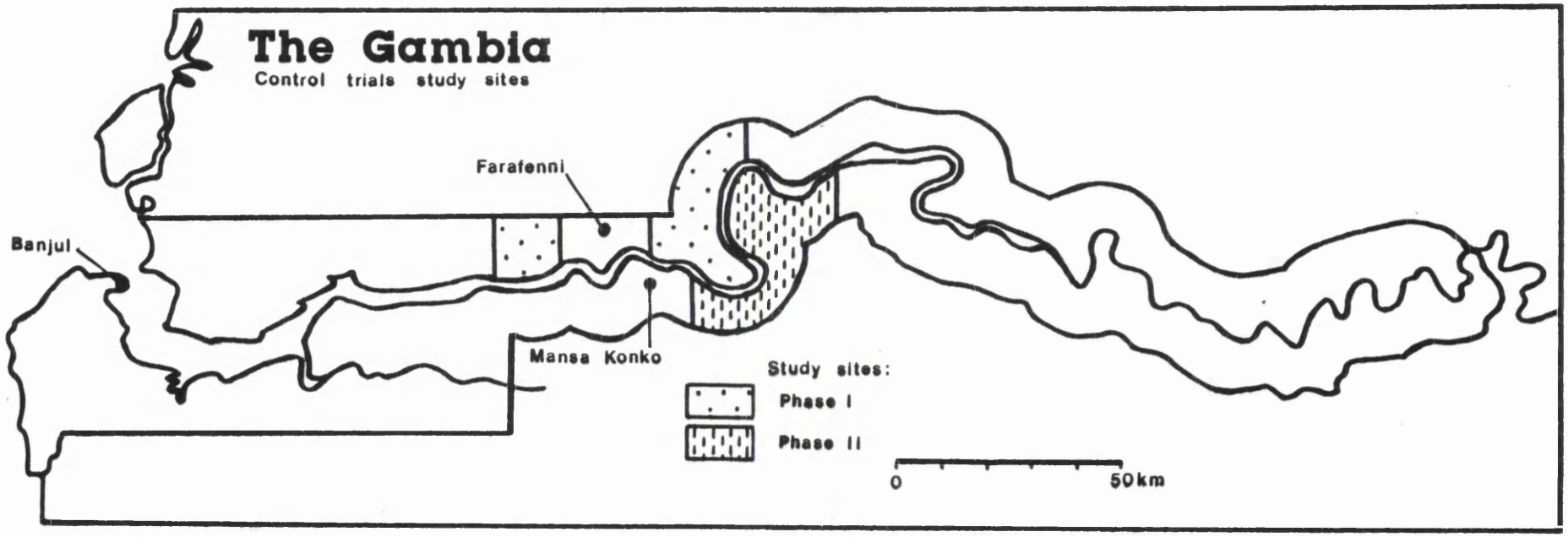

The Gambia
Control trials study sites
Farafenni
Banjul
Mansa Konko
Study sites:
Phase I
Phase II
0
50km

Figure 2.6

Trials were carried out to compare the effect of two malaria control strategies on mortality and morbidity of those under seven years old. The use of chemotherapy alone was compared with the use of chemoprophylaxis combined with chemotherapy, all administered by Village Health Workers (VHW) within the newly formed Primary Health Care (PHC) Programme.

Studies prior to The Gambia, such as one carried out in Kenya, indicate that community based treatment programmes (i.e. chemotherapy alone) had no overall effect on mortality amongst infants and children, (Greenwood *et al.* 1987). The use of chemoprophylaxis has also been considered previously, but trials have not been sufficiently conclusive to make this method of control viable in practice. Additionally the conditions in one region may not be suitable for effective implementation of a control programme which has been successful in another region.

Chemotherapy was available in all PHC villages, and chemoprophylaxis administered every two weeks to children under the age of seven years. A control population received a placebo, but had access to chemotherapy. Possible distortions to the results such as proximity to the larger centre, Farafenni, and different ethnic groups' social practices were considered and corrected for in the results.

Menon *et al.* (1990) suggests that those populations receiving chemoprophylaxis experienced a dramatic improvement in disease specific mortality rates from 9.5 per 1000 to 1.5 per 1000. Those receiving the placebo experienced no decrease in rates. Morbidity was reduced in the study population, those receiving chemoprophylaxis experienced a dramatic reduction in the number of episodes of fever.

Possible reasons suggested for the ineffectiveness of chemotherapy alone, include the short period between visible symptoms and death. Another possibility is that VHWs are part time volunteers whose income or subsistence comes from agricultural work, therefore they only have limited time to perform health care duties. It was found in the trials that each child received an average of 0.34 courses of chloroquine per year, but experienced between 0.5 and 1.0 episodes of clinical malaria per year.

There were no significant problems recorded relating to the use of chemoprophylaxis. Chemoprophylaxis was not sustained in an individual

child for long enough to have any detrimental effects to the development of their natural immunity and there was little evidence of drug resistance found amongst malaria parasites.

The cost of delivery was kept very low; only the cost of the drugs and transportation had to be covered since VHWs do not receive pay. The cost per child was around seven Dalasi, or fifty pence per year (Greenwood *et al.* 1987). The momentum in delivering chemoprophylaxis was found to be sustainable; a follow up survey carried out two and a half years after the trial noted that the system continued to run efficiently (Menon *et al.* 1990).

The trials in the Farafenni area have also considered the use of bed nets as a potential method for controlling malaria. Snow *et al.* (1988) indicate that, as expected, the prevalence of clinical malaria amongst groups using nets was found to be lower than those without, but factors such as location have a significant influence. Results collected in 1984 suggest that children using bed nets experienced 0.6 episodes of fever caused by malaria per year, whereas non-users experienced 1.1 episodes. Protection afforded by nets alone is, however, limited and separate studies have shown that there is little significant difference in malaria mortality between users and non-users. Apparent differences in incidence of malaria between users and non-users living close together could be due to an increase in the level of bites experienced by unprotected individuals due to there being fewer 'targets' for mosquito biting.

Significant advantages were noted in the performance of bed nets where they were treated with an insecticide, such as permethrin. The studies suggest that this will reduce the feeding success of mosquitoes by 90%. It was found that the treated nets were most effective towards the beginning of the rainy period, and less so at the end. It was suggested that this could be due to the prevalence of mosquitoes being greatest towards the end of the period and that treated nets are most useful in low to moderate transmission areas. This trend was also noted in studies in Burkina Faso, where the transmission rates are even higher than The Gambia, rendering treated bed nets less feasible in that country.

Due to the seasonality of malaria transmission, it is only necessary to treat a net once a year to remain effective, provided it is not washed Bradley *et al.* (1986). This can be a problem, since most Gambian mothers

would not dream of letting a bed net get dirty. The insecticide is likely to be completely removed after around two to three washes. The treating of nets is quick, cheap and easy to do by the people who use them under the initial supervision of VHWs.

iii) Malaria Control Trials. Phase II: South Bank of the River Gambia.

Malaria control trials were carried out on the south bank of the River Gambia between 1988 and 1991 by the MRC. The study area was approximately 200km from the coast, east of the town of Manso Konko as shown in Figure 2.6. Greenwood *et al.* (1993) discuss the methodology of the trials. Villages within 10km of the regional health centre at Manso Konko were excluded to reduce the influence of treatment available there. The purpose of the study was to examine the use of insecticide treated bed nets and chemoprophylaxis as effective measures for the control of malaria. This trial was intended to be more comprehensive than previous ones by confronting the local conditions and realities of actually implementing a workable scheme. Trials were set within the PHC programme to establish the workability of community oriented interventions within an existing health care system. It was hoped that the bed net option would prove to be more effective than chemoprophylaxis, which, as discussed before could have potential problems.

In the trial, chemoprophylaxis was administered to part of the child population, whilst a control group was given a placebo. Chemotherapy was available to all groups. The population using bed nets was given insecticide with which to impregnate their nets and guidance as to how to apply it. The control group consisted of those without nets.

Of the seventy three villages included in the study, seventeen were part of the PHC programme set up by the Gambian government in the early 1980s. Settlements of over 400 inhabitants qualified to become PHC villages. The majority of inhabitants of the area were either of the Mandinka or Fula groups. The majority of PHC villages were occupied by Mandinkas.

During the study period, the *post-mortem* interview technique was used, backed up by clinical methods to establish levels of malaria morbidity amongst children. It was found that child survival was improving throughout the 1980s in both PHC and non-PHC villages. However, the year preceding the trials, the infant and child mortality rates were 120 and 41 respectively. There was no significant mortality variation between the sexes. Morbidity surveys suggested that 64% of children had malaria parasitaemia, 94% of which was the *P. falciparum* parasite. Strong associations were found between parasitaemia and cases of fever.

Alonso *et al.* (1993) suggest that the introduction of treated bed nets and chemoprophylaxis resulted in a considerable reduction in mortality amongst those under five years. However, chemoprophylaxis seemed to have no significant additional benefit on mortality levels on top of the nets, but was found to have some influence on the number of cases of fever due to malaria.

The use of bed nets is a socially acceptable part of many people's lives in The Gambia. Aitkins *et al.* (1993) indicate that the trials had the effect of increasing people's awareness of the benefits and in a survey after the trial, 93% of people said that they would be prepared to pay to have their nets treated (Picard *et al.* 1993).

This set of trials is one of the most comprehensive to date. Aspects examined, in addition to epidemiological studies and investigations into mortality and morbidity improvements, included a full survey of the entomological characteristics of the area, a survey of perceived causes of malaria amongst the population and a study of the cost effectiveness of bed net impregnation and chemoprophylaxis.

The Gambian government aims to comprehensively provide insecticide treatment for bed nets over a two year period as a result of the surveys carried out in these trials. This has resulted in the inception of the National Impregnated Bed Net Programme (NIBP) in 1992 which will be discussed in the next section.

iv) The National Impregnated Bed Net Programme.

The National Impregnated Bed Net Programme was inaugurated in 1992 and is partially backed by the WHO and managed by the Gambian Ministry of Health and the MRC. The National Impregnated Bed Net Project Document (1991) indicates the aims of the programme as follows:

a) Bed nets to be impregnated in all PHC villages in The Gambia over a two year period.

b) To evaluate the impact of the programme on mortality and morbidity amongst children under five years.

c) To evaluate the impact of the programme on the outcome of pregnancies and birth weights.

d) To monitor entomological behaviour in relation to impregnated bed nets.

e) To develop a strategy to delay the onset of insecticide resistance.

f) To evaluate the cost effectiveness of the programme and appraise methods of financing it.

The implementation of the programme is the responsibility of the Ministry of Health. Activities included sensitisation meetings and awareness campaigns as well as the logistical planning of the supply of insecticide and equipment. Figure 2.7 shows a government awareness poster. The dipping of nets was controlled by regional health teams and carried out by the VHWs.

The monitoring of the programme is the responsibility of the MRC. The main activity was to monitor the change in mortality and morbidity between pre and post intervention using the *post-mortem* questionnaire technique. Comparisons were made between PHC villages which had received the bed net impregnation and the non-PHC villages which had not. Five study sites were chosen for monitoring to represent the diversity of ecological and epidemiological characteristics in The Gambia.

A BED-NET DIPPED IN INSECTICIDE WATER KILLS OR KEEPS AWAY MOSQUITOES AND BED-BUGS.

MINISTRY OF HEALTH IN CO-OPERATION WITH UNICEF - THE GAMBIA

Figure 2.7 Government NIBP Awareness Campaign

Although the results of these five study sites are unavailable at present, the demographic impact of the NIBP will be simulated in chapter four. The results of the malaria control trials outlined above will be used as surrogate results from the NIBP.

2.3 HEALTH CARE IN THE DEVELOPING WORLD.

2.3.1 Health and Development.

Health is inexorably linked with development. Not only will health influence development, but development will influence health. A healthy population will help to stimulate economic development and an unhealthy population may be a hindrance. However, the possibility that investments in a nation's health may be recovered in terms of improved GNP has been recognised as rather simplified (Grosse and Harkavy 1980). The two issues are highly associated but, there is no simple cause and effect relationship between health and development.

Populations of developed nations have, on the whole, an overall better quality of health, reflected in better life expectancies and lower mortality rates than less developed nations. In the developing world, however, development may not have an automatic impact on health.

Seers (1979) suggests that development involves acquiring the universal capacity to acquire food and physical necessities, paid employment and egalitarian distribution of resources. Economic indicators merely suggest a potential for development. However, where economic development does occur, the potential for increased welfare for an entire population may not be fulfilled.

Frequently, wealth accumulated by economic/ industrial expansion in the developing countries does not benefit the majority of the population. Often the developed countries gain more from the process than the developing ones. The belief has been, until recently, that the 'western' industrial model of development is the optimum way for a country to develop. This has been questioned and the emphasis has shifted towards social development programmes. The shift in emphasis has resulted in the recognition that, for example, the provision of egalitarian health care is

an important aspect of effective development. It is probable that this may be more beneficial to the country than the often misguided belief that industrial income may 'trickle down' to benefit the entire population.

However, the provision of health care is expensive and the next section will consider a more appropriate and possibly cheaper system of delivery than the large city hospitals that reflect colonial and post-colonial western influences.

Firstly, it should be stressed that health care provision is just one of a large number of possible programmes that could improve people's welfare through better health. Improvements is 'standards of living' of the majority of the population are also likely to have an impact on health and therefore demographic change. Improvements in nutrition are extremely important in improving welfare and contribute towards high levels of infant and child mortality. In addition, the lack of uncontaminated water is an issue of particular significance to the health of children and infants particularly (Phillips 1990).

Quantifying how significant the malaria intervention programmes are compared to other social development possibilities is beyond the scope of this dissertation. However, given the Gambian economy is highly underdeveloped, this dissertation will suggest that one isolated example of social development, the NIBP, can have some demographic impact. This will augment the argument that meaningful social development can occur within an underdeveloped economy.

2.3.2 The Changing Philosophy of Health Care in the Developing World.

The National Impregnated Bed Net Programme within the Gambian PHC programme reflects changes that have occurred in the philosophy of health care delivery in the developing countries since the 1970s. Shifts in the philosophy of health care are associated with changes in emphasis in terms of people served, services provided and levels of coverage of health programmes. The movement is from urban oriented hospitals serving

small urban/ elite populations in countries where the majority of the population are rural, to universally available health care.

Before the changes in focus, 'western' style health services, which were legacies of colonial development, dominated in many less developed countries and The Gambia is no exception. Large sophisticated hospitals staffed by professional health workers prevailed and the emphasis was on curative care. In short, as well as being unjustifiably expensive, health care was and in some cases remains, inappropriate and inaccessible to the requirements of the majority of the population (Werner 1980). In parallel to this notion is the recognition that health is not simply an absence of illness, but 'a state of complete physical, mental and social well being...'. That is, it is not enough to simply cure sick people, but to ensure a more holistic welfare (Feachem *et al.* 1989, Phillips 1990).

Recent emphasis has changed from urban hospital based services to community based ones, such as Primary Health Care. This served the purpose of providing a more 'prevention' based and broad service involving education on health issues such as hygiene with a reduced emphasis on curing illnesses. This is therefore a more appropriate and effective health service in the light of the epidemiological characteristics of developing countries. Additionally, the changes have involved a movement towards many small delivery outlets, often on a village by village basis, making health care more accessible. Tanzania was one of the first countries to introduce a PHC programme in the developing world, and many have followed (Pearson 1986). The WHO aims to assist countries in achieving health for all by the year 2000 (Mahler 1974).

In 1981, a village based PHC programme was set up in The Gambia in an effort to change the emphasis from the dominant urban hospitals. Ten years after inception, the programme had achieved universal coverage in the larger villages. Villages with a population over 400 were invited to nominate a Village Health Worker (VHW) and a Traditional Birth Attendant (TBA) who would undergo a six week course of formal training at a regional health centre. VHWs are provided with an initial set of drugs which are sold to the villagers when necessary. The money is used by the VHW to buy more drugs. VHWs and TBAs are under the supervision of community health nurses who cover five villages, and are in turn supervised by a regional medical officer. Studies suggest that a child

would visit the VHW on average one or two times per year. Villages with a population under 400 were excluded from the scheme, which represents its major weakness.

The MRC carried out mortality and morbidity surveys to evaluate the effectiveness of the PHC programme in reducing child and infant mortality. It was found that mortality rates dropped in both PHC and non-PHC villages in the Farafenni area. Improvements occurred in both PHC and non-PHC villages in roughly equal amounts. This is not due to failure of the PHC programme. Suggested reasons include the improvement of health facilities in Farafenni itself which acquired a new health centre and additional medical staff in the 1980s. In 1986 a new regular bus service was set up linking the larger villages with Farafenni and in 1987 a new private hospital was built. In addition, dispensaries were created, one to the east and one to the west of the town to aid the delivery of health treatments to the surrounding area. The significant increase in 'regional' health facilities is likely to be responsible for the similar improvements in PHC and non-PHC villages. Additionally it has been suggested that VHWs also treated people from non-PHC villages. Farafenni is not an isolated case, upgrading of regional health care has taken place throughout The Gambia, therefore these trends are reflected nationally.

Even after the introduction of the programme, it was found that only around 30% of children who died had visited a VHW during their final illness. Around 20% saw the traditional healer in the village. Low numbers of children visited doctors overall and few visited health centres, dispensaries and hospitals (Greenwood *et al.* 1990). More research needs to be carried out to determine why, if few children visited the 'regional' health facilities, do these appear to have a significant impact on health in the area, possibly over and above the PHC programme? Another anomaly is why do so few people visit VHWs and health centres when they are apparently accessible and appropriate? Finally, why have infant and child mortality rates dropped significantly if there is supposedly low levels of contact between health services and the rural population?

CHAPTER THREE.

MALARIA EPIDEMIOLOGY IN THE GAMBIA.

3.0 INTRODUCTION.

Chapter two briefly reviewed the geographical patterns and environmental determinants of malaria on a world scale as well as within sub-Saharan Africa. This chapter will examine the epidemiology of malaria within The Gambia.

The Gambia lies within the savannah region of sub-Saharan Africa, which is associated with particular patterns of malaria transmission, effected by temperature and water availability factors. However, it was expected that due to the location of The Gambia, in a coastal region dominated by the River Gambia, that local factors may also play a part in determining patterns of malaria.

To analyse the impact of a malaria control programme it was considered beneficial to investigate the local scale variations in malaria and the factors effecting those variations. It was hoped that it would then be possible to simulate the impact of the programme within different regions of differing malaria epidemiology. However, as this research progressed it rapidly became evident that neither the peculiarities of malaria epidemiology, nor the data available allowed for a full analysis.

3.1 DIFFICULTIES WITH AND LIMITATIONS OF A SPATIAL STUDY.

Malaria transmission has been shown in studies to be enormously varied on the local scale. Differences may be profound between villages only a few km apart or may even occur between compounds and individual buildings. Therefore the spatial pattern of infant and child malarial mortality is extremely complex and small scale.

Although the literature covers a broad analysis of the spatial characteristics of malaria and its determinants, no nation-wide epidemiological survey exists which has examined all the local variations in malaria and malarial mortality. It is simply not practical to examine spatial variations on such a detailed level.

Findings suggest that there is an unexpected relationship between factors which favour mosquito populations and levels of malaria transmission. This exacerbates difficulties in measuring physical and human factors to predict malaria prevalence.

The MRC has looked in some detail at patterns of malaria in five study sites, comparing malaria mortality amongst children and infants before and after the NIBP intervention. Although this is not a nation-wide survey, it does allow for comparison between different areas which were chosen by the MRC to represent the maximum ecological diversity in The Gambia. Therefore, a more spatially meaningful evaluation of the impact of the intervention may be possible when the results are published.

Additionally, the unpublished reports available, (Thomson *et al.* 1994 a&b), that discuss the geographical determinants of malaria and the relationship between malaria transmission and vector density currently only allow for a qualitative discussion.

3.2 VARIATIONS AND DETERMINANTS OF MALARIA EPIDEMIOLOGY IN THE GAMBIA.

Firstly it is necessary to distinguish between the terms vector density and malaria transmission. In general, environmental factors play a role in providing suitable habitats for mosquitoes (the malaria vector being the *Anopheles* species mosquito). Therefore, if the environment provides favourable conditions for mosquito populations to proliferate, the vector density will be high. However, a high vector density will not automatically result in high levels of malaria transmission and very often human activities may have an influence.

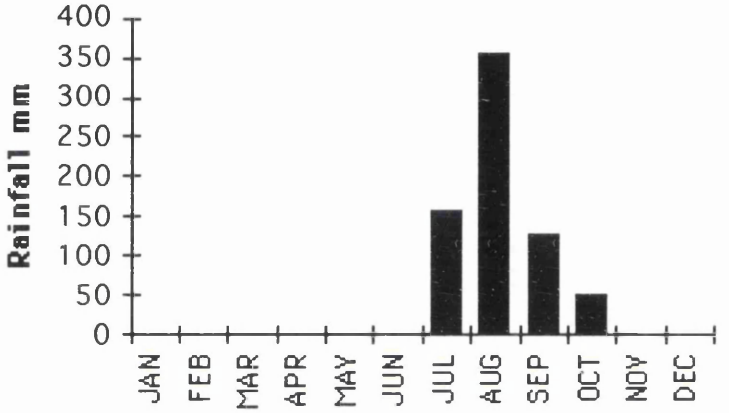
The various factors effecting malaria epidemiology will now be examined before considering the relationship between vector density and malaria transmission as found in The Gambia.

Climate is not uniform throughout The Gambia, although it broadly falls within the savannah climatic region of Africa. Heavy storms may effect very small areas and only a small number of villages may be

effected. This contributes to the total rainfall in a given area, but heavy storms tend to disturb mosquito breeding sites and therefore reduce vector density.

Figure 3.1 shows the seasonality of rainfall in Banjul. The wet season is in the four months of the year July to October. The pattern of rainfall varies from region to region in terms of the timing of the wet season and overall rainfall. Inland areas experience the beginning of the wet season four weeks before coastal areas. The total length of the wet season inland is usually longer than that in coastal areas.

FIGURE 3.1 THE SEASONALITY OF RAINFALL IN BANJUL 1991



Source: Derived from Statistical Abstact of The Gambia 1992.

Areas close to the coast also have higher relative humidity than inland areas (that is during the dry season). During the wet season all areas experience a rapid rise in humidity, which is favourable to mosquito populations.

Temperature is also varied within The Gambia. Mean temperatures are greater away from the coast. Basse, in the east of the country, experienced a maximum temperature of 40.7 degrees centigrade and Banjul a maximum of 31.3 degrees centigrade in April 1992. However, no part of The Gambia has a low enough temperature to exclude malaria transmission. The hotter temperatures in the dry season are more likely to evaporate many areas of surface water than the cooler areas. Water availability would appear to be a more important factor affecting vector density than temperature differentials in The Gambia.

The availability of water is a more important factor influencing vector densities than rainfall as such, and this is influenced by geomorphology and hydrology. The geomorphology of The Gambia is heavily influenced by the River Gambia. Alluvial deposits are associated with the past and present course of the river. These are deposited on sandstone soils and the demarcation between these two main soils forms a bluff line. As expected, vector densities are greater within the alluvial areas than the sandstone areas. The alluvial areas are more likely to have surface water and are more liable to flood. In addition to soils, the distance from the river is, in itself, an important variable affecting vector density. Mangrove swamps proliferate on the river margins, which provide ideal habitats for mosquitoes.

Mosquito populations will be effected by the water salinity at any given point. There are three varieties of the *Anopheles* species of mosquito in The Gambia. The most serious vector is the *A. Gambiae* variety which survives only in freshwater, therefore will be only prevalent in the salt free areas away from the coast. The variety can, however, survive further down river in the wet season. The *A. Melas* variety of mosquito does proliferate in the saltwater areas, but is a comparatively poor malaria vector.

The flow of the river itself is highly seasonal and is influenced by the rains at its source in Guinea. Due to the flatness of The Gambia, there is salt water for much of the length of the river. The position of the salt water 'threshold' is mostly affected by the flow of the river which will be greatest at the end of the rainy season (October). The salt water threshold will be nearest the coast in the rainy season since the high level of freshwater generated by the rains will wash this down river. The first 180 km from the river mouth is dominated by salt water for most of the year. However, during the wet season the availability of surface water close to the river, such as pools and swamps will increase. Further upriver, the water ceases to be saline, and flooding is comparatively rare, therefore suitable breeding sites for mosquitoes rely on local rainfall. The transitional middle river zones are therefore likely to be favourable for mosquito breeding (Thomson *et al.* 1994b).

As suggested above, human activities have an effect on vector densities and malaria transmission. Greenwood *et al.* (1993) indicate that urban

settlements have low levels of malaria mortality and morbidity compared to rural areas. The low prevalence of surface water plays a part, as does the availability of malaria treatments

Rice is a major food crop in The Gambia, and in the 1950s large areas of land were opened up for rice cultivation by constructing causeways into the swamplands. However, whilst these programmes served to augment agricultural output, they also increased the area suitable for mosquito breeding and have therefore become high vector density areas.

All these factors suggest that the levels of vector density are highly variable at the local scale. It would therefore be expected that malaria transmission would be closely associated with areas of high vector density. In The Gambia, studies have suggested just the opposite, an inverse relationship exists between vector densities and malaria prevalence.

The cause of this inverse relationship is related to the traditional use of bed nets. Snow *et al.*(1988) suggests that in The Gambia bed nets were already used at different levels amongst various ethnic groups. Of the Mandinka ethnic group, all children under the age of ten were found to use bed nets 93% for the whole year, whereas 79% of Wollofs made use of nets, but only 61% used them for the whole year. Of the Fula group, only 60% were users and only 55% users for the whole year. On the whole, women were found to use nets more than men, with men aged ten to nineteen showing the lowest utilisation rates. The condition and quality of nets also varied, Mandinkas using the best nets and Fula the worst.

Where vector densities are high, the population will tend to use nets heavily to avoid the insect nuisance factor. Although privacy is also a noticeable factor especially in polygamous households, 99% of Gambians stated that the protection from mosquito bites was the main reason for bed net ownership. Only a minority, 25% of the population, were aware of the association between mosquitoes and malaria. In addition, inhabitants of high vector density areas normally go to bed early to avoid the evening biting period (Aitkins *et al.* 1993). In areas of low vector density, bed net usage is light, therefore protection from malaria is low (Thomson *et al.* 1994 b).

A survey was carried out by the MRC to investigate the association between physical factors and bed net usage. This is highly pertinent to the planning of the NIBP or a similar scheme, since only those people who owned nets received insecticide, those without nets did not benefit from the programme. It was found that net usage was most common in the middle river area where rice cultivation is common and salinity is low. In addition those villages on the alluvial soil or close to the bluff line also had high net usage. Distance from the River Gambia and its tributaries is also a major determinant of net use.

The physical factors appear to have a much stronger influence on net use that ethnic background. In villages in areas of high vector density, net usage will be high regardless of ethnic composition.

3.3 CONCLUSIONS.

The best method of measuring the variables potentially contributing to high malaria transmission is to study levels of bed net use. The areas of high density and therefore high net use are likely to become the major benefactors of the NIBP. However, it has been concluded that variations are so local that it would be very difficult to consider the impact of the NIBP on such a local scale even if a nation-wide detailed survey was carried out. Even the NIBP five study site results (each study site being around fifteen villages), when available, will provide only a very simplified generalisation of the impact on mortality after the intervention. This study will use the results of the phase II malaria trials to evaluate the demographic impact of the NIBP. The assumption is made that the phase II results represent the typical impact that the intervention will have. There is considerable potential for future research to use GIS as a method of examining the large range and diversity of the data.

CHAPTER FOUR.

THE IMPACT OF THE NATIONAL IMPREGNATED BED NET PROGRAMME ON THE RURAL POPULATION.

4.0 INTRODUCTION.

In this chapter, the demographic impact of the NIBP on the rural Gambian population will be investigated. Life tables are used to project the population from 1993 to 2003.

The NIBP affects the PHC population only, which will therefore be separated from the non-PHC and urban populations. Since the urban malarial and non malarial mortality regime is very different to that of the rural, and that urban settlements are not involved in the NIBP, they will not be considered in this study. The rural population will be split into PHC and non-PHC villages for comparison, but with no further spatial breakdown. 10% of the Gambian rural population is dispersed and will be enumerated within the non-PHC group.

The results of the Phase II malaria control trials are used to represent 'typical' mortality pre-and post-intervention. Despite the limitations of assuming this area is typical, the notion that this region alone should be studied was rejected. It was considered desirable to evaluate the impact of the programme on the entire rural population that the NIBP would effect. In addition, difficulties are likely to occur in working with a small population. Minimal data is available regarding the population characteristics of the Phase II site; national data is more readily available.

The main population data sources to be used are the Population and Housing Census Report 1983 and the 1993 Provisional Report. The 1993 census is especially useful, despite having no age/ sex break down, since it coincides with the NIBP implementation of 1992- 1994. This study will therefore use 1993 as the 'baseline' population year as well as the 'intervention year'.

4.1 METHODOLOGY.

4.1.1 Population Projections.

A number of methods are available for projecting populations, ranging from very simple to highly complex. Simple methods include extrapolating

forward in time a population based on present numbers and growth rate. An alternative is to graphically fit a 'best fit' line to past population trends and project it forward. The weaknesses of these methods of projection are that they assume the population will follow mathematical rules and rely on very crude historical information.

Another major problem with these simple projections is that they are limited in terms of the information they convey. For example, there is no consideration of the age/ sex composition of the present and projected population. This information is essential if any meaningful planning is going to be carried out. The accuracy of the projection can also be improved if the age/ sex composition of the present population is known. These factors are particularly important in this research since child and infant mortality need to be distinguished from mortality in other groups.

The 'component' method of projection is an improvement on the above methods, but relies on more detailed input data (Newell 1994). The technique can range from relatively simple to an extremely complex analysis. The method looks at the individual components of a population and considers them separately. The basic equation is as follows:

Population t+1= Population t + births - deaths + net migration.

This research will consider in detail the mortality component of the above equation. Data constraints allow for no analysis of migration and only a highly simplified allowance for births. Therefore the assumption has to be made that there is no migration affecting rural populations. Rural-urban migration is taking place, although the future significance of this has not been estimated. This represents a weakness of the data analysis and the resulting totals are limited in accuracy. It is likely that overall net migration between PHC and non-PHC villages is not significant at the national level. Therefore the analysis remains strong in terms of comparison since all populations compared are deemed to be equally affected by rural-urban migration.

To consider the mortality component of the equation, life tables will be used which break down the population into (in this case) five year cohorts with a probability of survival (or mortality) allocated to each. Insufficient detail is available within the Gambian census data to estimate the survival probabilities for each age group in the population. Therefore

published model life tables will be used to represent these probabilities. Life tables are particularly suitable for the projection of populations in this research. Malaria is a disease which only significantly affects those under five years old. Therefore the under five year cohort can be 'adjusted' separately from the rest of the population to account for an impact on the mortality in that group alone.

4.1.2 Model Life Tables.

A plethora of published model life tables are available. Of those based on the distillation of patterns of mortality from real life tables, that is, 'empirical' model life tables, three sets were seriously considered: The Princeton Regional Model Life Tables (the 'Coale-Demeny Set') published in 1966 and 1983; the 1955/6 United Nations Set; and the United Nations Model Life Tables for Developing Countries set published in 1982.

The 1955/6 UN. Set (UN. 1955, 1956) was rejected for use due to a number of weaknesses. The set has been criticised for being inaccurate, especially amongst the younger age groups on which this research is concentrating. Other criticisms include problems of statistical bias in the process of deriving the models and artificial smoothing and adjusting which has diminished their performance. The groups of tables which consider high mortality populations are based on small samples and are therefore unreliable. In addition the models are inflexible since no account is taken of the nuances of the age-specific death rates in a particular population; the choice is based on a simple aggregated death rate.

The Princeton Regional Model Life Tables (Coale and Demeny 1966, 1983) are an improvement on the UN. 1955/6 Set in that they allow for four major patterns of mortality. These are referred to as the 'North', 'South', 'East' and 'West' 'regions'. The main criticism of this set of model life tables is that they are based exclusively on empirical data from European other developed countries. This renders them inappropriate for work on developing countries since the patterns of mortality are incompatible. This set was therefore rejected

The UN. Model Life Tables for Developing Countries set (UN. 1982) was considered the most appropriate set for this study. This set is similar to the Princeton one in that it is based on a number of major patterns of mortality (in this case five patterns). The data on which they are based originates from developing countries, making them more suitable for work on The Gambia, despite them being based on no empirical data originating from sub-Saharan African countries. Selection of the pattern of life tables was based on the characteristics of the tables matching those of the Gambian rural population as closely as possible. Little data is available regarding age-specific mortality rates amongst all Gambian population age cohorts, therefore the choice of pattern is based on generalities, not specific rates. The Latin American pattern is characterised by relatively high infant and child mortality due to high levels of diarrhoeal and parasitic diseases. Old age mortality is relatively low due to low levels of western degenerative illnesses. This pattern most closely matches that of the Gambian population and will therefore be used in this study.

4.1.3 Specific Life Tables.

Data constraints limit the number of factors that can be weighed up in making the choice of specific life table. The process of choosing a life table will therefore be reasonably simple, but given more detailed data could be quite involved. The two factors to be used in fitting the best life tables will be infant mortality and life expectancy at birth.

Problems involved in considering the choice of life table include large differences amongst published infant mortality rates and little published on life expectancies. Additionally, there is little data on the differentials between urban and rural mortality rates. The results of the projections will therefore provide 'indications' of probable absolute changes. They will, however provide a strong base for comparison. The UN. has produced population projections based on the 1983 census and include projected estimates of future infant mortality rates and life expectancy at birth between 1985 and 2005. Table 4.1 summarises this data.

TABLE 4.1

THE GAMBIA	YEAR	IMR	LIFE EXP.
UN ESTIMATES	1985-90	161.1	43.4
FOR INFANT MORTALITY	1990-5	145.9	45.35
RATES AND LIFE	1995-2000	130.7	47.36
EXPECTANCY.	2000-5	115.6	49.46

Source: Zachariah and Vu 1988.

Notes: IMR= deaths per 1000 live births., both sexes, national level.

Life exp. = Life expectancy at birth, both sexes, national level.

The infant mortality rate for the years 1985-90 is consistent with the 1983 estimate of 167 per 1000 nationally as published in the Population and Housing Census (1983). This adds confidence to the use of these estimates for the years 1990-2005. The UN. figures (Zachariah and Vu 1988) combine rural and urban estimates, but infant mortality is likely to be higher in rural populations than urban ones. However, it is felt that since the majority of the population of The Gambia is rural, these figures will be closer to rural infant mortality than urban. In addition, the low estimate for 1995 (UN. estimate for 1995: 1,008,000, actual population 1993, 1,025,867) suggests that national infant mortality has been estimated slightly high for the period. In addition, high levels of international immigration and little reduction in fertility have contributed to higher growth rates than have been predicted. Therefore these figures are deemed reasonable surrogates for the true rural infant mortality rates.

On the basis of the above discussion, the Latin American 'males infant mortality rate 149 per 1000' was chosen for the 1993-98 projection and the 'males infant mortality 134 per 1000' for the 1998-2003 projection of both male and female Gambians combined.

There is range of conflicting infant mortality rates published of which the UN. estimates discussed above are at the 'top end'. It is therefore considered necessary to use an additional lower infant mortality rate to give a range of projections with 'reality' falling somewhere in between. The

results of the Phase II malaria control trials suggest that rural infant mortality is around 115.5 to 127.1 per 1000, which represent the optimistic end of the range. On this basis the Latin American 'males infant mortality rate 124 per 1000' was chosen for the 1993-98 'low' projection and the 'males infant mortality 115 per 1000' for the 1998-2003 'low' projection. The UN. (1982) publication suggests that it is acceptable to use 'male' tables for female or 'combined' population projections provided the pattern of mortality is compatible. Table 4.2 shows the age-specific deaths rates for the 'low' and 'high' infant mortality projections derived from the UN. life tables.

TABLE 4.2.

		Qx			
		1993-8	1998-2003	1993-8	1998-2003
LATIN AMERICA	AGE(x)	HIGH IMR	HIGH IMR	LOW IMR	LOW IMR
MODEL LIFE TABLE	0-4	0.2349	0.20774	0.1904	0.17377
(MALES)	5-9	0.02858	0.02412	0.0214	0.01892
	10-14	0.0156	0.01333	0.012	0.01066
	15-19	0.02182	0.01882	0.017	0.01524
	20-24	0.03249	0.02811	0.0254	0.02284
	25-29	0.03702	0.03217	0.0292	0.0263
	30-34	0.04212	0.0366	0.0332	0.02994
	35-39	0.04971	0.04367	0.0399	0.03627
	40-44	0.05919	0.0527	0.0486	0.04461
	45-49	0.07332	0.06629	0.0618	0.05736
	50-54	0.09175	0.0843	0.0794	0.07465
	55-59	0.12108	0.11293	0.1075	0.10217
	60-64	0.16126	0.15216	0.1461	0.13995
	65-69	0.22697	0.21597	0.2085	0.201
	70-74	0.31136	0.2987	0.2901	0.28122
	75-79	0.41101	0.3979	0.3889	0.3795
	80-85	0.52852	0.51698	0.5089	0.50053
	85+	1	1	1	1

Source: UN. Model Life Tables for Developing Countries 1982.
Note: Under 5 mortality derived by combining under 1 and 1-4 rates from tables.

Health trials have suggested that infant and child mortality differentials between PHC and non-PHC villages were not significant before the inception of the NIBP intervention (Greenwood *et al.* 1990). This suggests that rates of growth will be similar in PHC and non-PHC villages before the intervention. It was therefore deemed acceptable to allocate the same life tables to both PHC and non-PHC villages.

Indicators suggest a general downward trend in mortality. Therefore lower mortality life tables will be consistently used for the 1998-2003 period than the 1993-98 period. The under five mortality rates will be 'adjusted' to allow for the impact of the malaria control programme.

4.1.4 Malaria Specific Mortality Rates.

Alonso *et al.* (1993) suggested that there was no improvement in malaria-specific infant and child mortality between the pre and post-intervention periods in non-PHC villages. That is, the intervention did not affect the bed net or insecticide usage in the non-PHC villages. Therefore the mortality rates derived from the Phase II trials will only be applied to the PHC population. Table 4.3 shows the results of the Phase II trials.

TABLE 4.3

		MALARIA SPECIFIC MORTALITY		
THE GAMBIA	AGE(years)	PRE-INTERVENTION	POST-INTERVENTION	DIFFERENCE
MORTALITY RATES PRE & POST	<1	19.5*	3.6*	15.9*
INTERVENTION	1-4	20.6#	3.4#	17.2#
IN PHC VILLAGES	0-4	39.7$	7.0$	32.7$

Source: Alonso *et al.* 1993

Notes: * IMR: Mortality per 1000 live births

CMR: Mortality per 1000 1-4 year population

$ Mortality derived from IMR and CMR

The age composition of the rural male population was very similar to the rural female population, which suggests that the mortality regime is similar for both (Wadda and Craig 1993). Greenwood *et al.* (1993) suggested that malaria mortality has a similar impact on both male and female under five years old. Therefore both male and female populations will be aggregated and projected forward together.

A weakness of relying on these figures is that it is difficult to establish how typical this area is in terms of malarial mortality and bed net use. Chapter three suggested that malaria was extremely variable spatially as

is bed net use. However, in the absence of further data, the results of this trial will be assumed to represent the national rural 'average'.

Malaria mortality is very low amongst the over five years population (Knell 1991). For the purposes of this exercise it will be assumed to be non existent, therefore mortality rates will not be adjusted to account for malaria in the over five year population

4.1.5 Fertility Assumptions.

Data available on fertility is extremely crude. UN. estimates suggest a reduction from a crude birth rate of 45.3 per 1000 population for 1990-5 to 41.7 for 1995-2000 (Zachariah and Vu 1988). These rates are consistent with those published in the Population Data Bank 1993, but are limited in that they are national estimates, not rural estimates. These rates will be used, but it is expected that actual rural crude birth rates may be higher than the above rates over the period. Therefore growth will be, to a certain extent, under estimated. In addition, crude birth rates are not ideal for predicting numbers of births, since no account is taken of the age/ sex composition of the population. The results of this section will therefore be strongest for use in comparative analysis, less so in terms of absolute outcomes.

4.1.6 Preparation of Population Data for Life Table Projections.

The PHC/ non-PHC population split is not available for 1993. The information is available 'within' the 1983 census, but needs to be extracted. Those villages with a population over 400 were designated PHC villages in 1981. The Health Service Statistics (1991) list the PHC villages.

The 1983 census report suggests that the proportion of the population living in PHC and non-PHC villages varied significantly between regions. It was therefore deemed necessary to calculate the population of all PHC to non-PHC villages separately. It was found that, for example in Mansa Konko LGA, 74% of the rural population lived in PHC villages, whereas

42% lived in PHC villages in Georgetown LGA. Table 4.4 shows the urban, rural PHC and non-PHC populations in 1983.

TABLE 4.4

THE GAMBIA	BREAKDOWN	POPULATION	% OF TOTAL	
URBAN AND RURAL	URBAN	211848	30.8	
(PHC/ NON-PHC)	RURAL			
POPULATION	PHC	290258	42.2$	61.0*
1983	NON-PHC	185711	27.0$	39.0*
	TOTAL	475969	69.2	
	TOTAL POP.	687819	100	

Source: 1983 Population and Housing Census (Derived).
Notes: $= population as % of total population
*= population as % of rural population

The proportion of the total population classified as rural diminished from 69.2% in 1983 to 62.3% in 1993 although the total rural population increased from 475,969 to 639,115 over the period. Since the assumption has been made that growth has increased equally in PHC and non-PHC villages on a national level, the populations of both types of villages can be estimated for 1993 as shown in Table 4.5.

TABLE 4.5

THE GAMBIA	BREAKDOWN	POPULATION	% OF TOTAL	
URBAN AND RURAL	URBAN	386752	37.7	
(PHC/ NON-PHC)	RURAL			
POPULATION	PHC	389860	38.0$	61.0*
1993	NON-PHC	249255	24.3$	39.0*
	TOTAL	639115	62.3	
	TOTAL POP.	1025867	100	

Source: 1983 Population and Housing Census (Derived).
1993 Population and Housing Census Provisional Report
Notes: $= population as % of total population
*= population as % of rural population

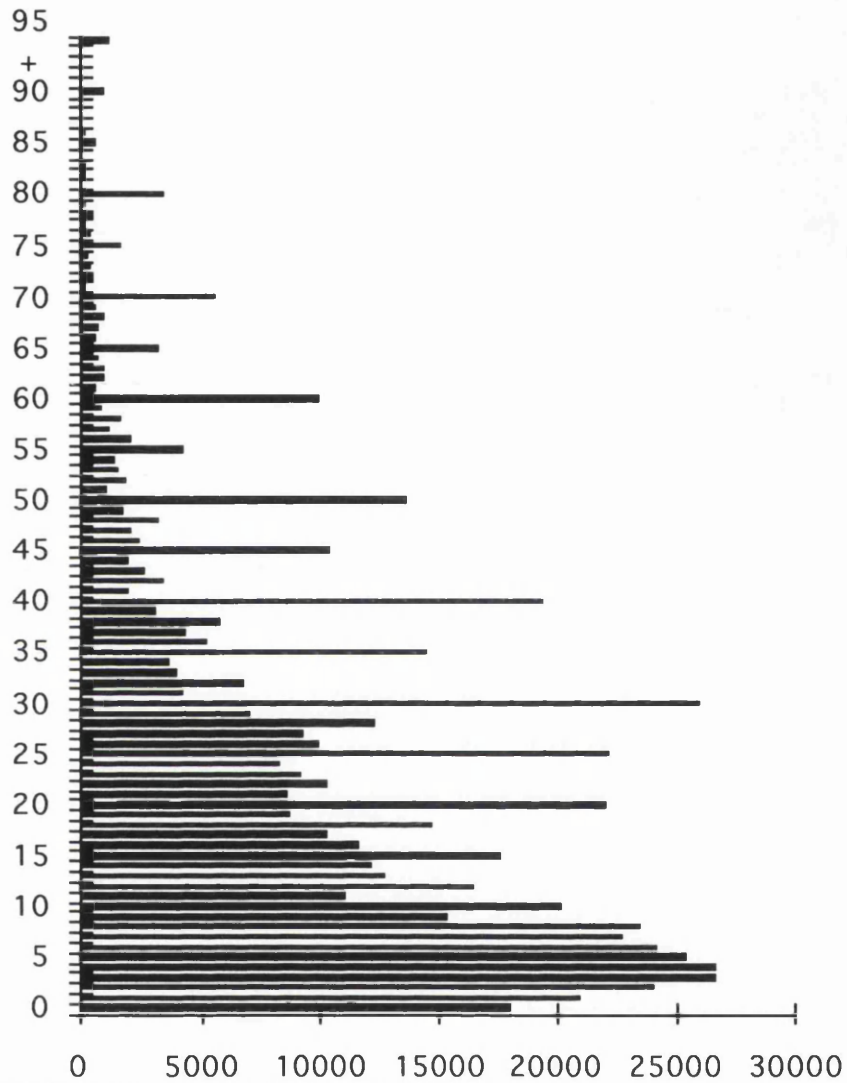
The populations now need to be disaggregated by age structure. The 1983 Population and Housing Census breaks the population down by single year cohorts. This level of detail is not available in the 1993 Population and Housing Census Provisional Report.

The age distribution of the combined male and female 1983 populations is shown in Figure 4.1. The Figure clearly illustrates the phenomena known as 'age heaping'. This problem of inaccuracy is common in census reports in less developed countries with low literacy rates and lack of infrastructure. Participants in censuses or surveys often either do not know their age or choose not to tell the truth. Very often the census interviewer will have to estimate peoples' ages. Frequently ages ending in zero or five will be over represented in the census results since ages are often rounded up or down. Notably the older aged cohorts of the population are most likely to be subject to this phenomena, which is often due to less education in those groups or lack of birth recording.

One method of quantifying this type of inaccuracy is to use Whipple's Index which calculates the proportion of the population reporting ages ending in zero or five in relation to the whole population. This was calculated for the Gambian 1983 population as 243.3, which rates as 'very rough' on the UN. score for estimating reliability of age data. Therefore the age structure data was viewed with caution.

One way of reducing this problem of inaccuracy is to use five year cohorts to 'smooth' out the age heaping. Wadda and Craig (1993) show the age/ sex structure by five year cohorts of the urban and rural populations by socio-economic group in 1992. In using this, the issue of age heaping is, to some extent, mitigated. Although the Wadda and Craig survey only enumerated a sample of the population, it does have the advantage of being based on the 1992 , not 1983 population. All socio-economic groups were aggregated as were the male and female populations. This gives a good surrogate of the 1993 age structure, which is shown in Table 4.6. It is assumed that no major differences occurred to the age structure of the rural population between 1992 and 1993.

FIGURE 4.1. THE GAMBIA 1983 AGE STRUCTURE. ONE YEAR COHORTS.



Source: Population and Housing Census 1983

Notes: Male and female combined

TABLE 4.6

THE GAMBIA	AGE	% TOTAL POP.	PHC POP.	NON-PHC POP.
RURAL POPULATION	0-4	16.0	62378	39881
AGE STRUCTURE BY	5-9	19.3	75243	48106
PERCENTAGE AND	10-14	13.1	51072	32652
PHC/ NON-PHC	15-19	9.8	38206	24427
POPULATIONS	20-24	7.1	27680	17697
	25-29	7.6	29629	18943
	30-34	5.7	22222	14208
	35-39	4.2	16374	10469
	40-44	4.0	15594	9970
	45-49	2.7	10526	6730
	50-54	2.7	10526	6730
	55-59	1.8	7018	4487
	60+	6.0	23392	14955
	TOTAL	100	389860	249255

Source: Wadda and Craig 1993

Population and Housing Census 1993

The Tables in Wadda and Craig (1993) aggregate the over sixty population into one cohort. This cohort needs to be disaggregated to make the population data compatible with the model life tables. An estimate of the structure of the cohorts 60-64...85+ is therefore required. Wadda and Craig (1993) suggest that the proportion of the population over 60 is similar in urban and rural populations. Reference to the Population and Housing Census 1983 suggests that this proportion has not changed significantly since 1983. It is therefore unlikely that any significant changes have occurred to the proportions of the population in each five year cohort over sixty years of age. The over-sixty population is therefore disaggregated to conform to the structure of that in 1983 as shown in Table 4.7.

TABLE 4.7.

THE GAMBIA	AGE	POPULATION	% 60+ POP.	PHC-POP.	NON-PHC POP.
OVER 60s	60-64	13504	34.7	8117	5189
POPULATION	65-69	6597	16.9	3953	2527
	70-74	7226	18.5	4328	2767
	75-79	3295	8.6	2012	1286
	80-84	4379	11.2	2620	1675
	85+	3964	10.1	2362	1511
	Total	38965	100	23392	14955

Source: Wadda and Craig 1993

Population and Housing Census, 1983,1993

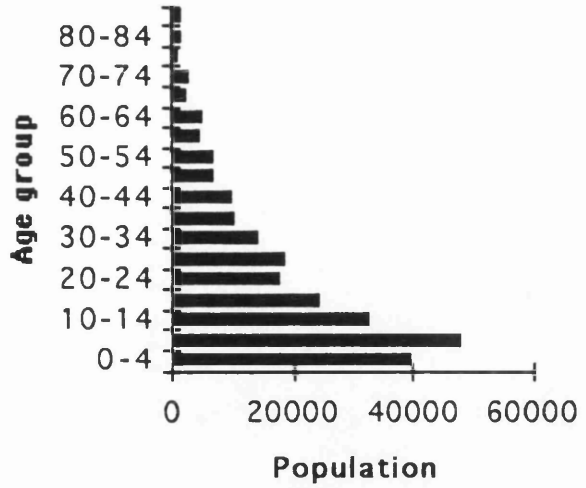
Tables 4.6 and 4.7 were combined to give the definitive breakdown of the rural population by PHC and non-PHC village as shown in Table 4.8. Figures 4.2 and 4.3 display the data graphically.

TABLE 4.8

THE GAMBIA	AGE	% TOTAL POP.	PHC POP.	NON-PHC POP.
RURAL POPULATION	0-4	16.0	62378	39881
AGE STRUCTURE BY	5-9	19.3	75243	48106
PERCENTAGE AND	10-14	13.1	51072	32652
PHC/ NON-PHC	15-19	9.8	38206	24427
POPULATIONS	20-24	7.1	27680	17697
	25-29	7.6	29629	18943
	30-34	5.7	22222	14208
	35-39	4.2	16374	10469
	40-44	4.0	15594	9970
	45-49	2.7	10526	6730
	50-54	2.7	10526	6730
	55-59	1.8	7018	4487
	60-64	2.1	8117	5189
	65-69	1.0	3953	2527
	70-74	1.1	4328	2767
	75-79	0.5	2012	1286
	80-84	0.7	2620	1675
	85+	0.6	2362	1511
	Total	100	389860	249255

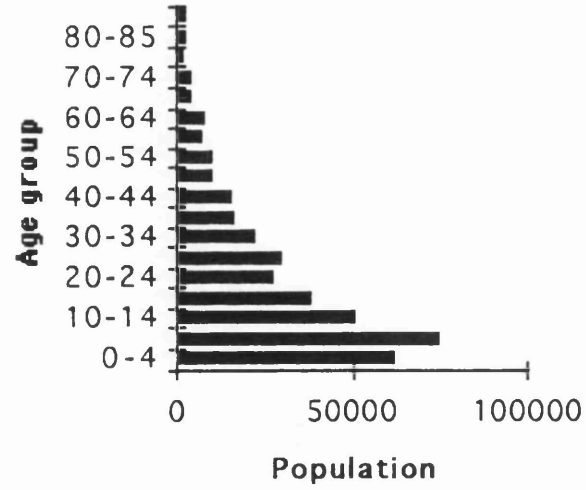
Source: Wadda and Craig 1993
Population and Housing Census 1993

FIGURE 4.2. THE GAMBIAN NON PHC POPULATION 1993.



Source: Derived from Wadda and Craig 1993,
Population and Housing Census 1983, 1993.

FIGURE 4.3 GAMBIAN PHC POPULATION 1993.



Source: Derived from Wadda and Craig 1993
Population and Housing Census 1983, 1993.

4.1.7 Life Table Analysis.

The model life tables chosen were used to project the PHC and non-PHC populations separately. Since five year cohorts are used to break down the population, it was convenient to project the population in five year intervals. Each five year cohort was 'moved down' to the next cohort after five years, for example the zero to four years old population in 1993 became the five to nine years population in 1998 and the ten to fourteen years population in 2003. Probabilities of survival based on the published probabilities of death are multiplied by the population to give the surviving population in each cohort. This is carried out twice, once for the interval 1993-1998 and once for the interval 1998-2003. The total population for each year was also calculated.

A ten year projection period was selected for two reasons. Firstly, there are difficulties in making assumptions as to future demographic trends. The further into the future projected, the less reliable assumptions become, therefore a short period was decided upon. Secondly, it was deemed likely that a decline in mortality in the PHC villages may contribute to stimulating fertility change in the longer term. If this was the case, it would be difficult to compare various populations in which mortality was different if fertility was also different. Fertility is unlikely to be affected by the intervention within the ten year study period.

Eighteen life tables (Tables A1-A18, Appendix) were prepared to simulate the affect of various malaria control 'options', such as, 'no intervention' and the NIBP intervention. In addition it was considered useful to simulate the impact of the eradication of the disease. This may come about if the bed net intervention was considerably more effective or if a vaccine was available. This is a hypothetical option since in reality, malaria is highly unlikely to be eradicated within the ten year study period. High and low infant mortality variants are used to give a range of results for any one option.

PHC and non-PHC options can be selected and combined to give a number of 'scenarios' of the whole rural population for comparison. For example, growth rates in PHC intervention villages together with no intervention in non PHC villages can be compared to, say, intervention in both types of villages.

Comparison of the various 'options' and 'scenarios' is useful for two reasons. Firstly it illustrates that various malaria control options will have a variety of demographic impacts. The expected 'reality' option can be compared to the hypothetical 'no-intervention' option. By comparing the growth rates and projected 2003 populations, it is possible to establish the additional population and increased growth rate as a direct result of the intervention. Secondly, the composition of the hypothetical options is useful for planning purposes. Not only can the demographic consequences of various potential intervention options be explored, but it also provides a useful tool for planners to establish the optimum solution in terms of lives saved.

An estimate was made for the fertility component of the projections and inserted into the zero to four year cohorts of the 1998 and 2003 populations as new births. The 1998 and 2003 new birth cohorts were derived from the 1993 population and the crude birth rates discussed in section 4.1.5.

4.2 RESULTS AND ANALYSIS.

The figures discussed in this section are all derived from the life table analysis carried out as part of this research.

4.2.1 Growth Rates and Absolute Population Increase.

Table 4.9a describes the various scenarios which will be considered in this section.

TABLE 4.9a DESCRIPTION OF LIFE TABLES.

TABLE	DESCRIPTION
A1	PHC village, NIBP intervention in 1993, low IMR
A2	PHC village, NIBP intervention in 1993, high IMR
A3	PHC village, unadjusted (no intervention), low IMR
A4	PHC village, unadjusted (no intervention), high IMR
A5	PHC village, malaria eradicated in 1993, low IMR
A6	PHC village, malaria eradicated in 1993, high IMR
A7	PHC village, NIBP intervention in 1993 + eradication in 1998, low IMR
A8	PHC village, NIBP intervention in 1993 + eradication in 1998, high IMR
A9	Non PHC village, unadjusted (no intervention), low IMR
A10	Non PHC village, unadjusted (no intervention), high IMR
A11	Non PHC village, NIBP intervention in 1993, low IMR
A12	Non PHC village, NIBP intervention in 1993, high IMR
A13	Non PHC village, NIBP intervention in 1998, low IMR
A14	Non PHC village, NIBP intervention in 1998, high IMR
A15	Non PHC village, eradication in 1993, low IMR
A16	Non PHC village, eradication in 1993, high IMR
A17	Non PHC village, eradication in 1998, low IMR
A18	Non PHC village, eradication in 1998, high IMR

TABLE 4.9b summarises the results of the life table projections. Full life tables are shown in the Appendix. The difference between total populations and growth rates in PHC and non-PHC populations can be compared.

TABLE 4.9b SUMMARY OF LIFE TABLE ANALYSIS RESULTS.

TABLE	VILLAGE	DESCRIP.	IMR	POPULATION 1993	1998	2003	GROWTH RATE P.A. % 1993-1998	1998-2003	1993-2003
A1	PHC	Intervention	Low	389860	451754	505330	3.18	2.37	2.96
A2		1993	High	389860	446386	495158	2.90	2.19	2.70
A3		Unadjusted	Low	389860	449715	500441	3.07	2.26	2.84
A4			High	389860	444346	490280	2.80	2.07	2.58
A5	PHC	Eradication	Low	389860	452191	506377	3.20	2.40	2.99
A6		1993	High	389860	446822	496203	2.92	2.21	2.73
A7		Erad 1998	Low	389860	451754	505948	3.18	2.40	2.98
A8		Int 1993	High	389860	446386	495776	2.90	2.21	2.72
A9	Non PHC	Unadjusted	Low	249255	287522	319954	3.07	2.26	2.84
A10			High	249255	284090	313458	2.80	2.07	2.58
A11	Non PHC	Intervention	Low	249255	288826	323080	3.18	2.37	2.96
A12		1993	High	249255	285394	316577	2.90	2.19	2.70
A13		Intervention	Low	249255	287522	321801	3.07	2.38	2.91
A14		1998	High	249255	284090	315304	2.80	2.20	2.65
A15	Non PHC	Eradication	Low	249255	289105	323749	3.20	2.40	2.99
A16		1993	High	249255	285673	317244	2.92	2.21	2.73
A17		Eradication	Low	249255	287522	322196	3.07	2.41	2.93
A18		1998	High	249255	284090	315699	2.80	2.23	2.67

Notes: Derived from life table analysis
Intervention' refers to adjustments made as a result of NIBP.
Eradication refers to 100% eradication of malaria. That is all malarial mortality is removed from the non disease specific mortality rate

It is expected that, given the NIBP intervention took place in 1993, the PHC population ('low IMR') will grow from 389,860 in 1993 to 505,330 in 2003, a rate of 2.96% p.a. Given that no intervention is likely to be implemented in the non-PHC villages over the ten year study period, it is expected that the population will increase from 249,255 in 1993 to 319,954 in 2003. That is a growth rate of 2.84% p.a. Clearly the intervention is likely to result in a greater rate of growth in the PHC villages than the non-PHC villages.

Table 4.10 is extracted from Table 4.9b for clearer comparison of the results. This table shows the various hypothesised options for comparison with the projected 'reality', in terms of expected population growth rates over the period in PHC villages.

TABLE 4.10 PHC POPULATION AND GROWTH. LOW IMR.

	POPULATION		GROWTH RATE % P.A.
PHC VILLAGES	1993	2003	1993-2003
UNADJUSTED	389860	500441	2.84
INTERVENTION 1993 *	389860	505330	2.96
INTERVENTION 1993+ ERADICATION 1998	389860	505948	2.98
ERADICATION 1993	389860	506377	2.99

Note: Taken from Table 4.9b

* 'Reality' Option.

The PHC population growth rate over the ten year period is expected to be 2.84% p.a. if the intervention was not implemented, compared to the 2.96% p.a. estimated for the intervention ('reality') population. The growth rate for the reality option is lower that for the other two

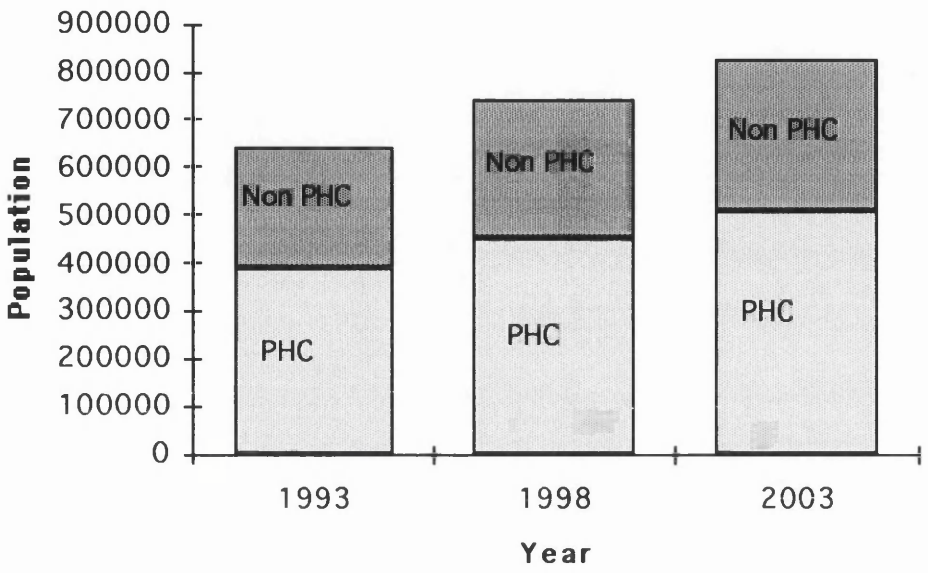
hypothetical options. "Eradication 1993', that is if malaria was eradicated in 1993, resulting in a malaria specific mortality rate of 'zero', is expected to result in a growth rate over the ten year period of 2.99% p.a. The growth rate over the period is predicted to be 2.98% p.a. if the NIBP programme was implemented until 1998, followed by the hypothetical eradication of the disease.

Growth rates have also been increased as a result of the intervention. Clearly, the difference in the rate of growth between the 'unadjusted' option and the 'intervention 1993' option is around 1% over the ten year period. This has resulted in the PHC 'intervention 1993' population being 4,889 greater than it would have been if no intervention had taken place in 2003. If the mortality differential between the intervention and hypothetical unadjusted populations was sustained over a longer period this 'additional' population is likely to expand to significant levels. The growth rates in the additional two options are very similar to that of the intervention 1993 population. This suggests that eradication of malaria would have little additional impact on top of the intervention. Eradication would be expected to result in an additional total population of 1,047 above the intervention population by 2003. This highlights how effective the NIBP intervention is expected to be; it is quite close to total eradication of malaria in terms of demographic impact.

The population of the PHC villages is expected to increase at a greater rate and therefore significantly greater absolute numbers than the non-PHC villages. The (low IMR) PHC population grew by 115,470 (2.96% growth p.a.) between 1993 and 2003 against 70,699 (2.84% growth p.a.) for the non-PHC villages.

Figure 4.4 shows the increase in the total rural population between 1993 and 2003 broken down into PHC and non-PHC villages.

FIGURE 4.4 PHC AND NON PHC POPULATION GROWTH.



Notes: Low IMR
Derived from results of life table analysis. PHC villages subject to intervention, non-PHC villages unadjusted mortality

Clearly, over a longer period of time, and a sustained growth rate differential, the proportion of the rural population living in PHC villages is likely to increase. At present it is around 60%, and likely to increase by about 0.5% over the ten year period.

The life table analysis was carried out to examine growth within a range of 'background' (non-cause specific) infant mortality rates. True rural infant mortality is likely to fall somewhere within the range. The difference between the total population and growth rate outcomes is considerable. For example, using the low infant mortality rate variant, the PHC population ('intervention 1993') is projected to increase by an additional 115,470 people (rate of growth 2.96% p.a.). Using the high infant mortality variant, lower growth rates (2.70% p.a.) are likely to result in an increase of 105,298 people, 10,172 less than the low infant mortality variant. It is anticipated that actual rates of growth between

1993 and 2003 and the population in 2003 will come between the high and low variant projections.

Assumptions regarding fertility over the period are based on the minimal data available and the final outcomes are highly dependent on these assumptions. The assumption was made that the crude birth rate would decline over the ten year study period resulting in 169,589 new births being estimated. If the crude birth rates remained at 1985 to 1990 levels, that is around 48 per 1000, the number of births are likely to total 187,132, an additional 17,543 births. Clearly 'overall' mortality and fertility assumptions have a significant influence on the final outcome.

It is also interesting to look at growth in a number of other 'scenarios'. The rural population is considered as a whole by combining the various PHC and non PHC 'options'. Table 4.11 indicates the scenarios that will be examined for comparison.

TABLE 4.11. TOTAL RURAL POPULATION: DESCRIPTION OF SCENARIOS.

SCENARIO	DESCRIPTION	LIFE TABLE REF.$
a)*	PHC villages intervention 1993 Non PHC villages unadjusted	A1, A2 A9, A10
b)	PHC villages unadjusted Non PHC villages unadjusted	A3, A4 A9, A10
c)	PHC villages intervention 1993 Non PHC villages intervention 1998	A1, A2 A13, A14
d)	PHC villages interv. 1993+ erad 1998 Non PHC villages unadjusted	A7, A8 A9, A10
e)	PHC villages interv. 1993+ erad 1998 Non PHC villages eradication 1998	A7, A8 A17, A18
f)	PHC villages eradication 1993 Non PHC villages eradication 1993	A5, A6 A15, A16

Notes: * 'Reality' scenario.
$ Life tables in Appendix.

Figure 4.4 above represents scenario (a), which is 'reality', provided no intervention is carried out in non-PHC villages within 10 years or malaria is not eradicated over the period. The results are shown in Table 4.12.

TABLE 4.12 SUMMARY OF TOTAL RURAL POPULATION ANALYSIS.

		Population			Growth		
		Rural total			Total *	% total inc. $	% p.a.
Scenario @	IMR	1993	1998	2003	1993-2003	1993-2003	1993-2003
a)	High	639115	730476	808616	169501	26.52	2.65
	Low	639115	739276	825284	186169	29.13	2.91
b)	High	639115	728436	803738	164623	25.76	2.58
	Low	639115	737237	820395	181280	28.36	2.84
c)	High	639115	730476	810462	171347	26.81	2.70
	Low	639115	739276	827131	188016	29.42	2.94
d)	High	639115	730476	809234	170119	26.62	2.66
	Low	639115	739276	825902	186787	29.23	2.92
e)	High	639115	730476	811475	172360	26.97	2.70
	Low	639115	739276	828144	189029	29.58	2.96
f)	High	639115	732496	813447	174332	27.23	2.72
	Low	639115	741296	830126	191011	29.89	2.99

Notes: * Additional population over period

$ Total % increase over period

@ Refer to TABLE 4.11

Looking firstly at the low IMR 'variant', clearly, the highest total predicted population by 2003 is associated with the lowest overall mortality scenario. If malaria had been eradicated in 1993 (scenario f) this analysis predicts that the population would be 9,731 greater than if malaria was totally unchecked over the period (scenario b). This suggests that without intervention or eradication, approximately this number of malarial deaths are likely to occur over the period.

If malaria was eradicated in PHC villages in 1998 after five years of NIBP intervention (scenario d), the 'additional' population is predicted to be 618 above if intervention, but no eradication took place (scenario a). If eradication took place in both PHC and non-PHC villages in 1998, the additional population would be 2,860 greater than scenario (a). These are clearly not huge numbers, but since the additional populations approximate the number of lives saved over the period, then eradication of malaria by 1998 should be strongly advocated.

A comparison of the 'high' and 'low' infant mortality variants suggests that there is a considerable range of outcomes. For example, the low IMR population for scenario (a) is 16,668 higher than that of the high IMR population. However, when comparing the high IMR variant of one scenario with the high variant of another, the difference is found to be very similar to when comparing low with low. If malaria is eradicated in the total rural population, high IMR (scenario f), the total population would be 9,703 greater than if malaria was totally unchecked over the period (scenario b). This is a very similar outcome to the low IMR prediction (9,731) discussed above.

As well as comparing the differences between the absolute outcomes in various scenarios, growth rates can also be considered. As expected, growth rates are higher if the infant mortality is lower, that is in those scenarios with lower malarial mortality. For example, if malaria was totally eradicated (low IMR) the growth rate is expected to be 2.99% p.a. (scenario f), compared to 2.84% p.a. if the disease was unchecked.

It is interesting to compare the range of rates of growth predicted in this research with historical growth. Over the period 1973 to 1983, the total rural population grew by 2.51% p.a. The rate of growth of the population increased to 3.42% p.a. between 1983 and 1993. The predicted growth rate

of 2.91% p.a. (scenario a) is of a similar magnitude, but the upward trend in growth rates experienced between 1973 and 1993 has been reversed between 1993 and 2003. However, this figure does not account for international immigration, a large component of population growth suggested in section 2.1.1. It also indicates that levels of fertility may have been underestimated and the rate of decline in fertility over the period may have been over estimated.

4.2.2 Under fifteen population growth.

Growth in the under fifteen population was considered since it is this group which is affected directly by the intervention over the ten year period. The total under fifteen population was extracted from the life tables in the Appendix between 1993 and 2003 for PHC and non-PHC villages (Low IMR). Under fifteen years old populations, in PHC and non-PHC villages, as proportions of the totals, were compared over the ten year period as shown in Tables 4.13 & 4.14.

TABLE 4.13

		1993	1998	2003
PROPORTION OF	<15 TOTAL	188693	214472	208676
POPULATION UNDER 15	TOTAL POP.	389860	451754	505330
PHC VILLAGES	% OF TOTAL	48.40	47.48	41.29
LOW IMR	<15			

Note: Derived from table A1.

TABLE 4.14

		1993	1998	2003
PROPORTION OF	<15 TOTAL	120639	135818	130291
POPULATION UNDER 15	TOTAL POP.	249255	287522	319954
NON-PHC VILLAGES	% OF TOTAL	48.40	47.24	40.72
LOW IMR	<15			

Note: Derived from table A9.

Additionally, the proportion of the total rural population under fifteen was examined as shown in Table 4.15.

TABLE 4.15

		1993	1998	2003
PROPORTION OF	<15 TOTAL	120639	135818	130291
POPULATION UNDER 15	TOTAL POP.	249255	287522	319954
PHC+ NON-PHC	% OF TOTAL	48.40	47.24	40.72
LOW IMR	<15			

Note: Derived from TABLES 4.13 & 4.14.

Table 4.13 shows an increase in the under fifteen population between 1993 and 1998 in PHC villages, but a small reduction in this total between 1998 and 2003. Overall, the under fifteen population is, however, expected to be 19,983 greater in 2003 than in 1993. The negative growth in the population of this cohort between 1998 and 2003 is due to a reduction in the fertility rates used over the ten year period resulting in

diminishing births. As suggested in the last section, there is potential for an over estimation in the rate at which fertility is declining.

The population of non-PHC villages (Table 4.14) is shown to follow the same pattern as PHC villages. The population of under fifteen years old is show to be 9,652 greater in 2003 than 1993. Therefore the total rural population under fifteen years old is predicted to be 29,635 greater in 2003 than 1993. If no intervention was to occur in the PHC villages, this total is estimated as 24,747. The intervention is therefore expected to result in an additional 4,888 under fifteen years old over ten years. That is, the difference between the intervention and unadjusted PHC options is entirely accounted for by the expansion of the under fifteen population.

It was expected that the intervention would result in an increase in the proportion of the population under fifteen, accounted for by diminishing mortality rates over the period. Again, this is greatly influenced by the number of new births derived from fertility assumptions and results in the proportion of the population under fifteen diminishing over the period from 48.4% to 41.29%, which was not expected. The same trends are noted in non-PHC population, but the proportion of the population under fifteen has declined more rapidly in this group, which was expected. Table 4.15 suggests that the proportion of the total rural population which is under fifteen, is likely to decrease from 48.40% in 1993 to 40.72% in 2003.

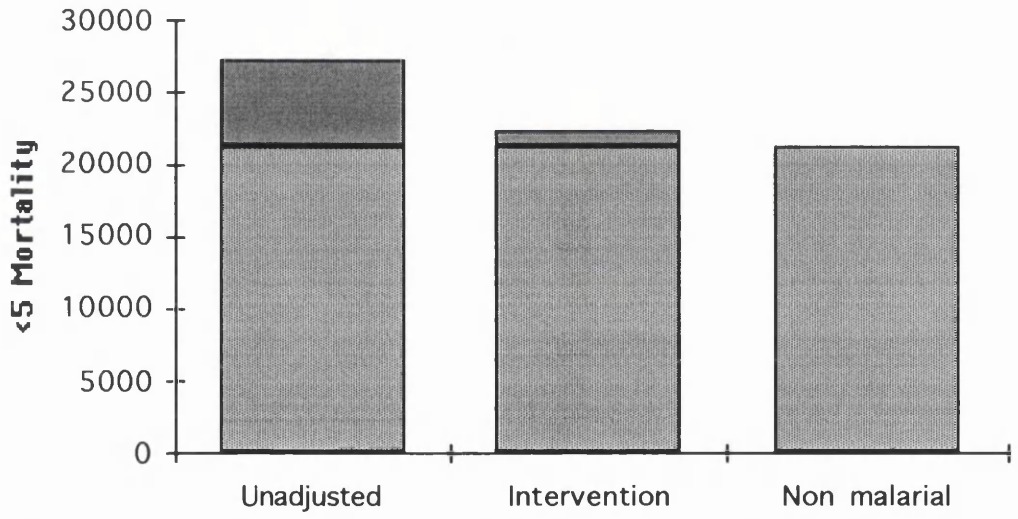
Fertility assumptions have contributed to the diminishing proportion of the population under fifteen years. Given a less dramatic reduction in fertility than that assumed in this study (that is a greater overall number of births), the proportion of the population under fifteen years will decline less rapidly, or increase depending on estimate of future fertility.

4.2.3. Under five mortality.

The number of deaths, by malaria and by all other causes amongst the population under five years old was calculated for the 'reality' scenario (a), low IMR. Results of the life table projections suggest that 22,297 deaths amongst the under five years age group will occur in the period 1993 to 2003 in the PHC intervention population (all causes). If the

intervention had not taken place, 27,223 deaths are predicted to occur. This suggests that 4,926 lives will be saved in PHC villages as a direct result of the NIBP intervention between 1993 and 2003. That is an average of around 493 lives per year. Given the small population of The Gambia, this is very significant. This figure for the ten year period is 1.26% of the 1993 PHC population, 0.77% of the total rural population and around 0.5% of the total Gambian population. If malaria did not exist or had been eradicated in 1993, 21,242 deaths are expected to occur over the ten year period. It is therefore predicted that 1,055 malarial deaths will occur over the same period despite the NIBP intervention. The total number of malarial deaths that are likely to occur if the intervention were not to take place is therefore 5,981. The intervention is expected to result in a 82.4% reduction in malaria mortality over the ten year study period. The outcomes are summarised in Figure 4.5.

FIGURE 4.5 UNDER FIVE MORTALITY IN UNADJUSTED, INTERVENTION AND NON MALARIAL OPTIONS. LOW IMR.



Notes: Light shaded area refers to non malaria mortality
Dark shaded area refers to malaria deaths.

If the intervention had not occurred, malaria is predicted to account for 22% of all infant and child mortality amongst the rural population over the ten year period. As a result of the intervention, malaria is expected to account for 4.7% of infant and child mortality in PHC villages and therefore only 12% of the total rural population mortality as shown in Figures 4.6-4.8.

FIGURE 4.6 PROPORTION OF DEATHS ATTRIBUTED TO MALARIA IN THE UNDER FIVE YEARS OLD PHC POPULATION ASSUMING NO INTERVENTION TAKES PLACE.

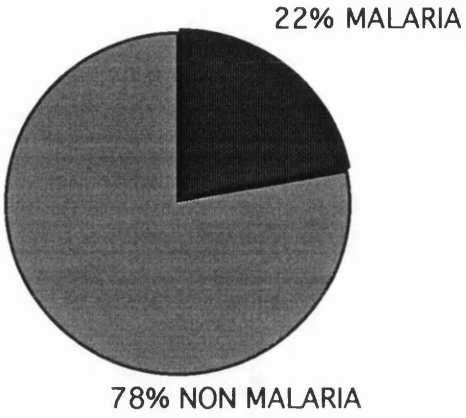


FIGURE 4.7 PROPORTION OF DEATHS ATTRIBUTED TO MALARIA IN THE UNDER FIVE YEARS OLD PHC POPULATION ASSUMING INTERVENTION TAKES PLACE IN 1993.

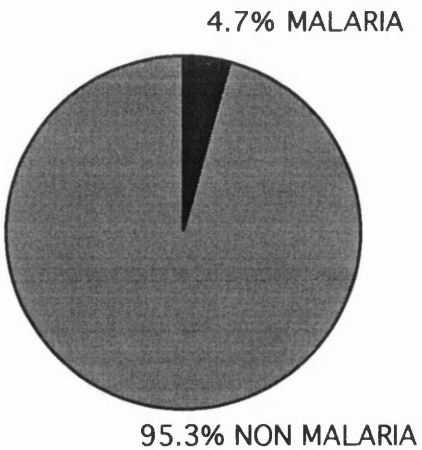
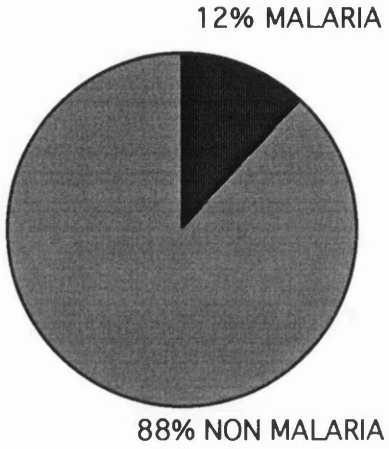


FIGURE 4.8 PROPORTION OF DEATHS ATTRIBUTED TO MALARIA IN THE UNDER FIVE YEARS OLD TOTAL RURAL POPULATION ASSUMING INTERVENTION TAKES PLACE IN 1993 IN PHC VILLAGES.



There is also a strong argument for the expansion of the present NIBP programme to include non-PHC villages. However, due to the probable difficulties, this is unlikely to be possible to achieve. Given that the intervention will not take place in non-PHC villages, 17,405 children under five are predicted to die (low IMR of all causes). Of these, 13,581 are likely to be non-malarial and 3,824 malarial. If the NIBP intervention expanded to cover non-PHC villages by 1998, 15,559 deaths are expected amongst the under five population. Therefore it is estimated that an additional 1,846 lives would be saved between 1993 and 2003. This would represent a 48% reduction in malarial mortality over the period in non-PHC villages.

Interestingly, the high infant mortality variant yields very similar results. For example, the intervention is expected to save 4,928 lives over the ten year period, but 1,055 lives will still be lost. This is almost identical to the low infant mortality variation and therefore suggests that these results are reliable.

4.3 CONCLUSIONS.

The data analysis has demonstrated that the NIBP is likely to result in, at least within the ten year study period, a positive impact on the rate of rural growth. Analysis of the projected PHC intervention population suggests that the population will be nearly five thousand greater than that if no intervention had taken place. Although this does not appear to be a very great number, it is 0.5% of the present Gambian total population. In addition it approximates the number of under five years old lives saved as a direct result of the NIBP. The reduction in malaria specific mortality due to the intervention is also likely to result in malaria declining, from being the cause of around quarter of under five deaths, to less than one in twenty of this number.

The potential for expanding and improving the NIBP intervention is considerable. If the NIBP scheme were to expand to include non-PHC villages by 1998, around two thousand lives are expected to be saved. There are difficulties envisaged relating to the expansion of the intervention to include the non-PHC villages. At present there is a health care structure in the PHC villages which supports the delivery of the bed net programme. Village Health Workers are an important element of the programme. They are involved in instructing and assisting in the process of insecticide impregnation and ensuring the momentum of the programme is retained. This structure is absent in non-PHC villages, therefore to expand the PHC system is likely have considerable cost implications, but many advantages.

Another possibility is for the NIBP scheme to expand to include the supply of bed nets and insecticide to present non-users. This is likely to have most impact on low vector density areas which tend to have low bed net usage and therefore high malaria transmission rates.

The under fifteen years old rural population is likely to increase by nearly thirty thousand between 1993 and 2003. Of this approximately twenty thousand is in PHC villages and ten thousand in non-PHC villages. The intervention has had an impact on population growth in this age group and therefore has planning implications, for example by increasing demand for education. Given the fertility assumptions made over the period, the rate of growth of this group will not be as great as that of the

total population and therefore dependency ratios are expected to diminish. However, if the total under fifteen years population is going to increase in numbers of the order of magnitude suggested above, this is of considerable concern to planners. The increase in the total numbers of the population under fifteen years old, implies an increase in the demand for education. Present rural enrolment rates for primary schooling are low, well below urban rates. Female education is even further behind male levels (Educational Statistics 1984/5, 1991/2). To achieve universal primary school education in the future, not only will the present deficit have to be made up, but also the future increase in the school age population would have to be provided for.

It has been shown that the results of this study are highly dependent on the assumptions made regarding mortality, fertility and migration. For example estimates for the projected PHC intervention population by 2003 range from 495,158 for the high infant mortality assumption to 505,330 for the low mortality assumption, a difference of 10,172.

In addition, fertility assumptions have been shown to be of major significance to the final results. If fertility were to remain at 1985-90 levels, that is a crude birth-rate of 48 per 1000 population over the ten year period, an additional 17,543 births would be expected in the PHC population on top of those projected in this study.

When examining the absolute outcomes of the projections, it is therefore essential to be mindful of the limitations of the assumptions made and in using data of a crude nature. The results of comparative analysis are more robust. For example, to calculate the likely number of under five years lives to be saved, the intervention and eradication populations need to be compared. Both the high and low infant mortality variations yield almost identical results. This suggests that, since fertility and migration assumptions were identical for both variations and therefore affected both equally, comparison with a good degree of confidence is possible.

The use of the life tables has proved to be a useful way of comparing populations which have been subjected to a health care intervention with those without. The results yielded in the life table analysis could be improved in terms of accuracy if better quality of data were available. Particular problems were encountered regarding the coarseness of fertility and migration data. However, since all populations in the analysis were

subject to the same fertility and migration assumptions, this technique endures as a comparative tool. Increasingly refined data, if available, could easily improve the 'absolute' outcomes. Given more detailed fertility data, such as age specific fertility rates, a more precise measure of the actual number of births would be possible. If better data were available regarding spatial variations in mortality generally and malarial mortality specifically an assessment could be made of the impact of the intervention regionally. The pending results of the five study site NIBP evaluation trials would provide data for some limited spatial comparison. This could be facilitated by the publication of the full 1993 Population and Housing Census report, which will provide a good deal more detail than the Provision Report in terms of regional variation in age structure.

There is some room for improvement regarding the technique itself. One improvement would be to split the population into one year cohorts. An analysis of single year mortality would therefore be possible and more detailed results would be yielded. In addition, under five years mortality could be disaggregated and intervention 'adjustments' made to the probabilities in the life tables accordingly. This would prove a useful refinement since malaria mortality levels are highly age specific within the under five years population.

The life table analysis employed in this study has shown that a number of different 'options' can be simulated and comparatively evaluated. This could be adapted to examine the impact of other malaria control techniques, such as chemotherapy and/or chemoprophylaxis. In addition, any health care or other interventions that could have an impact on age specific mortality could be evaluated. Various programmes to control malaria have been explored in this chapter. It would also be possible, for example, to analyse the demographic impact of a measles vaccination programme or increased access to safe water on a developing country population. Local, regional or national analysis could be made. It would be necessary to monitor in the field pre and post intervention mortality rates amongst each cohort affected. These rates could then be used to 'adjust' the prevailing mortality regime of the age groups affected. The results of the analysis would provide not only an indication of 'lives saved' on a population scale, which is a useful tool in evaluating potential options, but also an indication of the likely impact on age specific population growth, information useful for planners.

In conclusion, the technique appears to be a useful method of evaluating the impact of the malaria intervention. It has shown that the NIBP has had a demographic impact on PHC populations, but factors such as the prevailing fertility and mortality regimes are also very significant. Room for improvement lies in the availability and use of higher quality data.

CHAPTER FIVE.

CONCLUSIONS.

This research has suggested that the implementation of a community based intervention programme will have demographic implications. Rates of growth in the PHC villages have been shown to be positively affected by the reduction in infant and child mortality in the short term compared to non-PHC villages. Despite the predicted demographic impact of the programme, chapter four has suggested that 'background' fertility and mortality are the underlying influences on population growth and age structure.

Mortality and fertility levels are mutually reinforcing. Determinants of fertility change include levels of mortality, especially infant and child mortality in a population. It has been suggested that infant and child mortality have an influence on fecundity. If breast feeding is cut short by the death of an infant or child, this natural contraception will be lost, which will result in increasing a woman's fecundity. However, in the longer term, high levels of infant and child mortality will also influence the fertility preference of a family. That is, to achieve a desired family size, high infant mortality will be balanced with high fertility.

It has also been suggested that a reduction in mortality may result in a correspondingly greater reduction in fertility, leading to an overall decline in rates of population growth. The policy question is whether an intervention designed to reduce mortality would be effective in reducing fertility to such an extent as to result in decreasing the rate of population growth (Cochrane and Zachariah 1983). The demographic transition model suggests that the fertility transition will lag behind the epidemiological transition, resulting in significant population growth until both fertility and mortality stabilise at a lower level. Countries which have rapidly passed through the demographic transition, such as Singapore and Hong Kong have experienced a time lag of around twenty years between the onset of the epidemiological transition and the fertility transition (Phillips 1990). It is highly unlikely that The Gambia will experience such a rapid transition as these two countries and therefore the period between the onset of the two transitions is expected to be longer than twenty years. The assumption is made in this study that fertility will not 'react' to a rapid decline in mortality due to the intervention within the 1993 to 2003 study period. It is however considered probable that due to the 'contribution' the malaria

intervention will make to the epidemiological transition, fertility reduction is likely to occur in PHC villages ahead of non-PHC villages.

It is, however, questionable whether mortality decline will in itself be necessary to initiate fertility decline since many other factors have an influence. In less developed countries 'risks' are high. As well as the comparatively high risk of mortality, economic opportunities will usually be poor and intermittent and often there is no state social security. Parents will tend to rely on large families for economic security and old age 'risk insurance' (Cain 1983). If a reduction in risks occurs, parents may find it desirable to reduce their family size.

Despite the introduction of the intervention programme, infant and child mortality are and will remain high over the study period and beyond. Low standards of living are generally the underlying cause of low life expectancy in the developing world. Successful social development initiatives, for example improved health and education facilities in the economically backward southern Indian state of Kerela, have gone a long way to improving welfare and reducing mortality. However, it is the economically developed nations which have experienced major declines in mortality. In a country such as The Gambia, it is considered unlikely that, despite sound social development policy, mortality will reach 'western' levels without significant economic improvements. The NIBP is significant in terms of the humanitarian ends it meets, but should be considered one of many social and economic development possibilities which will affect mortality and therefore welfare.

Despite the benefits of the NIBP, in terms of infant and child lives saved, malaria remains a significant cause of mortality. Expansion of the scheme to include non-PHC villages is one possibility. Chapter four suggests that malarial mortality will remain reasonably significant over the ten year study period even if this were to be implemented. Another possibility is to provide nets to those presently without. There have been no indications that the Gambian government plan to implement either of these two potential schemes in the near future. A vaccine is also unlikely to be available for some time and if it were it is questionable whether it would result in complete immunity to malaria for someone receiving the injection. Eradication, or even near eradication is therefore unlikely to

occur within the current economic, technological and cultural constraints.

Greenwood *et al.* (1990) suggested that non-PHC villages benefited from the PHC programme. One of the reasons for this 'flow' of benefits was the improved awareness of health issues that the programme generated in the rural population as a whole. It remains to be seen whether the increased awareness of the benefits of impregnated bed nets will flow from PHC to non-PHC villages. Research on this subject could yield a better understanding of how to go about sensitising wide areas to the benefits of modern medicine.

A 'model' malaria control strategy implemented successfully in one area may not be feasible in another. This is due to significant spatial variations in malaria transmission as well as human settlement and health care delivery patterns. Bed nets are not effective in areas where vector densities are significantly greater than in The Gambia, therefore chemoprophylaxis and chemotherapy may be the only possibilities. Control programmes may not be feasible in areas without a health care structure or with poor accessibility. The PHC and therefore the NIBP benefit from the concentration of the rural population in villages, but interventions may not be practicable in areas of dispersed population. The NIBP is therefore a useful model in considering interventions designed to control infectious or parasitic disease, but would need considerable adaptation to be feasible in many other areas.

Future research could be carried out given better quality data than was available for this study. The results of the NIBP multi-site evaluation would add a spatial dimension to the examination of the demographic impact of the programme. The availability of the full 1993 Population and Housing Census would improve the quality of population data used.

Research needs to be undertaken into the cost/ benefits of expanding the NIBP. Additionally, the significance of other causes of infant and child mortality need to be addressed in the calculation and action taken within the present health care structure. The optimum all round health care and development solutions need to be implemented within present economic constraints.

Projects aimed at reducing infant and child mortality have obvious humanitarian benefits. In addition, policy makers need to be informed of the demographic impact that interventions may have for planning purposes. For effective planning of services, it is necessary to be able to predict future demand. As well as total population numbers it is essential to be aware of the structure of the population. This study examined the population age structure, which is useful for the planning of, for example, education facilities. Further studies could examine other population sub-groups, such as sex, marital status and educational attainment depending on the aspect of planning being considered.

Planners should also be aware of a potential 'catch-22' situation. The supply of a health care facility may have a demographic impact, for example increasing rates of population growth. Supply has therefore resulted in increasing demand. In addition, as the population becomes aware of the benefits of modern facilities, demand is also stimulated.

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APPENDIX.

TABLE A1

PHC SETTLEMENTS INTERVENTION 1993 LOW IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	62378	0.15774	0.84226	88303	0.14107	0.85893	81286
5-9	75243	0.02142	0.97858	52538	0.01892	0.98108	75846
10-14	51072	0.01195	0.98805	73631	0.01066	0.98934	51544
15-19	38206	0.01698	0.98302	50462	0.01524	0.98476	72846
20-24	27680	0.0254	0.9746	37557	0.02284	0.97716	49693
25-29	29629	0.02915	0.97085	26977	0.0263	0.9737	36699
30-34	22222	0.03318	0.96682	28765	0.02994	0.97006	26267
35-39	16374	0.03988	0.96012	21485	0.03627	0.96373	27904
40-44	15594	0.04857	0.95143	15721	0.04461	0.95539	20705
45-49	10526	0.06177	0.93823	14837	0.05736	0.94264	15020
50-54	10526	0.07944	0.92056	9876	0.07465	0.92535	13986
55-59	7018	0.10754	0.89246	9690	0.10217	0.89783	9139
60-64	8117	0.14607	0.85393	6263	0.13995	0.86005	8700
65-69	3953	0.20854	0.79146	6931	0.201	0.799	5387
70-74	4328	0.29006	0.70994	3129	0.28122	0.71878	5538
75-79	2012	0.38885	0.61115	3073	0.3795	0.6205	2249
80-84	2620	0.50892	0.49108	1230	0.50053	0.49947	1907
85+	2362	1	0	1287	1	0	614
TOTAL	389860			451754			505330

TABLE A2

PHC SETTLEMENTS INTERVENTION 1993 HIGH IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	62378	0.2022	0.7978	88303	0.17504	0.82496	81286
5-9	75243	0.02858	0.97142	49765	0.02412	0.97588	72847
10-14	51072	0.0156	0.9844	73093	0.01333	0.98667	48565
15-19	38206	0.02182	0.97818	50275	0.01882	0.98118	72118
20-24	27680	0.03249	0.96751	37372	0.02811	0.97189	49329
25-29	29629	0.03702	0.96298	26781	0.03217	0.96783	36322
30-34	22222	0.04212	0.95788	28532	0.0366	0.9634	25919
35-39	16374	0.04971	0.95029	21286	0.04367	0.95633	27488
40-44	15594	0.05919	0.94081	15560	0.0527	0.9473	20356
45-49	10526	0.07332	0.92668	14671	0.06629	0.93371	14740
50-54	10526	0.09175	0.90825	9754	0.0843	0.9157	13698
55-59	7018	0.12108	0.87892	9560	0.11293	0.88707	8932
60-64	8117	0.16126	0.83874	6168	0.15216	0.84784	8481
65-69	3953	0.22697	0.77303	6808	0.21597	0.78403	5230
70-74	4328	0.31136	0.68864	3056	0.2987	0.7013	5338
75-79	2012	0.41101	0.58899	2980	0.3979	0.6021	2143
80-84	2620	0.52852	0.47148	1185	0.51698	0.48302	1795
85+	2362	1	0	1235	1	0	572
TOTAL	389860			446386			495158

TABLE A3

PHC SETTLEMENTS UNADJUSTED LOW IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	62378	0.19044	0.80956	88303	0.17377	0.82623	81286
5-9	75243	0.02142	0.97858	50499	0.01892	0.98108	72959
10-14	51072	0.01195	0.98805	73631	0.01066	0.98934	49543
15-19	38206	0.01698	0.98302	50462	0.01524	0.98476	72846
20-24	27680	0.0254	0.9746	37557	0.02284	0.97716	49693
25-29	29629	0.02915	0.97085	26977	0.0263	0.9737	36699
30-34	22222	0.03318	0.96682	28765	0.02994	0.97006	26267
35-39	16374	0.03988	0.96012	21485	0.03627	0.96373	27904
40-44	15594	0.04857	0.95143	15721	0.04461	0.95539	20705
45-49	10526	0.06177	0.93823	14837	0.05736	0.94264	15020
50-54	10526	0.07944	0.92056	9876	0.07465	0.92535	13986
55-59	7018	0.10754	0.89246	9690	0.10217	0.89783	9139
60-64	8117	0.14607	0.85393	6263	0.13995	0.86005	8700
65-69	3953	0.20854	0.79146	6931	0.201	0.799	5387
70-74	4328	0.29006	0.70994	3129	0.28122	0.71878	5538
75-79	2012	0.38885	0.61115	3073	0.3795	0.6205	2249
80-84	2620	0.50892	0.49108	1230	0.50053	0.49947	1907
85+	2362	1	0	1287	1	0	614
TOTAL	389860			449715			500441

TABLE A4

PHC SETTLEMENTS UNADJUSTED HIGH IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	62378	0.2349	0.7651	88303	0.20774	0.79226	81286
5-9	75243	0.02858	0.97142	47725	0.02412	0.97588	69959
10-14	51072	0.0156	0.9844	73093	0.01333	0.98667	46574
15-19	38206	0.02182	0.97818	50275	0.01882	0.98118	72118
20-24	27680	0.03249	0.96751	37372	0.02811	0.97189	49329
25-29	29629	0.03702	0.96298	26781	0.03217	0.96783	36322
30-34	22222	0.04212	0.95788	28532	0.0366	0.9634	25919
35-39	16374	0.04971	0.95029	21286	0.04367	0.95633	27488
40-44	15594	0.05919	0.94081	15560	0.0527	0.9473	20356
45-49	10526	0.07332	0.92668	14671	0.06629	0.93371	14740
50-54	10526	0.09175	0.90825	9754	0.0843	0.9157	13698
55-59	7018	0.12108	0.87892	9560	0.11293	0.88707	8932
60-64	8117	0.16126	0.83874	6168	0.15216	0.84784	8481
65-69	3953	0.22697	0.77303	6808	0.21597	0.78403	5230
70-74	4328	0.31136	0.68864	3056	0.2987	0.7013	5338
75-79	2012	0.41101	0.58899	2980	0.3979	0.6021	2143
80-84	2620	0.52852	0.47148	1185	0.51698	0.48302	1795
85+	2362	1	0	1235	1	0	572
TOTAL	389860			444346			490280

TABLE A5

PHC SETTLEMENTS ERADICATION 1993 LOW IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	62378	0.15074	0.84926	88303	0.13407	0.86593	81286
5-9	75243	0.02142	0.97858	52975	0.01892	0.98108	76464
10-14	51072	0.01195	0.98805	73631	0.01066	0.98934	51973
15-19	38206	0.01698	0.98302	50462	0.01524	0.98476	72846
20-24	27680	0.0254	0.9746	37557	0.02284	0.97716	49693
25-29	29629	0.02915	0.97085	26977	0.0263	0.9737	36699
30-34	22222	0.03318	0.96682	28765	0.02994	0.97006	26267
35-39	16374	0.03988	0.96012	21485	0.03627	0.96373	27904
40-44	15594	0.04857	0.95143	15721	0.04461	0.95539	20705
45-49	10526	0.06177	0.93823	14837	0.05736	0.94264	15020
50-54	10526	0.07944	0.92056	9876	0.07465	0.92535	13986
55-59	7018	0.10754	0.89246	9690	0.10217	0.89783	9139
60-64	8117	0.14607	0.85393	6263	0.13995	0.86005	8700
65-69	3953	0.20854	0.79146	6931	0.201	0.799	5387
70-74	4328	0.29006	0.70994	3129	0.28122	0.71878	5538
75-79	2012	0.38885	0.61115	3073	0.3795	0.6205	2249
80-84	2620	0.50892	0.49108	1230	0.50053	0.49947	1907
85+	2362	1	0	1287	1	0	614
TOTAL	389860			452191			506377

TABLE A6

PHC SETTLEMENTS ERADICATION1993 HIGH IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	62378	0.1952	0.8048	88303	0.16804	0.83196	81286
5-9	75243	0.02858	0.97142	50202	0.02412	0.97588	73465
10-14	51072	0.0156	0.9844	73093	0.01333	0.98667	48991
15-19	38206	0.02182	0.97818	50275	0.01882	0.98118	72118
20-24	27680	0.03249	0.96751	37372	0.02811	0.97189	49329
25-29	29629	0.03702	0.96298	26781	0.03217	0.96783	36322
30-34	22222	0.04212	0.95788	28532	0.0366	0.9634	25919
35-39	16374	0.04971	0.95029	21286	0.04367	0.95633	27488
40-44	15594	0.05919	0.94081	15560	0.0527	0.9473	20356
45-49	10526	0.07332	0.92668	14671	0.06629	0.93371	14740
50-54	10526	0.09175	0.90825	9754	0.0843	0.9157	13698
55-59	7018	0.12108	0.87892	9560	0.11293	0.88707	8932
60-64	8117	0.16126	0.83874	6168	0.15216	0.84784	8481
65-69	3953	0.22697	0.77303	6808	0.21597	0.78403	5230
70-74	4328	0.31136	0.68864	3056	0.2987	0.7013	5338
75-79	2012	0.41101	0.58899	2980	0.3979	0.6021	2143
80-84	2620	0.52852	0.47148	1185	0.51698	0.48302	1795
85+	2362	1	0	1235	1	0	572
TOTAL	389860			446822			496203

TABLE A7

PHC SETTLEMENTS INTERVENTION 1993/ ERADICATION 1998 LOW IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	62378	0.15774	0.84226	88303	0.13407	0.86593	81286
5-9	75243	0.02142	0.97858	52538	0.01892	0.98108	76464
10-14	51072	0.01195	0.98805	73631	0.01066	0.98934	51544
15-19	38206	0.01698	0.98302	50462	0.01524	0.98476	72846
20-24	27680	0.0254	0.9746	37557	0.02284	0.97716	49693
25-29	29629	0.02915	0.97085	26977	0.0263	0.9737	36699
30-34	22222	0.03318	0.96682	28765	0.02994	0.97006	26267
35-39	16374	0.03988	0.96012	21485	0.03627	0.96373	27904
40-44	15594	0.04857	0.95143	15721	0.04461	0.95539	20705
45-49	10526	0.06177	0.93823	14837	0.05736	0.94264	15020
50-54	10526	0.07944	0.92056	9876	0.07465	0.92535	13986
55-59	7018	0.10754	0.89246	9690	0.10217	0.89783	9139
60-64	8117	0.14607	0.85393	6263	0.13995	0.86005	8700
65-69	3953	0.20854	0.79146	6931	0.201	0.799	5387
70-74	4328	0.29006	0.70994	3129	0.28122	0.71878	5538
75-79	2012	0.38885	0.61115	3073	0.3795	0.6205	2249
80-84	2620	0.50892	0.49108	1230	0.50053	0.49947	1907
85+	2362	1	0	1287	1	0	614
TOTAL	389860			451754			505948

TABLE A8

PHC SETTLEMENTS INTERVENTION 1993/ ERADICATION 1998 HIGH IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	62378	0.2022	0.7978	88303	0.16804	0.83196	81286
5-9	75243	0.02858	0.97142	49765	0.02412	0.97588	73465
10-14	51072	0.0156	0.9844	73093	0.01333	0.98667	48565
15-19	38206	0.02182	0.97818	50275	0.01882	0.98118	72118
20-24	27680	0.03249	0.96751	37372	0.02811	0.97189	49329
25-29	29629	0.03702	0.96298	26781	0.03217	0.96783	36322
30-34	22222	0.04212	0.95788	28532	0.0366	0.9634	25919
35-39	16374	0.04971	0.95029	21286	0.04367	0.95633	27488
40-44	15594	0.05919	0.94081	15560	0.0527	0.9473	20356
45-49	10526	0.07332	0.92668	14671	0.06629	0.93371	14740
50-54	10526	0.09175	0.90825	9754	0.0843	0.9157	13698
55-59	7018	0.12108	0.87892	9560	0.11293	0.88707	8932
60-64	8117	0.16126	0.83874	6168	0.15216	0.84784	8481
65-69	3953	0.22697	0.77303	6808	0.21597	0.78403	5230
70-74	4328	0.31136	0.68864	3056	0.2987	0.7013	5338
75-79	2012	0.41101	0.58899	2980	0.3979	0.6021	2143
80-84	2620	0.52852	0.47148	1185	0.51698	0.48302	1795
85+	2362	1	0	1235	1	0	572
TOTAL	389860			446386			495776

TABLE A9

Non- PHC SETTLEMENTS UNADJUSTED LOW IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	39881	0.19044	0.80956	56456	0.17377	0.82623	51970
5-9	48106	0.02142	0.97858	32286	0.01892	0.98108	46646
10-14	32652	0.01195	0.98805	47076	0.01066	0.98934	31675
15-19	24427	0.01698	0.98302	32262	0.01524	0.98476	46574
20-24	17697	0.0254	0.9746	24012	0.02284	0.97716	31770
25-29	18943	0.02915	0.97085	17247	0.0263	0.9737	23464
30-34	14208	0.03318	0.96682	18391	0.02994	0.97006	16794
35-39	10469	0.03988	0.96012	13737	0.03627	0.96373	17840
40-44	9970	0.04857	0.95143	10051	0.04461	0.95539	13238
45-49	6730	0.06177	0.93823	9486	0.05736	0.94264	9603
50-54	6730	0.07944	0.92056	6314	0.07465	0.92535	8942
55-59	4487	0.10754	0.89246	6195	0.10217	0.89783	5843
60-64	5189	0.14607	0.85393	4004	0.13995	0.86005	5562
65-69	2527	0.20854	0.79146	4431	0.201	0.799	3444
70-74	2767	0.29006	0.70994	2000	0.28122	0.71878	3540
75-79	1286	0.38885	0.61115	1964	0.3795	0.6205	1438
80-84	1675	0.50892	0.49108	786	0.50053	0.49947	1219
85+	1511	1	0	823	1	0	393
TOTAL	249255			287522			319954

TABLE A10

Non- PHC SETTLEMENTS UNADJUSTED HIGH IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	39881	0.2349	0.7651	56456	0.20774	0.79226	51970
5-9	48106	0.02858	0.97142	30513	0.02412	0.97588	44728
10-14	32652	0.0156	0.9844	46731	0.01333	0.98667	29777
15-19	24427	0.02182	0.97818	32143	0.01882	0.98118	46108
20-24	17697	0.03249	0.96751	23894	0.02811	0.97189	31538
25-29	18943	0.03702	0.96298	17122	0.03217	0.96783	23222
30-34	14208	0.04212	0.95788	18242	0.0366	0.9634	16571
35-39	10469	0.04971	0.95029	13610	0.04367	0.95633	17574
40-44	9970	0.05919	0.94081	9949	0.0527	0.9473	13015
45-49	6730	0.07332	0.92668	9380	0.06629	0.93371	9424
50-54	6730	0.09175	0.90825	6237	0.0843	0.9157	8758
55-59	4487	0.12108	0.87892	6113	0.11293	0.88707	5711
60-64	5189	0.16126	0.83874	3944	0.15216	0.84784	5422
65-69	2527	0.22697	0.77303	4352	0.21597	0.78403	3344
70-74	2767	0.31136	0.68864	1953	0.2987	0.7013	3412
75-79	1286	0.41101	0.58899	1905	0.3979	0.6021	1370
80-84	1675	0.52852	0.47148	757	0.51698	0.48302	1147
85+	1511	1	0	790	1	0	366
TOTAL	249255			284090			313458

TABLE A11

Non- PHC SETTLEMENTS INTERVENTION 1993 LOW IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	39881	0.15774	0.84226	56456	0.14107	0.85893	51970
5-9	48106	0.02142	0.97858	33590	0.01892	0.98108	48492
10-14	32652	0.01195	0.98805	47076	0.01066	0.98934	32955
15-19	24427	0.01698	0.98302	32262	0.01524	0.98476	46574
20-24	17697	0.0254	0.9746	24012	0.02284	0.97716	31770
25-29	18943	0.02915	0.97085	17247	0.0263	0.9737	23464
30-34	14208	0.03318	0.96682	18391	0.02994	0.97006	16794
35-39	10469	0.03988	0.96012	13737	0.03627	0.96373	17840
40-44	9970	0.04857	0.95143	10051	0.04461	0.95539	13238
45-49	6730	0.06177	0.93823	9486	0.05736	0.94264	9603
50-54	6730	0.07944	0.92056	6314	0.07465	0.92535	8942
55-59	4487	0.10754	0.89246	6195	0.10217	0.89783	5843
60-64	5189	0.14607	0.85393	4004	0.13995	0.86005	5562
65-69	2527	0.20854	0.79146	4431	0.201	0.799	3444
70-74	2767	0.29006	0.70994	2000	0.28122	0.71878	3540
75-79	1286	0.38885	0.61115	1964	0.3795	0.6205	1438
80-84	1675	0.50892	0.49108	786	0.50053	0.49947	1219
85+	1511	1	0	823	1	0	393
TOTAL	249255			288826			323080

TABLE A12

Non- PHC SETTLEMENTS INTERVENTION 1993 HIGH IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	39881	0.2022	0.7978	56456	0.17504	0.82496	51970
5-9	48106	0.02858	0.97142	31817	0.02412	0.97588	46574
10-14	32652	0.0156	0.9844	46731	0.01333	0.98667	31050
15-19	24427	0.02182	0.97818	32143	0.01882	0.98118	46108
20-24	17697	0.03249	0.96751	23894	0.02811	0.97189	31538
25-29	18943	0.03702	0.96298	17122	0.03217	0.96783	23222
30-34	14208	0.04212	0.95788	18242	0.0366	0.9634	16571
35-39	10469	0.04971	0.95029	13610	0.04367	0.95633	17574
40-44	9970	0.05919	0.94081	9949	0.0527	0.9473	13015
45-49	6730	0.07332	0.92668	9380	0.06629	0.93371	9424
50-54	6730	0.09175	0.90825	6237	0.0843	0.9157	8758
55-59	4487	0.12108	0.87892	6113	0.11293	0.88707	5711
60-64	5189	0.16126	0.83874	3944	0.15216	0.84784	5422
65-69	2527	0.22697	0.77303	4352	0.21597	0.78403	3344
70-74	2767	0.31136	0.68864	1953	0.2987	0.7013	3412
75-79	1286	0.41101	0.58899	1905	0.3979	0.6021	1370
80-84	1675	0.52852	0.47148	757	0.51698	0.48302	1147
85+	1511	1	0	790	1	0	366
TOTAL	249255			285394			316577

TABLE A13

Non- PHC SETTLEMENTS INTERVENTION 1998 LOW IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	39881	0.19044	0.80956	56456	0.14107	0.85893	51970
5-9	48106	0.02142	0.97858	32286	0.01892	0.98108	48492
10-14	32652	0.01195	0.98805	47076	0.01066	0.98934	31675
15-19	24427	0.01698	0.98302	32262	0.01524	0.98476	46574
20-24	17697	0.0254	0.9746	24012	0.02284	0.97716	31770
25-29	18943	0.02915	0.97085	17247	0.0263	0.9737	23464
30-34	14208	0.03318	0.96682	18391	0.02994	0.97006	16794
35-39	10469	0.03988	0.96012	13737	0.03627	0.96373	17840
40-44	9970	0.04857	0.95143	10051	0.04461	0.95539	13238
45-49	6730	0.06177	0.93823	9486	0.05736	0.94264	9603
50-54	6730	0.07944	0.92056	6314	0.07465	0.92535	8942
55-59	4487	0.10754	0.89246	6195	0.10217	0.89783	5843
60-64	5189	0.14607	0.85393	4004	0.13995	0.86005	5562
65-69	2527	0.20854	0.79146	4431	0.201	0.799	3444
70-74	2767	0.29006	0.70994	2000	0.28122	0.71878	3540
75-79	1286	0.38885	0.61115	1964	0.3795	0.6205	1438
80-84	1675	0.50892	0.49108	786	0.50053	0.49947	1219
85+	1511	1	0	823	1	0	393
TOTAL	249255			287522			321801

TABLE A14

Non- PHC SETTLEMENTS INTERVENTION 1998 HIGH IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	39881	0.2349	0.7651	56456	0.17504	0.82496	51970
5-9	48106	0.02858	0.97142	30513	0.02412	0.97588	46574
10-14	32652	0.0156	0.9844	46731	0.01333	0.98667	29777
15-19	24427	0.02182	0.97818	32143	0.01882	0.98118	46108
20-24	17697	0.03249	0.96751	23894	0.02811	0.97189	31538
25-29	18943	0.03702	0.96298	17122	0.03217	0.96783	23222
30-34	14208	0.04212	0.95788	18242	0.0366	0.9634	16571
35-39	10469	0.04971	0.95029	13610	0.04367	0.95633	17574
40-44	9970	0.05919	0.94081	9949	0.0527	0.9473	13015
45-49	6730	0.07332	0.92668	9380	0.06629	0.93371	9424
50-54	6730	0.09175	0.90825	6237	0.0843	0.9157	8758
55-59	4487	0.12108	0.87892	6113	0.11293	0.88707	5711
60-64	5189	0.16126	0.83874	3944	0.15216	0.84784	5422
65-69	2527	0.22697	0.77303	4352	0.21597	0.78403	3344
70-74	2767	0.31136	0.68864	1953	0.2987	0.7013	3412
75-79	1286	0.41101	0.58899	1905	0.3979	0.6021	1370
80-84	1675	0.52852	0.47148	757	0.51698	0.48302	1147
85+	1511	1	0	790	1	0	366
TOTAL	249255			284090			315304

TABLE A15

Non- PHC SETTLEMENTS ERADICATION 1993 LOW IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	39881	0.15074	0.84926	56456	0.13407	0.86593	51970
5-9	48106	0.02142	0.97858	33869	0.01892	0.98108	48887
10-14	32652	0.01195	0.98805	47076	0.01066	0.98934	33229
15-19	24427	0.01698	0.98302	32262	0.01524	0.98476	46574
20-24	17697	0.0254	0.9746	24012	0.02284	0.97716	31770
25-29	18943	0.02915	0.97085	17247	0.0263	0.9737	23464
30-34	14208	0.03318	0.96682	18391	0.02994	0.97006	16794
35-39	10469	0.03988	0.96012	13737	0.03627	0.96373	17840
40-44	9970	0.04857	0.95143	10051	0.04461	0.95539	13238
45-49	6730	0.06177	0.93823	9486	0.05736	0.94264	9603
50-54	6730	0.07944	0.92056	6314	0.07465	0.92535	8942
55-59	4487	0.10754	0.89246	6195	0.10217	0.89783	5843
60-64	5189	0.14607	0.85393	4004	0.13995	0.86005	5562
65-69	2527	0.20854	0.79146	4431	0.201	0.799	3444
70-74	2767	0.29006	0.70994	2000	0.28122	0.71878	3540
75-79	1286	0.38885	0.61115	1964	0.3795	0.6205	1438
80-84	1675	0.50892	0.49108	786	0.50053	0.49947	1219
85+	1511	1	0	823	1	0	393
TOTAL	249255			289105			323749

TABLE A16

Non- PHC SETTLEMENTS ERADICATION 1993 HIGH IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	39881	0.1952	0.8048	56456	0.16804	0.83196	51970
5-9	48106	0.02858	0.97142	32096	0.02412	0.97588	46969
10-14	32652	0.0156	0.9844	46731	0.01333	0.98667	31322
15-19	24427	0.02182	0.97818	32143	0.01882	0.98118	46108
20-24	17697	0.03249	0.96751	23894	0.02811	0.97189	31538
25-29	18943	0.03702	0.96298	17122	0.03217	0.96783	23222
30-34	14208	0.04212	0.95788	18242	0.0366	0.9634	16571
35-39	10469	0.04971	0.95029	13610	0.04367	0.95633	17574
40-44	9970	0.05919	0.94081	9949	0.0527	0.9473	13015
45-49	6730	0.07332	0.92668	9380	0.06629	0.93371	9424
50-54	6730	0.09175	0.90825	6237	0.0843	0.9157	8758
55-59	4487	0.12108	0.87892	6113	0.11293	0.88707	5711
60-64	5189	0.16126	0.83874	3944	0.15216	0.84784	5422
65-69	2527	0.22697	0.77303	4352	0.21597	0.78403	3344
70-74	2767	0.31136	0.68864	1953	0.2987	0.7013	3412
75-79	1286	0.41101	0.58899	1905	0.3979	0.6021	1370
80-84	1675	0.52852	0.47148	757	0.51698	0.48302	1147
85+	1511	1	0	790	1	0	366
TOTAL	249255			285673			317244

TABLE A17

Non- PHC SETTLEMENTS ERADICATION 1998 LOW IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	39881	0.19044	0.80956	56456	0.13407	0.86593	51970
5-9	48106	0.02142	0.97858	32286	0.01892	0.98108	48887
10-14	32652	0.01195	0.98805	47076	0.01066	0.98934	31675
15-19	24427	0.01698	0.98302	32262	0.01524	0.98476	46574
20-24	17697	0.0254	0.9746	24012	0.02284	0.97716	31770
25-29	18943	0.02915	0.97085	17247	0.0263	0.9737	23464
30-34	14208	0.03318	0.96682	18391	0.02994	0.97006	16794
35-39	10469	0.03988	0.96012	13737	0.03627	0.96373	17840
40-44	9970	0.04857	0.95143	10051	0.04461	0.95539	13238
45-49	6730	0.06177	0.93823	9486	0.05736	0.94264	9603
50-54	6730	0.07944	0.92056	6314	0.07465	0.92535	8942
55-59	4487	0.10754	0.89246	6195	0.10217	0.89783	5843
60-64	5189	0.14607	0.85393	4004	0.13995	0.86005	5562
65-69	2527	0.20854	0.79146	4431	0.201	0.799	3444
70-74	2767	0.29006	0.70994	2000	0.28122	0.71878	3540
75-79	1286	0.38885	0.61115	1964	0.3795	0.6205	1438
80-84	1675	0.50892	0.49108	786	0.50053	0.49947	1219
85+	1511	1	0	823	1	0	393
TOTAL	249255			287522			322196

TABLE A18

Non- PHC SETTLEMENTS ERADICATION 1998 HIGH IMR

AGE	1993	5Qx	5Px	1998	5Qx	5Px	2003
0-4	39881	0.2349	0.7651	56456	0.16804	0.83196	51970
5-9	48106	0.02858	0.97142	30513	0.02412	0.97588	46969
10-14	32652	0.0156	0.9844	46731	0.01333	0.98667	29777
15-19	24427	0.02182	0.97818	32143	0.01882	0.98118	46108
20-24	17697	0.03249	0.96751	23894	0.02811	0.97189	31538
25-29	18943	0.03702	0.96298	17122	0.03217	0.96783	23222
30-34	14208	0.04212	0.95788	18242	0.0366	0.9634	16571
35-39	10469	0.04971	0.95029	13610	0.04367	0.95633	17574
40-44	9970	0.05919	0.94081	9949	0.0527	0.9473	13015
45-49	6730	0.07332	0.92668	9380	0.06629	0.93371	9424
50-54	6730	0.09175	0.90825	6237	0.0843	0.9157	8758
55-59	4487	0.12108	0.87892	6113	0.11293	0.88707	5711
60-64	5189	0.16126	0.83874	3944	0.15216	0.84784	5422
65-69	2527	0.22697	0.77303	4352	0.21597	0.78403	3344
70-74	2767	0.31136	0.68864	1953	0.2987	0.7013	3412
75-79	1286	0.41101	0.58899	1905	0.3979	0.6021	1370
80-84	1675	0.52852	0.47148	757	0.51698	0.48302	1147
85+	1511	1	0	790	1	0	366
TOTAL	249255			284090			315699