4.0 DISEASE-SPECIFIC DATA

There are several sources of high quality disease-specific data for Cameroon: 1) Government MOPH publications, including June 1998 and year 1997 data, 2) incidence and prevalence survey data published in the scientific and medical literature and 3) 1995 expatriate Peace Corps volunteers (PCV) morbidity and mortality survey results (Peace Corps, 1997). These data are particularly relevant because the PCV exposures and subsequent illness/injury profile are expected to be similar to expatriates who will work on the project. The Peace Corps has a comprehensive preventive medicine and education program for its volunteers. The literature category includes WHO studies (e.g., onchocerciasis, guinea worm, schistosomiasis, trypanosomiasis, hepatitis, malaria, STDs/AIDS, tuberculosis World Bank-funded efforts, USAID-sponsored surveys and reports). In addition, there are voluminous high-quality collaborative studies published by Cameroonian University scientists and French research institutes, e.g., ORSTOM, OCEAC, Pasteur. All of these sources were researched so that an in-depth disease-specific profile for the project corridor and the country as a whole could be developed. The current survey provides powerful insight into the geographic location and disease spectrum in Cameroon.

Not surprisingly, there are some limitations to the type and comparability of available medical data:

- Data are not always consistently obtained by the same survey instruments; however, the government's mortality and morbidity data were obtained using standardized collection forms.

- Data are collected as either incidence or prevalence rate. Both of these types of rates involve or imply some time relationship. The prevalence rate describes a group at a certain point in time (i.e., it is a "snapshot" of our existing condition). The incidence rate describes the development of a disease in a group over a period of time, which is included in the denominator:

$$Prevalence\ \ rate = \frac{Number\ \ of\ \ persons\ \ wth\ a\ disease}{Total\ \ number\ \ within\ \ a\ group}$$

$$Incidence\ rate = \frac{Number\ of\ persons\ developing\ a\ disease}{Total\ number\ at\ risk}$$

- Clinical diagnoses without laboratory information, particularly in a rural setting, are frequently used and reported in statistical summaries. This presents a problem of case confirmation and is universally experienced with SSA data. Misdiagnoses and miscategorization undoubtedly occur throughout the data set. The government survey data are both relatively consistent across time and similar in rank order of disease problems across different provinces. The reporting system is inherently passive, i.e., patients must be present for medical attention at locations that collect and process data. This type of system, which is extremely common in SSA, will underreport the "true" burden of disease in the community or village. In addition, since there can be a lack of diagnostic laboratory infrastructure within the health system, diagnoses are sometimes clinical rather than laboratory confirmed. Nevertheless, there is a substantial body of peer-reviewed published data, which confirms the clinical diagnostic data set. Therefore, there is more than sufficient level of "hard" data that can be utilized for strategy planning and monitoring purposes for the project.

- Childhood data may not be entirely predictive of the indigenous adult disease situation; however, it is more predictive of "immunologically naive" expatriates. This problem was discussed previously; however, the childhood data, particularly for infectious diseases, do provide insight on the geographic location and magnitude of many diseases. For most of the major diseases, there are a number of published studies that focus exclusively on adults. The two data sources provide a level of detail that is more than sufficient for project planning and evaluation.

4.1 SUB-SAHARAN AFRICA DISEASE

Until recently, there was optimism that the ability to achieve control over infectious diseases was at hand (WHO, 1996a). Small pox was eradicated; polio, guinea worm, leprosy, leishmaniasis and neonatal tetanus were targeted for eradication or elimination. However, due to the emergence of new diseases (e.g., AIDS), pathogens resistant to antibiotics, and insects resistant to insecticides, the substantial progress recorded to date may decline or reverse. In addition to the burden of infectious diseases, SSA has significantly elevated incidence and prevalence mortality rates due to traffic accidents, injuries, violence, war, and tobacco-related illnesses. Table 9 presents a comparison of morbidity in SSA, EMEs, and worldwide levels for selected infectious diseases and other non-communicable causes of death. These data are obtained from the 1996 WHO Global Health Statistics (WHO, 1996b). Both incidence and prevalence rates are presented. Data represent 1990 statistics and are compiled from a variety of WHO and World Bank sources. SSA rates are consistently higher in all categories versus either worldwide or EME rates. A comparison of SSA to other lower-income regions would also demonstrate a pattern of elevated communicable and non-communicable mortality and morbidity rates.

4.2 SUB-SAHARAN INFECTIOUS

Infectious diseases can be classified according to their mode of transmission from their source (human, animal, or environmental) to a new host. Transmission can happen via direct person-to-person contact, through insects and other vectors, by way of contaminated food or water, or in other complex ways (WHO, 1996a). Table 10 presents selected diseases and conditions by

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four main modes of transmission. A fifth category, "Other emerging issues" is also shown to encompass the problems of antibiotic resistance and health care facility infections. Each of these four modes of transmission will be presented with Cameroon-specific data. In addition, the general problem of antibiotic resistance will also be briefly discussed. The role of poisonous animals (snakes and invertebrates) and plants (dermatitis and systemic effects) is potentially significant and will be presented as part of a health matrix gap analysis. This analysis is being undertaken to assist in project health and safety planning.

4.3 CAMEROON MORBIDITY AND MORTALITY

There are two main sources of general morbidity and mortality data for Cameroon: 1) MOPH data and 2) the 1991 Demographic Health Survey. Kamdoum has recently summarized the MOPH data in two recent publications (Kamdoum, 1996a and b). These papers present countrywide morbidity and mortality data for 1977 and 1992. In addition, similar data from the MOPH are now available for 1993-1997. Table 11 presents a comparison of disease and reported diagnose over the years 1977-1993. As this table illustrates, overall morbidity causes have remained quite constant and are dominated by infectious diseases, particularly malaria and intestinal parasites. Similar data for the four Provinces, which will be the proposed project, have been presented in the supporting data for Figure 1 through 13. Tables 12 and 13 present age-specific causes of morbidity. Table 14 presents the leading causes of mortality across all ages, while Table 15 shows similar data for 1993 for children less than 5 years old (MOPH, 1996). A comparison of Tables 14 and 15 readily demonstrates that malaria is a dominant source of both childhood and adult mortality. These data are consistent with the morbidity figures and clearly demonstrate the heavy burden of malaria across Cameroon. A detailed analysis of malaria and the other major infectious diseases will be presented in subsequent sections.

As previously noted, general provincial morbidity/mortality data are available. As an example, Table 16 presents 1991-1995 crude morbidity data for the Adamoua Province. As this table illustrates, while there are rank order differences versus countywide data, the overall dominance of the infectious diseases, particularly malaria, is obvious. The burden of accidents (vehicular and non-vehicular) injuries (intentional and non-intentional) is also significant for both adults and children. Accurate data for these categories are difficult to obtain; however, accidents and injuries represent a substantial morbidity and mortality burden across Sub-Saharan Africa. Therefore, it is likely that Cameroon is similarly affected.

As previously mentioned, the Peace Corps reported health events per hundred volunteers (events/100 PC). In 1995, the most commonly reported events per hundred were: 1) acute diarrhea (64), 2) upper respiratory illness (28), 3) dermatitis (23), 4) dental problems (23), 5) febrile illness (21), 6) mental health needs (18), and 7) unintentional injuries (15). Two-thirds of all hospitalizations for PCVs were caused by infections, e.g. gastrointestinal (44 percent), respiratory (16 percent). Interestingly, malaria-related hospitalizations were only 4 percent,

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illustrating the benefits of a comprehensive prophylaxis and control (impregnated clothing, bednets). These data indicate that expatriates will both encounter and experience the existing in-country diseases; however, the impact can be clearly mitigated by a comprehensive medical/education program.

Overall, the project corridor passes through areas that have high endemic levels of infectious diseases. A detailed analysis of these diseases, including geographic disease maps based on published data, will be presented in the next subsections.

4.4 PERSON-TO-PERSON INFECTIOUS DISEASES

Person-to-person transmission of infectious diseases covers an enormous range of different disease categories. Table 10 lists over twelve major disease types. This list would be even longer if the myriad number of STDs (e.g., syphilis, gonorrhea, chlamydia, and herpes) were separately enumerated. Due to the critical importance of the STDs (including AIDS and hepatitis), these disease groups will be discussed in a separate section.

In terms of the proposed project, the most important person-to-person diseases, excluding AIDS/STDs/hepatitis, are acute respiratory infections (ARI), meningitis, and tuberculosis. Each of these will be discussed.

4.4.1 Acute Respiratory Infections

ARI are one of the leading causes of morbidity and mortality throughout Cameroon and SSA (Jamison, 1993). ARI is an amalgam term that includes many conditions and a variety of clinical manifestations caused by a myriad of etiological agents. ARI are subdivided into acute upper and middle respiratory infections (AURI) and acute lower respiratory infections (ALRI) which refer to conditions affecting the respiratory tract below the epiglottis. AURI include the common cold, otitis media, pharyngitis, tonsillitis, croup, tracheobronchitis, and acute epiglottitis. These are usually mild and self-limiting and infrequently lead to death. On the other hand, ALRI are more serious and include pneumonia and bronchiolitis. These two diseases are common complications in children of measles and pertussis (whooping cough). In SSA, pneumonia in young children is mainly due to bacterial causes such as strep pneumoniae and Hemophilus influenzae. Both of these bacteria are treatable with antibiotics; however, issues of antibiotic-resistant strains due to overuse of drugs are becoming a significant issue (see Section 4.8). The 1992-1993 Cameroon data report both upper and lower respiratory infections. Both morbidity and mortality levels are high (Tables 11-15) and these family of diseases are invariably in the top ten problems for a given year. While the true magnitude of ALRI in the adult population (ages 15-60) is unknown, the spread of either upper (AURI) or lower (ALRI) respiratory infections is an important consideration for the design and operation of labor camps associated with proposed project construction activities. Furthermore, it is anticipated that there is a marked seasonality to the respiratory disease rates that could impact a labor force living in a work camp environment.

4.4.2 Meningitis

Cerebrospinal meningitis is potentially a significant disease for Cameroon, particularly in the dry season in the savanna provinces (North and Extreme North). The southern wooded savanna zones are also susceptible to meningitis; however, epidemics are less frequently reported (Riou, 1996). Parts of Cameroon are in the designated "meningitis belt" of SSA and in 1993-94 an outbreak of the invasive and highly pathogenic sero-group A subgroup III occurred (Riou, 1996). Epidemics within the African meningitis belt have typically occurred every 8 to 12 years; however, the intervals between large outbreaks have become shorter and more irregular since the early 1980s. There are multiple factors that affect the occurrence and spread of meningococcal disease: 1) decreasing antibody levels in the population, 2) overcrowding, 3) climatic changes (i.e., dry season or prolonged drought), 4) frequent cases of ALRI (lower respiratory) and 5) periods of dry and cool weather.

The most common organism in the epidemics of cerebrospinal meningitis in Africa are Neisseria meningitides sero-group A; however Group C has also been reported. As of March 27, 1996, information from Cameroon had been received on 5 cases with one death (WHO, 1996). Meningitis is potentially preventable through vaccination of both children and adults and the use of antibiotics to protect close contacts of those already infected. The early detection of outbreaks is essential so that appropriate containment measures can be instituted. In general, if the local incidence level exceeds 15 cases per 100,000 population during two consecutive weeks, then epidemic conditions are likely and the need for mass vaccination is imperative (WHO WER, 22 March 1996).

4.4.3 Tuberculosis (TB)

Over the last 10 to 15 years, TB rates per 100,000 have increased by over 50 percent in SSA (WHO WER, March 1996). The spread of TB has been accentuated by the increase in travel, migration, a general decline in overall health probably related to prolonged economic recession, and the growing AIDS epidemic. TB is primarily a disease of adults aged 15 to 44 and has formed a lethal partnership with AIDS. TB is the leading cause of death in AIDS-positive individuals (one-third of all deaths) in the developing world. In addition, drug-resistant TB is rapidly increasing and severely complicates an already difficult treatment situation.

Tuberculosis in Cameroon has received increasing attention from health authorities (Kuaban, 1995a; Lemardeley, 1995; Noeske, 1998; Bercion, 1998, 1997). Tuberculosis rates in Cameroon have slowly increased during the 1980s and 90s such that the annual risk of infection is calculated to be 1.5 to 2 percent. The estimated incidence rate is 100 cases per 100,000 (Kuaban, 1995b). These statistics are further complicated by the high positive case rate associated with each patient that comes to formal medical attention. For example, the "normal" international case finding rate is 5.6 percent. This means that among direct contacts with the original case, it would be expected that another 5.6 percent of direct family/relatives would also be TB positive. In Cameroon, Kuaban (1995b) reports a 14.5 percent positive case finding. In previous studies (LeMoal, 1991) the ability to contact and find these other probable cases was estimated to be only 40 percent. Therefore, the "true" estimated burden of bacillus positive (BK+ in French) cases is 11,000 per year (LeMoal, 1991). Tables 17A, B and C present both national and provincial data from 1987-1989.

These data demonstrate that the smear positive (BK+) percents of actual identified cases are quite high. Furthermore, as LeMoal et al. (1991) reports, these data are significant underestimates. The 1995 data are presented in Tables 18A - B. These data indicate several trends: 1) there continues to be an under-reporting of cases versus the true estimates, and 2) the age groups 25-34 and 35-44 dominate the case load. The latter observation is further reinforced by Kuaban's (1995c) report of 273 consecutive adult patients admitted to the Jamot Hospital Pulmonary Unit (University Yaoundé) over an eight-month period. Overall, 64.1 percent of these cases presented with advanced and extensive disease characterized by infiltrates with or without cavities and occupying a whole lung field. Over 77 percent of the cases had multiple large (greater than 2 cm) cavities by x-ray. Kuaban also noted that intradermal skin testing was not a helpful diagnostic modality versus direct bacteriologic evaluation of pulmonary secretions. Ominously, drug resistance was also observed to be a significant problem (Bercion and Kuaban, 1995; Bercion, 1998) in a study of 105 isolates, a serious pattern of drug resistance was noted (Table 19). The most current published resistance data (Version, 1998) demonstrates increasing problems: 21 percent to one drug and 6.3 percent to two or more drugs.

This problem of multi-drug resistance seriously complicates treatment and threatens to make some cases incurable. In addition, multi-drug resistance compromises the WHO program of "directly observed treatment, short-course" (DOTS). This program can theoretically cure 95 percent of all cases for $11(US); however, target cure rates will not be met if drug resistance continues to climb.

While Cameroon has begun a National Program Against Tuberculosis, know by its French acronym of PNLT (Programme National de Lutte contre la Tuberculose), the magnitude and complexity of the problem is severe (Noeske, 1998). The number of cases will undoubtedly increase in association with the mounting AIDS epidemic. TB is the leading killer of HIV-positive individuals and accounts for over 30 percent of AIDS deaths worldwide (WHO, 1996). Overall, tuberculosis represents a serious and growing health problem across Cameroon that generally targets adults in their most productive years. Aggressive programs of 1) case-finding, 2) subject contact that include appropriate diagnostic equipment and treatment are necessary to prevent a further expansion of an already serious problem.

4.5 FOOD, WATER, AND SOIL-BORNE INFECTIOUS DISEASES

Contaminated food, water, and soil are capable of transmitting bacteria, viruses, and parasites. Some of the most important medical conditions and diseases associated with these media are schistosomiasis, diarrhea, cholera, typhoid, intestinal worms, hepatitis (A and E), and tetanus. Poor sanitation is a major contributing cause of these infectious problems. The true incidence and prevalence of these diseases (particularly diarrhea and hepatitis) are difficult to accurately assess in a developing country (WHO, 1996a). The water and food-borne diseases are the most widespread health problems in the developing world and are an important source of low or poor economic productivity (WHO, 1996a). Cameroon is affected, by varying degrees, from all of the major water/soil/food infectious diseases. The two most important categories of diseases to the project are water-borne diseases (e.g., typhoid, dysentery, cholera, schistosomiasis) and food-borne illnesses (e.g., salmonellosis, hepatitis A). On a positive note, dracunculiasis (guinea worm disease) is close to being eradicated on a worldwide basis (WHO, 1996a) and the caseload in Cameroon is now quite low. Separate subsections for the major diseases in the water/food/soil categories will be presented in the next sections.

4.5.1 Intestinal Parasites

Intestinal parasites have consistently been listed as one of the top three causes of morbidity in Cameroon (MOPH data 1984-1995). A national survey of *Ascaris lumbricoides* and *Trichuris trichuria* was performed on more than 22,000 children from October 1985 to November 1987 (Ratard, 1991). Prevalence rates were highly correlated with climate type (Figure D-3): a) tropical zone - less than 5 percent, b) Guinea-type climate - 60 to 85 percent for *A. lumbricoides* and 85 to 95 percent for *T. trichuria*, and c) Cameroon-type climate - 50 to 70 percent for *A. lumbricoides* and 70 to 90 percent for *T. trichuria*. Dondji (1998) has confirmed these data in another study in Mokolo (Extreme North Province). The age group distribution followed a pattern that indicated acquisition early in life, rapid increase in early childhood and development of a stable adult prevalence. Table 20 presents a summary table for each province, while Figure 14 illustrates a more detailed mapping of the study results. Within specific climatic zones there do not appear to be significant differences in prevalence rates between rural villages, small towns, cities or as a function of altitude (Ratard, 1991). However, environmental conditions, such as heat and low humidity, are significant since Ascaris eggs remain dormant under dry conditions while Trichuris eggs are adversely affected by desiccation. In addition, direct exposure to sunlight is also toxic to Ascaris and Trichuris eggs.

Overall, prevalence is very low in the dry, hot and sunny environments where annual rainfall is less than 1,500 mm and sparse vegetation and sandy soil conditions exist. Conversely, prevalence rates are extremely high in the equatorial zone conditions of the Center and South Provinces.

As previously mentioned, there is a clear age-dependence associated with infection. Adult rates (age 20-44) are significantly lower than school children: a) Douloumi-Sudan - type climate: 0 percent/0 percent Ascaris/trichuris, b) Obili (Yaoundé): 17.9 percent/49.3 percent, c) Kindig-Guinea/Savanna: 28.6 percent/55.7 percent, d)Mfou-forest area: 27 percent/49.2 percent, and e) Kumba: Cameroonian-type - Southwest Province: 37 percent/45 percent. While these percent infected levels are substantially below the corresponding childhood rates, they still represent a significant health burden on the adult population.

4.5.2 Cholera

The incidence of cholera has risen dramatically in West Africa. Despite a WHO sponsored project involving 16 West African countries, 13 of the 16 countries reported disease in 1996, compared to only six in 1993 (WHO, Sept 26, 1996). The annual number of cases in this region has increased by six-fold since 1993, i.e. 7,000 cases in 1993 to over 40,000 through September 1996. New significant cholera outbreaks have been reported in 1997. Similarly, the case fatality rate has dramatically increased by nine-fold such that the West Africa region accounts for two-thirds of all cases on the continent and more than 70 percent of all cholera deaths (Press Release, 26 Sept 1996).

There are multiple factors which have been invoked to explain the rise of cholera in West Africa: 1) prevalence of humid area with many pools and reservoirs of polluted water, 2) overcrowded living conditions and poor hygiene, and 3) mass movements of populations along roads and rivers associated with pilgrimages, festivals and political instability.

Cameroon specific data for the first 10 months of 1996 is available and presented in Table 21. The data from the Littoral Province represents data reported from January 1 - October 31; however, data from the other three Provinces is associated with discrete focal epidemics that had limited time spans, e.g. South (February-April), Extreme North and North (June-September) (MOPH, 1997).

The epidemic in the Extreme North appeared to be associated with a combination of drought and heavy late rains. At present, the situation is stable; however, the possibility of episodic outbreaks remains quite high.

4.5.3 Schistosomiasis (Bilharziasis)

Schistosomiasis is a chronic disease that has been recognized in Cameroon for decades. Prior to 1985, there were isolated surveys that indicated high levels of endemicity for *S. hematobium* in the northern provinces. Discrete foci were also noted in the Southwest and East Provinces (Agbor-Tabi, 1989).

In 1985, a schistosomiasis research project further identified endemicity of other schistosome species (*S. intercalatum* and *mansoni*) scattered throughout the country. A detailed National

Bilharziasis Survey was conducted under the Cameroon Ministry of Higher Education [Institute for Medical Research and Study of Medicinal Plants (IMPM)]. This project was carried with collaboration by USAID and Tulane University. The results have been published in numerous well-known scientific journals (Ratard 1990, 1992; Greer 1990, 1992; Bausch and Cline 1995).

Beginning in 1985, the IMPM-Tulane University team performed a systematic nationwide survey for human cases and snail intermediate hosts. Over 19,000 urine and 22,000 fecal samples from children and young adults (ages 10-19) were examined, representing every subdivision in Cameroon. Over 700 sites were sampled. The net result of this effort is a series of schistosomiasis disease and vector distribution maps that are probably the most accurate and detailed in existence for a specific country (Figures 15 through 19).

Overall, results from these maps indicate that schistosomiasis is primarily concentrated in the northern half of the country. Over 80 percent of all cases occur in three Provinces: Extreme North, North and Adamoua. The principal sites of transmission in these regions are small seasonal temporary bodies of water; however, there are areas, such as the Mbéré Valley which appear to be permanent foci of transmission (Raccurt, 1987). There are, however, areas of endemicity in the southern half of the country particularly *S. intercalatum* and occasionally *S. mansoni*. Since schistosomiasis is a focal disease, it is important to realize that prevalence observed in isolated foci may not be representative of "true" regional prevalences (Ratard, 1992). The National Survey confirmed this observation since the actual survey based calculated infectious case load was almost three times lower than WHO estimates based on limited sampling (Ratard, 1992).

As previously mentioned, in the northern Provinces, transmission of both urinary and intestinal schistosomiasis is highly seasonal and usually occurs in small temporary bodies of water (Greer, 1992). This observation is highly consistent with the extensive, multi-year study performed by Audibert et al. (1990) that examined the impact of a massive rice irrigation project on schistosomiasis infection rates.

This study took place in the Extreme North Province (Mayo-Danai) and covered the time period from 1979-1985. A stratified sample of 4,000 inhabitants, living in 28 areas was initially evaluated for both schistosomiasis and malaria. Due to population migrations, an additional 1,500 persons were added to the initial sample. Significantly, the prevalence of schistosomiasis and malaria remained constant over the six-year study period. In addition, no changes in the transmission sites were observed. Both improved sanitation activities (drain cleaning and well construction) and decreased rainfall were felt to be significant ameliorative factors (Audibert, 1990).

Overall, this study is highly consistent with the observation that large well-managed and maintained projects do not necessarily adversely impact schistosomiasis transmission and infection rates.

4.5.4 Food-borne Illnesses

The food-borne illnesses are potentially a major problem for the project because of the daily requirements to provide catering services for large mobile labor camps during the construction phase. Based on existing countrywide morbidity data, diarrheal diseases, which would include enterotoxigenic E. Coli and Campylobacter, are quite common. In addition, exposure to Hepatitis A is over 90 percent (see Section 5.0). Therefore, it would be expected that food-borne illness could episodically become a major problem during construction. This problem is amenable, however, to standard sanitation interventions that are discussed in Section 7.8 and 8.8 of the Environmental Assessment.

4.6 INSECT VECTOR-BORNE INFECTIOUS DISEASES

The insect vector-borne diseases are some of the most difficult epidemiological, pharmacological, and immunological challenges in the project region (Feachem, 1991). While there have been tremendous control improvements with some of the diseases (e.g., onchocerciasis, leishmaniasis, and trypanosomiasis), malaria has continued to be a stubbornly vexing cause of morbidity and mortality. The vectorial capacity of *A. gambiae* and *An. funestus* is undiminished, and the resistance of these vectors to insecticides and of the parasites to drugs has increased (World Bank, 1991; Butler, 1997). This section will discuss the major insect vector-borne diseases in detail. A system of GIS maps based on published or in-progress studies of disease and vector locations are available in this report. Basic geographic disease distribution maps are included in this report. As a group, these diseases have been and continue to be the subject of major WHO and World Bank funded efforts; hence, the only constant is change. Due to the quantity and quality of the existing database, a detailed disease distribution picture for the insect vector-borne diseases within Cameroon can be presented. Similar data is also available from the international Mapping Malaria Risk in Africa (MARA) project (OCEAC, 1997). Cameroon, through its National Program is a participant in their effort along with other OCEAC members (Lemardeley, 1997).

4.6.1 Malaria

The overall malaria situation in SSA in general, and Cameroon in particular, has reached a critical stage. This crisis has been triggered by the rapid rise in the parasites resistance to chloroquine, the main means of chemoprophylaxis and treatment on the continent (Butler, 1997). A seven-fold increase in malaria deaths over five years in parts of West Africa has been attributed to the emergence of chloroquine resistance. By a wide margin, malaria is the top cause of disease mortality in Cameroon (Table 14). Since 1985, the rise and spread of chloroquine resistance in Cameroon has been dramatic. In order to understand better the complex interaction between malaria transmission rates, drug resistance and disease incidence, a brief discussion of the transmission dynamics will be presented.

Malaria transmission is higher in SSA than any other location in the world because of the abundance of the highly efficient African mosquito vectors of malaria, *A. gambiae* and *An. funestus* (Bradley, 1991). The longevity of the anopheline mosquito is critical to the perpetuation of malaria transmission. Development of the infective sporozoite parasites in the vector takes at least one week and is influenced by ambient temperature. Therefore the mosquito must survive longer than one week after feeding on a human host if transmission is to be continued.

In order to understand malaria transmission, the concept of basic case reproduction rate (BCRR) must be understood. BCRR is the mean number of new cases of malaria to which one case will directly give rise after passing once through the vector mosquitoes under conditions of zero immunity in the human population (Bradley, 1991). For example, a BCRR of 5 means that one case will give rise to five cases in the next generation and 25 in the succeeding generation of cases (Bradley, 1991). Conversely, if the BCRR falls below 1, the disease transmission will gradually diminish and cease. Therefore, as a general rule, malaria transmission is directly proportional to the density of the vector, the square of the average number of blood meals on a person per day and the 10^{th} power of the probability of the mosquito surviving for one day (Mouchet, 1993).

In an endemic area, the supply of uninfected individuals who are susceptible is limited and "herd immunity" becomes important in reducing transmission and severity of disease. In this situation, there are two important scenarios that can occur: 1) the criteria for directly observing the BCRR will not be met and must be calculated based on mosquito biology (i.e., density of mosquitoes, their man-biting habit, and their longevity), and 2) a sudden influx of non-immune or non-protected individuals is introduced into an area and an explosive epidemic occurs.

For effective malaria transmission, two conditions must occur: 1) the mosquito species needs to be long-lived and 2) have a high man-biting habit. Unfortunately, both *A. gambiae* and *An. funestus* meet these criteria and are associated with BCRRs in excess of 1,000. Thus, there is a tremendous reservoir of capacity for malaria transmission far in excess of that required in order to maintain levels of endemicity (see Table 22 for endemicity definitions).

Endemicity of malaria is traditionally defined by either using spleen or parasite rates in children ages 2-9. In areas which are hyper or holoendemic people are constantly infected. Eventually, a state of "premunition" is achieved such that repeated infections cause little or no serious clinical effects. This form of immunity does not prevent infection but does control, at some level, clinical symptomatology (White, 1996b).

These biological facts have several significant consequences:

- Transmission is extremely hard to control since BCRRs must be reduced by a thousand-fold

- Everyone in areas of high endemicity is usually affected at an early age and if they survive early childhood, develop premunition (immunity which protects against severe disease)

- Despite yearly variations in the determinants of transmission, BCRRs do not fall to 1, and malaria remains highly endemic and stable

- Non-immune adults who enter an area of hyperendemicity can eventually acquire protective immunity; however, the likelihood of an explosive epidemic outbreak is increased if large number of non-immune individuals is present.

Table 23 presents the common ecological categories of malaria transmission in Africa. The pipeline area potentially crosses through categories 1-3; therefore, malaria should be expected to be a constant threat, especially during the peak transmission periods.

4.6.1.1 Malaria Mapping in Cameroon

The first published epidemiological map of malaria in Cameroon was by Languillon (1956, 1957). Malaria was hyperendemic in almost all areas (Figure 20). The most common types of malaria were: *P. falciparum*, *P. malariae*, and *P. ovale.* Over 22 species of Anopheles were identified: *gambiae*, *funestus*, *moucheti*, *nili*, and, *hancocki*, among others. Mouchet (1961) developed detailed maps of the Anopheles distribution (Figures 21 and 22). Malaria eradication campaigns (1953-1964) were organized throughout Cameroon using a variety of organochlorine pesticides. After a period of improvement, transmission rates accelerated and malaria prevalence continued at near hyperendemic levels due to lack of sustainability, financial considerations and political instability (Moyou, 1992).

In 1969, Abane and Delfini (1969) developed a new epidemiological map for malaria in Cameroon based on data from the 1962-69 time period. In this map, Cameroon was divided into eight ecological zones; however, overall transmission levels were still high and appeared to have increased since the 1950's eradication campaigns. Since the 1969 compilation, malaria endemicity has begun to vary quite substantially as a function of urbanization and deforestation (Moyou, 1992). Malaria is still perennial south of the Adamoua Province; however, in the southern regions, transmission levels are somewhat higher in rural and deforested locations versus the main urban areas of Yaoundé and Douala (Louis, 1995).

In a 1990 article, Ripert (1990), published the results of 20 new malaria surveys in Cameroon. This effort was based on the assumption that prevalence rates had changed since Abane and Delfini’s 1969 studies. In Ripert’s paper, the results of 12 standard epidemiological surveys, six in rural areas and six in southern rainforest locations, plus eight similar studies in various urban areas were reported. Three malaria indices in children ages 2-9 were utilized: 1) parasitemic, 2) serologic and 3) spleenic. The parasitemic index is based upon the number of parasites per microliter of blood. Typically, *P. falciparum* parasites counts over 100,000/ul are associated with substantially increased morbidity and mortality. Counts over 500,000/ul generally have mortalities over 50 percent. These counts cannot be considered as absolute indicators since relatively high counts can be tolerated by children living in areas of intense transmission as compared to non-immune adults. For example, counts over 2000,000/ul are fairly typical in semi-immune children who are clinically symptomatic. A similar level in a non-immune adult would produce severe disease. The sensitivity and specificity of this indicator is limited but can be improved by staging parasite development, i.e. the greater the number of mature parasites, the worse the prognosis (White, 1996b). Only some stages of malaria parasites in the blood, the *gametocytes*, are infective to mosquitoes. This observation means that under conditions of intense transmission, *gametocytes* are confined to extremely young children and malaria is primarily transmitted by this subgroup (Bradley, 1991). Table 24 illustrates this observation, based on data from Uganda.

The spleen rate is a clinical measurement of spleen size that is easy to perform in field conditions. Historically, the spleen rate correlates with the parasite rate (Table 22). Table 25 presents parasitemic (*gametocyte*) index and parasite form for the 20 study locations. As this table illustrates, *P. falciparum* is the dominant malaria form and is occasionally seen in association with *P. ovale* and/or *malariae*. *Gametocyte* indices were relatively low, probably due to the age distribution of the study groups (ages 2-9).

Table 26 presents the overall parasitemic, serologic and spleenic indices for all of the study sites. Based on the results in this table, Ripert et al. categorized Cameroon as mesoendemic with areas of hyperendemicity in certain southern forest areas. In cities, the results were variable and ranged from hypoendemic to hyperendemic. Cartographically, these results are presented in Figures 23 to 25 and can be contrasted with the 1957 maps.

The overall results are consistent with the perennial transmission seen in the southern region and the seasonal pattern present in the northern region. These patterns are consistent with the categories presented in Table 23. In areas occupied formerly by tropical forest (Category 1, Table 23), malaria transmission is continuous and intense. Further north, transmission in the savanna (Category 2, Table 23) is seasonal, although individuals can receive hundreds of inoculations per year (Bradley, 1991). In the Sahelian zone (Category 3, Table 23) malaria intensity is highly variable and is extremely dependent upon climatic conditions, i.e. rainfall and temperature. Category 4, high altitude, pattern is seen quite regularly in parts of Cameroon; however, these areas are generally not within the project corridor. As Ripert's results indicate, urban area malaria is quite variable (e.g., over 50 percent in Edea). This variability is not only between cities, but also within a given urban location.

Manga et al. (1993) studied the distribution of *A. gambiae* in Yaoundé and Edea. The study areas are characterized by hilly relief and swampy valleys. Human-biting rates demonstrated a marked gradient between the valley ("0" meters) and the hilltops (350 meters). The overall results explain why malaria transmission is extremely heterogeneous within districts and is primarily centered around valleys and at the base of hills. In urban areas the *A. gambiae* bites near its breeding areas, which, in both study locations, had high density of houses, e.g. less than 2-meter separation. Given the high number of available hosts, the mosquitoes did not disperse in the vertical direction and a marked fall in transmission was observed as a function of distance from the valleys to the hilltops. The public health implications of these findings are obvious.

Finally, renewed efforts at mapping are currently underway using GIS techniques for all of Sub-Saharan Africa (Le Sueur, 1996) This new mapping effort is known as the "Mapping Malaria Risk in Africa/Atlas du Risque de la Malaria en Afrique" (MARA/ARMA) and is a worldwide collaborative effort (Le Sueur, 1996). Published results are now beginning to appear in the literature as previously noted.

4.6.1.2 Chloroquine Resistance

The resistance of *P. falciparum* to chloroquine, the major anti-malarial used in SSA, was first reported in two expatriate children in Cameroon in 1985 (Sansonetti, 1985). Chloroquine resistance spread rapidly and was found in Kribi, Yaoundé, Goroua, and Douala by 1987 (Moyou, 1992). In 1985, OCEAC began a national *in vivo* surveillance system for anti-malarial drug resistance (Louis, 1995).

The OCEAC methodology is very simple (Jambou, 1988):

- 200 school children are given chloroquine at a dose of 25 mg/kg body weight over three days, i.e. 15 mg - Day 0, then 5 mg - Day 1 and 5 mg - Day 2.
- A thick smear is taken for each child at Day 0.
- Those children who have a thick smear positive have repeat smears at Day 3 and Day 7 in order to document therapeutic efficacy.

In-vivo drug resistance is typically categorized using criteria developed by WHO (White, 1996b):

- R_1 (low grade): relapse of the infection between 7 and 28 days of completing treatment following initial resolution of symptoms and parasite clearance
- R_2 (high grade): reduction of parasitemia by greater than 75 percent at 48 hours, but failure to clear parasites within 7 days
- R_3: parasitemia does not fall by greater than 75 percent within 48 hours.

  These criteria are broad and useful for surveillance purposes but do have several limitations if more precise analyses are required (White, 1996b):

- Few patients are followed for 28 days. The OCEAC methodology is a 7-day study and may underestimate resistance. Short protocols may not be able to distinguish between reinfection and relapse.
- Therapeutic failure may be due to dosing problems, poor compliance, absorption problems and other host pharmacokinetics factors.

Despite these and other more complex considerations, both the surveillance protocol and resistance criteria are appropriate tools. The overwhelming majority of published studies in Cameroon use these approaches and is the basis of the data that has been developed and published.

Table 27 presents chloroquine resistance data for southern Cameroon in 1989 and 1993-94. While these data are quite variable, there is a pattern of increasing resistance levels. Brasseur (1992) reported similar data from 1986-1988 for locations in both the Northern and Southern regions. *In vivo* 7-day assays from 389 individuals from the southwest showed R_2 - R_3 levels of resistance in 18-52 percent of cases as a function of location (Brasseur, 1992). Data from the Northern region, e.g. Ngaoundéré (6 percent resistance), Garoua (7 percent), and Maroua (7 percent) demonstrated substantially lower levels of resistance. Figure 26 presents a countrywide chloroquine resistance map based on published studies between 1985 and 1995.

The difference between the Northern (dry) and Southern (rainy) regions is quite striking. Data from the Southern region is consistent with rapid spread from an initial focus and eventual establishment of a stable plateau level. In contrast, the northern region data are not consistent with a rapid geographic spread. There are multiple potential explanations for this observation: 1) lower rate and seasonal nature of mosquito transmission of the parasite in the Sahelian geography and 2) substantially lower use, almost two-fold different, of chloroquine in the North versus the South (Brasseur, 1992). The implications of the observed North-South differences are significant for the proposed project since it will cross zones of widely differing malaria prevalence and chloroquine resistance. Mitigation strategies are presented in Sections 7.8 and 8.8 of the EA and are further developed in the Environmental Management Plan (EMP). Bouchité (1997) has begun a large-scale intervention program utilizing in pregnated netting in Mbandjock, a village 110-km northeast of Yaoundé. This is a two year study involving 10,000 people and includes Knowledge, Attitude, and Practice (KAP) assessment and intervention.

4.6.2 Onchocerciasis

Onchocerciasis (river blindness) is due to infection with *O. volvulus*. Man is the natural host and the vectors are different species of the Simulium complex (blackflies), e.g., *S. damnosum*, *S. sirbanum*, *S. squamosum*, etc. *Simulium* flies breed optimally in well-oxygenated water. The pregnant *Simulium* oviposits into rapidly flowing rivers and streams. Transmission is maximized near these locations. This observation accounts for the moniker "river blindness."

Clinically, the major manifestations of onchocerciasis are dermatitis, eye lesions and nodule formation. Significant morbidity is produced only after extensive and prolonged exposure over many years. It is not uncommon to find individuals with biopsy positive microfilariae in their skin who otherwise have no overt signs or symptoms (McMahon and Simonsen, 1996).

The control of onchocerciasis (river blindness) in recent years has dramatically changed due to the WHO Onchocerciasis Control Program (OCP). OCP has eliminated the disease as a public health problem from 11 countries in West Africa through a combination of extensive insecticide spraying of vector breeding sites and the widespread distribution of a safe, effective drug, Ivermectin. However, despite the progress of the WHO-OCP project, onchocerciasis is still hyperendemic in many areas of Cameroon.

The level of endemicity of onchocerciasis in a population has been classified by the OCP on the basis of the age-standardized microfilarial prevalences: a) sporadic (<10 percent), b) hypoendemic (12-29 percent), c) mesoendemic (30-59 percent) and d) hyperendemic (60 percent or greater). There has been further augmentation of this criterion based on the addition of findings other than microfilarial load: 1) presence of at least one nodule or any other clinical sign and 2) presence of microfilariae in the anterior chamber of the eye. The addition of these criterion increased prevalence rates by 10 percent in one study in Sierra Leone (McMahon and Simonsen, 1996). In the forest of southern Cameroon, the prevalence of nodules and skin lesions are strongly predictive of high levels of endemicity.

The epidemiology of onchocerciasis is significantly influenced by the density, biting, infectivity rates and flight range of the vectors. Flies of the *S. damnosum* complex have specific breeding requirements: 1) adequate velocity of water, 2) appropriate food supplies, and 3) suitable attachment sites, e.g. rocks, sticks, vegetation. Exposed rocks that create white water rapids are primary larval habitats. In general, female blackflies restrict their flight range to within a few kilometers of breeding sites; however, based on wind direction and speed, the flies can migrate several hundred kilometers from one river basin to another (McMahon and Simonsen, 1996). Biting is usually most intense within the immediate vicinity of breeding sites. Unlike the *A. gambiae* mosquitoes, peak biting activity is during daylight hours (as apposed to midnight to 0400 hours for anopheline mosquitoes).

The main West African members of the *S. damnosum* complex can be generally divided into savanna species, e.g. *S. damnosum* s.s. / *S. sirbanum* and forest species, e.g. *S. yahense* and *S. squamosum*. *S. mengense* has been described in southwestern forest zone; however its vector potential has not been clearly defined (Traoré-Lamizana and Lemasson, 1987).

4.6.2.1 Vector and Disease Mapping

Figures 27 and 28 are geographic distribution maps produced by ORSTOM for the *Simulium damnosum* complex in Cameroon during the wet and dry season. These maps are primarily focused on the northern regions of Cameroon (Traoré-Lamizana, et al. 1987). An onchocerciasis disease distribution map (Figure 29) was produced as part of the 1993 Cameroon River Blindness (Ivermection Distribution) Program sponsored by USAID (Boyle, 1993). The 1993 disease map corresponds quite well to the 1987 ORSTOM *S. damnosum* distribution. As part of the WHO-OCP new disease distribution maps have been created. The Rapid Epidemiological Mapping of Onchocerciasis (REMO) is a major component of the OCP and covers both the project area and other contiguous locations. Based on REMO data, Cameroon was divided into six division:

- Division I - Extreme North, dry sahelian climate
- Division II - Northern Guinea Savanna Zone from approximately 8 to 10 N, with a southern boundary being the escarpment of Ngaoundéré and the northern watershed of the Sanaga basin
- Division III - From 4 to 7 30'N. This is the watershed of the Sanaga river basin. A large empty zone that is virtually uninhabited north of the Sanaga River is included.
- Division IV - Tropical rainforest area, covering south of 3 N and the whole area east of 12 15'E. The northern boundary is the watershed between the Sanaga and Nyong Rivers.
- Division V - Littoral or coastal plain approximately 20 km wide. This area is generally unsuitable for onchocerciasis vectors.
- Division VI - Generally English speaking west Cameroon. A large portion of the land is above 2,000 meters.

Figure 30 is a map of these divisions and zones.

Based on the 1994-96 data supplied by the MOPH, a new disease map using REMO data has been constructed (Figure 31). These data are keyed to prevalence of nodules in male patients who were examined as part of the REMO survey. Other 1987-1997, non-REMO studies are combined and graphically presented in Figure 32 and indicate significant onchocerciasis transmission in southern Cameroon.

Overall, vector and disease distributions are consistent. There are substantial areas of hyperendemicity, particularly in the North and Center Provinces and perhaps in the South Province as well. The proposed project corridor crosses through many areas that are hyperendemic. The use of safe, short acting insecticides, e.g. temiphos (Abate®), is a major consideration and will be discussed in both the EA and EMP.

4.6.3 Filariasis

4.6.3.1 Lymphatic Filariasis

One prevalence survey in 1980 was performed in the Logone Valley, Yagoua (Extreme North) (Ripert, 1982). This study, which is out of the project area, examined the prevalence of bancroftian filariasis (*W. bancrofti*). Prevalence was determined by using both microfilarian rates and detection of specific antibodies. Over 600 individuals were studied in 12 villages. Mircrofilarian rates were 22.1 per 100 in males and 9.8 per 100 in females. These results were felt to be consistent with older reported studies. The national survey noted that female *A. gambiae*, also an important malaria vector, were the mosquitos most frequently observed in surveyed households.

4.6.3.2 Loa Loa

Loa Loa is a filarial parasite of man with a distinct geographical distribution in the tropical rain forest of Western and Central Africa. Clinically, prolonged exposure is associated with localized angioedema (Calabar swelling) and subconjunctival migration of adult worms across the eye ("African eye worm") (Nutman, 1988). Human *L. loa* is transmitted by day-biting female tabanid flies of the genus *Chrysops*. *Chrysop* flies are abundant in the forest canopy and are attracted by movement, dark colors and wood smoke. Transmission takes place primarily during the rainy season (McMahon and Simonsen, 1996).

Loiasis is hyperendemic in the Southern region. It has been estimated that in Cameroon exposed individuals may receive one infective bite every five days (Mommers, 1994). Despite this observation, studies in southern Cameroon consistently demonstrate a 30 to 35 percent prevalence of microfilarial carriers (Garcia, 1995; Fain, 1981; Mommers, 1994). A map of the distribution of *L. loa* in Cameroon is shown in Figure 33.

Garcia et al. (1995) published the first longitudinal epidemiologic survey of loiasis in the region of Mbalmayo at both the population and individual level. This study was located in the region of Mbalmayo, 70 km southeast of Yaoundé (Figure 33). Data was obtained on 738 subjects on both sides of a 10 km long trail across the forest. At the population level, both the prevalence and the log transformed parasite density were stable over time, ranging between 26.8 and 29.0. These results were consistent with those of previous cross-sectional studies. The implication of this observation is that the epidemiologic situation can be assessed by a one-time survey, without loss of significant information (Garcia, 1995).

Demanou (1997) has undertaken a similar study in Ngat, a village 70 km south of Yaoundé.

4.6.4 Trypanosomiasis

The human African trypanosomiases (HAT or sleeping sickness) are caused by parasites of the genus *Trypanosoma*. The organisms responsible for HAT are members of the species *T. brucei*, a group of organisms that can be transmitted to man by the bite of the tsetse flies, *Glossina*. HAT is endemic only in areas where *Glossina* species are found. The "*Glossina* belt" is approximately from 14 N from Senegal in the west to 10 N in southern Somalia in the east and 20 S corresponding to the northern fringes of the Kalahari and Namibian Desert.

HAT in the Central African states has been well described in many review articles (Lemardeley, 1995; Penchenier, 1996). Figure 34 presents the 1990 Central African Region map of active or possible active HAT foci (WHO, 1990). The estimated population at risk for HAT in Central Africa, including Cameroon is shown in Table 28 while Table 29 presents new cases of HAT in Central Africa. The transmission of *T. b. gambiense* as seen in Cameroon, is associated with particular sites, usually near riverine vegetation, river crossings, water collection points, washing sites, sacred forests and villages adjacent to rivers or lakes (Molyneux, 1996).

The history of HAT in Cameroon is long and extremely well documented (Lemardeley, 1995; Penchenier, 1996; Noncho Amida, 1990; Louis, 1995; Ebó'O Eyenga, 1995; Ghogomu, 1989). Throughout the 20th Century HAT has been endemic in Cameroon. The first cases were discovered early in the 20th Century. Infection rates were from 30 to 90 percent and epidemics were common, particularly in the area between the Nyong River and the Sanaga River.

By 1930, Cameroon was described by the famous French physician, Dr. Eugene Jamot as having "...an epidemic fire...burning in the South of Cameroon" (Ghogomu, 1989). See Figures 35 and 36. After extensive public health campaigns, HAT is only reported in a few areas in Cameroon (Figure 37). The 1977-1986 case load is shown in Tables 30A - B. There continues to be an active HAT foci in the Fontem area; in addition, Bafia, Campo and Douala occasionally report cases. Since 1990, government support for HAT programs has disappeared and surveillance activities are only passive rather than active case finding (Personal Communication to Dr. B. Cline, 1997). While at present, the prevalence of HAT in Cameroon is quite low, epidemic spread is still possible since the most contagious stage of the disease occurs before overt clinical signs and symptoms are present. Fortunately with the exception of the Chad portion of the project, the pipeline corridor is not in close contact with any of the Cameroonian foci with the possible exception of the Kribi area.

In December 1998, OCEAC has reported the occurrence of several new cases in the Bipindi-Lolodorf area. Recently, a joint team of OCEAC and ORSTOM are in the area executing a survey and will integrate its findings in the mitigation measures for trypanosomiasis.

4.6.5 Yellow Fever

Cameroon has had sporadic but significant outbreaks of Yellow Fever that have been documented over the 1990-1994 time period. In December 1990, a major epidemic occurred in the Mayo-Sava and Mayo-Tsanaga departments. Two towns Mokolo (M-Tsanaga) and Mora (M-Sava) were impacted. One hundred eighty-two cases were reported with 125 deaths. Scientists from the Centre Pasteur de Garoua reported that "true" estimates of cases were between 5 and 20,000 with 500 to 1,000 deaths (Vicens, 1993).

In November 1994, a restricted outbreak of 10 cases and 5 deaths was reported in the town of Ngaoundéré, in Adamoua Province. Entomological surveys confirmed the presence of *Ae. aegypti* and the virus was isolated from these mosquitoes. This outbreak was limited due to its occurrence during the dry season, which tended to inhibit *Ae. africanus* and *aegypti* vector densities and subsequent jungle and urban transmission (WHO WER, 18 Oct 1996). No cases were reported in 1995. A highly effective and safe vaccine exists for yellow fever and can be used to prevent infection and control epidemics.

4.6.6 Cutaneous Leishmaniasis

Leishmaniosis is a disease caused by infection with parasites of the genus *Leishmania*. The parasites are transmitted between long-lived vertebrate hosts by short-lived phlebotomine sand flies. Typically, the leishmaniasis are zoonoses of wild animals, usually rodents, endentates or canines, which includes the domestic dog. Humans are infected by the bite of an infected sand fly. In Cameroon, Dondji (Dondji, 1997, 1998) has identified a cutaneous leishmanivois (CL) focus in the Mokolo Region of Extreme North Province. The possibility, in the Extreme North Province, for other foci if CL or viscerul leishmaniosis (UL) exists and is under investigation.

4.7 ANIMAL-BORNE INFECTIOUS DISEASES (INCLUDING NEW AND EMERGING DISEASES)

Infectious diseases that are transmitted from animals to humans are called zoonoses. Of these, rabies and brucellosis are well known examples. Ebola-Marburg hemorrhagic fever probably has an animal host; however, this has not yet been definitely established. There have been no known outbreaks of Ebola in Cameroon; however there have been three episodes in nearby Gabon in 1994 and 1996 (Dispatches, 1997). Figure 38 is a map of the locations of the Gabon outbreaks. Reportedly, there is an extremely low antibody prevalence against Marburg virus in northern and southern Cameroon; however, a mid-1980s survey found a 10 percent antibody prevalence for an "Ebola-like" virus (Personal Communications, 1997). Lassa Fever is transmitted by direct or indirect contact with dust or food contaminated with urine from infected rodents. Person-to-person transmission can also occur. Lassa Fever is possibly enzootic in the Extreme North. Low antibody prevalence was detected in human sera from residents in Mora

(Extreme North, Mayo-Sava). Sporadic outbreaks have been reported in West Africa other than Sierra Leone (e.g., Liberia, Nigeria, and Guinea).

4.8 EMERGING DISEASES AND ANTIBIOTIC RESISTANCE IN INFECTIOUS DISEASES

Antimicrobial resistance by disease-causing organisms is an issue of increasing public health concern. A growing number of infections have become increasingly untreatable or more difficult to control (e.g., TB, malaria (see Figure 26, cases of malaria with chloroquine failure), cholera, dysentery, and pneumonia). According to WHO, a major cause of this problem is the uncontrolled and inappropriate use of antibiotic drugs (WHO, 1996a). WHO currently has an active program, WHONET, of global surveillance of bacterial resistance to antimicrobial agents. The practice of mass drug administration will be carefully reviewed and considered on a disease by disease basis.