CHAPTER 3

THEORETICAL FRAMEWORK

3.1 Introduction

To construct a suitable model aimed at gaining an insight into the relationship of the elements of Malaria clinical services and to identify the type and extent of this relationship for the purpose of prediction, the problem of variable selection and the functional specification of the model are of paramount importance.

The questions to be answered while formulating a model to be used are, which variables should be included, and in what form should they be included; that is, should they enter the model equation as an original variable, X, or as some transformed variable such as X^2, log X, or a combination of both? The answer to the first part of the above questions - the kind of variables to be included - is the subject of discussion in this section. The other questions will be dealt with in the subsequent chapters.

For the purpose of convenience, this chapter is divided into the following two sections all dwelling on the theoretical considerations designed to determine the variables to be included in the model formulation.

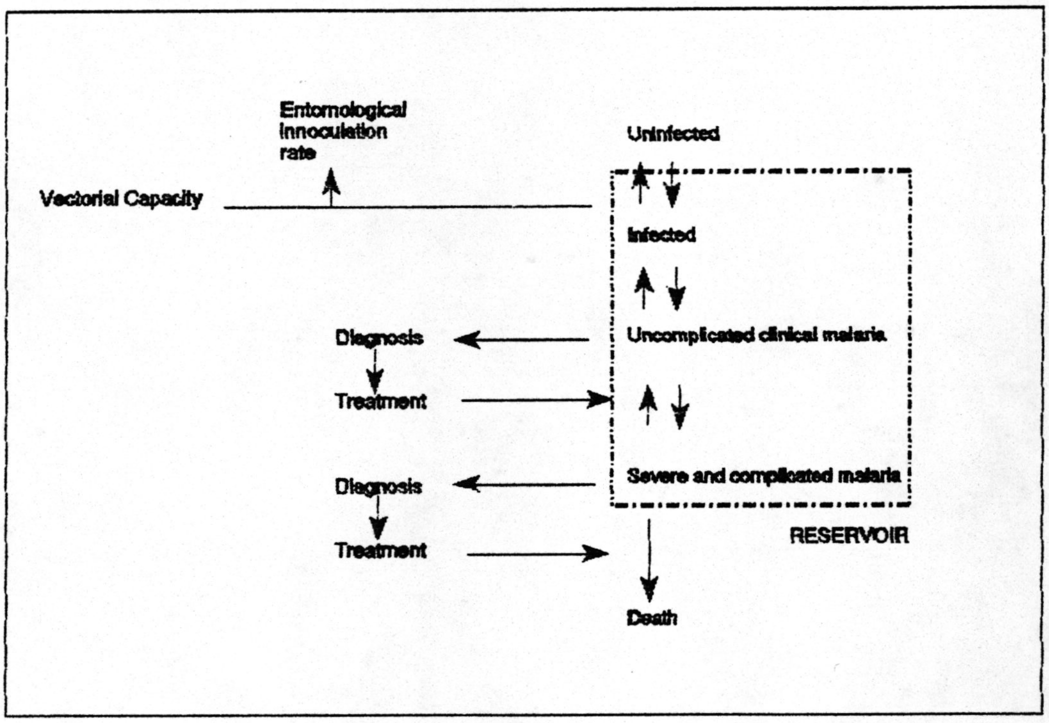
These are,

1. Malaria diagnosis and treatment model and
2. Consumer demand model for services at Malaria clinics.

3.2 Malaria Diagnosis and Treatment Model

The conceptual model (Molineux, 1968) underlying the Control of Malaria through diagnosis and treatment is schematically represented in Fig 3.1 and can be outlined as follows:

Figure 3.1 The Conceptual Model Underlying the Control of malaria through diagnosis and treatment.



1. With respect to malaria infection and disease all persons are distributed among 5 mutually exclusive states; uninfected; infected (but not sick); sick (uncomplicated malaria); severely sick (severe and complicated malaria, life-threatening malaria); and death; a fraction of those in one state moves to the next. As shown, transmissions except the last one (death), are reversible, even spontaneously. The transmission rate of malaria within the community produces a collective immune response, which has protective effect on the community;

2. Early detection of uncomplicated clinical malaria and its timely and effective treatment, should prevent evolution towards severe and complicated malaria, and death;

3. Early detection of severe and complicated malaria and its timely and effective treatment should prevent death.

4. Diagnosis and treatment of clinical malaria reach only part of the parasite reservoir. Malaria clinical services do not affect the vector densities and even in human host only a few proportion of positive cases is detected by malaria clinics. Kaewsonthi, 1984, for example, found out that only 30% of positive cases in five sampled villages in Thailand attended malaria clinics.

Molineux scheme also presents the concept of vectorial capacity which is a convenient way of expressing the malaria transmission risk, or, in other words, the `receptivity' to malaria of defined area . Vectorial capacity C, can be expressed mathematically as:

$$C = \frac{ma^2p^n}{-\log_e P}$$

Where

ma = man biting rate with m, representing the relative density of female Anopheles to man and a, the man biting habit or the probability that a mosquito will feed on man during a day.

P = the probability of survival of Anopheline mosquitos through one day

P^n = the probability of survival of Anopheles through n days of the duration of sporogonic period i.e. the incubation period of malaria parasite in the mosquito.

In epidemiological terms this equation may be translated as follows: when a person is bitten ma time per day and a population P^n of the vector population survives the incubation period of the malaria parasite in the mosquito, and if this proportion is expected to live for another ($1/\log_e P$) days, during which they bite another person a times a day, then we may estimate the rate of potentially infective bites. This is the measure of transmission, which determines the endemic level of malaria in given conditions and indirectly the impact of eventual control activities. Vector control by larvicides or other measures will reduce m, screening of houses, use of bed nets etc will reduce a, while residual spraying will also greatly reduce the factor p.

The Molineux conceptual model suggests two approaches that can be adopted to influence Malaria clinical services, assumed in this study to comprise of diagnosis of suspected patients and treatment of positive cases. These are:

(1) reduction of the vectorial capacity or/and
(2) reduction of the parasite reservoir.

3.2.1 Reduction of the Vectorial Capacity

The reduction of the vectorial capacity includes reduction of man-mosquito contact, vector breading habitats, vector densities and of longevity of vector population. This can be achieved in two broad ways, either by individual protection or by vector control.

Individual protection methods include the use of mosquito repellents and bed nets, house screening, house siting, pyrethrum house spraying and the use of antimosquito fumigants. These are meant to reduce man-mosquito contact and hence the vectorial capacity. In the communities, the adoption of these types of malaria control measures is solely a household affair and depends on the individual annual household income and knowledge of their use. The size of the household income therefore becomes an important factor that can affect the rate of infection of malaria in a household assuming all other factors constant.

Vector control measures include environmental modification and manipulation, chemical and biological larvicides, insecticide space spraying and residual insecticide spraying. Environmental modification and manipulation as well as chemical and biological larvicides are meant to reduce vector breeding habitats; insecticide space spraying, vector densities and residual insecticide spraying, the longevity of vector population.

Vector control is usually very technical requiring in most cases an expensive labour input and therefore usually beyond the reach of the communities. In Thailand, though there is some levels of community participation in these control measures (Okanurak et al, 1992), about all expenditures involving vector control are borne from the government annual budget for such control activities. In fact, any effective malaria control can only be assured if a regular budget is provided and maintained over the whole duration of the project (Bruce-Chwatt, 1985). Countries where there is little or no political will on the part of their governments to allocate adequate budget for malaria control have experienced a high incidence of malaria. Examples are the border countries of Thailand which have high incidence of malaria as compared to Thailand itself where there is currently a low incidence of malaria as a result of a sustained huge government expenditure allocated for malaria control over the years. The control of the disease along the border towns and villages in Thailand has been very difficult due to imported malaria from these border countries.

3.2.2 Reduction of the Parasite Reservoir

The frequency of transmission of malaria depends not only on the density and infectivity of anopheline vectors but also on the fluctuations of the source of infections namely gametocyte carriers. The gametocytes are the sexual forms of the malaria parasites in human host - the only stage that can infect the vector mosquito after blood feed. The greater the gametocyte output in a community the greater the infectivity of man to the mosquito and therefore the higher the inoculation rate - the mean daily number of infective bites inflicted on the human victim - assuming a high expectation of infective life of the vector population and high man-mosquito contact.

The various antiplasmodial measures such as treatment of acute cases of malaria, prophylaxis and suppression of malaria infection and radical treatment of relapses are all designed to eliminate the malaria parasite and prevent transmission. In theory, it is expected that early diagnosis and effective treatment of cases of malaria should restrict the gametocyte output in human host (thus lessening the infectivity of man to the mosquito) and therefore prevent transmission.

In Thailand, malaria clinics have been set up in the sector offices to provide prompt antiplasmodial services to complement the efforts of other vector control activities, health education and so on, in a collective attempt to control malaria to a level of little or no public health importance. Though services consumption by malarious persons in these clinics are provided free of charge - at the government expenses - demand for these services is constrained by income level, the price of antimalarial inputs, consumption activities, and the opportunities for transforming the antimalarial inputs into health ie being free of malaria. The demand for malaria services at the malaria clinics and the constraints associated with it are examined in the consumer model described in the next section.

3.3 The Consumer Model for Malaria Services

Considering households exposed to malaria as rational decision-making units, they are assumed to seek optimization of their welfare status by using market goods and time of its members to produce commodities so as to maximize an index of the form.

$$U = f(A.X)$$

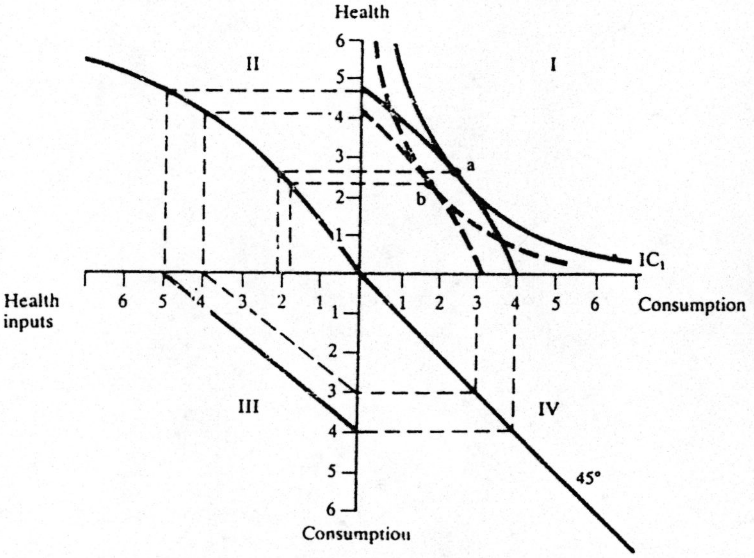
where

U = household welfare index
A = antimalarial commodities and
X = other commodities produced by the household.

Consumers are held to demand for antimalarial commodities for two reasons. As a consumption commodity, the antimalarial commodity enters their utility functions directly. As an investment commodity, it determines the amount of time available for work, which allows consumers to produce money earnings, and the amount of time available for leisure, with leisure time being combined with other commodities which in turn produce commodities which directly enter their consumption functions. Malaria is an acute disease which seriously affect human productivity and, therefore, is a cause of economic losses to those who are infected by the disease. It is expected that households in lower socioeconomic groups derive more utility from antimalarial activities, given the higher relative value of their health at subsistence levels.

The assumption that the consumer is a utility maximizer can be represented through indifference curve analysis indicating that the individuals objective is to attain the highest consumption possibility contour, subject to the conditions that he operates on both his budget constraint and his health production function. The individual's utility maximizing behaviour can be analyzed based on Wagstaff (1986b), with regard to the four-quadrant diagram given as Fig.3.2.

Figure 3.2 The Effect of Falling Income on the Household production of health



Source: Wagstaff (1986b)

Quadrant II outlines the health production function which, as is shown, encompasses the law of diminishing marginal product. This function shows how much health can be obtained for a given quantity of health input, given technical knowledge. Quadrant III outlines the budget constraints upon the individual's utility maximizing behaviour.

As neither health inputs nor consumption activities are costless, the consumer, in line with traditional neoclassical economics, must allocate his income between these activities. The slope of the curve reflects the relative costs. The consumer is assumed to have perfect knowledge over these costs.

The budget constraint and health production are both included in the same diagram in Quadrant I. This allows the determination of the combination of consumption and health input activities that the consumer will actually choose. Quadrant I transforms the information given in Quadrant III through the 45^0 line of Quadrant IV. The IC, curve outlines part of the consumer's indifference curve. The concave is the consumption possibility frontier. Equilibrium is given in a.

Figure 3.2 outlines the effect of changing income under the assumption that the consumer has adequate information to allow rational decisions to be made. Assuming a fall in the individual's income, as in Figure 3.2, resulting in a parallel movement towards the origin of the budget constraint, moving round the quadrants, we can follow through the effects on this fall in income. Given the underlying assumptions, a low income means that the number of feasible combinations of health input and consumption activities open to the individual are diminished. Equilibrium at a is no longer possible, the individual's new equilibrium is at b, at which point he has a lower level of health and consumes less. His health stock is reduced because he has less to spend on health inputs. Thus a fall in income is predicted to result in a reduction of the quantity of health inputs employed and a deterioration in the individual's health status and vice versa.

In the case of malaria, households in endemic areas with less income to spend on personal protective methods such as house screening, pyrethrum house spraying and use of mosquito repellents, bed nets and antimosquito fumigants, become easy prey to infective mosquito bites and so may easily contract the disease. Furthermore, households who do not stay near Malaria clinics and therefore have to travel long distances to seek care when sick of malaria incur huge losses in terms of costs of travel and waiting time and therefore may consume less of malaria health inputs for the malaria clinics.

Generally, most health economists consider that an individual has his own initial stock of health and he always compares his expected health status and the perceived one (Grossman, 1970). The expected health status is defined as a desirable health status at any given time influenced by some objective factors such as economic and family status, education, agency relationship at household level, age, past health experience and so on. On the other hand, the perceived health status is defined as actual health status that the individual perceives in terms of signs, symptoms, disturbances, and so on, at any given time.

The health status disequilibrium can occur when the perceived health status is below the expected one. Then if disequilibrium generates a degree of felt need for some action, a decision process is made in order to choose the appropriate action (Berki, 1972).

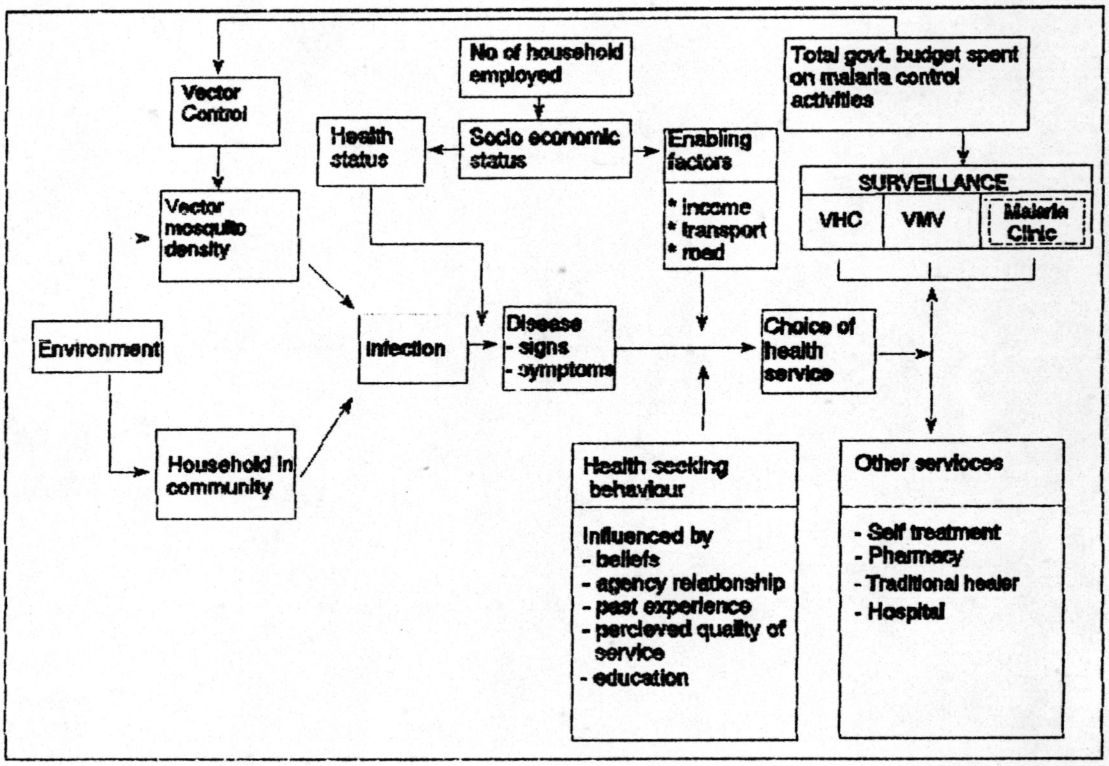
There are four alternatives for each malarious person to take as shown in Figure 3.3:

1. Do nothing, but wait for the disequilibrium to return to the initial condition
2. Self-treatment by using common drugs purchased at nearby pharmacy shops etc.
3. Find some information and advice from informal sources i.e. traditional healers, friends etc.
4. Go to either malaria clinics at the sector offices in the Provinces (in the case of Thailand) or to other medical care

providers such as government hospitals, health posts, health centers, private hospitals and clinics etc.

It is only in the last option that a malaria patient will involve the medical care system. Then his felt need has been translated into the effective demand by the assumption of the existence of some prefer- ences function dictated by knowledge of the disease, income etc.This research study looks at the demand for services as a whole comprising of microscopic diagnosis and drug treatment of positive cases.

Figure 3.3 Factors Influencing Demand for Malaria Services



From the above theoretical considerations, five elements considered to be influencing demand for malaria treatment at the clinic level have been selected for this study. These are

(1) incident rate of malaria
(2)Government budget
(3) household income
(4) travel distance and
(5) Number of blood slides.

1. Incidence Rate:

Incidence rate describes the frequency of illness commencing during a defined period: it refers to the number of new cases or infection occurring per unit of population during a given time interval. Incidence is the most basic measure of frequency and is the best indicator of whether a condition is decreasing, increasing or remaining static.

It is, therefore, the best measure to use in evaluating the effectiveness of health programmes (WHO, 1983). It is the measure used in surveillance system and for analyzing how people are using the health services. The difficulty of distinguishing between a new malaria infection and a recrudescence or relapse has resulted in the conventional acceptance of the term incidence to mean always the frequency of cases of malaria over the period, irrespective of whether the disease resulted from a new infection or not. In this study, the incidence rate is based on recorded admissions or attendances at hospitals and other case detection sources in a district measured as the total number of positive cases in a district divided by the total population in that district i.e.

$$\text{Incidence rate} = \frac{\text{Total annual positive slides} \times 1000}{\text{Total population in the district}}$$

A high incidence rate of malaria in a district is expected to influence, ceteris paribus, a high demand for services at the Malaria clinics in that district.

2. Government Budget:

As stated above, any effective malaria control can only be assured if a regular budget is provided and maintained over the whole duration of the project. In 1992, Malaria Division spent about US$20 million (about 505 million bahts) on Malaria control programmes in Thailand (Malaria Division, Thailand and Country Report, 1993). This huge government expenditure on Malaria clinic services and other control programmes is obviously far beyond the reach of the communities themselves. In Thailand, almost all expenditure on control programmes is covered wholly from the central government budget.

Vector control measures, such as environmental modification and manipulation, space and residual insecticide spraying and others are applied in Thailand to reduce breeding habitats, vector densities and the longevity of vector population and therefore reduce the vectorial capacity of communities. Clinical services which are mainly antiplasmodial contribute to restriction in gametocyte output and hence reduction in transmission.

In fact a sustainable support from the central government is expected to reduce incidence rate of the disease and will in turn cut down the demand for the services at the Malaria clinics.

Because the present study focuses at trends of malaria in different districts at the same zone, using the absolute government expenditure on malaria control programmes can lead to invalid conclusions. The Population size of each district must also be considered before the districts can be compared. Therefore per capita government expenditure on Malaria control activities is used for the government budget variable and calculated as thus:

$$\text{per capita government expenses} = \frac{\text{Total annual government budget spend on Malaria control activities in the district}}{\text{Total population at the district at the end of the year.}}$$

The absence of consumer price indexes for the districts made it impossible to calculate the government expenditure in real terms. Therefore only nominal figures were used.

3. Household Income:

The theoretical derivations above indicate an inverse proportion of household income to the vulnerability of household to malaria parasite infection and disease. The higher income groups are more capable of converting antimalarial inputs into malaria-free health status then those of lower income group.

Given the stress on equity in the definition of health for all and of primary health care, the per capita GPP (Gross Provincial Product) was considered to be inappropriate for use in this study-though GPP data were more easily available than household income - as it does not give a correct picture of household income distribution in the districts. As a matter of fact GPP indicates disparity of productivity rather than that of welfare of household. Therefore, in order to compare the welfare levels of households between provinces (and districts) household income is a better concept than the per capita GPP. (Ikemoto, 1991).

Granted constant for other factors, increasing household income results in increasing application of antimalarial inputs and therefore the more protected the members of the household are from malaria infection and disease.

Also the choice of service outlets (ref. Figure 3.3) depends on the households socio-economic status, health seeking behaviour, availability of service, location of service and enabling factors such as travel distance, time cost, road condition and means of transportation. Ceteris paribus, a fall in a household income will definitely affect her use of Malaria services.

4. Travel Distance:

Travel distances from patients villages and towns to the Malaria clinics play an important role in the utilisation of services in the clinics. Long travel distances involve long travel time and transportation cost which deter most prospective users of the services. For example, the free malaria services might not be an incentive to remote rural area people because of high cost of travelling. On the other hand, when the cost of travelling is reduced in some ways (e.g. new short road, malaria clinic built near the village or town) demand for the services is likely to rise.

5. Number of Slides Examined in the Malaria Clinics:

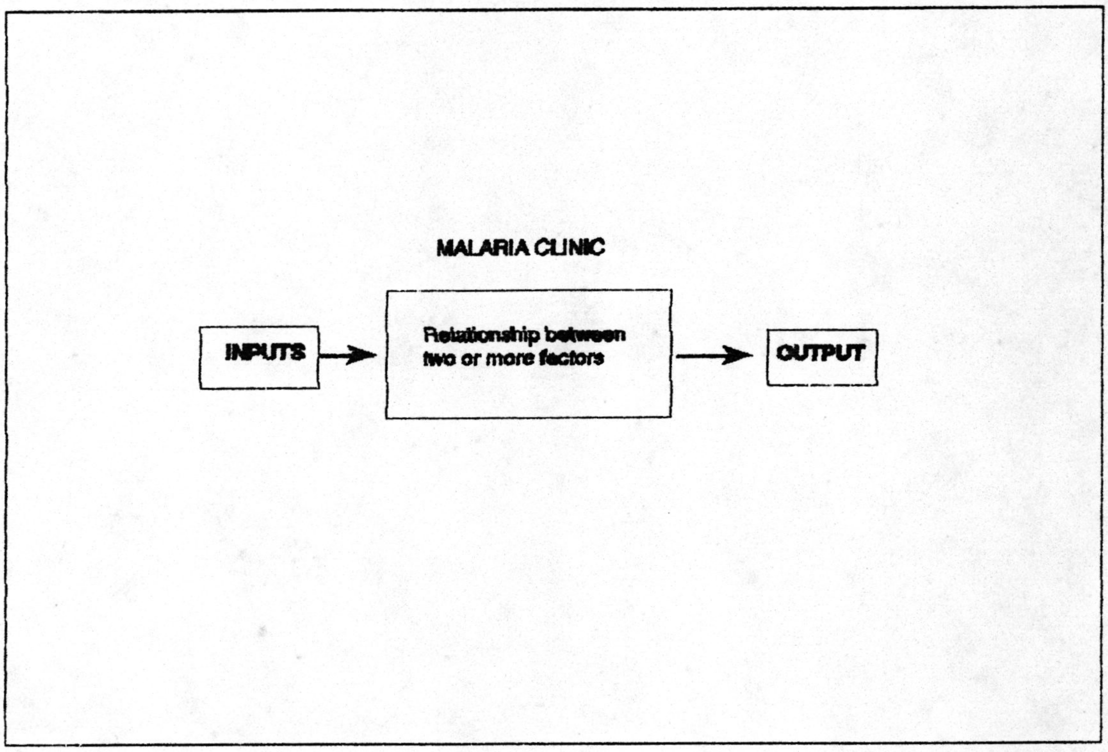
A substantial government expenses go into purchase of drugs and other antimalarial inputs used at the malaria clinics. As part of policy of the services to the public, a judicious use of these drugs is adopted in the Malaria clinics by making sure that only positive cases are diagnosed and effectively treated. Consequently, microscopic blood slide examinations to detect positive cases of malaria are a routine procedure in all the Malaria clinics in Thailand. In fact, microscopic examination of blood is the only certain means of diagnosing malaria infection. Though the presence of malaria parasites in the blood is a sign of infection and not necessarily a cause of disease, it is assumed that persons who visit the Malaria clinics do so because they perceive signs and symptoms associated with the disease. Another assumption is that all the microscopists in the malaria clinics are experienced (as the experience of the microscopists is a very important factor in the measure of demand for the services in this study).

Given a certain level of incidence rate of the disease in a district, it is expected that an increase in the number of slide examined will result in an increase in the number of positive cases detected - an indicator of high demand for the services at the Malaria clinics.

Assuming other factors constant, the demand for the treatment, Q, at the malaria clinics is theoretical derived as being a function of number of slides examined, S, household income, I, travel distance, X, incidence rate, R and per capita government expenses, G and mathematically expressed as

$Q = f(S, I, X, R, G)$ and schematically shown as in Figure 3.4.

Figure 3.4 Explanatory or Causal Relationship in a Malaria Clinic



3.3.1 Other Factors Assumed Constant:

Other factors also influence the demand for the services, some of which are:

1. Location of service such as nearness to a commercial centre, to family house etc.

2. Education i.e. knowledge of the disease will affect agency relationship at the household level and hence whether or not a patient will choose Malaria clinics or other available services.

3. Occupation of household determines the level of income and even the rate of contracting the disease. For example those household members who work at sugar plantations and in the forest are more likely to contract the disease compared to those who are employed as government employees in towns and big cities.

4. Type of plasmodium parasite determines the severity of the disease. Malaria from <u>Plasmodium falciparum</u> is more severe if not treated early enough than that of <u>P. vivax</u> or <u>ovale</u> or <u>malariae.</u>

5. Behaviour of vector determines the feeding and resting habits of vector mosquitos. Those who tend to feed on man and have a long expectation of infective life are likely to transmit the malaria parasite more than those which are more zoophilic and with shorter

infective life.

6. Health care seeking behaviour. This is influenced by many factors including, education of households, past experience at the Malaria clinics, cultural beliefs, type of agency relationship at the household level, household income, perceived quality of services etc. The household health care seeking behaviour will have a strong influence in the choice of health care services shown in Figure 3.2 above.

These and many others are real issues that were taken into consideration in the design of this study. One method used to overcome some of these very strong confounding factors was in the selection of the study area where consumers were assumed to have homogeneous preferences and subject to identical but independent health factors cited above. This approach is discussed in more detail under research methodology, Chapter 4.