CHAPTER 2

LITERATURE REVIEW

Malaria is one tropical communicable disease to which mathematical approach has been applied more widely or thoroughly. The first and most inspired attempt at formulating the quantitative laws of epidemiology of malaria and its transmission and control was made by Ronald Ross at the beginning of this century, (Bruce-Chwatt, 1985). He developed in what is now termed as Ross's Threshold Theorem for malaria. This theorem describes the endemic or steady state of malaria incidence in a community by the following relationship:

$$Pmiabsf(i-n) = rmp$$

Where

P	=	population of the area
m	=	proportion of population infected
i	=	proportion of infected individuals who are infectious
a	=	number of mosquitos per person per month
b	=	proportion of uninfected mosquitos which feed on humans
s	=	proportion of mosquitos which survive through the extrinsic incubation period
f	=	proportion of infectious mosquitos which feed on humans
r	=	recovery rate of infected individuals per month
n	=	the period of development of sporozoite

A number of other studies followed, but the interest in this subject died down until the 1950s, when Moshkowsky in the USSR and George MacDonald in Britain revived it in a series of remarkable investigations.

Macdonald (1957) for example formulated a model based on data obtained from East Africa in which he discussed the role of immunity as a regulating mechanism of transmission. His theory of control, aiming at the reduction of the basic reproduction rate below 1, is relevant to the interruption of transmission, as the first step of eradication. An expanded model which indicates the relationship of a number of endemic levels in relation to the whole range of 'vectorial capacity' involved in transmitting P. falciparum was developed as a result of the Garki Project in northern Nigeria, carried out in 1973-80 with the support of the WHO.

The model's main output variable was the prevalence of P. falciparum parasitaemia as a function of season, and of the age group of the population. It was fitted to the data obtained after 1 year of baseline observation in the field and after 2 years of insecticidal

spraying with propoxur; other data obtained in East Africa were also used. The model can be used to indicate the relationship between the prevalence of P. falciparum and vectorial capacity, when the latter undergoes natural or man-made changes.

It confirmed that the daily rate of the survival of the vector is the most crucial component of vectorial capacity.

The presence and degree of both the endemic and epidemic malaria depend on a number of factors which can be divided into three groups namely, man, malaria parasite and the mosquito vector. Russel (1957) showed a simple qualitative interdependence between the various elements of malaria transmission and he expressed it in a formula:

(X,Y,Z) pibect

in which X is the human carrier of the plasmodium Y, the Anopheles vector, Z the human recipient of the infection. The single letters of the acronym 'pibect' refer to P-the plasmodium, i-immunity, b-bionomics (habits-of both the man and of the mosquito), e-the environment, c-control of malaria in the locality, t-treatment.

In fact, the epidemiological and biological aspects of malaria have been well analyzed from the theoretical and methodological points of view (Yetukiel, 1965 and Molineaux, 1980).

However, little empirical work has been done on the factors influencing demand for malaria treatment and prevention despite the extreme usefulness of the results of such studies to decision makers (Mills, 1992). Most studies on demand for health care consumption have concentrated on medical care in general without taking cognizance of the role of individual diseases in influencing the utilization of services in our health institutions.

A review of some empirical studies of demand for hospital services will be presented to illustrate some efforts made to explain demand for services in the health institutions in developed countries. Studies on the demand usually emphasized price and income elasticities measurement because they are useful in predicting the future rate of utilization.

Rosenthal (1970) estimating the demand for hospital services, examined the effect of two alternative price variables on the length of stay of inpatients in hospitals. The analysis was based on the results of an investigation of admissions in the year 1962 to New England hospitals. Data were drawn from a sample of medical records and financial information from 68 individual institutions. The sample was divided into 28 cells defined by age, sex and diagnosis.

The model consisted of two equations as shown:

$$Y = aX_1b \quad (2.1)$$

$$Y = aX_2c \quad (2.2)$$

Where

Y = length of stay
X_1 = cash payment as percentage of total bill
X_2 = average room charge
b = elasticity of length of stay with respect to cash payment
c = elasticity of length of stay with respect to average room charge.

Log-linear regressions were made. Separating all services into twenty categories of medical care and eight surgical categories, Rosenthal found that the price elasticities of demand for hospital services, as defined by both coefficients b and c above, ranged from the positive value, most of which are significant, to -0.7 in some cases. The cash payment variable had a negative-signed coefficient that was significant at 5 per cent level in only 3 of the 28 groups. Average room charge variable was better because it had negative-signed coefficient that was significant at the 5 percent level in 11 of the 28 groups. Therefore, average room charge variable generally explained more of the variations in length of stay than did the cash payment variable.

For the surgical categories, the price elasticities ranged from -0.12 to -0.97, some of which were considerably higher (in absolute term) when post operative length of stay was used as the dependent variable. He claimed that the patients with more serious conditions, for which he did not give an explicit definition but took some medical categories such as arteriosclerotic and degenerative heart diseases for examples, were found to be less sensitive to price variables.

Rosenthal also analyzed the demand for hospital services at a macro level. Differently from the previous studies, he used 12 independent and 3 dependent variables to form 3 equations in his model in order to meet his two following objectives:-

1. To demonstrate causal relationship and to obtain forecasts.
2. To design a formula for allocation of hospital facilities in accordance with expected demand.

The model was expressed in form of the following equations:-

$$Y_1i = a+b_1X_1i + b_1X_1i + b_2X_2i + \ldots\ldots b_{12}X_{12}1 \quad (2.3)$$

$$Y_2i = a+b_1X_1i + b_1X_1i + b_2X_2i + \ldots\ldots b_{12}X_{12}1 \quad (2.4)$$

$$Y_3i = a+b_1X_1i + b_1X_1i + b_2X_2i + \ldots\ldots b_{12}X_{12}1 \quad (2.5)$$

Where

Y_1 = the number of admissions per 1,000 population
Y_2 = average length of stay per admission
Y_3 = patient days

X_1 = the mean of the most frequent charges for a two-bed room
X_2 = the percentage of population utilizing insurance
X_3 = the proportion of families and unrelated individual with annual income over $5,999
X_4 = the proportion of families and unrelated individual with annual income under $2,000
X_5 = the proportion of population over 65
X_6 = the proportion of population under 15
X_7 = the proportion of females aged 14 and over who were married
X_8 = the proportion of population aged 14 and over that was male
X_9 = the proportion of population residing in urban areas.
X_{10} = the proportion of population who was nonwhite
X_{11} = the proportion of population over 25 with 1 or more years of school.
X_{12} = the population per dwelling unit

a and b_1 to b_{12} = 9 constant term and parameters of the demand relationship.
e = some error term
i = the state i.

The data was obtained for the years 1950 and 1960 in the United States, with each of the individual states representing a single unit of observation. All of the equations were estimated by a linear multiple regression.

The findings showed that both years the multiple correlation coefficients (R^2) for the length of stay equations were higher than that for the admission ones. When comparing these two years, he found that the power of explanation (R^2) in 1960 were greater than those in 1950.

Among the independent variables, those found to have a significant effect with the correct sign are the proportion of males, marital status, non-white, price and insurance variables. The estimated price elasticities ranged from -.015 to -0.49 in 1950, and -0.22 to -0.65 in 1960.

When the total observations for both years were pooled and a new aggregate equation was estimated, with all variables as before plus the time variable as another independent variable, the time factor coefficient had a negative sign, indicating that for any given set of characteristics, there would have been less utilization in 1960 than in 1950. Or it might be inferred that there was a downward shift in this

demand relationship during the decade.

The results are summarized as follows. The price (room charge) varied inversely with the demand for inpatient services and the price elasticity was less than one in absolute value. The hospital insurance variable did encourage a patient with the welfare to obtain more of the inpatient services. Men received more inpatient services than women did while the married utilized the services less than the married. A positive sign of nonwhite suggested that the nonwhite population obtained less of the hospital services owing to the different incidence of illness.

Russel, (1975) attempted to explain the interstate variation of the demand for hospital admissions in short-term hospital under medicare. The study was based on state data for three calendar years; 1967-1969.

The model can be specified in the following function:-

ADM rate = f(Age, Sex, South, Rural Density, income, Fees, Beds, % Non teaching, ECF use, Home Health , Outpatient, Doctors) (2.6)

Where

ADM rate	=	short-term hospital admission per 100 enrollees in Medicare
Age	=	percentage of enrollees 75 years or older
Sex	=	percentage of enrollees who were female
Race	=	percentage of enrollees who were white.
South	=	1 for southern state, 0 otherwise
Rural Density	=	rural residents per square mile
Income	=	State per capita income
Fees	=	physicians' fee
Beds	=	short-term hospital beds per 10,000 population
% Nonteaching	=	percentage of short-term hospitals with no physician training programs
ECF use	=	extended-care facility use per 100 short-term hospital admissions
Home Health	=	home health care use per 100 short-term hospital admissions.
Outpatient	=	outpatient claims per 100 short-term hospital admissions.
Doctors	=	private physicians per 10,000 populations

All equations were estimated in linear and double log regression forms; the results of both were similar and only the results of linear form were reported. A state was a unit of observation. There were 48 observations, excluding Alaska, Hawaii, and the District of Columbia.

The results, in general, showed that the variables could largely explain the model. The adjusted R^2s were quite high about 0.80. The Durbin-Watson statistics indicated no regional bias in the

regression. The states with relatively more Medicare enrollees over 75 had significantly higher admission rate and those with a higher proportion of female enrollees was associated with a lower admission rate and those with a higher proportion of female enrollees was associated with a lower admission rate.

The availability of beds had a significant positive effect. Rural density variable gave a significant negative coefficient, indicating that physicians were apparently more likely, for reasons of safety and convenience, to hospitalize their patients who stayed far from the hospitals. Finally, outpatient variable did reduce admission rate as in the previous findings.

The summarize, the increase in age or availability of bed variables led to admissions of patient to the inpatient department. On the other hand, women, urban patients, and outpatients demand less of the inpatient services.

Davis and Russell (1972) looking at both the inpatient and out patient demand, investigated the properties of the demand for hospital outpatient care and its substitution effect. The model can be written as the following function.

$$OV = f(P_{ov}\ P_{inp}\ Y,\ Ins,\ Occ,\ Phy,\ Spec,\ Fee,\ Age,\ Mig) \qquad (2.7)$$

Where

OV = outpatient visits per adjusted population
P_{ov} = Price of an outpatient visit
P_{inp} = Price of inpatient hospital care
Y = Income per capita
Ins = extent of insurance coverage per capita
Occ = hospital occupancy rate
Phy = non-hospital primary health care physician per capita
Spec = ratio of specialist physicians unit
Fee = average charge for physician unit
Age = percentage of population under age 65
Mig = in-migration rate

The analysis on outpatient visits in the non-government, non-profit hospitals was for 48 states of the United States in 1969. All the equation were estimated in linear and log-linear regression forms. Both gave similar results, but only log-linear results were presented. They found that reducing the price of an outpatient visit increased demand significantly. The positive coefficient for inpatient price showed a substitution relation between inpatient and outpatient care. The insurance variable showed that Blue Cross had a significant positive influence on the demand for outpatient visits. This is because the insurance effect induces greater consumption of hospital services by reducing outpatient service expenditures to the consumer.

The hospital occupancy rate coefficient was significant and positive as expected. When hospital inpatient facilities were crowded, physicians switched more patients into outpatient care. The supply of primary care physicians in non-hospital practice was a significant positive influence on outpatient visits. This suggested that doctors served as a complement to outpatient services.

They further found out the effect of a change in the price of hospital outpatient services on the demand for inpatient services by constructing two equations as follows:

$$ADMf = f(P_{inp}\ P_{ov},\ Y,\ lns,\ Occ,\ Phy,\ Spec,\ Fee,\ Age) \quad (2.8)$$
$$MS = f(P_{inp}, P_{ov},\ Y,\ lns,\ Occ,\ Phy,\ Spec,\ Fee,\ Age) \quad (2.9)$$

Where

ADM = admission per adjusted population
MS = mean length of day

The other variables are defined as for (2.7) above

The outpatient price variable was significant at 1% level of confidence with an elasticity of 0.25. The cross elasticity of demand for outpatient care with respect to inpatient price increase was 4 times as high as the cross elasticity of demand for inpatient care with respect to outpatient price increase. They explained that this was to be expected since the cost of an admission was substantially higher than the cost of an outpatient visits.

The room charge (inpatient price) elasticity was -0.46. Insurance variable had a significant positive sign, indicating that an increase in insurance coverage led to an increase in hospital admissions. The occupancy rate coefficient was positive and was significant as in the previous equation.

Both primary care physician and the specialist-physician ratio variables had significant positive coefficients, showing that physician services acted as a complement to inpatient hospital care. The physician fee variable had a significant negative coefficient. The age variable indicated significantly that the elderly had more admission, other things being equal, than those under age 65. Unexpectedly, income variable had a significant negative sign, revealing that lower income groups were unhealthier and required more frequent admissions.

In brief, for all significant variables, the outpatient service price had a negative relationship with the outpatient services but a positive relationship with the inpatient services. Thus, it proved that outpatient and inpatient services were substitutes. Similarly, the inpatient service price was negatively associated with the inpatient services but positively associated with the outpatient services. Again, a positive insurance coefficient confirmed that the insurance led a patient to demand more of the hospital service. Moreover, hospital occupancy rate, the proportion of physicians per

capita and the proportion of specialists to all physicians had the same significantly positive relationship with both inpatient and outpatient services; indicating that if each variable increased then the demand for hospital services would arise.

It can be seen from the studies above that there are certain set of factors which showed similar outcomes, that they significantly affect the demand for hospital services. These factors include price, age, sex, urbanization and region. Moreover, the hospital insurance such as Medicare and Medicaid, a redistribution of health resources program among the population, also change the utilization of hospital services pattern.

Though the above empirical studies all concentrate on demand for medical services in developed countries, -- and few economist have focused on demand for medical services in developing countries — the general conceptual issues are very similar.

In Thailand, the free services provided to consumers at the malaria clinics are analogous to the hospital insurance such as Medicare and Medicaid in USA but with regards to sex and age, these factors are not important in the case of malaria infection, though children have generally a higher degree of susceptibility than adults (Bruce-chwatt, 1985, p.167).

Economic demand models of health care consumption may be appealing for their policy relevance and their broad theoretical foundation. But they ignore many of the unique characteristics of the health sector. Demand analysis treats health service consumption as one component of total consumption, relating the decision to use services to all other consumption decisions. This leads to the emphasis on price and income, since these factors affect consumption in general. In contrast, other social sciences studies such as one conducted by Anderson (1968) shows that the need variables (including illness and the response to it) are by far the most significant determinants of service use and that, in general, predisposing variables are more significant than enabling ones. That is, health beliefs and practices, and demographic and social factors appear to be more important than the traditional economic variables. Anderson notes, however, that these factors are often associated with economic variables at the household level. These results suggest that expanding utilization models beyond the traditional economic framework improves the explanatory power of empirical analysis.

Consequently, the present research study incorporates a number of other variables including epidemiological, enabling and demographic factors in order to attempt to explain demand for services at Malaria clinics instead of at hospitals as shown in the above review empirical studies. The Thai situation is quite unique making it very appropriate for demand analysis on a specific disease in a developing country setting.