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**AN INVESTIGATION OF THE RELATIONSHIP  
BETWEEN DEPTH TO GROUNDWATER  
AND MALARIA PREVALENCE,  
PUNJAB, PAKISTAN**

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## **Executive Summary**

THE AIM OF the study was to assess the accuracy of routinely gathered health center statistics and depth to groundwater maps and thereby determine their suitability for investigating the linkages between depth to groundwater and malaria. The study was conducted using a combination of questionnaires, key informant interviews, and visits to relevant institutions.

The study was conducted in the district of Bahawal Nagar, Punjab, Pakistan between October and December 1995 and it revealed that less than 10 percent of the actual cases are recorded in government malaria statistics due to low attendance at government health facilities. This low attendance is likely to be attributable to poor medical supplies and staffing of government institutions. Private facilities are the preferred institutions for treatment of malaria with 63 percent of the population seeking treatment exclusively at these facilities.

Since data relating to malaria were deemed too poor to support any further analysis, Pyrexias of Unknown Origin (PUO) were used as an indicator of malaria. The linkages between PUO, depth to groundwater, and percentage land under rice production were investigated. No significant correlation was found between the independent variables and the dependent variable.

It was concluded that data gathered at health facilities are too unrepresentative to support meaningful analysis. Any future studies in this area that seek to investigate the linkages between irrigated agriculture and health should be based upon primary data collection.

It is recommended that the association between land use and adult mosquito biting density is determined in the next phase of the study.

## Introduction

### MALARIA AND AGRICULTURE

IT HAS LONG been known that the social and environmental changes brought about by water resource development may adversely affect the health of local communities. Since its inception in 1948, the World Health Organization (WHO) has consistently warned of the dangers of increasing or introducing vector-borne diseases as a consequence of irrigation development (WHO 1959). Economic considerations have often taken precedence over concerns for public health and environmental impact.

As irrigation systems dramatically alter the ecology of an area, there exists the potential for an increase in breeding of mosquito vectors. However, it is necessary to establish the degree to which irrigation may actually be responsible for an increase in vector-borne disease. The influence of irrigation upon some vector-borne diseases is relatively well established. The associations between schistosomiasis, a snail-borne disease, and irrigation infrastructure have been well elucidated in Africa (Hunter et al. 1993; Tameim et al. 1985). Moreover, there are substantial links between Japanese Encephalitis, a mosquito transmitted disease, and rice field irrigation in Southeast Asia and Sri Lanka (Sanmuganathan and Amerasinghe 1991).

Studies which seek to examine the relationship between malaria and irrigation have revealed a complex picture. There are numerous examples of malaria endemicity increasing after irrigation development in a region. However, in some locations transmission has been demonstrated to be lower in irrigated areas than in contiguous, nonirrigated, savannah areas (Service 1989).

This variation prevents broad generalizations and necessitates the individual assessment of irrigation systems. Irrigation generally increases the amount of standing surface water but this does not automatically increase vector mosquito abundance. Variations in vector species, breeding habitat and availability of breeding sites, unrelated to the irrigation system, may all alter the influence of the irrigation system on vector density. Assessing the role irrigation plays in disease occurrence should be essential prior to the implementation of any management-based control strategy.

A classic example of how agricultural development can affect the prevalence of a disease can be taken from the Gezira area of Sudan. Before the construction of the Sennar Dam and the associated irrigation development, malaria was of minor importance. However, the development resulted in a proliferation of breeding sites for the vector, *Anopheles arabiensis*, and an epidemic of malaria occurred in 1950. This epidemic resulted in hundreds of deaths and one-third of the crops remaining unharvested (Rathor 1987).

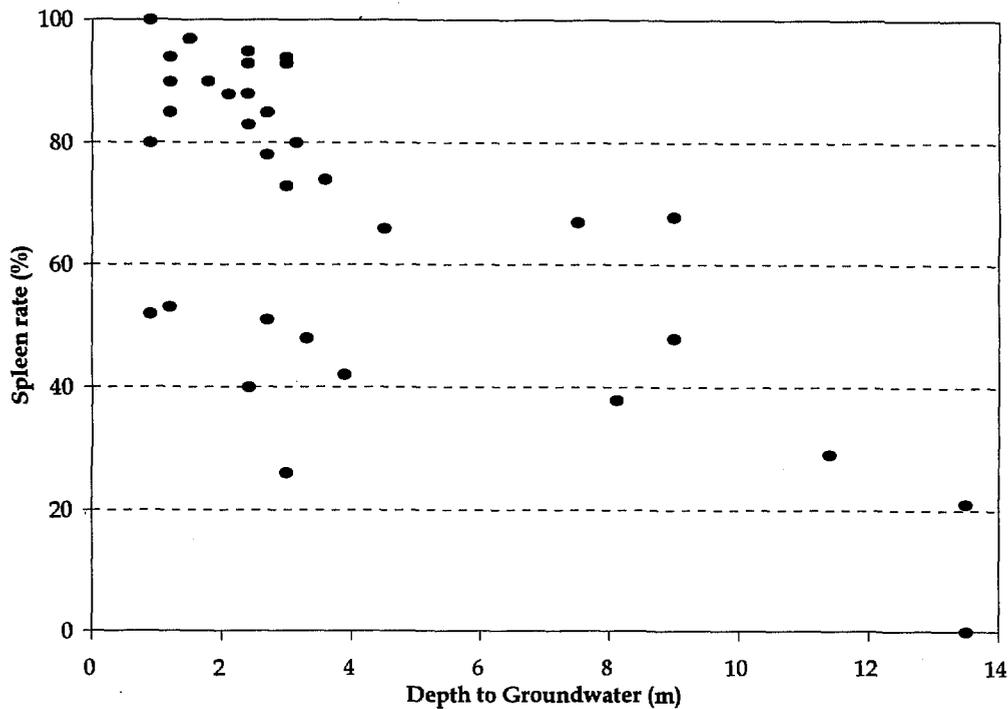
### GROUNDWATER AND MALARIA

Malaria is transmitted by mosquitoes of the genus *Anopheles* which characteristically breed in temporary bodies of standing water. It has been hypothesized, but remains unproven, that groundwater that is close to the surface may result in a larger area of surface water

which may increase mosquito abundance and thereby increase the prevalence of malaria. Two historical examples illustrate this theory. In these examples distended spleen is used as an indicator of morbidity. The percentage of children under 10 with a distended spleen is often used as an indicator of malaria endemicity.

Christophers (1911) used a transect study to demonstrate a relationship between depth to groundwater and morbidity in the Punjab (figure 1). In Bengal, Iyengar (1942) demonstrated an inverse correlation between depth to groundwater and percentage splenomegaly (figure 2).

Figure 1. Relationship between spleen rate and depth to groundwater in the Punjab.

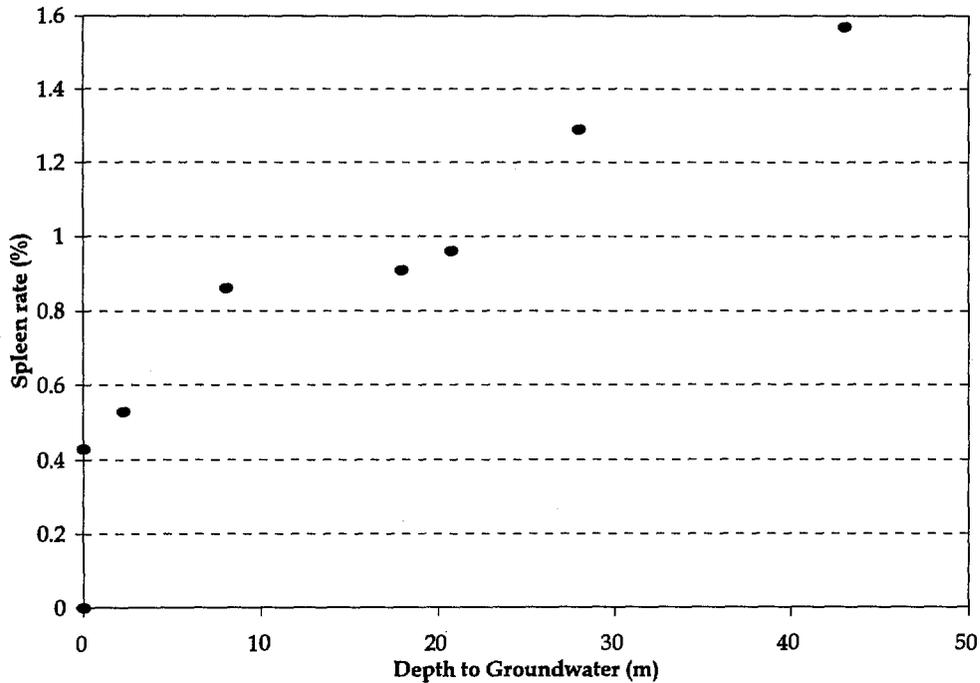


Source: Christophers. 1911. Malaria in the Punjab.

These radically different results were thought to be attributable to the differences in ecology of the two malaria vectors. In the Punjab *An. culicifacies* was the primary vector whilst in Bengal the primary vector was thought to be *An. philippinensis*. A small depth to groundwater in the Punjab was thought to result in an increase in standing water and therefore in breeding sites. The situation in Bengal was different. In this case, a small depth to groundwater may result in a reduction in the dissolved oxygen content of the water in the breeding sites. This, in turn, inhibited the growth of the nonfilamentous algae on which the mosquito larvae feed and thereby reduce mosquito numbers (Iyengar 1942; Birley 1993).

The correlation developed using Christophers' (1911) data is heavily reliant upon four outlying points. Christophers also comments upon the existence of considerable malaria infection when subsoil water is as low as 40 feet, indicating that there are many other confounding factors.

Figure 2. Relationship between spleen rate and depth to groundwater in Bengal.



Source: Iyengar. 1942. Studies on malaria in the Deltaic area of Bengal.

If a positive correlation between depth to groundwater and incidence of malaria does exist, strategies designed to lower the water table could also reduce the incidence of malaria. Late in the 1950s, Water and Power Development Authority (WAPDA) initiated a series of Salinity Control and Reclamation Projects (SCARPs) in the Punjab. These primarily comprised large numbers of high-capacity tube wells which pumped groundwater to prevent and reduce waterlogging and salinization. The water extracted is either used for irrigation or discarded, depending upon its salinity. These projects, together with the large numbers of privately operated tube wells, affect depth to groundwater and so may provide a reliable means to control malaria vectors. Since the tube wells are already *in situ* it may be possible to "passively" control malaria and the vectors with little additional expenditure.

## OBJECTIVES

The objectives of the study were:

- to assess the accuracy of both routinely gathered health center statistics and depth to groundwater maps, and to determine their suitability for analysis, within a given study area.

- to discuss possible methodologies for analyzing health center data, with a broader reference to future health related projects
- to investigate the link between depth to groundwater and malaria endemicity in the Punjab

**Premise.** It is thought that with a decreasing depth to groundwater there will be a concomitant decrease in the ability of soils to drain leading to an increase in surface standing water. This increase in surface water may lead to an increase in malaria vector density and to increased transmission of malaria.

The null hypothesis ( $H_0$ ) that follows from this premise is that *a change in depth to groundwater will have no effect on the prevalence of malaria.*

The alternative hypothesis ( $H_1$ ) is that *a decrease in depth to groundwater will result in an increase in the prevalence of malaria.*

## **Malaria and Malaria Control in Pakistan**

### **MALARIA IN PAKISTAN**

MALARIA IN PAKISTAN was formerly seasonal with a tendency for epidemics to break out over large areas, especially in the Sind and Punjab provinces. Early and prolonged monsoons resulted in extensive transmission of *Plasmodium falciparum* and *Plasmodium vivax*, the two forms of malaria present in Pakistan.

In the Punjab, epidemics were thought to occur in approximately eight-year cycles (Yacob and Swaroop 1944; Yacob and Swaroop 1946a). Christophers (1911) was the first to record this periodic behavior and he noted an association between high rainfall and high incidence of malaria. However, he also noted that whilst epidemics occur in years with above average rainfall not all such years have malaria epidemics.

Yacob and Swaroop (1944, 1946a and 1946b) attempted to demonstrate that there was a close association between rainfall levels and the occurrence of epidemics. However, there is neither evidence of periodicity in the rainfall data nor a theoretical underlying mechanism that could explain the periodicity. Birley (1990) cast doubt on the correlation between rainfall and epidemics and further stated that the cyclical pattern of epidemics may be explained by an intrinsic factor that favored a stable cycle.

### **MALARIA IN THE PUNJAB**

Historically, the Punjab was regarded as one of the most malarious regions in the Indian Subcontinent (Christophers 1911). During the epidemics of the late 19th and early 20th centuries both rural and urban areas were severely affected. In Amritsar, in present-day India, 1/16 of the population of 160,000 died during the epidemic of 1908. During October and November of that year, when the epidemic was at its highest, there were over 307,316 deaths in the area formerly referred to as the Punjab. These epidemics were said to have devastated trade resulting in food shortages.

The situation in the present-day Punjab is much improved. The cycle of wide-scale epidemics has apparently been suppressed and malaria has taken a lower public-health significance. However, there remains considerable variation in the epidemiology of malaria, and consequently its importance, in the various districts of the Punjab. In some areas malaria is endemic and stable, although seasonally transmitted (Strickland et al. 1987) whilst in others there is an apparent tendency for epidemic years to be interspersed with years of low transmission. The areas where malaria transmission is apparently stable tend to be characterized by proximity to permanent water bodies which, potentially, provide an increased number of anopheline breeding sites. The scale of the irrigation systems within the Punjab would suggest that permanent water bodies are a common occurrence.

Epidemic malaria is largely confined to the low-lying alluvial plain of the Punjab between the 508 mm (20") and 254 mm (10") annual rainfall isohyets. Above the 508 mm isohyet, in the North-West Frontier Province (NWFP) and North Punjab, transmission is mainly stable and endemic. Below the 254 mm isohyet, in the south of Punjab and Sind

Province, malaria transmission is thought to be mainly a result of vectors breeding in water associated with irrigation (de Zulueta, Mujtaba, and Shah 1980).

The study area of the district of Bahawal Nagar is almost entirely below the 254 mm rainfall isohyet. The area includes a section of the Cholistan Desert and in this area malaria is thought to be much reduced (Birley 1990).

## **MALARIA CONTROL IN PAKISTAN**

Prior to the marketing of cheap and effective insecticides late in the 1940s, malaria control in Pakistan was based primarily on environmental measures. There was limited treatment of larval habitats using petroleum-based surfactants. The oils were applied to the surface of a water body and any larvae or pupae in the water would be killed by a combination of suffocation and poisoning. Environmental measures, aimed at source reduction, involved flood control and increased drainage. It is more likely that these methods were primarily intended to increase or protect agricultural production and the possible reduction in malaria transmission can be regarded as a fortuitous but incidental effect.

At the end of the Second World War the advent of DDT and chloroquine made the eradication of malaria a seemingly obtainable goal. To achieve the global eradication of malaria WHO instigated large-scale projects which aimed to utilize these two methods.

In 1961, a UNICEF and USAID-supported project was launched in Pakistan, with the aim of malaria eradication. The campaign is alleged to have reduced malaria levels from 7 million cases in 1961 to 9,500 cases in 1967. Insecticide resistance combined with financial and administrative difficulties led to a resurgence of malaria culminating in an estimated 10 million cases in 1972.

In 1975, a five-year Malaria Control Program (MCP) was launched by the Government of Pakistan and a country-wide target API of 0.5 cases/1,000 population was set. The main tool of the control program was large-scale residual insecticide spraying. Resistance to BHC, the insecticide used in the program, developed rapidly and necessitated its replacement in 1976. Malathion was the insecticide chosen to replace BHC and initially there were numerous cases of insecticide poisoning amongst spray teams. The implementation of more stringent training procedures and regulation remedied this situation (De Zulueta, Mujtaba, and Shah 1980).

The end of this US-funded control campaign, which ran until 1980, resulted in a reduction in the supply of malathion. Targets for house spraying were set at 20 percent of the households but control units only had sufficient funds to spray approximately 6 percent of the households. Malathion spraying was then restricted to certain foci of the disease and this is thought to have resulted in an increase in compliance. This policy has also resulted in a reduction in the quantities of insecticide used (4,000 metric tonnes in 1983 to 1,200 metric tonnes in 1993).

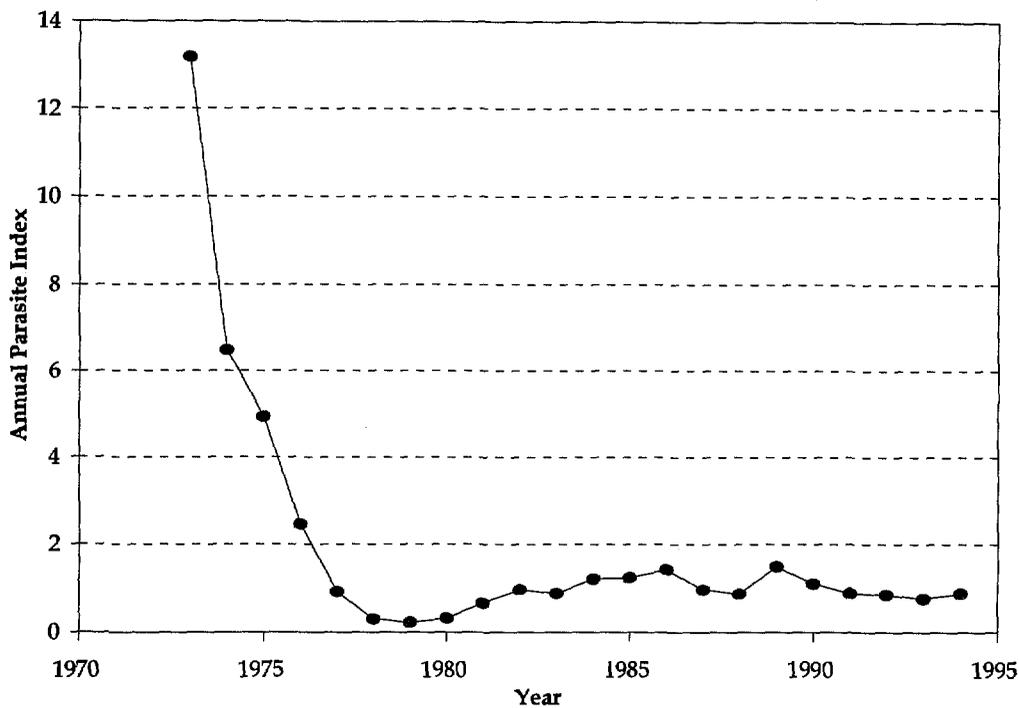
Compliance with house-spraying is thought to be in the region of 70-80 percent (Birley 1990). As is the case in other control programs, wealthy people may refuse spraying altogether whilst in poorer households walls may be washed immediately after spraying. The likelihood of compliance may also be affected by the householders' perception of the effectiveness of treatment against other nuisance arthropods such as bedbugs. In general,

bedbugs are more prevalent in the damper hill areas than on the plains and this may affect rates of compliance.

In the Punjab, deltamethrin, supplied by Rhone-Poulenc, has largely succeeded malathion as the insecticide of choice for residual spraying. It is estimated that approximately Rs 120 million was spent on insecticides in 1994 (Mahmood, *personal communication*).

Since 1980, official figures show that the malaria API has remained fairly constant at around 1 case per 1,000 (figure 3). WHO estimates the API as closer to 2/1,000 (Beljaev 1995). Such figures, which estimate number of cases for the entire population, are misleading. Only approximately 55 percent of the population of Pakistan live in malarious areas and variations in transmission within these areas can be extreme. Rowland (1995) demonstrated an API of 600/1,000 in Afghan refugee camps in the NWFP. This would suggest that in some areas, malaria is of far higher public health significance than official statistics would tend to indicate.

Figure 3. Variation in Annual Parasite Index (API) in Pakistan from 1975 to 1994.



Source: Mahmood and Nadeem, 1995.

### Treatment of Malaria

In addition to the vector evolving resistance to the insecticides, the parasite has evolved resistance to certain of the drug treatments. Parasite resistance to chemotherapeutics is almost exclusively confined to *P.falciparum* parasites and may in part explain the

increasing proportion of *P.falciparum* infections with respect to *P.vivax* infections (Fox and Strickland 1989). Parasite resistance to the drug of choice, chloroquine, was first recorded in 1983 (Fox et al. 1985). Resistance (RI) is now widely spread and there is evidence of RII resistance in some districts. In these districts a combination of sulfadoxine and pyrimethamine (Fansidar) is the recommended treatment.

Amodiaquine, which was formerly used to treat chloroquine resistant parasites, is now regarded as ineffective (Strickland et al. 1987; De Zulueta 1989). Fansidar is still regarded as an effective therapeutic (Strickland et al. 1987) but there is evidence that parasite resistance may be starting to develop. De Zulueta (1989) records the occurrence of a Fansidar-resistant infection in a patient from an Afghan refugee center whilst Edrissian et al. (1993) shows a possible Fansidar resistance in an Iranian patient probably infected whilst in Pakistan. Further studies are required to determine the wider significance of these findings.

However, chloroquine is still the antimalarial remedy routinely prescribed by government facilities. It is cheap and is still effective against *P.vivax* parasites and may partially suppress *P.falciparum* infections.

## **HEALTH SERVICE INFRASTRUCTURE**

### **Primary Components**

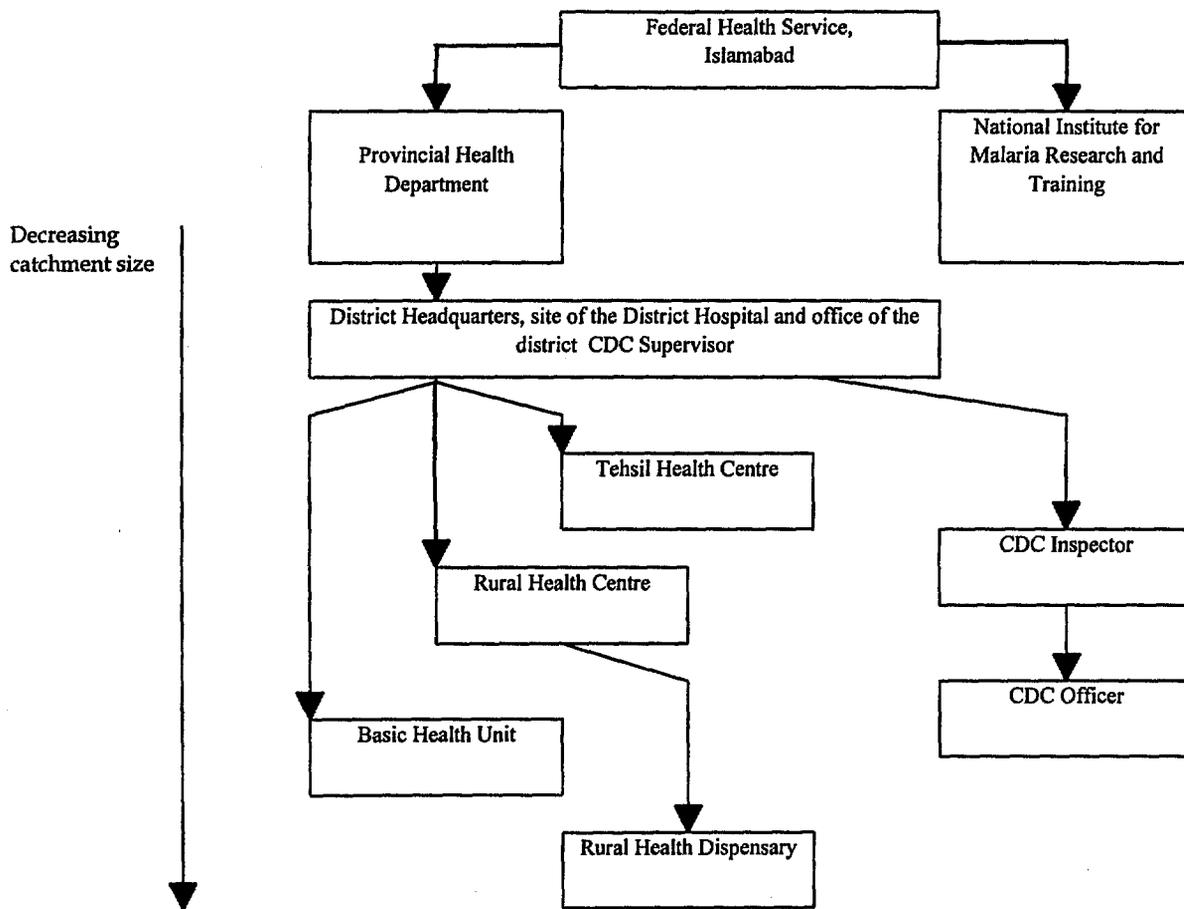
Health service administration in Pakistan is devolved from a central federal center, in Islamabad, to provincial centers in each of the four provinces. The administrative center for the Punjab is situated in Lahore. Throughout the Punjab, the provincial directorate supervises 29 districts, in charge of each of which is a District Health Officer (DHO).

The single district hospital is situated, along with the district's administrative staff, in the district's main city or town. This facility will provide in-patient-care for around 180 people and is commonly the major referral hospital for the area (figure 4).

The administrative level below the district hospital is the tehsil health center. There are approximately five tehsil hospitals in a district, usually sited in the major towns of the area. Each of these hospitals is usually staffed by five doctors offering in-patient-care for approximately 40 people. The hospital is often equipped with a diagnostic laboratory and x-ray facilities.

Within the area covered administratively by a tehsil hospital, there are usually four smaller facilities termed Rural Health Centres (RHCs). These centers serve a community of around 50,000 people and are generally staffed by two doctors. In-patient-care is provided for, on average, ten people. The members of the staff at the RHCs also administer approximately four Rural Health Dispensaries (RHDs). These RHDs are situated in villages and each is staffed by a dispenser who is provided with a limited number of treatments for common complaints.

Figure 4. Schematic diagram of the infrastructure of the Pakistani Health Service.



Note: CDC = Communicable Disease Control.

Also at the village level are a number of Basic Health Units (BHU). A single BHU serves approximately 5 villages or around 15,000 people. Provincial policy is for each of them to be staffed by nine personnel including a doctor, a medical technician, a lady health visitor and a dispenser. The treatment offered is exclusively on an out-patient level although each unit officially offers in-patient-care for two persons. These facilities are administered from the District Headquarters and are therefore distinct from the Rural Health Dispensaries.

### **Communicable Disease Control Officers**

In parallel to this organization, there exists a network of peripatetic health-care providers, termed Communicable Disease Control (CDC) officers. They are charged with the responsibility for around four villages which they are meant to visit, on at least a monthly basis. They check for five notifiable diseases, polio, measles, whooping cough, tetanus, and diphtheria in children below five years of age. In addition, they presumptively administer chloroquine to any febrile patient. At the same time the CDC officer is instructed to take a blood slide for parasite examination. This blood slide is then sent to the district laboratory or to one of the disseminated laboratories distributed throughout the district. Microscopists at these laboratories then examine the slide and if malaria parasites are detected instructions and chemotherapeutics are dispatched to the CDC officer. In reality, the time lag from taking the blood film to the microscopist examination of the slide may be as much as 2-3 weeks. The patient is therefore likely to have recovered or succumbed to the infection before the second course of drugs is given.

The network of CDC officers is administered from the district health center by a CDC supervisor through a hierarchy of CDC inspectors.

### **Health Center Data**

Health center records for the district are compiled at the district health center in Bahawal Nagar. Records of disease occurrence are compiled yearly for each basic health unit and only the number of cases of a disease are recorded at each health unit while no information on the identity or the location of the patient is recorded. Records kept at the individual centers do detail the patient's age, sex and treatment but not the location of the patient's home. These data are not transcribed into the yearly records, where only a disease frequency is given for 103 conditions. At the BHU level the vast majority of cases are assigned to diseases of the respiratory tract, diarrhoeal, dysenteric, and other enteric infections or pyrexias (fevers) of unknown origin.

Records of malaria cases are kept in a separate ledger, termed a G30, and in a more detailed manner. The cases recorded are only those that have been confirmed as malarial by microscopic examination of a thick blood film. The name, village, and household of every patient with malaria are recorded. These records are collated monthly and are used as the basis for control programs. Insecticide spray teams are dispatched to areas where there is an apparent focus of disease revealed by a large number of cases.

## STUDY AREA

The study area was the district of Bahawal Nagar in the south of the Punjab, approximately 192 km southwest of Lahore. This district, divided into five tehsils, Bahawal Nagar, Chistian, Minchinabad, Harunabad, and Fort Abbas, has a population of approximately 1.6 million. The district capital is Bahawal Nagar which is also the administrative center for the district health services and the site of the district hospital facility. The area is bounded by the Sutlej River to the North, by the Indian border in the east and south, and by the Cholistan Desert and the district of Bahawalpur in the West. The project area has a flat topography and the terrain slopes toward the southwest with an average gradient of less than 20 cm per kilometer. The underlying strata are mainly unconsolidated aeolian and alluvial deposits, formed by fine to medium grain sands, clays, and silts. There is some secondary consolidation, mainly as a result of calcareous infill.

The society is predominantly agrarian and the main industry is cotton-ginning (Ahmad and Bashir II 1973). The region is classified as a wheat/cotton agro-ecological zone. The climate is semiarid to arid with annual evaporation (2,400 mm) far in excess of annual rainfall (260 mm), 70 percent of which occurs in the monsoon season (Shamsi 1964). The predominant crops during *kharif* (mid-April to mid-October) are cotton, rice, and forage whilst during *rabi* (November to March) wheat and sugarcane are grown, in addition to forage.

Geographically, the area is dominated by the Sutlej River to the north and by an extensive irrigation system. The irrigation system consists of both perennial and non-perennial sections. All sections are supplied during *kharif* when, due to extensive meltwater production in the upland regions, water levels are at their highest. The supply of irrigation water to some areas is stopped/curtailed during *rabi* and in these areas agriculture is dependent upon groundwater and rain-fed irrigation. The system is known to be severely affected by salinity and high water tables.

## GROUNDWATER DATA

Maps that showed the depth to groundwater in the study area were obtained from the Salinity Management Office (SMO) of the Water and Power Development Authority (WAPDA). The groundwater maps are constructed by taking measurements of depth to groundwater along transects across the study area and then interpolating for the area in between in a linear manner.

## **Materials and Methods**

### **VERIFICATION OF SECONDARY DATA**

AS WITH ANY study which is reliant upon secondary data it is important to verify the accuracy of the data prior to any analysis. In this case, it was deemed appropriate to assess both the accuracy of the groundwater maps and the health center data.

#### **Method for Determining the Accuracy of Groundwater Maps**

It was not possible to verify the accuracy of the depth to groundwater maps obtained from the SMO. IIMI staff were of the opinion that they were relatively accurate at the scale at which they were drawn.

#### **Method for Determining the Accuracy of Routinely Collected Health Center Data**

The accuracy of the data collected from health centers could be influenced by a combination of any of the following factors.

- the health-seeking behavior of the general public
- staff ability, training and motivation
- data collection, recording, and transcription methods
- diagnostic criteria
- quality and maintenance of equipment

#### **Questionnaire Data**

A questionnaire was used to determine the likely pattern of health-seeking behavior of the population of the study area.

A social survey by questionnaire had been planned for the Chistian subdivision region of the study area. The primary objective for the questionnaire was to obtain agricultural production, socioeconomic, and environmental data as part of a performance assessment study. Approximately 500 farmers were sampled from 60 watercourses from all 14 distributaries and 7 minors off-taking from the Fordwah Branch Canal. Five questions were included on this questionnaire which had relevance to malaria and these were used as the basis of an assessment of health-seeking behavior.

The sample farmers were selected by a process of stratified random sampling. The farmer at watercourse level was regarded as the basic sampling unit. The main stratification criteria used for the selection of watercourses (from the distributaries) and farmers (from the water courses) were based on the water reach, namely, the head, middle, and tail of each distributary and watercourse. These reaches were considered the

strata for the sample. Simple random sampling was used for the selection of watercourses and farms (Anon 1995).

**Primary Units.** The 14 distributaries within the Chistian subdivision were all included in the sample. Four of the distributaries are regarded as having very large culturable command areas (CCAs) each in excess of 10,000 ha. The remaining 10 distributaries consist of CCAs each less than 5,000 ha. To account for this discrepancy in size, extra water courses were selected from the four large distributaries. Almost 17 percent of watercourses in the Chistian subdivision off-take from minors which, in turn, off-take directly from the main Fordwah Branch. Seven of these minors were also selected as primary units.

**Watercourse.** Sixty watercourses were randomly selected from amongst the 14 distributaries and 7 minors. The distributaries and minors were divided into head, middle, and tail reaches and the number of watercourses sampled from each area was determined with respect to the relative size of each unit. Large primary units had six watercourses selected, two each from the head, middle, and tail of the unit. Medium-sized units had three watercourses sampled, one from each of the reaches. Small units had a single watercourse, selected at random, that was included in the study.

**Farmers.** Six, nine or twelve farmers were sampled from each watercourse, depending upon the total number of farms situated on the watercourse. The number of farmers sampled increased with an increasing total number of farmers. All the farmers were sampled on watercourses with very few farmers (less than 9).

The questionnaire (see Appendix I) was designed to determine where treatment was sought for the last episode of what was presumed to be malaria. The questions referred solely to this episode as it was hoped this would allow the interviewee to focus on one particular incident, thereby aiding his recall and perhaps reducing the risk of amalgamating treatments from several episodes. Questions regarding the age and sex of the patient were asked both to facilitate this focusing behavior and to give an indication of the age groups most affected by febrile illness. Obviously, many of the cases of what was presumed to be malaria could be attributable to other infections so it is not possible to make any estimates of disease prevalence or endemicity. It was thought that a period of four months from July 1995 to October 1995, the present transmission season, would be a cautious limit for reliable recall. Any episodes that were alleged to have occurred earlier than July 1995 were excluded from the analysis. As a check on the accuracy of recall over this period, a recall period of the month of October was used as a guide.

Respondents were also asked whether or not a blood sample was taken from the patient. This was necessary as the diagnosis of malaria in governmental institutions requires parasitological confirmation of parasites in the blood. If a blood slide is examined and no parasites are found and the fever cannot be attributed to another cause the case is recorded as a Pyrexias of Unknown Origin (PUO). In addition, if a blood sample, from a febrile patient, is not taken and examined the case is also recorded as a PUO. All fever cases are given presumptive anti-malaria treatment.

Data were analyzed using the EPI INFO Program (Version 6) supplied by the Center for Disease Control and Prevention (CDC), Atlanta, Georgia, USA.

## **Key Informant Interviews, Group Discussions, and Assessment of Health Facilities**

The discussions with key informants and the visits to treatment facilities were used as a method for assessing the possible underlying reasons for the treatment-seeking behavior observed. At all the health centers visited informal discussions were held with the health workers present and, when possible, the center records were examined.

- visits to the district health center and a tehsil health center, including visits to the on-site laboratories
- visits to a rural health center, four basic health units, and a rural health dispensary
- visits to pharmaceutical suppliers and pharmacies
- visits and discussions with two private practitioners from within the district
- discussions with the Director and Staff of the National Institute for Malaria Research and Training
- discussions with delegates of the WHO Eastern Mediterranean Region Workshop on Integrated Disease Vector Control
- discussions with workers from Health Net International, Peshawar
- discussions with staff of the Provincial Directorate for Health
- group discussions with two groups of farmers
- meetings with two schoolmasters
- meetings with village headmen

## Preliminary Results and Discussion

### ANALYSIS OF HEALTH-SEEKING BEHAVIOR QUESTIONNAIRE

THE SECTION OF the questionnaire pertaining to malaria was completed by 549 out of 552 male respondents (over 99%). Of these, 454 (83%) claimed to have had an episode of, presumed, malaria in their households from July 1995 to October 1995. Curiously, there was a roughly 2:1 (308:146) male to female ratio. It was thought that the sample size would be large enough to indicate the underlying trend and so assuming equal exposure a 1:1 ratio was expected. It is unlikely that there is a major difference in the numbers of males and females in the population. It seems more plausible that this result is either an indication of higher exposure in males or, more likely, a reluctance on the part of the male respondents to venture information concerning the women in their families. Enumerators working on a similar study in the Rechna Doab, to the north of the study area, reported that farmers were often embarrassed by questions which referred to the sex and age of patients (IIIMI unpublished).

The respondents' knowledge of malaria, as indicated by the meetings with individual farmers and groups of farmers, was good. Most were aware that the disease is transmitted by mosquitoes and they were able to distinguish the disease from enteric fevers. They were aware that there was a marked seasonality to the prevalence of malaria and in some areas the colloquial term for malaria was seasonal fever. They listed fever, headaches, and general body pain as the symptoms of malaria. Whilst these symptoms may be found in patients with influenza and other febrile diseases, it was an indication that the farmers have at least some rudimentary knowledge of the disease. Therefore, the data generated by the questionnaire can be accepted as referring to episodes of a disease, with the symptoms which resemble those associated with malaria.

To determine the reliability of the recall period data from a subset of respondents, who had an episode of fever during the month of October, were compared with the data from the four-month recall period. The results shown in table 1 were used as the basis of the analysis whilst table 2 is included to demonstrate that the frequency distribution of facilities used was not significantly different in either table.

In conclusion, it can be seen that only 14 percent of patients availed themselves of the treatment offered by government health centers. Of those attending government institutions only 25 (40%) utilized a BHU which is perhaps indicative of the perceived effectiveness of the Primary Health Care system within this area. The CDC officers only treat a very small percentage (3%) of potential malaria cases. A substantial proportion of the population (23%) is at least partially reliant upon traditional forms of treatment, both herbal and spiritual. Private facilities are the predominant source (87%) of treatment for the study population. The treatment these institutions provide is, in general, highly effective since in 68 percent of cases it was the only source of care.

*Table 1. Health-seeking behavior of patients with suspected cases of malaria.*

Facilities	Case of those attending facility: number and %	Cases of those attending facility exclusively: number and %	Blood slides Percentage range
Government	62 (14)	9 (2)	10-42
CDC officer	15 (3)	0 (0)	0-33
Private	393 (87)	267 (59)	18-24
Traditional	106 (23)	13 (3)	-
Pharmacy	51 (11)	15 (3)	-
Home care	-	3 (1)	-
Total	627 (138)	307 (68)	-

*Note: Recall period July 1995-October 1995. Survey conducted from 4/10/95 to 7/11/95. n=454. Male respondents = 308 (68%). Female respondents = 146 (32%). Note 32 percent of patients seek treatment at more than one facility. Seventy three percent of the patients attending governmental facilities also attended private institutions.*

*Table 2. Health-seeking behavior of patients with suspected cases of malaria.*

Facilities	Cases of those attending facility: number and %	Cases of those attending facility exclusively: number and %	Blood slides Percentage range
Government	27 (19)	3 (2)	11-44
CDC officer	3 (2)	0 (0)	0
Private	126 (87)	81 (59)	12-19
Traditional	31 (21)	5 (3)	-
Pharmacy	17 (12)	4 (3)	-
Home care	-	1 (1)	-
Total	204 (141)	94 (65)	-

*Note: Recall period October 1995. Survey conducted from the 4/10/95 to 7/11/95. n=145. Male respondents = 97 (67%). Female respondents = 48 (33%). Note 35 percent of patients seek treatment at more than one facility. Seventy eight percent of the patients attending governmental facilities also attended private institutions.*

Therefore, the official statistics relating to malaria, in this area, are likely to be based on an exceptionally small sample of the population. It is unclear whether this result applies everywhere. A similar study was conducted in the Rechna Doab, to the north of the study area and similar results were found. In this area, attendance at governmental institutions was shown to be around 12 percent (IIMI, unpublished). This suggests that official malaria statistics may substantially underestimate the actual pattern of malaria found more widely in the Punjab.

A UNICEF report into the health and nutritional status of children working in brick kilns, carpet-weaving factories, and garages found that the percentage of patients seeking treatment, for unspecified ailments, at governmental institutions was as low as 4 percent

(Hamid 1993). The sample size in this study was only 50 from each group. Nevertheless, it does illustrate an underlying trend in treatment-seeking behavior.

## **ASSESSMENT OF DISTRICT HEALTH SERVICES IN BAHAWAL NAGAR**

The District of Bahawal Nagar is subdivided into five tehsils: Minchinabad, Bahawal Nagar, Harunabad, Fort Abbas, and Chistian. There are tehsil hospitals at each of these tehsil capitals with the larger district hospital being situated in the town of Bahawal Nagar. In addition, the area is served by 10 RHCs and 101 BHUs. For nonmedical administration purposes there are 96 Unit Councils and the aim of the health service is to have at least one BHU per Unit Council. The CDC supervisor is based in Bahawal Nagar and, at full strength, he should supervise 83 CDC officers. There are three microscopists at the District Headquarters in Bahawal Nagar and five more dispersed throughout the district. They are provided with well-maintained microscopes funded by USAID.

### **Possible Reasons for Low Health Center Attendance**

Possible reasons for the low numbers of patients seeking treatment at government facilities were determined from the key informant interviews and health center visits.

***Shortages of Anti-Malarials and Community Perceptions of Low Efficacy.*** Chloroquine is given to all patients who come to a BHU with fever. This fact combined with logistical problems in supplying outlying areas can result in shortages of anti-malarials, for large periods of the year. Drug supplies may also be insufficient for the areas' needs when they are supplied. In some areas, this may lead the community to believe that the operators of the facility within the distrust, have sold the drugs for personal gain. In one basic health unit visited, a doctor had been absent since early January, a period of nine months, and in his absence the dispenser had been treating presumed malaria cases with paracetamol, as chloroquine supplies had been exhausted in June. The supply of nonspecific drugs may contribute to community perceptions of a low quality of service. A common complaint amongst farmers interviewed was that the treatment offered at governmental facilities was the cheapest possible and was regarded as ineffective. In another instance, farmers revealed that they were offered two treatments for malaria, in addition to chloroquine tablets, which were used for what were perceived to be more severe cases. The treatments were injections of penicillin or a brufen-based anti-inflammatory. The latter was preferred as the penicillin injections did, on occasions, cause adverse side effects which resulted in the community to regard it as dangerous. Neither of these drugs has an antimalaria effect.

This shortage of chemotherapeutics means that even if their condition is diagnosed at a government institution it may be necessary to obtain the necessary drugs at a private pharmacy. Private facilities often provide drugs in addition to the diagnostic facilities. Even at the large district and tehsil hospitals, treatment is not completely free from expense.

Drugs are also in short supply and, in some cases, must be bought from private institutions. In the tehsil hospital in Chistian a charge is levied for the examination of a blood sample.

**Poor Staffing and Low Staff Morale.** The absence of a doctor was also cited as a reason for low attendance at government facilities. Data from 1992 show that a doctor was present at only 18 of the 89 (20%) BHUs, for which data were recorded (Offices of the District Medical Officer, Bahawal Nagar). In addition, 33/89 (37%) of BHUs had a medical technician and 60/89 (67%) had a dispenser. Reasons for this low number of attending physicians is the limited scope of the work. The physicians, who are paid, on average, Rs 1,000/month less than their colleagues in the city are demoralized both by the poor conditions and low pay and by the decreased chances of career advancement. It is felt that the period of three years that they spend at a BHU is wasted in professional terms since they gain experience in the treatment of only a limited number of diseases. Moreover, doctors in urban settings are commonly able to supplement their income by running private practices, an option denied those doctors working in rural areas. Of the four Basic Health Units visited it was only in one that a doctor was in attendance.

**Quality of Service at BHU.** Patients were aware that different ailments require different treatments. They feel that there are a limited number of treatments at government institutions. They believe the treatments they do receive are of an inferior quality, often citing cases when treatment provided by a government institution was insufficient and resulted in the patient becoming increasingly ill.

Table 1 shows that blood slides were taken infrequently at government facilities. It is possible that the patients may have come with obviously nonmalarial conditions but the low numbers of qualified doctors working at the BHUs would tend to suggest that there is unlikely to be a high level of diagnostic ability throughout the facilities in the area.

**CDC Officers.** The group discussions revealed that no farmers regarded the network of CDC officers as an effective method for the treatment of malaria. However, the farmers were highly satisfied with the CDC officers' work in vaccinating children against the five diseases mentioned earlier. Importantly, the vaccinators provided the service without demand of recompense.

Only 64 of a possible 83 CDC officer posts were filled. This has resulted in incomplete coverage of villages, with some CDC officers attempting to serve two areas.

## **HEALTH SERVICE FUNDING IN PAKISTAN**

Pakistan's primary health care system operates under severe financial constraints. Only 1 percent of the country's GNP is spent on health care. Approximately 85 percent of this amount is earmarked for tertiary care facilities with primary care facilities only receiving funds in the region of 1-5 percent (Ali 1995). Working within this enormous limitation it is perhaps not surprising that primary health facilities are inadequately staffed, maintained, and supplied.

## **Study Design**

INITIAL PLANS TO use a case-control methodology (Schlesselman 1982) in this study were canceled for the reasons given below.

### **ABSENCE OF A SUITABLE CONTROL GROUP**

A prerequisite of a case-control methodology is that both cases and controls are drawn from the same population. The variation in record keeping for malaria and all other diseases means that it is impossible to be assured that this is indeed the case. Malaria data are gathered at the village level but other diseases, which would form the control, are recorded at the BHU level (at least five villages).

### **SCARCITY OF DATA ON MALARIA**

The population of the district of Bahawal Nagar is approximately 1.55 million and in 1994 there were 613 confirmed cases of malaria. There are approximately 1,000 villages within the district so the low apparent incidence means that it would be impossible to detect any variation within the study area.

### **UNDERREPORTING**

The routinely collected health center data were shown by the study questionnaire to be underrepresentative of the actual malaria situation. It was found that only 14 percent of possible cases may have been detected by the government health service. Malaria prevalence rates of 45 percent have been detected in studies in the Kasur district while government statistics suggest an API of less than 0.1 percent (Strickland et al. 1987).

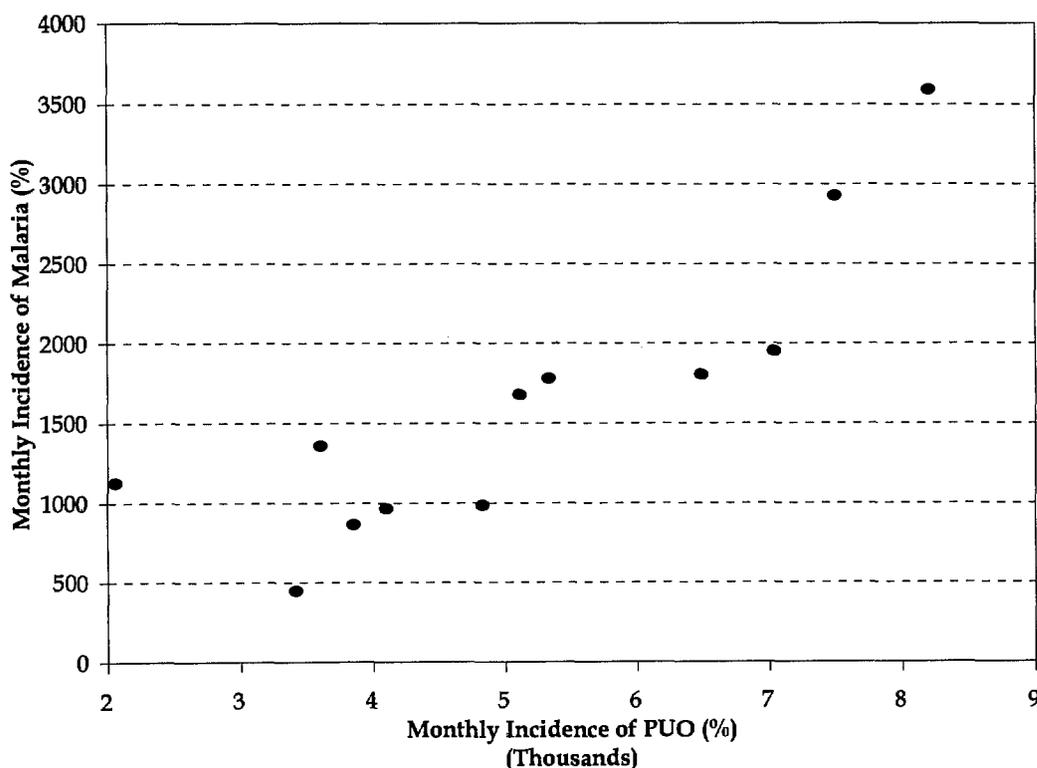
As early as 1980, de Zulueta Mujtaba and Shah (1980) were stating that it is impossible for a CDC officer to collect blood films from all the suspected malaria cases, in his sample area of 15,000 people. This situation has apparently not improved. At present, in the District of Bahawal Nagar, only 64 of the 83 CDC officer posts are filled and on average each CDC officer will have responsibility for approximately 25,000 persons. In 1994, 97 out of a total of 52,372 slides, collected by the active case detection method (ACD) were tested positive for malaria parasites. This SPR of 0.185 percent is an inconceivably low number of cases if all the slides were taken from febrile persons as specified.

During the same period there were 49,318 cases of PUO. Each of these cases should have had a blood-slide taken. Therefore, it is somewhat surprising that for the year 1994 only 9,620 slides were taken by this Passive Case Detection method.

## USE OF PUO DATA TO ESTIMATE MALARIA PREVALENCE

Pyrexias of unknown origin (PUO) have proved to be a reliable indicator of malaria incidence in NWFP and Baluchistan (Rowland, unpublished, see figure 5). The method was validated by a series of monthly malaria surveys, using strict control techniques, among an Afghan refugee population. The association remained significant when the data were recompiled into annual aggregates.

*Figure 5. The relationship between the monthly incidences of malaria and Pyrexias of Unknown Origin (PUO) in the North-West Frontier Province and Baluchistan.*



Source: Rowland, unpublished. 1995.

An advantage of this approach is that PUO is recorded independently of whether cases have been screened by blood slide examination for malaria. As explained above, this was a major source of inaccuracy in the malaria-recording system. A limitation to the use of a similar approach in the Punjab is the fact that about 85 percent of PUO would be undetected due to low attendance at government institutions.

The possible association of PUO and depth to groundwater was investigated.

# **An Analysis of the Link between Groundwater and Fever Incidence**

## **METHODOLOGY**

TO CALCULATE THE yearly incidence of PUO at each BHU it is essential to know the size of the population from which the cases are taken. However, since people are not obliged to attend the clinic to which they are assigned, estimates of sample population based upon geographical location are highly arbitrary. The most recent population census data available were those gathered by the district health authority at the mouza level. Health center catchments could therefore only be calculated using the mouza as the unit of measurement.

The average depth to groundwater for this area was estimated by digitizing the map supplied by the SMO and superimposing the mouza boundaries on top. The average depth to groundwater was then calculated.

Cropping data were supplied by the Canal Office, Bahawal Nagar. These data were also recorded at the mouza level and were used to calculate the percentage of the gross command area (GCA) under rice production.

The data were plotted and analyzed using the Quattro Pro program.

## **DATA ANALYSIS**

The data relating to both percentage GCA under rice and depth to groundwater were then individually regressed upon the incidence of the PUO data set.

## Results

### PUO INCIDENCE AND DEPTH TO GROUNDWATER

A MAP SHOWING the depth to groundwater and the locations of BHUs in the study area is given below (figure 6).

It can be seen (figure 7) that there exists no apparent relationship between the depth to groundwater in a mouza and the incidence of PUO recorded at the BHU within the mouza.

*Figure 6. Variation in depth to groundwater and location of Basic Health Units, District of Bahawal Nagar, Punjab.*

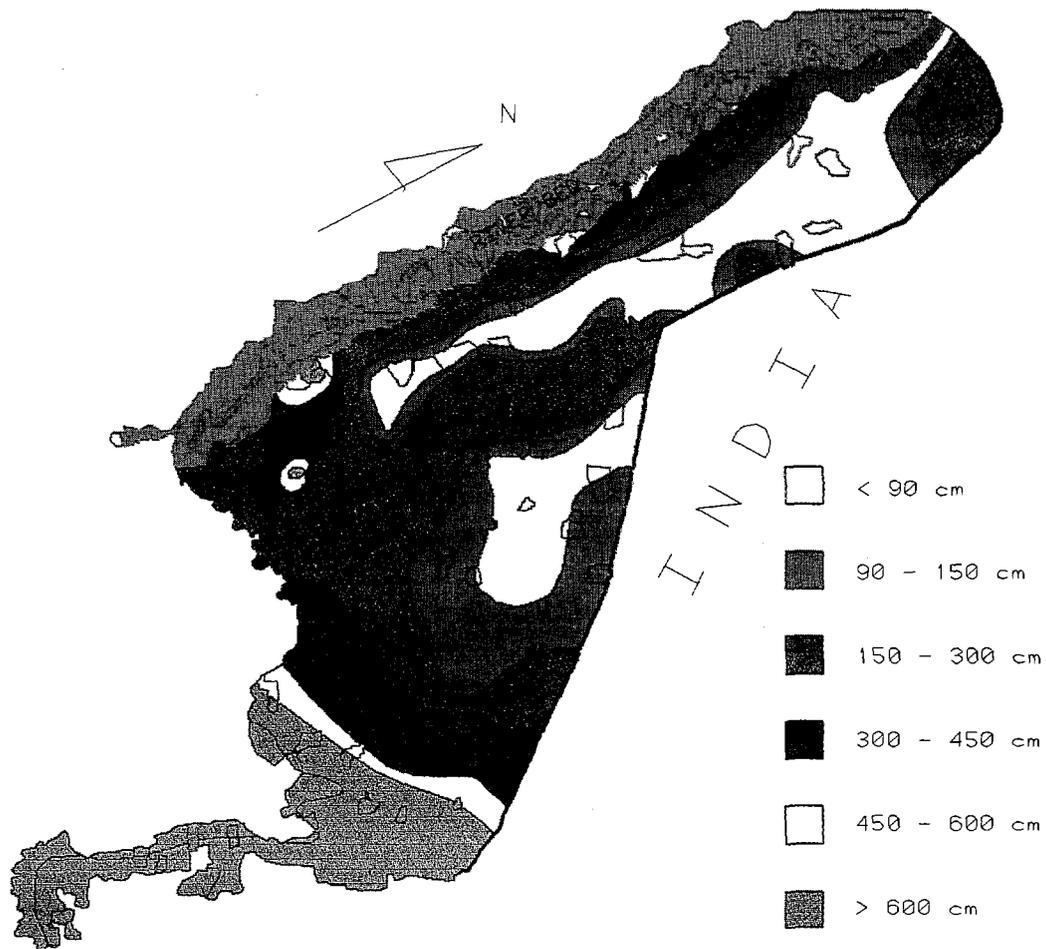
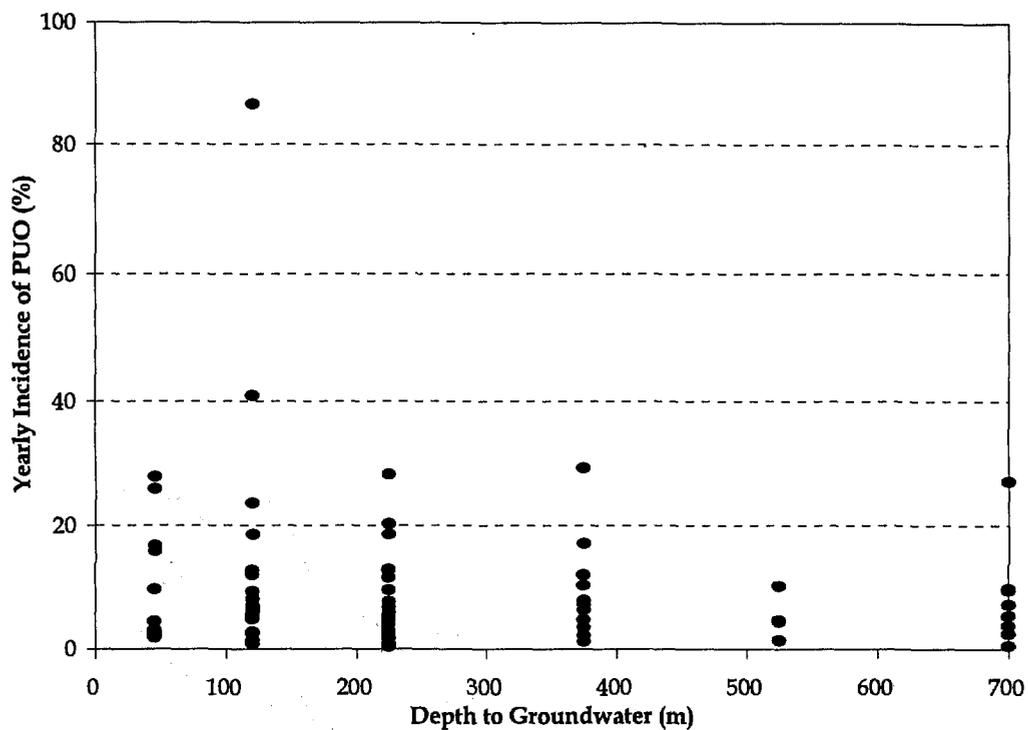


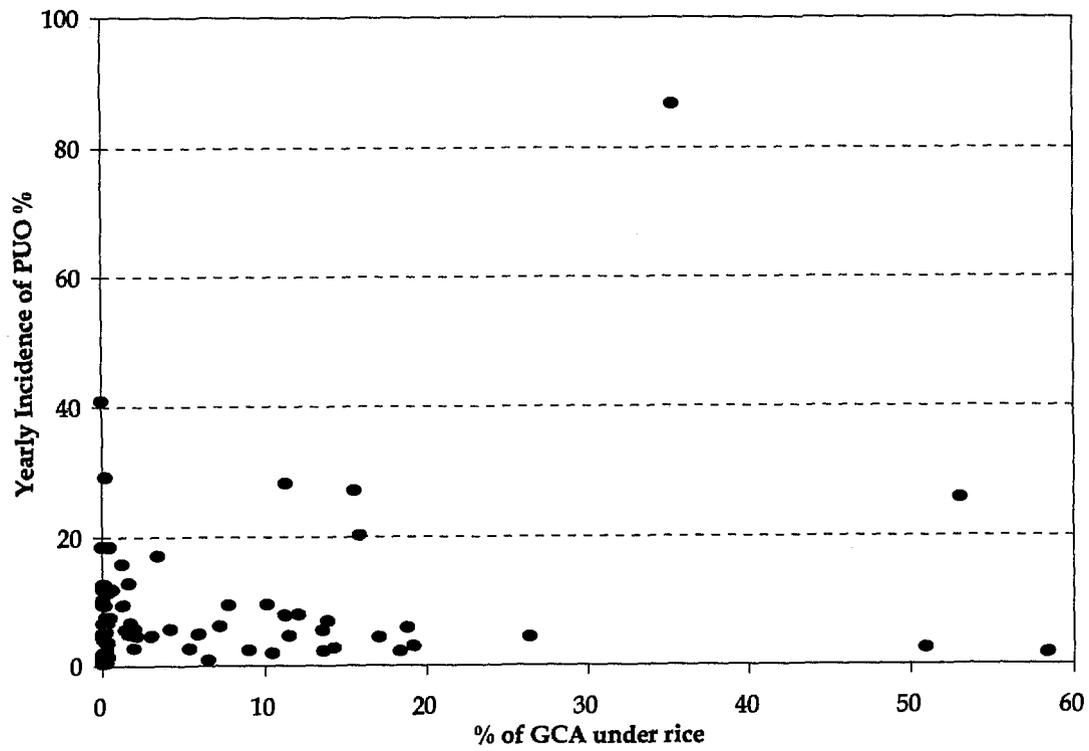
Figure 7. The relationship between the yearly incidence of PUO and depth to groundwater in each of the mouzas in which a Basic Health Unit is situated.



### PUO INCIDENCE AND PERCENTAGE OF MOUZA LAND UNDER RICE

From figure 8 it can be seen that there is no apparent relationship between the percentage of mouza land under rice and the yearly incidence of PUO recorded at the BHU within that mouza.

Figure 8. The relationship between the yearly incidence of PUO and percentage of GCA under rice in each mouza in which a Basic Health Unit is situated.



## Discussion and Criticism of Data

THIS STUDY WAS not able to demonstrate any linkage between either depth to groundwater or percentage area under rice and the incidence of PUO. It is perhaps not surprising considering the crude nature of both the groundwater data and the data gathered from clinics which are likely to have masked any underlying variation. For this approach to detect any differences in incidence the variation between areas would have to be extreme. It was concluded that the secondary data available were inappropriate for detecting an association between groundwater and malaria.

### CRITICISM OF HEALTH CENTER DATA

The data were such that it was impossible to stratify for these possible confounding factors. Whether this makes the analysis invalid is open to conjecture. The final analysis required an oversimplified approach.

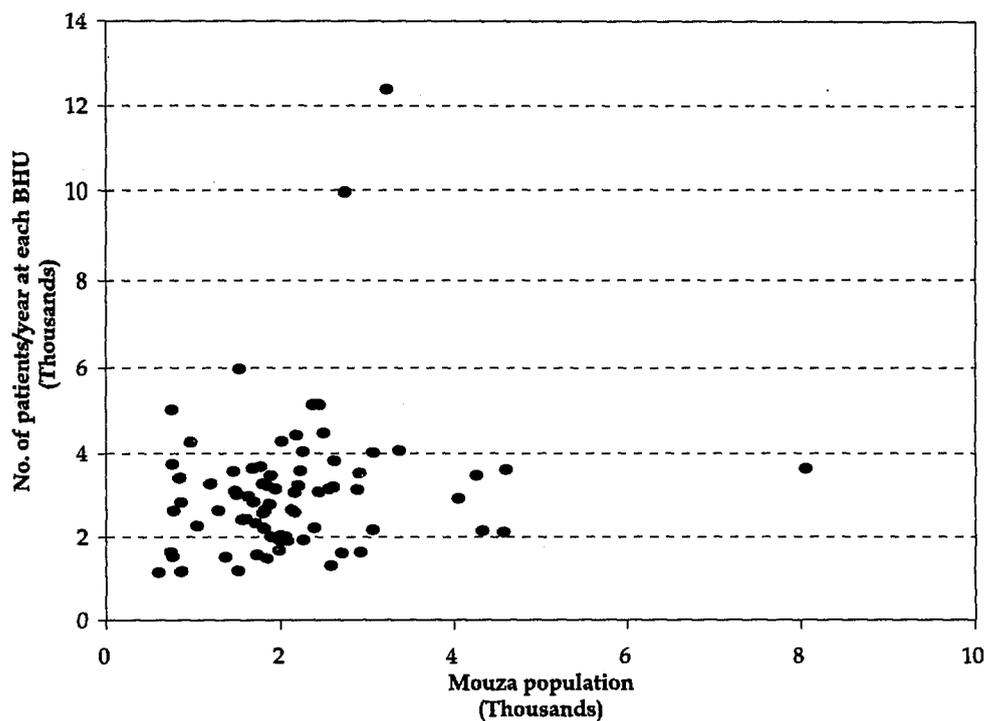
The analysis required the following assumptions to be made.

- census data are accurate
- mouza is a reliable estimate of catchment
- PUO data are accurate when we refute malaria data
- no significant variation between BHUs in treatment and diagnosis
- proportion of malaria cases in PUO relatively constant
- despite the low health center attendance the data will still constitute a representative sample

The catchment area of each BHU was, by necessity, crudely estimated. It can be seen that there is no apparent correlation between the numbers of patients attending a BHU and the population of the mouza in which the BHU is sited (figure 9). This brings into question the validity of using the mouza population as the base population for calculating yearly incidences. It would perhaps be better to define catchment area on geo-physical features rather than on political boundaries.

The variation between BHUs also remains a very important confounding factor. The variation in the quality of the facilities, particularly with respect to presence or absence of a doctor, means there is likely to be a large variation in both numbers attending a BHU for treatment and in the recording of cases.

Figure 9. The relationship between the total population of a mouza in which a BHU is situated and the number of patients attending the facility each year.



### CRITICISM OF DATA ON GROUNDWATER

It was not possible to verify the accuracy of the groundwater maps but at the large scale at which the work was performed this is likely to be of secondary importance. More detailed studies would require a more accurate measure of depth to groundwater. We have not yet verified whether there is a relationship between depth to groundwater and the extent of standing water. Observations suggested that there may be other factors that influence ponding.

## **Recommendations**

THE STUDY ESTABLISHED the need for prospective data collection. It also established, by personal observation, that there is little available expertise in the Punjab to support IIMI on malariology or medical entomology. Consequently, IIMI will have to be relatively self-sufficient and rely on external advice. The following three study designs investigate components of the overall problem and are each within IIMI's scope.

### **KNOWLEDGE, ATTITUDES, AND PRACTICE SURVEY**

Carry out a Knowledge, Attitudes, and Practice (KAP) survey to discover people's actual perceptions of the malaria problem. It is important to determine whether malaria is regarded as a severe problem or is more in the nature of an inconvenient nuisance. In addition, the study could incorporate an assessment of the impact, in economic terms, of each malarial episode. This would be a relatively easy project to integrate with ongoing performance assessment studies and would help determine the costs and benefits of irrigation.

### **ASSOCIATION OF MALARIA PREVALENCE AND VECTOR DENSITY**

Assess the linkages between abundance of malaria vectors and actual malarial morbidity. Any intervention strategy would be designed to decrease vector abundance; therefore it is essential to discover whether mosquito density is a limiting factor to malaria transmission. In many areas it has been shown that transmission dynamics are such that a drastic reduction in vector density is required prior to any significant decrease in malaria morbidity. This work should incorporate some studies into the possible effects on mosquito abundance of certain intervention strategies, to estimate their efficacy prior to implementation. It should be noted that those vector control strategies that have had most impact upon malaria were designed to decrease the longevity, rather than the density, of mosquitoes. A project that investigated malaria in both the human and vector hosts would require a considerable investment in skilled personnel.

### **THE RELATIONSHIPS BETWEEN VECTOR DENSITY AND LAND USE**

The objective would be to determine whether land use affects vector density. Adult biting mosquitoes would be sampled in a series of villages adjacent to different patterns of land use associated with irrigation development or rehabilitation. If an association is established, additional studies would investigate variations in malaria prevalence. Patterns of land use that decrease vector density and reduce malaria could be incorporated into irrigation

management plans. The project would require the services of an experienced medical entomologist assisted by research officers and local technicians. It should be relatively easy to integrate this project with ongoing IIMI research work and utilize the established infrastructure.

Depth to groundwater is too general an estimator for the irrigation system and its operations. Future epidemiological studies should not use depth to groundwater as an indicator of the possible number of breeding sites. Malaria is a much more focal problem than this so it is necessary to study constituent parts of the system to determine which risk factors may be of epidemiological significance.

### **OTHER POSSIBLE PROJECTS**

Environmental management measures for mosquito control include community action to prevent seepage, fill borrow pits, or practice intermittent irrigation. These could only be sustained if the community found them acceptable. Additional social surveys could use techniques and skills that have already been established at IIMI for agricultural studies.

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## Appendix I

Questions included on the performance assessment survey for the Chistian subdivision of Fordwah Eastern Sadiqia.

When did someone in your household last have an episode of malaria? (The term seasonal fever or a local name may be given instead)

Year: \_\_\_\_\_

Month: \_\_\_\_\_ (1 to 12 denote month of the year from January to December)

What was the age and sex of the patient?

Age: \_\_\_\_\_

Sex: \_\_\_\_\_ (Female = 0, Male = 1)

Where was treatment sought?

(Yes = 1, No = 0)

- Government health center \_\_\_\_\_  
Name of the center: \_\_\_\_\_
- Communicable disease control (CDC) supervisor/malaria man \_\_\_\_\_
- Private doctor/private clinic \_\_\_\_\_
- Pharmacy/medical store \_\_\_\_\_
- Traditional medicine/hakeem/spiritual treatment \_\_\_\_\_
- Only home treatment (No drugs used) \_\_\_\_\_

Did the patient have a blood-slide taken?

(Yes = 1, No = 0) \_\_\_\_\_

Was the patient referred to a higher-level government facility for further treatment?

(Yes = 1, No = 0) \_\_\_\_\_

## Appendix II

### Acronyms

ABER	Annual Blood Examination Rate, percentage of the population subject to an examination by blood slide
ACD	Active Case Detection. Cases or patients detected by personnel visiting homes/villages actively looking for patients with fever
API	Annual Parasite Index, number of cases of malaria parasitism per thousand people in the study population
BCH	Benzenehexachloride=Hexachlorocyclohexane
BHU	Basic Health Unit
CCA	Culturable Command Area
CDC Officer	Communicable Disease Control Officer
DDT	Dichloro diphenyl trichloroethane
DHC	District Health Centre
GCA	Gross Command Area
IIMI	International Irrigation Management Institute
MBS	Mass Blood Survey. The examination of blood slides taken from a large percentage of the population of both febrile and afebrile people
MCP	Malaria Control Programme
NIMRT	National Institute of Malaria Research and Training
PCD	Passive Case Detection. Cases or patients detected only when they come to a facility seeking treatment
PUO	Pyrexias of Unknown Origin
RHC	Rural Health Centre
RHD	Rural Health Dispensary
SMO	Salinity Management Organization
SPR	Slide Positivity Rate, percentage of blood slides examined that are positive for malaria parasites
THC	Tehsil Health Centre
TSE	Total Slides Examined
UNICEF	United Nations Children's Fund
WAPDA	Water and Power Development Authority
WHO	World Health Organization