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A Cutaneous Leishmaniasis Control Trial Using Pyrethroid-Impregnated Bednets in Villages near Aleppo, Syria

by

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ABSTRACT

An intervention field trial promoting the use of pyrethroid-impregnated bednets by the local inhabitants of four villages, 20 kms northeast of Aleppo City in the Aleppo Governorate, Syria, began in mid-1994. Its aim was to examine the efficacy of such bednets in controlling anthroponotic cutaneous leishmaniasis. Two villages were selected randomly as intervention villages and two others as control villages. All the 4 578 inhabitants of the 508 households in the villages were recruited for the study.

During May and June 1994, a pre-intervention house-to-house survey was conducted in the four villages to make a census and collect socio-economic and epidemiological baseline data. Pyrethroid-preimpregnated bednets were distributed to the households in the intervention villages, and non-impregnated bednets in the control villages. The number of bednets provided to each household was proportionate to the number of its members. In June 1995 and early May 1996, extra bednets were distributed to the households in both the intervention and control areas to substitute for lost or torn bednets and to ensure a sufficient supply to each household. Moreover, the bednets distributed previously in the intervention area were re-impregnated with pyrethroid. Health education messages were disseminated to ensure the population's compliance with the proper use of bednets. A leishmanin test was carried out on schoolchildren in all schools of the four villages during June 1995 to estimate the percentage of previous cases. Furthermore, an epidemiological survey took place every six months, in December of one year and June of the following year to evaluate the impact of intervention on incidence of cutaneous leishmaniasis in the first and second post intervention years. However during the third post-intervention year (from July 1996 to June 1997) this procedure was carried out monthly. Entomological surveys using the sticky paper technique were carried out in ten randomly selected households in the intervention villages every two weeks from May to November of 1994 and 1995 to assess the impact of insecticide-impregnated bednets on the density of *Phlebotomus. sergenti*, the vector of anthroponotic cutaneous leishmaniasis. Similar surveys were conducted in ten households in the control villages as well.

The study was not able to detect a significant impact on the reduction in density of the vector *P. sergenti* in the intervention area compared with the control area. However the results showed a sharp consistent reduction in cutaneous leishmaniasis incidence as a result of the use of pyrethroid-impregnated bednets in the intervention villages from 5.1% in the pre-intervention year to 1.2% in the third post-intervention year. The reduction was greater in the first year post-intervention period in households who had not washed the bednets during the previous transmission period. In the control area cutaneous leishmaniasis incidence doubled in the first post-intervention year from

2.4% (52/2182) to 4.6% (96/2102). In the second year, cutaneous leishmaniasis incidence regained its pre-intervention level of 2.3% (45/1985). It increased sharply in the following year (third post-intervention year) to reach 6.1% (118/1929). More studies are needed on a larger scale in different settings to confirm the impact. A comparison between the highly positive results of this study based on the use of pyrethroid-impregnated bednets and those obtained from the use of residual insecticide house spraying should help determine the most effective strategy in foci of anthroponotic cutaneous leishmaniasis

Keywords: Cutaneous leishmaniasis, *Leishmania tropica*, *Phlebotomus sergenti*, bednet, pyrethroid, control, Aleppo, Syria

INTRODUCTION

Cutaneous leishmaniasis is endemic in most of the countries of the Eastern Mediterranean region: Syria, Lebanon, Israel, the Palestinian Self-Ruled Territories, Jordan and Iraq (Laison and Shaw, 1987). The whole area is characterized as part of the classical Oriental Sore region which extends further to the east to include Iran, Afghanistan, Pakistan and northwestern India (Ashford, 1986). The disease has been prevalent in this area for hundreds of years and has acquired the names of the towns where it has been common, such as Aleppo, Baghdad, and Delhi. The lesion has been described as long lasting, usually taking a year to heal (*Hebt a Sinne*, translated by Russell and Russell, 1794, as "botch" of a year).

It is believed that antimalarial insecticide spraying during the 1950's contributed to a considerable decline in leishmaniasis incidence in Syria as a whole, particularly in Aleppo (WHO, 1991). During the years that followed, only a few cases were noticed in some villages near Aleppo (Abdou *et al.*, 1976, Zein El-Din, 1970). It has been documented that *Leishmania tropica* is the causative parasite for the disease in Aleppo (Rioux and Pratlong, unpublished observations). This is confirmed by clinical observations that untreated lesions do not heal in less than a year and recidivans cases are common. It is believed that the disease is transmitted by *P. sergenti* (WHO, 1990; Jalouk, 1993). Although cutaneous leishmaniasis is not a fatal infection, it is well known for its negative impact on public health and the economy due the high cost and length of treatment, not to mention the psychological trauma in children and young people brought on by facial disfigurement from post-healing scars.

In the mid-1980's the increasing number of anthroponotic and zoonotic cutaneous leishmaniasis cases in the traditional foci and their spread to new foci in Syria has been of concern to the Health Authorities (Ashford *et al.*, 1993; Tayeh *et al.*, 1997). All northwestern governorates including Edlib, Lattakia, Tartus, Hama, Aleppo as well as rural Damascus in the southwest, had a high percentage of reported cases during 1993. (Map 1) In subsequent years, the disease spread to the Al-Hasakeh and Deir al Zour Governorates in the east (Jalouk and Tayeh, 1996). This led to an increase of activities carried out by the Ministry of Health to control the disease. Treatment of cases in health centres and specialised hospitals with pentavalent antimonials, Sodium Stibogluconate (Pentostam®) and Meglumine Antimoniate (Glucantime®) has intensified. Dry ice and liquid-nitrogen have also been used recently in several health centres in Aleppo and Damascus to treat chronic forms of leishmaniasis lesions, mainly lupoid. Active case detections have been confined to schoolchildren in the Aleppo Governorate. Applications of Deltamethrin (K-Othrine®) house spraying began in the endemic areas in 1991 according to the guidelines of the World Health Organization (WHO).

However, residual insecticide house spraying did not produce the desired effects in many countries including Syria. Curtis (1994) mentioned several common reasons such as cuts in public spending, reservations among the people about the effects of spraying, denial of access to spray personnel,

low community participation, lack of trained manpower and inadequate logistics support, managerial problems, corruption and mismanagement of the expensive insecticide product including its diversion to the black market for agricultural purposes. Last but not least, the resistance of some vector populations to certain insecticides has been also an important setback.

Alternative sustainable technology usable by the people themselves is necessary for the control of vector-borne diseases. Pyrethroid insecticide-impregnated bednets trials financed by WHO and other agencies to investigate the effects on malaria mortality and morbidity have been carried out in several African and Asian countries. In West Africa, a 60% reduction in mortality and 45% in morbidity from malaria was shown in children from 1 to 4 years of age as a result of sleeping under impregnated bednets (Alonso *et al.*, 1993). Other studies in West African countries found a similar impact on mortality (Jaenson *et al.*, 1994), on reduction in malarionometric indices such as parasitaemia levels (D'Alessandro *et al.*, 1995), and a reduction in the number of premature births (D'Alessandro *et al.*, 1996). In East Africa, it was found that introducing insecticide bednets led to a 74-78% reduction in the weekly rate of reinfection with the malaria parasite in the Zanzibar population (Stich *et al.*, 1994). A 65% reduction of malaria incidence during a two-year period in China was shown by Dapeng *et al.* (1994). Another study in Thailand found that the use of bednets by pregnant women reduced malaria and anaemia during pregnancy (Dolan *et al.*, 1993). A study on the use of insecticide-impregnated bednets among Afghan refugees showed a significant impact on reducing malaria incidence (Rowland *et al.*, 1996).

The success of these trials in controlling malaria through the use of a simple technology has encouraged researchers to utilize the same technique to control non-zoonotic cutaneous leishmaniasis. Several controlled trials supported by WHO are underway in Asian and African countries including Afghanistan, Bangladesh, Iran, Nepal, Sudan and Syria. The trial in the Aleppo Governorate is one of the studies conducted under this programme.

The main advantages of pyrethroid-impregnated bednets are their low cost, safety, easy use, long lasting effects when not washed, sustainability and acceptability by the people. However, the main reservations are discomfort in warm climates, loss of efficacy if frequent washing and need of appropriate timing for entering under them. The cost-effectiveness of bednets in preventing mortality and morbidity from malaria has been demonstrated by Picard *et al.* (1993).

This paper describes a control intervention trial to prevent anthroponotic cutaneous leishmaniasis (ACL) through the use of pyrethroid-impregnated bednets in four villages northeast of Aleppo City in Syria.

MATERIALS AND METHODS

The study area

In April 1994 before the start of the intervention, four villages were identified as highly endemic with active cases ranging from 3.3% in Tal Shaeer to 1.2% in Halisa. The four villages are located 20-25 kms northeast of Aleppo, as seen in the sketch-map of the area. (Map 2) Halisa and Tal Shaeer are two small villages with about 700 people each, while Kafar Sagheer and Sheikh Najjar have a population of about 2000 each.

The area was very fertile until recently and well known among the people of Aleppo for its agricultural production. However, the expansion of cement, glass, stone masonry and other manufacturing industries from Aleppo to the Free-Zone area nearby resulted in a decline in agricultural production as pollution increased and farm labour migrated to the factories for alternate forms of work, e.g. as watchmen. Furthermore, the location of the weekly Aleppo Sunday Market on the main road between Kafar Sagheer and Sheikh Najjar and a scattering of government and private poultries in the area along with the presence of large borrow-pits for the solid waste from Aleppo City added to the environmental problems.

Compounds and houses usually consist of an entrance leading to a courtyard. There are rooms and other facilities on the sides of the courtyards. Most houses consist of one or more bedrooms, a living room, a small kitchen and a toilet. Each room has its own separate doors and windows opening onto the courtyard or corridor leading to the courtyard. Living rooms serve as bedrooms at night for children and older members of the family. People also eat in the living room in the winter. Grain, conserved foodstuffs such as jam and cheese, dried vegetable, and other food items are stored in the small kitchen. The toilet is usually located far from the major rooms. Although stables and shelters for the animals, mostly sheep, goats and sometimes cattle are usually built at the furthest end in the same compound opposite the living area, sometimes households keep their animals outside the compound but near enough to be watched closely.

The inhabitants perform various activities in the courtyards in the daytime during summer. They also watch television and sleep in the courtyards on summer nights when it is very hot. Some grow plants in the courtyards and others have kitchen-gardens. The farms are usually not very far from the villages. Agricultural products include grain, olives, grapes, and vegetables. The households generally have more mattresses than the number of members to accommodate visitors who stay overnight after late night festivals or other occasions such as weddings, religious rituals, or just visits.

Electricity is supplied to all four villages on a continuous basis through the main network. Hence, it is not unusual to find various household electrical appliances such as washing machines, refrigerators, radios, televisions, fans. Water supply is also generally continuous through government projects though some households have underground reservoirs and/or elevated

reservoirs which are filled with water bought from vendors. Some have their own boreholes and deisel pumps which serve their domestic and agricultural needs. There are no sewage networks in any of the four villages covered by the study but some compounds have septic tanks or pits-latrines. Unfortunately, waste water is not directed towards the pits latrines but flows onto the streets or courtyards forming small puddles in the clay soil which last for long periods and attract insects.

There is at least one mosque in each village but shops selling food and other small items can only be found in the two larger villages, Kaffer Sagheer and Sheikh Najjar. Each village has a school from grades one to six. Young people, especially males, who wish to continue their secondary education travel to secondary schools in the larger villages nearby. Halisa and Tal Shaeer with a small population have elementary schools with 160 and 161 students respectively. Kaffar Sagheer and Sheikh Najjar with a larger population have combined elementary and preparatory schools with 450 and 400 students respectively. The schools have a two-shift system, from 7:00 a.m. to noon, and the other from noon to 5:00 p.m.

None of the four villages have public health clinics. Patients from Halisa and Tal Shaeer frequent the health centre or private doctors in nearby Faifeen village or travel to Aleppo in case of emergency. A new popular private transportation system provides easy access to Aleppo by mini-bus. The inhabitants prefer to travel to Aleppo for treatment as they can have a good choice of clinics there. Early in 1995, some private medical doctors from Aleppo opened two clinics in Kaffer Sagheer.

The study population

The total population of the four villages was chosen for the study, viz., 4,578 people in 508 households, all of them Muslims. The people are basically subsistence farmers though a few depend upon livestock. Many of the men work as manual labourers or watchmen in nearby factories to earn cash, but farming as a source of agricultural production continues. Work in cement, glass, and masonry swing factories poses some degree of physical risk particularly for those using explosives for masonry excavations. The main activities of the women consist of household duties. They also work on the farms during spring and summer. The women and children seldom leave the village except to go for treatment in health clinics in Aleppo or to visit relatives. They invariably return to their village before nightfall.

Sleeping patterns

The people stem from one or two nucleus families who lived in the area earlier on in the century. They visit each other regularly as many have intermarried and are related. The children sometimes sleep in the homes of relatives either in the same village or in the ones nearby.

People usually wake up early in the morning between 6:00 and 8:00 and sleep early as well generally between 8:00 and 10:00 in the evening. Some stay awake until late and watch television. Many sleep in the courtyards in the summer, particularly those with no fans indoors. They generally sleep on mattresses on the floor because beds are rare. It is not unusual for boys and girls under the age of seven to sleep in the same bed, but older children either share a bed with children of their

own sex or sleep separately. Some couples sleep in private bedrooms which may have a fan or join other family members in the courtyard in summer. Local bednets are used sometimes. A few bedrooms and living rooms have ceiling fans.

Cutaneous Leishmaniasis in the study area

There is no evidence that the area was infected with cutaneous leishmaniasis much before 1990. According to the Head Master of the local school, a few cases were noticed in Tal Shaeer during the 1990-91 academic year. The Head Master of Halisa School said he had not noticed any cases before 1992. Several inhabitants in Kaffar Sagheer mentioned they had observed a few scattered cases during 1991-1992 but the prevalence of cutaneous leishmaniasis was higher during 1993-1994.

Rough estimates of cutaneous leishmaniasis cases were made by the project team from 20 to 26 April 1994 with the help of mosque microphones in the centre of each village. The ratio of recorded cases in each village was 1.2% (8/677) for Halisa, 3.3% (23/701) for Tal Shaeer, 1.4% (29/2127) for Kaffar Sagheer, and 2.5% (35/1392) for Sheikh Najjar. The project team was satisfied with the estimated prevalence and selected the four villages for the study. The villages were randomly assigned as intervention or control villages based on the prevalence and size of the villages. Halisa and Sheikh Najjar were considered as intervention villages, Tal Shaeer and Kaffar Sagheer as control villages.

Epidemiological survey

A baseline survey was conducted at the start of the project from May to June 1994 to calculate a one year prevalence of leishmaniasis from July 1993 to June 1994 and get general information on the socio-economic status, potential factors influencing disease transmission and other determinants involving the households: age, sex, education and profession of individuals. Data about the clinical and parasitological features of cutaneous leishmaniasis was also collected from infected individuals including the time of manifestation of the disease, number of lesions and type of treatment used.

Data on the incidence of cutaneous leishmaniasis was collected twice a year in December 1994 and June 1995 for 1994-1995. Similar survey procedures were carried out in December 1995 and June 1996 during the second year post-intervention (1995-1996). Since cutaneous leishmaniasis lesions caused by *L. tropica* generally last more than six to twelve months if untreated, the surveys were able to detect most new cases. However during the third post intervention year (1996-1997), a more comprehensive approach was adopted and data was collected every month from July 1996 to June 1997. The activities and their time schedule are shown in Figure 1.

Exclusion criteria in epidemiological surveys

Cutaneous leishmaniasis immunity due to *L. tropica* is a well known phenomenon. Hence, those individuals infected before July 1993 were excluded from the total population of 4,578 in order to

arrive at a more accurate analysis of prevalence of cutaneous leishmaniasis in subsequent years. Infected individuals in one year were added to the list of immune persons and excluded from the analysis in the following years. No new individuals were added to the study population after the census in June 1994. People who had subsequently died or had permanently left the study villages were excluded from the analysis on the respective dates. Also excluded were those who were absent from the study villages for some time between July of a one year to June the next year. However, persons registered in the census who were temporarily absent were re-included in the study in the year following their return to the area. These were generally a few young individuals called for temporary military service.

Entomological sampling, surveys, and laboratory work

The entomological surveys included four households in each small village and six households in each large village which were randomly selected from a sub-sample of households with high sandfly densities recorded during a brief survey at the beginning of the study. Thus, ten households were selected in the intervention area and a similar number in the control area. Entomological surveys were carried out twice a month from mid-May to early November 1994. In 1995, the month of May was skipped, so the surveys stretched from early June to early November. Normal A4-size papers were prepared in the laboratory, numbered and left to dip in a local oil overnight. 20 such sticky papers were placed in each household as sandfly baits for 72 hours: one was nailed to each corner (at the top) of the bedroom (in each house two bedrooms), one was placed on the front wall of each bedroom, two in the kitchen, two in the stable or animal shelter and six in each courtyard. Sandfly density was then estimated by checking both sides of the paper and the data was recorded on special forms for the entomological survey.

The trapped sandflies were removed, then stored in Berlese's medium and mounted later on slides for species identification through examination of their genitalia and armatures. The work was carried out in an entomological laboratory set up in the Leishmaniasis Eradication Centre in Aleppo with the help of WHO funds and expertise. Four locally trained laboratory technicians worked on the project to determine the species and sex of the sandflies as well as their density. The work was carried out under the supervision of one of our team members, L.J., who had received training in entomology in France. The entomological surveys were besieged with several problems during 1994 and 1995, a major obstacle being the continuous refusal of members of the selected households to cooperate and complaints of damage caused to furniture and walls by the oil drops. Thus, several households which had been selected at the initial stage had to be abandoned half-way during the survey seasons and a new selection of nearby houses, which were likely to have similar sandfly density, had to be made. Furthermore, these surveys were time consuming and risked overshadowing the epidemiological surveys. Unfortunately, the entomological surveys had to be stopped early in 1996 because of escalation in non-cooperation.

Distribution and re-impregnation of bednets

Table 1. shows the timing and the quantity of pyrethroid-preimpregnated and non-impregnated bednets distributed during the study period. In May 1994, 800 pyrethroid-preimpregnated bednets (Deltamethrin SC, K-Othrine®, 20-25 mg/m²) were imported from Siamdutch Mosquito Netting, Thailand by WHO and distributed to households in the intervention villages (Halisa and Sheikh

Najjar). A similar number of non-impregnated bednets were distributed to households in the control villages (Tal Shaier and Kafer Sagheer). The number distributed to each household was proportionate to the size and structure of the family. Three sizes of bednets were distributed: single (100), double (250), and family size (450). All the bednets ordered were white. They were made of polyester, with a 156 (12 x13 holes per sq.inch) mesh and a denier of 75. On an average, one bednet was allocated to three persons (1600/4578). Unfortunately, the single-sized bednets appeared too small to cover an adult adequately. A record was kept of the number and sizes of bednets distributed to each household in order to calculate the percentage of coverage per person. As the bednets were distributed free of charge, the demand for extras kept increasing.

During May 1995, in preparation for the second year of intervention all the bednets, previously provided to the households in the intervention villages, were re-impregnated with deltamethrin SC 1% (10g/l) K-Othrine® according to the technique (Schreck and Self, 1985) recommended by the WHO experts visiting the field. It was estimated that 25 ml was needed to treat 10 m² of bednet material to obtain a concentration of 25 mg/m². The different-sized bednets were an average of 10 m² (single: 8.76m², double: 10.20m², and family size: 11.64m²). As the absorption capacity of each bednet was considered to be 450 ml of water, 25 ml of K-Othrine® was added to 425 ml of water for each bednet. The K-Othrine® was mixed thoroughly with water and the nets soaked in the solution. The impregnation was performed by the inhabitants themselves in the centre of each intervention villages with support from the project team. The nets were then laid to dry on nylon sheets.

Additional 400 and 350 family size pre-impregnated bednets were distributed in May 1995 and 1996 in the intervention villages to replace those torn or lost and to provide for new members of the households. A similar number of non-impregnated bednets were distributed to the households in the control villages. Community participation was essential to achieve success. In the control villages, the bednets were not impregnated with a placebo solution as originally planned.

Health education

Health education messages were relayed to the study population to encourage the use of bednets and every opportunity was seized to encourage the population to comply with the correct and frequent use of bednets to attain prevention. The role of sandflies in transmitting the disease was explained to the people in the intervention and control villages on several occasions including interviews, distribution and impregnation of bednets, etc. The interviewers drew the attention of the households to the importance of using bednets when sleeping to protect themselves and their children from leishmaniasis and demonstrated their proper use. The study areas were visited during the evenings to better observe the use of bednets. The schools in the study area were also visited and teachers were urged to educate their students on the importance of using bednets to protect themselves from mosquito and sandfly bites.

Clinical and parasitological surveys

An experienced dermatologist has been clinically examining all lesions suspected to be leishmaniasis as part of the project and has carried out the clinical identification of cases during the epidemiological surveys. Parasitological surveys were usually conducted by two staff members of the Centre who accompanied the dermatologist to the field to take smears from suspected cases. These were then brought to the parasitological laboratory in the Leishmaniasis Eradication Centre of Aleppo and examined by qualified staff to determine whether the parasites in the smears were *leishmania*. The results were then sent to Dr Lama Jalouk, Head of the Centre. However, no identification of species was carried out as facilities were not available.

Leishmanin test

In June 1995, a leishmanin skin test survey (Montenegro test) was conducted during the epidemiological survey. The four schools in the four villages were visited and schoolchildren, 7 to 8 and 11 to 12 year old were injected using dermo-jets with the leishmanin supplied through WHO. The tests were read 72 hours later and considered as positive when the skin induration was equal to or over 5 mm diameters. This test is useful in assessing the percentage of the infected population and, therefore, immune to reinfection.

Data processing and personnel

Data collected in the field was usually entered into a database file in a personal computer then it was processed. (Figure 1.) The epidemiological and entomological surveys and related field and laboratory work were conducted by staff members and health workers seconded from the Directorate of Health in Aleppo and from the Leishmaniasis Eradication Centre. They carried out the numbering of households, census, collection of socio-economic and epidemiological data. About ten health workers were trained for two days at the start of each survey. The team was also responsible for health education, distribution, impregnation and monitoring the use of bednets as well as other related field work.

RESULTS

Characteristics of the study population and infected individuals

In 1994, the characteristics of the study population and households in intervention and control areas were comparable in terms of numbers of households, rooms per household, use of locally made bednets, use of fans and spraying habits. (Table 2) Ownership of livestock and electrical appliances were also nearly identical for both groups. However, ownership of cars, motorcycles and tractors was higher in the control group compared with the intervention group, though only a few possess such items. The average number of persons in each household was 8.8 (2227/252) in intervention areas and 9.2 (2351/256) in control areas. The total number of rooms in the households ranged from one to eight with an average of 2.4 rooms. A bedroom is usually used by 3.8 persons. Some houses were very old and several had been occupied for more than 80 years.

Only a small percentage of heads of households (11.2%; 57/508) mentioned using locally made bednets before the intervention. One-third of the households (31.6%; 154/488) reported using insecticide spraying but usually on plants in the courtyard. At least one fan was available in three quarters of the households (74.2%; 362/488). The remaining 20 households either did not respond or their responses were missing.

Although a large percentage did not mention any specific reason for not using bednets before the start of the intervention, however some reported the following reasons: 22.4% (101/451 households) claimed that a fan was sufficient to protect them from insects; 8.6% (39/451) were too poor to afford bednets; 3.8% (17/451) felt uncomfortable under bednets; 2.7% (12/451) maintained that they were free from insect bites in the courtyards; a similar percentage claimed there were no flies in their houses; 5.8% (26/451) mentioned other reasons, e.g., new residents, large families or no knowledge about bednets. (Table 3)

Cutaneous leishmaniasis prevalence during the pre-intervention period

At the beginning, 4 578 persons were interviewed and included in the study. It was subsequently found that 344 of these had been infected before July 1993 and were consequently immune to reinfection. Furthermore, 17 non-permanent residents of the area were excluded from the study. 155 persons were infected in the whole study area between July 1993 and June 1994, viz., a prevalence of 3.7% (155/4217) in one year. The prevalence in Hasisa (4.9%; 34/689) and in Sheikh Najjar (5.1%; 69/1346) was higher than in the other two villages of Tel Shaer (3.8%; 26/682) and Kafar Sagheer (1.7%; 26/1500). However, the results of leishmanin tests conducted on schoolchildren aged 7 to 12 years in all four villages by the end of May 1995 showed that previous infection in the former group considered as the intervention area and the latter group considered as the control villages were nearly similar (28%; 69/244 and 27% 41/166 respectively).

About 60% (92/154) of the individuals infected with cutaneous leishmaniasis sought treatment during 1993-1994. (Table 4) The percentage of sufferers who visited public clinics was approximately similar to those who visited private clinics (45%; 41/92 and 47%; 43/92 respectively). Home and traditional treatments were received by a smaller percentage (21%; 19/92 and 13% 12/92 respectively). One section of infected persons used more than one type of facility or modern treatment and also underwent home or traditional treatments. About three quarters of those who used western medicine were treated with perilesional injections (74%; 57/77). The remaining quarter were treated with intramuscular injections.

Generally half (47%) of the lesions were facial. (Table 5) , one-third were on the arms (34%), and the remaining were on the legs and other parts of the body (13% and 6% respectively). (Table 4) Many had multiple lesions on their bodies and the intensity of the disease was relatively high for the whole study population (average number of lesions per infected person was 3).

Bednet distribution

The distribution of free bednets created several problems. As a rule, bednets were allotted to each household according to the number of members recorded at the time of the census. Hence, it was difficult to establish the annual increase in the number of members or to estimate the number of torn or lost bednets. People tended to exaggerate in order to obtain extra bednets free of charge which were more robust and of a better quality than those available in the local market. However, it was estimated that the yearly increase in the population in the rural area was 3.5% (Syrian 1981 census figure). It was also assumed that 10% of the bednets were lost or torn each year. From these figures it is estimated that, during the first post-intervention year, 2.8 (2227/800) persons were allocated one bednet each in the intervention area. A similar percentage of single and double bednets was distributed in the control area. This increased the number of people who had one bednet each. In 1994 and 1995 more family size bednets were distributed. Thus, in the second and third cutaneous leishmaniasis transmission seasons, it is estimated that 2.1 and 1.8 persons were covered with one bednet each in the intervention area (calculated from Table 1).

*The mean density of female *P. sergenti**

The total number of sandflies collected in the study area during 1994 and 1995 was 10,914 and 9,990 respectively. The majority of the sandflies were male *P. sergenti* and *P. papatasi*, but included other species and subspecies as well. There was no significant difference in the mean density of sandflies in the intervention area compared with the control area. The number was about 5,000 sandflies in both years for both intervention and control areas. The percentage of captured female *P. sergenti*, the only vector believed to transmit *L. tropica*, was very small and did not exceed 3.0% (607/20904) of the total number of sandflies caught in both years.

Table 6 shows the mean density of female *P. sergenti* in the selected households of the intervention and control areas during the 1994 survey season. The mean total density of female *P. sergenti* per night/m² in the intervention villages was not very different from that in the control villages (0.18 and 0.22 respectively). There was no significant difference in the mean density of sandflies between intervention and control areas indoors (bedrooms), outdoors (courtyards), or in kitchens. Table 6 and Figure 2, demonstrate the mean densities of female *P. sergenti* caught in 1994 per night/m² of

sticky paper in the intervention and control areas. However, the mean densities of female *P. sergenti* in bedrooms for both intervention and control areas were less than that in the courtyards for both areas as can be seen from Figures 2a and 2b respectively and from Table 6. Figure 2c, shows the mean density to be higher in the kitchens in the control area, but the number was very small as only two sandflies were caught in the kitchen in the intervention area and only 18 in the control area during the surveys. Figure 2d represents the mean density of the total female *P. sergenti* caught during the entire 1994 season. There are two peaks, one during June and July and another in October 1994. An additional but smaller peak occurred in mid-August. This was mainly due to the peak during that period in the courtyards in the intervention area. (Figure 2b)

During 1995 the mean density of female *P. sergenti* in the intervention and control areas was similar. (Table 7) The mean density of female *P. sergenti* per night/m² in the intervention villages was not very different from that in the control villages (0.34 and 0.28 respectively). Figures 3 a, b, c show mean sandfly densities in different locations in the households and Figure 3d shows the mean total density. Similar mean sandfly density patterns persisted throughout the season as in 1994. However, a higher mean of female *P. sergenti* density occurred in the intervention area in 1995 compared with the mean density in 1994 in the same area (0.34 and 0.18 respectively, $Z=3.5$, $P<0.001$). There was no such difference between the female *P. sergenti* mean density in the two years in the control area (0.28 and 0.22 respectively, $Z=1.31$, n.s.).

Leishmanin test results

Both intervention and control areas had nearly an equal percentage of individuals who survived without contracting cutaneous leishmaniasis before the start of the project. The leishmanin test conducted on students aged 7 to 12 during May 1995 in the schools of each village showed that the proportion of students infected at some point in their lives in the intervention and control villages were almost equal (28%; 69/244 and 26%; 62/240).

Impact of insecticide-impregnated bednets on reduction of cutaneous leishmaniasis incidence

Table 8 shows cutaneous leishmaniasis cases in each village during the pre-intervention period (July 1993 to June 1994) and the post-intervention study period (July 1994 to June 1997). During the pre-intervention period, cutaneous leishmaniasis prevalence was high in both intervention villages, Halisa (4.9%; 34/689) and Sheikh Najjar (5.1%; 69/1346). Incidence declined greatly in both villages after the introduction of insecticide-impregnated bednets coupled with health education. Both villages reached an identical cutaneous leishmaniasis incidence of 1.2% (Halisa 7/596 and Sheikh Najjar 14/1173) in the third and last year following the intervention.

In the control villages, cutaneous leishmaniasis prevalence during the pre-intervention period (July 1993 to June 1994) was 3.8% (26/682) in Tal Shaeer and 1.7% (26/1500) in Halisa. During the post intervention period, the incidence fluctuated but never declined greatly from its initial level. In the first post-intervention year, the incidence nearly doubled from the pre-intervention level. During the

second post-intervention year, the initial level was retained. The incidence declined further to 1.7% (10/580) for Tal Shaer village, but increased sharply in Kafar Sagheer village to 8.0% (108/1349).

The result of combining the villages of both categories, viz., intervention and control is seen in Table 9. *In intervention villages*, cutaneous leishmaniasis incidence declined from the pre-intervention level of 5.1% (103/2035) to 3.1% (59/1910) in the first post-intervention year. The incidence declined further in the second year of intervention to 1.4% (25/1823) and levelled off in the fourth year to 1.2% (21/1769) with an approximate fourfold reduction from the pre-intervention period.

Simultaneously, in the control area cutaneous leishmaniasis incidence doubled in the first post-intervention year from 2.4% (52/2182) to 4.6% (96/2102). In the second year, cutaneous leishmaniasis incidence regained its pre-intervention level of 2.3% (45/1985). It increased sharply in the following year (third post-intervention year) to reach 6.1% (118/1929).

Comparison of the survival curves (Figure 6) of cumulative probability of freedom from the disease summarizes the impact of insecticide treated bednets in reducing cutaneous leishmaniasis incidence. Individuals in the intervention villages had a better chance of staying free of the disease than those in the control ones.

Non-compliance with health education

In December 1994, it was learned from many heads of households in the intervention villages that they washed their bednets at least once during the six months after the distribution of the insecticide-impregnated bednets. 110 heads of households in the intervention villages claimed their bednets had not been washed at all during June-November 1994. Only 99 household heads mentioned that they washed their bednets once or more often, viz., an average of 1.95 times. In a rare incident, one housewife washed it every week. Cutaneous leishmaniasis incidence was twice as high for individuals in households where bednets were washed at least once (4.1%; 37/910) than in the households where the bednets were not washed (2.0%; 17/852, $c^2=5.7$, $P<0.05$, Table 10). Such a pattern was not significant in the control area.

DISCUSSION

For more than a decade researchers have shown the effectiveness of insecticide-impregnated bednets in preventing morbidity and mortality and other health risks from malaria in several malaria endemic countries in Africa and Asia. (Alonso *et al.*, 1993; Dolan *et al.*, 1993; Jaenson *et al.*, 1994; Stich *et al.*, 1994; Dapeng *et al.*, 1994; D'Alessandro *et al.*, 1995; D'Alessandro *et al.*, 1996; Rowland *et al.*, 1996) Field trials with treated bednets to prevent anthroponotic cutaneous leishmaniasis are currently being undertaken in a few countries, mostly with the support of the Division of Control of Tropical Diseases (CTD), of WHO. This study is one of the few intended to explore the effectiveness of pyrethroid-impregnated bednets in the control of anthroponotic cutaneous leishmaniasis in the rural areas of Aleppo, Syria.

The highly promising results of pilot field trial, should pave the way for a large scale trial in a epidemiologically similar area of Syria. The results reported here are based on data collected from only four villages, a small number for a field trial, however the results shed light on the clear impact of this technique in reducing anthroponotic cutaneous leishmaniasis incidence. Moreover, as the disease incidence was considerably high in the study population, the trial has been providing strong evidence of the desired impact. The longitudinal design of the study allowed all individuals to be followed up for three years after the distribution of the bednets thus reducing the margin of error and gradually making the estimate of previously infected individuals more accurate. Although the intervention and control areas had many characteristics in common (Table 1), more people were infected in the intervention area at the beginning of the trial. This did not create a major problem for the study as the important factor was to ensure an equal percentage of susceptible individuals in each area. In fact, the two areas had an equal percentage of previously infected individuals as shown by the leishmanin test which was performed on a sample group of similar aged schoolchildren in both areas during 1995. Although people who were infected previously were excluded from the analysis, their number may have been underestimated due to a long recall period. Another problem was keeping the study double blind. Although the study population and the team conducting the field work including the interviewers, the dermatologist and laboratory technicians were not aware which villages were intervention areas and which were control areas, the management team including the epidemiologist were aware of this. Several of the team members who participated in the impregnation in the intervention areas were not aware whether the bednets in the control areas were impregnated or not. Besides, the interviewers worked in shifts during the impregnation and only a few took part in the process. Although there were various risk factors associated with the disease incidence in both areas, the evidence that both areas were comparable reduced their effects. However, their effects were found to strengthen the impact of the treated bednets rather than reduce it.

There was no evidence in this study that the use of pyrethroid-impregnated bednets had an impact on reducing the mean total density of female *P. sergenti* in the intervention area compared with the control area. The mean density was similar in the intervention and control areas during the 1994

and 1995 transmission seasons. One would have expected that the insecticide absorbed by the bednets would have resulted in a lower mean sandfly density in the intervention area compared with the control area. However dead insects, including sandflies, were found in the mornings on and around the treated bednets during survey team visits to households in the intervention villages. This indicates a possible impact on the reduction of the overall density of the insect population, including sandflies.

Several factors may have played a role in influencing the entomological findings of this study. It is likely that the sticky paper technique was not sensitive enough in detecting a possible reduction in the mean sandfly density. Moreover, the number of villages covered in this study was too small to provide a comprehensive result. Even if a baseline survey had been conducted during the pre-intervention transmission season, it may not have provided substantial evidence of such a reduction later on. In fact, the mean total sandfly density was significantly higher in 1995 than in 1994 in the intervention area, although the disease incidence was lower in the same area. There was also some difficulty in selecting an adequate household sample size to evaluate a reduction of sandfly density because of a lack of cooperation from household members during the longitudinal study. Continuous refusal meant that households selected in the initial stages of the study had to be abandoned and a new selection made through a time consuming process with increased logistics, staff, and laboratory work. As only 3.0% of all sandflies caught were *P. sergenti*, the only known vector in transmitting anthroponotic cutaneous leishmaniasis, it was discouraging to have to put in so much effort to identify the species and sex of about 20,000 sandflies in order to obtain data on only a few. Moreover the design of the houses in the area, particularly the large bedrooms with high ceilings, meant that the sandflies had plenty of space in which to escape when repelled by the insecticide. Finally the trial should have included the use of exit traps to evaluate the excito-repellent effect of the pyrethroid used.

Human behaviour plays an important role in influencing sandfly behaviour as the insects tend to extract blood meals from human subjects thus transmitting the disease. For example, in the hot summer months people choose their sleeping place arbitrarily. From early June to the end of August they either sleep indoors or in the courtyards depending on the weather and many stay awake and watch television in the courtyards. Since the *P. sergenti* is mainly exophilic and exophagic, it is difficult to estimate the reduction in the sandfly density. This situation is different from other study areas where inhabitants do not have electricity or television and sleep early mainly indoors and also wake up early.

The difficulty in evaluating the decrease in sandfly density is confirmed by the results of several other published studies which found no significant impact of insecticide-impregnated bednets in reducing the vector population which transmits malaria or leishmaniasis. Lindsay *et al.* (1993b) found that the use of insecticide treated bednets did not have a significant impact in reducing the survival of mosquitoes in intervention villages although insecticide-treated bednets provided protection for people under the nets by reducing malaria incidence (Lindsay *et al.*, 1993a). Alexander *et al.* (1995) evaluated the impact of deltamethrin-impregnated bednets and curtains against phlebotomine sandflies in Colombia. The author found no significant difference between the overall number of sandflies collected in rooms with or without impregnated curtains. However,

significantly fewer sandflies were caught on human baits under impregnated bednets compared with sandflies collected outside the net in the same room or in unprotected rooms. Another study aimed at evaluating the impact of pyrethroid-impregnated bednets on controlling anthroponotic cutaneous leishmaniasis in Iran found no significant reduction in the sandfly population through the use of the sticky paper technique. (Nadim *et al.*, 1995)

This study has shown a considerable and consistent reduction over a certain period of time in anthroponotic cutaneous leishmaniasis incidence in the intervention area following the introduction of pyrethroid-impregnated bednets compared with the control area (Figure 4, 5, and 6). Although females *P. sergenti* were abundant in the intervention area, the results of the study suggest that their ability to transmit *L. tropica* was greatly reduced because of the treated bednets. In the first post-intervention year, the reduction in incidence from the pre-intervention year was considerable but relatively small (5.1% to 3.1%). This may have been due to various factors, the main one being a deficiency in the number of bednets distributed to the population in the intervention area. One bednet was allocated to 2.8 (2227/800) persons in the study area. Moreover, about half of these bednets (single and double size) were very small. (Table 1). Thus, the allocation exceeded three persons per bednet. Furthermore, about half of the single and double size bednets distributed in the first year were also very small, thus increasing the ratio of persons per bednet. Another factor could have been the failure of some individuals to comply with the health education messages on the proper use of bednets.

Compliance with instructions on the correct use of bednets was essential to obtain good results. Many household members did comply with the health education messages and used the bednets frequently as could be judged from the pale colour of the bednets brought for impregnation. Some claimed they watched television in the courtyard from under the bednets. Others did not bring all the bednets they received either because they were not used or were given to family members living outside the study area. In early December 1994, less than six months after the distribution of the first batch of bednets, many housewives in the intervention areas said they washed their bednets during summer and early winter (Table 10) thus inadvertently removing residual insecticide from the textile. Members of households where insecticide-impregnated bednets were washed were twice as prone to be infected than those in households where treated bednets were not washed. Unfortunately, as the bednets collect dust when people use them to sleep in courtyards or on rooftops during the hot summer months, they require washing. The results of this study suggest that if people in the intervention area had not washed their bednets during the 1994 transmission season, it is likely that the level of the first year post-intervention incidence would have been the same as that for unwashed bednet users, viz., 2.0%.

The fact that the mean sandfly density during the 1995 transmission season was significantly higher than that of 1994 (0.18 and 0.34 sandflies/night/m² respectively, $Z=3.5$, $P<0.001$) while the disease incidence was lower (3.1% and 1.4%) suggests that the use of bednets had a greater impact on reducing the disease incidence in the intervention areas. Other things being equal, one would expect

the disease incidence to follow the mean density of the disease vector. But, this pattern may not be evident as inhabitants probably take more care when the density is higher, and the nuisance from mosquitoes in this area may force the people to use bednets to protect themselves.

The consistent parallel decline in the incidence in both intervention villages (Halisa and Sheikh Najjar, Table 9) have strengthened evidence that the insecticide-impregnated bednets have produced the desired effect. However, this impact was not absolute as a relatively low cutaneous leishmaniasis incidence (1.2%) continued to occur three years after the intervention. The reason for this may have been the change in the interval of collecting the epidemiological data during the third post intervention year from six months (during the first two post-intervention years) to one month (during the third post intervention year). This means that hardly cases were missed.

It is interesting to note that treatment has not been a factor in preventing transmission of the disease in the study population. It was found that at least 60% of the patients sought treatment during 1993-94. (Table 4) The survey team thought that the presence of two private clinics in one important control village, Kafar Sagheer, would bias the results by reducing the incidence in the control area. The physicians in the two clinics in Kafar Sagheer were actively involved in the treatment of cutaneous leishmaniasis lesions. However, the high prevalence of the disease throughout the post-intervention period in the control area showed that treatment did not play a major role, although the fact that many patients interrupted treatment before the lesions healed completely may have mitigated the effects.

The intensity of the disease as manifested by the number of lesions per person was not significantly different in the intervention area compared with the control area, and the number of lesions per person was identical (2.1/person) in both areas during the first year of intervention and remained the same during the following years. However, the issue of intensity was not given much emphasis as the main aim of the project was to look into incidence rather than intensity.

The efficacy of pyrethroid-impregnated bednets observed in this study confirms the findings of another similar recent trial carried out in the Islamic Republic of Iran and also supported by WHO (CTD/TRY) (Nadim *et al.*, 1995). However, their results showed higher cutaneous leishmaniasis incidence in females in the intervention area. This was in contrast to our results which showed that there was no difference in incidence among males and females in the intervention area compared with the control area. Although there was some indication that females were significantly less infected than males during one or more years of post-intervention, the longitudinal study showed that the difference could diminish later on. Similar results were reached for children <10 years of age compared with those aged 10 and above.

In the absence of a second control area with no bednets at all, it is difficult to know whether the non-impregnated bednets had produced any impact in reducing cutaneous leishmaniasis incidence in the control villages. However the size of the mesh of the imported bednets used in this study (the same as those for mosquitoes) did not prevent the sandflies from entering into the bednet and from biting the human subject, when non-impregnated. That could explain the increase of the incidence in the control villages. However, the response of the majority of heads of households in the control

area was similar to that of those in the intervention area, namely, that the bednets were useful as a protection against insects bites. It is possible that a control area with no bednets at all could have shown an even higher impact for insecticide-impregnated bednets.

In anthroponotic foci, where, by definition, the patients are the sole reservoir, pyrethroid impregnated bednets act as a double barrier, protecting healthy people from the bite of an infected sandfly and protecting sandflies from being infected after biting patients, especially those called "recidivans cases". Those are considered as residual reservoirs are highly infective for the vector.

POLICY IMPLICATIONS

The high efficacy of insecticide-impregnated bednets in reducing anthroponotic cutaneous leishmaniasis incidence as found in this study together with similar results emerging from other trials should have important policy implications. For example, it should pave the way for less dependence on the current policy of selective residual insecticide spraying and could lead to the eventual adoption of a new policy encouraging the use of pyrethroid-impregnated bednets to control the disease in anthroponotic cutaneous leishmaniasis foci. Moreover, the extensive experience, gained in trials using the same technique for malaria, could prove helpful in making the implementation of this strategy smoother and more effective.

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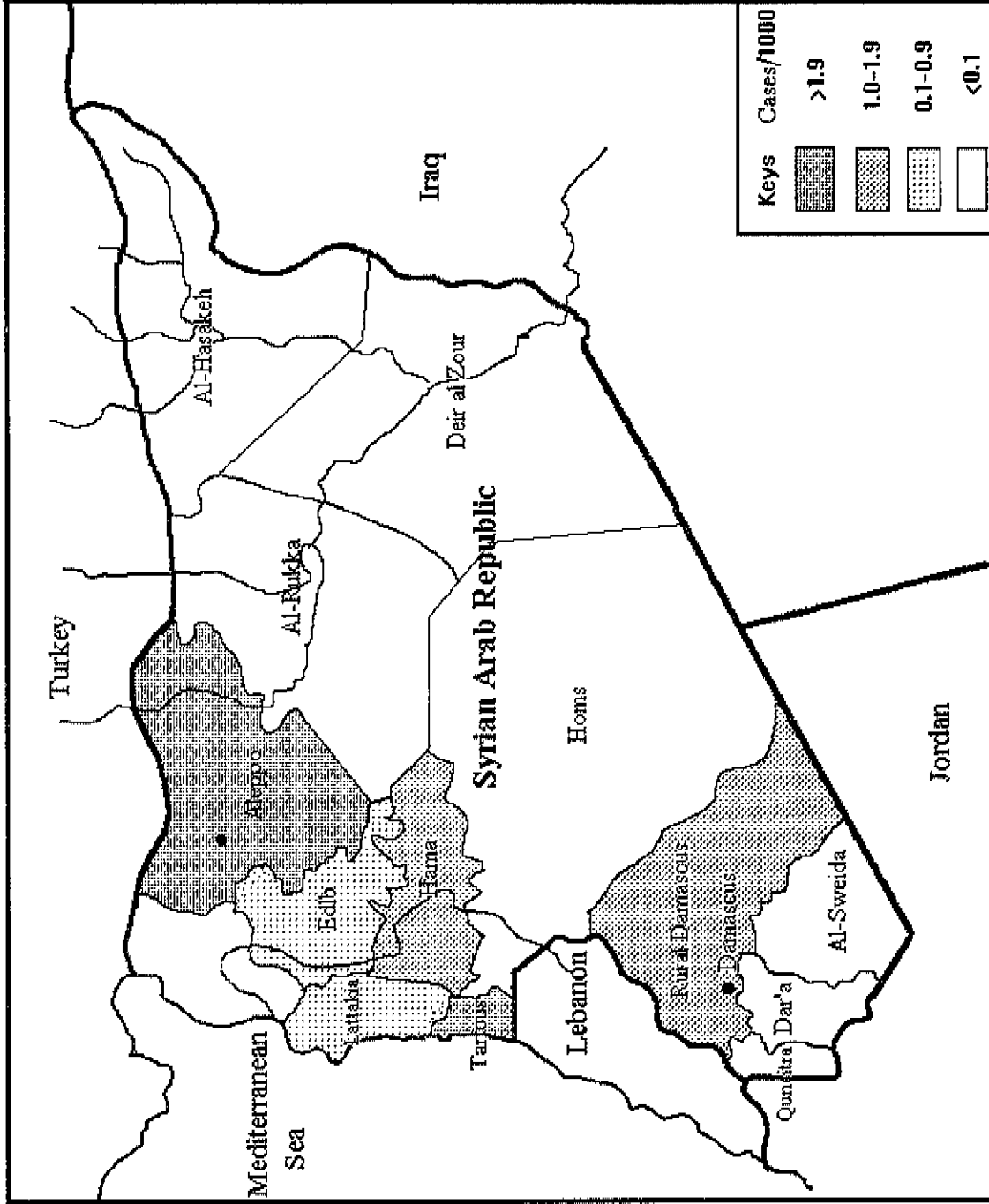
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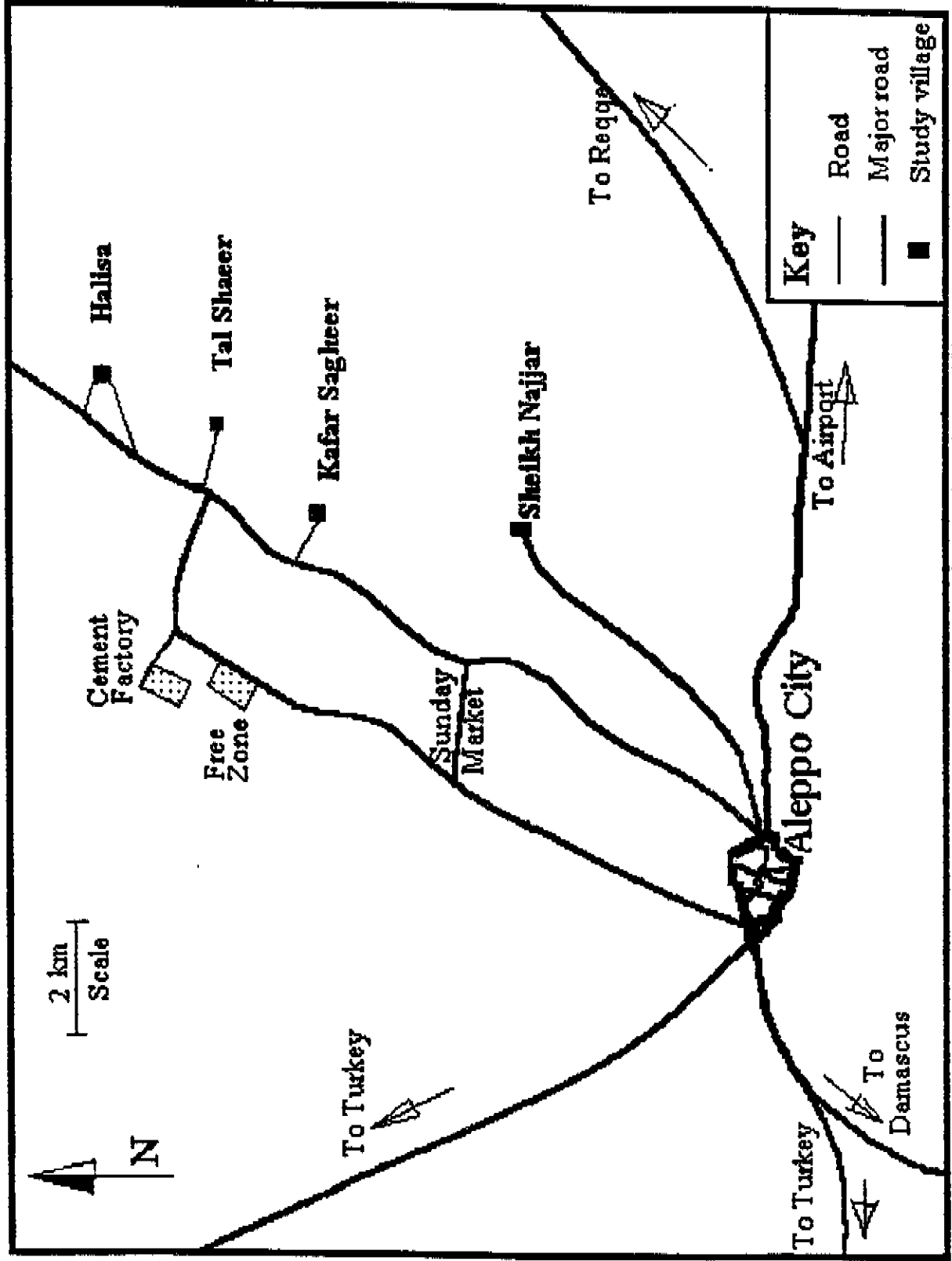
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Map 1.
Sketch-map of Syrian Arab Republic showing cutaneous leishmaniasis per 1000 of population of governorates in 1993



Map 2. Sketch-map of the study villages

Table 1. The quantity of bed nets and the timing of distribution according to the area

| Area (bed net type) | Population | June 1994* | June 1995** | May 1996** | Total |
|-----------------------------------|------------|------------|-------------|------------|-------|
| Intervention (pre-impregnated) | 2227 | 800 | 400 | 350 | 1550 |
| Control (non-impregnated) | 2351 | 800 | 400 | 350 | 1550 |
| Total | 4578 | 1600 | 800 | 700 | 3100 |

* Bed nets size distributed by area (450 family, 250 double, and 100 single).

** Family size bed nets.

Table 2. Comparison between the characteristics of intervention and control area

| Features | Intervention area | Control area | Total | Intervention/Total (%) |
|-----------------------------|-------------------|--------------|-------|------------------------|
| Population | 2227 | 2351 | 4578 | 48.6 |
| Number of households | 252 | 256 | 508 | 49.6 |
| Number of rooms | 619 | 602 | 1221 | 50.7 |
| Using bednet, fan, spraying | 186 | 215 | 401 | 46.4 |
| Sheep, goat, or cattle | 137 | 145 | 282 | 48.5 |
| Electrical appliance* | 208 | 226 | 434 | 47.9 |
| Car, motorcycle, or tractor | 59 | 86 | 145 | 40.7 |

*Television, refrigerator, or washing machine

Table 3. Reasons claimed by householders for not using bed nets before the intervention

| Reason | Response | % of total |
|----------------------------|----------|------------|
| Depended upon fan | 101 | 22.4 |
| lack of money to buy | 39 | 8.6 |
| Not used to bed net | 17 | 3.8 |
| There is no insects around | 12 | 2.7 |
| Sleep outside | 12 | 2.7 |
| Other reasons | 26 | 5.8 |
| No response/missing value | 244 | 54.0 |
| Sub-total | 451 | 88.8 |
| Using bed net already | 57 | 11.2 |
| Total | 508 | 100 |

Table 4. Clinics and types of treatment used for cutaneous leishmaniasis lesions in 1993-1994

| Treatment | Type of treatment | Response/Total | % of total |
|-------------------------------|-----------------------------------|----------------|------------|
| Treatment and facilities used | Treatment in public clinics | 41/92 | 45 |
| | Treatment in private clinics | 43/92 | 47 |
| | House treatment | 19/92 | 21 |
| | Traditional treatment | 12/92 | 13 |
| Total sought treatment | | 92/154 | 60 |
| Injection type | Intramuscular injection | 20/77 | 26 |
| | Localized injection around lesion | 57/77 | 74 |

*Multiple responses frequently occurred.

Table 5. Site of cutaneous leishmaniasis lesions (1993-1994)

| Number of lesions | Frequency | | | | Total |
|-------------------|-----------------|-----------------|----------------|---------------|------------------|
| | Face | Hands | Legs | Other | |
| 1 | 57 | 30 | 10 | 12 | 76 |
| 2 | 17 | 14 | 2 | 2 | 25 |
| 3 | 14 | 9 | 2 | 1 | 15 |
| 4 | 6 | 5 | 1 | 0 | 16 |
| 5 | 4 | 2 | 2 | 0 | 8 |
| 6 | 3 | 2 | 0 | 0 | 4 |
| 7 | 1 | 1 | 0 | 0 | 2 |
| 8 and more | 1 | 2 | 3 | 1 | 13 |
| Total (%) | 210 (47) | 150 (34) | 58 (13) | 27 (6) | 445 (100) |

Table 6. The mean density of females *P. sergenti* in the intervention and control areas in 1994

| | In-door | | Out-door | | Kitchen | | Total | |
|----------------------------------|--------------|---------|--------------|---------|--------------|---------|--------------|---------|
| | Intervention | control | Intervention | Control | Intervention | Control | Intervention | Control |
| Number of female sandflies | 55 | 52 | 55 | 84 | 2 | 18 | 112 | 154 |
| Sticky Paper area (sq.m.) | 113.1 | 117.3 | 53.5 | 70.4 | 16 | 24.4 | 182.7 | 212.1 |
| Mean density (sandfly/night.sqm) | 0.17 | 0.14 | 0.23 | 0.40 | 0.04 | 0.24 | 0.18 | 0.22 |

Table 7. The density of females *P. sergenti* in the intervention and control areas in 1995

| | In-door | | Out-door | | Kitchen | | Total | |
|----------------------------------|--------------|---------|--------------|---------|--------------|---------|--------------|---------|
| | Intervention | Control | Intervention | Control | Intervention | Control | Intervention | Control |
| Number of female sandflies | 73 | 80 | 95 | 78 | 4 | 11 | 172 | 169 |
| Sticky paper area (sq. m) | 83.5 | 78.9 | 68.8 | 83.5 | 13.1 | 23.1 | 165.4 | 185.5 |
| Mean density (sandfly/night.sqm) | 0.29 | 0.34 | 0.46 | 0.31 | 0.10 | 0.16 | 0.34 | 0.28 |

Table 8. Cutaneous leishmaniasis according to villages (July 1993 to June 1997)

| Village | July 1993-June 1994 | | July 1994-June 1995 | | July 1995-June 1996 | | July 1996-June 1997 | |
|----------------|---------------------|----------------|---------------------|---------------|---------------------|---------------|---------------------|---------------|
| | Interviewed | Prevalence (%) | Interviewed | Incidence (%) | Interviewed | Incidence (%) | Interviewed | Incidence (%) |
| I Halisa* | 689 | 34 (4.9) | 642 | 16 (2.5) | 619 | 11 (1.8) | 596 | 7 (1.2) |
| Sheikh Najjar* | 1346 | 69 (5.1) | 1268 | 43 (2.4) | 1204 | 14 (1.2) | 1173 | 14 (1.2) |
| Tal Shaier | 682 | 26 (3.8) | 647 | 41 (6.3) | 601 | 22 (3.7) | 580 | 10 (1.7) |
| Kafer Sagheer | 1500 | 26 (1.7) | 1455 | 55 (3.8) | 1384 | 23 (1.7) | 1349 | 108 (8.0) |
| Total | 4217 | 155 (3.7) | 4012 | 155 (3.9) | 3808 | 70 (1.8) | 3698 | 139 (3.8) |

* Intervention villages. The remaining are control villages

Table 9. Cutaneous leishmaniasis according to intervention and control areas (July 1993 to June 1997)

| Area | July 1993-June 1994* | | July 1994-June 1995 | | July 1995-June 1996 | | July 1996-June 1997 | |
|--------------|-------------------------|----------------|----------------------|---------------|-----------------------|---------------|-------------------------|---------------|
| | Interviewed | Prevalence (%) | Interviewed | Incidence (%) | Interviewed | Incidence (%) | Interviewed | Incidence (%) |
| Intervention | 2035 | 103 (5.1) | 1910 | 59 (3.1) | 1823 | 25 (1.4) | 1769 | 21 (1.2) |
| Control | 2182 | 52 (2.4) | 2102 | 96 (4.6) | 1985 | 45 (2.3) | 1929 | 118 (6.1) |
| Significance | $\chi^2=20.6, P<0.0001$ | | $\chi^2=5.5, P<0.05$ | | $\chi^2=3.7, P=0.053$ | | $\chi^2=61.9, P<0.0001$ | |
| Total | 4217 | 155 (3.7) | 4012 | 155 (3.9) | 3808 | 70 (1.8) | 3698 | 139 (3.8) |

*Pre-intervention.

Table 10. The impact of washing bed nets in 1994 transmission season on cutaneous leishmaniasis incidence during 1994-95

| Village | Washed their bed nets interviewed | infected (%) | Did not wash their bed nets interviewed | infected (%) | Significance |
|---------------|--------------------------------------|--------------|--|--------------|----------------------|
| Halisa | 398 | 12 (3.0) | 225 | 3 (1.3) | n.s. |
| Sheikh Najjar | 512 | 25 (4.9) | 627 | 14 (2.2) | $\chi^2=5.2, P<0.05$ |
| Total | 910 | 37 (4.1) | 852 | 17 (2.0) | $\chi^2=5.7, P<0.05$ |

Figure 2. The density of females *P. sergenti* in 1994
(a) In-door (b) Out-door

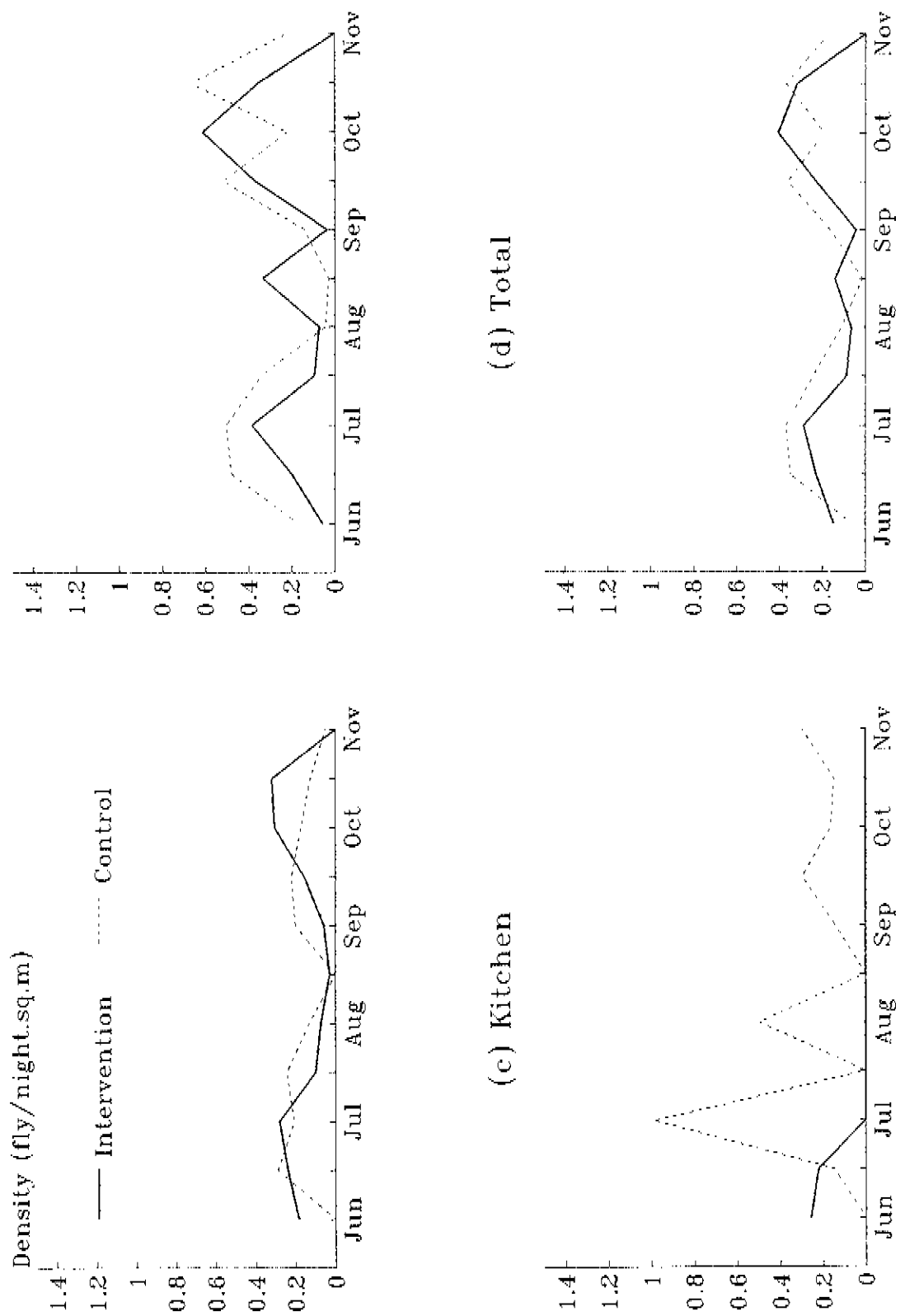


Figure 3. The density of females *P. sergenti* in 1995
(a) In-door
(b) Out-door

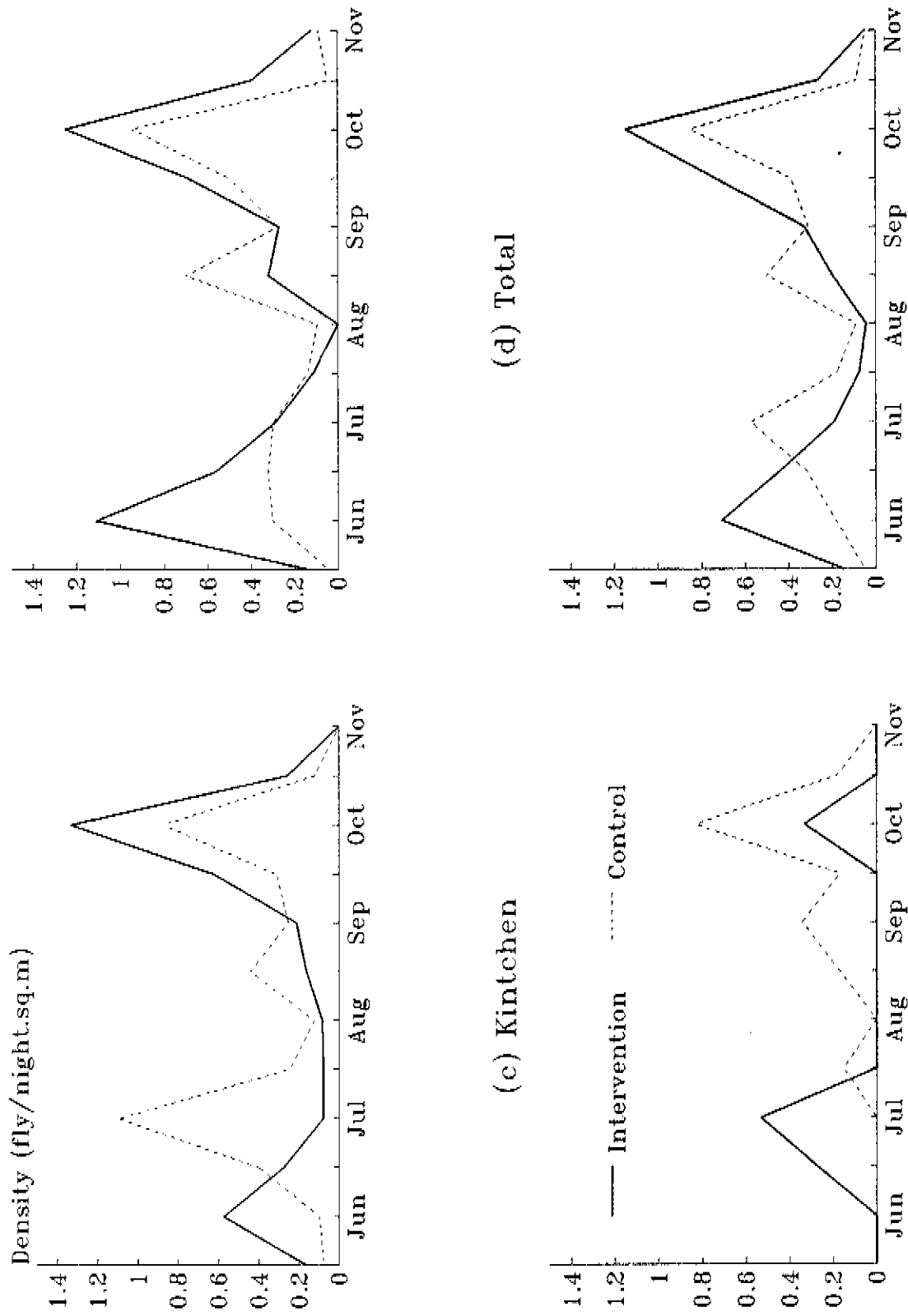


Figure 4. Cutaneous leishmaniasis according to seasons

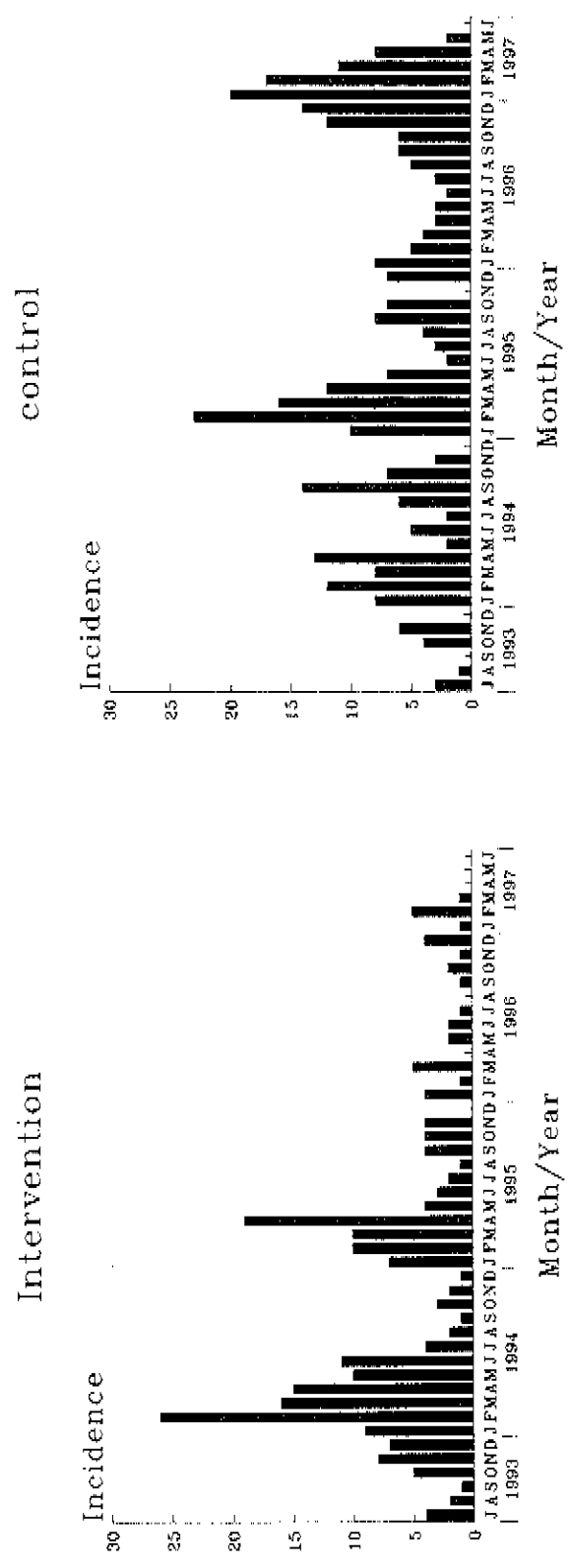


Figure 5. The impact of impregnated bed nets on incidence

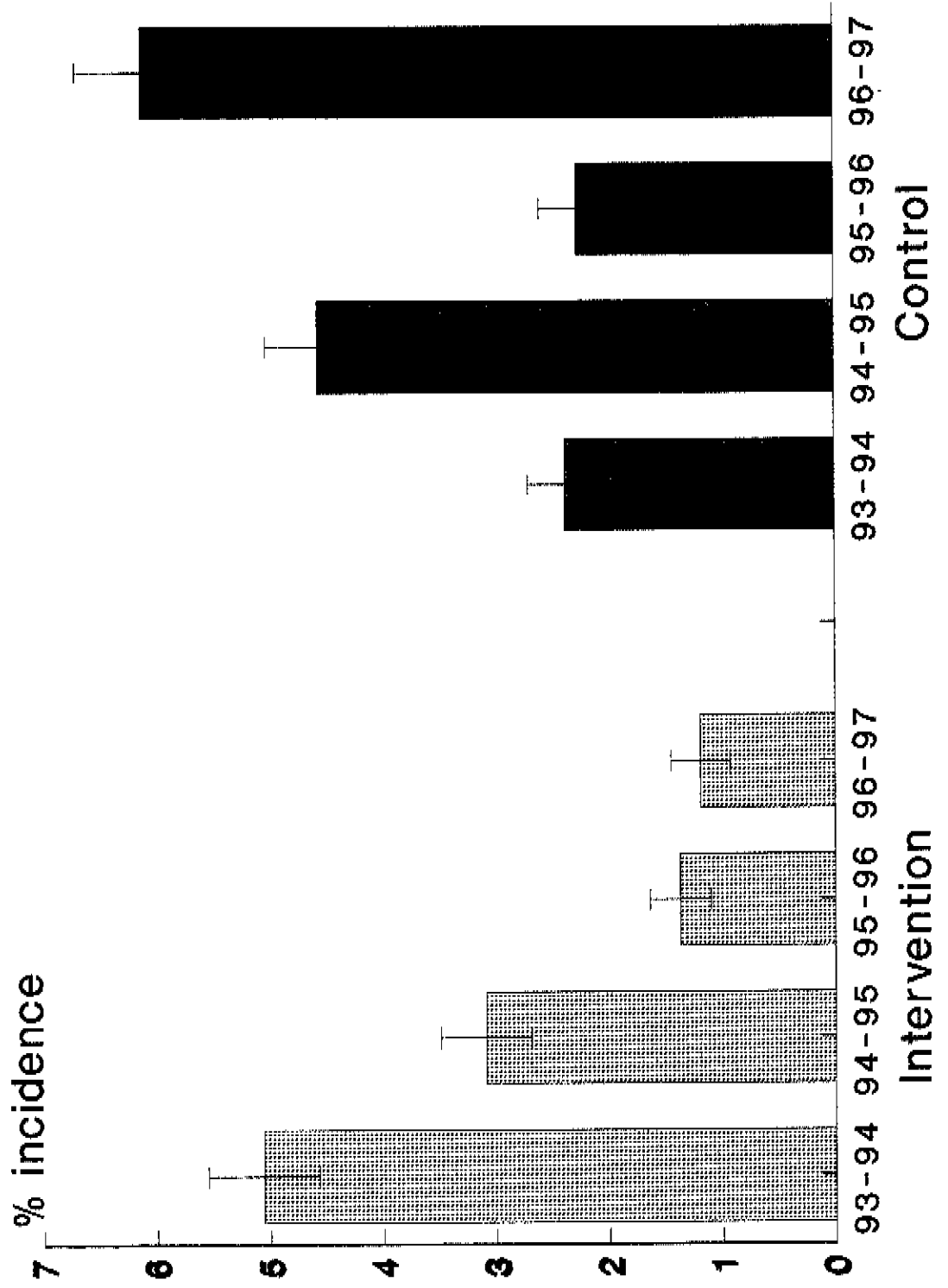


Figure 6. The cumulative probability of survival CL during post-intervention

