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WHO Epidemiologic Random Sample Surveys of Leprosy in Northern Nigeria (Katsina), Cameroon and Thailand (Khon Kaen)[1, 2, 3]

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The World Health Organization Leprosy Advisory Team (LAT) is composed of a leprologist (team leader), a statistician, and a laboratory technician.

The functions of the LAT are:

1. To collect and improve the quality of information concerning leprosy control projects;
2. To assess the results obtained; and
3. To advise regional offices and headquarters on the control measures necessary, or on special problems on which its advice is requested.

Therefore, the team is used for assessment and evaluation of leprosy field projects, and the data collected are also valuable for epidemiologic and other studies connected with leprosy patterns, assessment of therapeutic results, and frequency and types of disabilities. The team has worked in Africa and in Asia.

In this paper we shall consider some of the epidemiologic data collected by the team in Nigeria (Katsina), Cameroon and Thailand (Khon Kaen), with special reference to prevalence and lepromatous rates and leprosy in relation to sex, age, and ethnic groups.

MATERIALS AND METHODS

Material

I. *Katsina Emirate*

The Katsina Emirate comprises almost the whole area of Katsina Province, one of the twelve provinces in the Northern Region of Nigeria. Its population is about

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1,550,000, the density being approximately 160 persons per square mile. Katsina is mainly populated by two different ethnic groups, the Hausas and the Fulani.

The Hausas have a mixed ancestry, and the adoption of a common language has been the essential factor in binding them together as one people. They are generally well-built, dark-skinned, intelligent people. They practice many crafts, such as farming, weaving and cloth dyeing, leatherwork, and ornamental work in brass, copper and silver, etc. Hausa people are very good in trade; in fact they are to be found in any African country south of the Sahara practicing their favorite trading work.

Hausa houses are of two main types. In the towns they are flat-roofed with thick mud walls; in the country they are generally of circular shape with mud walls and conical straw roofs. In the country, where the population is generally very scattered, many of these circular huts are surrounded by a common wall forming a compound. Several families live in each compound, ten, twenty or even more, each family owning as many huts as the man has wives. Members of this type of community have very close relationships and it is difficult and often impossible to establish the type of contact, i.e., whether neighbor or family contact, both types being very close and meaning practically the same from the epidemiologic point of view.

The Fulani are believed to have arrived in this part of Africa some six hundred years ago. They are thought to be of Semitic origin and have characteristic racial features that make them easily recognizable. They are tall and slim, with long straight hair and light skin. Three main divisions can be considered among the Fulani:

(a) The Bororo or "Cow Fulani" keep up the traditions of the tribe, original language and the old customs of nomadic herdsmen, moving with their cattle from place to place according to the season. They are very proud and do not intermarry with other tribes. Their only occupation is taking care of their cattle, farming being against their nomadic habits. They do not eat meat, their food being largely milk and cheese and some kind of farming food, which they buy with the products from the sale of milk and butter. Their houses, which are of a temporary nature, consist of branches of trees mixed with mud or leaves.

(b) The "Settled Fulani" are some groups of the old Cow Fulani which gave up their nomadic life and settled on the land. Keeping cattle is their main occupation, although they are also farmers. However, they are seldom good at farming and their farms are generally poorly tended. Their houses are of circular shape, very similar to those of the Hausas, but less well built.

(c) The "Town Fulani" are descendants of the conquerors in the Holy War at the beginning of the last century. At present they are integrated in the ruling classes of Katsina as well as of many northern emirates. This division of the Fulani tribe lost their original customs long ago and adopted Hausa habits, dress and even language; they cannot therefore be considered as Fulani any longer, and are really Hausas.

Means of living. Agriculture is the main source of wealth in Katsina and in general in Northern Nigeria. The Hausas are excellent farmers and, besides their own food, produce crops, including varieties of guinea-corn, millet and cassava, and large amounts of peanuts and cotton for export. Even during the long dry season they manage to irrigate their gardens and produce fresh vegetables, mainly onions.

Cattle raising plays an important role in the economy of the country, mainly among Fulani people, although it is not sufficient in quality or quantity to provide the whole population with a suitable diet of meat and milk.

In general, the scanty rainfall, long dry season, and poorness of the soil, which is mostly sand, require very hard work, which scarcely covers the food necessities of the whole population. Living standards are generally low and in many places in the country extremely low. Evident symptoms of bad nutrition are frequently found among young people, probably as a result of lack of animal proteins.

Administrative divisions. The Katsina Emirate is divided administratively into 21

districts, each ruled by a district head directly appointed by the Emir. They are not only the political heads of the districts, but also the administrative chiefs of all the services of the district, including the Health Services.

This administrative division of Katsina was the base for stratifying the population in the statistical plan for the WHO Leprosy Survey in Katsina Emirate.

II. *Cameroon*

Three zones were selected for the survey. Each zone was fully representative of each climatic region of Cameroon, viz., a forest area (Sangmelina), savannah (Diamare), and highland up to 1,000 meters above sea level (Bamoun). Each zone was representative of one of the three different leprosy prevalence rates in the country, viz., Sangmelina, 10 to 20 per 1,000, Diamare 1 to 10 per 1,000, and Bamoun 20 to 30 per 1,000.

The population of Cameroon, according to the last census (1958) is about 3,173,000, which means some 7.3 inhabitants per square kilometer. The population is unequally distributed throughout the country, however; there are over-populated areas with 100 or even 200 people per square kilometer, such as the Wouri delta and some areas of the Bameliké and Diamare departments; on the other hand, there are extensive zones in the south and in the central plateau which are practically deserted. From the ethnic point of view there is a wide difference between the races of the northern region and those of the southern region.

In the north, most of the population belong to the Sudanese ethnic group (Kirdis, Guizigas, etc.); some of them, like the Foulbes, who constitute the ruling class in the north, seem to be of Semitic origin. In this region practically the whole population is Islamic, highly attached to their traditions, which are well observed. The social structure is based on a strong hierarchy, the authority of the traditional chiefs (Sultans, Lamidos) being considerable. The standard of living in this area is generally low. The main occupations are cattle raising, some rudimentary agriculture, trading, and some crafts at which the Foulbe people are skilled.

Houses are similar to those in Northern Nigeria. They are circular in shape, with mud walls and conical straw roofs, without windows, and with a gate only. Generally these huts are grouped together and surrounded by a common wall to form a compound (sarré) in which live several families belonging to the same clan. The houses are primitively furnished.

In the southern region, the population belong to the Bantu ethnic group (Doula, Bassa, Ewondo, Boulou, Fang, etc.). Most of them are Christians. In these communities the social structure is based mainly on the patriarchal clan, and the authority of the traditional chiefs is more lax. The main occupations are agriculture, hunting and fishing. People in this region are more developed, and the standard of living is much higher than in the north. The average house in the south is rectangular in shape, with mud walls and palm-leaf roofs; it is divided into several rooms and has doors and windows. Housing in the South Cameroon is rapidly being improved and many good new houses built of bricks and cement, metal roofed and well furnished, are to be found in all the villages.

The population of the Bamoun and Adanaoua departments may be regarded as transitional between those of the northern and southern regions. The Islamic religion is slightly predominant (60%), but Muslim habits are not as strict as in the north. Semi-Bantus and Sudanese groups are mixed here and speak a semi-Bantu language.

Agriculture is the main occupation of the population. In the south the main resources of the country are: cocoa, coffee, palm nuts, palm oil, bananas, and timber, besides their own food, such as cassava, millet, maize, etc. There are also some minerals, including gold, aluminum, and tin. The standard of living in South Cameroon is higher than the average standard in Africa south of the Sahara.

Main resources in the northern region are: millet and guinea-corn for food, and peanuts and cotton for export. The raising of cattle plays an important role in the

economy of this region. Milk is an important item in the diet of many of the population, mainly among the Foulbe people, and the export of cow hides is probably the most important source of wealth in North Cameroon. The standard of living is considerably lower than in the south. However, the general appearance of the people is very healthy, and it is rare to find any symptoms of bad nutrition among them.

III. *Thailand*

The population belongs to the Thai group of peoples whose original home is southwestern China. They are not of wholly unmixed Thai stock, as there has been intermingling with other ethnic groups, mainly with Chinese and Burmese.

Over 90 per cent of the total population (22,295,000) live in small villages averaging from 500 to 750 inhabitants. Only about 10 per cent live in urban communities of more than 5,000; these include the cities of Bangkok and Thom-Buri, which, together, account for most of the urban residents. Usually the villages are compact and have well-defined boundaries. They are generally located along a canal or road, or in the valleys.

Houses are usually built on pillars some two meters above ground level, the space between the ground and the floor of the house being given over to domestic animals. All the houses are built of wood, with metal or tiled roofs; only in the remotest and poorest villages are the roofs made from palm leaves. The houses comprise several rooms, and generally they are ample, clean and well-ventilated, though poorly furnished. Mosquito nets are in common use. The systems for water-supply and disposal of excreta and refuse leave much to be desired, and constitute one of the biggest problems in rural areas.

The Thai family is a simple nuclear unit averaging five or six members. Each married couple usually establishes its own house and has its own land. In rural Thailand there is no striking difference among social classes, and wealth seems to be evenly distributed. A typical community in rural areas is a small village of roughly similar houses, occupied by people of about the same financial standing.

Thailand is almost exclusively an agricultural country. More than 88 per cent of Thai people are farmers or fishermen. The prosperity of the people depends on the chief commodity, rice, the climate and conditions being particularly favorable to its production. Other important commodities produced and exported are tin, rubber, teak wood, and cattle.

Rice is the basic food in Thailand; however, the findings of dietary surveys carried out throughout the country show that the diet of the urban people is much better than that of the rural, about 60 per cent of the calorie intake being derived from rice in urban areas, and roughly 80-90 per cent in rural areas. Insufficiency of essential nutrients, such as thiamin, riboflavin, and animal protein is common.

The northeastern region, where the survey was made, is a vast plateau about 200-500 meters above sea level, and is the least favored region of Thailand, having poor soil and relatively sparse rainfall.

Methods

A random sample survey of the population was carried out in each of the countries in order to (a) establish prevalence as accurately as possible, (b) study lepromatous rates, (c) study leprosy in relation to sex, age and ethnic groups, (d) study leprosy patterns, classification and frequency, and (e) assess therapeutic results.

The planning and execution of the survey were carried out with respect to the following successive steps:

1. Study of all available leprosy statistics so as to obtain an overall picture of leprosy in the country.[5]

2. Selection of one or several areas in the country, taking into consideration geographic and climatic conditions as well as other characteristics of the population, so that these zones were fully representative of the country.

[5] In Katsina Emirate a pilot survey was carried out in order to obtain preliminary information about leprosy for the statistical plan of the general survey.

3. Determination of sample sizes, adequate for the needs of the survey and in accordance with the strictest statistical technic.

4. Stratification of the population. The rational scheme was to adopt a stratified sampling plan, using a district for the individual stratum or block. The total sample size was spread over the entire area in such a way that each block would be represented adequately, with probability proportionate to its population. The stratification would reveal the variation (if any) among the districts which might be of importance from an epidemiologic point of view.

5. Construction of sampling units and their selection. For this purpose the most recent census of each country was used. It was thus possible to obtain the census figures of each village and the population of each district or block. The whole population of each block was then divided into groups (sampling units) of 480-520 people, averaging about 500 in each unit; this figure represents the optimum that can be examined clinically in one day. The sampling unit might be a fraction of a village (if the village population was greater than 500 people), or it might be a combination of two or more small villages in order to reach the required sampling unit size. The populations of the sampling units thus constructed were listed, and running totals were made in order to select the required number of sampling units by means of the random number table used.

6. Location and listing of sampling units. Once the selection of a sampling unit was made, the village population list was consulted to locate the 500 people belonging to the sampling unit. The difference between this list and the corresponding sampling unit as recorded in the survey was found to be almost negligible; nevertheless it was corrected. Temporary visitors were excluded from the list; on the other hand, new arrivals coming to live permanently in the sampling unit (due for example to marriage, migration, etc.) were included. All persons listed were asked to appear for medical examination, at the time and place fixed with the village authorities.

7. Checking the list and medical examination of the people. Immediately before sending the sample population for examination, the list was verified again for every household, by calling out the names. Any inclusion of newborn, or omission of old people, was carefully noted, and obvious errors in sex, age, etc., were corrected. After the statistician had carefully checked every person listed, the members of each household were sent for examination; this was carried out in separate rooms, one for men and the other for women. Examination was performed by experienced male and female nurses with good training in leprosy diagnosis. The people were examined one by one, every part of the body being systematically inspected. Examinations were carried out under the immediate and constant supervision of the team leader.

Persons suspected to be suffering from leprosy were reported to the team leader leprologist, who, after clinical examination, confirmed or rejected the diagnosis. If the diagnosis of leprosy was confirmed, the corresponding leprosy assessment card was completed by the team leader. The patient was immediately sent to the laboratory technician for bacteriologic examination.

8. Processing and method of estimating prevalence of leprosy. Processing of the information was carried out at headquarters in Geneva; the ratio method for estimating the prevalence of leprosy in each country was used. It was obvious that there would be some variation in the sampling units, due to births, deaths and migrations after the last census. A substantial improvement in precision of prevalence from this ratio method was apparent because of these variations and also the possibility of finding correlation between the sampling unit population and leprosy cases belonging to the sampling unit. The prevalence rate of leprosy in each country was estimated by computing the number of cases found and the number of persons examined. The sampling error for the prevalence rate of leprosy in each country was, however, worked out.

9. Selection of leprosy cases for assessment. In addition to ascertaining the prevalence of leprosy by means of the above statistically designed sampling plan, the

LAT was interested also in collecting other information about leprosy from the patients for assessment purposes. Since the sampling plan could not provide an adequate number of cases for this purpose, it was decided to increase the number of leprosy cases by including patients under ambulatory treatment in mobile or static clinics, or in institutions. No statistical plan was considered necessary for the selection of these cases, as they did not, of course, form part of the prevalence study.

PREVALENCE AND LEPROMATOUS RATES[6]

Leprosy is highly endemic in all three countries. The prevalence is higher in Cameroon and Northern Nigeria than in Thailand (Khon Kaen), but the lepromatous rate is not so high as in the latter country. The tuberculoid rate is also higher in the first two countries, following a pattern common to many areas in Africa (Table 1).

1. Environmental, climatic and biologic factors, including genetic mechanisms, involved in the transmission of leprosy may vary from one country to another. In the countries or areas where these factors act on the population in the same way and exposure is similar, there would be a correlation between the lepromatous rate and prevalence. This was observed in Thailand in the different sample blocks of Khon Kaen province, where there was correlation between lepromatous rate and prevalence (Table 3). When we compare different countries, sometimes even two areas of the same country, the acting factors may vary. Therefore, a correlation between lepromatous rates and prevalence may or may not exist. In Cameroon such correlation does not exist between North and South (Table 2), probably because they are like different countries, the ethnic groups, climate, customs and living conditions being different.

2. A certain proportion of nonlepromatous patients, especially the tuberculoid cases in reaction (major tuberculoid), may have a certain degree of infectiveness and therefore contribute to the persistence and/or spread of the disease. The role of these cases may be important in many areas of Africa where they are particularly numerous.

TABLE 1. *Prevalence and rate of each form of leprosy in Cameroon, Northern Nigeria (Katsina) and Thailand (Khon Kaen).*

Country	Population examined	No. cases	Prevalence per 1,000	Rate per 1,000			
				L	T	I	B
Cameroon	14,473	374	25.84	2.90	14.37	8.49	—
N. Nigeria	24,538	705	28.73	2.08	13.89	12.55	0.20
Thailand	16,568	205	12.37	4.58	4.76	3.01	—

TABLE 2. *Prevalence and lepromatous rate in sample blocks of Cameroon.*

Sample block No.	Population examined	Lepromatous leprosy		
		No. cases	Rate per 1,000	Prevalence per 1,000
1	4,886	7	1.4	24.15
2	5,012	20	4.0	36.91
3	4,575	15	3.3	15.52
Total	14,473	42	2.9	25.84

Apparently the findings show that there was no correlation between lepromatous rate and prevalence. This could be explained as follows:

[6] By lepromatous rate is understood the number of these cases per 1,000 inhabitants.

TABLE 3. *Correlation between lepromatous rate and leprosy prevalence in the sampling blocks in Thailand (Khon Kaen).*

Block No.	Population examined	Lepromatous cases	Leprosy cases	Lepromatous rate per 1,000	Leprosy prevalence per 1,000
6	1,001	2	5	2.00	5.00
7	1,467	3	5	2.04	3.40
9	1,016	3	7	2.95	6.88
5	2,290	8	14	3.49	6.11
4	1,421	6	17	4.22	11.96
1	3,019	13	34	4.30	11.26
2	2,448	15	49	6.12	20.01
8	1,449	9	18	6.21	12.42
3	2,457	17	56	6.91	22.79
TOTAL	16,568	76	205	4.58	12.37

3. Greater exposure to lepromatous patients in Nigeria and Cameroon may occur, because the houses (huts) are grouped together and surrounded by a common wall, forming a compound, in which live several families belonging to the same clan.

PROPORTION AND RATE OF LEPROMATOUS AND TUBERCULOID CASES

When the data on classification of leprosy cases are examined (Table 1), it is interesting to note that in Cameroon and Northern Nigeria, as in many other African countries, the proportion of lepromatous patients is relatively low as compared with that in South American countries and some countries in Asia. Figures from the survey are as follows:

		Per cent
Cameroon	Lepromatous	11.2
	Tuberculoid	55.6
Northern Nigeria (Katsina)	Lepromatous	7.2
	Tuberculoid	48.3
Thailand (Khon Kaen)	Lepromatous	37.1
	Tuberculoid	38.5

We must add that variations in the percentages of lepromatous patients may be observed in different areas of the same country, as was seen in Cameroon. In fact the proportion of lepromatous cases varied in the three sample blocks: 5.9, 10.8 and 21.1 per cent for sample blocks Nos. 1, 2 and 3 respectively. These differences are statistically significant between blocks 1 and 3: $\chi^2 = 1.78$ (1 and 2); 3.38 (2 and 3) and 7.65 (1 and 3). On the other hand, the differences between the percentages of tuberculoid patients in the three sample blocks (1 = 55.9; 2 = 52.4, and 3 = 63.3) are statistically insignificant.

If we take into consideration the lepromatous rate, we see that the rates in Cameroon and Northern Nigeria are relatively high, more than we could expect, considering only the proportion of lepromatous cases among other forms of leprosy. This may be explained by the high prevalence rate. On the other hand, the relatively high lepromatous rates (usually higher than those observed in South America) would explain the persistence or spread of leprosy in Cameroon, Northern Nigeria and probably in other African countries. In addition to lepromatous patients, undoubtedly the most important source of infection, tuberculoid patients in reaction (major tuberculoid), may also play a role in the spread of leprosy, as they are numerous and may temporarily be bacteriologically positive.

The lepromatous rate in Thailand (4.58 per 1,000) was significantly higher than in the Cameroon (2.90 per 1,000) and Northern Nigeria (2.08 per 1,000), while the tuberculoid rate was significantly higher in the last two countries (Cameroon 14.37 per 1,000; Northern Nigeria 13.89 per 1,000, and Thailand 4.76 per 1,000). It is true that

the leprosy prevalence rate is at least twice as high in the two African countries, and therefore the tuberculoid rate is also increased; even so, this rate is higher than in Thailand. We do not have a satisfactory explanation for this fact; it is possible that genetic mechanisms may be involved.

LEPROSY AND SEX

Among data collected for study of the rates of leprosy among males and females and the form of the disease among them, those obtained in intensive surveys usually are the most useful and more free of bias. Such surveys undertaken by Doull *et al.*[15] in Cebu, Philippines, Nagai [21] in Kakai Islands, Innes [18] in the British Solomon Islands, Lowe [20] in West Bengal, India, and Guinto and Rodriguez [17] in Talisay (Cebu), Philippines, have shown that: (1) the leprosy rate is higher in males; (2) such difference starts to be observed after 14 years of age, and (3) lepromatous cases are more often observed in males.

Degotte [11] in an intensive survey in the Belgian Congo, did not observe such differences, and Del Favero [12] in Candelas, Brazil, noticed that the leprosy rate was slightly higher in males, but only in the adults. In the Nauru epidemic, males and females, children or adults, were similarly infected and acquired the disease [6, 27].

The differences observed have been explained by a greater exposure of the males, and also, according to some authors, by a lower degree of resistance.

Prevalence. The population examined by random survey, the leprosy cases, and the rates in males and females, are shown in Table 4. In Thailand the differences in prevalence rates for the two sexes are statistically insignificant. The differences are significant in Katsina (Nigeria) and in Cameroon. The table shows that the leprosy prevalence rate is higher in females in Katsina, but higher in males in Cameroon, while in Thailand the rates are similar. As far as can be determined from consideration of these data, there is no indication of a greater susceptibility of males or females to the contraction of leprosy. The differences in rates would depend on the degree of exposure to the disease, living conditions, etc., which would vary in the different areas.

Proportion of lepromatous, tuberculoid and indeterminate leprosy in males and females. The differences between the ratios of lepromatous leprosy in males and females are significant in Thailand and Nigeria (Table 5). The difference is significant for tuberculoid leprosy in Nigeria and Cameroon. A higher proportion of lepromatous cases in males was observed in Thailand and Nigeria, while in Nigeria and Cameroon females had a higher percentage of tuberculoid leprosy.

The frequency of lepromatous, indeterminate, tuberculoid, and borderline leprosy in males and females can be seen more properly when the rate per 1,000 of each form in the population is studied.

Lepromatous, tuberculoid, indeterminate, and borderline rates in males and females. The data are grouped in Table 6. In Cameroon, the lepromatous rate is more than twice as high in men as in women, the difference being significant. The lepromatous rate also is significantly higher in men in Nigeria (Katsina) and Thailand. Differences in lepromatous rates between males and females may vary in the same country, as observed in Cameroon (blocks 1, 2 and 3, Table 7).

Considered singly, these data would in-

TABLE 4. *Leprosy rates in males and females in Cameroon, Northern Nigeria (Katsina) and Thailand (Khon Kaen).*

Country	Males			Females		
	Population examined	No. cases	Rate per 1,000	Population examined	No. cases	Rate per 1,000
Cameroon	7,449	217	29.13	7,024	157	22.35
N. Nigeria	12,284	323	26.29	12,254	382	31.17
Thailand	7,573	107	14.12	8,995	98	10.89

TABLE 5. *Proportion of lepromatous, indeterminate, tuberculoid, and borderline leprosy among males and females in Thailand (Khon Kaen), Northern Nigeria (Katsina) and Cameroon.*

	Thailand				N. Nigeria				Cameroon			
	Male		Female		Male		Female		Male		Female	
Classification	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Lepromatous	47	43.9	29	29.6	34	10.5	17	4.5	30	13.8	12	7.7
Indeterminate	24	22.4	26	26.5	169	52.3	140	36.6	79	36.4	44	28.0
Tuberculoid	36	33.7	43	43.9	118	36.6	222	58.1	107	49.3	101	64.3
Borderline	0	0.0	0	0.0	2	0.6	3	0.8	1	0.5	0	0.0
TOTAL	107		98		323		382		217		157	

TABLE 6. *Lepromatous, tuberculoid, indeterminate, and borderline rates per thousand among males and females in Cameroon, Northern Nigeria (Katsina) and Thailand (Khon Kaen).*

		Population	Lepromatous		Tuberculoid		Indeterminate		Borderline	
Country	Sex	examined	No.	Rate	No.	Rate	No.	Rate	No.	Rate
Cameroon	M	7,489	30	4.0	107	14.4	79	10.6	1	0.1
	F	7,023	12	1.7	101	14.4	44	6.3	0	0.0
N. Nigeria	M	12,284	34	2.77	118	9.6	169	13.8	2	0.2
	F	12,254	17	1.39	222	18.1	140	11.4	3	0.2
Thailand	M	7,573	47	6.20	36	4.8	24	3.2	0	0.0
	F	8,995	29	3.22	43	4.8	26	2.9	0	0.0

TABLE 7. *Comparative lepromatous rate between sexes in Cameroon.*

Sample block No.	Sex	Population examined	Lepromatous cases	Lepromatous rate per 1,000
1	M	2,329	6	2.6
	F	2,557	1	0.4
2	M	2,783	15	5.4
	F	2,229	5	2.2
3	M	2,337	9	3.6
	F	2,238	6	2.7
TOTAL	M	7,449	30	4.0
	F	7,024	12	1.7

dicate a higher susceptibility of males to the lepromatous type of the disease. However, these findings must also be considered in relation to other data.

The indeterminate rate in males and females (Table 6) was similar in Thailand and Nigeria, but higher in males in Cameroon.

There was no difference in the tuberculoid rate (Table 6) in Cameroon and Thailand, but in Nigeria the rate was higher in females.

As tuberculoid leprosy indicates a relative resistance of the host to *Mycobacterium leprae*, we can deduce that in Cameroon and Thailand males and females would have a similar resistance; however, this was higher in the females of Nigeria, who, on the other hand, had a higher leprosy prevalence. We may assume that in the first two countries males and females have a similar resistance and that differences in prevalence could be determined by the degree of exposure.

What are the factors that determine such differences between males and females?

What role do the genetic mechanisms play? Only a detailed study of the different factors involved in the transmission of leprosy and lepromin testing in each area might bring some explanation of the variations observed.

General appraisal of the data collected. The data obtained in the three countries must not be considered singly but all together and in conjunction with other data and observations, in order to ascertain whether the differences observed in males and females in the epidemiologic data depend on greater exposure or on the degree of resistance to the infection. The following facts are noteworthy:

1. The lepromin reactivity of males and females can give useful indications on resistance since "a positive lepromin test is regarded as an expression of a certain amount of resistance to *M. leprae* directly proportionate to the degree of positivity." [10]

Studies with the lepromin test have not shown significant differences in males and females: Rotberg [23] found 50.2 per cent of positive reactions in 179 young males up to 15 years of age and 42.6 per cent in 136 females, all contacts of leprosy parents. Lara [19] confirmed these results in 110 children under 18 months of age, and Guinto *et al.* [16] observed in children and adults 66.5 per cent of positivity in 776 males and 69.9 per cent in 1,075 females. Del Favero [12] did not observe any differences in results in males and females in an intensive survey of Candelas, Brazil. Souza Campos and Souza Lima [25] noted 97.6 per cent of lepromin positivity in females and 84.2 per cent in males.

The results of lepromin reactivity, therefore, tend to indicate that males and females have a similar resistance to *M. leprae*. If these data are confirmed by further studies, it could be deduced that the degree of exposure, living conditions, and other factors, are responsible for the differences observed in the leprosy rates and lepromatous rates. More intensive action of these factors in lepromin-negative males could account for the development of more lepromatous cases among them.

2. The leprosy rate is similar in boys and girls up to 14 years of age [5, 7, 9, 12, 15].

3. In the Nauru epidemic the leprosy rate was similar in males and females [1, 27].

In our own material, obtained by random surveys, the prevalence rate in males and females varied from one country to another: it was similar in Thailand, higher in males in Cameroon, and higher in females in Katsina. The indeterminate rate was higher in males in Cameroon. On the whole, these data do not show striking differences between males and females. However, the lepromatous rate in the three countries was significantly higher in males. This confirms the findings obtained in intensive surveys by Doull *et al.* [15] in Cebu, Philippines, Lowe [20] in West Bengal, India, and Guinto and Rodriguez [17] in Talisay, Cebu, Philippines. Souza Campos *et al.* [24] also observed more lepromatous cases among males in 2,881 leprosy patients of São Paulo, Brazil.

It would seem; therefore, that after puberty, physiologic and other factors or differences in living conditions would predispose males to have more lepromatous leprosy. If, in the light of the data available on lepromin reactivity, we admit that males and females have a similar resistance to leprosy, we may assume that after puberty several factors, environmental, intercurrent diseases, etc., may act more strongly in the male lepromin-negative patients, leading to the lepromatous type of the disease.

From the available data, and especially the results of lepromin reactivity, it seems that in a general way males and females have a similar resistance to leprosy, but that the factors involved in the transmission and spread of the disease, including those connected with genetic mechanisms, could determine in certain countries and/or areas the different epidemiologic aspects noted in males and females. Random sampling surveys and intensive surveys and further studies on lepromin reactivity, the influence of genetic mechanisms, and environmental and other factors, among males and females, should be made to provide more data for the clarification of various points, especially the higher lepromatous rates among males.

LEPROSY AND AGE

Leprologists agree that leprosy may be contracted at any age. It has been observed in children, young adults, adults, and old people. There is no agreement, however, concerning the following questions: Do the first signs of leprosy appear more commonly in children or in adults? Are children more susceptible to the disease than adults, or is it simply that they have been exposed earlier to leprosy? The subject is important for the control of the disease, for if children are more susceptible to leprosy they will need more accurate surveillance.

In a limited area of the Congo (Leopoldville) Degotte ([11]) observed higher leprosy prevalence in adults. In the Philippines Doull *et al.* ([15]), in an intensive survey (Cordova, Cebu), registered high prevalence rates in the age group 10-14 years, followed by the age group 15-19 years. In the Philippines Rodriguez ([22]) confirmed the report that the highest prevalence was in the age group 10-14 years. In Indonesia, among household contacts, Boenjamin ([5]) observed a predominance of leprosy in children. In Nauru, among leprosy cases, the proportion of individuals of 0-20 years was 52.9 per cent in 1924 ([26]), 37.9 per cent in 1928 ([1]), 60.5 per cent in 1937 ([8]) and 69.2 per cent in 1952 ([27]). The last named two authors concluded that after the first phase of the epidemic, leprosy became more prevalent in the lower age groups.

On the basis of a study of leprosy prevalence in natives and immigrants from nonendemic areas in the State of São Paulo, Brazil, Bechelli and Rotberg ([3]) stated that exposure played a preponderant role in determining an earlier onset of the disease in the natives and a later onset in the foreigners. Therefore in endemic areas leprosy tends to be more prevalent in children or young adults. In view of the epidemiologic data and the results of the lepromin test, Bechelli and Rotberg ([4]) and Bechelli ([2]) concluded that the higher prevalence of leprosy in children or adults, or in the different age groups, depends on exposure to the disease either earlier or later in life, and on the resistance of the individuals exposed.

According to Doull ([13]), "the age at which leprosy is contracted depends primarily upon opportunities for exposure, but . . . in areas where the disease is common the controlling factor is the acquirement of resistance from unknown causes."

Some difficulties hamper the proper study of the subject: (1) many patients do not know their exact age; therefore, in the LAT surveys the following age groups were considered: 0-1, 1-4, 5-14, 15-44 and 45+ years; (2) it is very difficult to determine the onset of the disease; (3) wide variations occur in the incubation period; (4) generally many years elapse before a patient shows evident signs of lepromatous leprosy. It is therefore understandable that in the majority of fairly advanced lepromatous patients, 25 to 30 years old, the onset of the disease might have been 10 years previously or even longer; if we add 3-5 years for an average incubation period, we may easily estimate that the infection started 13 or 15 years earlier, and therefore was acquired early in life.

Comparative Prevalence Among Age Groups

Northern Nigeria. The leprosy prevalence rate increased from 2.10 per 1,000 in the age group 1-4 years to 50.78 in that of 45+. The rates were similar for the age groups 5-14 and 15-44 (Table 8). The reason for this seems to be an accumulation of cases in the older age groups, where there are many patients who have had the disease for a long time. In fact, when studying *onset*, we shall see that the distribution of leprosy cases in each age group is different.

TABLE 8. *Comparative leprosy prevalence between age groups in Northern Nigeria (Katsina).*

Age group (years)	Population examined	No. cases	Prevalence per 1,000
0-1	1,110	0	0
1-4	3,801	8	2.10
5-14	5,370	175	32.59
15-44	12,012	408	33.66
45 & over	2,245	114	50.78
TOTAL	24,538	705	28.73

Cameroon. The same fact was observed in the Cameroon, the tendency being toward higher prevalence among older people (Table 9). Nevertheless, there was a very interesting difference among the three sample blocks as far as leprosy prevalence in age groups was concerned. In sample block No. 1 (Sangmelina) the prevalence among children (age group 0-14 years) was 1.1 per 1,000, and among adults (age group 15 years and over) 37.1, the child/adult ratio being 1:33.7.

TABLE 9. *Comparative leprosy prevalence between age groups in Cameroon.*

Age group (years)	Population examined	No. cases	Prevalence per 1,000
0-1	425	0	0
1-4	1,809	2	1.5
5-14	3,201	24	7.5
15-44	6,335	191	30.1
45 & over	2,703	157	58.1
TOTAL	14,473	374	25.8

In sample block No. 2, the prevalence rate among children (0-14 years) was 6.1 per 1,000, and among adults (15 years and over) 62.4, the child/adult ratio being 1:10.2.

In sample block No. 3 the prevalence rate among children (0-14 years) was 7.1 per 1,000, and among adults (15 years and over) 19.2 per 1,000, the child/adult ratio being 1:2.7.

The differences are significant for blocks 1 and 2, and for 1 and 3, as indicated by the following figures:

$\chi^2 = 6.3$ between blocks 1 and 2
$\chi^2 = 0.13$ between blocks 2 and 3
$\chi^2 = 7.4$ between blocks 1 and 3

Therefore, in the same region, leprosy prevalence among children and adults may vary from one area to another.

Thailand (Khon Kaen). In Thailand, as in Nigeria and Cameroon, leprosy prevalence was higher in older people (Table 10). However, the age at the onset of the disease varied. Grouping only the rates of prevalence (Table 11), we noted that in Nigeria the prevalence in children (5-14 years) was higher than in the other two countries, including Cameroon, in which the prevalence for all the population examined was similar to that of Nigeria. Such a high rate indicates that in Northern Nigeria (Katsina) exposure to leprosy would have started earlier than in Cameroon.

TABLE 10. *Comparative leprosy prevalence between age groups in Thailand (Khon Kaen).*

Age group (years)	Population examined	No. cases	Prevalence per 1,000
0-1	903	0	0
1-4	3,145	1	0.31
5-14	4,301	14	3.25
15-44	5,986	117	19.54
45 & over	2,233	73	32.69
TOTAL	16,568	205	12.37

Onset of the Disease

The data concern all patients taken in both the sample survey and from outside the sample (leprośaria, mobile and static units) in order to increase the efficiency of the interpretation of results (Table 12).

The onset of the disease was more frequent in the age group 15-44 years, followed by the 5-14 years group in both Northern Nigeria and Cameroon, while in Thailand it was more frequent in the age group 5-14 years, followed by the group 15-44 years.

The data show that the disease may start earlier or later in life according to the region, depending on the factors involved in the transmission of leprosy, chiefly of exposure, as we shall see later.

TABLE 11. *Comparative leprosy prevalence in age groups in Cameroon, Thailand (Khon Kaen) and Northern Nigeria (Katsina).*

Age group (years)	Prevalence per 1,000		
	Cameroon	Thailand	N. Nigeria
0-1	0	0	0
1-4	1.5	0.31	2.10
5-14	7.5	3.25	32.59
15-44	30.1	19.54	33.66
45 & over	58.1	32.69	50.78

TABLE 12. *Age at onset of leprosy in Northern Nigeria (Katsina), Cameroon and Thailand (Khon Kaen).*

Age groups (years)	N. Nigeria		Cameroon		Thailand	
	No.	%	No.	%	No.	%
0-1	2	0.12	0	—	0	—
1-4	80	4.89	54	3.5	14	1.4
5-14	514	31.46	377	24.5	536	54.5
15-44	943	57.72	961	62.4	411	41.8
45 & over	95	5.81	148	9.6	23	2.3
TOTAL	1,634	100.00	1,540	100.00	984	100.00

TABLE 13. *Classification of leprosy patients by age and rate per 1,000 in Northern Nigeria (Katsina).*

Age group (years)	Population examined	Lepromatous		Tuberculoid		Indeterminate		Borderline		Prevalence per 1,000
		No.	Rate	No.	Rate	No.	Rate	No.	Rate	
0-1	1,110	0	0.0	0	0.0	0	0.0	0	0.0	0
1-4	3,801	0	0.0	5	1.3	3	0.8	0	0.0	2.10
5-14	5,370	3	0.56	91	16.9	81	15.1	0	0.0	32.59
15-44	12,012	28	2.33	198	16.5	180	15.0	2	0.2	33.66
45 & over	2,245	20	8.91	47	20.9	44	19.6	3	1.3	50.78
	24,538	51		341		308		5		

Lepromatous, Tuberculoid and Indeterminate Rate by Age Group

Northern Nigeria (Katsina). The lepromatous rate in the 45 years and over group was 8.91 per 1,000, decreased to 2.33 per 1,000 in the age group 15-44 years, was only 0.56 per 1,000 in the group 5-14 years, and was zero in the age groups 0-1 and 1-4 (Table 13). These differences are highly significant, indicating a strong correlation between lepromatous rate and age, the tendency being toward a higher lepromatous rate in older people[7].

The tuberculoid rates per 1,000 were 1.3, 16.9, 16.5 and 20.9 respectively in the age groups 1-4, 5-14, 15-44, and 45+. We see that the older groups of population, 15-44 and 45+, were capable of developing the tuberculoid type of the disease as often as the group 5-14. The rate was much lower in the age group 1-4[8]. These figures give a better idea of the capacity of the patients of different age groups to develop the tuberculoid type of leprosy, since the studies based on the proportion of the different forms of the disease in each age group very often lead to the conclusion that younger patients, especially below 5 years, are more prone to develop tuberculoid leprosy. The misinterpretation is understandable, for in the studies based on the proportion of each form of the disease, the absence or reduced number of lepromatous cases in the age groups 0-4 and 5-9 years caused an indirect increase in the proportion of tuberculoid and indeterminate cases. In fact, lepromatous cases usually develop from indeterminate leprosy and this evolution usually takes some years. These facts lead some authors to state that in children leprosy is more benign.

On the other hand, in the light of the data obtained, we cannot go to the other extreme and state that patients from 1-4

[7] The differences between lepromatous rates among the patients 45 + and the other age groups are highly significant. The differences between patients of 15-44 years and those in the age groups 5-14 and 1-4 are also significant.

[8] The differences in tuberculoid rates between the patients of age groups 5-14, 15-44 and 45 + and the patients 1-4 years old, are highly significant (at the 1% probability level). The difference between the 45 + and the 5-14 and 15-44 age groups was not significant.

TABLE 14. *Classification of leprosy patients by age and rate per 1,000 in Cameroon.*

Age group (years)	Population examined	Lepromatous		Tuberculoid		Indeterminate		Borderline		Prevalence per 1,000
		No.	Rate	No.	Rate	No.	Rate	No.	Rate	
0-1	425	0	0.0	0	0.0	0	0.0	0	0.0	0
1-4	1,809	0	0.0	1	0.6	1	0.6	0	0.0	1.5
5-14	3,201	1	0.3	20	6.2	3	0.9	0	0.0	7.5
15-44	6,335	23	3.6	93	14.7	74	11.7	1	0.2	30.1
45 & over	2,703	18	6.7	94	34.8	45	16.4	0	0.0	58.1
	14,473	42		208		123		1		

years of age are less resistant, because among them we have found a rate of only 1.3 per 1,000 of tuberculoid leprosy, which is much lower than the rates observed in other age groups. This may be explained by the fact that the leprosy rate among children 1-4 was 2.10 per 1,000, while in the subsequent age groups it was 32.59, 33.66 and 50.78 per 1,000. The usually long incubation period of leprosy also explains why the disease is less common in the 0-4 and 5-9 age groups.

The rate of indeterminate leprosy follows about the same pattern as the tuberculoid rate.

Considering all the rates as a whole, we see that patients in the 5-14, 15-44 and 45 + age groups seemed to have a similar capacity to develop tuberculoid and indeterminate leprosy. The lower tuberculoid rate in the 0-4 age group would depend on the low prevalence rate in such age group. The higher rate of lepromatous cases as the ages rose depended on the accumulation of lepromatous cases among older people, as there was more time for the indeterminate cases to evolve to that type of the disease.

According to these data, resistance to *M. leprae* in Nigeria (Katsina) would be similar in the different age groups, and the difference in prevalence would depend chiefly on the earlier or later exposure to leprosy bacilli. When the exposure starts early in life, children and young adults have higher leprosy rates; on the contrary, when adults are more exposed to leprosy (for instance, immigrants in endemic areas), higher leprosy rates are observed among older people. The conclusion is similar to that of Bechelli and Rotberg [3] based on material collected in the State of São Paulo, Brazil. The different prevalence rates among children and adults in the three sample blocks of Cameroon, referred to on page 234, offer support to this conclusion.

Cameroon. The data indicate that a higher rate of lepromatous leprosy was observed in the older age groups, as well as of tuberculoid and indeterminate rates (Table 14)[9]. This would be explained by the higher prevalence rates also observed in older age groups. Therefore, in a general way, the L, T and I rates in age groups seem to follow the same pattern as in Northern Nigeria and support the deduction drawn concerning this country.

Thailand (Khon Kaen). As in Cameroon, the L, T and I rates are higher in the older age groups[10], but the prevalence rate is also higher in these age groups (Table 15).

General appraisal of the data. The data concerning the onset of the disease showed that it was more frequent in the age groups 5-14 and 15-44 years. This would be expected in highly endemic countries where children or young adults have the oppor-

[9] The lepromatous rate was significantly higher in the age groups 15-44 and 45+ (at the 1% probability level); the difference between age groups 15-44 and 45 + was not significant. The difference in tuberculoid rates between each age groups 15-44 and 45+ was not significant. The indeterminate rate was significantly higher in age groups 15-44 and 45+; the difference in rates in these two age groups was not significant.

[10] The differences between lepromatous rates among the patients 45+ years old and the other age groups were highly significant, and also between 15-44 and the other age groups. The same occurred in the tuberculoid rates. The indeterminate rates in age groups 15-44 and 45+ were significantly higher than in the other age groups.

TABLE 15. *Classification of leprosy patients by age and rate per 1,000 in Thailand (Khon Kaen).*

Age group (years)	Population examined	Lepromatous		Tuberculoid		Indeterminate		Borderline		Prevalence per 1,000
		No.	Rate	No.	Rate	No.	Rate	No.	Rate	
0-1	903	0	0.0	0	0.0	0	0.0	0	0.0	0
1-4	3,134	0	0.0	0	0.0	1	0.3	0	0.0	0.31
5-14	4,301	0	0.0	9	2.1	5	1.2	0	0.0	3.35
15-44	5,986	44	7.4	41	6.8	32	5.3	0	0.0	19.54
45 & over	2,233	32	14.3	29	13.0	12	5.4	0	0.0	32.69
	16,568	76	4.6	79	4.8	50	3.0	0	0.0	12.37

tunity of being exposed to leprosy. Those more susceptible will acquire the disease and the more resistant will be able to resist it throughout their lives. Therefore, the oldest group of the population is formed by a majority of people already exposed to leprosy and resistant to it, and of a minority in which a proportionately reduced number is prone to acquire the disease after exposure to *M. leprae*. Children exposed from 0-4 years usually do not present the disease at this age, since the incubation period is, on an average, 3-5 years. Perhaps many of the oldest people exposed to *M. leprae* late in life will not show signs of the disease in view of the long incubation period, and may die before leprosy manifests itself.

On the other hand, the data from sample blocks indicate that the onset of the disease in a certain region may vary from area to area. These variations do not seem to be determined to a large extent by variations of resistance in age groups in each area, in view of the data concerning L, T and I rates. It appears that earlier or later exposure is responsible for such variation.

From the study of L, T and I rates in the three countries it appears that individuals have similar resistance to *M. leprae* in the different age groups and are similarly capable of developing tuberculoid or lepromatous leprosy.

In the light of our data the difference in prevalence in the various age groups would depend chiefly on earlier or later exposure to *M. leprae*. This is confirmed by the observation made in countries with a great number of immigrants from countries where leprosy is not endemic, among whom the onset of the disease is observed in the older age groups more often than in the native population.

LEPROSY IN ETHNIC GROUPS

Northern Nigeria (Katsina). The study was made in Northern Nigeria (Katsina). Reference to the Hausa and Fulani groups was made in the section on MATERIALS AND METHODS.

Prevalence. The prevalence of leprosy in the Hausa group was 29.10 per 1,000 (Table 16); in the Fulani group it was 27.45 per 1,000. The difference is not significant.

TABLE 16. *Comparative leprosy prevalence between ethnic groups in Northern Nigeria (Katsina).*

Ethnic group	Population examined	No. cases	Prevalence per 1,000
Hausa	19,038	554	29.10
Fulani	5,500	151	27.45
TOTAL	24,538	705	28.73

Rates. The lepromatous rate in the Hausa group was 2.15 per 1,000 and in the Fulani group 1.82 per 1,000 (Table 17). The difference between the groups was statistically not significant. Tuberculoid, indeterminate and borderline rates were also similar.

Disabilities. Frequency of disabilities, according to WHO criteria, was higher in Hausa (33.04%) than in Fulani (26.30%) patients ($\chi^2 = 4.01$). This might be explained by a difference in their living conditions.

TABLE 17. *Classification of leprosy patients and rates per 1,000 in Hausa and Fulani groups, Northern Nigeria (Katsina).*

Ethnic group	Population examined	Lepromatous		Tuberculoid		Indeterminate		Borderline		Total
		No.	Rate	No.	Rate	No.	Rate	No.	Rate	
Hausa	19,038	41	2.15	270	14.1	239	12.5	4	0.21	554
Fulani	5,500	10	1.82	70	12.7	70	12.7	1	0.18	151
TOTAL	24,538	51		340		309		5		705

General appraisal of the data. From the data obtained, there is no indication of any differences among the Hausa and Fulani groups involving prevalence and patterns of leprosy, with the exception of disabilities, which are more frequent among the Hausas.

SUMMARY

Some epidemiologic data collected by the WHO Leprosy Advisory Team (LAT) in random sample surveys in Northern Nigeria (Katsina), Cameroon, and Thailand (Khon Kaen) are reported and commented on.

Prevalence and lepromatous rate. Correlation between the lepromatous rates and prevalence was observed in Thailand, in the different sample blocks of Khon Kaen province.

Proportion and rate of lepromatous and tuberculoid cases. In Cameroon and Northern Nigeria, as in many other African countries, the proportion of lepromatous patients is relatively low (11.2% and 7.2% respectively) as compared with South American countries and some countries in Asia. However, the lepromatous rate in Cameroon and Northern Nigeria is relatively high and would explain the persistence or spread of leprosy in the two countries and probably in other African countries. In addition to lepromatous patients, tuberculoid patients in reaction (major T) may also play a role in the spread of leprosy, as they are numerous and may be temporarily bacteriologically positive.

Leprosy and sex. The leprosy prevalence rate was higher in females in Katsina, but higher in males in Cameroon, while in Thailand the rates were similar. There was no difference in the tuberculoid rate in Cameroon and Thailand, but in Nigeria the rate was higher among females. The lepromatous rate was significantly higher in men in Cameroon, Nigeria and Thailand.

Leprosy and age. The onset of the disease was more frequent in the age group 15-44 years, followed by the 5-14 group, in both Northern Nigeria and Cameroon, while in Thailand it was more frequent in the 5-14 age group, followed by that of 15-44 years. A higher rate of lepromatous, tuberculoid, and indeterminate leprosy was observed in the older age groups. This would be explained by the higher prevalence rates also observed in the older age groups.

In the light of these data, it appears that:

1. The difference in prevalence in the various age groups would depend chiefly on earlier or later exposure to *M. leprae.*

2. In the three countries, individuals would have similar resistance to *M. leprae* in the different age groups and are similarly capable of developing tuberculoid or lepromatous leprosy.

3. In highly endemic countries where children and young adults have the opportunity of being exposed to leprosy, the onset of the disease will be observed more often up to 20 or 25 years of age, as the more susceptible individuals will acquire the disease and those with more resistance will be able to resist it throughout their lives.

Leprosy in ethnic groups. From the data obtained there is no indication of any difference with respect to prevalence and lepromatous, tuberculoid, and indeterminate rates in the Hausa and Fulani groups (Northern Nigeria).

RESUMEN

Se comunica y comenta información de carácter epidemiológico, reunida por el Leprosy Advisory Team (LAT) de la Organización Mundial de la Salud, en una encuesta de muestras al azar en Nigeria del Norte (Katsina) Cameroon y Thailandia (Khon Kaen).

Prevalencia y tasa lepromatosa.—Correlación entre la tasa de lepra lepromatosa y prevalencia de lepra se observó en Thailandia, en la provincia de Khon Kaen, en las diferentes agrupaciones seleccionadas.

Proporcion y tasa de formas lepromatosas y tuberculoides.—En Cameroon y Nigeria del Norte, como en muchos otros países Africanos, la proporción de enfermos lepromatosos es relativamente baja (11.2% y 7.2% respectivamente) comparados con países de Sud América y algunos países de Asia. Sin embargo, la tasa de formas lepromatosas en Cameroon y Nigeria del Norte es relativamente alta y explicaría la persistencia o dispersión de la lepra en los dos países y probablemente en otros países Africanos. Además de los enfermos lepromatosos, pacientes con formas tuberculoides en forma reaccional (T mayor) peuden desempeñar un papel en la expansión de la lepra, pues ellos son numerosos y pueden ser bacteriologicamente positivos, temporalmente.

Lepra y sexo.—La tasa de prevalencia de la lepra, fué mas alta en mujeres en Katsina, pero mas alta en hombres en Cameroon, mientras en Thailandia las tasas fueron semejantes. No hubo diferencia en la tasa de formas tuberculoides en Cameroon y Thailandia, pero en Nigeria la tasa fué mas alta entre mujeres. La tasa de formas lepromatosas fué significantivamente mas alta en hombres en Cameroon, Nigeria y Thailandia.

Lepra y edad.—El primer ataque de la enfermedad fué mas frecuente en el grupo de edad 15-44 años, seguido por el grupo de 5-14 años, en Nigeria del Norte y Cameroon, mientras en Thailandia el comienzo fué mas frecuente en el grupo de edad 5-14 años, seguido por los de 15-44 años. Una tasa mas alta de formas lepromatosas, tuberculoides e indeterminadas fué observada entre los grupos de mas edad. Esto podría ser explicado por la prevalencia mas alta también notada en el grupo de mas edad.

A la luz de estos datos parecería que:

1. La diferencia de la prevalencia en los grupos de diferentes edades dependería mayormente en la exposición temprana o tardía al *M. leprae*.

2. En tres países las personas tendrían resistencia frente al *M. leprae* en los grupos en diferentes edades y serían igualmente capaces de desarrollar lepra en sus formas tuberculoide o lepromatosa.

3. En países con alta endemia, donde niños y adultos jóvenes tienen la posibilidad de estar expuestos a la lepra, el comienzo de la enfermedad se observará mayormente hasta los 20 o 25 años de edad, en tanto que los mas susceptibles contraerán la enfermedad, y aquellas personas con mas resistencia podrán defenderse de la enfermedad durante su vida.

Lepra en grupos etnicos.—De la información obtenida no hay indicación de que haya diferencias, con respecto a prevalencia y tasa de formas lepromatosas, tuberculoides e indeterminadas, en los grupos estudiados en Hausa y Fulani (Nigeria del Norte).

RÉSUMÉ

On présente ici, avec les commentaires adéquats, certaines des données épidémiologiques recueillies par le "Leprosy Advisory Team" (équipe consultante pour la lèpre) ou LAT, de l'OMS, lors d'enquêtes menées hasard au Nigéria du Nord (Katsina), au Cameroun et en Thaïlande (Khon Kaen).

Prevalence et taux de la lèpre lépromateuse.—Une corrélation a été observée entre les taux de la lèpre lépromateuse et la prévalence dans les différents blocs échantillonnés dans la province de Khon Kaen, en Thaïlande.

Proportion et taux des cas de lèpre lépromateuse et tuberculoïde.—Au Cameroun et au Nigéria du Nord, ainsi qu'il en est dans de nombreux autres pays africains, la proportion de malades lépromateux est relativement basse (respectivement 11.2% et 7.2%), lorsqu'on la compare à la proportion rencontree dans les pays d'Amérique du Sud et dans certains pays d'Asie. Au Cameroun et au Nigéria du Nord, toutefois, le taux de lèpre lépromateuse est relativement élevé et pourrait expliquer la persistance ou la diffusion de la lèpre dans ces deux pays, ainsi que dans d'autres pays d'Afrique. Outre les malades lépromateux, les malades tuberculoïdes en réaction (T majeure) peuvent également jouer un rôle dans la diffusion de la lèpre, vu leur nombre et le fait qu'ils peuvent témoigner temporairement d'une bactériologie positive.

Sexe et lèpre.—Le taux de prévalence de lèpre était plus élevé chez les femmes à Katsina, mais plus élevé par contre chez les hommes au Cameroun, alors qu'en Thaïlande les taux étaient semblables chez les hommes et les femmes. Il n'y avait pas de différence dans les taux de prévalence de lèpre tuberculoïde au Cameroun et en Thaïlande. Au Ni-

géria, le taux était supérieur chez les femmes. Le taux de lèpre lépromateuse était significativement plus élevé chez les hommes au Cameroun, au Nigéria et en Thaïlande.

Age et lepre.—Au Nigéria et au Cameroun, c'est dans le groupe d'âge allant de 15 à 44 ans que se situait le plus fréquemment l'éclosion de la lèpre, puis ensuite dans le groupe de 5 à 14 ans. Par contre, en Thaïlande, le début survenait le plus souvent dans le groupe d'âge de 5 à 14 ans, le groupe de 15 à 44 ans venat en deuxième. Des taux plus élevés étaient observés pour la lèpre lépromateuse, pour le lèpre tuberculoïde et pour la lèpre indéterminée dans les groupes d'âge les plus avancés. Ceci pourrait être expliqué par les taux de prévalence plus élevés qui sont également observés dans les groupes d'âge plus avancés.

A la lumière de ces données, il apparaît que:

1) les différences enregistrées pour la prévalence aux différents âges pourraient surtout dépendre de l'exposition précoce ou tardive à *M. leprae*;

2) dans les trois pays étudiés, les individus présenteraient une résistance similaire à *M. leprae* dans les différents groupes d'âge et sont pareillement capables de développer une lèpre lépromateuse ou tuberculoïde;

3) dans les pays hautement endémiques où les enfants et les jeunes adultes ont l'occasion d'être exposés à lèpre, le début de la maladie sera observé plus souvent avant l'âge de 20 ou 25 ans, du fait que les individus les plus susceptibles contracteront la maladie et que ceux dotés d'une résistance meilleure seront aussi capables de résister à la maladie durant toute leur vie.

Groupe ethnique et lepre.—Des données obtenues, on ne peut tirer aucune indication se rapportant à prévalence ou au taux de lèpre lépromateuse, tuberculoïde ou indéterminée dans les groupes Haoussa et Fulani (Nigéria du Nord).

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APPENDIX

Determination of Sample Size

Let p be an estimate of the true prevalence (P) of leprosy in the Khon Kaen province,[11] and d be the margin of error as best can be tolerated in the prevalence with a small risk (a) indicating that the actual error is larger than d. That is:

$$\text{Probability} \quad p - p \qquad d = a \cdots \quad (1)$$

If the real prevalance lies with a margin of error within 30 per cent of this p ($d = .3p$) with probability ($1 - a = .95$), then, assuming p a normally distributed variate for large sample size n, the probability equation (1) could be written as:

$$Pr \quad p - p \qquad .3p = .95$$

$$\text{i.e.,} \quad 1.96 \sqrt{\quad}_{n} = .3p$$

$$\text{or} \qquad n = \frac{3.84pq}{(.3p)^2}$$

Substituting the value of $p = .013$, as mentioned in the Statistical Plan (Part VI), $q = 1\text{-}p$, and solving for n, the nominal sample size is about 3,240. But this estimated .013 leprosy prevalence of Khon Kaen province had to be accepted in the presence of biases such as noncommital of variation of population as well as leprosy cases from district to district, etc.; the computed nominal sample size is almost always an underestimated one. For its compensation, a relative efficiency factor (REF) of 5.1 was considered to be optimum to raise the total sample size to about 16,500 ($5.1 \times 3{,}240$), and simultaneously to comply with the required degree of precision in assessing the prevalence of leprosy in each district and in Khon Kaen province as a whole.

[11] The same method was used in Cameroon and Northern Nigeria.

Statistical Theory of Estimation (Ratio Estimation) for Prevalence Rate and Its Sampling Error

The prevalence rate of leprosy in Khon Kaen province, or in each district or block, is estimated by simply computing the ratio of the number of cases found to the number of persons examined in each randomly selected sampling unit of each block. The sampling error is estimated by the following statistical theory:

Let x_{ij} = number of persons having leprosy in sampling unit j of block or district i, and

y_{ij} = number of persons examined in sampling unit j of block i,

then

$X_i = \sum_j x_{ij}$ = total number of leprosy cases in block i, and

$Y_i = \sum_j y_{ij}$ = total number of persons examined in block i.

Therefore, the estimated prevalence rate of block i is:

$$P_i = \frac{X_i}{Y_i}$$

and the variance of $P_i = V(p_i) = p_i^2 N_i^2 \dfrac{(N_i - n_i)}{N_i - 1} 1/n_i$

$$\left[\frac{S_{ix}^2}{X_i^2} + \frac{S_{iy}^2}{Y_i^2} - \frac{2\ \mathrm{Cov}_i\ (xy)}{X_i Y_i}\right]$$

where N_i = total number of sampling units belong to the i block,

n_i = total number of randomly selected sampling units from i bloc ,

S_{ix}^2 = the variance in the number of leprosy cases from sampling unit to sampling unit belonging to the i block,

S_{ix}^2 = the variance of the population examined from sampling unit to sampling unit belonging to the i block, and

Cov_i (xy) = covariance between the population and leprosy cases from sampling unit to sampling unit belonging to the i block.

The estimated prevalence rate for the i block is

$$(P_i \pm \sqrt{V(p_i)} \quad)$$

Similarly the prevalence rate for Khon Kaen is

$$p = X/Y$$

$$\text{and } V(p) = p^2 \sum_j^k N_i^2 \frac{(N_i - n_i)}{(N_i - 1)} 1/n_i \left[\frac{S_{ix}^2}{X^2} + \frac{S_{iy}^2}{Y^2} - \frac{2\ \mathrm{Cov}_i\ (xy)}{XY}\right]$$

when k = total number of blocks in Khon Kaen

X = total number of leprosy cases from all the blocks

Y = total number of people examined from all the blocks

and the rest of the symbols stand as described as before.

Therefore, the prevalence rate for Khon Kaen is:

$$(p \pm \sqrt{V(p)} \quad)$$