THE INCIDENCE OF LEPROSY IN CORDOVA AND TALISAY, CEBU, P. I.

JAMES A. DOULL, RICARDO S. GUINTO, JOSE N. RODRIGUEZ and HULDAH BANCROFT*

I. INTRODUCTION

The prevalence of leprosy in the municipalities of Cordova and Talisay, as revealed by a single physical examination of the inhabitants, has been the subject of previous reports (1, 2). The two communities are similar as regards age distribution of population but differ in topography, in occupations and in certain other respects. At the time of the survey prevalence rates were high. In Cordova the total rate was 17.2 per 1,000 in 1933 but exclusion of neural cases considered to be quiescent or arrested lowered this to 13.4. In Talisay the prevalence rate for all cases was 19.5 in 1936-37, reduced to 15.2 by exclusion of inactive neural cases. In Cordova 44.2 per cent and in Talisay 50.0 per cent were classified as open, that is, known to be positive bacteriologically. The highest rates were found in persons of 20 to 29 years of age in Cordova and in those of 30 to 39 years in Talisay. In both communities a marked excess was observed in males, especially of cutaneous leprosy.

Incidence as distinguished from prevalence: Such data are of immediate practical importance, since they indicate more or less exactly the magnitude of the current leprosy problem. Of even greater significance are statistics of incidence, the rates at which cases occur in specified periods of time. Incidence, not prevalence, is the elementary epidemiological ratio. In general terms and assuming no restrictions on exposure, incidence of an infectious disease is dependent upon the balance which exists between resistance of the population and pathogenicity of the microorganism. This balance determines what may be called the force of morbidity. Prevalence is more complex. It is the resultant of the force of morbidity and those factors which determine whether the interval between onset and termination shall be short or long, whether a disease shall be acute or chronic. In the absence of migration, the relationship between prevalence and incidence for a given popula-

* The authors are, respectively, Professor of Hygiene and Public Health, Western Reserve University, Cleveland, Ohio; Junior Epidemiologist of the American Leprosy Foundation (Leonard Wood Memorial); Chief of the Leprosy Section, Bureau of Health of the Philippines; and Instructor in Biometrics, Western Reserve University. Drs. Guinto and Rodriguez did not have an opportunity to read this manuscript in its final form. The basic tabulations were prepared when Dr. Guinto was in Cleveland in 1940. When last heard from, both of these authors were in the Philippines.

These studies have received support from the American Leprosy Foundation, the Bureau of Health of the Philippines and Western Reserve University.

tion may be expressed as follows, the same unit of time being used for incidence as for duration:

$$Prevalence = Incidence \times Duration$$

In tuberculosis, for example, if prevalence in a given population is 10 per 1,000 and if the average duration of illness, from onset to recovery or death, is ten years, annual incidence in that population must be, more or less, one per 1,000, since

$$P\ (0.01) = I\ (0.001) \times D\ (10)$$

Because duration of illness from a given infectious disease is subject to variation in different population groups and at various times and places, it is clear that statistics of prevalence may lead to an erroneous concept of variation in the force of morbidity. Recently it was discovered, for example, that among relief clients in New York City (3) prevalence of tuberculosis was approximately the same for white persons as for Negroes. Since the greater risk of the Negro, as judged from common experience and from death rates, is well established, the explanation lies in shorter duration of illness in the Negro. In this instance no error of interpretation was made.

Another example is more pertinent to the present subject: It is a well-known fact that in most areas leprosy is more prevalent in males than in females. Rather complex explanations have been offered. It follows from the above discussion that this excess may be the result of any of the following conditions:

(a) Higher incidence in males, associated with longer, equal or even shorter duration in males than in females; or,

(b) Equal incidence in males and females, associated with longer duration in males than in females; or,

(c) Lower incidence in males, associated with disproportionately longer duration in males than in females.

This question will be discussed more fully later. At present it is cited only to emphasize that the rate of elimination of leprosy from any population group must be taken into account in the interpretation of prevalence.

Difficulties of obtaining basic data: Although incidence rates for leprosy are highly desirable their acquisition is a matter of considerable difficulty. Reliable data on the rate of occurrence of milder forms of leprosy can be secured only by keeping a considerable population of an endemic area under sufficiently close observation to estimate dates of onset with reasonable accuracy. This necessitates repeated physical examinations of the inhabitants at intervals which apparently should not be longer than two or three years (4). For more severe types of the disease it is, nevertheless, quite possible to estimate past rates of incidence from histories, if care be taken to secure basic population statistics at the same time as the histories are obtained.

In planning studies in Cordova and Talisay, limitations of prevalence rates were recognized and historical facts necessary for the study of incidence were collected by clinic staff and enumerators. The items which were included on the schedule were given in the first report (1). For the entire municipality of Cordova efforts were made to secure a complete record of each household since its establishment. Similar data were collected in Talisay but because of its size only a part of the municipality was included. The age or date of birth was obtained for each individual. For those not present on investigation the date of death or of departure to another residence was secured. For those who had developed leprosy the date of onset was estimated. Physical examinations were made of all except a very small proportion of the current members of all households in both areas.

It should be added that at the time of enumeration, information regarding the previous occurrence of leprosy or suspected leprosy was sought not only for all present and former members of the household but also for parents, grandparents and other relatives. The not infrequent appearance of the name of the same leprous relative on several family schedules permitted cross-checking and contributed to the accuracy of the records. Segregation of bacteriologically-positive cases of leprosy was not enforced in the Philippine Islands until about 1907, but many patients from Cordova and Talisay had been segregated previously in the old Carreta Leprosarium at Cebu. Fortunately a list of all admissions to this institution was available. This was supplemented by the lists of admissions to Culion and to Eversley Childs Treatment Station at Cebu. The former was established in 1907; the latter in 1931.

It is considered, therefore, that the data from all sources constitute a sufficiently complete record of cutaneous leprosy for those households existent at time of survey. Doubtless information regarding neural leprosy is less complete but few cases with conspicuous deformity are likely to have been omitted. Persons with minimal neural lesions, especially those with minor macules which had failed to progress, are likely to have been omitted from the records unless the individual was living and examined. In some instances these persons were already under observation because, since 1929, a number of individuals from these localities have been examined at the Cebu Skin Dispensary and found to have minimal lesions.

Life-table method is necessary: To determine the risk of leprosy during the period covered by the lives of those included on the records it is necessary to use a modified life-table method. This permits the division of the life of any individual into years during which he was present in the community and household and those during which he was absent. It also permits division into years prior and subsequent to household exposure, as is necessary, for example, when a person from a non-leprous household enters a

leprous family. In calculating rates persons are included in the denominator only for those periods of their lives during which they are known to have been present, that is, they are entered as of date of establishment of household or as of date of birth if born in the household and they are removed as of date of death or departure. Weinberg (5) used this procedure in calculating mortality rates for children of tuberculous parents in Stuttgart. Frost (6) modified the method and demonstrated its applicability and potentialities in the analysis of field records of tuberculosis. Doull (7) applied it in a preliminary study of the leprosy data collected in Cordova. Adaptations of the method have been used in other fields of epidemiology.

The population is expressed in person-years, that is, each year of life of each individual is regarded as a unit. For a whole community the sum of the years of life recorded on the schedules constitutes the denominator. This population can readily be broken down according to sex, age, calendar years bounding the life-experience or other limitation. Only persons developing the disease while resident in the community are counted in the numerator. The results are expressed as attack rates per 1,000 person-years, that is, as the average number of cases per 1,000 persons observed for one year. The schedules include individuals who were born eighty years or more before the enumeration and infants born only a day or two before. In the summation of the total experience therefore it should be borne in mind that the rates are not applicable to the present but are a statement of what has occurred during the life-experience of inhabitants of these communities whose households were represented by one or more living members at the time of enumeration.

Defects inherent in the data: Historical records of this type frequently yield extremely low mortality rates. This is attributable in part to difficulty of obtaining a complete record, children dying in infancy being particularly liable to be overlooked. Also such surveys usually do not include those not living with an organized household group, persons who are generally supposed to have high mortality rates. Families which have died out completely or which have broken up on account of excessive mortality or other cause are omitted. And since there is a greater likelihood of finding surviving members of large than of small families, the schedules are weighted somewhat with the more prolific strains of the community.

It is not so obvious that in each family there must have been at least one individual who supplied the necessary information, the *informant,* who theoretically cannot be regarded as having been at risk of death since survival to the time of enumeration is essential. This is a statistical matter which has nothing to do with the actual risk of death for any individual. This source of error was detected by Frost and was first taken cognizance of at his suggestion in the analysis of tuberculosis records by Stewart, *et al.* (8) and by

Downes (9). The first of these reports deals with the risk of household exposure and will be discussed later. The second is an analysis of records of 1,400 families included in a morbidity survey of the general population of a rural area in Cattauraugus County, N. Y. By exclusion of the informant in each family, Downes demonstrated that the age-specific mortality experience of these families followed closely the age curve of death as derived from the 1901 life-table for the rural part of the Original Registration States.

Leprosy, unlike tuberculosis, is usually a contributory rather than a primary cause of death. The question which arises therefore is whether or not the informants constitute a selected group, in the statistical sense, as far as contracting leprosy is concerned. Admittedly there is selection to the extent that the disease shortens the duration of life. In Cordova and Talisay, because of segregation of bacteriologically-positive cases, a disproportionately small number of informants were themselves patients. In areas where segregation is not practiced or in which access to segregated patients is convenient they would be used as informants probably almost as frequently as other persons.

Persons included in the surveys are also selected in that leprosy on occasion breaks up the family, which may result in departure of all members from the community. There are, however, many conditions other than leprosy which cause dissolution of households and there is no basis on which to decide whether or not the incidence of leprosy is or has been significantly greater among individuals belonging to existent households than among those whose families have ceased to exist as separate entities.

In estimating the true risk of leprosy in Cordova and Talisay, after taking these considerations into account, attack rates have been calculated by the modified life-table method without exclusion of the informants. As a matter of interest, however, rates for certain groups have been calculated with the omission of those periods of the lives of informants during which they were members of the families for which they were historians; if during other parts of their lives these persons were members of other households these years of life-experience were not removed. As will be seen, the removal of informants affects only incidence rates for *cutaneous* leprosy. Except when specifically stated, incidence rates used in this study are based upon the entire population. These rates are considered to be as nearly correct as can be obtained by the historical method.

Working rules of this study: The following working rules were adopted:

1. To include only families in which it was possible to complete the life-experience of every known member from entrance into the family either to death, to development of leprosy, to departure to another household or community, or to the end of the

period of observation, taken as June 30th, 1933, for Cordova and October 30, 1936, for Talisay.

2. The beginning of observation was considered to be the date of entrance into the household or the date of birth if born in the household. Since usually only the year was given and not the actual birth or entrance date, it was assumed that birth or entrance was on July 1st of the calendar year stated. The usual rules of life-table procedure were followed in that a person, unless he was born in the household, was assigned one-half year of life-experience at the age at which he entered. Those departing were assigned one-half year at the age of departure. Those individuals who entered the household and left in the same year were allotted each one-quarter of a year of life-experience.

3. Similarly, the date of onset of leprosy was taken as the mid-point of the year given in the record. Patients who had been removed to a leprosarium were considered to retain their status as residents of the community.

II. Incidence in the General Population

For Cordova there are included 1153 family units, comprising 8,057 different individuals and for Talisay 2,051 family units with 13,734 individuals. Those included are classified according to survivorship and present residence in Table 1.

Table 1. *Classification of persons included on the schedules according to status at time of survey, for Cordova and Talisay.*

Classification	Cordova 1933	Talisay 1936-1937
1. Living		
(a) Residents		
Examined	5587	9855
Not Examined	53	40
(b) Former Residents		
Examined	82	31
Not Examined	407	1245
2. Deceased	1928	2563
Total	8057	13,734

For Cordova these 8,057 individuals contributed 117,287 person-years of life-experience and 160 cases of leprosy, an average annual attack rate of 1.38 per 1,000 person-years. For Talisay there

were 217,729 person-years with 242 cases, an attack rate of 1.11 per 1,000. Adjustment for age differences, using the age distribution of the entire life-experience as a standard, does not affect these rates appreciably.

Of the Cordova cases in the households included in this study, 101 were living at the time of investigation and 59 were dead. Of the Talisay cases, 183 were living and 59 dead. Detailed information regarding populations and cases is given in the Appendix.

Attack rates for age groups: The estimated age of onset in leprosy as in any chronic disease is subject to considerable error. Nevertheless it is of interest that the age-specific attack rates for Cordova are very similar to those for Talisay. In both communities the highest incidence occurred in the age period 10 to 14 years. After 30 years of age the attack rate fell off greatly but cases continued to occur even among persons over 50 years of age. In Cordova the rates were higher in the younger ages than in Talisay and lower in the older, as shown in Table 2 and illustrated in Figure 1.

TABLE 2. *Average annual incidence rates for Cordova and Talisay for specified age grouping of life-experience and for the two areas combined by sex and age.*

Age in years	Attack rates per 1,000 person-years				
	Cordova total	Talisay total	Cordova and Talisay combined		
			Male	Female	Total
Under 5	0.04	0.02	0.05	0.00	0.03
5 - 9	1.60	1.06	1.55	0.94	1.25
10 - 14	4.18	2.57	3.74	2.48	3.12
15 - 19	3.38	1.82	3.12	1.67	2.37
20 - 29	1.14	1.37	2.01	0.64	1.28
30 - 39	0.56	0.82	1.09	0.38	0.73
40 - 49	0.50	0.95	1.04	0.56	0.80
50 and over	0.19	1.18	0.88	0.89	0.89
All ages*	1.38*	1.11*	1.58*	0.84*	1.20*

* For this and the following tables where adjusted rates are given, they are based on the total life-experience of both communities.

FIGURE 1. *Annual incidence of leprosy, Cordova and Talisay, P. I., by age groups.*

Classification of cases and incidence by clinical type and sex: Of 402 cases from both communities included on the schedules, 262 were classified as cutaneous, 122 as neural and 18 as unknown. Cases of unknown type had occurred in individuals who had not been treated in a leprosarium and who had died prior to the study.

The relationship of sex to the type of leprosy is shown in Table 3. About 70 per cent of all with the cutaneous type were males and only 53 per cent of those with the neural type.

It is of interest that in 30 instances the informant was leprous but that only in five of these was the disease of the cutaneous type. All of the five had been paroled.

Incidence rates per 1,000 person-years have been calculated for each type of disease for males and for females with and without omission of the informants and their life-experience. These have been adjusted for differences in the age constitution of male and female populations using the entire life-experience of Cordova and Talisay as a standard. These rates are given also in Table 3.

TABLE 3. *Attack rates for males and females for Cordova and Talisay combined, according to type of leprosy.*

Type and sex	Informants included			Informants excluded		
	Cases (402)	Rate per 1000		Cases (372)	Rate per 1000	
		*Crude	Adjusted		*Crude	Adjusted
Cutaneous						
male	183	1.10	1.11	181	1.27	1.29
female	79	0.47	0.47	76	0.57	0.57
Neural						
male	65	0.39	0.39	52	0.37	0.34
female	57	0.34	0.34	45	0.34	0.33
Unknown						
male	13	0.08	0.08	13	0.08	0.11
female	5	0.03	0.03	5	0.04	0.03

* Person-years of experience used in calculation of rates: Informants included, males, 166,619; females, 168,397. Informants excluded, males, 142,155; females, 133,304.

As would be anticipated from the foregoing discussion, removal of informants raises the incidence rates for cutaneous leprosy and lowers slightly those for the neural type. The relative positions of males and females are not appreciably affected. In the cutaneous type the average annual incidence rate for males has been more than twice that for females. In the neural type, the sexes have been attacked about equally.

Excess prevalence in males attributable to higher incidence rates: Based upon the experience of Cordova and Talisay it may be demonstrated that excess prevalence of leprosy among males is attributable almost entirely to higher incidence rates. For total leprosy in both communities the average annual *incidence* for males was 1.58 per 1,000 and for females 0.84, a ratio of 1.88 to 1. Total *prevalence* rates (1, 2), were, respectively, 25.2 per 1,000 and 12.3, a ratio of 2.05 to 1.

If I = incidence, D = duration, P = prevalence, f = female, and m = male, then, since $P = I \times D$:

(1) $\frac{Pm}{Pf} = \frac{Im \times Dm.}{If \times Df}$ (2) $2.05 = 1.88 \frac{Dm}{Df}$ (3) $\therefore \frac{Dm}{Df} = 1.10$

From this experience it appears that the duration of leprosy is only slightly longer, about 10 per cent, in males than in females.§ *The major component, therefore, of the disparity in prevalence (2.05 times) must be higher incidence among males and not longer duration.*

Restricting the study to the cutaneous type, the incidence rate in males is to the incidence rate in females as 2.36 is to 1, whereas the prevalence rate in males is to that in females as 3 is to 1. By a similar calculation the duration of the cutaneous type in males is apparently about 27 per cent longer than in females. This is again the minor component and it may be concluded that greater *incidence* is the chief factor responsible for excess prevalence of cutaneous leprosy in males but that longer duration also may contribute.

Relationship between prevalence as estimated from cumulated incidence rates and actual prevalence as determined in surveys: If it be assumed that persons with leprosy do not die off at a significantly faster rate than the general population, and that incidence has remained more or less the same during the period, then prevalence at any age may be estimated by summation of incidence rates for preceding years of life (Table 4). This is apparently a

TABLE 4. *Prevalence of leprosy, Cordova and Talisay combined by sex: Estimated by cumulation of incidence rates and actual as found by physical examination, per 1,000 population.*

Age in years	Males		Females		Total	
	*Estimated	**Actual	*Estimated	**Actual	*Estimated	**Actual
Under 5	0.15	0.75	0.00	0.00	0.08	0.38
5 - 9	4.18	1.66	2.35	0.83	3.28	1.24
10 - 14	17.40	12.94	10.90	11.14	14.20	12.04
15 - 19	34.55	33.29	21.28	15.75	27.92	24.58
20 - 29	52.40	57.31	28.65	23.41	39.25	39.57
30 - 39	67.90	49.01	33.75	23.62	49.30	36.08
40 - 49	78.60	29.52	38.45	10.99	56.95	20.15
50 and over	92.65	23.78	50.15	14.59	68.95	18.73

* Rates on which these are based are given in Table 2.

** From published reports (1, 2).

§ For Talisay this method indicates approximately equal duration of the disease in males and females; the difference arises only in the smaller experience of Cordova.

sufficiently accurate procedure up to the age of 25 to 30 years. Summation of the rates of Table 2, after multiplication by the number of years in the respective class intervals, gives an expected *prevalence rate* of 39.3 per 1,000 at 25 years of age. This is remarkably close to the actual findings. *In Cordova at the time of the survey the prevalence rate for persons 20 to 29 years was found to be 41.8 per 1,000, for Talisay it was 38.3 and for both communities it was 39.6.*

But if the cumulation be continued beyond 30 years of age the earlier disappearance of leprosy patients from the population, presumably by death, is evident from the disagreement between estimated and actual prevalence rates. Cumulative incidence rates and actual prevalence are compared by sex and age in Table 4 and illustrated in Figure 2.

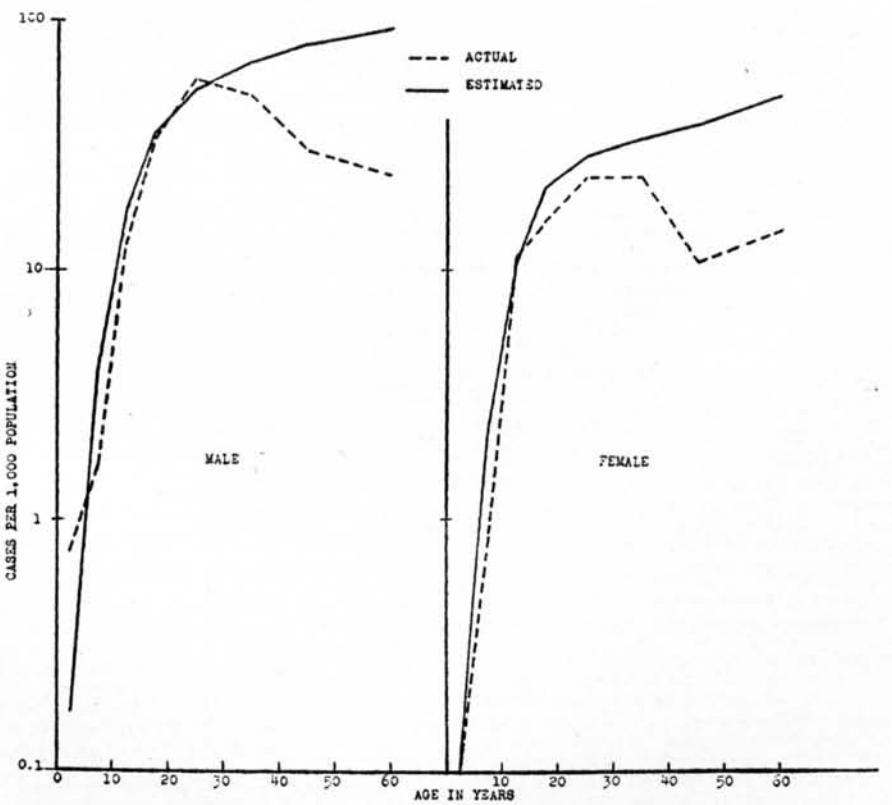

FIGURE 2. *Prevalence of leprosy, Cordova and Talisay combined, by sex: estimated by cumulation of incidence rates and actual as found by physical examination.*

Examination of Figure 2 throws light on a problem discussed above, namely, the relative duration of life in females and in males attacked by leprosy. The divergence of the estimated from the actual prevalence appears earlier in females than in males although the total disagreement by the age of 60 years is about the same for both sexes. The shorter duration of life in females attacked by leprosy is attributable to higher mortality in early adult life.

III. The Risk of Household Exposure

Chapin was the first fully to appreciate the potentialities of the invaded household as a field for observation of infectious diseases. In diseases in which transmission is direct the chance of effective exposure is more nearly equivalent when persons are living in the same household than under any other circumstances of ordinary civilian life. Differences in attack rates, therefore, as between various classes of individuals in these households, lead to a first assumption of variation in susceptibility.

The secondary attack rate: As a measure of the risk of exposure to diphtheria, Chapin (10) devised the secondary attack rate in 1903. Later he extended its use to scarlet fever and to measles. Parallel tabulations were made for household associates and for those of their number who were attacked within a year of the onset of the primary case, both being classified by age, sex, history of prior attack and certain other attributes. The attack rate, for each class, was expressed as the number of secondary cases for every one hundred persons exposed. Other methods have been utilized to describe the concentration of cases of an infectious disease around the primary case in the household but none has the simplicity and usefulness of that of Chapin (11). It is not to be assumed that secondary cases are infected by the first; the rate is merely an expression of the risk of attack for individuals living in a known relationship to a reported case.

In calculating the risk of household exposure to leprosy the principle of Chapin's method has been followed. As in the study of community incidence, however, the denominator has been obtained with greater accuracy by the use of person-years of life-experience rather than by estimating the average number of individuals.

The index person method has not been used: In field studies of tuberculosis in Williamson County, Tennessee, Stewart, *et al.*, (8, 12) upon the advice of Frost, adopted an ingenious and useful device in the measurement of the risk of household exposure. One source of error in family studies already has been mentioned, namely, that in each family there must be a survivor (the informant) who cannot be considered to have been at risk of death during the period between his entrance into the household and reporting of the case. To compensate for this factor the person who

brings the household to the attention of the clinic, called the *index case* or, preferably, the index *person* (13) is regarded as the informant. The period of observation is limited in a backward direction to the date when the index person entered the household. This person must have survived to the date of investigation but since he does not enter into the population under consideration his survival does not effect the attack rate.

A very important reason for not attempting to date secondary attack rates in tuberculosis from the onset of the primary case is that households coming to attention of clinics or health departments are "selected"; that is, they do not include all existent households in which tuberculosis has occurred. The denominator is incomplete. There are in every community a certain number of households which are unknown to the health authorities in which there have been one or more tuberculosis cases or deaths. Of these households, only those in which a secondary case occurs will come into future records if investigation be limited to reported cases of the disease. Consequently the secondary attack rate will be increased, varying with the frequency of such unknown tuberculous households and with the proportion of the total secondary cases which they contribute (14). If the risk for household associates is considered to commence at the date of onset of the disease in the index person, this error is avoided.

The present study is based not upon reported cases but upon community surveys. The date of establishment of all households was obtained with reasonable accuracy. It has been shown that correction for the lower risk of informants is a refinement which is not as essential as in similar studies of tuberculosis. Also, since all households of both areas were included, the error of selection of those in which a secondary case followed a missed case or death has been avoided completely. The index person method, therefore, has not been used in this analysis although it would be the correct procedure in a study of families brought to the attention of health departments by reporting of cases.

Additional procedures adopted: In addition to the rules which were applied to all households the following procedures were adopted in studying the risk of household exposure:

1. A household associate was considered to have been exposed to leprosy if he had lived under the same roof as a case for at least one month. Subsequently for as long as he lived in the community he was considered to have been a household associate at risk of developing leprosy. His status remained unchanged even if the patient had been removed soon after discovery, as is done with bacteriologically-positive cases, or if the associate himself removed to another residence in the municipality.

2. The *preexposure* life-experience of household associates, from date of entrance into the household to date of onset of the

first case of leprosy in the household, was added to that of the remainder of the community, as suggested by Frost (6).

3. Individuals born into a household in which there was a case of leprosy were regarded as at risk from birth. Those present in the household at the time of onset of the primary case were allotted one-half year of exposed life-experience at the ages at which they were at that time. Persons entering the household while a case was present were likewise given only one-half year of exposed life-experience at their ages at the time of entrance. Departures were treated in a similar manner.

Incidence rates for exposed and non-exposed: On the Cordova schedules there are included a total of 11,773 years of life-experience after exposure to leprosy in the household, during which there occurred 61 cases, an incidence rate of 5.18 per 1,000 person-years. For Talisay there are 15,580 years of post-exposure life-experience with 89 cases, a rate of 5.71. For the communities combined, the average incidence rate for exposed persons was 5.48 per 1,000 person-years.

For persons not exposed (but including preexposure experience of those subsequently exposed in households) there are recorded, for both communities, a total of 307,663 person-years with 252 cases, an incidence rate of 0.82 per 1,000. A summary is given in Table 5.

TABLE 5. *Incidence rates per 1,000 person-years for Cordova and Talisay for persons exposed in the household and for those not exposed, for all forms of leprosy.*

Area	Exposed			Not exposed		
	Person-years	Cases	Incidence rates	Person-years	Cases	Incidence rates
Cordova	11,773	61	5.18 (4.95)	105,513	99	0.94 (0.95)
Talisay	15,580	89	5.71 (5.60)	202,150	153	0.75 (0.76)
Total	27,353	150	5.48 (5.35)	307,663	252	0.82 (0.83)

The excess risk for those in household contact, after adjustment for differences in age distribution, is 4.52 (5.35-0.83) per 1,000. Expressed as a ratio the risk for the exposed group is four and one-half times that for all the population and six times that for those not known to have lived in the same household as a person with leprosy.

Incidence rates for exposed and not exposed by sex and age: The average annual incidence rates for males and females of exposed and non-exposed populations are given for various age groups in Table 6.

TABLE 6. *Annual incidence of leprosy (all forms) based on family histories for those exposed in the household and for those not exposed, by age and sex, for Cordova and Talisay combined.*

Age-period of life-experience in years	Attack rate per 1,000 person-years					
	Exposed in household			Not exposed in household		
	Male	Female	Total	Male	Female	Total
0 - 4	0.68	0.00	0.36	0.03	0.00	0.01
5 - 9	10.89	6.03	8.59	0.93	0.62	0.78
10 - 14	18.80	9.06	14.16	2.34	1.91	2.13
15 - 19	11.58	7.91	9.77	2.15	1.02	1.56
20 - 29	6.60	3.93	5.23	1.54	0.33	0.90
30 - 39	1.21	2.01	1.65	1.07	0.21	0.64
40 - 49	2.04	1.15	1.56	0.91	0.46	0.69
50 and over	2.85	2.68	2.75	0.52	0.42	0.47
Total (adjusted)	6.69	3.87	5.33	1.11	0.55	0.83

The first point of interest is that the higher attack rate in males, observed in the general population, is still in evidence among persons known to have lived in leprous households (Figure 3). This would suggest as the first assumption that the responsible factor is not primarily greater exposure of males than of females but rather greater susceptibility of males to the disease. This explanation gains support from the fact that incidence among males was higher than among females as early as the ages 5 to 9 years and 10 to 14 years. Considering the period of incubation, if greater exposure be the factor, this must occur at an age when environmental conditions would appear to be identical for both sexes. This evidence therefore points to greater inherent susceptibility of males during childhood and adolescence. The peak of incidence in both males and females occurred in the age group 10 to 14 years. In males the rate for this age group was almost two *per cent* annually.

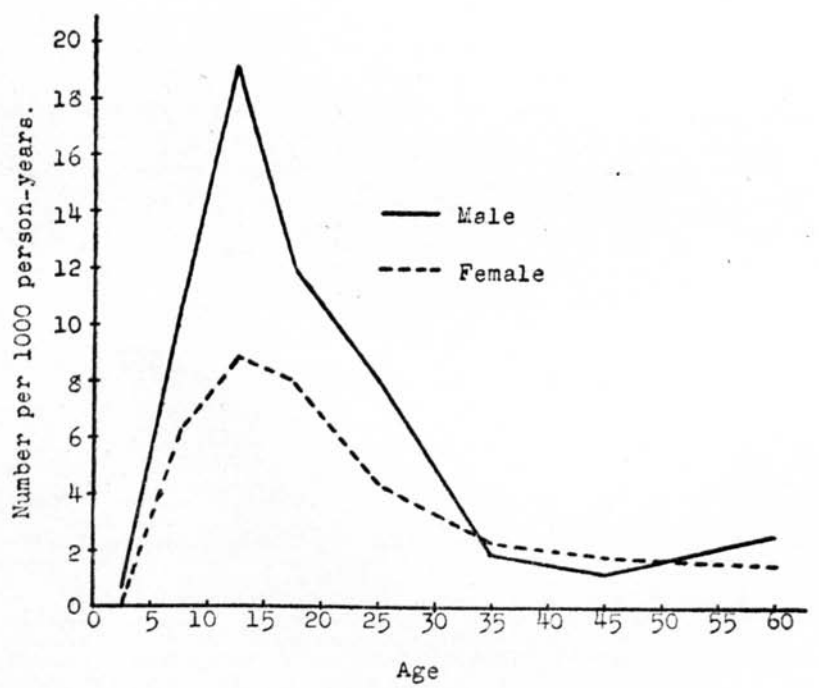

FIGURE 3. *Annual incidence of leprosy for males and females exposed in household: Cordova and Talisay, combined.*

It was also rather unexpected to find the peak of age-incidence in the same age group for those exposed in the household as for those not subjected to household exposure (Figure 4). In leprous households the *average* age at onset nevertheless was much earlier; the age curve declines sharply after its peak. Among the non-exposed, on the other hand, the decline is gradual; cases continued to occur at more or less the same rate even in the later decades of life.

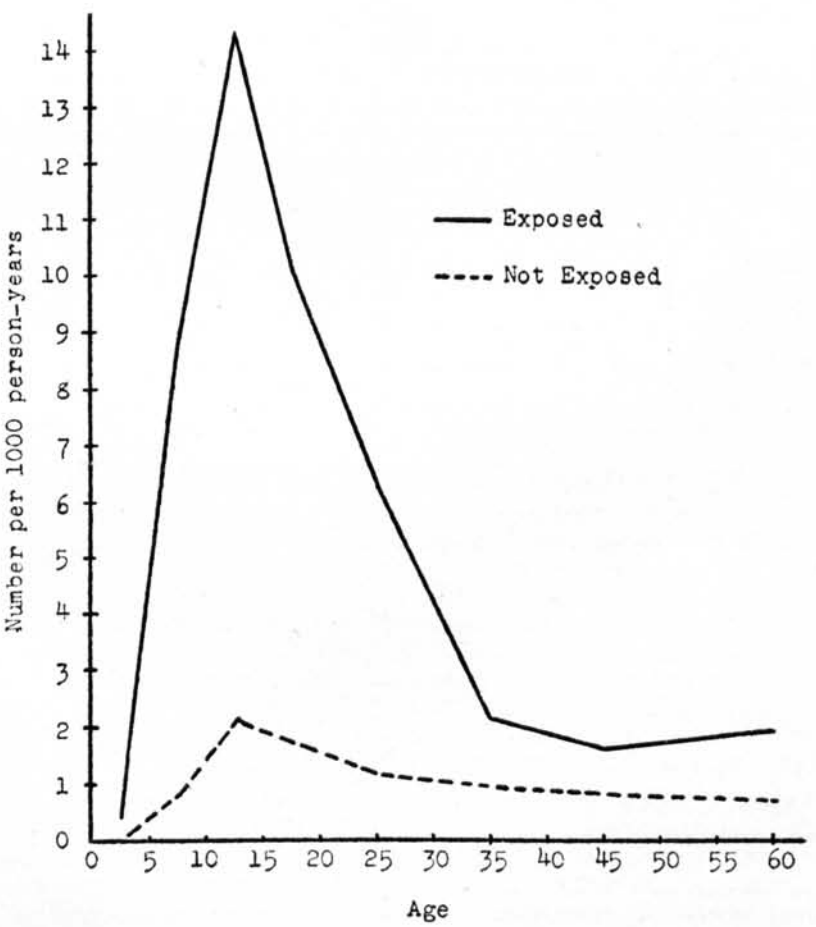

FIGURE 4. *Annual incidence of leprosy for persons exposed and not exposed in the household: Cordova and Talisay, combined.*

Risk of household exposure in relation to type of primary case: In the Philippines it has been the practice for many years to remove those with cutaneous leprosy from their homes as promptly as feasible following discovery. Those suffering from the neural type usually have remained in their own households. In Table 7 a comparison is made of attack rates in households in which the type of primary case was (a) cutaneous, (b) neural or (c) unknown. The attack rate for non-exposed persons is given for comparison (d).

TABLE 7. *Attack rates for leprosy per 1,000 person-years according to type of primary and secondary case.*

Type of leprosy in primary case	Type of leprosy in secondary case			
	Cutaneous	Neural	Unknown	Total
a) Cutaneous	4.56 (4.38)	1.89 (1.70)	0.15 (0.14)	6.60 (6.23)
b) Neural	0.86 (0.85)	0.86 (0.75)	no cases	1.72 (1.60)
c) Unknown	1.59 (1.98)	2.54 (3.51)	no cases	4.13 (5.49)
All types	3.58 (3.55)	1.79 (1.68)	0.11 (0.10)	5.48 (5.33)
d) None (remaining population)	0.53 (0.53)	0.24 (0.26)	0.05 (0.05)	0.82 (0.83)

Adjusted rates are given in parentheses.

The highest attack rate (6.23 per 1,000 person-years) occurred in those exposed to cutaneous cases. When the primary cases were neural the rate was only 1.60. The risk for household associates exposed to cutaneous cases was about eight times that for persons not exposed, whereas the risk for those exposed to neural cases was only about twice that for persons who had not been subjected to exposure in their own households.

It is curious that when the primary case was cutaneous the risk of contracting cutaneous leprosy (4.38) was about two and a half times the risk of contracting the neural form (1.70); but when the primary case was neural the attack rates for the two types were about equal. Further data on this question are necessary but it may be that there is a familial tendency toward the neural form.

Attack rates when primary case was cutaneous, by sex and age: For those exposed to cutaneous leprosy, the most infectious form, attack rates are given by type of secondary case, sex and age in Table 8.

TABLE 8. *Attack rates among persons exposed to cutaneous leprosy in the household, by sex and type of secondary case.*

Age in years	Cases of leprosy per 1,000 person-years of experience								
	Cutaneous			Neural			Total		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
0 - 4	0.00	0.00	0.00	1.04	0.00	0.57	1.04	0.00	0.57
5 - 9	9.77	2.01	6.30	2.44	2.01	2.25	12.22	5.03*	9.00*
10 - 14	19.42	6.16	13.20	3.11	2.64	2.89	22.52	9.68*	16.50*
15 - 19	10.97	6.25	8.68	2.53	1.79	2.17	13.51	8.04	10.85
20 - 29	6.92	2.13	4.42	2.31	3.19	2.77	9.23	5.32	7.20
30 - 39	0.88	2.80	1.95	0.00	0.00	0.00	0.88	2.80	1.95
40 - 49	0.95	0.81	0.87	0.95	0.81	0.87	1.90	1.62	1.75
50 and over	0.00	0.00	0.00	2.02	3.62	2.95	3.04*	3.62	3.38*
Total	6.69	2.50	4.56	1.88	1.90	1.89	8.68*	4.60‡	6.60§
Total, adjusted for age	6.16	2.38	4.38	1.77	1.58	1.70	7.99	4.22	6.23

* Includes one case of leprosy of unknown type.
‡ Includes two cases of leprosy of unknown type.
§ Includes three cases of leprosy of unknown type.

For all ages and for all types, as stated above, the adjusted attack rate was 6.23 per 1,000 person-years. For males the rate was 7.99 and for females 4.22.

For all ages and for the cutaneous type only, the attack rate for males was 6.16 per 1,000 person-years and, for females, 2.38. In the younger ages the disparity between the sexes was even greater than this, the risk being nearly five times greater for males than for females at 5 to 9 years and more than three times greater at 10 to 14 years.

In males the *average* age of onset for cutaneous leprosy was substantially lower than in females. The peak of incidence was reached at 10 to 14 years in males and at 15 to 19 years in females.

The attack rates for neural leprosy, on the other hand, do not indicate selectivity for either sex. From the data, the age of onset

appears to be much older than for the cutaneous type but it may be subject to greater error.

Estimated prevalence at 25 years of age. Cumulation of age-specific attack rates for household associates of cutaneous cases yield results which are rather startling. For both sexes and for all types, the estimated prevalence reaches 22 per *cent* at 25 years of age; for males, the figure is actually 29 per cent. For females, the figure is only 14 per cent.

Restricting the discussion to the expected prevalence of *cutaneous* leprosy in persons exposed to cutaneous primary cases, cumulation of the rates to the age of 25 years yields a total of 23.5 per cent. For females the cumulation is only 8 per cent.

Probably it has never been appreciated that approximately one male in four would contract leprosy under these circumstances in Philippine communities. Of the approximate correctness of the figures there can be little doubt. It is unlikely that more than the actual number of cases would be recorded on the schedules. Undoubtedly there are omissions from the denominator but even if such amounted to fifty per cent, which is highly improbable, the expected prevalence rate at 25 years of age would still be 20 per cent, more or less, for all types of leprosy in males exposed in the household to cutaneous cases.

IV. Summary

A study is presented of the incidence of leprosy in the municipalities of Cordova and Talisay, Cebu. The primary data were collected in the homes and were supplemented by statements of patients in leprosaria and from records of these institutions. All save a very few of the residents of these communities were examined in clinics established for the purpose. The statistical methods employed are discussed in detail.

Incidence in the general population:

1. The average annual incidence for all forms of leprosy, for the period included on the schedules, was 1.38 per 1,000 person-years for Cordova and 1.11 for Talisay. For both communities the average attack rate was equivalent to 1.20 cases per 1,000 persons annually.

2. The peak of incidence occurred in the age group 10 to 14 years in both communities.

3. For the cutaneous type, for both communities, the average annual incidence was 1.11 for males and 0.47 for females; for the neural, it was 0.39 for males and 0.34 for females.

4. Excess *prevalence* of total leprosy in males, noted in previous reports (1, 2), is demonstrated to be attributable chiefly to higher incidence in males than in females and not to longer dura-

tion of the disease in males. In the cutaneous type, however, a minor part of excess prevalence in males is apparently attributable to longer duration of the disease.

5. Cumulation of age-specific incidence rates to the age of 25 years yields an expected prevalence for all types of leprosy of 39.3 per 1,000. This is remarkably close to the prevalence rate (39.6) observed at the time of examination in persons of this age. Beyond 30 years of age, however, the higher mortality of leprosy patients than of other persons is indicated by the disagreement between actual and estimated prevalence rates.

The risk of household exposure:

1. For persons exposed in the household the average incidence rate, for all types of leprosy, was 5.35 per 1,000 person-years. This is more than six times the rate for persons not known to have been subjected to household exposure.

2. For age periods, the highest incidence in both males and females occurred at 10 to 14 years both in household associates and in other persons. The *average* age of onset, however, was lower for those exposed in the household than for other persons.

3. When the primary case was cutaneous, the risk of developing any type of leprosy, for household associates, was about *eight* times that for persons not exposed to leprosy in the household. It was four times as great as when the primary case was neural.

4. When the primary case was cutaneous, the risk of developing cutaneous leprosy was about two and a half times the risk of contracting the neural form; whereas when the primary case was neural the secondary attack rates for the two types were about equal.

5. When the primary case was cutaneous, the secondary attack rate for males, for all types of leprosy, was 7.99 per 1,000 person-years and, for females, 4.22. The secondary attack rate for cutaneous leprosy only was 6.16 for males and 2.38 for females. No sex selectivity is indicated by the secondary attack rates for the neural type.

6. The greatest disparity between the rates for the sexes appeared in the secondary attack rates for cutaneous leprosy, in children of 5 to 9 years of age exposed to primary cases of the cutaneous type. Here the rate for males was 9.77 and that for females was only 2.01. This suggests greater inherent susceptibility of males rather than difference in environment as the principal cause of sex variation.

7. Cumulation of age-specific attack rates to the age of 25 years, for persons exposed to primary cases of the cutaneous type, gives an expected prevalence, of all types of leprosy, of 293 per 1,000 for males and 140 per 1,000 for females. Considering cutaneous secondary cases only, the expected prevalence for males is 235

per 1,000 and for females 83. These figures are very much higher than is generally appreciated and throw new light on the infectiousness of leprosy.

References

(1) Doull, J. A., Rodriguez, José N., Guinto, Ricardo and Plantilla, Fidel C. A field study of leprosy in Cebu. Internat. Jour. Lep. 4 (1936) 141-170.

(2) Guinto, R. S. and Rodriguez, J. N. A field study of leprosy in Talisay, Cebu, Philippines. Internat. Jour. Lep. 9 (1941) 149-166.

(3) Edwards, H. R. Tuberculosis case-finding. Studies in mass surveys. American Rev. Tuberculosis. 43 (1941) 491-503.

(4) Rodriguez, José N. and Guinto, Ricardo S. A field study of leprosy. II. Reexamination of cases of leprosy at Cordova, Cebu Province, Philippine Islands. Internat. Jour. Lep. 6 (1938) 285-302.

(5) Weinberg, W. Die Kinder der Tuberkulösen. S. Hirzel, Leipzig, 1913.

(6) Frost, W. H. Risk of persons in familial contact with pulmonary tuberculosis. American Jour. Pub. Health. 23 (1933) 426-436.

(7) Doull, J. A. The importance of field studies of leprosy, with especial reference to the risk of household exposure. American Jour. Hyg. 29 (1939) 27-33.

(8) Stewart, H. C., Gass, R. S., Gauld, R. L. and Puffer, R. R. Infection, morbidity and mortality in the families of the tuberculous. American Jour. Hyg. 26 (1937) 527-556.

(9) Downes, Jean. The risk of mortality among offspring of tuberculous parents in a rural area in the nineteenth century. American Jour. Hyg. 26 (1937) 557-569.

(10) Twentieth Annual Report of the Superintendent of Health of the city of Providence for the year ending December 31, 1903.

(11) Frost, Wade H. The familial aggregation of infectious diseases. American Jour. Pub. Health. 28 (1938) 7-13.

(12) Puffer, Ruth R., Doull, J. A., Gass, R. S., Murphy, W. J., and Williams, W. C. Use of the index case in the study of tuberculosis in Williamson County. American Jour. Pub. Health. 32 (1942) 601-605.

(13) Gauld, Ross L., Reed, Lowell J., and Merrell, Margaret. The index person — Relation to incidence rates in family studies. American Jour. Pub. Health. 32 (1942) 577-584.

(14) Opie, Eugene L., Putnam, Persis and Saward, E. Joyce. The fate of Negro persons of a tropical country, Jamaica, B. W. I., after contact with tuberculosis. American Jour. Hyg. 16 (1941) Monographic Series.

APPENDIX A. *Person-years of life-experience in various age groups for males and females, exposed and not exposed in the household in Cordova and Talisay.*

Age in years	Males				
	Cordova		Talisay		
	Exposed	Not exposed	Exposed	Not exposed	Total
0- 4	609	12,730	871	22,640	36,850
5- 9	687	8,519	966	16,325	26,497
10-14	749	6,076	952	12,299	20,076
15-19	694	4,519	860	8,988	15,061
20-29	1,138	8,958	1,288	15,017	26,401
30-39	708	6,615	940	11,990	20,253
40-49	638	3,400	832	7,557	12,427
50 and over	543	2,257	860	5,394	9,054
Total	5,766	53,074	7,569	100,210	166,619

Age in years	Females				
	Cordova		Talisay		
	Exposed	Not exposed	Exposed	Not exposed	Total
0- 4	600	12,214	728	21,816	35,358
5- 9	687	8,254	805	15,770	25,516
10-14	694	5,883	851	11,929	19,357
15-19	668	5,055	848	9,593	16,164
20-29	1,112	9,781	1,434	17,371	29,698
30-39	849	6,157	1,142	12,702	20,850
40-49	723	3,239	1,009	7,534	12,505
50 and over	674	1,857	1,193	5,225	8,949
Total	6,007	52,440	8,010	101,940	168,397

APPENDIX B. *Person-years of life-experience in various age groups for males and females, exposed in the household, according to type of primary case (Cordova and Talisay combined.)*

Age in years	Males			
	Primary case			
	Cutaneous	Neural	Unknown	Total
0- 4	955	405	120	1,480
5- 9	1,228	305	120	1,653
10-14	1,287	290	124	1,701
15-19	1,185	247	122	1,554
20-29	1,733	441	252	2,426
30-39	1,136	283	229	1,648
40-49	1,055	215	200	1,470
50 and over	988	190	225	1,403
Total	9,567	2,376	1,392	13,335

Age in years	Females			
	Primary case			
	Cutaneous	Neural	Unknown	Total
0- 4	812	375	141	1,328
5- 9	995	325	172	1,492
10-14	1,136	257	152	1,545
15-19	1,119	271	126	1,516
20-29	1,879	380	287	2,546
30-39	1,431	243	317	1,991
40-49	1,232	223	277	1,732
50 and over	1,382	203	282	1,867
Total	9,986	2,277	1,754	14,017

APPENDIX C. *Cases of leprosy in males and females by type* and age at onset for those exposed and not exposed in the household, classified by type of primary case.*

Age in years	Type	Males									Females									TOTAL CASES
		Cordova				Talisay				Total cases	Cordova				Talisay				Total cases	
		Exposed to			Not exposed	Exposed to			Not exposed		Exposed to			Not exposed	Exposed to			Not exposed		
		C	N	U		C	N	U			C	N	U		C	N	U			
0 - 4	N	—	—	—	1	1	—	—	—	2	—	—	—	—	—	—	—	—	—	2
5 - 9	C	5	—	—	7	7	1	—	8	28	—	—	1	1	2	—	—	4	8	36
	N	1	—	—	3	2	1	1	4	12	2	—	1	6	—	—	2	4	15	27
	U	—	—	—	1	—	—	—	—	1	1	—	—	—	—	—	—	—	1	2
10 - 14	C	12	—	1	13	13	2	—	18	59	4	—	1	8	3	—	—	16	32	91
	N	—	—	—	9	4	—	—	3	16	1	—	2	4	2	—	—	6	15	31
	U	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	1
15 - 19	C	5	—	—	7	8	—	—	11	31	4	—	1	8	3	—	—	3	19	50
	N	2	1	1	3	1	—	—	6	14	2	1	—	1	—	1	—	1	6	20
	U	—	—	—	1	—	—	—	1	2	—	—	—	—	—	—	—	2	2	4
20 - 29	C	1	—	—	9	11	—	—	17	38	1	—	—	1	3	—	—	2	7	45
	N	3	—	—	1	1	—	—	6	11	3	—	—	3	3	—	—	2	11	22
	U	—	—	—	2	—	—	—	2	4	—	—	—	—	—	—	—	1	1	5
30 - 39	C	—	—	—	5	1	—	1	8	15	—	—	—	1	4	—	—	3	8	23
	N	—	—	—	1	—	—	—	2	3	—	—	—	—	—	—	—	—	—	3
	U	—	—	—	1	—	—	—	3	4	—	—	—	—	—	—	—	—	—	4
40 - 49	C	—	—	—	2	1	—	—	5	8	—	—	—	—	1	—	—	3	4	12
	N	1	—	—	—	—	—	1	2	4	1	—	—	—	—	—	—	2	3	7
	U	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	1
50 and over	C	—	—	—	—	—	1	—	2	3	—	—	—	—	—	—	—	1	1	4
	N	1	—	—	—	1	—	—	2	4	—	—	—	—	5	—	—	2	7	11
	U	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	1
All ages	C	23	—	1	43	41	4	1	69	182	9	—	3	19	16	—	—	32	79	261
	N	8	1	1	18	10	1	2	25	66	9	1	3	14	10	1	2	17	57	123
	U	—	—	—	5	1	—	—	7	13	2	—	—	—	—	—	—	3	5	18
Total		31	1	2	66	52	5	3	101	261	20	1	6	33	26	1	2	52	141	402

* C = Cutaneous or mixed. May be considered bacteriologically-positive or "open."
N = Neural. May be considered bacteriologically-negative or "closed."
U = Type unknown.