

THE PATHOGENESIS OF LEPROSY

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From the earliest days till the sixteenth century nobody ever doubted that leprosy was a contagious disease. This explains the methods used to combat it, chiefly the isolation of the sick in asylums. However, in the sixteenth century it was discovered that a large part of those supposed to be leprosy were really suffering from the so-called "lepra spuria" or "sanabilis"—syphilis, scurvy, etc., which formerly had been mistaken for leprosy. It was then realized that the striking cases which had apparently occurred through contagion were curable by mercury. Consequently, there arose doubt whether "lepra vera" was contagious at all, and since it had been observed that whole families were often affected, it was thought that the disease must be hereditary. So it was that in the middle of the nineteenth century only a few leprologists still held to the old view that leprosy was a contagious disease.

When in 1873 Hansen discovered the leprosy bacillus opinion changed again. Since then the frequent cases of infection of whole families have not been considered proof of heredity, but of family infection caused by the close association of its members. Many authors have published observations of importation of the disease into a country which had been quite free from it, and its subsequent spread therein. The seemingly spontaneous appearance of leprosy in a person who has lived for a long time in a country free from this disease is explained on the ground that leprosy has various and sometimes prolonged periods of incubation, so that infection or at least exposure to infection may have occurred many years before the development of the disease, and the occasion of exposure may not be recalled.

However, this question has not been solved definitely. Something seems to be amiss here. It is possible that the Hansen bacillus may be only a harmless parasite. There is lacking positive experimental proof of the contagiousness of leprosy such as can easily be demonstrated with tuberculosis and other diseases. It is not possible to make decisive experiments with animals, for the Hansen bacillus can-

not be grown in culture and animals have as yet proved immune to infection by it. The seriousness of the disease prohibits extensive experimenting on mankind, though Danielssen and Profeta both inoculated several people, none of whom acquired the disease, and several others have made such attempts. Arning inoculated one man in Hawaii and had a positive result, but it was found that two close relatives of the patient had leprosy, so that he might have been infected by family contact before he was inoculated.

On the other hand, there have been reports of cases occurring in consequence of wounds which seem to have the value of deliberate inoculation. For example, Hillebrand told of a child in Borneo who stuck a thorn into his flesh immediately after a leper had done it, infection following. In the same way, according to Solano, a boy in Colombia who had first pricked his leper companion with a needle and then himself became infected. Ehlers reported the case of a doctor who hurt his finger while operating on a leper and was thus infected, and Hundaze recorded another doctor infected through inoculation of a wound of his finger when opening an abscess. Other cases are cited by Rogers and Muir (⁹).

But these cases again are only isolated ones which cannot be proved, and the question still remains why so many people who come into contact with the infection do not acquire the disease. If experimentation thus fails to prove its contagiousness the only remaining possibility of proving this is by epidemiological investigation. There are other diseases in which animal experiments are without result, and of which we not even know the infecting organism, notwithstanding which nobody doubts their infectiousness.

It has to be proved: (1) That every newly infected case of leprosy has at least had the possibility of being infected by a previous case. (2) That leprosy never develops autochthonously, but that where it appears for the first time it has been imported. (3) An explanation is needed for the fact that leprosy so often is not contagious when it might be expected to be; that sometimes after intimate intercourse of many years it does not infect, while at other times it does so with only slight contact.

1. In Estonia leprosy can be traced as an endemic back to the oldest times. From among one million inhabitants twenty to thirty fall ill every year. Because of the relatively small numbers of cases,

observations of it are few and the statistical figures small. On the other hand, the very fact that the numbers of cases are comparatively small, together with the relatively high standard of culture of the people and the circumstance that in this country they do not live as crowded together as in tropical countries, offers some advantages in the study of this disease.

Systematic observations of leprosy began to be made here in 1901. Since that time all new cases have been registered and the infectious cases confined in asylums. In 1921 the late Siegfried Talvik, a professor at Dorpat, published a study made in the island of Oesel, where he was the head physician of the Audako leper asylum from 1903 to 1920 (12). He gives an account of the cases treated from 1820 to 1878 at the hospital of Arensburg, the only town on Oesel; of another 22 cases which Lohk had observed in Oesel in 1894 (6); and finally of 202 cases which he himself had treated at the Audako asylum. Of this last group he gives case-reports of 190 cases, which makes it possible to study the material from a viewpoint other than that of the author himself.

In 1933 the late Arthur Kupffer, head of the asylum in Kuda where are confined the lepers of North Estonia—that is, that part of the Estonian republic which until 1918 formed a Russian province—published reports which he had collected in the course of 35 years (5). The two monographs referred to, as well as an unpublished list of Kupffer's 424 cases in which he had noted all details such as birthplace, home, source of infection, etc., have been studied by me, and from them I have tried to give, as far as possible, a reply to the questions propounded above. Among other data of Kupffer's I have used statements concerning 21 cases which occurred in Estonia after 1921 but for which detailed information is missing, and another 18 cases were not included in his lists because they had only "lepra frustra," by which is meant that they were only suspected to be lepers.

Among Talvik's 202 cases there are 97 which he called "family leprosy," because they occurred in husband or wife, children, grandchildren and other relatives of lepers—cases in which there was known intercourse with the diseased persons. In the other 105 cases Talvik was unable to trace leprosy among relatives. "On the other hand, about all these cases we can have, as far as it is possible, precise details . . . of more exterior intercourse with leprosy." Nine

of these cases returned from abroad with the disease and no definite details could be obtained.

Of the 424 cases in Kupffer's list he had found in 262 instances the individual from whom the infection had been gotten. As with the people from Oesel, most of them had lepers among relatives living with them, or they had in some other way been in intimate intercourse with lepers; they had worked with them, nursed them, etc. In the other 162 cases it had not been possible to trace any individual as the source of infection, but with nearly all it could be shown that before they became infected they had lived among lepers, or had had intercourse with them, or had leper acquaintances. However, in 7 cases even this could not be shown, but these individuals had served in Russia as soldiers and had returned infected from there, where they probably had had chances of infection.

The first of the requirements set forth, namely, that every case at least had the opportunity of infection from a previous case, is thus met as far as it could be expected in material available in Estonia. That in 5 per cent of the cases, persons who returned home infected after many years abroad, such contact cannot be proved is easily understood.

2. The second requirement, that leprosy does not develop autochthonously, is next to be considered. Talvik and Kupffer observed the appearance of leprosy in limited areas. In Oesel the principal focus is the little Sworbe peninsula, with parishes of Anseküll and Jamma and the neighbouring parish of Kielkonid. From this district have come 72 per cent of the cases of that region, whereas only 28 per cent are ascribed to the eight other parishes and the town of Arensburg. On the continent the parishes of Kusal, Kegel, Johannis and others are infected.

Furthermore, in these main foci new cases do not appear sporadically and irregularly, but they are limited to certain farms and villages where the condition always reoccurs, while other districts are permanently free from the disease. In all cases that occurred in one of the parishes free from the infection it could be shown that they arose only after contact with persons who themselves were infected in leprous areas.

Talvik was successful, without exception, in obtaining proof of this for the new leprosy foci in Oesel. In the North of Estonia, including the island of Dago, eleven parishes were free from leprosy

in 1901, when systematic search for the disease began. Later, cases occurred in ten of them and were responsible for the forming of more or less large foci. In every instance Kupffer proved that the infection came through lepers from parishes already affected. Thus, as far as is possible with relatively limited material, for Oesel and North Estonia the contagiousness of leprosy has been proved from its epidemiology.

3. If the data of Kupffer and Talvik can be accepted—and also those of many foreign authors—the question still remains why in so many cases where infection could be expected it does not take place, while on the other hand it so often occurs easily. Of 162 of the North Estonian cases we only know that they had been in leprosy areas, though they could not name specifically any lepers with whom they had been in contact. In such cases it would seem that infection must be caused by superficial and passing intercourse. There are possibilities of infection by such contacts as smoking the same pipe, or drinking out of the same vessel, or wearing the same objects, or shaking hands—kissing is not customary in this country, as a rule—or by droplet-infection, germ-carriers, or insects. We must presume that with these 162 cases infection occurred in some such way.

On the other hand there are many instances in which the possibility of infection certainly existed but in which contagion did not take place. I shall note here some instances from the experience and observations of Kupffer and myself.

(1) In my parent's home, when my brothers and sisters and I were ten to fifteen years old, we had a leper cook who often also did the rooms, made beds, etc. This "old Anna," who had a clear case of "facies leonina," very often while cooking hurt and burnt her hands, which were anesthetic. For these injuries she was treated by a doctor, but her condition was not diagnosed at the time. Later she went into a leper asylum. (2) At the vicarage of Kusal a coachman with nodular leprosy served for eight years. The clergyman had six children twelve years of age or less, and they were often at the coachman's house, used the same reins that he did, and otherwise contacted the infection. Quite by chance a doctor saw him and sent him to a leper asylum. (3) A man with leprosy served as cook on different estates, and became cook for an old gentleman who suffered from a disturbance of the bladder and who showed the cook how to catheterize him. (4) An Estonian family with numerous children had for many years a nurse who was leprosy. (5) On an estate in Livland there was for many years a footman who was leprosy and who later was made an overseer because he could no longer hold the dishes on account of his crippled fingers. In not one of these cases was the infection transmitted to the contacts.

These cases are some of those that, quite by chance, are well known among many unrecognized instances in which people for years have had intimate intercourse with lepers, living or working with them without being infected. There is, of course, a much greater number of cases in which people have had only superficial intercourse with lepers without infection. The number of people so exposed who have not developed the disease is much greater than the number of those who have been infected under the same circumstances. The only explanation is that most people are immune to leprosy.

Most leprologists have come to the view that a certain susceptibility is required in order for infection to take place. It is generally acknowledged (^{9b}) that children and young people up to about the age of twenty are especially susceptible. After thirty the danger of infection decreases, though it is not quite abolished thereafter. In general, about 50 per cent of lepers were infected between their first and twen-

TABLE 1.—*Age of infection in different countries, by decades.*

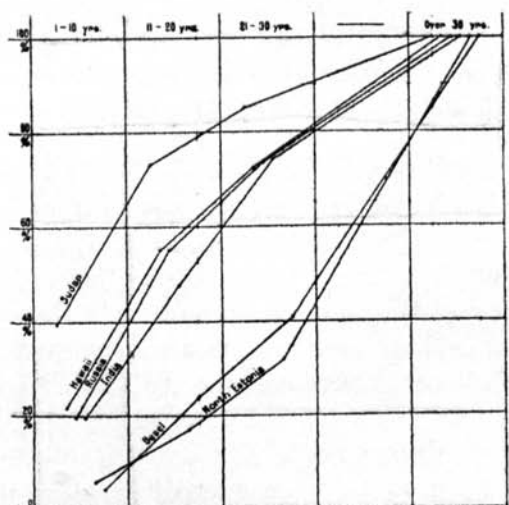
Country or region	Age group			
	0-10	11-20	21-30	Over 30
Sudan	39.1	34.1	11.8	15.0
Hawaii	21.5	33.2	17.8	27.5
Russia	19.4	35.3	18.8	26.5
India	19.6	27.9	26.1	26.7
North Estonia	5.6	11.1	15.1	67.9
Oesel	4.1	20.0	16.8	59.0

tieth years, and about 75 per cent before the age of 30. It is of interest to see how this compares with the findings in Estonia. The data in Table 1 for other countries I have calculated by decades in order to compare them with ours.

The figures for North Estonia and Oesel are just the opposite of those for the other countries. This is clearly to be seen in the table, but it is shown graphically in Text-fig. 1, the curves of which are cumulative. Whereas in other countries most infections occur by the age of twenty and there is a sharp decrease after thirty, here in Estonia most of the cases are infected only after thirty. Most striking is the difference between the Sudan and Estonia; in the former 25.4 per cent occur in the first five years, while in North Estonia the corresponding figure is 1.8 per cent. Hawaii, Russia and India are intermediate; the curves for the first two are almost identical

while that for India is flattened by the practical equality of the 11 to 20 and 21 to 30 groups.

These striking differences can be explained only in the following way: individuals who are susceptible at all to the infection have this quality from birth. In a country where leprosy is wide-spread and the hygienic circumstances bad, such persons are exposed and infected in their earliest childhood, so that in later years most of the susceptible people are already diseased; thus those who were not infected in childhood are not susceptible at all.¹ On the other hand, in a country like Estonia where leprosy is comparatively infrequent, and where the people do not live crowded together and the hygienic



TEXT-FIG. 1. Curves to illustrate the differences between the usual data on age of infection and those for Estonia.

circumstances are comparatively good, the possibility of infection is small. Thus the susceptible people need not have been infected in their youth, and afterwards remain still susceptible to the disease. This also explains the fact that in Oesel, where the lepers live more crowded together than on the continent, 40 per cent are infected by the age of thirty while in North Estonia the corresponding figure is only 32 per cent. This leads us to the conclusion that age does

¹ Vandyke Carter, according to Rogers and Muir (9c) found in India that there was a greater development of leprosy in childhood in badly infected districts (16.7 per cent) than elsewhere (9.0 per cent).

not constitute a decisive factor in the susceptibility to infection by leprosy.

Talvik tries to explain the frequent cases of non-infection between husband, wife and children of lepers, in spite of their living together for years, on the ground that perhaps the infected person usually discharges only limited quantities of bacilli, and that these cause the production of specific antibodies in the healthy ones, which makes them immune to the disease (see also Noel, 8). The view that, in general, weakening diseases favor infection may be right, but that is not of great consequence with people who for years live with lepers without being infected. But Talvik's hypothesis does not explain the frequent non-infection of strangers exposed to infection, people who could not have been immunized in that manner.

Because in the opinion of some authors certain features of the epidemiology of leprosy are not to be explained by known facts, they have returned to the old idea of heredity. However, this is not invoked in its earlier sense that the disease itself is hereditary; but that there is only a hereditary predisposition to it, or in the contrary case a hereditary immunity. Virchow, in 1897, took this point of view. Later, other authors, influenced by isolated observations, adopted the view of hereditary predisposition.² However, as far as I know this was done without any attempt to support it with extensive data. I shall now try to see whether I can answer, from the data from North Estonia and Oesel, the question why different individuals show such differences in liability to infection.

As far as I can see there are four different possibilities as regards infection by leprosy:

1. Exposed persons *remain well*: i.e., the power of resistance of the body is so great that they are immune to infection.

² Sääsk (10) states that a special constitution is required to make it possible for the leprosy bacillus to spread in the body and that this constitution is hereditary and sometimes appears in grandchildren; otherwise the cases where children of lepers living with the diseased remain healthy would be incomprehensible. He reports amongst others three instances in which small children lived for years with their parents in leper asylums and were not infected, and who remained healthy for years after leaving the institutions. Aoki (1) found from his material that blood-relatives were infected twelve times more frequently than non-relatives. Bargehr (2) believes that the continual appearance of leprosy in a family, affecting without exception only the blood-relatives, compels the assumption of a hereditary condition that increases the disposition to infection.

2. *Lepra abortiva* occurs; i.e., infection takes place but the power of resistance is sufficient to overcome it. The manifestations of the disease are limited to an anesthetic spot or some similarly slight change, and otherwise the person remains healthy.

3. *Lepra maculosa* develops; i.e., infection occurs and becomes general, but the resistance suffices to limit the spread of the bacilli in the body, and the full development of the disease does not take place.

4. *Lepra tuberosa* develops; i.e., resistance fails so far that the disease attains full development.

The number of the persons who do not become diseased in spite of exposure to infection cannot be shown statistically, nor can the number of abortive cases be determined. For this reason I have not attempted to ascertain what circumstances determine susceptibility to infection, but instead I have inquired what circumstances exist most often when a lower resistance to the infection is shown (i.e., where the nodular form of the disease is common), than where the resistance is higher and the macular form is more frequent. In Kupffer's report I find the following:

In cases where one and the same individual infects blood-relatives and non-relatives, it is of interest to note whether the disease is equally serious in both, or whether there can be observed a difference in the seriousness of the cases, as well as in the time before the disease appears. It seems that it is more severe in the case of a blood-relative, but it does not always happen that he falls ill earlier. For example, two persons lived together with a nodular leper and both fell ill in 1907; of these the sister of the leper had *lepra tuberosa* and the non-relative *lepra maculosa*. A nodular leper, his son and his father-in-law lived together from 1890 on; in 1895 the father-in-law developed macular leprosy and in 1908 the son acquired the nodular form. Similarly, there lived with a man who had had nodular leprosy since 1884, his son who was born in 1899 and a servant girl; the servant fell ill in 1908 with *lepra maculosa*, and the son in 1914 with *lepra tuberosa*.

In Talvik's case-reports I find seven similar cases, though he apparently gave no special attention to the facts which he recorded that bear on this point.^{*} Kupffer on the other hand examined his

^{*} Case 44 infected her brother with *lepra tuberosa*, but her friend with *lepra maculosa*. T. O. infected three sons with nodular leprosy; one of these lived together with a distant relative (Case 2) and he was infected with the macular form. Case 99 infected two grandchildren with *lepra tuberosa*, but her friend with *maculosa*. Case 124 infected his nephew with *tuberosa*, but a lodger with

material to ascertain whether persons infected by a near relation more frequently develop the nodular form than do those infected by a stranger, and found that the latter more often show the macular type.

In the following two tables I have collected the data of Talvik and Kupffer, not from the viewpoint of whether the diseased were infected by leper relatives, but of whether they had such relatives. For instance, a person who is infected by a stranger might have a leprous brother. The data from Talvik are given in Table 2.

TABLE 2.—*Type of leprosy in patients with and without leprous relatives, Talvik's cases.*

Group	Lepra abortiva	Lepra maculosa	Lepra tuberosa	Proportion mac. : tub.
A. Children with at least one leprous parent * ...	5	3	19	1 : 6.3
B. Patients who had leprous brothers and sisters ...	1	4	20	1 : 5.0
C. Sum of A and B, all persons living with leprous relatives	6	7	39	1 : 5.5
D. Patients without leprous relatives but leper lodgers ^b	1(+2)	10	23	1 : 2.3
E. Sum of all cases in which leper relations can be proved		36	108	1 : 3.0
F. Sum of all lepers who had no leper-relations ..		37	56	1 : 1.5

* 340 children remained healthy, 27 were infected.

^b Not including married couples.

Talvik himself mentions that among 202 patients 97 were cases of "family leprosy." Among these he counted not only parents, children, grandchildren, uncles, aunts, cousins and other relatives, but also husbands of lepers, and he included cases not observed by himself. There were 5 instances in which one of a married couple

maculosa. Case 138 infected an aunt with tuberosa but an acquaintance (Case 143) with maculosa. Case 144 infected her sister and brother with the nodular form and a neighbor (Case 140) with the macular, but a co-worker, who was not a relative, acquired lepra tuberosa.

infected the other. Of these 97 cases, 94 had lepra tuberosa and 3 lepra maculosa. My figures, made up from his material, differ from his and after deducting the cases of married couples—which are not concerned in this problem—I find a ratio of 9 cases of tuberosa to 1 of maculosa. The remaining 105 cases of Talvik's group had no leprous relatives. To these we may add the married couples. There were 79 with the nodular form and 29 with the macular; in 2 cases the type was unknown. In this group the proportion was 2.7 tuberosa to 1 maculosa.

A similar analysis of Kupffer's data gives the figures shown in Table 3. Kupffer did not state the total number of children con-

TABLE 3.—*Type of leprosy in patients with and without leprous relatives, Kupffer's cases.*

Group	Lepra maculosa	Lepra tuberosa	Proportion of mac. : tub.
A. Children with at least one leprous parent	7	31	1 : 4.4
B. Patients who had leprous brothers and sisters	10	29	1 : 2.9
C. Sum of A and B, all persons living with leprous relatives	17	60	1 : 3.5
D. Patients without leprous relatives but leper lodgers	21	7	1 : 0.3
E. Sum of all cases in which leper relations can be proved	29	111	1 : 3.8
F. Sum of all lepers who had no leper-relations	112	172	1 : 1.5

cerned, and I have been unable to determine it except for Kusal parish, for which I have found the necessary details at the government family registry office. According to this, in 26 leper marriages there were 41 children, of whom 33 remained healthy and 8 developed the disease, 3 with lepra maculosa and 5 with lepra tuberosa. The infection rate in this small group is 19.5 per cent, but in Talvik's much larger group (Table 2) it was only 7.4 per cent.

With all these figures a certain inexactness cannot be avoided, since the relationships that existed could be proven only by pedigrees, whereas both authors were dependent upon the statements of their patients. The figures in the individual rubrics are too small to be used alone for statistical purposes. However, the results are

everywhere so similar that we are forced to conclude that blood relatives of lepers develop lepra tuberosa relatively more often than do those who have no leprous relatives.

The conditions among married couples I have not yet considered. It has been observed by all authors that when a husband or wife is leprous the other seldom becomes diseased; only 2 to 5 per cent of such cases are reported. In Talvik's material there were 115 leper marriages, all of the diseased having the nodular form. In 107 of these the healthy mate remained well. Of the 8 becoming infected 3 had lepra abortiva, 2 maculosa, and 3 tuberosa. Kupffer recorded 230 leper marriages, in 213 of which the mate remained well. The abortive form occurred 5 times, the macular 10 times, and the nodular twice. Here also the proportions of conjugal infections are small, 6.9 and 7.4 per cent, respectively.

The latter figure is the same as that for infected children in Talvik's material. However, there is a distinct difference in the maculosa: tuberosa ratios in the infected mates and infected children; with the latter it is 1:6.5 (Talvik) and 1:4.4 (Kupffer), while with the former the figures of both authors together give 1:0.4. Both groups, mates and children, lived together in the family, the only difference being that husband and wife are never close blood relations—at most they are only distantly related. These findings serve to confirm our conclusions with regard to the influence of blood-relationship on the degree of susceptibility to leprosy⁴.

But if it can be proved statistically that blood relationship with lepers is determinative of the degree of disposition to leprosy, it means nothing more than that the *disposition* is hereditary. Those cases of nodular leprosy in which no leprous relatives can be traced do not contradict this statement by any means. The opportunity of infection of the relatives may have been missing, or the condition that led to the development of that form of the disease may have arisen only through a complex inherited from both parents. If a hereditary disposition is assumed in the case of the nodular form we must also assume a similar disposition but of lesser degree for the macular form.

⁴ Lowe, in India (7), in the course of eight years, observed only 8 cases of infection by marriage. It was remarkable that in all these cases only the mild form of the disease developed, whereas the children of lepers more often acquired the serious form.

All infectious diseases involve a special disposition for infection. With some diseases, as measles, malaria, plague, etc., this exists in all people insofar as they have not acquired an immunity. With scarlet fever infection fails with about 60 per cent, with diphtheria about 80 per cent. The susceptibility is always fixed by the hereditary type, and can be only modified by the conditions of environment.

In unions of persons with different susceptibilities the proportions in the descendants differ; one part develops the qualities of the father, another of the mother, and about one-half are intermediate. The elimination of those with the highest grade of frailty continues (scil. through death) and the result must be a gradual increase of the power of resistance.

So wrote Gottstein (3) about infectious diseases, with special reference to diphtheria, concerning which proofs are easily obtained.

That the proportion of the healthy children to the diseased is such a small one—1 : 13.1 or 1 : 15.5 depending on whether we consider the abortive cases as diseased or healthy^{*}—is naturally explained by the fact that inherited susceptibility alone is not sufficient to produce the disease; the actual infection must be added to this, and this can be prevented.

With leprosy it is very much as with psoriasis; for that also, a hereditary susceptibility is presumed, but in addition there is required some other factor, as yet not definitely known, in order that the person may fall ill. So with leprosy; besides the inherited susceptibility for the disease an infection is necessary. With psoriasis, again, if the well-known laws of heredity are valid, many more children should be hereditarily susceptible than actually fall ill, and as a matter of fact only 1 child falls ill to 13.6 who remain healthy (4). With leprosy the proportion is nearly the same, so that the question arises whether not the same laws are in force in both cases.

SUMMARY

My study of material collected by Kupffer and Talvik confirms the view that leprosy is only gotten by infection. Nobody gets leprosy who has not been exposed to infection by a leper, and nowhere does leprosy appear without a previous case having been imported from a leprous region. That of all those who are exposed to the infection

^{*} Cf. Simonds (11), who among 367 children of leper parents found 22 clinically and bacteriologically positive cases, the same figures as in Talvik's material.

only a comparatively small percentage is infected must be explained on the ground that to acquire leprosy there must exist, besides the infection, a specially inherited predisposition. The hereditary nature of this disposition is shown by the fact that among blood relatives of lepers there are many more serious cases (*lepra tuberosa*) and fewer light cases (*lepra maculosa*) than among non-relatives.

REFERENCES

- (1) AOKI. Japanese Jour. Dermat. 32 528. [*Ref.*: Zentralbl. f. Haut- u. Geschl. Kr. 42 (1932) 623.]
- (2) BARGEHR. Zur Epidemiologie der Lepra. Geneesk. Tijdschr. Nederlandsch-Indië 66 (1926) 112. [*Ref.*: Zentralbl. f. Haut- u. Geschl. Kr. 28.]
- (3) GOTTSTEIN. Die Lehre von den Epidemien. Berlin, 1929.
- (4) HODE. Umwelt und Erbllichkeit bei der Entstehung der Schuppenflechte. Leipzig, 1932.
- (5) KUPFFER, A. Ueber die Verbreitungsweise der Lepra: Beobachtungen aus Estland. Beih. z. Arch. f. Schiffs- u. Tropenhyg. 36 (1933).
- (6) LOHK, H. Epidemiologische Untersuchungen über die Lepra und den ätiologischen zusammenhang ihrer Einzelerkrankungen. Arch. f. Dermat. u. Syph. 40 (1896).
- (7) LOWE, J. Epidemiology of leprosy in Hyderabad (Deccan), India. Internat. Jour. Lep. 1 (1933) 17. [*Ref.*: Zentralbl. f. Haut- u. Geschl. Kr. 48.]
- (8) NOEL. Etiologie (etc.) de la lèpre. Rev. prat. mal. Pays chauds (1923) No. 2. [*Ref.*: Zentralbl. f. Haut- u. Geschl. Kr. 18, 800.]
- (9) ROGERS, L. AND MUIR, E. Leprosy. Bristol, 1925. (a) p. 95 et seq; (b) 72 et seq; (c) p. 76.
- (10) SÄÄSK. Eesti Arst. 10 (1931) 307.
- (11) SIMONDS. Die Lepra auf der Insel Ambon. Mededeel. v. d. Dienst d. Volksgezondh. in Nederlandsch-Indië 22. [*Ref.*: Zentralbl. f. Haut- u. Geschl. Kr. 48, 419.]
- (12) TALVIK, S. Die Lepra im Kreise Oesel. Tartu, 1921.