WHAT ARE THE DANGERS OF INFECTION FOR CHILDREN UNDER EIGHT IN TUBERCULOUS HOMES?

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SINCE 1918 the Tuberculosis Department of the Board of Health of Christiania has carried out systematic cutaneous tuberculin tests, in addition to the ordinary clinical examinations, of the children from tuberculous homes under the supervision of the Board of Health. These investigations should help to show what risks of infection are run by children in such homes, and are a small supplement to the cutaneous tuberculin tests of Norwegian children in the national schools, and to Dr. Y. Ustvedt's investigations of the health of infants in tuberculous families.

The period covered was from September, 1918 to December, 1920, and of the 500 children examined between the ages 0 and 8, and recruited from 310 tuberculous homes, 245 were boys and 255 were girls. None of these children had begun to attend school, and they belonged to homes where one or more patients, suffering from tuberculosis, lived or had lived after the birth of these children, and had been notified to the Board of Health, under whose supervision they had been placed. Most of these homes were poor working-class homes kept together under insanitary housing conditions in the east quarter of the town.

The method adopted was v. Pirquet's cutaneous tuberculin test, as it is a test which is generally accepted as reliable, is not harmful, is easily carried out, and is the test which has been extensively applied in Norway and other countries in the wholesale examination of children. Dr. Leegaard [1] has controlled 55 negative v. Pirquet reactions by subcutaneous injections of tuberculin, but only in one was the subcutaneous test positive. Professor Hamburger [2] recommends the "Stichreaktion" devised by himself, and so does Dr. Selter [3] because he believes that this reaction is more reliable and gives a higher proportion of positive results. Dr. Mantoux's intracutaneous reaction has also been highly recommended. These comparatively complicated tests are, however, not easily applied to relatively healthy children examined wholesale and not in a hospital.

The technique adopted was that recommended by v. Pirquet. Koch's old tuberculin (100 per cent.) made in the State Veterinary Laboratory, and containing, according to Professor Holth's account, both human and bovine tuberculin, was used. The control tests were carried out according to Dr. Frölich's [4] technique with glycerine bouillon reduced to the concentration of tuberculin by evaporation to 1/10th. After the skin of the flexor aspect of the forearm had been cleaned with ether, three abrasions were made with v. Pirquet's needle, the interval between each being about 4 cm., the middle abrasion being used as a control and a small drop being applied to each abrasion. After the sites of inoculation had been left undisturbed for about 10 minutes, they were covered by a small sterile dressing to protect them from scratching. They were examined 24 hours later and, in doubtful cases, after another interval of 24 hours. No ill effects from the tuberculin reactions were observed, but in some

cases fairly severe local reactions occurred, and they subsided in a few days under a boracic compress. The reaction was regarded as positive when there appeared a definitely palpable red infiltration, with a diameter of about 5 mm. about the site of inoculation. The determination of the degree of the severity of the reaction depended on the judgment of the individual observer, but it has impressed me that as a rule the reaction showed a marked tendency to exudation and formation of vesicles in those children who showed clinical signs of tuberculosis, and who had been exposed to constant and massive infection. The following table shows the results classified according to the ages of the children examined.

TABLE I.—V. PIRQUET'S REACTION IN 500 CHILDREN IN TUBERCULOUS HOMES.

Age	Number of children	Pirquet +	Per cent.	Pirquet -	Per cent.
0—1	113	60	53.1	53	46.9
1—2	84	49	58.3	35	41.7
2—3	61	41	67.2	20	32.8
3—4	67	39	58.2	28	41.8
4—5	75	48	64.0	27	36.0
5—6	63	37	58.7	26	41.3
6—7	27	18	66.7	9	33.3
7—8	10	8	80.0	2	20.0
0—8	500	300	60.0	200	40.0

As this table shows, *53.1 per cent. of the children in the first year of life had already become infected.* During the following years the number of infections grows irregularly and gradually, and among the children who had attained the age of 8 years four-fifths were found to be infected. Of the total of 500 children between the ages 0 and 8 years, 300 or 60 per cent., proved to be infected. The youngest child giving a positive reaction was 98 days old. In such an investigation as this, the findings may depend on several factors, one of the most important of which is the presence or absence of tubercle bacilli in the sputum of the patient in whose home the child lives. The next most important factor is the housing accommodation in each case.

To ascertain whether the patients in these homes were sputum-positive or sputum-negative, all the notifications were investigated. When there was no bacteriological report, but the patient's dossier showed that he had been admitted to a tuberculosis hospital, inquiries were addressed to this hospital as to the presence of tubercle bacilli in the sputum. Steps were also taken by the Tuberculosis Department to get patients to send their sputum for examination to the Board of Health. In the case of 268 children the source of infection was found to be sputum-positive; for 174 children the source of infection was sputum-negative, and for 58 children no report was available as to the bacteriology of the sputum of the patient. The following table shows the results of the tuberculin tests according as the children were in contact with sputum-positive or sputum-negative patients.

TABLE II.—V. PIRQUET'S REACTION WITH SPUTUM-POSITIVE AND SPUTUM-NEGATIVE SOURCES OF INFECTION.

T.B. found or not found in the source of infection	+ T.B.		- T.B.		0 T.B.	
	Number	Per cent.	Number	Per cent.	Number	Per cent.
+ v. Pirquet's reaction	186	69.4	87	50.0	28	48.3
- v. Pirquet's reaction	82	30.6	87	50.0	30	51.7

As this table shows, children are more often infected in homes where a patient has, or has had, tubercle bacilli in the sputum than in homes where the patient is sputum-negative. But even when, at some earlier date, the patient has been sputum-positive, he may have become sputum-negative without the knowledge of the Board of Health, and before the birth of the child under examination. With this possible fallacy in view, the notifications of the sources of infection were scrutinised, and it was found that 76 per cent. of these notifications dealt with the last five-year period. By taking only the notifications of sputum-positive cases for 1918, 1919, and 1920, it is possible to form a uniform group of infectious cases about which the Board of Health has full information, and to study the tuberculin reactions of the children associated with this group. Most of the patients in this group were unfit for work, were at home and partially bedridden, being the subjects of advanced phthisis. The children associated with this group numbered 168, and their reactions to v. Pirquet's test are classified in the following table, according to the age of the child:—

TABLE III.—V. PIRQUET'S REACTION IN 168 CHILDREN IN HOMES WITH GREAT RISK OF INFECTION.

Age	Number	+ Pirquet	Per cent.	- Pirquet	Per cent.
0-1	40	27	67.5	13	32.5
1-2	30	23	76.7	7	23.3
2-3	18	15	83.3	3	16.7
3-4	27	17	63.0	10	37.0
4-5	25	17	68.0	8	32.0
5-6	19	15	78.9	4	21.1
6-7	5	5	100.0	...	...
7-8	4	4	100.0	...	...
0-8	168	123	73.4	45	26.6

A comparison of Table I with Table III shows a considerable difference in disfavour of the children in homes where the danger of infection is greatest. This difference is particularly great in the age-period 0-3 years. Dr. Elise Dethloff's [5] tuberculin examinations of children from tuberculous homes in Bergen showed a uniformly lower incidence of positive reactions than my material shows. She obtained the following figures from her material consisting of 137 children, whose ages ranged from 0-8 years. Her figures for each year were: 14.29 per cent., 47.37 per cent., 56.25 per cent., 61.11 per cent., 57.14 per cent., 81.82 per cent.,

82·61 per cent., and 77·27 per cent. Very noticeable is the difference between her figures and mine for the age-period 0—1 year, in which I found as many as 53·1 per cent. to be already infected. The explanation may possibly be found in the fact that Dr. Dethloff's material consisted of only 14 children of this age, whereas mine included 113 children of the same age. Housing conditions and the degree of the danger of infection may also have been different, but our technique has been practically the same. In this connection it is interesting to note that both Dr. Dethloff and Dr. Överland [6] found a lower ratio of positive results from wholesale tuberculin examinations of children in the national schools in Bergen, than did Dr. Frölich, who examined school children in Christiania. Dr. Bergman [7] examined 187 children, under the age of 8 years, exposed to infection in Upsala, Sweden. His positive reactions for each of these eight years were: 28·6 per cent., 27·8 per cent., 40 per cent., 50 per cent., 50 per cent., 42·9 per cent., 53·8 per cent., and 71 per cent. Pollak [8] has examined with tuberculin 49 children between the age of 6 months and 1 year, and living in tuberculous surroundings. He obtained a positive reaction in 95·9 per cent. Among 123 school children from tuberculous homes in Christiania Dr. Frölich obtained a positive reaction in 95·1 per cent. Dr. Arnfinnsen [9] has obtained a positive reaction in 66·9 per cent. of school children belonging to the same class in Trondhjem.

The position in the family of the source of infection affected to a certain extent the tuberculin reactions in the children. Thus, of 174 children with tuberculous fathers, 118 (68 per cent.) gave a positive reaction; of 178 children with tuberculous mothers, 102 (57 per cent.) gave a positive reaction; of 76 children with a tuberculous brother or sister, 47 (62 per cent.) gave a positive reaction. But of 74 children living in the same home with more distant relatives or with lodgers suffering from tuberculosis, only 34 (46 per cent.) gave a positive reaction. It will thus be seen that the differences were so slight that they might depend on accident when the sources of infection were a father, mother, brother, or sister. But when the source of infection was a more distant relative or a lodger, the incidence of infection was comparatively small. All the same, every case of pulmonary tuberculosis, whatever the position of the patient in the family may be, is a serious danger to young children in homes the members of which live closely together.

TABLE IV.—310 TUBERCULOUS FAMILIES' HOUSING CONDITIONS.

Number of rooms	Number of houses or flats	Number of inhabitants		Total	Average number	
		Children under 14 years	Adults		Per home	Per room
1 room without kitchen	10	20	24	44	4·4	4·4
1 room plus kitchen ...	150	407	434	841	5·6	2·8
2 rooms plus kitchen ...	132	410	497	907	6·9	2·3
3 rooms plus kitchen ...	13	37	61	98	7·5	1·9
Over 3 rooms plus kitchen	5	6	35	41	...	...
Total	310	880	1,051	1,931	6·2	...

To ascertain the influence of housing, the dossiers of these cases have been scrutinised, and altogether 310 tuberculous homes investigated. As Table IV shows, the number of occupants per room rises as the number of rooms in each home falls.

It will be seen from this table that the average number of persons in each of these tuberculous homes was 6.2, and that the overwhelming majority (292 out of 310) of these homes possessed only one or two rooms in addition to a kitchen. How many of these homes were overcrowded? It is usual to regard as overcrowded the home in which there are more than two persons to a room, kitchen included. This standard has been adopted in these investigations—two children under the age of 14 being taken as the equivalent of one person above this age. Table V shows the average number of person-units in each home and in each room, kitchen included.

TABLE V.—AVERAGE NUMBER OF PERSON-UNITS IN 310 TUBERCULOUS HOMES.

Number of rooms	Number of houses or flats	Average number of person-units	
		Per house or flat	Per room
1 room without kitchen ...	10	3.4	3.4
1 room plus kitchen ...	150	4.3	2.2
2 rooms plus kitchen ...	132	5.3	1.8
3 rooms plus kitchen ...	13	6.2	1.6
Over 3 rooms plus kitchen ...	5	7.6	...
Total ...	310	4.8	...

According to this calculation 160, or 51.6 per cent., of these 310 tuberculous homes were overcrowded. A comparison can be made with the findings [10] of the Statistical Office of the Christiania Municipal Council in the period 1913-1914, when 24.86 per cent. of 10,332 small homes, with up to two rooms and a kitchen, were found to be overcrowded. In this calculation the person-unit standard was two children under 10 equals one person over 10. Although my figures are comparatively small, and the figures of the Statistical Office include a great number of one-person establishments, the two sets of figures are sufficiently comparable to indicate that, in the matter of overcrowding, the tuberculous homes are worse off than those of the general population; and this is particularly noticeable in the homes where, owing to the illness or death of the breadwinner, the economic status is bad.

In the case of 416 children, the source of infection lived in the home, and in 18 per cent. had a separate bedroom. Provision of a separate bedroom for the source of infection did not appear to be reflected in a reduction in the proportion of positive reactions, for 65 per cent. of the children in this category gave a positive reaction. As in most of these cases the source of infection was a patient with advanced phthisis, and as the bedroom in which the patient slept alone was sometimes also the kitchen the isolation effected by sleeping alone was somewhat illusory.

The nurses attached to the Tuberculosis Department have obtained information about all but four of the 500 children as to their feeding in infancy. They were classified according as they were: (1) exclusively breast-fed for at least three months; (2) breast- and bottle-fed, the mothers

often going out to work; and (3) exclusively bottle-fed. It was found that 358, or 72·2 per cent., belonged to the first; 68, or 13·7 per cent., to the second; and 70, or 14 per cent., to the third category. *A study of the tuberculin reactions in these three categories showed little difference whether the child was breast- or bottle-fed.* Among the 358 breast-fed children there were 214, or 59·8 per cent., with a positive reaction; among the 68 breast- and bottle-fed children there were 44, or 64·7 per cent., with a positive reaction; and among the 70 exclusively bottle-fed children there were 42, or 60 per cent., with a positive reaction. Somewhat different was the state of affairs for children under one year with tuberculous mothers, as the following table shows:—

TABLE VI.—V. PIRQUET'S REACTION IN CHILDREN AGED 0—1 YEAR WITH TUBERCULOUS MOTHERS.

Age	Number	Breast-fed	+ Pirquet	Bottle-fed	+ Pirquet	Breast + bottle	+ Pirquet
0—1	42	18	8 (44 %)	13	6 (46 %)	11	8 (73 %)

The figures in this table are too small to warrant definite conclusions, but they suggest that breast-feeding protects the infant against tuberculous infection quite as well as artificial feeding, and considerably better than mixed feeding when the tuberculous mother remains at home and attends her child.

All these children were examined clinically as well as by tuberculin, and the information given by their relatives was recorded. The children were weighed, their eyes, ears, skin, and bones were examined, and search was made for enlarged cervical glands and chest signs. The state of nutrition was definitely bad in 142, or 28·4 per cent.; among the remainder the state of nutrition was normal for the social class to which they belonged. Large, suppurating glands with cicatrization were observed only in two cases, in both of which the tuberculin reaction was positive. In 96 children there was definite enlargement of the glands in the sub-maxillary region, or along the sterno-mastoid muscles down to the supra-clavicular fossæ. In 70, or 73 per cent., these children gave a positive reaction. In 254 cases there was slight enlargement of the glands of little diagnostic importance, and in 148 cases there was no enlargement of the glands. It is difficult to diagnose enlargement of the bronchial glands, and one can arrive at little more than a "probability diagnosis." The expiratory dyspnoea and high-pitched cough, which Hamburger [11] regards as classical evidence of tuberculosis of the bronchial glands, have not been observed by us. We have made this diagnosis when, according to Dr. Frölich, we have heard marked, blowing expiration in the interscapular region, from the first to the fifth dorsal vertebra. All these children have been examined by the X-rays, which have, as a rule, confirmed the clinical diagnosis. Of the 14 children with signs of enlargement of the bronchial glands 12 gave a positive reaction.

Of the 12 children with evidence of lung disease, such as old pleurisy, protracted bronchitis and clinically definite pulmonary tuberculosis, 10 gave a positive reaction. Of the 18 with diseases of the eyes (recent or old phlyctenules) 16 gave a positive reaction. Of the six with prolonged

suppurating otitis, four gave a positive reaction. Of the 23 with scrofulous changes of the skin, 21 gave a positive reaction. Of the six with tuberculosis of the bones and joints (spondylitis, spina ventosa) five gave a positive reaction. It will thus be seen that of the 300 children, between the age 0—8 years, giving a positive reaction, 68, or 22·7 per cent. showed clinical signs of tuberculosis. Enlargement of the cervical glands did not, in our estimate, place children among those with clinical signs of tuberculosis. These figures could, no doubt, have been considerably increased by a more thorough, special examination than that which is feasible in a polyclinic. All these children were regarded as well by their parents, and were not under medical treatment at the time of examination. The object of the tuberculosis department is, among other things, to detect early, hitherto undiagnosed cases of tuberculosis in tuberculous homes, and to see that adequate treatment is provided. The department does not carry out any treatment itself.

Dr. Ustvedt [12] has shown that the mortality among children born in tuberculous families is much above the normal. In the five-year period 1911-1915, he found that of 480 children born in tuberculous homes, 92, or 19·2 per cent., had died before the completion of the first year, whereas the average mortality for the whole population under 1 year was only 10·8 per cent.

Dr. Permin [13] has investigated the prognosis for children born in tuberculous families, and has followed the fate of 46 such children with a positive v. Pirquet reaction in the age period 0—2 years. He found that of the 15 children with a positive reaction under the age of 1 year, six had died, two within the first year of life. Of the nine survivors, one was slightly scrofulous, but the remainder were alive and well at ages ranging from 1 to 7 years. Of the 31 children with a positive v. Pirquet reaction in the age period 1—2 years, only two had died; the oldest of the surviving 29 children had reached the age 7—8 years. Several of these children, however, showed tuberculous symptoms, but the prognosis for this class would seem to be less bad than is commonly supposed.

It is, of course, impossible, after so short an observation period, to draw prognostic conclusions from my material. But I have considered it worth while, even at this early stage, to investigate the fate of these children, and on December 31, 1920, a census was taken. Thanks to the skilled and untiring labours of our tuberculosis nurses, we succeeded in tracing 494 of the children, and only six could not be found because they had been put out to nurse or the family had moved from Christiania.

TABLE VII.—AFTER EXAMINATIONS OF 500 v. PIRQUET-EXAMINED CHILDREN.

Apparently well	Under medical treatment at home	Admitted to hospital	Dead	Unknown	Total
433	25	14	22	6	500

This table shows that 433 children were stated on December 31, 1920, to be well, 39 were under medical treatment, and 22 were dead. Of the 39 under medical treatment, 25 were at home, and no definite diagnosis

was available. Of the remaining 14 children under medical treatment in hospital, four were suffering from bronchitis, two from pulmonary tuberculosis, and one each from phlyctenular conjunctivitis, coxitis, pneumonia, infiltration of the lungs, tuberculous meningitis, abdominal tuberculosis, tuberculous spondylitis and scrofula. *Thus the overwhelming majority of the children treated in hospital were suffering from manifest tuberculosis.* Of the 22 children who had died, eight had died in hospital, 14 at home. v. Pirquet's reaction had been positive in 14 of these cases, negative in eight. According to the notification of deaths to the Board of Health of Christiania, the causes had been diphtheria (1), fits (2), pneumonia (2), meningitis (1), hæmoptysis (1), tuberculous bronchitis (1), pulmonary tuberculosis (2), intestinal tuberculosis (1), tuberculous meningitis (10). The child who died of hæmoptysis was examined post mortem and found to be suffering from tuberculosis of the lungs, glands and intestines. *Thus the cause of death in 15 cases was tuberculosis, and the most frequent cause was tuberculous meningitis.* An investigation of the age of the child at the time of death showed that 10 of the 22 had died under the age of 1 year. *Of all the children examined those under the age of 1 year have shown the greatest mortality.*

The conclusions to be drawn from these investigations are briefly the following: Children in tuberculous families, living under bad housing conditions, run a very great risk of infection which is greatest when the disease of the source of infection is most advanced. In such homes infection occurs early, more than half the children being infected before they are a year old. Effective isolation of the tuberculous in homes containing young children is not feasible even when the patient is given a bedroom to himself. The practical conclusions to be drawn have long ago been indicated among others by Dr. Andvord in his important address on tuberculosis to the Medical Society of Christiania in 1912, when he insisted that we ought, by all possible means, to try to protect the child from massive infections, either by removing the source of infection from the child's neighbourhood, or by isolating the child. But this system requires institutions for the tuberculous where they can, and are willing to, remain for a long time; children's homes where they can be cared for till they have reached a more resistant age; and a tuberculosis law which gives the Board of Health powers under certain conditions to separate mother from child. My best thanks are due to my chief, Dr. J. Jørgensen, for permission to use the material in his department, and for welcome advice and help in utilising this material.

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