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A Comparison in the United States of America of Two Tuberculins, PPD-S and RT 23

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A comparison of PPD-S and RT 23 was carried out in three pairs of population groups. Tuberculin sensitivity was thought to have resulted, in one of each pair, almost entirely from infection with Mycobacterium tuberculosis, *and in the other, from the diverse causes operating in the United States of America. Among persons with specific tuberculin sensitivity, 2.5 TU of RT 23 in a saline buffer containing Tween 80 were approximately equivalent to 5 TU of PPD-S in phosphate-buffered saline diluent. Among persons whose sensitivity appeared to have resulted from infections with organisms antigenically similar to the Battey strain of unclassified mycobacteria, 2.5 TU of RT 23 in Tween 80 gave considerably more reactions than 5 TU of PPD-S.*

The availability of a large quantity of a purified tuberculin which has been carefully prepared, packaged and standardized is a prerequisite for epidemiologic studies of tuberculin sensitivity. A prime source of such material has been the Statens Serum-institut in Copenhagen, Denmark, whose purified tuberculins—designated by the letters RT and a lot number—have been very widely used, especially in studies sponsored by the World Health Organization. To meet the continuing demand, the latest batch was prepared in a quantity sufficient for 33 000 million tests (Magnusson & Bentzon, 1958).

Designated as RT 23, the new tuberculin was standardized by Guld et al. (1958) in animals and man against several other widely used tuberculins. Of interest to tuberculosis workers in the United States of America were the comparisons of RT 23 with PPD-S—the international standard of mammalian-type PPD tuberculin and prototype of the product used in the United States—particularly the finding that RT 23 in a solution containing Tween 80 [5] was more potent than equal quantities of PPD-S in a diluent without Tween 80. There was, however, considerable variation in the potency ratios of these two preparations in different populations, ranging from 3:1 to 6:1. Because of this variation, it appeared desirable to conduct a careful standardization of RT 23 against PPD-S in the United States of America.

MATERIALS AND METHODS

Three purified tuberculins were used in this study: PPD-S prepared by Dr Florence B. Seibert, RT 23 prepared by the Statens Seruminstitut, and PPD-B prepared under Dr Seibert's direction from the Battey strain of unclassified mycobacteria. PPD-S was given to all subjects in a dosage containing 0.0001 mg of protein—5 Tuberculin Units (TU) [6]—in 0.1 ml of a phosphate-buffered saline diluent (Seibert & Glenn, 1941). RT 23 in 0.1 ml of a 0.05‰ solution of Tween 80 in phosphate-buffered saline (Magnusson and co-authors, 1958) was also

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[5] Polyoxyethylene derivative of sorbitan mono-oleate (Atlas Powder Company, Wilmington, Del., USA).

[6] Although the use of the term TU involves certain difficulties, as pointed out by Guld et al. (1958), the doses of both PPD-S and RT-23 are expressed in TU in the present paper. It should be emphasized that 1 TU of PPD-S equals 0.00002 mg of protein, and 1 TU of RT-23 equals 0.00002 mg of the dry substance.

given to all subjects in one of the following three doses, expressed in terms of weight of dried powder: 0.00002 mg (1 TU), 0.00004 mg (2 TU) and 0.00005 mg (2.5 TU). In addition to these two antigens, PPD-B was also given to one group of subjects. The dosage contained 0.0001 mg of protein in 0.1 ml of phosphate-buffered saline (Affronti, 1959). All tests were given intracutaneously in the volar surface of the forearm and were carefully measured 48 hours later by specially trained nurses.

Six populations were studied: two groups of Eskimo children from the Bethel area of Alaska; one group of tuberculosis patients from Tulare–Kings Counties Hospital, Calif.; and three groups of recruits at the US Naval Training Centers in Great Lakes, Ill., and San Diego, Calif.

The Eskimo children were tested by nurses assigned to the Bethel Area Field Station of the Arctic Health Research Center. Each child was given PPD-S in one forearm and RT 23 in the other. The dose of RT 23 was the same for all children throughout each village, but in half the villages it was 1 TU, in the other half 2 TU. Although the two population groups of children are very similar, they are not entirely comparable, largely because of differences in age composition. All testers gave about the same number of tests with each antigen. The work was arranged so that the product responsible for the reaction being measured was not known to those making the measurements.

The tuberculosis patients from the Tulare–Kings Counties Hospital were tested by nurses from the Tuberculosis Program, Public Health Service, US Department of Health, Education, and Welfare. PPD-S was given in one forearm and 2.5 TU of RT 23 in the other. Again the system of administration ensured that the reader of the tests could not know which antigen had caused the reaction being measured.

The work in the two Naval Training Centers was also done by nurses from the Tuberculosis Program. As part of the routine physical examination on entrance to the Navy, all recruits were given two intracutaneous tests in each forearm with the following antigens: 5 TU of PPD-S, 1 : 100 histoplasmin, 0.0001 mg of PPD-B, and one of the three doses of RT 23 mentioned previously. With large numbers to be examined each day, it was not feasible to allocate the three doses of RT 23 randomly. Each dose had to be used in the testing procedure for a specified period of time, and consequently the three population groups of recruits may not be entirely comparable with respect to geographical representation, although each group contains sizeable numbers of persons from all sections of the United States. There was still another problem related to the need for testing rapidly with a system designed to give maximum protection against errors. The antigens could not be randomly allocated to the four testing-sites for each individual, and it was therefore possible for the readers to know the cause of the reactions they were measuring.

These populations were selected because it was necessary for each comparison of PPD-S and RT 23 to have one group whose tuberculin sensitivity appeared most likely to have resulted from infection with *Mycobacterium tuberculosis* and another group whose sensitivity would reflect the situation throughout the United States, where much of the tuberculin sensitivity arises from infections with mycobacteria other than *Myco. tuberculosis*. The former group was represented by Eskimo children and by tuberculosis patients. Previous testing of Eskimos in the Bethel area of Alaska had shown that their tuberculin sensitivity appeared to result almost exclusively from infection with *Myco. tuberculosis* (Comstock & Porter, 1959). The tuberculosis patients, at one time or another, had all had sputum cultures made, from which organisms apparently typical of *Myco. tuberculosis* had grown. The second group of subjects was furnished by the Navy recruits, who came from all areas of the United States. Although these subjects were limited to males who were almost all between the ages of 17 and 22 years, they afforded the best available sample of the various kinds of tuberculin sensitivity existing in the country.

RESULTS

On the basis of the work by Guld et al. (1958), it was anticipated that the dose of RT 23 in Tween 80 equivalent to 5 TU of PPD-S would lie between 1 TU and 2 TU. Consequently, these doses were used in the first comparisons of the two antigens among 1104 Eskimo children and 11 232 Navy recruits. The results of the comparisons of 1 TU of RT 23 and 5 TU of PPD-S are summarized in the upper section of the table opposite, and the correlations are shown in Appendix Tables 1 and 2. It is readily apparent that in both populations 1 TU of RT 23 in Tween 80 was weaker than 5 TU of PPD-S. Not only did RT 23 in this dosage cause a smaller proportion of reactions than PPD-S, but among those having reactions to *either antigen*, the mean induration to RT 23 was appreciably smaller than to PPD-S.

PROPORTION OF PERSONS REACTING WITH 6 mm OR MORE OF INDURATION TO 5 TU PPD-S AND TO 1, 2, OR 2.5 TU RT 23 IN TWEEN 80, AND MEAN REACTION SIZE (mm) AMONG PERSONS WITH SOME INDURATION TO PPD-S OR RT 23 IN TWEEN 80

Dose of antigen (TU)		Groups tested	Total number of persons	Percentage with induration of 6 mm or more to:		Induration of 2 mm or more to one or both antigens		
PPD-S	RT-23			PPD-S	RT 23	Number	Mean size of induration (mm) to: PPD-S	RT 23
5	1	Eskimo children	525	62.9	57.3	361	16.6	11.8
		Navy recruits	9 283	5.8	4.8	1 205	7.5	6.1
5	2	Eskimo children	579	47.5	46.3	336	13.9	12.9
		Navy recruits	1 949	6.1	7.4	391	4.6	5.2
5	2.5	Tuberculosis patients	205	97.6	96.1	202	18.6	17.1
		Navy recruits:						
		Total	5 537	8.5	10.0	887	8.6	9.4
		PPD-S & RT 23 > PPD-B	254	99.2	98.8	254	19.5	18.0
		PPD-S ≥ PPD-B ≥ RT 23 or RT 23 ≥ PPD-B ≥ PPD-S	3 676	2.7	3.3	214	6.2	7.1
		PPD-S & RT 23 < PPD-B	1 607	7.5	11.2	419	3.3	5.3

In a dosage of 2 TU, RT 23 in Tween 80 yielded results much closer to those obtained with 5 TU of PPD-S. This comparison is shown in the second section of the table above, and the correlations in Appendix Tables 3 and 4. Among Eskimo children, the proportion of subjects with induration measuring at least 6 mm was almost the same for both antigens, and the average reaction size was only a little smaller for RT 23. Among Navy recruits, both the proportion of reactors and the average reaction size among those reacting to either antigen were somewhat higher for RT 23 than for PPD-S.

From the results among Navy recruits, whose tuberculin sensitivity resulted from infections with a variety of mycobacteria, the dose of RT 23 in Tween 80 equivalent to 5 TU of PPD-S did appear to lie between 1 TU and 2 TU. But for subjects whose tuberculin sensitivity probably resulted only from infections with *Myco. tuberculosis* (the Eskimo children), the equivalent dose of RT 23 in Tween 80 appeared to be somewhat greater than 2 TU.

Consequently, two additional groups were tested, the dose of RT 23 being increased to 2.5 TU. In this comparison, 205 tuberculosis patients and 5537 Navy recruits participated. The results are summarized in the lower section of the table above, and the correlations appear in Appendix Tables 5-8. Among tuberculosis patients, both tuberculins gave similar results, but with RT 23 still causing somewhat smaller reactions on the average. Among recruits, 2.5 TU of RT 23 caused both slightly more, and among those reacting to either RT or PPD-S, slightly larger mean reactions than 5 TU of PPD-S.

These results confirm previous findings that potency ratios of RT and PPD-S vary in different populations (Nissen-Meyer, 1952; WHO Tuberculosis Research Office, 1955). This variation might result from the differences in composition of the two tuberculins, so that the reactions each tuberculin elicited might well depend on the source of sensitization in different populations. This possibility could be investigated among Navy recruits, all of whom had also been tested with 0.0001 mg of PPD-B. The relative sizes of reactions to antigens prepared from *Myco. tuberculosis* and from the Battey bacillus were utilized to indicate the probable source of sensitization of the subjects. This classification was justified by findings among guinea-pigs and patients that the largest reactions were caused by antigens prepared from the strain of mycobacterium with which the subject was infected (Palmer et al., 1959). Other studies have shown that the " antigenic spec-

trum " of PPD-B is quite broad, and that this antigen causes reactions larger than those to PPD-S among subjects infected with several strains of unclassified mycobacteria (Edwards et al., 1960).

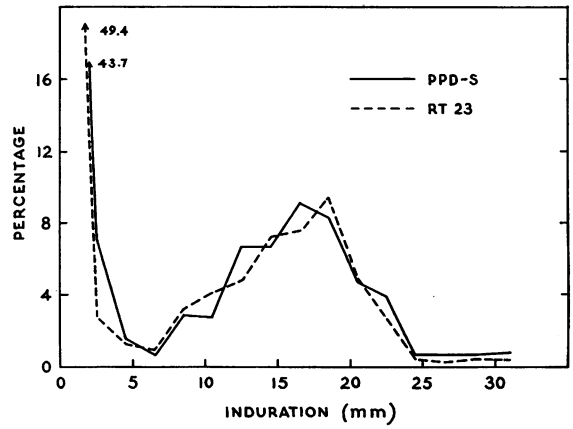
On the basis of these findings, Navy recruits whose induration to both PPD-S and RT 23 was larger than that to PPD-B were considered to have been infected with *Myco. tuberculosis*. Conversely, those whose induration to PPD-S and to RT 23 was smaller than that to PPD-B were considered to have been infected with one of the unclassified mycobacteria. Recruits with induration to PPD-B between or equal to that caused by PPD-S and by RT 23 were considered as having sensitivity of undetermined cause. Although such a classification is undoubtedly not accurate in every instance, it is probable that the bulk of subjects infected with *Myco. tuberculosis* are in the group with larger reactions to PPD-S and RT 23, and those infected with other mycobacteria are concentrated in the other two groups. Those whose source of sensitization is antigenically similar to the Battey bacillus are probably concentrated among the group whose reactions to PPD-B are larger than to either PPD-S or RT 23.

For the Navy recruits given 2.5 TU of RT 23, the comparison with PPD-S is shown in the lowest section of the table above according to the relative size of their reactions to PPD-S, RT 23 and PPD-B. Among those whose sensitivity probably resulted from infection with *Myco. tuberculosis*, 2.5 TU of RT 23 is a little weaker than 5 TU of PPD-S. The two products are also nearly equivalent for the group of subjects with an undetermined source of sensitivity. Among those whose sensitivity probably resulted from infection with mycobacteria antigenically similar to the Battey bacillus, 2.5 TU of RT 23 in Tween 80 caused considerably more and, among those reacting with 2 mm or more to either RT or PPD-S, larger mean reactions than 5 TU of PPD-S.

The practical significance of the difference in specificity between RT 23 and PPD-S may be illustrated by comparing the distributions of sizes of reactions to the two antigens among Eskimo children and among Navy recruits from two areas of the United States. The Eskimo children have shown almost no evidence of non-specific sensitivity. Recruits who had been lifelong residents of the northern and western parts of the country have shown only a moderate degree of non-specific sensitivity, while those residing in the south-eastern States have a high prevalence of non-specific sensitivity.

FIG. 1

PERCENTAGE DISTRIBUTIONS OF 579 ESKIMO CHILDREN BY SIZE OF REACTION TO 5 TU PPD-S AND TO 2 TU RT 23 IN TWEEN 80



Among Eskimo children, the comparison between 2 TU RT 23 in Tween 80 and 5 TU PPD-S is shown in Fig. 1. The two distributions are nearly identical except that PPD-S caused more reactions 2-3 mm in diameter. For all practical purposes, the two antigens will be interchangeable in this population.

The distributions of Navy recruits by sizes of reactions to 2.5 TU RT 23 in Tween 80 and 5 TU PPD-S are shown in Fig. 2. Among those who do not come from the south-eastern States,[1] the distributions are similar for persons with indurations of 10 mm or more, but with RT 23 causing more small reactions than PPD-S. Among recruits from the south-eastern States, the distributions are similar only for reactions of 15 or more mm in diameter, RT 23 again causing a much higher proportion of smaller reactions. Thus, if persons with 6 mm or more of induration were classified as reactors, 2.5 TU RT 23 in Tween 80 identified about 10% more reactors among the northern and western recruits than 5 TU PPD-S, and about 40% more among south-eastern recruits. Even if the definition of a reactor were changed to include only persons with 10 mm or more of induration, 2.5 TU RT 23 in Tween 80 would still identify about 40% more reactors among south-eastern recruits than 5 TU PPD-S.

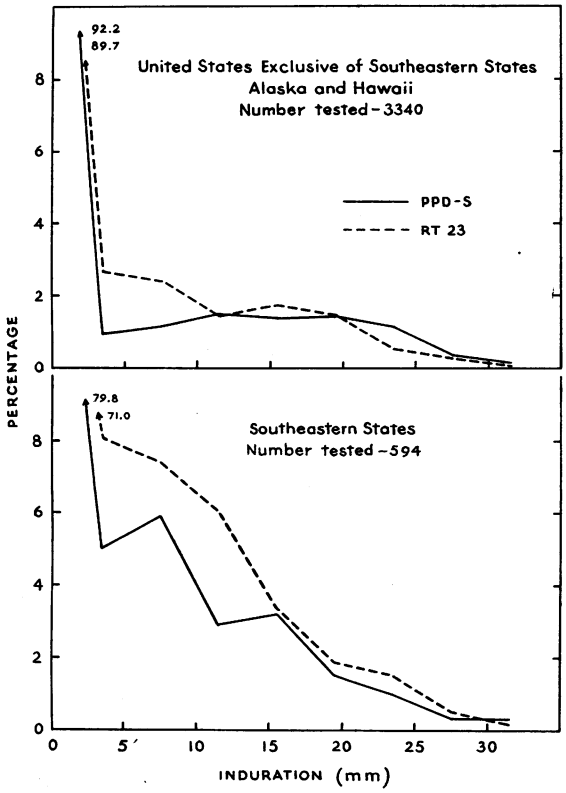
DISCUSSION

The findings of this comparative study illustrate a problem which is not always recognized in stan-

[1] The south-eastern States include Texas, Oklahoma, Arkansas, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina and North Carolina.

FIG. 2

PERCENTAGE DISTRIBUTIONS OF NAVY RECRUITS FROM TWO SECTIONS OF THE USA BY SIZE OF REACTION TO 5 TU PPD-S AND TO 2.5 TU RT 23 IN TWEEN 80 [a]



[a] These distributions are based on only 3934 recruits who were classified as lifetime residents of a single State, and exclude 1603 who had either lived in another State for more than six months or were residents of Alaska or Hawaii.

dardization of tuberculins—namely, the relationship of the type of population to the purpose of the standardization. If standardization is done to determine the dose of the new tuberculin which will detect the same proportion of specifically infected persons as the standard preparation, the comparative tests must be done on subjects whose only demonstrable source of sensitivity is the specific organism for which one is testing. In most current situations, this will be *Myco. tuberculosis*. On the other hand, if one wishes to know what dose of the new tuberculin will give results in a given population comparable to those obtained by the standard tuberculin regardless of the etiological agents involved, the standardization must be carried out on subjects whose sources of sensitization are similar to those of the population to be studied.

From this and previous comparisons of RT and PPD-S, it is apparent that RT elicits non-specific tuberculin sensitivity more effectively than PPD-S (Nissen-Meyer, 1952; WHO Tuberculosis Research Office, 1955; Comstock, 1960). This characteristic of RT, presumably related to the fact that it is a less purified preparation than PPD-S, has not been eliminated by the use of a diluent containing Tween 80. Whether or not this difference between the two antigens will be important in practice depends on the relative prevalence of specific and non-specific sensitization among the population to be tested. When specific sensitivity is much more common than non-specific sensitivity, as it is among Alaskan Eskimos, PPD-S and RT 23 will probably be equally satisfactory, and the use of a diluent containing Tween 80 will make the equivalent dose of RT 23 only about half that of PPD-S without Tween 80. But where non-specific sensitivity is considerably more frequent than specific sensitivity, the tendency for RT 23 to cause more reactions than PPD-S may constitute a significant drawback to its use.

It should also be noted that the *relative* prevalence of non-specific sensitivity can increase without any change in its absolute frequency merely as the result of a diminishing rate of infection with *Myco. tuberculosis*. As true tuberculous infection becomes uncommon, the premium on a skin-testing antigen which will identify only specific tuberculin sensitivity will become increasingly greater. Although PPD-S appears to perform better than RT 23 in such a situation, none of the presently available antigens is as specific as would be desired in many areas where tuberculous infections are already rare.

In selecting the tuberculin preparation best suited for a given area and purpose, it should be kept in mind that RT 23 has some clear advantages over most other tuberculins. It has already been very carefully standardized in a wide range of subjects and conditions. The large amount prepared for lot 23 should last for many years. These are not insignificant advantages, and should do much to offset the tendency for RT 23 to be less specific than PPD-S, especially when both antigens are undoubtedly more specific than many tuberculin preparations in common use. Nevertheless, in the United States of America, as in other countries, where among the younger age-groups tuberculous infection is now becoming a rarity, PPD-S remains the tuberculin of choice.

RÉSUMÉ

Afin d'obtenir, pour les enquêtes épidémiologiques d'ensemble sur la sensibilité à la tuberculine, le meilleur antigène possible, les auteurs ont comparé les deux tuberculines les plus utilisées à l'heure actuelle: le RT 23, préparé par le Statens Seruminstitut de Copenhague et le PPD-S (Etalon international de Dérivé protéinique purifié de Tuberculine de Mammifères). Pour ce faire ils ont effectué des réactions simultanées chez 6 groupes de sujets: 2 groupes d'enfants Esquimaux de l'Alaska, 1 groupe de tuberculeux (anciens ou actifs) traités dans des hôpitaux spécialisés et 3 groupes de recrues de la Marine américaine. Le choix de ces groupes est dicté par le fait que chez les Esquimaux et les tuberculeux la sensibilité tuberculinique résulte pour ainsi dire exclusivement de contacts avec *Mycobacterium tuberculosis*, tandis que chez de nombreux jeunes Américains faisant leur service militaire une telle sensibilité provient en grande partie de contacts avec des mycobactéries autres que *Myco. tuberculosis*.

Contrairement à ce qu'avaient affirmé d'autres auteurs en 1958, la tuberculine RT 23 n'est pas 3 à 5 fois plus puissante que le PPD-S. En fait il faut environ 2,5 unités tuberculiniques de RT 23 pour obtenir une réaction comparable à celle obtenue par 5 unités tuberculiniques de PPD-S.

Le fait que chez les sujets tuberculeux la réaction déclenchée par le RT 23 soit un peu plus faible que celle obtenue après injection de PPD-S et que chez les recrues de la Marine elle soit au contraire plus forte vient confirmer la notion — déjà ancienne — de la variabilité des rapports de puissance antigénique de deux tuberculines selon la population testée.

Les comparaisons montrent par ailleurs que le RT 23 met mieux que le PPD-S en évidence des états de sensibilité *non spécifique*. Ceci est dû au fait qu'elle est moins purifiée que le PPD-S.

Quant aux conséquences pratiques qu'il convient de tirer de cette étude comparative, il semble bien qu'elles seront largement fonction de l'état général de sensibilité spécifique ou non spécifique de la population à tester. Lorsque existe (comme c'est le cas dans le Sud ou l'Ouest des Etats-Unis) une assez forte sensibilité non spécifique, l'utilisation du RT 23 est à rejeter. Cependant, sur d'immenses territoires, le RT 23 présente d'irremplaçables qualités du fait de sa standardisation effectuée sur de très nombreux sujets et dans des conditions fort diverses, du fait aussi de la quantité préparée (le lot 23 contient en effet 33 millions de doses).

Aux Etats-Unis et dans les pays où l'infection tuberculeuse devient très rare dans les groupes d'âge inférieurs, le PPD-S demeure l'antigène de choix.

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APPENDIX TABLE 1

DISTRIBUTION OF ESKIMO CHILDREN BY SIZE OF REACTIONS TO 5 TU PPD-S AND 1 TU RT 23 IN TWEEN 80

Induration (mm) to PPD-S	Induration (mm) to RT 23 (1 TU)																Total
	00-01	02-03	04-05	06-07	08-09	10-11	12-13	14-15	16-17	18-19	20-21	22-23	24-25	26-27	28-29	30 +	
0-1	**164**	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	167
2-3	18	**3**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	21
4-5	3	2	**1**	—	1	—	—	—	—	—	—	—	—	—	—	—	7
6-7	2	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	4
8-9	1	—	1	—	**1**	1	—	1	1	—	—	—	—	—	—	—	6
10-11	—	3	3	1	3	**3**	3	—	1	—	—	—	—	—	—	—	17
12-13	4	1	3	3	10	3	**5**	7	—	—	1	—	—	—	—	—	37
14-15	—	1	3	2	4	5	5	**5**	5	—	1	—	—	—	—	—	31
16-17	1	—	3	1	13	8	11	7	**5**	6	—	—	—	—	—	1	56
18-19	—	—	2	1	5	7	6	**13**	7	**10**	2	1	—	—	—	—	54
20-21	1	—	1	2	6	6	9	13	6	6	**1**	3	1	—	—	—	55
22-23	—	—	—	2	4	5	6	7	6	7	1	**1**	1	—	—	1	41
24-25	—	—	—	—	1	1	—	2	1	2	3	2	—	—	—	—	12
26-27	—	—	—	—	—	—	—	3	—	—	—	1	—	—	—	—	4
28-29	—	—	—	—	—	1	—	1	2	2	2	—	—	—	—	—	8
30 +	—	—	—	—	1	—	—	—	—	—	1	2	1	—	—	—	5
Total	194	13	17	12	49	40	46	59	35	33	12	10	3	—	—	2	525

APPENDIX TABLE 2

DISTRIBUTION OF NAVY RECRUITS BY SIZE OF REACTIONS TO 5 TU PPD-S AND 1 TU RT 23 IN TWEEN 80

Induration (mm) to PPD-S	Induration (mm) to RT 23 (1 TU)																Total
	00-01	02-03	04-05	06-07	08-09	10-11	12-13	14-15	16-17	18-19	20-21	22-23	24-25	26-27	28-29	30 +	
0-1	**8 078**	237	113	24	7	2	—	1	—	—	—	—	—	—	—	—	8 462
2-3	136	**25**	10	5	—	—	—	—	—	—	—	—	—	—	—	—	176
4-5	74	17	**8**	7	3	1	1	—	—	—	—	—	—	—	—	—	111
6-7	22	3	9	**5**	2	1	2	—	—	—	—	—	—	—	—	—	44
8-9	25	5	9	9	**3**	1	1	2	1	1	—	—	—	—	—	—	57
10-11	15	6	10	9	13	**10**	3	3	—	1	—	—	—	—	—	—	70
12-13	16	3	2	9	7	11	**8**	6	1	4	—	—	—	—	—	—	67
14-15	5	—	5	—	5	13	9	**7**	2	1	1	1	—	—	—	—	49
16-17	1	—	—	1	6	7	9	7	**9**	7	3	1	—	—	—	—	51
18-19	1	1	2	3	2	8	9	19	13	**7**	1	—	—	—	—	—	66
20-21	—	—	1	1	—	2	4	8	14	8	**5**	—	2	—	—	—	45
22-23	—	—	—	1	2	4	3	5	9	7	4	**7**	1	1	—	—	44
24-25	—	—	—	—	—	1	1	—	4	6	3	2	**2**	2	—	—	21
26-27	—	—	—	—	—	1	—	2	1	1	3	1	—	—	—	—	9
28-29	—	—	—	—	—	—	—	—	2	1	—	1	2	1	—	—	7
30 +	—	—	—	—	—	—	—	—	—	3	—	—	—	—	1	—	4
Total	8 373	297	169	74	50	62	50	60	56	47	20	13	7	4	1	—	9 283

APPENDIX TABLE 3

DISTRIBUTION OF ESKIMO CHILDREN BY SIZE OF REACTIONS TO 5 TU PPD-S AND 2 TU RT 23 IN TWEEN 80

Induration (mm) to PPD-S	Induration (mm) to RT 23 (2 TU)																Total
	00-01	02-03	04-05	06-07	08-09	10-11	12-13	14-15	16-17	18-19	20-21	22-23	24-25	26-27	28-29	30 +	
0-1	**243**	6	3	—	1	—	—	—	—	—	—	—	—	—	—	—	253
2-3	37	**4**	—	—	—	—	—	—	—	1	—	—	—	—	—	—	42
4-5	2	5	**1**	—	—	—	1	—	—	—	—	—	—	—	—	—	9
6-7	—	—	—	—	1	—	1	—	1	—	—	—	—	—	—	—	3
8-9	1	1	1	1	**4**	7	—	1	1	—	—	—	—	—	—	—	17
10-11	—	—	—	1	1	**4**	1	4	2	2	1	—	—	—	—	—	16
12-13	—	—	—	3	4	4	**6**	9	4	6	2	—	—	—	—	—	38
14-15	2	—	1	—	4	6	4	**7**	5	8	1	—	—	—	—	—	38
16-17	1	1	2	—	1	4	6	7	**9**	13	5	3	1	—	—	—	53
18-19	—	—	—	—	2	1	5	6	10	**10**	9	4	—	1	—	—	48
20-21	—	—	—	—	—	—	1	5	6	5	**5**	5	—	—	—	—	27
22-23	—	—	—	—	1	—	2	2	5	6	3	**2**	1	—	—	—	22
24-25	—	—	—	—	—	—	—	—	—	2	1	—	—	—	—	—	3
26-27	—	—	—	—	—	—	—	—	—	1	1	1	—	—	—	—	3
28-29	—	—	—	—	—	—	—	—	1	—	—	—	—	—	**2**	—	3
30 +	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	**2**	4
Total	286	17	8	5	19	26	27	42	44	55	28	15	2	1	2	2	579

APPENDIX TABLE 4

DISTRIBUTION OF NAVY RECRUITS BY SIZE OF REACTIONS TO 5 TU PPD-S AND 2 TU RT 23 IN TWEEN 80

Induration (mm) to PPD-S	Induration (mm) to RT 23 (2 TU)																Total
	00-01	02-03	04-05	06-07	08-09	10-11	12-13	14-15	16-17	18-19	20-21	22-23	24-25	26-27	28-29	30 +	
0-1	**1 558**	87	32	28	6	—	—	—	—	—	—	—	—	—	—	—	1 711
2-3	73	**7**	5	5	—	1	—	—	—	—	—	—	—	—	—	—	91
4-5	21	2	**3**	1	1	1	—	—	—	—	—	—	—	—	—	—	29
6-7	9	1	1	**1**	4	—	—	—	—	—	—	—	—	—	—	—	16
8-9	2	—	—	8	**6**	5	2	2	2	—	—	—	—	—	—	—	27
10-11	3	—	—	—	3	**1**	1	6	1	—	—	—	—	—	—	—	15
12-13	—	—	1	1	1	3	**3**	6	1	3	—	—	—	—	—	—	**19**
14-15	—	—	—	—	1	3	3	**2**	1	1	—	—	—	—	—	—	11
16-17	—	—	—	—	—	3	4	1	**1**	4	—	—	—	—	—	—	13
18-19	—	—	—	—	—	—	1	—	3	**2**	1	—	—	—	—	—	7
20-21	—	—	—	—	—	—	1	1	2	2	**1**	—	—	—	—	—	7
22-23	—	—	—	—	—	—	—	—	—	—	2	**1**	—	—	—	—	3
24-25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
26-27	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
28-29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30 +	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	1 666	97	42	44	22	17	15	18	11	12	4	1	—	—	—	—	1 949

APPENDIX TABLE 5

DISTRIBUTION OF TUBERCULOSIS PATIENTS BY SIZE OF REACTIONS TO 5 TU PPD-S AND 2.5 TU RT 23 IN TWEEN 80

Induration (mm) to PPD-S	Induration (mm) to RT 23 (2.5 TU)																Total
	00-01	02-03	04-05	06-07	08-09	10-11	12-13	14-15	16-17	18-19	20-21	22-23	24-25	26-27	28-29	30 +	
0-1	3	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	4
2-3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4-5	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
6-7	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
8-9	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
10-11	2	—	—	—	—	—	1	1	1	—	—	—	—	—	—	—	5
12-13	—	1	—	—	2	3	3	3	1	1	—	—	—	—	—	—	14
14-15	—	—	—	—	—	2	4	7	3	4	—	1	—	—	—	—	21
16-17	—	—	—	—	—	3	1	5	9	7	1	2	2	—	—	—	30
18-19	—	—	—	—	1	3	2	5	11	14	5	3	—	—	—	—	44
20-21	—	—	—	—	—	—	1	3	5	9	13	5	—	—	—	—	36
22-23	—	—	—	—	—	—	—	—	5	7	7	4	2	1	—	—	26
24-25	—	—	—	—	—	—	—	—	2	3	2	4	—	—	—	—	11
26-27	—	—	—	—	—	—	—	—	—	2	2	1	1	—	—	—	6
28-29	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	2
30 +	—	—	—	—	—	—	—	—	2	—	—	—	—	1	—	—	3
Total	6	1	1	1	3	12	12	24	39	48	30	20	5	3	—	—	205

APPENDIX TABLE

DISTRIBUTION OF NAVY RECRUITS WITH REACTIONS TO 0.0001 mg PPD-B SMALLER THAN THEIR REACTIONS TO 5 TU PPD-S OR 2.5 TU RT 23 IN TWEEN 80 BY SIZE OF REACTIONS TO 5 TU PPD-S AND 2.5 TU RT 23 IN TWEEN 80

Induration (mm) to PPD-S	Induration (mm) to RT 23 (2.5 TU)																Total
	00-01	02-03	04-05	06-07	08-09	10-11	12-13	14-15	16-17	18-19	20-21	22-23	24-25	26-27	28-29	30 +	
0-1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2-3	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	2
4-5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6-7	—	—	1	—	1	—	—	—	1	—	—	—	—	—	—	—	3
8-9	—	—	—	1	1	1	1	—	—	—	—	—	—	—	—	—	4
10-11	—	—	1	—	1	—	—	2	1	—	—	—	—	—	—	—	5
12-13	—	—	—	—	1	4	1	4	1	—	1	1	—	—	—	—	13
14-15	—	—	—	—	—	3	7	6	9	5	—	—	1	—	—	—	31
16-17	—	—	—	1	2	—	1	7	10	8	—	—	1	—	—	—	30
18-19	—	—	—	—	—	1	3	4	9	13	7	5	4	2	—	—	48
20-21	—	—	—	—	—	1	—	4	8	4	6	2	1	—	—	—	26
22-23	—	—	—	—	—	—	3	2	12	7	5	2	3	2	1	—	37
24-25	—	—	—	—	—	—	—	—	1	3	4	10	1	3	—	—	22
26-27	—	—	—	—	—	—	—	—	2	4	3	4	—	—	1	—	14
28-29	—	—	—	—	—	—	—	—	—	—	2	—	4	1	2	2	11
30 +	—	—	—	—	—	—	—	—	—	—	1	2	2	2	1	—	8
Total	—	1	2	3	6	10	16	29	54	44	29	26	17	10	5	2	254

APPENDIX TABLE 7

DISTRIBUTION OF NAVY RECRUITS WITH REACTIONS TO 0.0001 mg PPD-B EQUAL OR INTERMEDIATE TO THEIR REACTIONS TO 5 TU PPD-S AND 2.5 TU RT 23 IN TWEEN 80 BY SIZE OF REACTIONS TO 5 TU PPD-S AND 2.5 TU RT 23 IN TWEEN 80

Induration (mm) to PPD-S	Induration (mm) to RT 23 (2.5 TU)																Total
	00-01	02-03	04-05	06-07	08-09	10-11	12-13	14-15	16-17	18-19	20-21	22-23	24-25	26-27	28-29	30 +	
0-1	**3 462**	9	22	15	18	7	10	2	1	—	1	—	—	—	—	—	3 547
2-3	10	—	—	2	—	—	—	—	1	1	—	—	—	—	—	—	14
4-5	14	—	—	—	1	1	—	—	—	1	—	—	—	—	—	—	17
6-7	5	—	—	—	1	2	1	—	—	—	—	—	—	—	—	—	9
8-9	10	—	1	1	—	2	4	—	3	—	—	—	—	—	—	—	21
10-11	5	—	2	1	6	**1**	—	2	—	—	1	—	—	—	—	—	18
12-13	5	—	3	—	4	2	—	3	—	2	—	—	—	—	—	—	19
14-15	2	—	—	1	1	—	1	—	—	1	—	—	—	—	—	—	6
16-17	3	—	—	1	2	1	1	2	**1**	1	2	1	—	—	—	—	15
18-19	1	—	—	—	1	2	2	—	—	—	—	—	—	1	—	—	7
20-21	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	2
22-23	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
24-25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
26-27	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
28-29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30 +	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Total	3 518	9	28	21	34	18	19	9	7	6	4	1	—	2	—	—	3 676

APPENDIX TABLE 8

DISTRIBUTION OF NAVY RECRUITS WITH REACTIONS TO 0.0001 mg PPD-B LARGER THAN THEIR REACTIONS TO 5 TU PPD-S OR 2.5 TU RT 23 IN TWEEN 80 BY SIZE OF REACTIONS TO 5 TU PPD-S AND 2.5 TU RT 23 IN TWEEN 80

Induration (mm) to PPD-S	Induration (mm) to RT 23 (2.5 TU)																Total
	00-01	02-03	04-05	06-07	08-09	10-11	12-13	14-15	16-17	18-19	20-21	22-23	24-25	26-27	28-29	30 +	
0-1	**1 188**	69	76	41	34	17	1	—	—	—	—	—	—	—	—	—	1 426
2-3	10	**2**	4	—	1	—	—	—	—	—	—	—	—	—	—	—	17
4-5	27	2	**2**	6	2	2	—	2	—	1	—	—	—	—	—	—	44
6-7	14	1	6	**5**	2	6	—	—	—	—	—	—	—	—	—	—	34
8-9	11	2	2	6	**6**	6	3	1	2	—	—	—	—	—	—	—	39
10-11	7	1	—	4	3	**4**	3	—	1	—	—	—	—	—	—	—	23
12-13	2	—	—	1	1	1	**3**	2	1	—	—	—	—	—	—	—	11
14-15	—	—	1	—	—	2	—	—	1	—	—	—	—	—	—	—	4
16-17	—	—	—	—	—	1	1	—	**3**	—	—	—	—	—	—	—	5
18-19	—	—	—	—	—	—	1	—	2	—	—	—	—	—	—	—	3
20-21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22-23	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
24-25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
26-27	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
28-29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30 +	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	1 259	77	91	63	49	39	12	5	10	2	—	—	—	—	—	—	1 607