The findings of a study of 205 family groups for tuberculosis and tuberculosis contacts are reported. These show that tuberculosis exists in "pools" involving large numbers of cases. Public health efforts should be directed to these pools of infection, and contact investigation has proved very efficient in finding pools. Intensive contact investigation will permit wide chemoprophylaxis amid children and young adults.

CONTACT INVESTIGATION: A PRACTICAL APPROACH TO TUBERCULOSIS ERADICATION

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IN THE United States, as the flood tides of tuberculosis recede, pools of infection remain. These pools continue as breeding places of tuberculosis. One of the most potent methods of locating these pools is contact investigation. Used as a public health measure, contact investigation can help speed the present trend toward eradication of the disease.

Children with tuberculosis may be compared to sensitive Geiger counters, since a positive tuberculin reaction in a young child is indicative of an adjacent case of tuberculosis. When the Houston Children's Tuberculosis Clinic was opened in 1954, an attempt was made to examine the family contacts of children with the disease. This project was initiated by a public health nurse loaned by the Houston-Harris County Tuberculosis Association. Because of the amazing number of cases found,[1] application of this method on a wider scale was attempted. This was made possible by the availability of research grants from Houston-Harris County Tuberculosis Association, Texas Tuberculosis Association, and the National Tuberculosis Association. In July, 1957, a full-time public health nurse and a stenographer were engaged, and a Family Contact Investigation Service was inaugurated under the direction of the Houston Children's Tuberculosis Clinic. This article is a report of that project during the period from July 1, 1957, to June 30, 1959.

Materials and Methods

Selection of Families for Contact Investigation

Family contact investigation was initiated only in homes which had children. The reason for this selectivity was the fact that the project was conducted by the Children's Tuberculosis Clinic, which could establish relationship with a family only through a child patient. Because of limited personnel and facilities, complete contact investigation as described below was limited to the following types of cases:

1. Children under 36 months of age with a positive tuberculin reaction.*
2. Older children whose tuberculin reactions

* Throughout this study, a tuberculin test refers to an intradermal test with 5 T.U. PPD-S read at 48 hours.

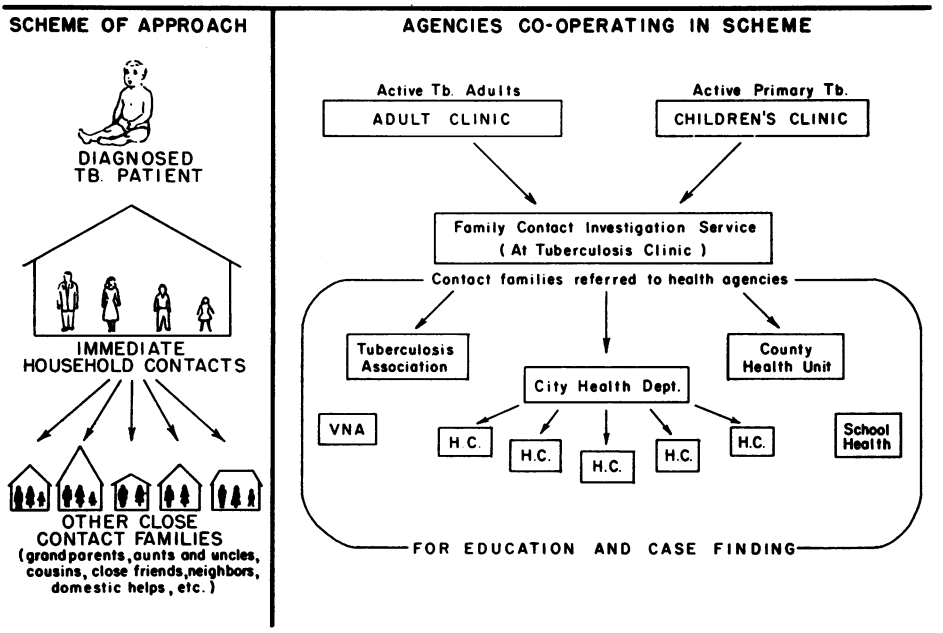

Figure 1—The Scheme for Tuberculosis Contact Investigation

converted from negative to positive within one year.

3. Demonstration of tubercle bacilli in cultures taken from gastric contents, urine, biopsy material, or other specimens.
4. Radiographic or clinical manifestations of active tuberculosis.

Sources of Child Patients

Children came to the Tuberculosis Clinic from two main sources (see Figure 1):

1. Positive tuberculin reactors found by routine tuberculin testing of the general children population at the health centers of the city and county health departments, pediatric clinics, physicians' offices, and schools.
2. Children who are known contacts of a newly diagnosed case of active tuberculosis.

The Index Case

If a child were found to have tuberculosis on routine tuberculin testing and there was no known contact with tuberculosis at the time of testing, the child was considered the index case. In this study, 85 family groups were investigated because of a child index case.

If, however, a child were taken for tuberculin testing because an adult in the family had been found to have tuberculosis, the adult patient was considered the index case. In this study, 120 family groups investigated had an adult as the index case.

Scheme of Approach and Agencies Utilized

Figure 1 shows the scheme of the procedure and the agencies cooperating in the project. Tuberculosis examination of the immediate family as well as the families in proximity were made. Microfilm study was advised for the adults, and, if needed, a further examination. The children were tuberculin tested, and, if the initial test were negative, periodic re-testing was advised. Positive reactors were admitted to the Children's Tuberculosis Hospital for a thorough examination which included gastric and urine cultures for tubercle

Table 1—Clinic Status of 364 Tuberculin Reactors

A. Positive Tuberculosis Culture		59
Positive gastric culture	50	
Positive urine culture	8	
Positive spinal fluid	1	
B. Active Tuberculosis in Chest Radiograph		102
Parenchymal disease	21	
Pleurisy	5	
Moderate enlargement of mediastinal nodes	67	
Very large mediastinal nodes	9	
C. Positive Tuberculin Reactors Under 3 Years of Age Without Radiographic Manifestations		45
D. Recent Infection, Tuberculin Converters		57
Conversion in one month	28	
Conversion in 2-7 months	29	
E. Probably Recent Infections		85
F. Tuberculin Reactors		16
Total		364

bacilli, posteroanterior and lateral chest radiograph, and a complete physical examination.

Results of Contact Investigation

Families who were considered to be in close social and physical contact, because of frequent interhousehold visiting, were categorized as a single family group. In this study, 205 family groups were investigated and 2,373 contacts were examined. The results of investigation within six months are shown as follows:

The Infected Children and Their Clinical Status

There were 1,375 children who were tuberculin tested, 364 (26.5 per cent) of which showed a positive reaction. Among the positive reactors, 95.5 per cent had an indurated area greater than 10 mm, only 4.5 per cent had a mild reaction of 6-10 mm.

The clinical status of positive tuberculin reactors was determined by a thorough initial examination in the Children's Tuberculosis Hospital followed by periodic checkups at the clinic. The findings in these children within six months are summarized in Table 1. Each case was classified under one criterion which was considered the most valid. Class A and Class B include 161 cases which must be reported as active primary tuberculosis.[2] Class C and Class D include 102 cases which are not reportable, but they should be treated as having active primary tuberculosis.[2] Class E includes 85 children who showed a strongly positive tuberculin reaction of over 20 mm on the initial test. Being household contacts of a newly diagnosed case, the infection was most likely of recent origin. Application of chemoprophylaxis in such cases would greatly reduce the chance of developing active tuberculosis.[3] Class F includes 16 children whose tuberculin reaction was weakly positive or who had had only casual contact with tuberculosis.

New Cases Found in Adult Contacts

Among the 998 adult contacts examined, 98 had a suspicious 70 mm microfilm. Eighty-three of these came for examination at the Tuberculosis Clinic; 60 were diagnosed as active pulmonary tuberculosis, 3 probably active pulmonary tuberculosis, and 20 as inactive cases. The remaining 15 suspects did not come to the Tuberculosis Clinic and the results of their follow-up study were not available to the Contact Investigation Service.

Contact Attendance

Of the 3,130 contacts, 2,373 or 76 per cent reported for their initial examination. Contact attendance for initial examination according to closeness of contact and age is shown in Figure 2. It may be noted that there was 90 per cent attendance of the household contacts which apparently was due to

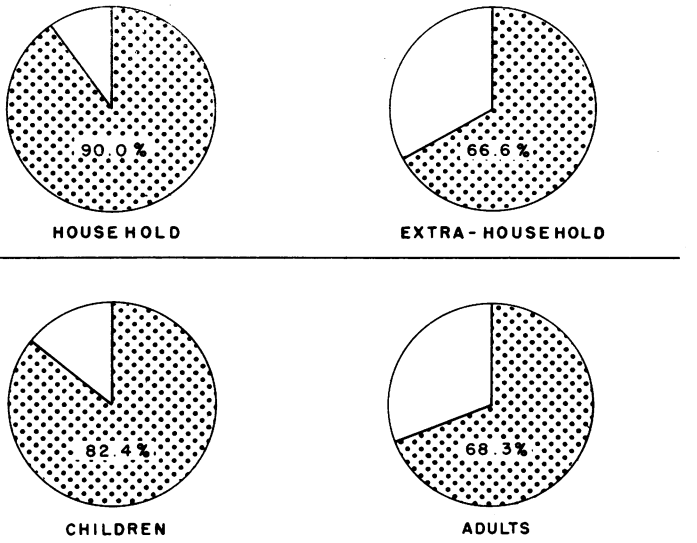

Figure 2—Contact Attendance

their awareness of the danger of the disease. The extra-household contacts were less concerned, and only 66.6 per cent reported for their examination. The attendance of adult contacts was much less than the children, especially among the working men who found it difficult to take time off for the required examination.

Case Yield According to Age of Index Case

The case yield from an adult index case and a child index case is summarized in Table 2. It may be noted that contact investigation beginning with a young child yielded more new cases than with an older child, and investigation beginning with an adult yielded a large number of cases in children. This observation emphasizes the importance of the dual approach, i.e., contact investigation of both the child and the adult patients.

The High Risk of Infection in Tuberculous Homes

The correlation of tuberculosis contact and tuberculous infection in children is shown in Figure 3. Children living with a tuberculous patient ran a tremendous risk of infection, as 64 per cent of them proved tuberculin positive. The risk of infection was considerable even by frequent visiting with a tuberculous patient, since as high as 24 per cent were infected. In contrast, incidental infection in the general children population was very low. At the Lyon's Avenue Health Center where a large number of well children were given Mantoux test as a routine procedure, only 2 per cent showed positive reactions. This was in an area of substandard housing. An even lower infection rate may be expected in better housing districts.

It is quite obvious that contact with tuberculosis was the cause of the high infection rate. Because the infection rate in the contacts was so much higher than that in the general population, it may be assumed that most of the infection as found in the child contacts of a new case of active tuberculosis was recently acquired. This was the reason why the 85 cases under Class E of Table 1 were considered recent infections and treated as such.

Previously Known Cases in the Family Groups

In this study, 300 known cases of adult tuberculosis were encountered in 205 family groups, 120 of which were index cases of this contact investigation. The others were traced from the contact history. These previously diagnosed patients were not counted as cases found in this project. They are mentioned here to show the prevalence of tuberculosis in the families under study. Most of these known cases were undoubtedly the source of infection of the children under study. One hundred and thirty-eight were living in the same house with the children, 121 were frequent visitors, and only 41 had had no direct contact with the children. At the time the case records were reviewed the clinical status of these known cases was as follows:

Active pulmonary tuberculosis	235
Inactive pulmonary tuberculosis	15
Suspected active tuberculosis	3
Dead	47
Total	300

Discussion

A recent report from New York State recounted how one school bus driver with active pulmonary tuberculosis caused an outbreak of primary infection among school children.[4] In this report, 85 of 266 children who rode with the tuberculous bus driver were infected, and 52 developed active primary tuberculosis with hilar and/or parenchymal disease. Such instances of wide-spread infections from a single source, although shocking occurrences, are not rare. Indeed, this is what might be expected in homes and communities where there is an active case of tuberculosis. Unfortunately, the infected individuals are often lost in the crowd because primary tuberculosis is usually asymptomatic, and without contact investigation few persons become aware of what has happened.

This study has clearly shown that right now tuberculosis exists in "pools" in the community. In each pool there may be one or more contagious cases surrounded by satellites of newly infected individuals. The great concentration of tuberculosis in these pools is evidenced in this study by the tremendous number of new cases found, the very high infection rate of the children, and the surprisingly large number of previously known cases re-encountered. In contrast, the sparsity of tuberculosis in the general population

Table 2—Yield of New Cases According to Age of the Index Case

Type of Index Case	No. of Index Cases	Children			Adult			
		No. Contacts Examined	No. Cases Found*	No. Found per 1,000 Examined	No. Contacts Examined	No. Cases Found		No. Found per 1,000 Examined
						Active	Probably Active	
Child under 36 months	49	382	40	105	312	27	1	90
Child 3-12 years	36	260	16	62	179	14	0	78
Adult	120	733	207	282	507	19	2	41
Total	205	1,375	263*	191	998	60	3	63

* Including 161 reportable cases of active primary tuberculosis (Classes A and B, Table 1) and 102 nonreportable cases, which however should be treated as having active primary tuberculosis (Classes C and D, Table 1).

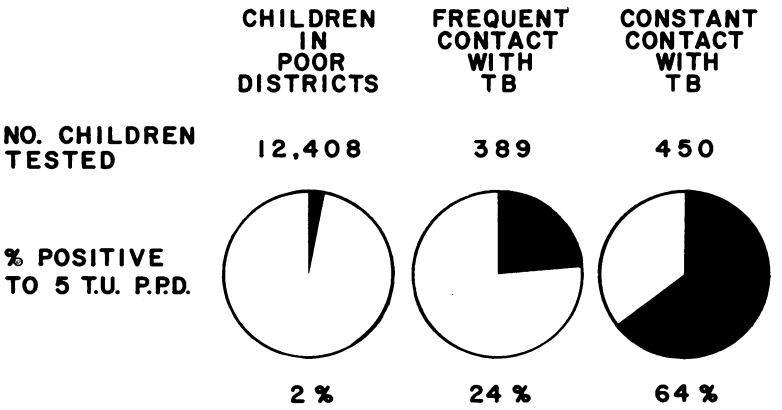

Figure 3—Contact with Tuberculosis and Risk of Infection in Children, 1957-1959

is evidenced by the very low infection rate of the children.

The Magnitude of the "Pool" Problem

The following figures taken from the 1958 report of the National Tuberculosis Association[5] show the magnitude of the "pool" problem in the United States: 150,000 patients with known active tuberculosis; 100,000 cases of active tuberculosis unknown to the health authorities. The estimated 100,000 unknown cases constitute a great public health menace because each case would create a pool which breeds tuberculosis. These cases must be detected without delay.

The 150,000 patients with known active tuberculosis constitute the other major part of the "pool" problem. The most disquieting fact about the known cases is that only 60 per cent were hospitalized, which means that 40 per cent were unhospitalized and therefore they continue to be sources of infection.[6] A recent and comprehensive survey of nonhospitalized tuberculous patients shows that over 80 per cent of them were in advanced stages of tuberculosis, and that in nearly half the cases the sputum had not been examined during the six months preceding the survey. Because one of the most urgent clinical facts about these active cases had not been determined, the author commented that, "Indeed, it is incredible that we are trying to supervise half our known cases at home with no information concerning sputum status."[7]

A Plea for Proper Attention to Child Contacts

It should be emphasized that virtually all children found to have active primary tuberculosis in this study were apparently well and healthy looking. The parents were unaware that anything was wrong until, on contact investigation, the tuberculin tests revealed the primary infection. This stresses the great importance of tuberculin testing and warns against the illusion that child contacts with ostensible health do not need medical attention. Indeed, signs of active tuberculosis can be discerned in a surprising number of cases on close examination.[8,9] The case yield as shown in Table 1 may appear unusually high to most readers, but it must be pointed out that the intensive examination of children as carried out in this special study is not the usual practice. However, a study of this kind does bring to light the true condition of the child

contacts and points to the need of giving them proper attention. Children with normal chest radiograph on the initial examination may develop active disease within a few months. Negative tuberculin reactors on initial test may convert to positive on subsequent tests. Cases with normal or equivocal radiographic findings may turn up with a positive gastric culture or urine culture for tubercle bacilli.

Until recently, little could be done for children with primary tuberculosis, and the outcome as to whether the infection would remain quiescent or become fulminating was a matter of chance. Since the advent of isoniazid, however, a potent agent has become available to protect infected children from developing active disease.[3,8-12] The efficacy of chemoprophylaxis has now been formally recognized and approved.[13] It is now the professional responsibility of physicians and public health officers to avail the children of this protection. By so doing one may expect a substantial reduction of new cases and death from tuberculosis in the present generation.

The Human Touch in Contact Investigation

When a diagnosis of active tuberculosis is made, it is the responsibility of the attending physician to inform the family of the contagiousness of the disease. Fortunately, the physician now has available chemoprophylaxis and chemotherapy by which he can afford patients and their families both hope and help. The importance of contact investigation should be explained to the patient or his parents so as to prepare the family in advance for subsequent interviews and home visits by the public health nurse. These procedures then come to be regarded as a safeguard to the welfare of the entire family rather than an official and irritating invasion of privacy.

Although initiated by the physician, the actual contact investigation is largely the responsibility of a health department toward the indigent families. A public health nurse working in a familiar district can work with definite advantage, as previous associations and knowledge of background will help her solve many problems with tact and skill. It should be mentioned that the understanding and cooperation of the public health nurses of Houston and Harris County have been crucial to the success of this contact investigation project.

Educational Material and Instruction

Education of professional personnel as well as the laity should be an integral part of a contact investigation service. Simple and specific instructions are necessary, and it is essential that the physicians and nurses at the clinic and the public health nurses in the field be consistent in their instructions to patients and families. For this purpose, a handbook has been prepared for distribution to clinic staff and field personnel.[14] In this booklet, specific and simple instructions are given, and the need for examination of contacts explained. Pictures are used to illustrate the ways by which infection is spread in the family groups.

A New Challenge to the Tuberculosis Association and Health Department

The results of this study have shown that an efficient program of contact investigation will discover significant numbers of unknown and undiagnosed cases both in adults and in children. A good example of comparable success in other communities is afforded by the results reported recently from Willacy County, Tex.[15] In this instance, a contact investigation service was attached to the Harlingen State Tuberculosis Sanatorium. A nurse and a social worker were sent out to Willacy County to investigate the contacts of the tuberculous pa-

tients admitted from this county to Harlingen Tuberculosis Sanatorium and were successful in tuberculin testing 356 contacts. X-ray of 109 positive reactors revealed 18 cases of active tuberculosis requiring immediate hospitalization and an additional 9 suspicious cases which needed further examination.

The great case yield by contact investigation is also borne out by the recent nation-wide study of the U. S. Public Health Service. Examination of 25,512 household contacts of newly discovered cases of tuberculosis yielded 479 new cases of active tuberculosis on initial examination, a rate of 19 per 1,000. This rate of new cases found is about 30 times greater than the yield of an average community x-ray survey.[3]

The study of tuberculous contacts in Seoul, Korea, in 1959 showed several points of interest.[16] In this study 3,526 household contacts of 900 cases of active pulmonary tuberculosis were examined at 5 clinics in the city. Three hundred and fifty-seven new active cases were found among 3,002 contacts who received x-ray examinations—a rate of 119 per 1,000. This case yield was 3 to 5 times higher than that of mass x-ray survey in that country. The type of new cases found among the contacts was especially worth noting. There were 65 per cent minimal cases, 26.3 per cent moderately advanced cases, and only 8.7 per cent far advanced cases. Thus, the majority of the cases were discovered in the early stages of the disease when the therapeutic success was the highest and public health hazard minimal.

There is no doubt that contact investigation and chemoprophylaxis will greatly hasten tuberculosis eradication as this method has already proved its efficiency and success. Hence, if the medical profession, tuberculosis associations, and health departments will join forces and put this method to widespread application, the goal of tuberculosis eradication can be realized soon.

Summary

The rationale and results of a Family Contact Investigation Project, in which 205 family groups were investigated, have been cited and discussed.

This study has shown that tuberculosis exists today in "pools"; that an enormous number of cases of tuberculosis are to be found in these "pools"; and that there is a general scarcity of tuberculosis between pools.

All public health efforts should be directed toward these pools of infection, and contact investigation has proved very efficient in finding pools. A dual approach is necessary by which cases are traced from child patients to adult contacts, and from adult patients to child contacts.

Intensive contact investigation will permit early diagnosis and wide application of chemoprophylaxis to children and young adults in these pools. Such an approach will greatly reduce the number of new cases and hasten eradication of the disease.

ACKNOWLEDGMENTS—The author gratefully acknowledges the active cooperation of all agencies participating in this study as represented by the following persons: Emmeline J. Renis, executive director, Houston-Harris County Tuberculosis Association; Edith Rennick, R.N., director of nurses, Houston City Health Department; Norma Myers, R.N., director of nurses, Harris County Health Unit; Vae Laird, R.N., public health nurse, Tuberculosis Clinic; Danie McKaskle, R.N., nursing director, Tuberculosis Clinic. Grateful appreciation is also extended to Mr. Ben Taub, chairman, Board of Managers of Jefferson Davis Hospital (City and County), and Mr. A. S. Reeves and the late Mr. H. G. Fonville, the administrators of Jefferson Davis Hospital, for their support of this project; and also to Dr. Daniel E. Jenkins, chief, Pulmonary Disease Division, Jefferson Davis Hospital, for his constant interest in this project and his good advice.

REFERENCES

1. Hsu, K. H-K. The Tuberculin Test as a New Approach to the New Era of Tuberculosis Control. Dis. Chest 33:23, 1958.

2. Diagnostic Standards and Classification of Tuberculosis. New York, N. Y.: National Tuberculosis Association, 1961.
3. Ferebee, S. H., and Mount, F. W. Tuberculosis Morbidity in a Controlled Trial of the Prophylactic Use of Isoniazid Among Household Contacts. Am. Rev. Resp. Dis. 85:490, 1962.
4. Mahady, S. C. F. An Outbreak of Primary Tuberculosis in School Children. Ibid. 84:348, 1961.
5. Annual Report of the National Tuberculosis Association for the Year Ending March 31, 1958. New York, N. Y.: The Association, 1958, p. 2.
6. Glaser, S.; Trauger, D. A.; and Wyman, A. H. Estimate of Tuberculosis Prevalence in the United States, 1956. Pub. Health Rep. 72:963, 1957.
7. Blomquist, E. T. The Nonhospitalized Tuberculosis Patient. A.J.P.H. 46:149, 1956.
8. Hsu, K. H-K. Should Primary Tuberculosis in Children Continue To Be Neglected? J. Pediat. 48:501, 1956.
9. Hsu, K. H-K. Diagnosis and Antimicrobial Therapy of Primary Tuberculosis in Children. J.A.M.A. 164: 1204, 1957.
10. Mount, F. W., and Ferebee, S. H. Preventive Effects of Isoniazid in the Treatment of Primary Tuberculosis in Children. New England J. Med. 265:713, 1961.
11. Brissaud, H. E.; Kaplin, A. S.; Noufflard, H.; Raynaud, J.; Hanoteau, J.; and Pignier, J. Treatment of Primary Tuberculosis in Children. Pediatrie 13:369, 1958.
12. Hsu, K. H-K. Isoniazid Therapy of Primary TB in Children. Dis. Chest 37:499, 1960.
13. A Statement by the Committee on Therapy, American Thoracic Society. The Use of Chemotherapy as a Public Health Measure in Tuberculosis. Am. Rev. Resp. Dis. 84:609, 1961.
14. Hsu, K. H-K. Tuberculosis in Children and Finding Tuberculosis Through Examination of Contacts (rev. ed.). Austin, Tex.: The Texas Tuberculosis Association, 1962.
15. Dilly, A. H. (Personal communication.)
16. Struthers, E. B.; Lee, H. K.; Ham, S. S.; Park, S. O.; Park, S. J.; Lee, K. Y.; Hong, J. K.; and Choi, Y. O. Tuberculosis Contacts in Seoul, Korea. Am. Rev. Resp. Dis. 83:808, 1961.

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This study is a report of a pilot project conducted at a Children's Clinic and has been supported by grants from the Houston-Harris County Tuberculosis Association, the Texas Tuberculosis Association, and the National Tuberculosis Association in 1957-1958, and by the Houston-Harris County Tuberculosis Association and the Texas Tuberculosis Association in 1958-1959.