Applied Epidemiology of Tuberculosis in British Columbia

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THE OCCURRENCE and distribution of tuberculosis in a community depend entirely upon the ecologic relationships between the causative agent, the human host, and the environment. In the light of changing conditions, certain facts regarding the communicability of tuberculosis need reemphasis.

These facts may be briefly summarized as follows: The only important source of tuberculous infection for man is other human beings with tuberculosis; tubercle bacilli almost always enter the human body through the respiratory tract; the risk of infection is proportional to the amount of exposure; infants and children with tuberculosis do not constitute a serious danger to others; and in adolescents and adults the greatest danger arises from contact with persons with undiagnosed "open" cases of the disease, which often masquerade under some other diagnosis.

This discussion will concern itself with the supervision of known tuberculosis cases; undiagnosed cases will be studied later. Not all cases require the same kind and amount of care, treatment, and supervision, and the problem is to define those which require priority of supervision, according to their relative clinical and public health significance.

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The key to establishing priorities is the classification of pulmonary tuberculosis adopted by the National Tuberculosis Association in the United States (*1*). NTA standards classify cases of pulmonary tuberculosis into three categories—active, inactive, and activity undetermined—according to roentgenologic, symptomatic, and laboratory status. An active case is defined as "one in which lesions as observed in serial roentgenograms are usually progressive or retrogressive but may be stationary. Symptoms of tuberculous origin are commonly present but may be absent. Sputum and gastric contents almost always contain tubercle bacilli although, in some instances, tubercle bacilli cannot be demonstrated even after repeated cultures and animal inoculations. The tuberculin test is almost always positive." Thus, the immediate epidemiologic problem is concerned with active cases of tuberculosis, and cases with undetermined activity and inactive cases, in that order, have lower priorities.

In attempting to assess the magnitude of the problem, what health departments and voluntary health agencies really want to know is the prevalence of tuberculosis and the extent of the breeding ground for new infection. A recent WHO report emphasizes this viewpoint (*2*). Accurate knowledge of the prevalence of active cases of tuberculosis on a geographic basis would make it possible to make intensive surveys of high-prevalence areas to locate undiagnosed cases of the disease. To obtain reliable geographic data on the known reservoir of tuberculosis in British Columbia in terms of prevalence of active cases has been the prime objective of the present studies.

The division of vital statistics of the British

Columbia Health Services Department maintains records on the number of active cases of tuberculosis in British Columbia and routinely makes a punchcard for each new case of tuberculosis reported. The record of the activity status of each case is kept current through followup reports. An analysis of all known active cases of tuberculosis, by health unit and school district, for the years 1956–58 was obtained from the division of vital statistics, and from these data prevalence ratios were computed for the Province as a whole and by area of residence of the patients. Active cases comprise between 30 and 40 percent of the known caseload in the Province (table 1). Approximately 48 percent of the patients with active tuberculosis lived in the Metropolitan Health Committee area (Greater Vancouver), and approximately 40 percent in school district No. 39, Vancouver City (table 2).

For the 3 study years six health jurisdictions had prevalence ratios higher than those for the Province as a whole (table 3). Furthermore, they had within their boundaries approximately two-thirds of the active tuberculosis caseload of the entire Province. As of December 31, 1958, school district No. 39 had the highest number of known cases and the second highest prevalence ratio of all six areas. These areas constitute the major reservoir of active tuberculosis in British Columbia and probably harbor most of the undiagnosed cases of the disease as well. While the trends of the prevalence ratios are downward, they do not give grounds for complacency but rather must provide the stimulus to further efforts at reducing the known reservoir of tuberculosis in these areas.

Table 1. Prevalence of tuberculosis in British Columbia as of Dec. 31, 1956, 1957, and 1958

Year	Total cases	Active cases	
		Number	Percent
1956	17, 097	7, 544	44. 1
1957	17, 580	7, 287	41. 4
1958	17, 955	5, 474	30. 5

Casefinding

The great volume of unrecognized cases of tuberculosis is largely responsible for perpetuation of the disease. Casefinding mechanisms may be divided into five main groups—a high index of suspicion by the private physician, the general hospital, and clinics other than tuberculosis clinics; health education; contact investigation; screening by chest X-ray surveys; and tuberculin testing.

Inquiries regarding the effectiveness of these casefinding procedures might be made along the following lines: Which is the best method of casefinding? How much emphasis should be placed on each method in a tuberculosis control program? Which factors influence the efficiency of these methods? The answers to these and other questions presuppose the existence of methods for quantitating casefinding and are only to be found by comparative and evaluative studies.

Unfortunately, casefinding is often quantitated purely on the basis of volume statistics. such as the total number of chest X-rays taken per year. Occasionally the relative efficiency of

Table 2. Known active cases of tuberculosis in British Columbia as of Dec. 31, 1956, 1957, and 1958, by residence of patient

Residence	1956		1957		1958	
	Number	Percent	Number	Percent	Number	Percent
Total	7, 544	100. 0	7, 287	100. 0	5, 474	100. 0
Metropolitan Health Committee area (Greater Vancouver)	3, 655	48. 4	3, 479	47. 7	2, 565	46. 8
School district No. 39 (Vancouver City)	3, 094	41. 0	2, 949	40. 5	2, 168	39. 6
Other areas	3, 889	51. 6	3, 808	52. 3	2, 909	53. 2

Table 3. Known active cases of tuberculosis in British Columbia and in six health jurisdictions, as of Dec. 31, 1956, 1957, and 1958

Area of residence	1956		1957		1958	
	Total	Per 1,000 population	Total	Per 1,000 population	Total	Per 1,000 population
British Columbia	7, 544	5. 5	7, 287	5. 0	5, 474	3. 6
South Central Health Unit, Kamloops	323	8. 9	341	8. 6	296	7. 3
Simon Fraser Health Unit, New Westminster	446	7. 2	437	6. 3	405	5. 5
Skeena Health Unit, Prince Rupert	208	8. 0	167	6. 0	145	4. 9
Victoria-Esquimalt Union Board of Health	498	6. 0	483	7. 3	275	4. 1
North Okanagan Health Unit, Vernon	208	5. 7	192	5. 0	152	3. 9
School district No. 39, Vancouver	3, 094	8. 4	2, 949	7. 8	2, 168	5. 6

various casefinding measures is assessed in terms of the percentage of total new cases found by various means. Ideally, in addition to being quantitated on a relative basis, casefinding mechanisms should be quantitated on an absolute basis so that trends in achievement may be determined and comparative as well as evaluative studies carried out.

Contact Investigation

In the present studies, contacts are defined as persons exposed to known active cases of tuberculosis; contact investigation, as a selective process that brings to examination only persons exposed to known active cases. To permit analysis of results of the contact investigation program on both a volume and a yield basis, for each new active case of tuberculosis reported specific information was sought on how many contacts were examined and on the findings among these contacts.

In British Columbia contact investigation is a responsibility of local health services, but formal recommendations regarding examination and supervision of contacts have been outlined by the division of tuberculosis control of the provincial health services department, for the guidance of health personnel in the field. Because of this dichotomy of supervision, practically no information existed on the results of contact investigation, and no attempt has been made at correlation between the findings for the contacts and for the index cases which initiated the contact investigation.

Correlation of data was attempted by the use of casefinding indices in a combined retrospective-prospective study covering the 3 years 1955–57. The division of vital statistics in Victoria supplied lists, by health unit or school district, of all active cases of tuberculosis reported during these years. The list for each unit contained the names of residents with known active tuberculosis, of persons who had first been reported from that jurisdiction but had moved out of the Province, and of those whose current addresses were unknown. It was presumed that contact information for residents would be available in the field office of their health jurisdiction. The names of contacts who had moved out of the reporting jurisdiction and for whom contact information was inadequate were forwarded to the health unit of their new residence with a request for the desired information.

A summary of the results of tuberculosis contact investigation in British Columbia is presented in table 4. The improvement in the yield from contact investigation in 1957 compared with the yield in 1955 and 1956 is quite evident. Undoubtedly, this study stimulated a great deal of interest in the individual health units.

Since the epidemiologic attack on tuberculosis is concerned with mass phenomena, the methods used must give maximum numerical returns for the time, money, and effort expended. In 1957 it was possible to define some of the variables affecting the outcome of contact investigation. Among the variables affecting the index case which also affected the yield of contact investigation were activity of the disease, extent of lesion, age, sex, and sputum

status. Classification of contacts—household, close nonhousehold, or casual—also affected the yield of cases.

Attack rates for tuberculosis vary among contacts of persons with active cases of the disease, depending upon several characteristics of the index cases and upon the proximity of the contact. Such variables should be studied in order to rationalize programs for the examination and supervision of contacts. The many barriers to effective contact investigation of tuberculosis should prompt investigators to limit supervision of contacts to those among whom the search for new cases of tuberculosis is most likely to be successful.

Chest X-ray Surveys

In the last 15 years the tuberculosis problem in British Columbia has changed rapidly, and one of its most salient features is the reduction in the number of new cases found despite the enormous increase in the number of persons X-rayed in mass miniature radiography surveys. Inevitably there has been some criticism of these surveys as presently organized. As a result, attempts have been made to be more selective in the use of X-ray facilities. Undoubtedly the surge of interest in the tuberculin test as an epidemiologic tool and the growing public concern over the hazards of radiation have contributed to development of the demand for more selective use of mass miniature radiography of the chest.

Present-day statistics are largely gathered on the basis of the total volume of X-rays taken in surveys, but these statistics do not indicate how many X-rays were taken in various geographic areas or in various population groups so that the number of X-rays may be related to the population at risk and thus permit calculation of the yield of new cases. The location of X-ray survey units is often decided on a purely arbitrary basis and not upon the known prevalence of tuberculosis, as determined by the yield of active cases in different population groups, geographic or otherwise. Survey programs have relied upon an appeal to the public for voluntary participation and, with few exceptions, little attempt has been made to achieve total community coverage.

The following changes in the organization of mass X-ray survey programs are indicated:

- Recording of survey findings upon the basis of the population receiving the service.
- Assessment of results of surveys in terms of statistical indices with which to measure both the volume of X-rays taken and the yield of new and new active cases in the group involved.
- Identification of population groups having a high prevalence of tuberculosis.
- Determination of location of X-ray survey facilities according to the needs of high-prevalence groups.
- As complete coverage as possible when survey facilities are located among high-prevalence groups.

Only when these changes have been made will it be possible to reorient tuberculosis casefinding through the mass X-ray survey from a diffuse technique with low yields of cases to a more focal or selective technique which might reasonably be expected to produce higher yields.

Table 4. Results of contact investigation in British Columbia, 1955–57

Year	New initial cases				New cases in contacts			
	Total reported	Contacts			Number found		Active	
		Total	Cases found		Total	Per 1,000 contacts	Total	Per 1,000 contacts
			Total	Per 1,000 contacts				
1955	718	1,713	47	27.4	19	11.1	16	9.3
1956	676	2,020	50	24.7	16	7.9	16	7.9
1957	724	2,018	88	43.6	40	19.8	39	19.3

In the analyses in this paper the achievements of mass miniature X-ray screening are assessed in terms of the following indices: number of persons screened, new cases found, new active cases found, new cases per 1,000 persons screened, and new active cases per 1,000 persons screened. The use of such standardized indices permits evaluative and comparative studies over a period of years between different elements of the mass miniature radiography program.

A number of difficulties were encountered in making the analyses. Casefinding is the epidemiologic technique which concerns itself primarily with the detection of new cases of tuberculosis; caseholding is the corresponding technique for dealing with known cases of the disease. In assessing the yields of casefinding, therefore, the critical indices are those which measure the number of new cases and new active cases and the rate at which they are found as a result of a particular casefinding activity. Hence, data pertaining to previously known cases of tuberculosis should not be included in statistics on yield from mass X-ray survey programs.

Other difficulties in ascertaining casefinding yields arise from the necessity of establishing the definitive diagnosis in each case not reported as active tuberculosis, inactive tuberculosis, or nontuberculous disease. For example, all suspects must be followed through to establish the diagnosis as tuberculosis or nontuberculous disease; all cases bearing the temporary diagnosis of "activity undetermined" must be followed until final classification as active or inactive tuberculosis; and all diagnoses of tuberculosis must be classified as active or inactive disease according to the new nomenclature of the current National Tuberculosis Association standards (*1*). These tedious and time-consuming steps are necessary for accurate quantitation of the casefinding yield from mass miniature X-ray screening.

Table 5. Results of mass X-ray screening for tuberculosis, British Columbia, 1955–57

Facility	Persons screened			New cases per 1,000 persons screened					
				Total			Active cases		
	1955	1956	1957	1955	1956	1957	1955	1956	1957
Total	303, 817	308, 259	307, 227	1. 0	0. 9	0. 7	0. 5	0. 4	0. 3
Provincial mobile survey	40, 700	37, 182	46, 715	1. 2	1. 0	. 4	. 4	. 4	. 2
Metropolitan mobile survey	63, 941	64, 267	63, 788	. 6	. 4	. 3	. 3	. 2	. 1
Metropolitan and stationary clinics	89, 403	91, 416	84, 501	1. 4	1. 2	1. 2	. 8	. 6	. 7
Hospital admission survey:									
Inpatients	84, 120	88, 916	87, 848	1. 0	. 9	. 5	. 4	. 3	. 1
Outpatients	25, 653	26, 478	24, 375	. 8	1. 2	. 9	. 3	. 4	. 3

Table 6. Results of tuberculin tests of grade 1 school children, Metropolitan Health Committee, Vancouver, B.C., school years 1951–52 through 1955–56

School year	Enrollment	Children tested		Tuberculin positive		New cases found
		Number	Percent	Number	Percent	
Total	27, 896	18, 236	65. 4	581	3. 2	7
1951–52	4, 544	3, 507	77. 2	140	4. 0	1
1952–53	5, 622	2, 188	38. 9	70	3. 2	0
1953–54	6, 203	4, 174	67. 3	126	3. 0	1
1954–55	5, 676	4, 075	71. 8	125	3. 1	4
1955–56	5, 851	4, 292	73. 4	120	2. 8	1

The results of four mass X-ray surveys—provincial mobile, metropolitan mobile, institutional (hospital) admissions, and metropolitan and stationary clinic survey—undertaken in British Columbia in the years 1955–57 are shown in table 5. From this table it is apparent that casefinding by mass X-ray screening is becoming increasingly unproductive in the provincial mobile survey and the metropolitan mobile survey and in hospital inpatients, as these programs are now organized. The exact point at which a given casefinding procedure becomes so unproductive that it should be discontinued is a matter for administrative decision, but these figures suggest that the decision is one which cannot be long delayed.

Another factor to be taken into account is that, for some of the surveys, the majority of the new and new active cases are being found by only a small proportion of the X-ray units participating in the programs. This confirms the need for redisposition of casefinding resources. Certainly some of the existing resources should be moved into areas of British Columbia with a high prevalence of tuberculosis, with the objective of obtaining complete coverage of those areas.

Tuberculin Testing

Large-scale use of the tuberculin test is another technique which is applicable to community casefinding. Since infection with the tubercle bacillus precedes the disease, routine tuberculin testing will provide the leads to cases which might otherwise escape detection. If the tuberculin test is positive in a young child, the infection must be recent, and its source is likely to be an active case of tuberculosis among his close associates. In an older child the source of infection would be more remote. The size of the reaction to the tuberculin test is important also. Not only are persons with major reactions much more likely to have active tuberculosis, but higher rates of tuberculosis are found among their contacts.

Excellent methods of collecting data for and reporting on large-scale tuberculin testing programs have been formulated by the National Tuberculosis Association, but these will not be discussed here. This paper is concerned with the development of methods for quantitating the results of tuberculin testing through the development of appropriate statistical indices. These indices include the numbers of persons tested and reactors found, total new cases and new active cases among reactors, and number of new cases and new active cases per 1,000 persons tested and per 1,000 reactors.

For a number of years the Metropolitan Health Committee carried out a limited program of tuberculin testing of grade 1 pupils in the Vancouver schools. Originally these pupils were patch tested, but the intradermal technique is now used. Through the courtesy of Dr. R. E. Willits, director of school health services, we have been able to follow up reactors to determine whether or not a diagnosis of tuberculosis was established following tuberculin testing. The relevant data for the school years 1951–52 through 1955–56 are presented in table 6. The 7 new cases of tuberculosis found on followup of the 581 reactors represent 0.4 new case per 1,000 persons tested and 12.0 new cases per 1,000 reactors.

Since all of the persons with new cases had active tuberculosis, the new case and new active case yields were identical. With the advent of large-scale tuberculin testing for casefinding purposes in British Columbia, use may be made of these statistical indices for program evaluation.

Recent Developments

Since 1958 a number of intensive casefinding surveys have been made in British Columbia. These differed from earlier surveys in that they

Table 7. Results of "operation doorstep" surveys in Vancouver and Victoria, B.C., 1958–60

Cases	Vancouver			Victoria
	1958	1959	1960	1960
Persons screened	8,051	9,893	19,529	17,807
New cases:				
Total	52	32	29	38
Per 1,000 persons screened	6.4	3.2	1.5	2.1
New active cases:				
Total	39	15	9	16
Per 1,000 persons screened	4.8	1.5	.5	.9

were conducted in high-prevalence areas, on a block-to-block and door-to-door basis, and involved X-ray screening, either alone or in combination with tuberculin testing. A summary of the results of four surveys made in the years 1958–60 is given in table 7.

The 1958 survey was the first large-scale "doorstep"-type survey done in British Columbia. The east end of downtown Vancouver, an area of high tuberculosis prevalence, was chosen. This area contained 60 city blocks with an estimated population of 13,600 persons, including 1,600 children. Even though many residents are transients, it was estimated that 67 percent of the adult population were screened.

The 1959 survey was also carried out in the east end of Vancouver, in an area adjacent to that surveyed in 1958. Of an estimated population of 30,000 persons, including 5,000 children, it was estimated that 46 percent of the total population were surveyed. In this survey, in addition to mass X-ray screening of adults, all students in schools in the surveyed area were offered a tuberculin test, with the following results:

Students tuberculin tested	3,979
Reactors found	450
New cases	6
New active cases	5
New cases:	
Per 1,000 students tested	1.5
Per 1,000 reactors	13.3
New active cases:	
Per 1,000 students tested	1.2
Per 1,000 reactors	11.1

Two surveys were done in 1960, a resurvey of the area of Vancouver surveyed in 1958 and a survey in downtown Victoria, which is also listed as a high-prevalence area. In Vancouver a somewhat larger area was surveyed than in 1958 and some industries in the area were included. In downtown Victoria, which contains the business section of the city, a special attempt was made to X-ray persons working in the area.

In the four surveys, the yield of new cases by mass miniature radiography, ranging from 6.4 to 1.5 per 1,000 persons screened (table 7), may be compared with 0.3 per 1,000, the yield from the metropolitan survey in Vancouver in 1957 (table 5). The yield of new active cases, 4.8 to 0.5, also compares favorably with the 1957 figure of 0.1 for the same survey. The yield from the 1960 survey in Vancouver demonstrated that it is worthwhile to repeat communitywide surveys at frequent intervals in areas with known high prevalence of the disease.

Summary

Studies of the tuberculosis problem in British Columbia have attempted to identify the reservoir of tuberculosis in terms of prevalence of the disease and to develop and apply statistical indices to the quantitation of casefinding in tuberculosis control.

The prevalence of tuberculosis influences the measures used for its control, and the changing picture of the disease makes it increasingly important to reorient the control program toward the epidemiologic approach. Further and continuing study is urgently required if measures aimed at further control or eradication of tuberculosis are to be intelligently planned.

REFERENCES

(1) National Tuberculosis Association: Diagnostic standards and classification of tuberculosis. New York, 1955.

(2) World Health Organization: Chemotherapy and chemoprophylaxis in tuberculosis control. Technical Report No. 141. Geneva, 1957.

Certification in Public Health

The American Board of Preventive Medicine has announced that the next examination for certification in public health will be held on a regional basis at various schools of public health in April 1963. The final date for filing applications is November 30, 1962. Applications and inquiries may be sent to Dr. Tom F. Whayne, Secretary-Treasurer, American Board of Preventive Medicine, 4219 Chester Avenue, Philadelphia 4, Pa.