National Tuberculosis Control Program in Denmark and the United States

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AN INDISCRIMINATE mass approach to finding cases of tuberculosis is not in keeping with the present-day epidemiologic picture either in Denmark or the United States. In both countries persons infected with tubercle bacilli comprise about 10 percent of the population. Most of the new cases each year develop in new patients—first-timers, not repeaters—and arise in the already infected one-tenth of the population. In both countries the major share of new cases come from the vast numbers of persons with negative results on the chest X-ray survey film. Traditional casefinding by mass chest X-ray surveys of the general population is not productive: screening 10,000 adults to find one or two active cases can hardly be justified as a profitable investment of time and money.

Denmark

In Denmark a model has been developed to pinpoint and measure the public health problems in tuberculosis control (fig. 1). It seeks to answer graphically such questions as: Which groups in the general population are contracting tuberculosis? How long is a patient considered to have active disease? Under the existing health system, what are the patient's chances of being cured, having a relapse, or dying?

The general population (upper left corner, fig. 1) consists of a large group of noninfected persons and a small group of infected ones, the tuberculin reactors. The number of persons in the population infected with tubercle bacilli depends on the impact of infection from the patients with active disease (arrow to left). In some of the infected persons, sooner or later active disease develops; they then leave the general population and flow to the pool of active cases as the stream of first-timers.

Some of the previous patients in the pool to the upper right reactivate and flow to the pool of active cases as relapses. The two streams of first-timers and relapses meld and form the total input into the pool of active cases; this input gauges

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the incidence. There is also an output from the pool of active cases that illustrates the success as well as the failure of treatment: the cures flow to the pool of previous cases, and the deaths from all causes terminate in the last pool—that of the deceased.

The interplay between the different flows and pools is of mathematical as well as of biological interest. This dynamic describes the life of the disease in the population: the number of new cases arising each year; the lethal effect of the disease on patients (those with active disease as well as those who are called cured); and the chance the patient has of being cured or being crippled. We shall, however, confine ourselves to one aspect —the identification of risk groups in the general population. In other words, we shall consider how we can garrotte the flow into the pool of active cases.

In the early 1950s, a mass campaign against tuberculosis was conducted in Denmark (*1*). It was directed toward young adults. All who participated were screened by photofluorography and a tuberculin test. Figure 2 shows the result over the next 16 years for the 286,250 positive tuberculin reactors identified in the campaign. They all represent initially healthy persons since all previous patients and newly diagnosed active cases found in the campaign have been excluded. The positive reactors are subdivided into three groups according to the results of their initial photofluorogram: two small groups of persons with either suspicious or inactive lesions and a large group with no abnormality.

The three streams in the middle of the diagram depict the patients in whom tuberculosis developed during the 16-year period. The bars at the bottom line measure the attack rate in each X-ray group. The case rate was highest among persons who had suspicious lesions at the time of the mass campaign; of these, one-half percent fell ill each year. This rate is very high, so high that it indicates a need for treatment. The knowledge necessary to treat these persons was, however, not

Figure 1. Dynamics of tuberculosis infection, morbidity, and mortality

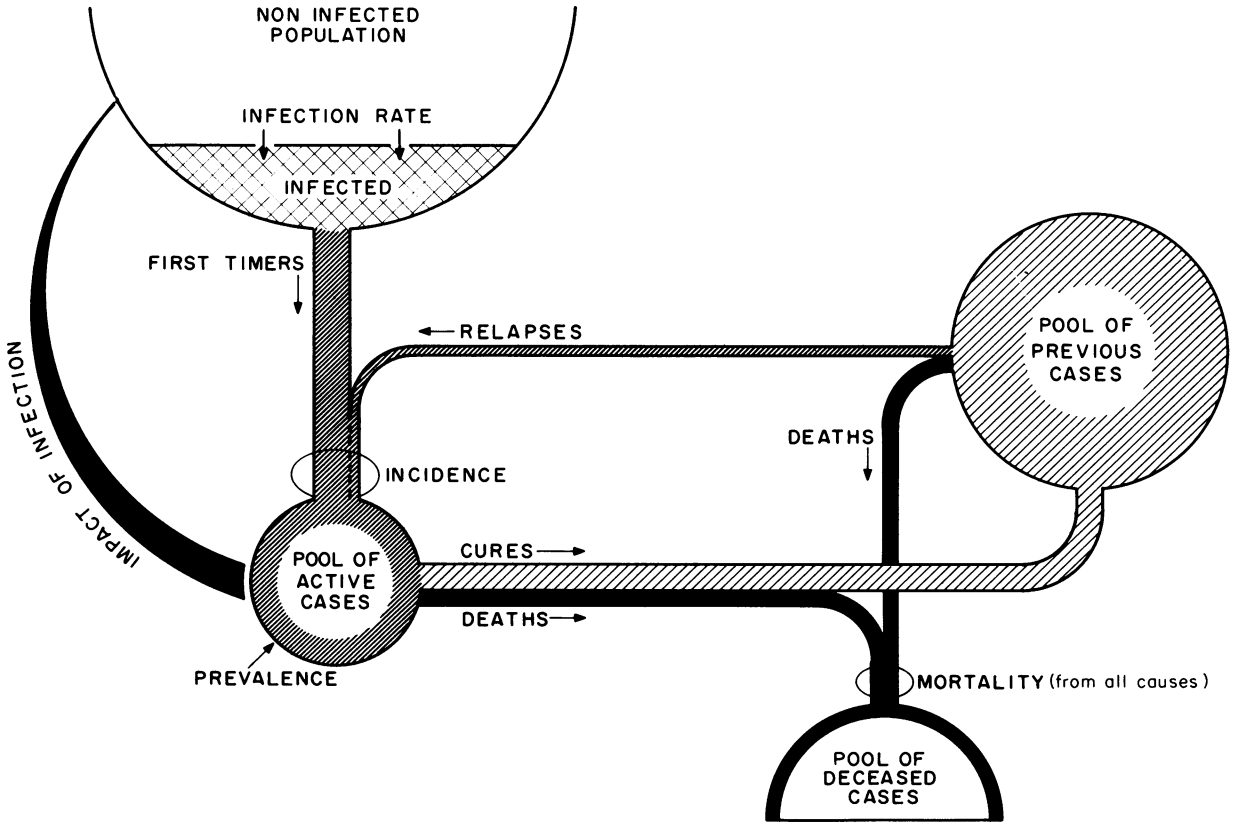
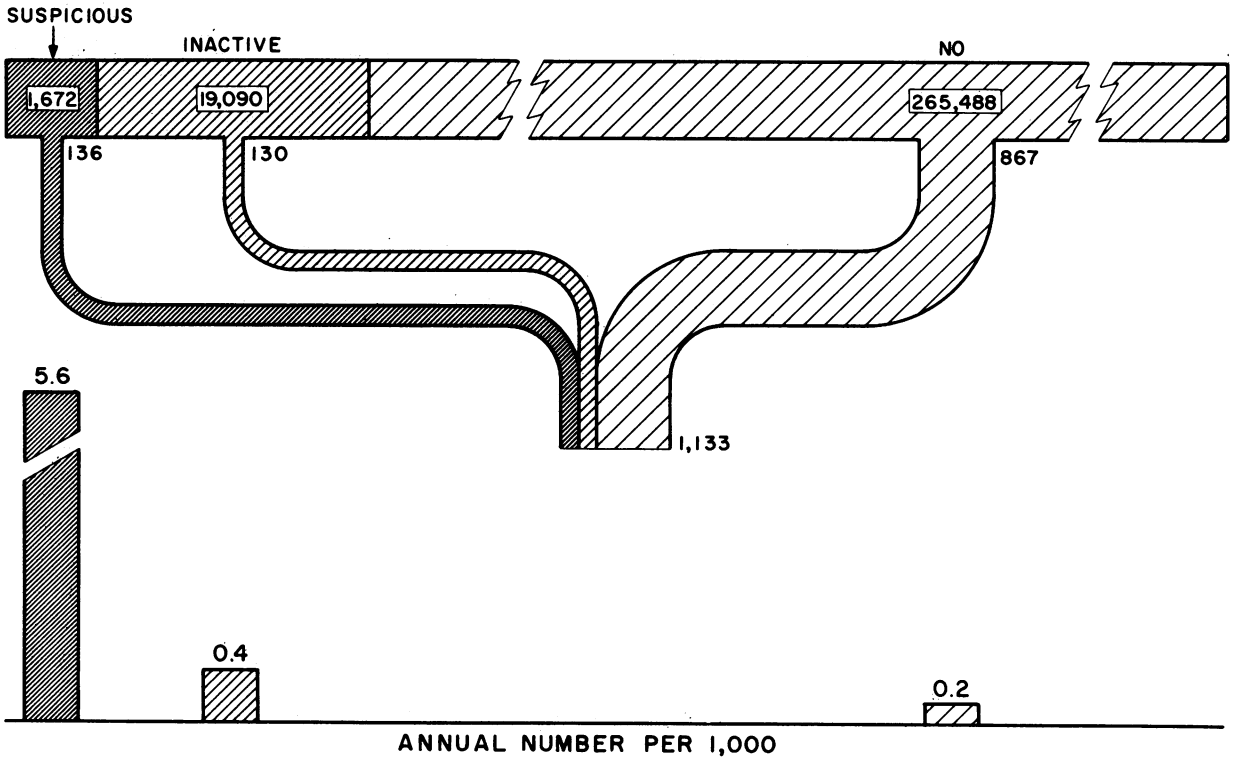


Figure 2. Incidence of tuberculosis among 286,250 reactors during 16-year followup, according to chest X-ray findings in mass tuberculosis control campaign in Denmark in 1950s



available in 1950; no preventive measures were therefore taken at that time.

Let us for a moment assume that all persons in the group with suspicious lesions had been treated in 1950. What impact would this treatment have had on the overall tuberculosis problem among reactors? Only a small one. The total number of patients would have been reduced by 12 percent. The reason that the effect, as seen from a public health point of view, is so small is that the number of persons in the group is small. Although the rate is high, this group yields few patients; only one-tenth of all cases diagnosed in the study population stems from it.

It is clearly seen from the table that the major problem in casefinding—and we believe that this also applies to many other chronic diseases including cancer—is the vast group of normal persons. It is the positive reactors with negative chest X-ray results who produce the major part of the tuberculosis caseload, more than three-quarters of it. To find a possible hard core that would be deserving of surveillance and preventive treatment, the group was subdivided according to a number of different criteria, some demographic, such as age, and some clinical, such as size of tuberculin reaction. None of these criteria, however, was productive. Quite another approach for casefinding was therefore needed, and we discuss this approach in the last part of this paper.

Risk of disease of 286,250 tuberculin reactors during 16-year followup, according to chest X-ray findings in mass tuberculosis control campaign in Denmark in 1950s

Classification of findings on initial chest X-ray[1]	*Percentage in classification*	*Annual rate of TB cases per 1,000*	*Percentage yield of total TB cases*
Suspicious	0.6	5.6	12
Inactive	6.7	.4	11
No lesion	92.7	.2	77
Total	100.0	0.2	100

[1] At time of mass campaign.

The objectives for a casefinding program are:

1. *Simplicity*: Delineation of the high-risk groups must be simple and easy. The search by EDP (electronic data processing) from popula-

tion registers or from hospital records is an example.

2. *Limitation in size*: The target group should be small so that it is manageable and supervisable.

3. *High risk*: The groups must have a high rate of disease so that preventive treatment, which may cause complications, is justifiable.

4. *High yield*: The high-risk group must produce so many cases that preventive treatment has a significant effect on the group's overall morbidity.

The indiscriminate mass approach used in Denmark did not meet these demands.

The United States

Two charts (figs. 3 and 4) summarize the situation today for countries like ours with relatively low, and falling, tuberculosis rates. Figure 3 is a profile of the total U.S. population, showing (in black) our best estimate of the age distribution of the 16 million persons already infected with tubercle bacilli. Most persons in the infected population are over 30 years of age. Relatively few new infections are now occurring: the average infection rate is down to about 1 new infection per 3,000 persons per year, perhaps even lower.

Figure 4 is a schema of the current epidemiologic picture in the United States. In the total population of 206 million persons, 39,500 active tuberculosis cases developed during 1971. This figure includes previously unknown cases, the so-called "new active cases," plus reactivations. Of the 16 million reactors shown on the right-hand side of figure 4, the 2,100,000 persons with positive X-ray results are considered to be at high risk. Some of them had a previous diagnosis of tuberculosis, and some had positive X-ray results, presumably of tuberculous origin; altogether they contributed 34 percent of all the cases. Without doubt, tuberculin-positive persons with positive X-ray results are priority candidates for preventive treatment. As a group they fulfill our requirements for a good target group, in that a relatively small number of persons who are at high risk produce a

Figure 3. Tuberculosis infection by age group, U.S. population

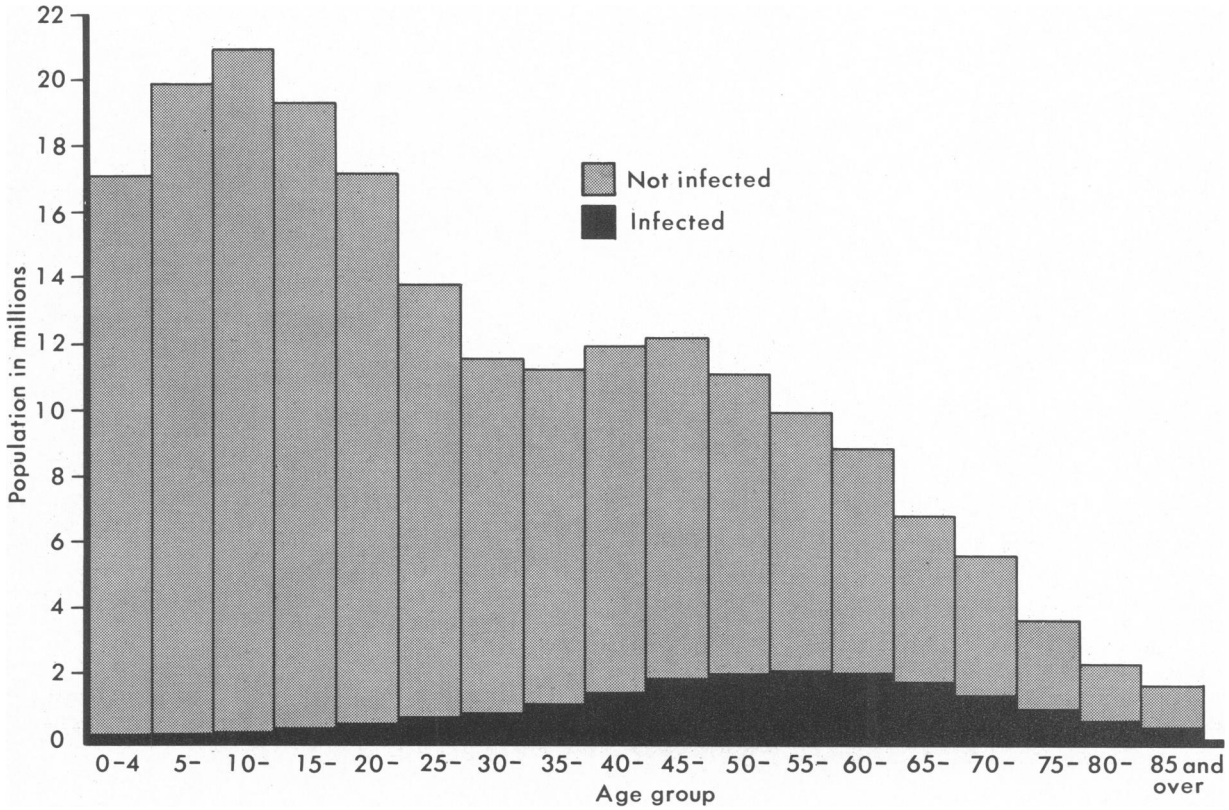
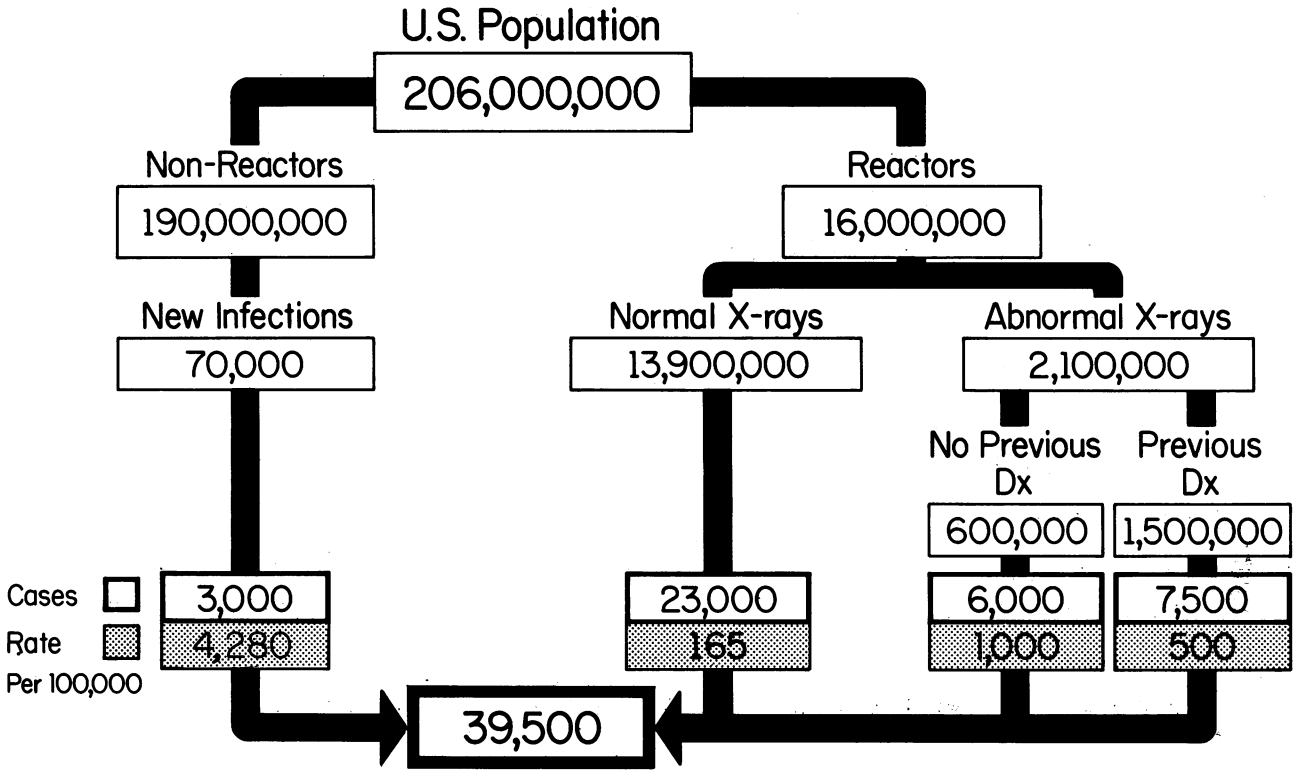


Figure 4. Tuberculosis in the United States, 1971—(schema)



substantial proportion of the total number of cases, and most of these persons can be identified readily from existing medical records.

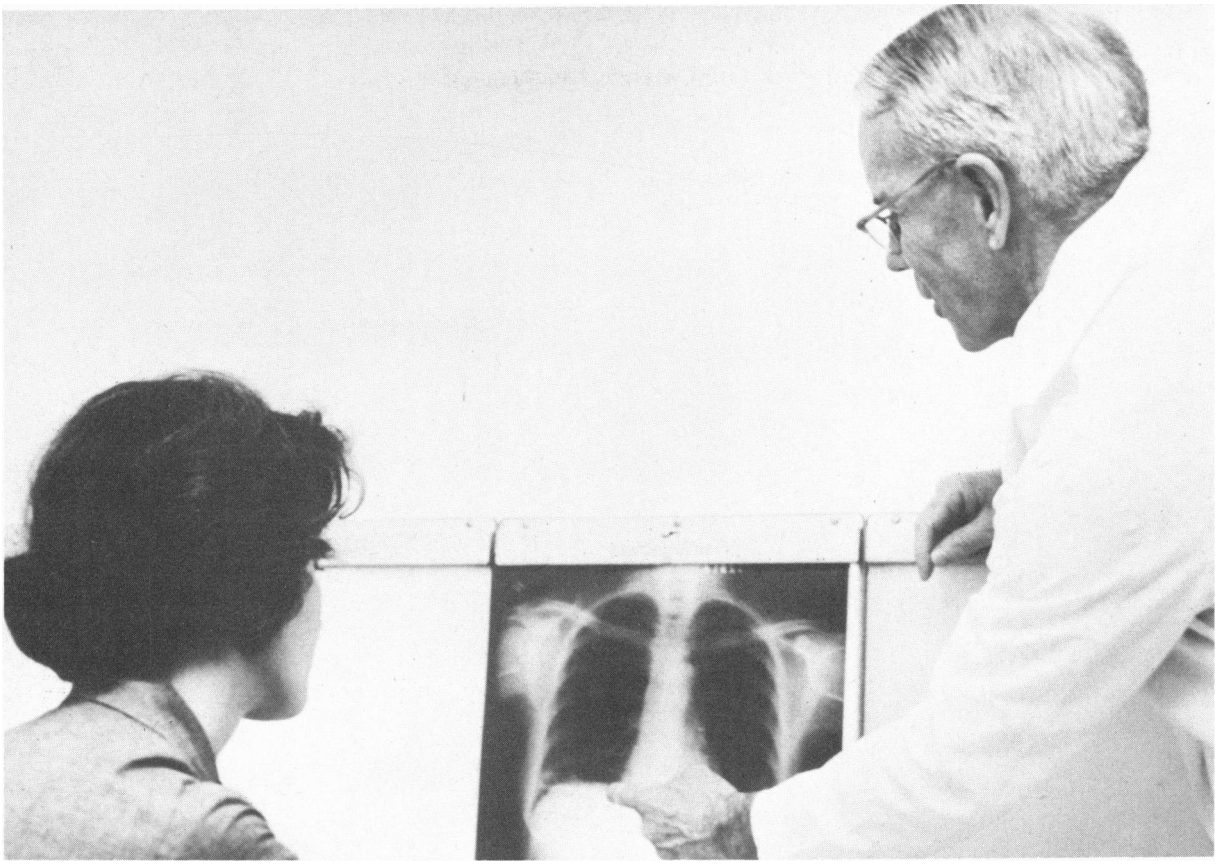
Most of the 16 million reactors have negative X-ray results; they contribute 23,000 new active cases, about 58 percent of the total. This group presents our greatest challenge, because it may contain several small subgroups at very high risk that contribute most of those 23,000 cases, while the bulk of the 14 million may serve merely as diluent with a very low, or even a negligible, risk.

At the left side of figure 4 is the handful of new infections, an estimated 70,000, which occur during the year. These persons are infected by patients with sputum-positive pulmonary tuberculosis; within the first year after infection they produce about 3,000 cases, or 8 percent of the total caseload. Emphasis on the examination and preventive treatment of infected contacts can prevent most of these cases. Because the numbers of contacts are so small, they are another profitable target group, even though their impact on the total caseload is modest.

We return, then, to that large group of tuberculin reactors with negative chest X-ray results, among whom are found nearly 60 percent of the cases arising each year. Who are these people? How do they differ from the crowd? Are they "marked" in some way so that they can be easily identified?

The "typical" case in this country today occurs in a white male over 45 years of age. To that we can add another simple demographic characteristic: the "lonely" male—divorced, single, or widowed—is at significantly higher risk of contracting disease than the married man (*2,3*). We know that people who seek medical care for a variety of reasons and who are in the so-called low socioeconomic groups, particularly in urban communities, contribute more tuberculosis than does the general population.

Among the conditions associated with tuberculosis are diabetes, immune deficiency diseases and immunosuppressive therapy, the pneumoconioses, gastrectomy, and heavy drinking. There may be many other, and perhaps more frequent conditions, which alone or in combination might point to the type of person who is "marked" for



a future case. Current studies are aimed at testing some of these clues and others as possible "markers" of where tuberculosis is likely to be found or is likely to develop in the reservoir of infected persons.

The incidence of tuberculosis is low and falling both in Denmark and the United States; the infection rate is correspondingly low. As a consequence, most of the new cases are now coming from the already infected reservoir, which constitutes about 10 percent of the total population. Within that group, a small but high-risk target group of persons with positive X-ray results can be identified. In Denmark, this group contributes 12 percent of the cases and in the United States, 34 percent. In both countries, the bulk of the cases come from the vast numbers of infected persons with negative X-ray results who, as a group, have a relatively low risk of disease. Traditional casefinding methods with mass surveys using chest X-rays and tuberculin skin testing are no longer productive. Instead, as tuberculosis becomes increasingly clustered in identifiable segments of the population, our national tuberculosis control programs must be directed toward cutting off the flow into the pool of active cases by preventing the disease from developing in these target groups.

In many respects, this approach to solving public health problems is not unique to tuberculosis. Knowledge of the epidemiology of acute communicable diseases has been applied successfully to their control. Now, as public health efforts focus increasingly on chronic diseases and disabilities, we again turn to epidemiology to provide a rational basis for effective control measures.

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