Directly Observed Therapy and Treatment Completion for Tuberculosis in the United States: Is Universal Supervised Therapy Necessary?

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ABSTRACT

Objectives. This study examined the relationship between directly observed therapy and treatment completion rates in the years before and after infusion of federal funding for tuberculosis (TB) control in 1993.

Methods. An ecological study of estimated directly observed therapy rates and 12-month treatment completion rates from 1990 through 1994 was undertaken for TB control programs in all 25 cities and counties across the nation with 100 or more incident TB cases in any year from 1990 to 1993. Three cohorts were formed: high treatment completion, intermediate completion, and low completion.

Results. In 1990, the median 12-month treatment completion rate was 80% for the entire study population, with a median estimated directly observed therapy rate of 16.8%. By 1994, those rates had increased to 87% and 49.4%, respectively, and increases were shown in all 3 cohorts.

Conclusions. Directly observed therapy has had a marked impact on treatment completion rates in jurisdictions with historically low rates. But TB treatment completion rates of more than 90% can be attained with directly observed therapy rates far lower than those proposed by advocates of universal supervised therapy. (*Am J Public Health.* 1998;88:1052–1058)

Introduction

In the late 1970s, it was estimated that between 20% and 30% of tuberculosis (TB) patients in the United States failed to complete their therapy within the prescribed 24-month period. Within that context Addington, in a widely cited article, noted that noncompliance was "the most serious remaining problem of tuberculosis."[1] Such concerns were not new; indeed, they mirrored observations made at the dawn of the era of the chemotherapeutic treatment of TB.[2–6]

Yet with TB cases continuing their decades-long decline, these failures provoked little sustained public health attention. They were far from the minds of the public, which had relegated TB to the status of a marginal health issue of little concern to the American mainstream.

This changed in the early 1990s, when public alarm emerged as a consequence of the increasing incidence of TB. Between 1985 and 1992, 52 000 more cases of TB were diagnosed than would otherwise have been anticipated,[7] and an apparent increase in the prevalence of multidrug-resistant strains of *Mycobacterium tuberculosis* was reported.[8] These occurrences and the fear that TB might revert to the status of an untreatable disease affecting the population at large fueled concern about the rate at which patients failed to complete their therapy in cities such as New York, NY; Chicago, Ill; Newark, NJ; Washington, DC and others.

With remarkable speed, the notion of directly observed therapy, rarely used in the United States despite a long history of advocacy on its behalf, emerged as the preferred policy response to this public health challenge.[9–12]

This change in perspective was endorsed at the local level across the nation. By 1996, the Centers for Disease Control and Prevention (CDC) estimated that between 1000 and 1200 outreach workers were administering directly observed therapy in the United States.[13] Also, selective reports generally underscoring the centrality of supervised treatment to the effective control of TB have been published.[14–18]

Treatment completion is, of course, a necessary but not sufficient measure of effective TB control. Nevertheless, public health officials over the past decade have adverted to that singular outcome as a way of measuring program effectiveness and as a justification for insisting upon changes in the funding and organization of TB control efforts. Indeed, when the Advisory Council for the Elimination of Tuberculosis issued its far-reaching recommendations in 1993, it stipulated that universal directly observed therapy be considered in all locales where treatment completion rates fell below 90%.[10]

This is the first study to examine the US experience with directly observed therapy since 1990, a baseline year selected to capture the relationship between treatment supervision and treatment completion prior to the change in national policy recommendations in 1993. We examined the relationship between directly observed therapy and treatment completion rates in every city and county that had 100 or more incident TB

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Editor's Note. See related articles by Horsburgh (p 1015), McKenna et al. (p 1059), and Liu et al. (p 1064) in this issue.

cases in any year from 1990 through 1994, and we sought answers to the following questions:

1. What was the relationship between the extent of directly observed therapy and treatment completion rates in the period prior to the change in federal policy and funding in 1993?
2. To what extent have jurisdictions across the nation embraced the practice of directly observed therapy since the change in federal policy?
3. What impact, if any, have the changing rates of directly observed therapy had upon treatment completion rates?
4. Is universal directly observed therapy necessary to achieve treatment completion rates that are compatible with the public health goal of ensuring that at least 90% of diagnosed TB patients undergo a full course of therapy?

Methods

Study Population

The study sample comprised any city or county with 100 or more incident cases of TB, as reported by the CDC, in any year from 1990 through 1994. This criterion identified 28 jurisdictions, and the TB control programs for these sites were contacted.

Instrument and Measures

A survey instrument, intended to be a guide for the contact person (typically the TB control program manager or medical director) to prepare for a subsequent telephone interview, was mailed to all identified sites in December of 1994. The survey sought programmatic data for the period 1989 through 1994 including annual incidence, 12-month treatment completion rates, and directly observed therapy rates. Information was also sought on the implementation of directly observed therapy and efforts at enhancing treatment completion either through the use of incentives or through links with other social service programs.

Of the 28 sites identified and then contacted, 25 (89.3%) agreed to participate. When the local jurisdictions could not retrieve data regarding incidence and completion rates, data were obtained from the CDC, when possible, from either published or unpublished data sources. Data on directly observed therapy were available only from the local jurisdiction. Indeed, it was not until 1993 that the CDC included data on directly observed therapy among the surveillance variables to be reported by local TB control programs.[19]

Three measures for the years 1990 through 1994 were selected for the purpose of this analysis. The first was number of incident cases of TB for each year, as reported by TB control program managers or medical directors. The second measure was 12-month treatment completion rates, as reported by TB control program managers or medical directors. Such data were generated from the standard CDC program management report form. The final measure was directly observed therapy rates. Only a few jurisdictions were able to provide these rates (the proportion of prevalent cases in any year placed in directly observed therapy) for a given year. In fact, programs could rarely report on the number of TB patients under treatment during any year. They could, however, provide us with the number of patients undergoing directly observed therapy at any given point in time or with a total number of patients undergoing such therapy over an entire year. It was possible, then, to calculate annual directly observed therapy rates using an algorithm that integrated an average monthly TB prevalence with the data provided on directly observed therapy. (The algorithm for estimating directly observed therapy rates is available from Dr Moïse DesVarieux, Division of Epidemiology, Columbia University School of Public Health, 622 W 168th St, PH18, New York, NY 10032.)

Finally, we validated our algorithm using the only locale (Newark) that could provide actual directly observed therapy rates for 1990 through 1994, as well as the number of prevalent cases and the number of patients with prevalent cases on directly observed therapy.

Analytic Procedures

Treatment completion rates in 1990 were used to define 3 cohorts that were roughly equal in size. The "high" cohort included those jurisdictions with treatment completion rates of 90% or higher at baseline; the "intermediate" cohort included those with treatment completion rates of 70% through 89.9%; and the "low" cohort included those with treatment completion rates of lower than 70%. The treatment completion and directly observed therapy rates for the 25 jurisdictions that constituted the 3 cohorts were tracked from 1990 through 1994. Changes in both rates for these cohorts over time were examined.

In addition, sensitivity analyses were performed to assess the variability in directly observed therapy rates that would result when the assumptions of the algorithm were changed. The duration of treatment for patients classified as completers was adjusted downward to 6 months as well as upward to 12 months. The duration of treatment for patients classified as dropouts was adjusted downward to 2 months and upward to 10 months, and duration of treatment was adjusted downward to 18 and upward to 28 months for patients on prolonged courses of therapy.

Results

Directly Observed Therapy and Treatment Completion in 1990

In the 25 jurisdictions studied, the median 12-month treatment completion rate for 1990 was 80% (Table 1). There were, however, wide differences across the country (Table 1). Seven jurisdictions had completion rates of 90% or higher (median: 95%; range: 90%–97.7%.), 10 had rates of 70% to 89.9% (median: 80%; range: 77%–88%), and 8 had rates of less than 70% (median: 60.5%; range: 32%–67.5%).

Those locales with the highest treatment completion rates tended to have the smallest number of incident cases, and those with the lowest completion rates had the largest number of incident cases (Table 2). In 1990, jurisdictions with treatment completion rates of 90% or higher had a mean number of incident cases of 178 (range: 95 to 334). The corresponding means were 358 (range: 117 to 1936) in those jurisdictions with treatment completion rates between 70% and 89.9% and 738 (range: 118 to 3520) in those with treatment completion rates below 70%. New York, NY; Chicago, Ill; Miami, Fla; and Houston, Tex, which ranked first, third, fourth, and fifth in terms of incident cases (data not shown) in 1990, ranked at or near the very bottom of completion rates for the same year (Table 1).

In 1990, the median nationwide directly observed therapy rate for the 25 jurisdictions for which we had data was 16.8% (range: 0% [no formal supervised therapy—Austin, Tex; Washington, DC; and Jacksonville, Fla] to 100% [Fort Worth, Tex] (Table 3).

Within the 3 treatment completion cohorts, there was considerable diversity in directly observed therapy rates in 1990 (Table 3). In the high treatment completion cohort, Fort Worth, Tex; Birmingham, Ala; and El Paso, Tex, had high directly observed therapy rates (100%, 75%, and 61%, respectively) while San Jose, Calif, and Austin and

TABLE 1—12-Month TB Treatment Completion Rates in 25 US Jurisdictions: 1990 Through 1994

Jurisdiction	1990	1991	1992	1993	1994
High treatment completion cohort					
Fort Worth–Tarrant County	97.7	90.7	96	99	100
El Paso	97	97	89	94	90
Dallas–Dallas County	96.4	95.2	92.8	100	96.2
Birmingham–Jefferson County	95	97	98	96	96
San Jose–Santa Clara County	93	94	93	93	99
Austin–Travis County	91[a]	91[a]	80	83	90
San Francisco	90	89	89	91	89
Median	95	94	92.8	94	96
Intermediate treatment completion cohort					
Los Angeles	88[a]	88[a]	81[a]	88.6	85.9
Seattle–King County	87.5	73.9	73.5	85.1	88.5
Boston	85.2	92	92.3	90	82
San Diego	82	80	88	95	96
Long Beach	80[a]	68[a]	82[a]	83	91.4[b]
Detroit	80	82	83	83	81
Philadelphia	80	82	72	74	77
Honolulu	80[a]	76[a]	83[a]	86.5	86.2
Washington, DC	79	82	81	75	60.9
Baltimore	77	78	90	91[b]	95.6
Median	80	81	82.5	85.1	86.1
Low treatment completion cohort					
Atlanta–Fulton County	67.5	73.7	79.8	70	75.6
Chicago	65	60.9	57.9	63.1	71
Jacksonville–Duval County	62	64	60	49	87
Newark	61	53.8	72.4	60	57
New York City	~60	60	54	83	89
Miami–Dade County	44.4	50.4	43	29.7[a]	43[c]
Houston–Harris County	40.9	54.3	53.3	75.1	78.2
Tampa–Hillsborough County	32[a]	41[a]	66	64	77.2
Median	60.5	57.2	59.0	63.6	76.4
Total (median)	80	82	81	83	87

Note. All rates are percentages. See text for cohort descriptions.
[a]As reported by the CDC.
[b]Rate for the first 6 months of the year.
[c]Estimated rate given available 1994 data at the time of the interview.

Dallas, Tex, had low rates (1.5%, 0%, and 4.9%, respectively).

This heterogeneity was less evident in the intermediate treatment completion cohort, in which directly observed therapy rates never exceeded 38%. Nevertheless, among locales where both treatment completion and directly observed therapy rates were available, Seattle, Wash, and Boston, Mass, which had the highest treatment completion rates (87.5% and 85.2%, respectively), differed in terms of directly observed therapy rates, (36.6% and 14%, respectively). Similarly, Washington, DC, and Baltimore, Md, the 2 cities with the lowest treatment completion rates (79% and 77%, respectively) in this group, had directly observed therapy rates of 0% and 38%, respectively (Table 3).

In the jurisdictions that had treatment completion rates below 70% in 1990, directly observed therapy rates were uniformly low, with no rate exceeding 24.4%. In Jacksonville, Fla, despite a completion rate of 62%, there was no formal directly observed therapy program, and in New York, NY, only 4.3% of patients were on directly observed therapy (treatment completion rate of less than 60%) (Table 3).

TABLE 2—Mean Number of Incident TB Cases, by Treatment Completion Rate: 1990 Through 1994

	Mean No. Cases (No. Jurisdictions)				
Completion Rates, %	1990	1991	1992	1993	1994
≥90	178 (7)	163 (7)	162 (6)	213 (9)	198 (8)
70–89.9	358 (10)	424 (10)	375 (13)	679 (11)	647 (12)
<70	738 (8)	741 (8)	994 (6)	315 (5)	232 (3)

Note. Data were not available on 2 (Tampa and Baltimore) of the 25 jurisdictions in 1994.

Directly Observed Therapy and Treatment Completion in 1994

In the 5 years from 1990 through 1994, changes occurred in both treatment completion rates and the extent to which directly observed therapy was used by local TB control programs. Treatment completion rates rose from a median of 80% in 1990 to a median of 87% in 1994. Most of that improvement occurred after 1993, and it was virtually completely accounted for by changes that occurred among the cohort of jurisdictions that had completion rates of less than 70% in 1990 (Table 1).

Between 1990 and 1994, there was a 3-fold rise in the proportion of prevalent cases placed on directly observed therapy. Median rates across the country in this 5-year period rose from 16.8% to 49.4% (Table 3).

Of the 7 jurisdictions that had completion rates of 90% or higher in 1990, all continued to have completion rates of 90% or higher in 1994, with the exception of San Francisco, which evidenced a 1% decline to 89%. Two additional cities for which data were available—San Diego and Long Beach, Calif—had attained 12-month treatment completion rates of 90% or better in 1994. While the overall directly observed therapy rate in the original high completion cohort jurisdictions rose almost 5-fold, completion rates changed little. In Dallas, while the directly observed therapy rate rose from 4.9% to 49.4%, completion rates were stable at 96% (Tables 1 and 3).

Among the intermediate jurisdictions, the picture was mixed. In Baltimore, San Diego, and Long Beach, increases in treatment completion were accompanied by increases in directly observed therapy rates; in Detroit, Mich, completion rates remained relatively unchanged, while directly observed therapy rates more than doubled. The same was true for Honolulu, where completion rates changed little in the face of rising directly observed therapy rates. In Washington, DC, in the face of rising directly observed therapy rates, treatment completion rates declined (Tables 1 and 3).

Among the 8 jurisdictions that constituted the original low completion cohort, only 2 still had treatment completion rates of less than 70% in 1994: Newark and Miami (for which reliable data were not available). In this cohort, median completion rates increased from 60.5% to 76.4%, while

TABLE 3—Estimated Directly Observed Therapy Rates in 25 US Jurisdictions: 1990 Through 1994

Jurisdiction	1990	1991	1992	1993	1994
High treatment completion cohort					
Fort Worth–Tarrant County	100	100	100	100	100
El Paso	61[a]	49[a]	80[a]	94[a]	94[a]
Dallas–Dallas County	4.9	6.2	6.8	6.8	49.4
Birmingham–Jefferson County	75[a]	75[a]	79[a]	75[a]	87[a]
San Jose–Santa Clara County	1.5[a]	1.5[a]	33[a]	60[a]	54.6
Austin–Travis County	0[c]	0[c]	57.9	100[b]	85.1
San Francisco	17.9	20.3	26.1	22.8	24.4
Median	17.9	20.3	57.9	60	85.1
Intermediate treatment completion cohort					
Los Angeles	. . .	. . .	19.3	27.2	11
Seattle–King County	36.6	12.3	9.9	18.7	35
Boston	14	18.5	19.4	24.7	25.9
San Diego	. . .	12[a]	18[a]	23[a]	46[a]
Long Beach	9.6	15.1	17.6	21.5	35
Detroit	25[a]	25[a]	32.5[a]	32.5[a]	66.3
Philadelphia	. . .	. . .	. . .	4.2	19.9
Honolulu	29.1	31.1	27	28.3[a]	54[a]
Washington, DC	0[c]	13	15.7	21.1	25[a]
Baltimore	38	38.9	40.4	54	91[a]
Median	25	16.8	19.3	23.9	35.6
Low treatment completion cohort					
Atlanta–Fulton County	15.4	13.1	56.3	94.7	90[a]
Chicago	8.4[a]	7.8[a]	7.8[a]	26.4[a]	28.5[a]
Jacksonville–Duval County	0[c]	0[c]	3.9	27.3	54.9
Newark	21.5[a]	21[a]	24.9[a]	35.3[a]	60[a]
New York City	4.3	3.7	9.9	24.5	33.2
Miami–Dade County	15.6	6.4	14.3	25.7	42.7
Houston–Harris County	24.4	26.3	56	43.9	85.5
Tampa–Hillsborough County	18	26.3	26.5	50.6	49.4
Median	15.5	12.8	19.6	31.3	52.2
Total (median)	16.8	15.1	25.5	27.2	49.4

Note. All rates are percentages. Directly observed therapy rates are based on estimated prevalent cases and reported numbers of patients on directly observed therapy. See text for cohort descriptions.
[a]Provided by respondent (not estimated).
[b]Rate exceeded 100%, as generated by the algorithm; estimate is reported at 100%.
[c]No formal supervised therapy program exists.

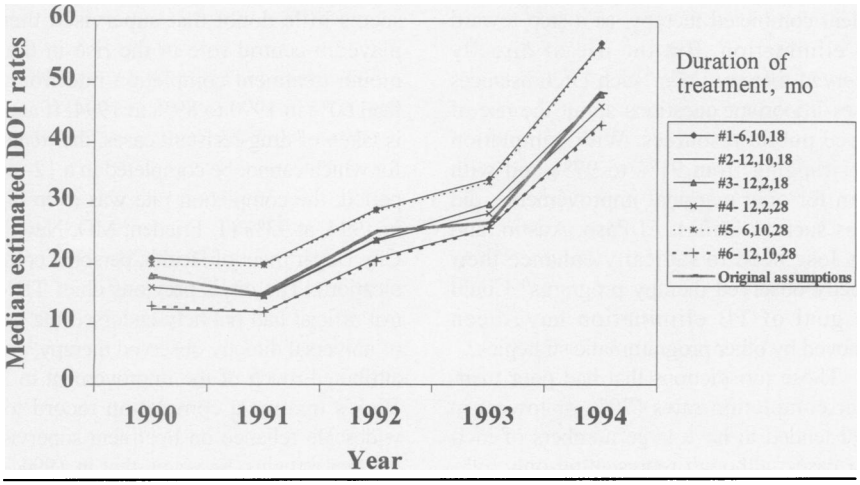

FIGURE 1—Sensitivity analysis: median estimated directly observed therapy (DOT) rates for all jurisdictions, 1990 through 1994 (variable assumptions: durations, in months, for completers, dropouts, and those in prolonged therapy).

directly observed therapy rates rose more than 3-fold to 52.2% (Table 3). Completion rates rose from approximately 60% to 89% in New York City, from 32% to 77% in Tampa, from 41% to 78% in Houston, and from 62% to 87% in Jacksonville. Each of these cities showed a rise in directly observed therapy rates: from 4.3% to 33.2% in New York, from 18% to 49.4% in Tampa, and from 24.4% to 85.5% in Houston. In Jacksonville, which had no formal directly observed therapy program in 1990, 54.9% of patients were placed on supervised therapy in 1994.

Because we were concerned about a possible ceiling effect, especially within those cohorts that started with high levels of completion in 1990, we performed a second set of analyses that sought to compare cohorts in terms of the extent to which they achieved improvements relative to what was, in fact, possible. The increase in directly observed therapy or treatment completion was then judged as a proportion of the maximum possible improvement. Thus, in the low cohort, the increase in directly observed therapy rates from 1990 to 1994 represented 43.4% of the maximum possible improvement. Concurrently, treatment completion rose 41% of what was maximally possible. In the high cohort, on the other hand, directly observed therapy rates increased 81.9% of what was maximally possible, while the improvement in treatment completion rates was only 20% of what could have been attained.

The inverse relationship between number of incident cases and completion rates that prevailed in 1990 through 1992 was absent in 1993 and 1994 (Table 2). In fact, by 1994 the mean number of incident cases for the 3 jurisdictions with treatment completion rates of less than 70% was 232, approximately one third the 1990 mean for such jurisdictions.

Validation

Validation of the estimation algorithm for directly observed therapy rates, performed for Newark, yielded rates similar to those observed in the earlier analyses. Actual rates and estimated rates were, respectively, 21.5% and 23.5% in 1990, 21% and 19.1% in 1991, 24.9% and 28.7% in 1992, and 35.3% and 38.6% in 1993.

Sensitivity Analysis

The sensitivity analysis, which varied the assumptions of the algorithm, produced slight changes in the number of prevalent cases of TB under treatment and, as a conse-

quence, only slight changes in estimated directly observed therapy rates. Results of the sensitivity analysis for the entire study population are displayed in Figure 1. The relationship between directly observed therapy rates and treatment completion rates over time from 1990 to 1994 was unchanged in all cohorts.

Discussion

In a 1993 editorial, "Directly Observed Treatment of Tuberculosis: We Can't Afford Not to Try It," Iseman et al. responded to the sense of national alarm sparked by the rising incidence of TB and the well-publicized increase in the number of multidrug-resistant cases of disease by pressing their long-standing commitment to universal supervised therapy. "We believe it is time for entirely intermittent directly observed treatment programs. . .to be used with *all* patients."[20] But in this instance, the call for universal directly observed therapy occurred in an environment much more sympathetic to such proposals than would have been the case just a few years earlier. By the mid-1990s, directly observed therapy had undergone a radical transformation. No longer a marginal feature of TB control efforts, it had become the standard of care.

We began this study with the assumption that the arguments put forth for universal or near-universal supervised therapy possessed a powerful public health logic,[21] one that was of sufficient moment to override some of the ethical and legal objections[22–24] to the idea of mandatory therapy, the predicate of universal directly observed therapy. We assumed that more directly observed therapy was better than less directly observed therapy, that universal supervised therapy was the only method that would resolve the ongoing problem of treatment failure and the attendant problem of drug resistance, and that such efforts would play a crucial role in halting the rise in the incidence of TB. Furthermore, a universal approach would preclude the stigmatizing effect of identifying groups at high risk for noncompletion.

The results of our research reveal a much more nuanced picture. It is a picture that challenges the proposition that universal directly observed therapy is a necessary feature of all programs that seek to improve treatment completion rates. Equally important, it is a picture that challenges the assumption that the adoption of universal or near-universal directly observed therapy is necessary or sufficient in locales that have had a long history of low treatment completion rates.

In the baseline year of 1990, we found that among those locales that had completion rates of 90% or higher, only one, Fort Worth, relied on universal directly observed therapy. More striking was the fact that in 3 of the 7 jurisdictions, directly observed therapy rates were negligible. And in San Francisco, where directly observed therapy was used in a very selective fashion for those patients deemed to be at high risk for noncompletion of therapy, only 17.9% of patients with prevalent cases were on supervised therapy.

What can account for such high levels of treatment completion in the absence of directly observed therapy? In general, the locales that had especially effective TB control efforts, with completion rates of 90% or better, were no more likely in 1990 to have established robust programs to enhance completion rates—by providing additional services ("enablers") to drug users, the homeless, and the mentally ill—than were less successful locales. San Francisco, however, stood out in one respect. It gave opiate users with TB priority admission into methadone maintenance treatment (G. Schecter, MD, San Francisco General Hospital, personal communication).

Despite the ability of a number of jurisdictions to achieve high treatment completion rates with little or very modest reliance on directly observed therapy, pressure has mounted in these locales to increase the extent to which patients are placed on supervised therapy. The availability of federal resources to pay for the cost of supervision has made such efforts not only possible but attractive. While some local TB control officials were clearly discomfited by the move toward greater reliance on directly observed therapy, believing the costs could not be justified by potential benefits, others saw it as an opportunity to ensure that each and every patient completed therapy, as a step toward TB elimination. But the use of directly observed therapy under such circumstances raises important questions about the use of scarce public resources. With completion rates ranging from 91% to 97% and with room for only marginal improvements, did cities such as Dallas, El Paso, Austin, and San Jose need to radically enhance their directly observed therapy programs? Could the goal of TB elimination have been achieved by other programmatic strategies?

Those jurisdictions that had poor treatment completion rates (70% or lower) in 1990 tended to have large numbers of incident cases; although representing only 32% of the jurisdictions, they included 55% of the incident TB cases in our study population. Indeed, 4 such jurisdictions—New York, Chicago, Houston, and Miami—represented 48.8% of the incident TB cases in our sample. Our 1990 data might be read to suggest that the higher number of incident cases in some cities may have been a factor accounting for difficulties in managing patient treatment in an effective manner. But whatever the possible contribution of demographic and epidemiological factors—rates of homelessness, drug and alcohol addiction, mental illness—to the dismal rates of treatment completion in 1990, this study makes it clear that enhanced resources allowing programmatic changes, especially the widespread use of directly observed therapy, can produce dramatic improvements in treatment completion rates. Social epidemiology is, after all, not destiny.

Directly observed therapy clearly had an impact on the capacity to ensure treatment completion in the jurisdictions that had fared so poorly in 1990. In those cities and counties, such therapy became the standard of care. In New York City, directly observed therapy rates rose from 4.3% to 33.2%; in Houston, the increase was from 24.4% to 85.5%; and in Tampa, rates increased from 18% to 49.4%. These increases were accompanied by radical improvements in treatment completion rates. It is hard to imagine that this association is spurious. Of course, factors other than directly observed therapy may have contributed to the variation in treatment completion rates over time. For instance, close case management, which may resemble directly observed therapy, or fixed combination therapy may have played a crucial role.

What is so striking, however, about these data is that, clearly, treatment completion rates can rise rapidly without the implementation of programs of universal directly observed therapy. New York City provides important evidence in this regard. There seems little doubt that supervised therapy played a central role in the rise in the 12-month treatment completion rate from less than 60% in 1990 to 89% in 1994. If account is taken of drug-resistant cases, the treatment for which cannot be completed in a 12-month period, the completion rate was even higher in 1994, at 93% (T. Frieden, MD, New York City Department of Health, personal communication). The city's previous chief TB control official had publicly endorsed the notion of universal directly observed therapy, and he attributed much of the improvement in New York's treatment completion record to the widescale reliance on treatment supervision; the fact remains, however, that in 1994, only slightly more than one third of TB patients in New York City had been placed on directly observed therapy.

What the experience of New York has demonstrated is the significance of the

combined effects of directly observed therapy, careful surveillance, the training of committed caregivers,[13] and administrative rigor on rates of treatment completion. The importance of these factors is underscored by the fact that, in cities where the TB control program or the public health infrastructure is in disarray, formal increases in directly observed therapy do not result in improvements in treatment completion. For example, in Washington, DC, despite an increase in directly observed therapy, treatment completion actually declined. This is not surprising, given a 1996 report of the Washington, DC, Medical Society and the American Lung Association that noted "shocking deficiencies" in the city's efforts to control the disease.[25] Finally, it is clear that even within a given city, not all directly observed therapy programs are equally effective. Much depends on the quality of the staff, the skill with which it is managed, and the capacity to establish ongoing relationships with patients.

There are a number of limitations to this study. For example, we used 12-month completion rates as a measure of efficacy. But such a standard may result in the mischaracterization of programmatic outcomes. For instance, in Boston, which had a treatment completion rate of 82% in 1994, virtually all but 4 "noncompleters" had finished their treatment within 18 months (J. Bernardo, MD, Boston TB Control Program, personal communication). San Francisco accommodates this mischaracterization of programmatic outcomes by calculating an "absolute" completion rate in addition to the prescribed 12-month treatment completion rate (G. Schecter, MD, San Francisco General Hospital, personal communication). Indeed, the CDC, in a recent analysis, questioned the validity of using 12-month completion as a measure of programmatic effectiveness.[26] Nevertheless, for purposes of the longitudinal and comparative analysis undertaken in this study, 12-month completion rates provided the only available data set.

Also, this study was ecological in nature. The unit of analysis was the TB control program. Therefore, conclusions should not be drawn about individual TB cases. While the implementation of directly observed therapy may not have dramatically improved the overall treatment completion rate in a particular jurisdiction, it may well have benefited individual patients in this population.

Although we feel confident that our validated algorithm, even with modified assumptions, is robust in painting the overall picture of the association between directly observed therapy and treatment completion, we caution that it provides only an estimation within the constraints of our assumptions and may not be appropriate for analyses of the experience of individual jurisdictions.

Finally, this study shares with others the limitations inherent to self-reported data. While we made every effort to obtain the most accurate information available to local data mangers, we acknowledge that measurement error probably occurred. Certain programs were more systematic in their record keeping than others. Some may have defined directly observed therapy more restrictively than others. Nevertheless, we sought to make the most judicious use of the data reported to us.

We have, in this paper, centered our analysis on treatment completion rates. There are, of course, other measures of programmatic success, such as the incidence of new cases, the rates at which patients become sputum negative, and the level of drug resistance in a community. Analyses of the relationship between directly observed therapy rates and such outcomes are necessary.

Conclusions

The call for universal directly observed therapy provided an important challenge to the practices of public health departments that had done so poorly in managing TB. But with the experience of the period between 1990 and 1994, it is clear that the simplicity of that call cannot serve as a singular guide to effective, budget-conscious TB control. Universal directly observed therapy can result in near-perfect treatment completion rates if carefully implemented. But pressing toward universal directly observed therapy in settings that have already achieved very high rates of treatment completion may produce only small improvements at very high marginal costs. This is also true in locales showing recent dramatic improvements in treatment completion rates attained through relatively high (but by no means near 100%) directly observed therapy rates.

The calls for universal directly observed therapy in the past have tended to assert that, given the costs of treating multidrug-resistant TB, the prevention of even very small numbers of cases makes universal treatment supervision worthwhile. The force of that claim needs to be re-examined in light of the relationship between directly observed therapy and treatment completion shown in this study.[27] We view our findings as providing an opportunity to reopen the discussion of TB policy, which may, in the mid-1990s, have moved to premature closure. □

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References

1. Addington W. Patient compliance: the most serious remaining problem in the control of tuberculosis in the United States. *Chest*. 1979;76(suppl):6.
2. Tuberculosis Chemotherapy Centre, Madras. A current comparison of home and sanitorium treatment of pulmonary tuberculosis in South India. *Bull World Health Organ*. 1959;21: 51–144.
3. Fox W. The problem of self-administration of drugs, with particular references to pulmonary tuberculosis. *Tubercle*. 1958;39:269–274.
4. Fox W. Self-administration of medicaments: a review of published work and a study of problems. In: *Proceedings of the XVI International Conference on Tuberculosis*. 1962:307–331.
5. Fox W. The chemotherapy and epidemiology of tuberculosis: some findings of general applicability from the Tuberculosis Chemotherapy Centre, Madras. *Lancet*. 1962; 473–478.
6. Bayer R, Wilkinson D. Directly observed therapy for tuberculosis: history of an idea. *Lancet*. 1995;354:1545–1548.
7. Centers for Disease Control and Prevention. Tuberculosis morbidity—United States, 1992. *MMWR Morb Mortal Wkly Rep*. 1993; 42:696–697, 703–704.
8. Centers for Disease Control and Prevention. Nosocomial transmission of multi-drug resistant tuberculosis among HIV-infected persons—Florida and New York, 1988–1991. *JAMA*. 1991; 226:1483–1485.
9. American Thoracic Society, Centers for Disease Control and Prevention, American Academy of Pediatrics, Infectious Disease Society of America. Control of tuberculosis in the United States. *Am Rev Respir Dis*. 1992; 146:1623–1633.
10. Advisory Council for the Elimination of Tuberculosis. Initial therapy for tuberculosis in the era of multidrug resistance: recommendations of the Advisory Council for the Elimination of Tuberculosis. *MMWR Morb Mortal Wkly Rep*. 1993;42(RR-7).
11. *Fiscal Year 1994 Application Guidance for Non-Completing Continuation Applications for*

Tuberculosis (TB) Elimination Cooperative Agreements. Atlanta, Ga: Centers for Disease Control and Prevention; 1994.
12. *Fiscal Year 1995 Application Guidance for Non-Completing Continuation Applications for Tuberculosis (TB) Elimination Cooperative Agreements*. Atlanta, Ga: Centers for Disease Control and Prevention; 1995.
13. Voelker R. 'Shoe leather' therapy is gaining on TB. *JAMA*. 1996;275:743–744.
14. Weis SE, Slocum PC, Blais FX, et al. The effect of directly observed therapy on the rates of drug resistance and relapse of tuberculosis. *N Engl J Med*. 1994;330:1179–1184.
15. Frieden TR, Fujiwara PI, Washko RM, Hamburg MA. Tuberculosis in New York City: turning the tide. *N Engl J Med*. 1995;333: 229–233.
16. Pablos-Méndez A, Sterling TR, Frieden TR. The relationship between delayed or incomplete treatment and all-cause mortality in patients with tuberculosis. *JAMA*. 1996;276: 1223–1228.
17. Chaulk CP, Moore-Rice K, Rizzo R, Chaisson RE. Eleven years of community-based directly observed therapy for tuberculosis. *JAMA*. 1995;274:945–951.
18. Cowell A. U.N. agency is optimistic on treatment to fight TB. *New York Times*. March 20, 1997: A1.
19. Bloch AB, Onorato IM, Ihle WW, Hadler JL, Hayden CH, Snider DE. The need for epidemic intelligence. *Public Health Rep*. 1996;3:26–33.
20. Iseman MD, Cohn DL, Sbarbaro JA. Directly observed treatment of tuberculosis: we can't afford not to try it. *N Engl J Med*. 1993; 328:576–578.
21. Bayer R, Dubler NN, Landesman S. The dual epidemics of tuberculosis and AIDS: ethical and policy issues in screening and treatment. *Am J Public Health*. 1993;83:649–654.
22. Annas G. Control of tuberculosis: the law and the public health. *N Engl J Med*. 1993;328: 585–588.
23. Hansell DA. The TB and HIV epidemics: history learned and unlearned. *J Law Med Ethics*. 1993;21:376–381.
24. Jacobs SL. Legal advocacy in a time of plague. *J Law Med Ethics*. 1993;21:382–389.
25. Goldstein A. D.C. shows jump in TB cases; study blasts city's efforts to track, fight disease. *Washington Post*. August 2, 1996:C1.
26. Bloch AB, Simone PM, Kelly GD, Dansbury KG, McCray E, Castro KG. Comparison of two methods for calculating completion of tuberculosis therapy in the US, 1993. Paper presented at: American Thoracic Society International Conference; May 1997; San Francisco, Calif.
27. Nardell EA. Beyond four drugs: public health policy and the treatment of the individual patient with tuberculosis. *Am Rev Respir Dis*. 1993;148:2–5.