COSTS OF IMPLEMENTING AND MAINTAINING A TUBERCULIN SKIN TEST PROGRAM IN HOSPITALS AND HEALTH DEPARTMENTS

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ABSTRACT

OBJECTIVE: To determine (1) the annual costs of implementing and maintaining tuberculin skin test (TST) programs at participating study sites, (2) the cost of the TST program per healthcare worker (HCW), and (3) the outcomes of the TST programs, including the proportion of HCWs with a documented TST conversion and the proportion who accepted and completed treatment for latent TB infection, before and after the implementation of *staffTRAK-TB* software (Centers for Disease Control and Prevention, Atlanta, GA).

DESIGN: Cost analysis in which costs for salaries, training, supplies, radiography, and data analysis were collected for two 12-month periods (before and after the implementation of *staffTRAK-TB*).

SETTING: Four hospitals (two university and two city) and two health departments (one small county and one big city).

RESULTS: The annual cost of implementing and maintaining a TST program ranged from $66,564 to $332,728 for hospitals and $92,886 to $291,248 for health departments. The cost of the TST program per HCW ranged from $41 to $362 for hospitals and $176 to $264 for health departments.

CONCLUSIONS: Costs associated with implementing and maintaining a TST program varied widely among the participating study sites, both before and after the implementation of *staffTRAK-TB*. Compliance with the TB infection control guidelines of the Centers for Disease Control and Prevention may require a substantial investment in personnel time, effort, and commitment (*Infect Control Hosp Epidemiol* 2003;24:814-820).

In 1994, the Centers for Disease Control and Prevention (CDC) published guidelines on infection control policies and measures that would reduce the risk of transmission of *Mycobacterium tuberculosis* in healthcare facilities. In this document, the CDC recommended periodic tuberculin skin testing of healthcare workers (HCWs) who are potentially exposed to *M. tuberculosis*.[1] In 1995, the CDC initiated a tuberculin skin test (TST) demonstration project in selected U.S. hospitals and health departments to develop model TST programs for HCWs consistent with CDC guidelines and to track and monitor TST, latent tuberculosis (TB) infection, and TST conversion data among HCWs through *staffTRAK-TB*, a microcomputer software system developed by the CDC.[2] This project was funded from January 1996 to September 1998. The CDC developed *staffTRAK-TB* as an adjunct to its recommendation to maintain all HCWs' TST data in a retrievable aggregate database, as well as in individual medical records.[1] The software was expected to save money by generating automated, rather than manual, reports to identify HCWs due or overdue for a TST or chest radiograph. It was anticipated that *staffTRAK-TB* would provide good baseline information and facilitate data management and tracking of HCWs by ensuring timely evaluation of HCWs who had positive TSTs and by identifying HCWs who were due or overdue for a TST or chest radiograph.

In April 2000, the American Thoracic Society and the CDC released updated guidelines for targeted tuberculin skin testing and treatment of latent TB infection, which recognize infection control activities in clinics, hospitals, and laboratories as essential components of the TB elimination strategy in the United States.[3] In the guidelines, the CDC recommends that healthcare facilities provide baseline two-step TSTs for newly hired HCWs who have a potential risk for exposure to *M. tuberculosis*, and

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that TST programs focus primarily on individuals at high risk for recent latent TB infection or with clinical conditions that increase the risk for TB disease, regardless of age. Follow-up TST screening is discouraged among HCWs who are determined to have a low risk of TB exposure.[3]

To date, no studies have addressed the costs of implementing and maintaining a model or comprehensive TST program in hospitals or health departments. Several studies have examined the costs of select components of hospital infection control activities, such as environmental controls,[4] training,[5,6] respiratory protection and fit-testing programs,[4,5,7] and TB control measures not related to respirators.[8] In one study, researchers assessed the actual expenditures for select TB control interventions in four urban hospitals (in two states) reporting previous healthcare-associated multidrug-resistant TB outbreaks.[8] Another rural community hospital in a different state that had experienced no TB outbreaks was used for comparison. The study focused on the costs of TST programs for HCWs, infection control measures, employee health service personnel, and the environmental controls currently in place and found that costs varied considerably among the study hospitals depending on the age and design of the physical plant, the adequacy and number of existing TB isolation rooms, and the existing TB infection control policies within the facility.

In 1997, Nettleman and Geerdes studied the cost-effectiveness of administering TSTs every 6 versus 12 months to physicians, a population considered to be at high risk for latent TB infection.[9] The authors suggested that programs providing TSTs every 12 months and treatment for latent TB infection avert cases of pulmonary TB, prevent TB deaths, and save life-years, and that improved compliance with these programs could more than triple the benefits currently derived.[9]

Another study indicated that the largest single facility expenditure in a hospital TST program was employee time away from the workplace to either provide or attend TST training. This included education on TB pathology and transmission, national and local epidemiology, the appropriate use of airborne infection isolation, and the placement and evaluation of TSTs.[6]

The objectives of this study were to determine, before and after the implementation of *staffTRAK-TB*, the following: (1) the annual costs of implementing and maintaining TST programs at participating study sites in the TST demonstration project; (2) the cost of the TST program per HCW; and (3) the outcomes of the TST programs, including the proportion of HCWs with a documented TST conversion and the proportion who accepted and completed treatment for latent TB infection.

METHODS

Costs associated with implementing and maintaining a TST program for HCWs were estimated for four hospitals (two university and two city) and two health departments (one small county and one big city) in the United States. The study sites were chosen from among recipients of a CDC cooperative agreement who reported 50 or more cases of TB in 1993. Sites were eligible for *staffTRAK-TB* project funds if they were adherent to current TB infection control guidelines of the American Thoracic Society and the CDC. In their proposals for the project, all sites indicated that they were adherent to the guidelines; however, due to the lack of resources, one health department did not perform two-step tuberculin skin testing on newly hired HCWs as recommended,[3] and one hospital did not have a respiratory protection program in place during the two periods. At all sites, the protocol was for HCWs with positive TSTs to receive an initial chest radiograph to rule out TB disease and then yearly medical evaluations for symptoms of TB disease.

Although the population of HCWs who received TSTs varied at each site, all sites tested a range of professional full-time and part-time employees, including physicians (eg, fellows, attendings, and residents or interns), nurses, administrative personnel, and health technicians. In addition, some sites included outreach workers, emergency services staff, and volunteers. One hospital included only pediatric HCWs, and one health department included correctional HCWs.

Selection of the sites for this study was based on willingness to participate, diversity of population density, completeness and timeliness of TB case reporting, feasibility of collecting cost data, and geographic location. This study was regarded by the CDC as human subjects research, but was exempt from a full review by the institutional review board due to the less than minimal risk to the participating study sites and HCWs given the nature of the data collection instrument, which consisted of collecting existing information on the number of HCWs enrolled in each site's TST program and the costs of implementing and maintaining the TST program and *staffTRAK-TB* at each site.

The CDC developed a standard cost analysis protocol, data abstraction forms, and instructions to complete the forms. The costs obtained in this study reflected the costs to the facility (except for overhead costs such as mailings, rent, telephones, or utilities, which were excluded), and did not include costs incurred by the CDC (eg, for training and software). Actual costs to the hospital or health department (eg, supplies, services, and procedures), as opposed to charges to the HCW, were determined and were based on the year that the costs were incurred.

Study coordinators collected costs for the two 12-month periods before and after the implementation of *staffTRAK-TB* (ie, before and after the sites received and loaded the software, were trained on its use, and began entering TST data for their HCWs). Because the study sites selected their own two 12-month periods based on the availability of data and hiring of project staff, the dates of the periods before and after the implementation of *staffTRAK-TB* ranged from 1993 to 1998 among the six sites. Accordingly, all costs were converted into 1998 constant U.S. dollars using the Consumer Price Index.[10]

Each site determined the appropriate data sources for collecting cost information. Local staff abstracted cost data from purchasing department records, hospital

TABLE 1
COSTS IN 1998 U.S. DOLLARS OF IMPLEMENTING AND MAINTAINING A TUBERCULIN SKIN TEST PROGRAM IN THE HOSPITALS

	Hospital 1		Hospital 2		Hospital 3		Hospital 4	
Cost*	**Period 1**	**Period 2**	**Period 1**	**Period 2**	**Period 1**	**Period 2**	**Period 1**	**Period 2**
Personnel	$38,084 (37.9%)	$71,232 (49.7%)	$64,338 (96.7%)	$127,382 (84.7%)	$119,147 (50.3%)	$138,080 (62.4%)	$214,777 (77.1%)	$271,410 (81.6%)
Training and education	$36,567 (36.3%)	$38,273 (26.7%)	$0 (0%)	$6,901 (4.6%)	$17,444 (7.4%)	$22,201 (10.0%)	$1,796 (0.6%)	$2,784 (0.8%)
Incentives	$0 (0%)	$0 (0%)	$0 (0%)	$235 (0.2%)	$1,530 (0.6%)	$1,487 (0.7%)	$0 (0%)	$0 (0%)
TST supplies	$831 (0.8%)	$999 (0.7%)	$93 (0.1%)	$1,736 (1.1%)	$3,195 (1.3%)	$2,086 (0.9%)	$1,181 (0.4%)	$1,006 (0.3%)
Time taken off from work by HCWs†	$24,562 (24.4%)	$28,872 (20.1%)	$2,004 (3.0%)	$2,466 (1.6%)	$47,816 (20.2%)	$48,303 (21.8%)	$6,753 (2.4%)	$3,091 (0.9%)
Follow-up evaluation‡	$366 (0.4%)	$0 (0%)	$129 (0.2%)	$1,272 (0.8%)	$45,285 (19.1%)	$5,612 (2.5%)	$6,845 (2.5%)	$14,295 (4.3%)
Data analysis and reports	$195 (0.2%)	$0 (0%)	$0 (0%)	$6,857 (4.6%)	$1,534 (0.6%)	$1,490 (0.7%)	$47,379 (17.0%)	$37,349 (11.2%)
Administration and materials	$0 (0%)	$4,052 (2.8%)	$0 (0%)	$3,566 (2.4%)	$1,100 (0.5%)	$2,216 (1.0%)	$0 (0%)	$2,793 (0.9%)
Total	$100,605	$143,428	$66,564	$150,415	$237,051	$221,475	$278,731	$332,728

TST = tuberculin skin test; HCW = healthcare worker.
*None of the hospitals incurred "other" costs.
†Time taken off from work by HCWs for TST placement and reading.
‡Follow-up evaluation for TST-positive HCWs at the facility.

records, health department records, pay scales, employee health records, and supply logs. When possible, cost data were validated at the site with other data sources.

All components of the facility's TST program were reviewed to identify associated costs including personnel salaries and fringe benefits, training and educational materials, TST supplies, data analysis and reports, and implementation and maintenance of *staffTRAK-TB*. Personnel costs were calculated as the proportion of staff time spent on each specified activity multiplied by the sum of salary and fringe benefits. Local staff estimated the amount of time that HCWs spent performing TST activities, and hourly salaries were based on a 40-hour work week.

Staff from each study site also estimated the amount of time that HCWs spent away from work to receive a TST and return for the results. Because not all of the sites provided follow-up evaluations for their HCWs at their facilities, costs incurred for evaluating HCWs with positive TSTs included only the cost of a chest radiograph. At one health department, HCWs with positive TSTs, unless they were TST converters, were referred to their private providers for follow-up, and other sites allowed HCWs to choose where to receive their follow-up care. Therefore, cost data for the follow-up treatment of latent TB infection and periodic symptom screenings were not available. Because information regarding follow-up care visits was incomplete, the costs associated with laboratory tests and treatment for latent TB infection were not assessed.

Each site provided information regarding TST program outcomes such as the number of HCWs tested at the facility during each of the selected times; the number of TST-negative HCWs; the number of TST-positive HCWs, defined as having an induration of 10 mm or more; the number of HCWs whose results were not read; the number of HCWs who received TSTs elsewhere; and the number of HCWs who had a documented TST conversion. As defined by this study, a TST conversion was an induration increase of 10 mm or more between the last two TSTs, if the first TST was less than 10 mm^2 (Appendix, Note A).

For those HCWs who were TST positive, information was provided regarding the number who received chest radiographs; the number who were offered, accepted, and completed treatment for latent TB infection; and the number who were diagnosed as having and completed treatment for active TB disease.

The data collected and submitted by the sites were reviewed by CDC staff, who worked closely with the sites to clarify any discrepancies, fill in data gaps, and ensure the quality of data used for analysis.

RESULTS

Hospitals

The results for the four participating hospitals for the periods before and after the implementation of *staffTRAK-TB* (between 1994 and 1998) are presented in Tables 1, 2, and 3. The numbers reflect a wide range of results. The annual cost of implementing and maintaining

TABLE 2
OUTCOMES OF THE TUBERCULIN SKIN TEST PROGRAM BEFORE AND AFTER THE IMPLEMENTATION OF *staffTRAK-TB* IN THE HOSPITALS*

	Hospital 1		Hospital 2		Hospital 3		Hospital 4	
Outcome	**Period 1**	**Period 2**	**Period 1**	**Period 2**	**Period 1**	**Period 2**	**Period 1**	**Period 2**
No. of TSTs performed at the facility	1,475	1,575	184	661	6,331	4,242	2,269	1,674
No. of HCWs who received TSTs at the facility	975	1,076	184	440	5,770	3,938	1,251	1,546
No. of HCWs tested but not read	0	0	0	1	593	0	290	0
No. of HCWs who tested negative	972	1,076	183	423	4,882	3,871	881	1,374
No. of HCWs who tested positive	3	0	1	16	295	67	80	172
Among HCWs who tested positive								
No. of HCWs who received a chest radiograph	3	0	1	9	290	37	80	172
No. of HCWs who did not receive a chest radiograph†	0	0	0	0	0	6	0	0
No. of HCWs who were offered INH therapy	3	0	0	7	58	43	80	172
No. of HCWs who accepted INH therapy	3	0	0	5	49	22	80	150
No. of HCWs who completed INH therapy	3	0	0	2	9	14	40	25
No. of HCWs who received TSTs elsewhere	0	0	UK	32	275	33	0	0
No. of HCWs with documented TST conversions‡	3	0	0	11	23	6	3	27
TST conversion rate, %	0.3	NA	NA	2.5	0.4	0.2	0.2	1.7
No. of HCWs with active TB disease	0	0	0	0	0	0	0	0

TST = tuberculin skin test; HCW = healthcare worker; INH = isoniazid; UK = unknown; NA = not applicable.
*Hospital 1: period 1 = September 1996–August 1997 and period 2 = September 1997–August 1998. Hospital 2: period 1 = January 1994–December 1994 and period 2 = January 1996–December 1996. Hospital 3: period 1 = July 1994–June 1995 and period 2 = July 1995–June 1996. Hospital 4: period 1 = May 1994–April 1995 and period 2 = May 1995–April 1996.
†HCWs seen at the facility, but who did not receive a chest radiograph as part of their medical evaluation.
‡Includes only those tested at the facility.

a TST program at these four hospitals in 1998 U.S. dollars ranged from $66,564 to $332,728 (Table 1); the cost of the TST program per HCW tested ranged from $41 to $362 for the two periods (Table 3) (Appendix, Note B).

The number of HCWs tested at the hospitals ranged from 184 to 5,770; the number of HCWs with documented TST conversions ranged from 0 to 27 (Table 2). Of the hospital HCWs tested, the percentage receiving TSTs that were not read ranged from 0% to 23%. The proportion of HCWs with a positive TST who received a follow-up evaluation—a symptom review and consultation with or without a chest radiograph—ranged from 56% to 100%. Among those HCWs who accepted isoniazid therapy, the percentage completing therapy ranged from 17% to 100%. The documented TST conversion rates among HCWs receiving TSTs at the hospitals ranged from 0.2% to 2.5%. No HCWs were diagnosed as having active TB disease during the two 12-month periods.

Health Departments

The results for the two participating health departments for the periods before and after implementation of *staffTRAK-TB* (between 1993 and 1998) are presented in Tables 3, 4, and 5. The annual cost of implementing and maintaining a TST program at these two health departments in 1998 U.S. dollars ranged from $92,886 to $291,248 (Table 4); the cost of the TST program per HCW tested ranged from $176 to $264 for the two periods (Table 3) (Appendix, Note B).

The number of HCWs tested at the health departments ranged from 454 to 1,102; the number of HCWs with documented TST conversions ranged from 0 to 10 (Table

TABLE 3
COSTS IN 1998 U.S. DOLLARS OF THE TUBERCULIN SKIN TEST PROGRAM PER HEALTHCARE WORKER TESTED IN THE HOSPITALS AND HEALTH DEPARTMENTS

Site	Period 1	Period 2	% Change
Hospital 1	$103	$133	+ 29
Hospital 2	$362	$342	- 6
Hospital 3	$41	$56	+ 37
Hospital 4	$223	$215	- 4
Health department 1	$205	$201	- 2
Health department 2	$176	$264	+ 50

5). Of the health department HCWs tested, the percentage receiving TSTs that were not read ranged from 0% to 6%. The proportion of HCWs with a positive TST who received a follow-up evaluation—a symptom review and consultation with or without a chest radiograph—ranged from 0% to 100%. The documented TST conversion rates among HCWs receiving TSTs at the health departments ranged from 0.2% to 0.9%. No HCWs were diagnosed as having active TB disease during the two 12-month periods.

Costs After the Implementation of staffTRAK-TB

After the implementation of *staffTRAK-TB*, all six study sites saw increases in personnel costs, which included costs for the TST program coordinator (if applicable), TST testers and readers, data entry staff, nurses and physicians involved in the TST program, and computer support staff (Tables 1 and 4).

Training and education costs decreased at the two health departments, but increased at the four hospitals. Training costs included the cost of educational materials for training those employees responsible for TST placement, reading, and management. Costs for analyzing data and creating reports decreased at four sites, although the number of HCWs tested increased at three of those sites. These costs were higher for two sites, but prior to the implementation of *staffTRAK-TB*, these sites neither analyzed their TST data nor created reports to indicate who was due or overdue for a TST or chest radiograph.

Administrative and material costs included the purchase of computers, printers, other supplies, and postage, and increased (as expected) for all six sites after the implementation of *staffTRAK-TB*. For the two periods, these costs ranged from $1,100 to $4,052 for the hospitals and $2,381 to $9,442 for the health departments (Tables 1 and 4).

After the implementation of *staffTRAK-TB*, the cost of the TST program per HCW decreased slightly for three facilities, but increased substantially for the other three facilities (Table 3). These cost variations may have been due to a noticeable increase or decrease in the number of HCWs tested, or total costs may have increased due to the purchase of computer hardware to support the implementation of *staffTRAK-TB* or to the more frequent generation of data analyses and reports in the second time period.

TABLE 4
COSTS IN 1998 U.S. DOLLARS OF IMPLEMENTING AND MAINTAINING A TUBERCULIN SKIN TEST PROGRAM IN THE HEALTH DEPARTMENTS

	Health Department 1		Health Department 2	
Cost*	Period 1	Period 2	Period 1	Period 2
Personnel	$71,304 (76.7%)	$74,295 (73.7%)	$22,012 (21.3%)	$251,911 (86.5%)
Training and education	$1,871 (2.0%)	$839 (0.8%)	$965 (0.9%)	$144 (0.1%)
TST supplies	$487 (0.5%)	$606 (0.6%)	$878 (0.9%)	$1,530 (0.5%)
Time taken off from work by HCWs†	$9,748 (10.5%)	$11,161 (11.1%)	$72,823 (70.6%)	$26,074 (9.0%)
Follow-up evaluation‡	$0 (0%)	$145 (0.1%)	$6,460 (6.3%)	$1,306 (0.4%)
Data analysis and reports	$5,369 (5.8%)	$4,067 (4.1%)	$0 (0%)	$841 (0.3%)
Administrative and materials	$2,381 (2.6%)	$7,855 (7.8%)	$0 (0%)	$9,442 (3.2%)
Other costs§	$1,726 (1.9%)	$1,800 (1.8%)	$0 (0%)	$0 (0%)
Total	$92,886	$100,768	$103,138	$291,248

TST = tuberculin skin test; HCW = healthcare worker.
*None of the health departments offered incentives.
†Time taken off from work by HCWs for TST placement and reading.
‡Follow-up evaluation for HCWs at the facility who had positive TSTs.
§Other costs for health department 1 included TST screening and follow-up for new hires who previously tested positive.

DISCUSSION

The cost of implementing and maintaining a TST program at the six sites during the two 12-month periods ranged from $66,564 to $332,728. The cost of the TST program per HCW tested ranged from $41 to $362 for the two periods. The average cost per TST performed at the four hospitals ranged from $37 to $362 in the first period and $52 to $228 in the second period (Appendix, Note C). In 1997, a study of five hospitals (four with and one without prior healthcare-associated multidrug-resistant TB transmission) by Kellerman et al. reported a cost range of $2,393 to $44,902 for a TST program in 1994 and a TST cost per HCW range of $4 to $13.[8] Another study by Kellerman et al. of two pediatric hospitals and one pediatric ward in a large tertiary-care hospital reported a cost range of $808 to $12,504 for a HCW TST program and a cost range of $7 to $12 per TST placed.[4]

Various factors contributed to the differences in total costs among the participating study sites and between the two 12-month periods for the same site. For example, at one site (health department 2), only newly hired HCWs were tested during the first period, but all HCWs were tested during the second period, which explains an almost threefold increase in the number of TSTs performed at this facility during the second period.

Also during the first period, new hires were tested elsewhere, which resulted in more time taken off from work for HCWs, making this cost category—at 71% of the total costs for health department 2—an exception to that of all of the other facilities. At another site (hospital 4), new HCWs receiving preemployment TSTs were tested during their own time, whereas employees receiving annual TSTs were tested during work hours (and allowed time off from work), which explains the large difference between the number of HCWs tested and the number taking time off from work for TSTs (1,251 vs 751 during the first period and 1,546 vs 345 during the second period). Another site (health department 1) only paid for the follow-up care of those HCWs with documented TST conversions.

In this study, we examined the costs associated with TST programs in hospitals and health departments. Personnel costs were the most dominant cost component for all sites but one, ranging from 21% to 97% of the total costs (this finding was consistent with the 1997 study by Kellerman et al.).[8] This substantial variation in personnel costs may have been due to the number of HCWs needed to administer each TST program in relation to the size of each site's HCW population, or to the wide variations in the cost of living among the six sites. Supply costs were clearly the least dominant at less than 1.5% for all sites. Administrative and material costs were higher during the second time period for all sites, owing to the purchase of computers, printers, and supplies for the use of *staffTRAK-TB* (Appendix, Note D). Thus, the major factors contributing to the costs of a TST program were personnel costs, time taken off from work by HCWs for TST placement and reading, and the training and education of HCWs.

The TST program cost per HCW in this study is much higher than that in each of the studies by Kellerman et al., given that the cost included many other components such as time taken off from work by HCWs, training and education, administration and materials, and data analysis and reports. Also, in this study, costs were incurred during 1-year periods ranging from 1993 to 1998, but were converted into 1998 U.S. dollars. In the 1997 study by Kellerman et al.,[8] TST program costs included only materials for TSTs, personnel time for placing and reading TSTs and counseling HCWs about positive and negative TST results, and performing and reading chest radiographs, all of which were incurred in 1994. In their 1999 study,[4] program costs included only TST supplies and personnel time to place and read TSTs and to counsel HCWs about TST results.

The CDC discourages tuberculin skin testing unless a plan has been developed to complete a course of treatment in individuals who have latent TB infection, including arrangements for a medical evaluation (eg, chest radiographs for individuals with positive TSTs) and for medical supervision of the course of treatment.[3] Regarding outcomes, only two hospitals and one health department provided follow-up care to all HCWs who had a positive TST. Treatment for latent TB infection is voluntary and is not a condition of employment. Among TST-positive HCWs who accepted isoniazid therapy initially, only 30% at the hospitals and 65% at the health departments completed the treatment. An analysis of methods to improve compliance with the treatment of latent TB infection is beyond the scope of this study but should be performed in hospitals and health departments.

In a previously referenced study, the rates of con-

TABLE 5
OUTCOMES OF THE TUBERCULIN SKIN TEST PROGRAM BEFORE AND AFTER THE IMPLEMENTATION OF *staffTRAK-TB* IN THE HEALTH DEPARTMENTS*

	Health Department 1		Health Department 2	
Outcome	**Period 1**	**Period 2**	**Period 1**	**Period 2**
No. of TSTs performed at the facility	513	605	586	1,418
No. of HCWs who received TSTs at the facility	454	501	585	1,102
No. of HCWs tested but not read	25	18	0	0
No. of HCWs who tested negative	417	468	296	1,038
No. of HCWs who tested positive	12	15	289	64
Among HCWs who tested positive				
No. of HCWs who received a chest radiograph	0	0	213	54
No. of HCWs who did not receive a chest radiograph†	0	0	76	10
No. of HCWs who were offered INH therapy	2	6	37	14
No. of HCWs who accepted INH therapy	0	5	32	12
No. of HCWs who completed INH therapy	0	5	22	5
No. of HCWs who received TSTs elsewhere‡	0	0	0	10
No. of HCWs with documented TST conversions§	0	1	3	10
TST conversion rate, %	NA	0.2	0.5	0.9
No. of HCWs with active TB disease	0	0	0	0

TST = tuberculin skin test; HCW = healthcare worker; NA = not applicable; INH = isoniazid; TB = tuberculosis.
*Health department 1: period 1 = April 1996–March 1997 and period 2 = April 1997–March 1998. Health department 2: period 1 = March 1993–March 1994 and period 2 = May 1995–May 1996.
†HCWs seen at the facility, but who did not receive a chest radiograph as part of their medical evaluation; or HCWs who received a chest radiograph outside of the facility, but had no appropriate documentation of it.
‡In period 1, new hires were tested elsewhere for health department 2, and are not included here.
§Includes only those tested at the facility.

version to a positive TST among HCWs at the study hospital ranged from 0.2% to 1.9% from 1968 to 1992 (Appendix, Note E).[5] At the participating hospitals in this study, the documented TST conversion rates among HCWs who received TSTs ranged from 0.2% to 2.5% (Appendix, Note F).

There were several limitations to this study. The benefit of *staffTRAK-TB* for tracking and identifying HCWs needing TSTs could not be determined because no information was available on how the sites analyzed their TST data prior to *staffTRAK-TB*.[2] The percentage of the target of HCWs tested was intended to be 100% because the sites were funded for this project on the basis that they would include all eligible HCWs in their TST program, but this could not be verified because the denominator data were not available. Total costs were underestimated because of the lack of costs for follow-up care and treatment, as this study captured costs only up to the point of diagnosis and evaluation for active TB disease or latent TB infection.

Data were also not available on whether (1) TST conversions may have been boosted reactions; (2) HCW exposure to environmental mycobacteria, which varies by geographic region, was possible; or (3) HCWs not born in the United States had received bacille Calmette–Guérin vaccinations. These important factors may influence the accuracy, effectiveness, and cost of a TST program. In addition, the cost of a TST program may increase as the proportion of HCWs from countries with high risk for TB increases, the proportion of HCWs who are newly hired increases, or the facility experiences greater HCW turnover.

The *staffTRAK-TB* software was to be piloted for a finite time period; however, several of the sites originally funded for this project continue to use the software to track and monitor TST data for their HCWs. Given that it is a practical and user-friendly tool, more than 70 additional healthcare providers in the United States and other countries, including Australia, New Zealand, Peru, Puerto Rico, Saudi Arabia, and Thailand, have requested and received the software. Because *staffTRAK-TB* was a demonstration project and data from the participating sites indicated low rates of TST conversions among HCWs, funding for the project was discontinued in 1995. However, several copies of the software and manual are still available for use from the corresponding author, although the CDC is unable to provide technical assistance for the software.

Compliance with the CDC guidelines regarding TB infection control may require a substantial investment in personnel time, effort, and commitment. Future studies should focus on identifying the most cost-effective measures for TB infection control in different healthcare settings.

APPENDIX

Notes

A. In the 1994 Centers for Disease Control and Prevention guidelines, a TST conversion is defined as a 10-mm or more increase in the size of the induration within a 2-year period for individuals younger than 35 years, and an increase of 15 mm or more within a 2-year period for individuals 35 years or older. A conversion within a 2-year period is usually interpreted as new *M. tuberculosis* infection, which carries an increased risk for progression to active disease. Two-step baseline TSTs were performed at all sites except one (health department 2), and each step was counted as one TST.

B. The cost of the TST program per HCW tested is calculated as the total cost divided by the number of HCWs who received at least one TST at the facility. The total cost includes all cost components for those who received TSTs at the facility. Hospitals 2 and 3 and health department 2 reported that 32 (6.8%), 308 (3.1%), and 10 (0.6%) of the HCWs received TSTs elsewhere, respectively. For those HCWs, only the costs of "HCWs' time off from work for TST placement and reading" were incurred by the facility.

C. This is the average cost per TST performed at a hospital, and was obtained by dividing its total program costs for a single period by the number of TSTs performed during that time period.

D. Because the computers and printers for *staffTRAK-TB* provided services beyond the second time period, including their costs may have overestimated total costs for that time period to some extent.

E. The definition of TST conversion in the study by Adal et al.[5] is different. A conversion was defined as a newly positive TST with an induration of 10 mm or more at 48 to 72 hours.

F. These rates may not reflect "true" TST conversion rates because the data do not allow us to separate out positive test results due to true conversion or the booster phenomenon.

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