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Randy L. Tubbs, Ph.D.
Douglas Trout, MD, MHS

PREFACE

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Randy L. Tubbs, Ph.D.
Douglas Trout, MD, MHS

SUMMARY

In September 1992, the National Institute for Occupational Safety and Health received a request for a health hazard evaluation from the Florida Department of Health and Rehabilitative Services regarding the occupational transmission of tuberculosis among employees working in laboratories where clinical specimens were processed. The request specifically involved the laboratories in Miami, Jacksonville, and West Palm Beach which provide diagnostic and reference laboratory services for the state of Florida. The tuberculin skin testing programs at the West Palm Beach Laboratory, the Miami Laboratory, and the Jacksonville Laboratory were evaluated, as were the heating, ventilating, and air conditioning systems at the first two laboratories. The ventilation system at the last facility was not inspected because the new building housing the laboratory was being commissioned during the time that a site visit was made in Jacksonville.

Ninety-five laboratory employees were identified at the three facilities. Fifty-six (59%) employees were excluded from further evaluation because they had either converted to a positive tuberculin skin test prior to 1985 or had insufficient testing. Thirty-nine (41%) employees met our criteria to participate in the evaluation of tuberculin skin test conversion rates, i.e., were currently employed at the laboratories, had a negative skin test at their time of hire, and had received follow-up testing after the initial skin test. Nine persons (23%) had documented convertions from a negative to a positive skin test between March 1989 and September 1992. An odds ratio of 1.06 showed that performing "TB work" was not associated with an increased risk of tuberculin skin test conversion. The ventilation system evaluations found many CDC recommended controls in use at the two facilities.

Workers performing laboratory and clerical work with viable *Mycobacterium tuberculosis* specimens may be at increased risk of becoming infected with TB while performing their job. With the employees using personal recall (in part) to document TST conversions, this study found that 9 of 39 persons employed in these laboratories converted from a negative to a positive tuberculin skin test over an eight-year period. However, the limitations of the study make it difficult to draw any definitive conclusions regarding the risk of occupational transmission of TB among the employees at these laboratories. It is imperative that the Office of Laboratory Services follow current CDC recommendations for handling TB samples. Recommendations are offered in the report to reduce the risk of occupational transmission of TB and to improve the working environment for the employees.

Keywords: SIC 8071 (Medical Laboratories), tuberculosis, TB, *Mycobacterium tuberculosis*, laboratory-acquired infections, skin testing, ventilation.

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INTRODUCTION

In September 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the Florida Department of Health and Rehabilitative Services (HRS) regarding the occupational transmission of tuberculosis (TB) among State employees working in laboratories where clinical specimens were processed. The HHE request focused on the three HRS laboratories (Miami, Jacksonville, and West Palm Beach) that provide diagnostic and reference laboratory services related to TB for the state of Florida, and specifically concerned those employees working with sputum samples.

The tuberculin skin testing (TST) programs at the West Palm Beach Laboratory, the Miami Laboratory, and the Jacksonville Laboratory were evaluated, as were the ventilation systems at the first two laboratories. The ventilation system at the latter facility was not inspected because the new building housing the laboratory was being commissioned during the time that a site visit was made in Jacksonville. The preliminary results of the ventilation inspection and any noted deficiencies in work practices were given to laboratory officials during the site visits. The initial findings of the TST program review were sent to the individual laboratories in March 1993.

BACKGROUND

Among the 34,000 sputum specimens processed for smear and culture in the three HRS laboratories during 1991, 3500 were positive for TB. The Jacksonville Laboratory received 2500 positive sputum samples for species indentification. The bacterium *Mycobacterium tuberculosis (Mtb*), the cause of most TB, is known to survive heat-fixed smears and may also be aerosolized during the manipulation of liquid cultures. A 1957 study has shown that laboratory workers working with *Mtb* have an increased rate of infection compared to other laboratory workers.[1] Given the fact that the number of reported TB cases in the United States increased 14% between 1985 and 1993, this HHE provided NIOSH with an opportunity to evaluate the potential for the occupational transmission of TB among these laboratory workers by determining the rate of TB infection among workers in the three laboratories, and to determine risk factors for infection.[2]

METHODS

Site visits were conducted at each of the HRS laboratories in the latter part of 1992. Confidential discussions were held with the workers who worked with *Mtb* samples at the laboratories, and appropriate personnel and medical records were reviewed by NIOSH investigators. In addition, the TB control programs were reviewed in detail at each facility. During two of the site visits, NIOSH investigators performed an industrial hygiene survey, including observation of work practices and measurements of a number of ventilation parameters.

To determine the rate of TB infection among the workers, NIOSH investigators evaluated the TST conversion rate among workers who met the following criteria: 1) currently employed at the laboratory; 2) had a known negative TST at the time of hire, or in 1985, whichever was later; and 3) had at least one follow-up TST three months or more after the initial TST. The starting time of 1985 was chosen because laboratory facility changes occurred at that time and because 1985 marks the early phase of the resurgence of reported TB cases in the United States.[2] Data were available through September 1992. Odds ratios (OR) were used to estimate the risk of TST conversion among employees working with *Mtb* specimens compared to the risk of employees who did not handle these kind of samples. The OR's were calculated with the Epi Info® statistical software package.[3]

The medical evaluation also included a review of employee health records to ascertain the quality of information recorded pertaining to the employee tuberculosis surveillance program. Records of

employees fitting three categories were reviewed: all employees with a reported work-related purified protein derivative (PPD) tuberculin skin test conversion from negative to positive since 1984 (21 total), all employees with a reported needlestick or related injury (13 total), and six randomly selected records. Additional sources of information included the summaries of each employee's initial physical examination and TST results.

The environmental evaluation included airflow measurements made with a Shortridge Instruments, Inc. FlowHood® Model CFM 88. Using this instrument, airflow through a supply diffuser or exhaust grille can be measured directly in cubic feet per meter (cfm). Smoke tests were conducted to evaluate (by visual observation) the relative pressures of the lab rooms with respect to the corridor. Temperature and relative humidity (RH) measurements were made with a Vaisala HM34 Humidity and Temperature meter.

EVALUATION CRITERIA

For aerosols containing *Mtb*, there is an increased risk to employees who manipulate cultures or specimens of *Mtb* of becoming infected from the tubercle bacilli.[4,5] Any airborne concentration of *Mtb* is assumed to present some risk of infection.[6,7] Recommendations for biosafety in microbiological laboratories are provided in the Centers for Disease Control and Prevention (CDC) and the National Institutes of Health (NIH) document: Biosafety in Microbiological and Biomedical Laboratories (BMBL).[8] Specific guidelines for handling *Mtb* in laboratories are described in a proposed Morbidity and Mortality Weekly Report (MMWR) Recommendation and Report which is expected to be published in late spring or early summer of 1997.[9] For laboratories which are handling concentrated cultures of *Mtb* and testing for drug susceptibility, a Biosafety Level (BSL) 3 laboratory is recommended. CDC and NIH have recommended a hierarchy of controls to prevent TB transmission in mycobacteriology laboratories. Listed in the order of importance, they include: (1) safe work practices, (2) use of containment equipment, and (3) specially-designed laboratory facilities. Utilizing a combination of these methods should reduce exposures to *Mtb*. These control measures are discussed below.

Hierarchy of Control Measures

Safe Work Practices

Personnel working in laboratories must receive training in laboratory procedures (e.g., use of safety equipment, decontamination procedures, clean-up of spills, use of an autoclave, and waste disposal). The laboratory door should be kept closed at all times during the processing of samples. All activities involving potentially infectious materials must be conducted inside a biological safety cabinet (BSC). The laboratory should also prepare a biosafety manual which identifies hazards associated with processing specimens containing *Mtb* and recommends procedures to minimize or eliminate the risks which are involved with these procedures.

Personnel should enter the laboratory only after they have been advised of the potential hazards related to *Mtb*. A biohazard warning sign should be posted on the door of the TB laboratory and should include the following information: contact person in case of an emergency, the identity of the infectious organisms present in the laboratory, requirements for the use of personal protective clothing, and any special entry requirements such as tuberculin skin testing.

To minimize the transmission of *Mtb*, early identification and treatment of infected employees, both with and without active disease, is necessary. New employees should receive a tuberculin skin test during their pre-placement physical. Screening for the identification of individuals with tuberculous infection is accomplished using the PPD tuberculin skin test (Mantoux test). There are standardized guidelines for interpreting the results of this test.[10] A "two-step" test procedure to detect boosting phenomena is recommended by CDC for the initial TST administered to a person being enrolled in a

tuberculosis surveillance system. If the first test is negative, a second TST is given one week later. If the second test is also negative, the person is considered to be free of *Mtb* infection and can then be enrolled in the periodic screening program (they need only receive a single TST at each subsequent periodic screening). Routine chest radiographs are not required for asymptomatic, PPD-negative workers. A formal employee tuberculin screening and follow-up program should be established in accordance with current CDC guidelines.[10]

In addition to identifying individuals for whom prophylactic treatment is appropriate, routine screening can also serve as a surveillance tool to identify areas where there may be an increased risk of tuberculosis transmission. If a person with a previously negative TST converts to positive, the test should be followed by a chest x-ray to determine whether active TB has developed.[10] Results of PPD skin testing should be recorded in individual employee health records, as well as in a central file for all PPD test results.

Containment Equipment

Activities which have been shown to produce aerosols in the mycobacteriology laboratory are listed in Table 1, along with recommended precautionary measures to minimize the production of aerosols.[11] All culture tube samples should be sealed tightly and placed in centrifuge safety cups (safety carriers) within the BSC. Following centrifugation, the safety cups should be transported to the BSC before opening them. The O-rings on the safety cups should be inspected frequently to ensure that there is an adequate seal. All contaminated supplies should be placed in a leak-proof biohazard container and then placed in an autoclave container before removal from the BSC.

Biological safety cabinets are enclosed work stations intended to protect both the worker and the biological specimen from contamination. According to the agent summary statement in the BMBL, a Class II BSC should be used when working with *Mtb*. Class II cabinets are designed to operate with an inward flow velocity of 75 - 100 linear feet per minute (lfpm) depending on the type (A or B) of BSC. Air is drawn across the cabinet face opening to prevent the escape of microorganisms. Another air stream is directed through a high efficiency particulate air (HEPA) filter and moves over the specimens to protect them from external airborne contamination. All air which is exhausted passes through a HEPA filter to protect the environment and to minimize the potential for re-entrainment of infectious aerosols. A listing of appropriately designed Class II BSCs, as well as performance standards are available from the National Sanitation Foundation International Standard 49.[12] The BSC should be certified at least annually, and more often if the cabinet is moved to another location or if there are changes to the room's ventilation system. Employees should receive training on the appropriate use of the BSC which should address actions or behaviors that could disturb the airflow patterns within the cabinet and/or at the face of the cabinet.

Protective clothing should be worn to provide an additional measure of personal protection. Protective laboratory clothing, such as solid-front gowns, should be worn in the laboratory and decontaminated before being laundered. Laboratory gowns protect against splatter and minimize the back-flow of cabinet air that may travel along the arms of the worker. Gloves should be worn when handling infectious materials.

Since no BSC is 100% effective and both physical and mechanical failures do occur, the use of respiratory protection is recommended by the CDC.[10] Although the CDC guidelines were based primarily on protecting workers from patients with TB, they are also applicable to protecting microbiologists from specimens containing *Mtb*, which may become aerosolized during laboratory procedures. A variety of manipulations of fluid suspensions of cultured *Mtb* in the laboratory produce aerosols in the same size range as an aerosol produced by coughing. Since the CDC recommendations were issued, the NIOSH procedures for certification of respirators have been revised.[13] The revised guidelines for certification of air-purifying respirators enable users

to select from a broader range of certified models that meet the performance criteria. NIOSH certifies three classes of filters, designated as the N-, R-, and P-series, using newly available particulate filter tests. Each series contains three levels of filter efficiency, 95%, 99%, and 99.7%, respectively. All classification tests of the filter employ the most penetrating aerosol size (i.e., 0.3 micron (µm) aerodynamic mass median diameter). The N-series of respirators are tested against an aerosol of sodium chloride (NaCl) and the R- and P-series filters are tested against an aerosol of dioctylphalate (DOP). For use in laboratory settings, currently available HEPA-filtered respirators or any respirators that are certified by NIOSH under the 42 Code of Federal Regulations, Part 84 are recommended. Surgical masks are not NIOSH certified respirators and should not be worn for respiratory protection.

Whenever respirators are offered to employees, a complete respirator program must be implemented that meets the requirements of the OSHA respiratory protection standard (29 Code of Federal Regulations 1910.134).[14] The minimum requirements for a respiratory protection program include the following components: written standard operating procedures, user instruction and training, cleaning and disinfection, storage, inspection, surveillance of work area conditions, evaluation of the respirator protection program, medical evaluation of users, and use of certified respirators.

Laboratory Facilities

BSL 3 laboratories have specific building design criteria as well as ventilation requirements. Personnel access to the laboratory should be through two doors with an air space between them (i.e., anteroom). To accommodate decontamination procedures, interior surfaces of walls, floors and ceilings should be sealed, and bench tops should be impervious to water and resistant to acids, alkalis, organic solvents, and moderate heat. Other design criteria include foot-operated hand washing facilities, automatic door closures, sealed utility penetrations and windows, and an autoclave.

General ventilation reduces the concentration of contaminants through dilution and removal of contaminated room air. The supply air should typically pass through a filter bed containing 35 to 60 percent efficient filters as a minimum (according to the ASHRAE estimated dust spot efficiency test).[15] A "single pass" system theoretically exhausts all room air to the outside. Exhaust air from the laboratory should be discharged to the outside through a HEPA filter. The outside exhaust must be directed away from occupied areas and air intakes.

Ventilation rates are frequently expressed in terms of air changes per hour (ACH). An ACH is defined as the theoretical ratio of the ventilation rate (volume of air entering the room per hour) to the room volume, assuming perfect mixing. Ideally, 6 to 12 ACH should be provided so that up to 99% of the airborne particulate matter will be removed per hour.[16] This is particularly important in the event that a major aerosol is generated outside the BSC, since personnel will then be able to estimate the amount of time which is needed before they can safely re-enter the laboratory to disinfect the area.

In addition to supplying the specified airflow, ventilation systems should also provide satisfactory airflow patterns both from area to area and within each room. Airflow should be from "clean" to "less clean" areas. This can be accomplished by creating a negative pressure in the area into which flow is desired relative to adjacent areas. Negative pressure is attained by exhausting more air from the area than is being supplied. The laboratory should be kept under negative pressure, relative to adjacent areas, at all times regardless of the operational status of the BSC.

The state of Florida, Agency for Health Care Administration has its own ventilation requirements for hospital licensure for laboratories in new hospitals and laboratories that are being remodeled.[17] Six ACH, with two of the six air changes being outside air, are the minimum ventilation requirements. The laboratories must have a pressure gradient that is negative in relationship to the adjacent areas. The air can be recirculated to the

laboratory but not to other parts of the hospital, except for Bacteriology and Histology labs which must exhaust 100% of the air. Variable air volume systems are not permitted in sensitive areas which include laboratories. Existing, nonconforming systems need not be brought into compliance with these ventilation requirements except when remodeling, but the facility should strive for compliance whenever equipment is replaced.

Employee Medical Monitoring

One purpose of a PPD skin testing program is to identify individuals who have recently become infected with *Mtb*. It may be appropriate to treat newly infected individuals prophylactically with medication to reduce their likelihood of progressing to active tuberculosis. Because there are side effects and medical contraindications included with chemoprophylaxis (anti-TB drug treatment), the appropriateness of treatment must be assessed on an individual, clinical basis.[18] Without chemoprophylaxis, approximately 5%-10% of persons develop active disease within 2 years of the primary infection.

The TST programs in the occupational setting have a dual purpose. As discussed above, they identify recently infected persons who may be evaluated for active TB and then receive chemoprophylaxis or treatment, as appropriate. Additionally, work-based testing programs serve as a surveillance function, identifying trends of infection among the workers. Identification of trends can lead to action preventing infection in other workers. The capability of a program to serve as a surveillance system largely depends on the adherence to an appropriate protocol, as well as conscientious maintenance of records. The CDC has published guidelines for the implementation of TST programs.[10]

RESULTS

Although TB control programs were in place at all three locations, there were marked variations among the programs. For example, the facilities had different policies on which employees received a TST, the time intervals between TSTs, who administered the TSTs, how the results were documented, and how the records were maintained. Participation in the TST program was voluntary at all locations. Employees at the three locations were wearing protective clothing and respiratory protection while working with TB samples. The respirators worn by the employees in TB laboratories were disposable, single-use, dust and mist particulate respirators. Good adherence to the respirator-use policy was seen during the site visits.

Ninety-five laboratory employees were identified at the three facilities. This included all employees at the Miami and West Palm Beach facilities, and all employees on the same floor as the TB laboratory at the Jacksonville facility. Because the employees at each of the facilities performed similar work duties, the data were analyzed as one group. Fifty-six (59%) employees were excluded from further evaluation because they had either converted to a positive tuberculin skin test prior to 1985 or had insufficient testing. Thirty-nine (41%) employees met our criteria to participate in the evaluation of tuberculin skin test conversion rates, i.e., were currently employed at the laboratories, had a negative skin test at their time of hire, and had received follow-up testing after the initial skin test. These 39 individuals, including 31 laboratory employees and 8 clerical workers, were classified into two groups ("TB work" [30 employees] versus "non-TB work"[9 employees]) dependent upon whether their job involved potential exposure to sputum and/or TB cultures (Table 2). An example of a clerical task involving potential exposure to TB is an employee logging in newly received specimens while sitting in a TB lab room. There were no significant demographic differences between workers in the two groups (Table 3).

From the medical records review and the discussions with the employees, it was determined that nine persons converted from a negative to a positive TST between March 1989 and September 1992, yielding an overall crude conversion rate of 23%. Performing "TB work" was not associated with an increased risk of TST conversion (odds ratio [OR]=1.06; 95%

confidence intervals [CI]=0.15-12.79) (Table 4). All TST conversions occurred among laboratory employees. When the laboratory employees were evaluated alone, performing "TB work" was again not associated with an increased risk of TST conversion (OR=0.78; CI=0.09-10.53) (Table 5).

The West Palm Beach Laboratory is a one-story building that houses only the laboratories and support services. Two recirculating HVAC systems supply the majority of the ventilation to the building. Additional conditioning of the air is provided by fan coil units installed at the ceiling in many of the laboratories. Biological safety cabinets and exhaust fans are located in several rooms. Inspection of the mechanical room revealed a torn connection in one air handling unit's duct upstream from the filter bank. The filters had been recently changed. A broken magnehelic gauge that measured the pressure drop across the filters was discovered during the visit. In the TB laboratory, an open metal cover over the return air grille was observed in the outer lab. This cover was to be closed by the employees in the case of an accidental spill.

The Miami Laboratory is located on the second floor of an office building. The first floor of the building serves as a public health clinic and reception area. Other clinics are housed in separate buildings that are connected by a covered breezeway. The air-handling system for the laboratory is located in a second floor mechanical room. It also uses recirculated air in a variable-air volume system. An electronic air filter was added to the air handlers to increase the efficiency of the air filtration. Inspection of the mechanical room of this facility revealed clean filters and no noticeable damage to any of the air handlers.

Several ventilation parameters were measured at the West Palm Beach and Miami laboratories. The results are summarized in Table 6 (West Palm Beach) and Table 7 (Miami). The calculated air changes per hour were consistently higher at the West Palm Beach Laboratory, ranging from 185 to 14 ACH, than at the Miami Laboratory, ranging from 18 to 5 ACH. The TB areas in each of the laboratory facilities had air changes in excess of 15 ACH. Temperature and relative humidity measurements were between 69°F to 76°F and 56% to 76%, respectively, at the West Palm Beach facility and from 71°F to 75°F and 55% to 62% at the Miami location.

DISCUSSION

There are several limitations to our evaluation of TST conversions among employees, including: 1) although the demographic characteristics evaluated were similar between the two groups, other potential markers for potential exposure to TB outside the workplace (such as socioeconomic status and place of residence) were not evaluated; 2) because of inadequate record-keeping, NIOSH investigators had to rely to a great extent on personal recall of the TST status and job history of workers; and 3) the distinction made between those workers performing "TB work" and "non-TB work" may have been an inadequate marker of potential exposure to *Mtb*. For example, laboratory and clerical workers handling non-sputum specimens, such as urine or cerebrospinal fluid, considered here as "non-TB work," may have been exposed to *Mtb*. It is known that *Mtb* may be present in these fluids. It is striking that of six laboratory employees in the "non-TB work" group, two converted.

The ventilation evaluation at the Miami and West Palm Beach Laboratories found many of the controls recommended by the CDC in use at the facilities. However, a few deficiencies in the TB controls were observed. The torn duct and broken magnehelic gauge were an indication that a preventative maintenance program is needed at the West Palm Beach Laboratory. The practice at the lab was to call a contract mechanical service whenever the HVAC system malfunctioned. This responsibility fell on the laboratory workers, the laboratory director, or a volunteer maintenance person. Because these individuals are not trained in the technical aspects of ventilation, it is not surprising that breakdowns occur in the system and are overlooked.

The practice of having a laboratory employee close a metal hatch over the return air duct in the TB labs' receiving area at the West Palm Beach Laboratory needs to be changed. In the event of an accidental spill of a TB sample, there may be a sufficient time delay for aerosolized *Mtb* to get into the return air duct and contaminate the entire system. The metal door is not easily accessible (it is in the ceiling with no fixed ladder in place) and could be forgotten in the confusion of an evacuation of the laboratory.

The Miami Laboratory's variable air volume air handling system should be phased out according to the State of Florida's Hospital Licensure regulations. When the HVAC system needs to be replaced, current regulations and guidelines should be consulted before contracting for a new air handling system. The use of electronic air cleaners, in place of HEPA filtration, needs further evaluation to insure that the criteria for air filtration in TB laboratories are not compromised.

CONCLUSIONS

Due to potential exposure to specimens containing viable *M. tuberculosis*, workers performing laboratory and clerical work at the HRS Laboratories may be at increased risk of becoming infected with TB while performing their job. Using employees' personal recall, in part, to determine TST conversions, this study found that 9 of 39 persons employed in these laboratories converted from a negative to a positive TST over an eight-year period. However, the limitations of the study make it difficult to draw any definitive conclusions regarding the risk of occupational transmission of TB among the HRS employees at these laboratories. It is imperative that the HRS Office of Laboratory Services follow current CDC recommendations for handling TB samples.

RECOMMENDATIONS

Based on the industrial hygiene measurements and observations, and the evaluation of the TST program at the three HRS laboratories, NIOSH investigators offer the following recommendations to lower the risk of occupational transmission of TB to employees at these laboratories and to improve the environment in which they work. Most of these recommendations have been relayed to laboratory management in closing conferences and a previous letter.

1. The Florida Department of Health and Rehabilitative Services should continue to identify those employees who have jobs that involve potential exposure to *Mtb* and should continue to perform training and educational activities related to TB for these employees. Personnel who handle other biological specimens (such as blood and urine) or who are exposed to waste materials (e.g., autoclave workers), need to be included in the program because of the potential for exposure to *Mtb*.

2. A continuing TST program should be available to all Florida Department of Health and Rehabilitative Services employees who have potential exposure to *Mtb*. Employee health personnel at each of the sites should be consulted to develop a formal, written program for the employees. This TST program should follow CDC guidelines.[10,18,19] Records should be maintained in an adequate manner, such as in a central card file, to allow appropriate evaluation of each worker's TST status.

3. Employees who leave the laboratory need to be aware that a PPD skin test done immediately prior to leaving may not reflect recent infection by *Mtb*. The employee should be given a final TST three months after termination to rule out an occupational transmission of the disease.

4. The respirators used by employees in the laboratories should meet the NIOSH respirator criteria for N-95 respirators, at a minimum. The dust and mist single-use respirators seen in use during the evaluation have not been certified by NIOSH as meeting these minimum requirements. A listing of the certified respirators is available through the NIOSH homepage on the Internet at the address: http://www.cdc.gov/niosh/homepage.html. A supply

of respirators should be available at the entrance door of the TB laboratories so that employees may don the respirator before entering the laboratory.

5. The laboratories should hire a maintenance person who is well versed in the operation of the ventilation systems rather than depend on the laboratory employees or laboratory director to notice malfunctions of the equipment. If this is not possible, the ventilation contract should stipulate that the contractor make routine, frequent visits to the laboratory to check on the operation of the air handling equipment rather than waiting until called by the laboratory when the system has obviously failed.

6. A new procedure for accidental spills at the West Palm Beach Laboratory should be developed to replace the manual closing of the exhaust vent grille. This could include a different way to close off the return with a motorized damper or a change in the system to exhaust all room air from the TB laboratory to the outside.

7. A routine maintenance schedule needs to be put into place to prevent problems such as the torn duct or the broken magnehelic gauge. The time frames for the schedule can be determined with the help of the ventilation contractor.

8. A number of ceiling tiles at the West Palm Beach Laboratory were observed to have been damaged from water leaks. The source of these leaks needs to be discovered and rectified. Damaged tiles need to be replaced as soon as they are noticed so that microbial growth will not contaminate the laboratory.

REFERENCES

1. Reid DD [1957]. Incidence of tuberculosis among workers in medical laboratories. Brit Med J 2:10-14.

2. CDC [1995]. Essential components of a tuberculosis prevention and control program: Recommendations of the advisory council for the elimination of tuberculosis. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention. MMWR 44, No. RR-11, September 8, 1995.

3. Dean AG, Dean JA, Burton AH, Dicker RC [1990]. Epi Info Version 5: A word processing, database, and statistics program for epidemiology on microcomputers. Centers for Disease Control and Prevention, Atlanta, GA.

4. Riley RL [1957]. Aerial dissemination of pulmonary tuberculosis. Am Rev Tuberc 76:931-941.

5. Riley RL [1961]. Airborne pulmonary tuberculosis. Bacteriol Rev 25:243-248.

6. Nardell EA [1990]. Dodging droplet nuclei: Reducing the probability of nosocomial tuberculosis transmission in the AIDS era. Am Rev Respir Dis 142:501-503.

7. Broom BR, Murray CJL [1992]. Tuberculosis: Commentary on a reemergent killer. Science 257:1055-1064.

8. CDC and NIH [1993]. Biosafety in microbiological and biomedical laboratories, 3rd ed. U.S. Government Printing Office. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, and National Institutes of Health. DHHS Publication No. (CDC) 93-8395.

9. CDC [1997]. Working safely with *Mycobacterium tuberculosis* complex species in clinical, research, and public health laboratories. MMWR Morb Mortal Wkly Rep, in press.

10. CDC [1994]. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health-care facilities, 1994. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and

Prevention. MMWR 43, No. RR-13, October 28, 1994.

11. Gilchrist MJR, Hindler J, Fleming DO [1994]. Laboratory safety management update: Aerosol borne microorganisms. In: Isenberg HD, ed. Clinical Microbiology Procedures Handbook. Washington, D.C.: American Society for Microbiology Press, Supplement #1.

12. NSF [1983]. Class II (Laminar Flow) Biohazard Cabinetry. National Sanitation Foundation Standard 49. Ann Arbor, Michigan.

13. DHHS [1995]. Respiratory protection devices: Final rules and notice. Department of Health and Human Services, Public Health Service, 42 CFR part 85. Federal Register 60:30335-30398.

14. Code of Federal Regulations [1992]. OSHA respiratory protection standard. 29 CFR 1910.134. Washington, DC: U.S. Government Printing Office, Federal Register.

15. ASHRAE [1991]. Health facilities. In: ASHRAE Applications Handbook. Atlanta, GA: American Society for Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), Chapter 7.

16. Kent PT, Kubica GP [1985]. Public health mycobacteriology: A guide for the level III laboratory. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control.

17. AHCA [1995]. Hospital licensure: Heating, ventilating and air conditioning systems. 59A-3.086. Tallahassee, FL: Agency for Health Care Administration, Licensure and Certification Program, Chapter 59A-3.

18. CDC [1990]. The use of preventative therapy for tuberculosis infection in the United States. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control. MMWR 39, No. RR-8, May 18, 1990.

19. CDC and ATS [1991]. Core curriculum on tuberculosis, 2nd ed. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, and New York, NY: American Thoracic Society, DHHS Publication No. 00-5763, April 1, 1991.

Table 1 (page 1 of 2)

Aerosols Producing Procedures in the Mycobacteriology Laboratory

Activity	Precautionary measures to minimize aerosol production[a]
Centrifuging (primary specimens for digestion and decontamination and broth cultures of AFB[b])	Place test material in culture tube, seal tightly, and place in centrifuge safety carriers, which must also be tightly sealed before centrifugation. Following centrifugation, transport sealed centrifuge safety carriers to BSC before opening. Inspect surface of culture tubes for leakage, and disinfect tubes and safety carriers if there is any evidence of contamination. Examine safety carrier O-rings regularly to make certain they support adequate seal; replace when necessary. Some BSCs are constructed with built-in centrifuge. Avoid placing centrifuge in BSC until safety engineer ensures that BSC can accommodate particular centrifuge safely without disturbing air currents. Centrifuge safety carriers may not be necessary if centrifugation is performed within BSC. Do not assume that so-called aerosol-proof tubes (particularly microcentrifuge tubes) will protect against any possibility of M. tuberculosis aerosols being produced during centrifugation unless manufacturer makes this specific claim.
Vortexing	Vortex tightly sealed tubes only. After mixing, invert tube slowly so that air in tube mixes with fluid to resorb aerosolized particles. Allow tube to stand for 30 min. before opening.
Pipetting (includes transferring liquid via syringe)	Pipette over disinfectant-soaked towel to catch any fallen drops that might subdivide on impact and produce aerosols. Do not blow out pipette. Immerse used pipettes in disinfectant, or place in discard container that is tightly sealed before being removed from BSC.
Preparing smears	Allow smear to air dry and then heat fix by placing slides on a 65-75°C heat block for at least 2 hr, passing slide through Bunsen burner flame several times, or placing slide on microincinerator retrofitted for heat fixing slides for 30 min or more. To further eliminate viable organisms, complete phenol-based staining before removing slides from BSC.

Table 1 (page 2 of 2)

Subculturing colonies to agar medium	Sterilize loops in safety microincinerator or remove AFB from loop by placing loop in phenol-sand trap before incineration in flame. Immerse disposable loops in disinfectant, or place in bag. Place each bag in secondary container that is sealed before being removed from BSC.
Sonicating	Conduct in BSC even if closed container is used to prevent sonicating (and aerosolizing) organisms that may be on external surfaces and to offer protection from aerosols that may form from tubes that accidentally open.
Removing cultures for discard from BSC	Seal plates and tubes containing viable M. tuberculosis or M. bovis with aerosol-proof seal, and place in autoclave containerc prior to removal from BSC for transport to autoclave. Autoclave all M. tuberculosis and M. bovis cultures before removing them from immediate laboratory area.
Removing contaminated supplies (e.g., disposable loops, sticks, swabs, etc.)	Place all contaminated items in biohazard bag, seal, and place in autoclave container[c] before removing it from BSC. If item has already been submersed in disinfectant, seal container before removal from BSC.
Blending	Blending is not recommended for clinical laboratories, primarily because large specimen volumes are needed. Do blending only in special containment blenders or total-containment BSC.

a All activities must be performed in a BSC. These procedures are primarily for the mycobacterial laboratory but can be applied to any specimen submitted for microbiological analysis.

b AFB, acid-fast bacteria.

c Autoclave container may be any container (e.g., stainless steel pan with lid) that can be sealed to afford aerosol containment during transport to the autoclave and allows efficient sterilization of contents during the autoclaving cycle.

Table 2
HRS Office of Laboratory Services
HETA 92-0377

Job Task and TB Exposure

	TB Work	Non-TB Work	Total
Clerical Worker	5	3	8
Laboratory Worker	25	6	31
Total	30	9	39

Table 3
HRS Office of Laboratory Services
HETA 92-0377

Demographic Characteristics of Workers Meeting Eligibility Criteria

	TB Work (N=30)	Non-TB Work (N=9)
Female (%)	80	67
Hispanic (%)	27	33
Age (Mean)	40	47
Months Employed (Mean)	49	66

Table 4
HRS Office of Laboratory Services
HETA 92-0377

TB Work and TST Conversion

	TB Work*	**Non-TB Work**	**Total**
TST Positive	7	2	9
TST Negative	23	7	30
Total	30	9	39

* Odds ratio (95% Confidence Interval)= 1.06 (0.15-12.79)

Table 5
HRS Office of Laboratory Services
HETA 92-0377

TB Work and TST Conversion Among Laboratorians

	TB Work*	**Non-TB Work**	**Total**
TST Positive	7	2	9
TST Negative	18	4	22
Total	25	6	31

* Odds ratio (95% Confidence Interval)= 0.78 (0.09-10.53)

Table 6 (Page 1 of 2)
Ventilation and Environmental Results at
West Palm Beach Laboratory
HRS Office of Laboratory Services
HETA 92-0377
June 16, 1992

LOCATION	TEMPERATURE [°F]	RELATIVE HUMIDITY	SUPPLY AIR VOLUME	EXHAUST AIR VOLUME	AIR CHANGES PER HOUR
TB Laboratory					
Outer Laboratory	69°	70%	183 cfm 163 cfm	325 cfm	16.0 ACH
Innoculation Room	70°	71%	414 cfm 358 cfm	415 cfm* 343 cfm*	42.9 ACH
Centrifuge Room	---	---	665 cfm	700 cfm*	184.7 ACH
Clinical Chemistry Laboratory	76°	56%	247 cfm 235 cfm 248 cfm 226 cfm	145 cfm 305 cfm 166 cfm	29.5 ACH
Wash Room	76°	58%	200 cfm 279 cfm 254 cfm 261 cfm	333cfm* 400 cfm* 38 cfm* 56 cfm* 45 cfm 34 cfm* 23 cfm*	26.9 ACH
"Eclectic Laboratory"	71°	68%	143 cfm 148 cfm 139 cfm 161 cfm	156 cfm 115 cfm 96 cfm	13.7 ACH
Sanitary Bacteriology	---	---	167 cfm 165 cfm 255 cfm 228 cfm 170 cfm 189 cfm 237 cfm	Unable to Measure	37.3 ACH
Serology					
Outer Laboratory	70°	66%	296 cfm 250 cfm 272 cfm 253 cfm	355 cfm 328 cfm	49.6 ACH
Room "a"	---	---	258 cfm	Unable to Measure	35.8 ACH
Prep Room	---	---	420 cfm	Unable to Measure	116.7 ACH

* Exhausts directly to outside of building

Table 6 (Page 2 of 2)
Ventilation and Environmental Results at
West Palm Beach Laboratory
HRS Office of Laboratory Services
HETA 92-0377
June 16, 1992

LOCATION	TEMPERATURE [°F]	RELATIVE HUMIDITY	SUPPLY AIR VOLUME	EXHAUST AIR VOLUME	AIR CHANGES PER HOUR
Rabies Laboratory	73°	65%	245 cfm	333 cfm	45.4 ACH
Microbiology Laboratory					
Outer Laboratory	71°	66%	166 cfm 170 cfm 180 cfm 70 cfm 159 cfm 180 cfm 81 cfm	75 cfm 65 cfm 2 Additional Diffusers: Unable to Measure	24.4 ACH
Room "a"	---	---	138 cfm 143 cfm	Through Bio-Safety Cabinet	39.0 ACH
Room "b"	---	---	174 cfm	Through Canopy Hood	24.2 ACH
Administrative Wing					
Library	76°	69%	273 cfm 295 cfm	172 cfm 201 cfm	16.9 ACH
Front Entrance	---	---	244 cfm	209 cfm	18.1 ACH
Front Hallway	---	---	110 cfm	None	---
Reception	76°	73%	240 cfm	167 cfm	20.8 ACH
Director's Office	76°	73%	222 cfm	150 cfm	19.2 ACH
Mailroom	74°	76%	401 cfm	398 cfm	49.5 ACH
Clerical Office	75°	76%	450 cfm 230 cfm 237 cfm	169 cfm 393 cfm 176 cfm	47.0 ACH

Table 7 (Page 1 of 2)
Ventilation and Environmental Results at
Miami Laboratory
HRS Office of Laboratory Services
HETA 92-0377
October 21, 1992

LOCATION	TEMPERATURE [°F]	RELATIVE HUMIDITY	SUPPLY AIR VOLUME	EXHAUST AIR VOLUME	AIR CHANGES PER HOUR
TB Laboratory					
TB Room	71°	62%	680 cfm 765 cfm	240cfm* 244 cfm* 326 cfm* 240 cfm* 260 cfm*	17.8 ACH
Inoculation Room	74°	58%	412 cfm	1053 cfm* 477 cfm* 193 cfm* 64 cfm*	15.2 ACH
Serology					
Outer Laboratory	75°	55%	300 cfm 305 cfm 147 cfm 288 cfm 251 cfm 325 cfm	630 cfm 908 cfm	12.0 ACH
Centrifuge Room	---	---	330 cfm	230 cfm	18.3 ACH
Parasitology	---	---	507 cfm	Through Bio-Safety Cabinet	14.8 ACH
Bacteriology	73°	60%	526 cfm 563 cfm	No Exhaust	8.5 ACH
Computer Room	75°	56%	295 cfm	1185 cfm	4.9 ACH
Rabies Proc. Room Including F.A.	74°	56%	210 cfm 125 cfm	810 cfm	10.6 ACH
HIV Virology Laboratory	73°	60%	240 cfm 260 cfm 325 cfm 230 cfm 230 cfm	630 cfm Laboratory Hood - Off	11.0 ACH
Media Prep Room	73°	58 %	185 cfm 200 cfm	585 cfm ◆	6.4 ACH

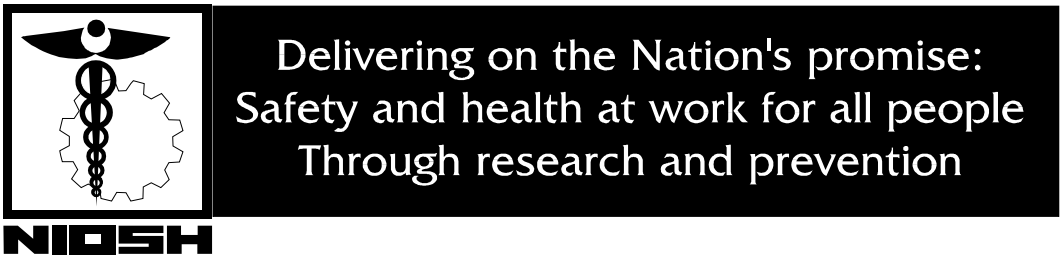
* - Exhausts directly out of building

Table 7 (Page 2 of 2)
Ventilation and Environmental Results at
Miami Laboratory
HRS Office of Laboratory Services
HETA 92-0377
October 21, 1992

LOCATION	TEMPERATURE [°F]	RELATIVE HUMIDITY	SUPPLY AIR VOLUME	EXHAUST AIR VOLUME	AIR CHANGES PER HOUR
Media Prep Room	73°	58 %	185 cfm 200 cfm	585 cfm ◆	6.4 ACH
Autoclave Room	74°	57%	324 cfm 187 cfm 368 cfm 222 cfm 154 cfm 104 cfm	106 cfm 61 cfm 38 cfm 34 cfm ◆	12.4 ACH
Storage Room 243	---	---	145 cfm	145 cfm	N.C.
Storage Room 240	74°	57%	37 cfm	665 cfm	N.C.
Rest Rooms					
Men - South Side	74°	58%	175 cfm	No Air Flow	N.C.
Women - South Side	75°	57%	70 cfm 170 cfm	No Air Flow	N.C.
Men - North Side	74°	55%	128 cfm	No Air Flow	N.C.
Women - East Side	72°	56%	123 cfm	No Air Flow	N.C.

◆ - Canopy hood exhaust inoperable during survey period

N.C. - Not calculated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