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**HETA 2000-0040-2800**  
**Hawaii State Department of Health**  
**Honolulu, Hawaii**

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## PREFACE

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## ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Teresa Seitz, Ken Martinez, and Yvonne Boudreau of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Desktop publishing was performed by Denise Ratliff. Review and preparation for printing were performed by Penny Arthur.

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## Highlights of the NIOSH Health Hazard Evaluation

### Evaluation of the TB Prevention Program

In December 1999, at the request of the Hawaii Department of Health (HDOH), NIOSH personnel visited the Lanakila Health Center (LHC) TB Clinic to evaluate the TB prevention program and review proposed ventilation and building design changes intended to make this a model clinic.

#### What NIOSH Did

- # We checked the ventilation system and air flow patterns.
- # We measured ultraviolet (UV) radiation levels from the germicidal lamps.
- # We performed respirator fit testing.
- # We reviewed renovation plans.
- # We talked to employees.
- # We reviewed the employee TB skin test records.

#### What NIOSH Found

- # Changes made in the main waiting and reception areas were effective in preventing employee exposures to tuberculosis.
- # Ventilation changes made in the sputum rooms were not sufficient to prevent exposures, but the problems were later fixed.
- # UV levels were not a hazard.
- # The available respirators did not fit some employees.
- # Employees were confused about when to wear respirators and concerned about being exposed to persons with TB.

# The TB skin test data were difficult to interpret because not all employees had enough skin test results entered in the data base.

#### What HDOH-LHC Managers Can Do

- # Offer periodic training on TB, respirators, and UV radiation.
- # Maintain sputum rooms under negative pressure.
- # Provide sufficient space for case consultations.
- # Schedule renovations for non-occupied hours when possible.
- # Follow the CDC guidelines to improve the usefulness of the employee TB skin test data.

#### What the HDOH-LHC Employees Can Do

- # Attend periodic training programs.
- # Ensure that persons who may have active TB are isolated.
- # Wait 15 minutes between uses of the sputum rooms.
- # Wear respirators at the right times.



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We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513/841-4252 and ask for HETA Report # 2000-0040-2800



**Health Hazard Evaluation Report 2000-0040-2800**  
**Hawaii State Department of Health**  
**Lanakila Health Center Tuberculosis Clinic**  
**Honolulu, Hawaii**  
**June 2000**

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## SUMMARY

In December 1999, at the request of the Hawaii State Department of Health (HDOH), National Institute for Occupational Safety and Health (NIOSH) personnel visited the Lanakila Health Center Tuberculosis (TB) Clinic in Honolulu, Hawaii, to evaluate their TB prevention program and review proposed design changes intended to make this a model clinic. The NIOSH evaluation included a ventilation assessment, measurement of ultraviolet (UV) radiation emitted by germicidal lamps, respirator fit testing, a review of proposed ventilation and clinic layout changes, a review of the employee tuberculin skin test (TST) data, and employee interviews.

Design changes to the sputum rooms, waiting areas, and reception areas were evaluated. Changes made in the main waiting area were effective in moving air from a "clean" to "less clean" area, minimizing employee exposures to infectious droplet nuclei. Changes to the sputum rooms were not sufficient because the rooms were not maintained under negative pressure. However, reports of work performed subsequent to the NIOSH visit indicate that the sputum rooms now meet applicable guidelines. The UV radiation measurements indicated that under usual conditions, employees would not be exposed to UV radiation in excess of occupational exposure limits. Several employees did not achieve an acceptable fit with the available respirators.

Forty-three of the 44 employees had at least one documented TST in the clinic's database. Twenty (47%) had reactions documented at  $\geq 10$  millimeters (mm) in size, considered "positive" according to HDOH policy. However, only eight of these positive employees had a documented prior negative TST, and five of those eight had only two documented TSTs and were positive on their second test, making it possible that the "positive" test could have been due to a booster effect. Two of the other three positive employees had complicated TST histories, making their results difficult to interpret. The final positive employee had two negative (0 mm) tests and then one test with a reaction of 10 mm. This indicated that the employee was most likely a true converter.

Numerous environmental and programmatic changes have been made at the Lanakila Health Center TB Clinic to improve TB prevention efforts. Future renovation efforts should include separating areas where individuals with known or suspected infectious TB are seen or evaluated from areas of general TST screening, and the provision of a sufficient number of negative pressure rooms for exams and interviews with clients. To improve the capabilities of the HDOH to assess TST conversion rates in employees, it would be helpful to document baseline two-step TSTs in all employees at the time they are hired, and then to provide periodic TSTs to the employees with negative tests. Recommendations addressing these issues are included in this report.

Keywords: SIC 9431 (Administration of Public Health Programs), tuberculosis, TB, health department, ventilation, tuberculin skin test, TST, ultraviolet radiation, UVGI, germicidal lamp, clinic.

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## INTRODUCTION

On October 29, 1999, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Hawaii State Department of Health (HDOH) for technical assistance at the Lanakila Health Center Tuberculosis (TB) Clinic in Honolulu, Hawaii. NIOSH was asked to evaluate engineering controls, conduct respirator fit testing, and review other relevant information concerning the prevention of tuberculosis transmission at this TB clinic. In addition, NIOSH was asked to provide technical input into proposed design changes for the clinic renovation project. On December 8-10, 1999, three NIOSH representatives visited the TB clinic to conduct environmental and medical evaluations. An interim letter summarizing the evaluation and preliminary recommendations was distributed in March 2000.

## BACKGROUND

TB control activities for the State of Hawaii are performed by the HDOH. From 1992 through 1998, the State of Hawaii reported the highest annual TB case rates in the United States. In 1998, 181 TB cases were reported in Hawaii, and in 1999, 184 cases were reported, an incidence rate of 15.5 per 100,000 persons.<sup>1</sup> The HDOH TB Program includes TB diagnosis and treatment services (chest X-rays, sputum smear and culture, tuberculin skin testing, anti-TB chemotherapy), TB prevention services, epidemiologic contact investigations, education, and targeted TB screening. With the exception of the laboratory work, the services mentioned above are all performed at the Lanakila Health Center. In 1998, there were over 40,000 patient visits to the TB clinic. During these visits, over 24,000 tuberculin skin tests (TSTs) were placed, and nearly 16,000 X-rays were performed. The TB Branch currently employs 44 people.

The high TB case rate in Hawaii and the active nature of the clinic have led HDOH officials to seek improvements in the clinic environment. The first phase of renovation (May to December 1999) involved replacing thermostats, fan coil units, and ductwork, and incorporating additional exhaust ventilation in the main waiting area. To reduce

employee contact with potentially infectious aerosols, the main patient waiting area was placed under negative pressure in relation to the employee-side reception area, and glass partitions were installed to provide a physical barrier between the reception employees and clinic visitors. Another major renovation project is scheduled to begin in late 2000. This renovation will involve changes in the layout of the clinic. One of the main goals of the upcoming renovation is to better separate areas where known or suspect TB patients are treated or evaluated (X-ray, sputum induction, examination, counseling) from office areas and locations where activities such as routine TST screening for employment occur. Because this is a more extensive renovation, the employees will be relocated during the reconstruction.

## METHODS

### Employee Interviews and TB Program Review

HDOH representatives informed all employees, in advance, of our visit and provided a sign-up sheet with 15-minute slots available for interviews. A NIOSH medical officer reviewed the HDOH Tuberculosis Control Program and employee TST data, and conducted private interviews with fifteen employees who volunteered to be interviewed.

### Respirator Fit Testing

NIOSH personnel offered respirator fit testing to clinic employees who were medically cleared for respirator use. Bitrex™ (denatonium benzoate), a bitter tasting substance, was used as the primary qualitative fit test challenge agent. For those employees who could not taste Bitrex, saccharin was used as a secondary challenge agent. Fit testing was performed using a 3M FT-10 Qualitative Fit Test Apparatus, following the qualitative fit testing procedures outlined in Appendix A of the Occupational Safety and Health Administration (OSHA) Respiratory Protection Standard for general industry.<sup>2</sup>

### Ventilation Assessment

NIOSH representatives met with architectural and engineering personnel to collect further information regarding the recent changes and future plans for the TB clinic. To evaluate air distribution, airflow measurements were made at the supply air diffusers and return or exhaust air grilles using a TSI model 8370 AccuBalance Flow Measuring Hood. A TSI VelociCalc anemometer was used to measure air velocity in locations that were inaccessible with the flow hood. Smoke tubes were used to visually assess air movement patterns (direction and velocity) in several locations. This was accomplished by releasing a thin trail of smoke to observe airflow in and out of several key areas including the sputum rooms, treatment rooms, interview rooms, waiting areas, and employee reception area. In some locations, quantitative measurements of air pressure differential were made using a Neotronics Model EDM-I micro-manometer.

## Ultraviolet Radiation Measurements

Eleven ultraviolet germicidal irradiation (UVGI) lamps are used in the clinic for upper air disinfection. These low-pressure mercury vapor lamps emit UV and visible radiation at specific wavelengths. The predominant radiant emissions are at 254 nanometers (nm), within the germicidal UV-C- range. To evaluate potential occupational exposures, UV radiation measurements were made using a calibrated model 1400A International Light (IL) radiometer connected to a SEL 240 detector. The measurement range is 0 to 1000 microwatts per square centimeter ( $\mu\text{W}/\text{cm}^2$ ) for emissions in the 200 to 320 nm range. Measurements were made in several representative work locations, as well as at the face of the lamps, to evaluate potential worst case exposures.

## EVALUATION CRITERIA

## Tuberculosis

Tuberculosis is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*. *M. tuberculosis* is carried in airborne particles called droplet nuclei, that can be generated when persons with TB of the lungs or throat cough, sneeze, or vocalize. The droplet nuclei are about 1-5 microns in size, allowing them to be dispersed throughout a room or building on normal air currents for hours. Infection occurs when a person inhales aerosolized *M. tuberculosis* and the bacteria become established in the alveoli of the lungs and spread throughout the body. Within 2-10 weeks, the immune system is usually able to prevent further multiplication and spread of the bacteria; however, some of the bacilli remain dormant and viable for many years. At this point, a person will usually have a positive tuberculin skin test. The dose required to initiate infection is not known. In general, people who become infected with *M. tuberculosis* have about a 10% risk for developing active TB during their lifetimes.<sup>3</sup> This risk is greatest during the first two years after infection. Immunocompromised persons have a greater risk for the progression of latent TB infection to active TB disease. Because of the risk of developing active disease once infected, the Centers for Disease Control and Prevention (CDC) recommends that such persons be evaluated for preventive drug therapy, to prevent the progression from latent TB infection to active TB disease.<sup>3</sup>

Groups of persons known to have a higher prevalence of TB infection include contacts of persons who have active TB, foreign-born persons from areas with a high prevalence of TB, medically underserved populations (including some Pacific Islanders), homeless persons, current or former correctional inmates, alcoholics, injecting drug users, and the elderly.<sup>3</sup>

Characteristics of the TB patient that enhance transmission include: disease in the lungs, airways, or larynx; presence of cough; presence of *M. tuberculosis* in the sputum; presence of cavitation on chest X-ray; insufficient treatment; failure to cover mouth and nose when coughing or sneezing; and undergoing procedures that can induce coughing or generation of aerosols of *M. tuberculosis*.<sup>3</sup> Environmental factors that enhance

transmission include: the sharing of a relatively small, enclosed space with an infectious person; inadequate ventilation that results in insufficient dilution or removal of infectious droplet nuclei; and recirculation of air containing infectious droplet nuclei.

## **Guidelines for Preventing TB Transmission**

In October 1994, CDC published TB prevention guidelines, which recommended that health-care facilities conduct a TB risk assessment and implement a TB control program appropriate to their level of risk of TB transmission.<sup>3</sup> CDC recommends a hierarchy of controls to prevent TB transmission in health care settings, these include: (1) administrative controls to reduce the risk for exposing uninfected persons to persons who have infectious TB; (2) engineering controls to reduce the spread and concentration of *M. tuberculosis* in a facility; and (3) the use of personal respiratory protection in the few areas where exposure to TB may still occur even when administrative and engineering controls are in place, such as in TB isolation rooms, during transport of infectious patients in an enclosed vehicle, and in areas where cough-inducing procedures are performed.

In February 1996, OSHA issued revised enforcement procedures and scheduling for occupational exposure to TB.<sup>4</sup> Hawaii has an approved state OSHA program and this program follows the federal OSHA compliance directive on occupational exposure to TB. The OSHA guidelines are based on the 1994 CDC guidelines mentioned above. The workplaces covered by the OSHA guidelines include health care facilities, correctional facilities, long-term care facilities for the elderly, homeless shelters, and drug treatment centers. Coverage of non-hospital health care settings such as clinics, includes only personnel present during the performance of high hazard procedures (including sputum inductions) on suspect or active TB patients. The OSHA guidelines include a protocol for the early identification of individuals with active TB; a skin test surveillance program for employees; medical evaluation and management of workers with positive skin tests or symptoms of active TB; worker education and training; use of engineering controls; use of respiratory protection; placement

of individuals with confirmed or suspected TB in isolation rooms; and the performance of high-risk procedures (sputum induction, aerosolized drug administration, bronchoscopy, etc.) in areas with negative pressure and either direct exhaust to the outside or through high efficiency particulate air (HEPA) filters.

## **Ultraviolet Radiation**

Most of the radiant energy emitted by the UVGI lamps is at 254 nm. The organs most critically affected by exposure to UV at this wavelength are the eyes and skin. Persons who are overexposed to UV at this wavelength without appropriate eye and skin protection would be at risk for developing acute effects such as erythema (redness) of the skin, conjunctivitis (inflammation of the membrane lining the eyelids and white part of the eye), and keratitis (inflammation of the cornea [the clear part of the eye], producing a painful sensation of “sand” in the eyes, tearing, and sensitivity to light). Because these effects usually manifest 6-12 hours after exposure, their relationship to an occupational exposure may be overlooked.

In 1972, NIOSH published a recommended exposure limit (REL) for UV radiation.<sup>5</sup> Because the biological effects from exposure to UV radiation are dependent on the intensity and energy distribution of the source, the NIOSH REL is wavelength-dependent in the spectral region of interest (200-315 nm). At 254 nm, the REL is 0.006 Joules per square centimeter ( $J/cm^2$ ). Permissible exposure times (in seconds) can be calculated by dividing the 8-hour dose level ( $0.006 J/cm^2$  at 254 nm) by the measured UV irradiance in  $Watts/cm^2$ .

## **RESULTS AND DISCUSSION**

### **Employee Interviews and TB Program Review**



Fifteen (34%) of the 44 employees participated in the medical interviews. They included physicians, nurses, administrative employees, technical experts, and radiology employees. They expressed concerns about being exposed to TB bacteria from both known and unknown cases of infectious TB because they felt that suspect cases of active TB are not always isolated from people in the rest of the clinic. They expressed confusion as to when they should wear respirators. They also noted that, when building renovations were conducted during regular working hours, it was difficult to perform their duties because of dust and noise in their work areas.

Review of the TST data revealed that 43 of the 44 employees had at least one documented TST in the clinic's database. Twenty (47%) of the tested employees had reactions documented at  $\geq 10$  millimeters (mm) in size, considered "positive" according to the HDOH State TB Policy. All employees with positive tests had received chest radiographs, in accordance with the policy, while employed at the Lanakila Health Center. Twelve of the positive employees were positive at the time of their first documented TST, and did not have documented prior TST results, so it is not possible to determine precisely when they converted from a negative to a positive TST. The other eight positive employees did have a documented prior TST of less than 10 mm, making them eligible for consideration as having converted from a negative to a positive TST during the time since their previous TST. However, of these eight employees, five had only two documented TSTs, and were positive on their second test, making it possible that the "positive" test could have been due to a booster effect rather than truly representing a new positive test. Another of the positive employees had an initial TST of 11 mm, but two subsequent TSTs of only 5 mm, which makes the initial TST difficult to interpret. Of the final two positive employees, each had two documented TSTs less than 10 mm and then a documented TST greater than 10 mm. However, one had reactions of 7 mm on their first two tests and then a reaction of 11 mm, an absolute increase of only 4 mm. The other employee had two tests with reactions of 0 mm and then reacted at 10 mm, making this person most likely a true converter.

## **Respirator Fit Testing**

Twenty-five employees participated in the respirator fit testing. Of these, two employees could not be fit tested due to the inability to taste either challenge agent – a prerequisite for conducting the test. Seventeen employees passed the qualitative fit test using the available NIOSH-certified, N95 filtering facepiece respirators (3M model 1860 [two sizes] and Survivair model 1930 [one size]). The remaining six employees did not achieve an acceptable fit with the available respirators.

## **Ventilation Assessment**

### ***Ventilation System Operation***

The clinic ventilation system is composed of 11 small fan coil units, 5 larger package systems, 2 outdoor air supply systems, and 2 dedicated exhaust systems, all of which are located in the space above the drop ceiling. Most of the air in the clinic is recirculated through ducted returns to the fan coil units or package ventilation systems, with the exception of the areas noted below that are exhausted directly to the outside. The dedicated exhaust systems serve the isolation areas, specialty areas (such as X-ray), restrooms, and the janitorial storage closet. The ventilation system supplies a constant volume of air at all times while the clinic is occupied. The outdoor air is tempered by chilled water coils or electric heater coils located immediately downstream of the filters. Additionally, single electric reheat coils are located in the outdoor air supply main ducts to temper the air serving the main waiting area and clinic waiting area.

The main dedicated exhaust system runs along the centerline of the clinic, exiting through a duct containing HEPA filtration, to the roof. Air from this system is exhausted directly to the outside; it comes from the sputum rooms, the lab (sputum preparation room), the main waiting area, and the X-ray waiting area. The exhaust diffusers for the sputum rooms and lab are located in the ceiling; the exhaust diffusers for the main waiting area and the X-ray waiting areas are located at floor level.

### ***Air Flow Measurements***

Table 1 presents the results of the airflow measurements. The measured air flow rates were in fairly good agreement with the flow rates listed on one of the heating, ventilating, and air-conditioning (HVAC) replacement and renovation plans (New Mechanical Plan - Existing Space, DAGS Job No. 12-20-2516, drawing M-2, no date), with the major exceptions being the X-ray area and the sputum rooms. In storage room #4, only 130 cubic feet per minute (cfm) of exhaust air was measured, while the design plan specifies that this area should have 540 cfm exhaust. Low exhaust air flows relative to the design plans were also noted in X-ray storage and X-ray #2, and in the developing room. Although the ventilation system had reportedly been recently balanced, the balancing report was not available for comparison with air flow rates. In sputum room #1, the measured flow rates from either diffuser were approximately 33 cfm, and in sputum room #2, the supply air flow was 43 cfm and the exhaust air flow was 33 cfm. The plans listed a design supply air flow of 50 cfm and exhaust of 70 cfm.

### ***Pressure Relationships and Air Change Rates***

The main waiting area consistently pulled smoke in through all access doors, indicating that this area was under negative pressure with respect to its surroundings. This was verified by the micro-manometer, which indicated a pressure of -0.002 inches water gauge (in. W.G.). Counter barriers were also evaluated; generated smoke moved away from the reception and survey employees toward the waiting area. Pressure measurements made at the reception desk and the survey areas indicated readings of  $<+0.001$  in. W.G. A potential problem point exists at the elevator doors that are within the isolation envelope of the main waiting area. As the elevator moves up or down it creates a piston effect that could impact the pressure relationship of the main waiting area to adjacent areas.

Smoke generation at all access doors to the X-ray clinic waiting area resulted in an inward movement from adjacent zones. This negative pressure indication was verified by the pressure manometer, which showed readings of -0.002 in. W.G. at all doors. However, when the door to the

X-ray technicians' office was opened, the pressure differential with adjacent zones was negligible, indicating that this door should remain closed at all times.

Smoke generation at the doors to sputum rooms #1 and #2 resulted in no significant movement either into or out of the rooms. This was consistent with the pressure manometer readings that indicated no perceptible pressure differential, and airflow measurements which showed very low volumetric flow rates through either the supply or exhaust diffusers. Based on the physical measurements of the rooms, air exchange rates were estimated to be 9.8 air changes per hour (ACH) in sputum room #1, and 13 ACH in sputum room #2. Because the rooms were not under negative pressure, NIOSH personnel recommended that they not be used for collection of sputum samples until appropriate ventilation changes could be made. CDC guidelines recommend that cough-inducing procedures performed on persons who may have infectious TB should be done using local exhaust ventilation or, if this is not feasible, in a room that meets the ventilation requirements for TB isolation (negative pressure, exhaust to the outside, and  $\geq 12$  ACH for renovated facilities).<sup>3</sup>

On December 15, 1999, NIOSH investigators were informed that the ventilation contractor had made modifications to the system, and that the sputum rooms were now supplying 50 cfm and exhausting 75 cfm of air directly to the outside. Based on the revised air flow data, the sputum rooms have an estimated air change rate of 22 ACH. Pressure manometer readings were reportedly between -0.002 and -0.003 in. W.G, exceeding the minimum pressure differential recommended in the CDC guidelines (-0.001 in. W.G.). On at least two subsequent occasions, smoke tube traces confirmed that the rooms were under negative pressure. Given this information, the sputum rooms meet current CDC guidelines and can be used for sputum collection.

Chemical smoke applied at the door of the lab showed an inward flow of air. This is consistent with the manometer reading indicating a pressure differential of -0.001 in. W.G. The exhaust air flow rate was 190 cfm, and the supply was 130 cfm. Subtracting the volume of the refrigerator

and the cabinetry results in an estimated air exchange rate of 18 ACH.

Pressure relationships were also evaluated at the access doors of the examination room, the consultation rooms, and the nurses' office area. These rooms were not connected to the dedicated exhaust system, so air was recirculated within these areas. Chemical smoke applied at the doors of the examination and consultation rooms moved outwardly, indicating that they were under positive pressure in relation to the hallway. Chemical smoke applied at the access doors of the nurses' office area showed no significant movement either into or out of the room.

### **Future Renovation Plans**

During a meeting with the contract engineering design team, NIOSH investigators had the opportunity to review a number of proposed plans for the clinic renovation. Each plan attempted to locate working areas of the clinic into zones characterized as "contaminated" and "uncontaminated." In our opinion, the most promising proposal included separate entry/exit doors for the general client population and for those known or suspected of having infectious TB. Clients would be received at a centrally located reception desk that is maintained under positive pressure to minimize exposures of the reception staff. General air movement, through the design of air pressure differentials between adjacent areas, was from the northeast corner to the entry/exit doors on the south end. A dedicated room for the administration and reading of TSTs was included in the design plan. One limitation with the proposed layout was the lack of sufficient space for consultation with persons who may have infectious TB. Such space is needed to eliminate the practice of conducting private interviews and exams on these individuals in the nursing work stations or in private physician offices that are on recirculating ventilation systems. Recent information provided by the HDOH indicates that revised plans have been submitted which address this issue by providing additional consultation rooms and a triage room for persons exhibiting symptoms of active TB. While the newly purchased portable, recirculating HEPA filtration units will provide additional air cleaning when used in the existing nursing stations, they should

not be relied upon as the primary engineering control when interviews are conducted on clients with infectious TB.

## **Ultraviolet Radiation Measurements**

UV measurement results are shown in Tables 2 and 3. Table 2 shows the maximum UV irradiance levels measured at the face of the germicidal lamps. These UV levels represent worst-case exposures, as might occur if an employee were to attempt to perform maintenance on the lamps without first turning them off. The NIOSH REL was used to calculate the permissible exposure times for the UV irradiance levels for employees with unprotected eyes and skin. The permissible exposure times are all less than one minute. While the permissible exposure times will generally increase with increase in distance from the source, UV exposures in the irradiated zone (the upper room) would be of concern if a person were painting or conducting ventilation system maintenance. Persons who are exposed to such levels of UV radiation without appropriate eye and skin protection would be at risk for developing erythema of the skin, conjunctivitis, and keratitis.

Table 3 lists the UV irradiance levels measured at various distances from the lamps in the lower room (the occupied space). These measurements are more representative of exposures of clinic employees; they were made at standing or seated eye height because of the sensitivity of the eyes to UV-C radiation. The detector was directed toward the lamp at the locations listed in the table, and the maximum UV level was recorded. With the exception of the sputum rooms (lamps #10 and #11), the permissible exposure times at the stated locations were all greater than 8 hours. (The third measurement for lamp #3 had a much higher UV irradiance level than the two preceding measurements; this is probably because the bulb was visible at that location due to insufficient shielding.)

Because the sputum rooms are very small, employees anywhere in the room would be in close proximity to the lamp. Although UV overexposure could occur in less than three hours, employees would not be expected to be present in

these rooms for such lengths of time, as they are used intermittently. Skin and eye protection would be required if employees were to spend extended time periods in the room while the lamps were in use.

## CONCLUSIONS

To improve TB prevention efforts at the Lanakila Health Center TB Clinic, numerous environmental and programmatic changes were being made. The first phase of the clinic renovation was nearly completed at the time of the NIOSH evaluation, so NIOSH investigators were able to evaluate the changes to the sputum rooms, waiting areas, and reception areas. The additional exhaust ventilation in the main waiting area and use of glass partitions in the reception area were effective in moving air from a “clean” to “less clean” area, thereby minimizing potential employee exposures to infectious droplet nuclei. Changes to the sputum rooms were not sufficient to meet current CDC guidelines at the time of our visit. However, reports of additional ventilation work performed in December 1999, indicate that the rooms now meet these guidelines.

While the focus of the NIOSH evaluation was on preventing employee exposures, improvements in the TB prevention program and in the environment will also benefit the many visitors to the clinic. As previously noted, there were over 24,000 TSTs placed in 1998. This is due to the aggressive screening program developed by the HDOH for students and individuals working in jobs with extensive contact with the public or with individuals at high risk for TB. Thus, continued efforts toward separating general TST screening areas from areas where individuals with known or suspected infectious TB are seen or evaluated are needed. In addition, the provision of a sufficient number of negative pressure rooms for exams and interviews with such potentially infectious clients is an important consideration for the upcoming renovation.

The UV measurements indicated that under usual conditions employees would not be exposed to UV levels in excess of current occupational limits. However, if employees were present in the sputum rooms for extended periods of time (> 2 hours), or if maintenance were conducted on the lamps or in

the upper space of the room while lights were activated, such as during painting, renovation, or ventilation system repair, then employees would be at risk for acute effects such as skin erythema, conjunctivitis, and keratitis.

Several employees did not achieve an acceptable respirator fit. Subsequent to the NIOSH visit, HDOH contacted a respirator manufacturer to provide additional fit testing on those who did not pass the initial fit testing and to provide a “train-the-trainer” session for those who would be conducting fit testing in the future. In addition, NIOSH investigators were informed that a written respirator program was developed and finalized on March 1, 2000.

## RECOMMENDATIONS

The following recommendations are offered to further minimize the potential for TB transmission at the Lanakila Health Center TB Clinic:

1. Formal education classes on TB should be developed and presented to all employees, with adequate time for questions and discussion. This training should cover the basic concepts of TB transmission, pathogenesis, diagnosis, signs and symptoms, proper precautions for minimizing risk of infection and active disease, purpose of testing, interpretation of TST results, principles of drug therapy, and follow-up procedures for TST conversions and suspicion of active disease. This training should be provided on an annual basis and should include information on other related hazards (such as UV radiation from UVGI lamps).
2. Based on the most recent air flow data for the sputum rooms, a minimum of 15 minutes should elapse between uses of the room to allow a sufficient amount of time for removal of airborne droplet nuclei, if present. In addition, smoke tubes should be used to confirm that these rooms remain under negative pressure. Smoke tube testing could be done prior to the first use of the room each day. Differential pressure-sensing devices could also be installed in the door to monitor negative pressure on a continuous basis. However, if such devices are installed, monthly checks should be performed, using smoke tubes, to verify their effectiveness.

3. In the upcoming renovation activity, address the need for additional rooms for consultation with suspect or known infectious TB patients. Ideally, such rooms would be similar to isolation rooms (i.e., negative pressure, 6-12 ACH, direct exhaust to the outside).

4. Because the layout of the clinic will be altered in the future, attention should be devoted to the optimum placement and operation of the UVGI units when they are re-installed. Consideration should be given to room ventilation patterns (including the placement of supply and exhaust diffusers) and creating a uniform irradiance zone in the upper air. The UV tubes in the fixture should not be visible to any person standing in the room. If necessary, the baffles or louvers can be adjusted to direct the UV irradiation to the upper air space. UV radiation levels should be measured in various locations in the rooms following the re-installing of the lamps to ensure that potential exposures do not exceed recommended limits. UV measurements should also be made in the irradiated zone to document that the lamps are working as intended. The on/off switch for the UVGI lamps should not be located on the same switch as the general room lighting. These UVGI switches are best positioned in locations where only authorized persons have access to them and/or they should be locked to ensure that they are not accidentally turned on or off. UVGI systems should be inactivated prior to any activity in the affected areas, such as when workers replace lamps or enter the upper air space for maintenance, renovation, or repair work. Warning labels should be visible on all UVGI lamps. The 1994 CDC TB guidelines can be consulted for further information on UVGI systems.<sup>3</sup>

5. Regardless of the renovation proposal selected, elements of the ventilation system will have to be redesigned. The exhaust system is a critical element in reducing the risk of occupational exposure to infectious droplet nuclei. Therefore, designated "isolation" or negative pressure areas should be located close to the exhaust system to optimize performance. Consideration should also be given to the location of the smaller package units when developing proposed layout changes. These systems are not as amenable to relocation as are the small fan coil units. Another consideration should be the location of the elevators with respect to negative

pressure areas. The piston effect that occurs during movement of the elevators can upset air pressure differentials. Consideration should also be given to relocating the supply diffusers in the sputum rooms to floor level to minimize the potential for short-circuiting of air (from the supply directly to the exhaust), thus improving overall ventilation effectiveness.

6. Respirator training should be conducted yearly in accordance with the OSHA Respirator Standard for *M. tuberculosis* [29 CFR 1910.139]. OSHA has proposed a health standard to control occupational exposure to TB. Until this standard is finalized, the use of respirators for TB exposures will be enforced under the respiratory protection standard cited above. (The use of respirators for exposures other than *M. tuberculosis* are covered under 29 CFR 1910.134.<sup>2</sup>) The training should emphasize when employees are required to wear the respirators. In general, respirators should be worn in rooms where patients with known or suspected infectious TB are being isolated, during cough-inducing or aerosol-generating procedures (such as sputum induction), during transport of infectious TB patients in an enclosed vehicle, and in other settings when the administrative and engineering controls may not adequately protect workers from airborne droplet nuclei (e.g., in patients' homes during administration of directly observed therapy to infectious patients). The use of masks by known or suspected TB patients should also be encouraged, particularly in waiting areas. The recent NIOSH publication entitled, "TB Respiratory Protection Program in Health Care Facilities – Administrators Guide"<sup>6</sup> can be consulted for additional information.

7. Because HDOH employees work with potentially infectious TB patients, we recommend that they be monitored for TB infection. The TB screening program should be developed in accordance with the most current OSHA enforcement guidelines and CDC recommendations.<sup>3,4</sup> Employee representatives should be involved in the development of the program, and the screening should be offered at no cost to employees.

8. Individual TST results and clinical evaluations should be maintained in confidential employee health records, and should be recorded in a retrievable aggregate data base of all

employee test results. Identifying information should be handled confidentially. Summary data (e.g., the percentage of positive reactions among all tested) can be reported to management and employees. Other than reporting to the tested individual, or providing information to public health authorities, results should remain confidential.

9. The rate of skin test conversions should be calculated periodically to estimate the risk of acquiring new infection and evaluate the effectiveness of control measures. On the basis of this analysis, the frequency of re-testing may be altered accordingly.

10. Given the high rate of TB in Hawaii, consideration should be given to using a more inclusive definition of a positive TST, such as a value of 5 mm or greater.

11. Efforts should be made to schedule building renovations during non-occupied hours whenever possible, and to inform employees of all renovations.

## REFERENCES

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4. OSHA [1996]. CPL 2.106 - Enforcement procedures and scheduling for occupational exposure to tuberculosis. U.S. Department of Labor, Occupational Safety and Health Administration, February 6, 1996.

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6. NIOSH [1999]. TB Respiratory Protection Program in Health Care Facilities – Administrator’s Guide. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 99-143.

**Table 1**  
**Ventilation Measurement Results**  
**Lanakila Health Center TB Clinic**  
**HETA 2000-0040-2800**  
**December 1999**

Location	Total Supply Air (cfm)	Total Return Air (cfm)	Exhaust Air (cfm)
Staff Lounge	320	210	
Staff Conference Room	395	145	
Doctor Office #1	190	145	
Doctor Office #2	200	140	
Doctor Office #3	225	130	
Doctor Office #4	130	115	
Hall #4	435	1000	
PMA 1	245	175	
Lab 2	140	not measured	
Social Worker	125	45	
PMA 2	140	65	
PMA 3	120	105	
Consult	135	40	
Misc Ofc	115	35	
Hall #3	225	700	
Nurse Supervisor	130	55	
Nurse's Area and Skin Test	560*		
Pharm. (76')	140		
Pharm. (160')	185	190	
Storage #3		275	
Admin #2	290	165	
Waiting #2 (triage)	360		440

**Table 1**  
**Ventilation Measurement Results**  
**Lanakila Health Center TB Clinic**  
**HETA 2000-0040-2800**  
**December 1999**

Location	Total Supply Air (cfm)	Total Return Air (cfm)	Exhaust Air (cfm)
Waiting #1 (main)	1595		1965
Hall #2	50		
Wait #4	160		
Hall #1	355		
Admin	905	845	
Registry	1350	1140	
Survey and Chest	2045	1515	
Sputum Room #1	33		33
Sputum Room #2	43		33
Lab (sputum prep/shipping)	130		190
Storage #4 (X-ray files)	495		130
Wait #5 and Waiting #3	590		615
X-Ray Dev.	115		45
X-Ray storage	125		60
X-Ray Tech Office	270		
X-Ray #2	140		145
X-Ray #3	160		60

\* One diffuser in this area was not accessible for measurement.



**Table 2**  
**UV Irradiance and Permissible Exposure Times at Face of UVGI lamp**  
**Lanakila Health Center TB Clinic**  
**HETA 2000-0040-2800**  
**December 1999**

<b>Lamp No.</b>	<b>Lamp Location</b>	<b>UV Irradiance (<math>\mu\text{W}/\text{cm}^2</math>)</b>	<b>Permissible Exposure Time (seconds)</b>
1	Outside Nurse Supervisor Office	180	33
2	Consult	210	28
3	Waiting Room #3 (X-Ray)	197	30
4	X-Ray	197	30
5	Storage #3	234	25
6	Reception/Chest	150	40
7	Registry	237	25
8	Waiting #1 (main)	200	30
9	Waiting #2 (triage)	205	29
10	Sputum Room #1	>280*	21*
11	Sputum Room #2	>365*	16*

\* Measurements were made 12" from the lamp face because the UV irradiance level at the face exceeded the instrument's response range of 1000  $\mu\text{W}/\text{cm}^2$ .

**Table 3**  
**UV Irradiance and Permissible Exposure Times at**  
**Specified Distances From UVGI Lamps**  
**Lanakila Health Center TB Clinic**  
**HETA 2000-0040-2800**  
**December 1999**

Lamp No. <sup>*</sup>	Distance From Lamp <sup>†</sup> (feet)	UV Irradiance at Measurement Location ( $\mu\text{W}/\text{cm}^2$ )	Permissible Exposure Time (hours)
1	5.2	0.01	>8
2	5.9	0.005	>8
3	12.5	0.01	>8
	20.8 <sup>‡</sup>	0.006	>8
	21.8	0.15	>8
4	8	0.01	>8
5	7	0.01	>8
6	15.3	0.01	>8
7	11.3	0.01	>8
8	10.3 <sup>‡</sup>	0.02	>8
	17.8 <sup>‡</sup>	0.01	>8
9	10.4	0.02	>8
10	2.2	0.6	2.8
11	2.4	0.6	2.8

\* See Table 2 for corresponding lamp locations.

† Unless otherwise noted, measurements were taken at a height of 4½ to 5' above the floor to correspond with a standing eye height.

‡ Measurements taken at approximately 3½' above the floor.

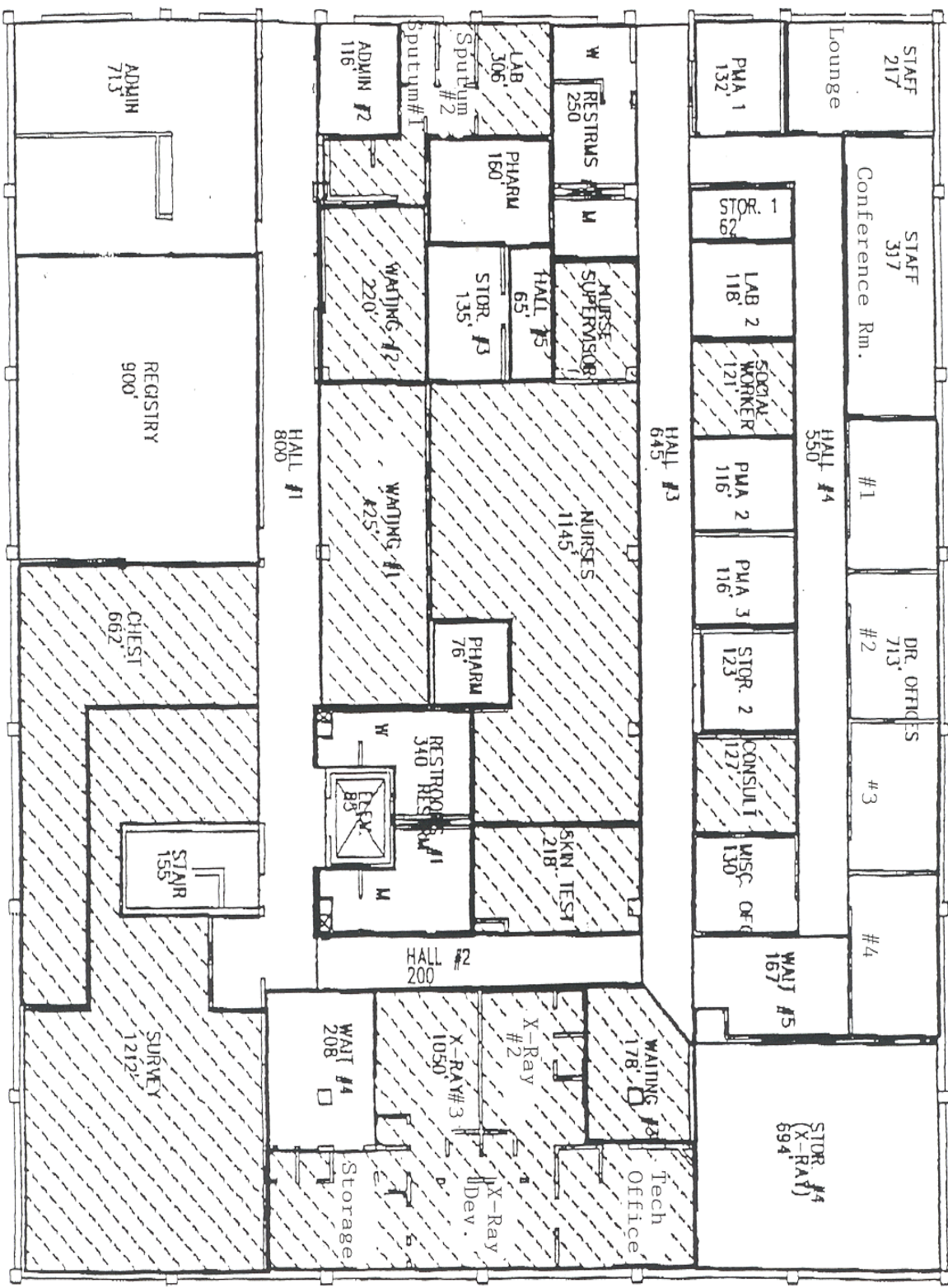


Figure 1. Floor Plan of the Lanakila Health Center TB Clinic.

For Information on Other  
Occupational Safety and Health Concerns

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