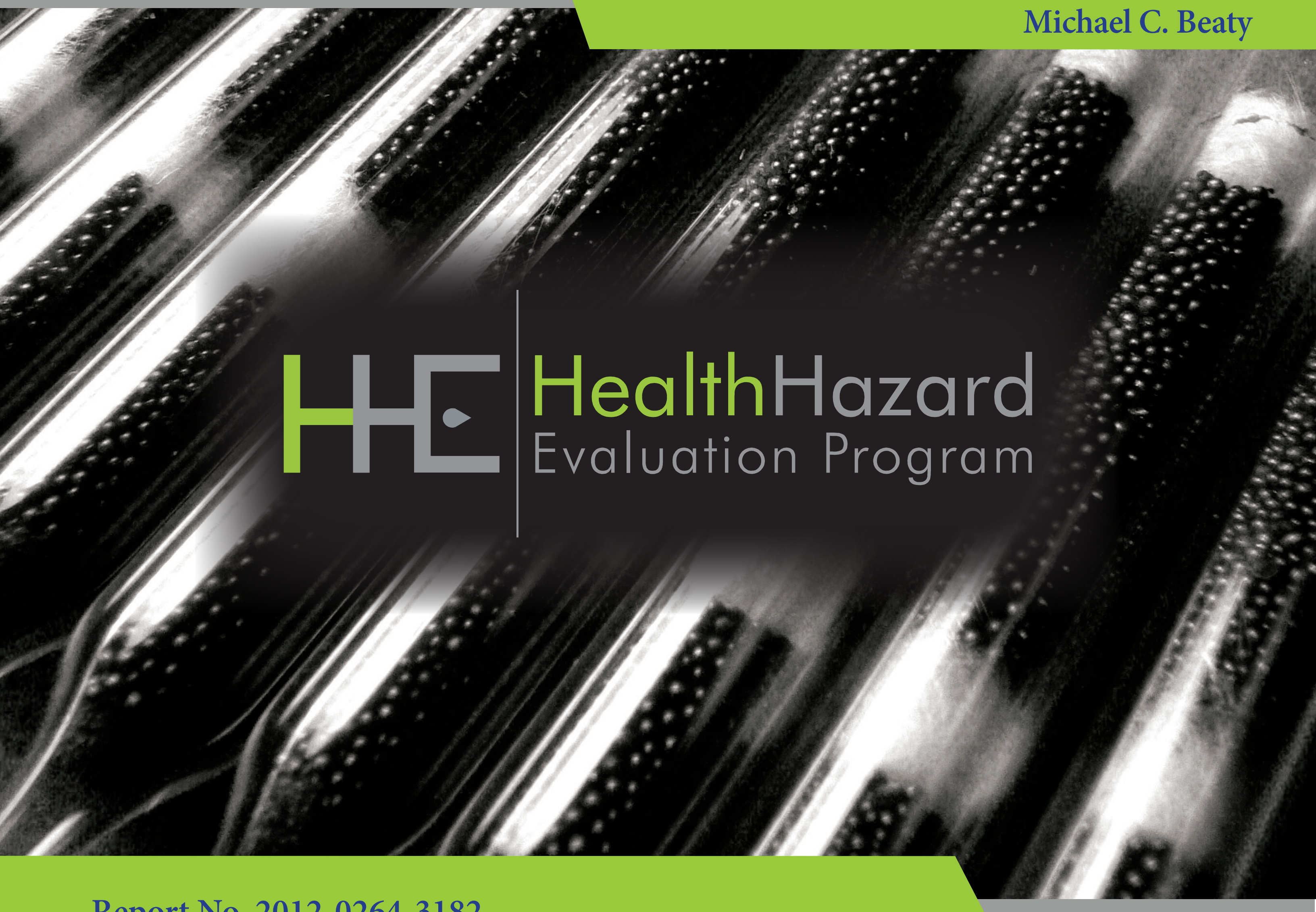
Evaluation of Environmental Controls at a Homeless Shelter Complex (City Rescue Mission–McDuff Campus) Associated with a Tuberculosis Outbreak – Florida

Stephen B. Martin, Jr., MS, PE
Kenneth R. Mead, PhD, PE
R. Brent Lawrence, MS, GSP
Michael C. Beaty



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Contents

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Highlights of this Evaluation

The National Institute for Occupational Safety and Health received a technical assistance request from the Duval County Health Department in Florida. The request asked that we assess the heating, ventilation, and air-conditioning systems and make recommendations to improve overall environmental controls at City Rescue Mission–McDuff Campus, a local homeless shelter complex with epidemiological links to an ongoing tuberculosis outbreak.

What NIOSH Did

- We visited City Rescue Mission–McDuff Campus on August 22, 2012.
- We met with representatives from the Duval County Health Department and City Rescue Mission–McDuff Campus to discuss the ongoing tuberculosis outbreak.
- We recorded the physical sizes of occupied spaces.
- We measured ventilation air flow into/from occupied spaces.
- We collected information on all shelter air-handling units.

What NIOSH Found

- City Rescue Mission–McDuff Campus was working in conjunction with the Duval County Health Department to improve administrative controls to identify guests on priority screening lists or those with symptoms of tuberculosis.
- Air-handling units were generally in good working order, but some had improper filter configurations installed, and one had standing water inside the condensate pan while the AHU itself was sitting in pooled rainwater.
- No fresh outdoor air was being supplied to the occupied spaces by building mechanical systems.
- There was no clearly defined area to separate guests suspected of having tuberculosis from the general guest population.
- A written respiratory protection plan did not exist.
- Most bathroom exhaust fans were not functional.

What City Rescue Mission–McDuff Campus Should Do

- Continue to work with the Duval County Health Department to improve overall administrative controls and help ensure rapid identification of guests suspected to have tuberculosis.
- Develop a comprehensive infection control plan with input from the Duval County Health Department and Florida Department of Health.
- Modify or augment shelter ventilation systems to provide adequate fresh outdoor air to all occupied spaces using a strategy compatible with existing ventilation system capacities.

- Strategically reposition supply and exhaust grill locations to improve air flow patterns in occupied spaces, particularly in the women's overnight bunk area.
- Install the highest efficiency air filters possible that is consistent with the proper operation of the air-handling units.
- Modify at least one family sleeping room in the women's overnight facility for alternate use as a respiratory separation area.
- Develop and implement a written respiratory protection program that meets the requirements of the Occupational Safety and Health Administration's respiratory protection standard 29 Code of Federal Regulations 1910.134.
- Repair or replace non-functional bathroom exhaust fans.
- Develop and implement a written operation and maintenance plan for all complex heating, ventilation, and air-conditioning systems, to include a filter replacement schedule.

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Abbreviations

µm	Micrometer
AHU(s)	Air-handling unit(s)
ACH	Air changes per hour
AII	Airborne infection isolation
ANSI®	American National Standards Institute
ASHRAE®	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CDC	Centers for Disease Control and Prevention
cfm	Cubic feet per minute
CFR	Code of Federal Regulations
DCHD	Duval County Health Department
DRDS	Division of Respiratory Disease Studies
DTBE	Division of Tuberculosis Elimination
FGI	Facility Guidelines Institute
HEPA	High-efficiency particulate air
HVAC	Heating, ventilation, and air-conditioning
ICP	Infection control plan
MERV	Minimum efficiency reporting value
NCHHSTP	National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention
NIOSH	National Institute for Occupational Safety and Health
O&M	Operation and maintenance
OSHA	Occupational Safety and Health Administration
RH	Relative humidity
TB	Tuberculosis

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Summary

In May 2012, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the Duval County Health Department as part of its response to an ongoing tuberculosis (TB) outbreak among homeless persons in Florida. The request asked NIOSH to assess heating, ventilation, and air-conditioning (HVAC) systems and make recommendations to improve overall environmental controls at four homeless facilities with epidemiologic links to past or ongoing TB disease transmission.

During an on-site evaluation of the City Rescue Mission–McDuff Campus homeless shelter complex in August 2012, we collected physical and ventilation measurements in all key areas of the facility. We focused on areas where guests typically congregate or spend significant amounts of time. We recorded the make and model number of all air-handling units (AHUs) providing supply air to the facility, and visually inspected the units. When possible, we measured the air flow rate through supply diffusers and return grilles.

NIOSH investigators conducted an assessment of environmental controls at the City Rescue Mission–McDuff Campus, a homeless shelter complex linked to an ongoing tuberculosis outbreak. The investigation revealed problems with the existing environmental controls, along with needed improvements in administrative controls and respiratory protection. Detailed recommendations are provided in this report to improve the shelter environment and reduce the likelihood of disease transmission.

The ventilation systems in place could have contributed to airborne disease transmission among shelter guests. With the exception of some improper filter configurations and standing water inside one unit, the AHUs appeared adequately maintained and were fully operational. Unfortunately, none of the AHUs provided fresh outdoor air to the occupied spaces, as required by the Florida Building Code and the American Society of Heating, Refrigerating and Air-Conditioning Engineers design standards. In addition to alleviating odors and maintaining occupant comfort, outdoor air serves to dilute infectious aerosols, such as *Mycobacterium tuberculosis* droplet nuclei that are responsible for TB transmission.

Since the TB outbreak began, City Rescue Mission–McDuff Campus has taken numerous steps to improve administrative controls, particularly when it comes to identifying guests showing signs and symptoms of TB. We recommend additional improvements to the administrative and environmental controls at the shelter. From a ventilation standpoint, we suggest that all occupied spaces at the shelter complex are supplied adequate amounts of outdoor air. In addition, we identified areas that could be converted for use as respiratory separation areas. These spaces could serve to separate guests suspected of having TB or other respiratory diseases from the remainder of the guest population, until medical evaluation, transport

or treatment could be obtained. We also recommend developing a written infection control plan, HVAC operation and maintenance plan, and a written respiratory protection program. Having these plans/programs in place will help the shelter under normal operating conditions, and especially during any future outbreaks of respiratory disease.

Keywords: NAICS 624221 (Temporary Shelters), tuberculosis, environmental controls, ventilation, homeless shelter, airborne infection, airborne transmission, respiratory

Introduction

Since 2004, the Duval County Health Department (DCHD), in conjunction with the Florida Department of Health and U.S. Centers for Disease Control and Prevention (CDC), has linked over 100 cases of active tuberculosis (TB) disease, resulting in 14 deaths, to a cluster having matching genotype results (PCR00160 or FL0046) in Duval County, Florida. Roughly half of the cases of active TB disease have been identified since 2010. Of the 100 cases, 79% had a history of homelessness, incarceration, or substance abuse, with 43% being homeless within one year of diagnosis.

In response to the ongoing outbreak, a team of epidemiologists from the CDC National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention (NCHHSTP), Division of Tuberculosis Elimination (DTBE) conducted an on-site investigation in February and March 2012. In their report dated April 5, 2012, the CDC team included a recommendation to improve environmental controls at homeless facilities implicated in possible disease transmission. On May 22, 2012, the Division of Respiratory Disease Studies (DRDS), National Institute for Occupational Safety and Health (NIOSH), CDC received a request for technical assistance concerning the TB outbreak in Duval County. The request was made by a CDC Public Health Advisor temporarily assigned to Duval County. The request specifically asked NIOSH to evaluate shelters' heating, ventilation, and air-conditioning (HVAC) systems and make recommendations to improve overall environmental controls. The request was initially made for an assessment at one homeless shelter. However, in subsequent discussions with the TB Program Manager at DCHD, a CDC Public Health Advisor with the Florida Department of Health, and representatives from CDC/NCHHSTP/DTBE, the request was expanded to include four facilities that provide assistance to the homeless and which had epidemiologic links to past or ongoing TB disease transmission.

In response to the expanded request, a NIOSH team visited the four facilities in August 2012. This report describes the measurements and associated findings from our assessment at the City Rescue Mission–McDuff Campus. It details and prioritizes our recommendations for improving environmental controls at the shelter, and outlines the current plan for future NIOSH involvement.

Background

Tuberculosis and Homeless Populations

TB is a disease caused by *Mycobacterium tuberculosis* (*M. tuberculosis*) bacteria. When a person with active TB disease coughs or sneezes, tiny droplets containing *M. tuberculosis* may be expelled into the air. Many of these droplets dry, and the resulting residues remain suspended in the air for long periods of time as droplet nuclei. If another person inhales air that contains the infectious droplet nuclei, transmission from one person to another may occur. Homeless people have been identified as a high-risk population for TB infection and disease since the early 1900s [Knopf 1914]. With the increase in homelessness in the United States since the 1980s, TB among homeless persons has become a subject of heightened interest and concern [CDC 1985; 1992; 2003a,b; 2005a; Barry et al. 1986; Slutkin 1986; McAdam et al. 1990; Nolan 1991].

City Rescue Mission–McDuff Campus

The City Rescue Mission–McDuff Campus is located on the former campus of Trinity Baptist College. The campus houses the administrative offices for City Rescue Mission, which serves nearly 300,000 meals a year and provides the homeless with clothing, emergency services, residential recovery, and skills and employment programs. It is also the primary location for the mission's New Day Workforce and LifeBuilders programs. The New Day Workforce Program offers job-related training to assist shelter guests in obtaining employment. Computer training, academic tutoring and many other individualized services are available. The LifeBuilders program is a faith-based, 15-month residential recovery program to ultimately enable participants to relearn how to care for themselves and their families. Men and women enrolled in the LifeBuilders program reside on McDuff Campus. Participants of the LifeBuilders program join in a variety of education and recovery services. Upon entering the program, participants receive an evaluation and a recommended program plan based on the individual's needs. While enrolled in the program participants are provided food, shelter, clothing, housing, medical care, and optional legal services. The LifeBuilders program also provides life skills training, course work leading to GED, and literacy programs. Approximately 75 staff members work at the McDuff campus. Of those, about 30 have routine contact with the guests residing there.

The campus consists of a four-story brick administration building, two separate buildings where men and women sleep, a two-story brick chapel, and several free-standing cottages. The chapel and free-standing cottages were not assessed as part of the NIOSH visit. The administration building is equipped with four central AHUs, each providing ventilation to one floor of the building. Supply air from each AHU travels through fiberglass-wrapped, galvanized ductwork to supply vents in the occupied spaces. There are no return grilles in most of the evaluated occupied spaces. All return air travels back to the AHUs via plenum space above the drop ceilings. Return air migrated into the plenum space via loose ceiling tiles and around light fixtures. Some spaces had return air grilles (e.g., first floor assembly/dining room), other dedicated return air paths into the plenum may have been present within administrative and other areas not accessed as part of this survey. The plenum spaces for all four floors feed a common vertical chase that extends to all four AHUs, so return air from one floor may be recirculated by an AHU on another floor. The first floor of the administration building houses the main reception area with a dining room, kitchen, and hospitality room on one side, and a medical clinic and chiropractic clinic on the other. The second floor houses staff offices and a large board room. Women participating in the LifeBuilders program live on the third floor of the building. The third floor has 16 separate living spaces, with bathroom and shower facilities, a fellowship room, a laundry room, and an exercise room. Each living space can house up to 3–4 women, if necessary. There were 24 women housed on the floor during the NIOSH visit. The fourth floor of the administration building contains additional staff offices, four classrooms, two computer laboratories, and a small library.

The one story brick women's sleeping facility was recently renovated to shelter women needing an overnight stay. The women are checked-in and screened at the New Life Inn in another part of town, prior to being transported to McDuff Campus for the night. Most of the interior space houses a large barracks-style sleeping area with 21 bunk beds (42 total beds) and an associated bathroom/shower facility. Women without children sleep in this bunk area. To accommodate women with children, the building has four individual family sleeping rooms with two bunk beds in each. The family sleeping rooms all share a separate bathroom/shower area. Two central AHUs installed in the ceiling plenum above the drop ceiling provide ventilation to this building. Supply and return air travel through galvanized and fiberglass flex duct to/from supply vents and return grilles. The building housing the women's sleeping facility also contains a small dental clinic, which was closed during our visit. From the outside, the dental clinic appeared to be ventilated by two recirculating window-type air-conditioners.

The men's sleeping area consists of a single-story brick building that formerly served as two small street-front stores. There are no windows in the building. The structure houses 23 bedrooms, four bathroom/shower rooms, two lounge/prayer areas, a large recreation room, and a weight room. Each bedroom in the building sleeps up to four men in bunk beds, and approximately 65 men are housed in the facility at a time. The men living in this facility are in the final 12 months of the LifeBuilders program, having completed the first 3 months of the program at a City Rescue Mission shelter in another part of Jacksonville. Two central AHUs serve the building. Supply air travels through galvanized and fiberglass flex ductwork to vents in the occupied spaces. The central AHUs use the corridors as a return air plenum. No functional return grilles exist in the rooms/occupied spaces, so return air travels through cracks and leaks into the hallways and through the hallways towards large return air grilles which transmit the return air directly back to each AHU.

Assessment

On August 20, 2012, an opening meeting was held at the Duval County Health Department. An update was given on the current status of the ongoing TB outbreak among the homeless population, and we provided background information on NIOSH, the nature of the technical assistance request, and the ventilation measurements we planned to collect at each facility.

Aside from NIOSH and DCHD staff, representatives from McDuff Campus and two of the three other homeless facilities to be visited during the week were in attendance.

We arrived at City Rescue Mission–McDuff Campus on Wednesday, August 22, 2012 and signed into the building. After we unloaded our equipment, the program operations manager provided us with all available floor plans of the campus and led us on a tour of the entire facility. After the tour, we began taking physical and ventilation measurements in all key areas. We focused on areas where guests typically congregate or spend significant amounts of time, but measurements were taken throughout the administration building (excluding the second floor where only staff offices are located), women's overnight sleeping facility (excluding the dental clinic that was closed during our visit), and the men's sleeping facility. We did not collect measurements in the chapel or the cottages on the premises during our visit.

We recorded the make and model number of air-handling units (AHUs) providing supply air to occupied spaces, and we visually inspected all of the units. When possible, we measured the air flow rate through supply diffusers and return grilles using a TSI Incorporated (Shoreview, Minnesota) Model 8373 Accubalance Plus equipped with an air capture hood appropriately sized to accommodate each supply diffuser and return grille. The Model 8373 measures volumetric air flow rates of 30–2000 cubic feet per minute (cfm) with an accuracy of ±5% of the reading and ±5 cfm. The Accubalance Plus is also equipped with a directional air flow indicator that provides confirmation of flow direction. We determined the approximate internal volume of the measured spaces with either a standard tape measure or a Zircon Corporation (Campbell, California) Model 58026 LaserVision DM200 laser distance measuring device. The device accurately measures up to 200 feet and has function keys for calculating the area and volume of a room for HVAC load formulas. When the existence of air flow or the air flow direction was questioned, we used a Wizard Stick hand-held fog generator (Zero Toys, Concord, Massachusetts) to confirm and visualize the air flow pattern.

After recording our measurements, we met briefly with the McDuff Campus programs operations manager on August 22, 2012, to discuss our general findings from the day's assessement. A formal closing meeting for our on-site response to the technical assistance request for all four facilities was held on August 23, 2012, at the DCHD. This meeting provided us an opportunity to discuss our general findings with representatives from the Duval County Health Department.

Results and Discussion

General Tuberculosis Infection Controll

All tuberculosis control programs should include three key components: administrative controls (e.g., intake questionnaires and policies), environmental controls (e.g., ventilation and filtration), and a respiratory protection program. Ideally, environmental controls and respiratory protection should supplement aggressive administrative controls. Detailed explanations for each of these key control elements, as well as a discussion on the hierarchy of their implementation, are outlined in CDC's *Guidelines for Preventing the Transmission of* Mycobacterium tuberculosis *in Health-Care Settings, 2005 and Prevention and Control of Tuberculosis in Correctional and Detention Facilities: Recommendations from CDC* [CDC 2005b, 2006]. In high risk environments, such as homeless shelters, or in areas where administrative controls alone are inadequate, environmental controls and respiratory protection should be used as secondary and tertiary levels of control, respectively.

Administrative Controls

During our visit, and in previous conversations with representatives from DTBE, the Florida Department of Health, DCHD, and McDuff Campus, it was apparent that limited TB administrative controls were in place at the shelter complex prior to the current disease outbreak. However, efforts were taken to improve the overall administrative controls in place at the time of the site visit. Employees and volunteers were trained on the symptoms of TB disease and prevention of TB transmission. Additionally, intake screening procedures are now in place to help identify guests on target screening lists, or others suspected of having TB, and refer them to DCHD for critical medical screening. These procedures will help identify infected individuals more rapidly in the future and serve to help keep infected guests away from those that are healthy.

We cannot overstate the importance of having robust administrative controls in place. As with most homeless facilities, McDuff Campus frequently provides services to large numbers of guests in very close proximity to one another. This is particularly the case in the administration building's first floor dining room and the third floor women's LifeBuilders sleeping areas, the women's overnight sleeping area, and the men's facility. Even the best ventilation systems are incapable of totally preventing the spread of disease between guests who are close to one another. Thus, identifying people with suspected disease, keeping them separated from the general guest population, and following up with appropriate medical evaluations and treatment (if necessary) are the most important elements of reducing or eliminating the spread of disease. While enhancing administrative controls is a significant step, the development of a written TB Infection Control Plan (ICP) for the campus should be considered. At the time of the NIOSH investigation, no such ICP was reported to exist. Information on creating detailed ICPs and TB ICP templates for homeless shelters can be found at the Curry International Tuberculosis Center website at http://www.currytbcenter.ucsf.edu/. Collaborating with DCHD and the Florida Department of Health would serve to further strengthen the written plan. These ICPs are particularly useful when overall TB infection control requires the coordination and subsequent follow-up of different agencies. In response to this current TB outbreak, there was good communication and coordination between McDuff Campus and DCHD. However, the process should be formally documented in a protocol or checklist format. This ensures that each time there is a TB-related incident, all necessary agencies understand their responsibilities and perform their necessary predetermined actions in a consistent manner. Incorporating the input of staff involved in the maintenance and operation of facility ventilation systems into the overall infection control program strengthens the program and provides these staff members with additional insight as to what ventilation requirements are necessary to prevent and/or isolate TB disease. Input from the ventilation staff should be sought during the formal creation of the ICP and during subsequent revisions to the plan.

Environmental Controls

General Ventilation System Information

General information on the AHUs in the assessed areas of McDuff Campus, including the areas served by each unit, is provided in Table 1. None of the AHUs delivered fresh outdoor air into the buildings. All AHU air filters are reportedly changed monthly and were replaced just prior to the NIOSH visit. As shown in Table 1, all four AHUs in the administration building had filter sizes/configurations that differed from manufacturers' recommendations. While the filters in place provided some filtration, the level was uncertain as the deviation from intended design provides ample opportunity for filter failure and bypass. We were unable to safely determine if filters were in place in the two AHUs serving the women's overnight facility. However, there were low-efficiency filters in place inside the return air grille openings leading back to each of the AHUs. If filters are correctly in place inside the AHUs, the filters in the return air grilles would provide some improved level of filtration. On the other hand, if proper filters are not installed inside the units, then overall filtration is less than preferred. Figure 1 shows the filters in the return air grille for AHU Women-1 which serves the women's overnight bunk area. The photograph clearly shows the filters have been pulled out of proper position due to the suction of the AHU fan. A similar effect, though not as severe, was noticeable with filters inside the return air grille back to AHU Women-2. If adequate filters are also installed inside the AHUs, this bypass is not of major concern. If the AHUs are not equipped with filters, those in the air return grilles should be removed and proper filters installed in the AHUs themselves. The two AHUs serving the men's facility were both equipped with filters, although the recommended configuration for AHU Men-2 was unknown because a model number for the unit could not be determined.

The mechanical spaces housing the AHUs in the administrative building were generally clear and free of clutter. On the day of our visit, all of the inspected AHUs were operational and capable of maintaining temperature and air flow. However, there was a substantial amount of standing water inside AHU Men-2 (Figure 2). Additional water was pooled outside of the unit. It was unclear whether the standing water inside the AHU resulted from normally-occurring condensate inside the unit or whether the pooled rainfall surrounding the outside of the AHU was leaking into the pan or perhaps interfering with the condensate pan's ability to drain. Whatever the reason, there should never be standing water inside an AHU so the issue needs to be resolved. Excess moisture inside an AHU is a recognized contributor to the development of microbial growth of public health concern [NIOSH 2013]. Proper sloping of condensate drain pans and clean unobstructed drain lines should eliminate these moisture accumulation problems.

Filtration

All of the ventilation filters used at McDuff Campus were Flanders Corporation (Washington, North Carolina) *Pre Pleat* 40 LPD pleated filters. The *Pre Pleat* 40 LPD filters have an American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Minimum Efficiency Reporting Value (MERV) of 8, which corresponds to a removal efficiency of greater than 70% for 3.0 to 10 micrometer (μm) particles [Flanders 2011; ANSI/ASHRAE 2007]. However, MERV 8 filters are only around 25% efficient at filtering particles in the 1.0–3.0 μm size range, which includes droplet nuclei responsible for *M. tuberculosis* transmission [ANSI/ASHRAE 2007].

To prevent the spread of *M. tuberculosis,* air filters should provide a removal efficiency of greater than 90% of particles in the 1.0-3.0 µm size range (corresponding to a MERV 13 or higher). During any future HVAC design modifications, system evaluations, or retrofits, the selection of filters for use in the AHUs, especially those serving the three main overnight sleeping areas, should be closely examined. Care should be taken when choosing more efficient filters, because increased efficiency is typically associated with increased pressure drop across the filter (resistance to air flow). Filters in the AHUs should have the highest possible efficiency (i.e., highest MERV rating) while still maintaining the air flow required for conditioning and outdoor air supply through each system.

<u>Preventive Maintenance</u>

The ventilation system preventive maintenance program at McDuff Campus was coordinated by the facilities manager. With the exception of the filter bypass issue with AHUs Women-1 and Women-2, and the condensate/flooding issue with AHU Men-2, all of the AHUs were fairly clean and appeared to be adequately maintained. The facilities manager informed us that the ventilation filters are changed monthly. Unfortunately, there is no written plan outlining the preventive maintenance schedules and procedures for HVAC systems. A written HVAC Operation and Maintenance (O&M) Plan should be developed. Currently, all preventive and emergency maintenance is managed, scheduled, and coordinated by the facilities manager. Actual tasks are performed by staff, volunteers or contractors, depending upon complexity. While this seems to be effective at the present time, there could be a void if the facilities manager leaves his current position or is unavailable for any significant period of time. Combining all maintenance tasks, schedules, procedures, and training requirements into a written plan would ensure that all equipment is properly maintained at appropriate time intervals and that any emergency maintenance issues are addressed correctly. A detailed plan would also ensure that the quality of work remains consistent as staff changes. Once developed, this written plan should be revised periodically to be current with any ventilation system and equipment modifications at the facility.

<u>Ventilation Measurements and Indoor Air Quality</u>

An adequate supply of outdoor air, typically delivered through the HVAC system, is necessary in any indoor environment to dilute pollutants that are released by equipment, building materials, furnishings, products, and people. In the State of Florida, the 2010 *Florida Building Code* mandates “minimum requirements to safeguard the public health, safety and general welfare through structural strength, means of egress facilities, stability, sanitation, adequate light and ventilation, energy conservation, and safety to life and property from fire and other hazards attributed to the built environment and to provide safety to fire fighters and emergency responders during emergency operations [ICC 2011].” The *Florida Building Code* applies to the “construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, location, maintenance, removal and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures” throughout the state. The Code is based on a variety of model building codes and consensus standards from national organizations, which have been modified to fit Florida’s specific needs, when necessary. When it comes to ventilation standards, in most cases, the *Florida Building Code* has adopted the recommendations published in *American National Standards Institute*

(ANSI)/ASHRAE Standard 62.1-2010: Ventilation for Acceptable Indoor Air Quality. These ASHRAE recommendations provide specific details on ventilation for acceptable indoor air quality [ANSI/ASHRAE 2010a].

The 2010 *Florida Building Code* and ASHRAE 62.1-2010 recommend outdoor air supply rates that take into account people-related contaminant sources as well as building-related contaminant sources. Similarly, exhaust air flow rate requirements for some spaces are also listed. Although there are no specific guidelines for homeless shelters and related facilities, there are published guidelines applicable to McDuff Campus. These outdoor air supply and exhaust air requirements are summarized in Table 2. Table 2 also lists the default occupant densities for various spaces. These default values, given in terms of number of occupants per 1000 square feet, are provided by the *Florida Building Code* and ASHRAE to assist building and HVAC system designers when actual occupant densities are unknown. Although actual occupant densities for the occupied spaces inside McDuff Campus facilities are generally known, the default values still serve as a reference to determine whether the occupant density in a given space is higher or lower than what is considered typical.

The physical and ventilation measurements collected are presented in Table 3. The second-to-last column of the table presents the actual occupant densities in each space. Values preceded by an asterisk (*) denote areas with occupant densities above typical values (i.e., higher than the default values presented in Table 2). High occupant densities are not solely indicative of ventilation problems. For instance, the sitting rooms off rooms F3 and F10 on the third floor of the administration building with high densities are typically only occupied by two people at a time. In these cases, the occupant densities are high simply because the sitting rooms are smaller than typical living rooms. However, the overnight bunk area and all four family sleeping rooms in the women's overnight facility show high occupant densities because many people actually sleep in close proximity to one another. In these cases, special consideration should be given to air flow patterns in the spaces to minimize the potential of exhalations from one person passing through the breathing zone of multiple other people. This is especially true when airborne disease transmission is a concern.

The last column in Table 3 presents the outdoor air requirements for each space, as established by the 2010 *Florida Building Code* and ASHRAE. As previously noted, none of the AHUs at McDuff Campus were delivering fresh outdoor air into any of the assessed buildings. In individual cases, an existing AHU may not have the tempering capacity to incorporate the introduction of outdoor air. If such capacity is available, introducing outdoor air through the AHUs would require some modifications and would result in increased annual energy costs. However, it is important to ensure that all occupied spaces at McDuff Campus are receiving adequate amounts of fresh outdoor air to reduce the potential for airborne disease transmission and to improve indoor air quality. In addition to alleviating odors and better maintaining occupant comfort, outdoor air serves to dilute infectious aerosols, such as *M. tuberculosis* droplet nuclei.

Two common approaches could be employed by McDuff Campus to introduce outdoor air into the occupied spaces (or a combination of the two). The first approach would be to make the necessary modifications to the existing AHUs to allow them to bring in the required outdoor air. This would initially require evaluation, by a knowledgeable HVAC engineer (a reputable ventilation or engineering design contractor that is familiar with ASHRAE, Facility Guidelines Institute (FGI), and CDC guidelines and recommendations), of each AHU's conditioning capacity to determine if it can handle the additional tempering and dehumidification burden introduced by the outdoor air. The AHU system modifications would require the installation of outdoor air intakes and dampers into each mechanical space housing an AHU. Depending upon the age/condition of some of the AHUs, replacement of an older AHU could be a cost-effective contribution to this approach. Although this may be the simpler of the two solutions and could require the least capital expense, it may cost significantly more in energy over time. In their current configurations, the AHUs are simply recirculating air that is relatively close to the desired indoor temperature and humidity conditions. After circulating through the occupied space, this air requires less conditioning to return it to the desired delivery temperature and humidity levels. Once outdoor air is mixed in with the room return air, the mixed air stream introduced to each AHU will be further from the desired indoor conditions for most of the year. Each AHU will then need to work harder to dehumidify and temper the mixed air stream.

A second common method of bringing outdoor air into the buildings would be to install dedicated outdoor air systems. This would involve installing a completely new AHU with ductwork extending to all occupied spaces of the administration building, with separate dedicated outdoor air systems for the men's and women's facilities. For the administration building, the new AHU should be sized to provide adequate outdoor air flow for the entire building (approximately 2500–3000 cfm) while also providing the entire capacity to temper and dehumidify this outdoor air. Similarly, the new AHUs for the men's and women's facilities would need to provide around 650 cfm and 450 cfm of outdoor air, respectively. Each new AHU should provide tempered and dehumidified (supercooled to 45°F–50°F dew point) outdoor air to each space (or existing AHU) in quantities necessary to meet *Florida Building Code* and ASHRAE outdoor air requirements. Terminal reheating or blending of this air with air delivered by the primary AHUs may be necessary to prevent thermal discomfort from the supercooled outdoor air. Conversely, multiple smaller dedicated outdoor air systems could serve the same purpose as one large system for a particular building. Regardless of how it is accomplished, the major advantage of the dedicated outdoor air systems is that they would not require major modifications to the existing AHUs, which would simply continue to recirculate air through the spaces they serve while providing air filtration, heating and cooling. The dedicated outdoor air systems would certainly require more capital expense and more excessive renovations for the required ductwork than the first option, but it could also provide significant energy cost savings, making it a more viable long-term solution.

A knowledgeable HVAC engineer should be consulted to discuss these and other potential options for introducing outdoor air into the McDuff Campus buildings. Although we did not access the small dental clinic in the same building with the women's sleeping facility, it appeared from the outside that the space is ventilated by two small window-type air-conditioners (assuming that both were functional). These units did not appear to provide outdoor air to the dental clinic. Various dental procedures have been identified as likely to produce aerosols, including potentially infectious bioaerosols. The dentist and any patients waiting for treatment in that space could potentially be exposed to infectious aerosols. Although there are currently no national or state consensus standards for ventilation of dental clinics, it is essentially analogous to a medical exam room. Therefore, the dental clinic should be provided with at least 6 total air changes per hour (ACH) and at least 2 ACH of fresh outdoor air [ASHRAE/ASHE 2008]. Additionally, if one does not already exist, an exhaust fan should be installed to maintain the clinical space under negative pressure any time dental procedures are being performed. Additional air cleaning through the use of engineering controls (e.g. portable high-efficiency particulate air (HEPA) filtration units and directional airflows) may also be desired due to the potential for higher TB disease risk among patients seen at this clinic. There are special design precautions that apply to the safe storage, delivery and recovery of nitrous oxide if it is used as an analgesic/anesthetic gas in this clinic. NIOSH engineers can provide additional guidance upon request.

The CDC TB Guidelines specifically address the issue of potential TB exposures within dental settings. As with other exposure settings, the key protective factor is prompt and accurate screening. For a patient with suspected or confirmed TB disease, non-urgent dental treatment should be postponed and these patients should be promptly referred to an appropriate medical setting for evaluation of possible infectiousness. If urgent dental care must be provided for a patient with suspected or confirmed infectious TB disease, the dental care should be provided in a setting that meets the requirements for an Airborne Infection Isolation Room (AII room) as prescribed in the CDC TB Guidelines [CDC 2005b] and respiratory protection (at least an N95 particulate filtering facepiece respirator) should be used while performing procedures on these patients.

While working to incorporate outdoor air into the occupied spaces at McDuff Campus, consideration should be given to optimizing air flow patterns to reduce the potential of airborne disease transmission between guests. The air flow pattern is important in any occupied space, but it is particularly important in the women's overnight bunk area. These guests are not integrated into City Rescue Mission programs so their backgrounds and medical status may be unknown. While even the best ventilation system cannot guarantee preventing disease transmission between people in close proximity to one another, improving air flow patterns could help reduce the overall transmission potential among guests in each sleeping area. In the women's overnight bunk area, one way that air flow patterns could be improved is to supply all air (fresh and recirculated) above the aisles between rows of beds using supply diffusers designed to discharge the air in a wide, downward deflected angle. At the same time, return grills should be installed low in the walls or in the ceiling along both outside walls of each space, parallel to the rows of beds. In this arrangement, supply air will generally pass over/across each bed and directly back to the AHU. This will reduce the potential of exhalations from one person passing through the breathing zone of multiple other people sharing the space. A qualified HVAC/ventilation engineer might recommend other air flow schemes that could be similarly effective at providing adequate ventilation while minimizing the potential for disease transmission. The final chosen design scheme should be smoke tested to verify performance.

We noticed additional issues affecting air flow patterns in other spaces as well. While a single supply vent and one return grille is appropriate in each of the family sleeping rooms, short-circuiting of air is a concern in these spaces as they are currently configured. As an example, Figure 3 shows the supply vent and return grille in the ceiling of family sleeping room #1. The close proximity of the supply to the return can easily result in short-circuiting of air, where supply air is immediately pulled into a return grille without providing any useful ventilation to room occupants. To alleviate this concern, the distance between the supply vent and return grille should be maximized to the extent possible. The other three family sleeping rooms had similar ventilation designs.

Several rooms in the men's facility illustrated another issue, common in homeless shelters, that adversely affects air flow patterns and overall ventilation effectiveness. Figure 4 shows the supply vent in room #9 of the men's facility covered with cardboard and tape. This is normally done for occupant comfort, but it clearly affects the ventilation air flow in room #9. However, it also affects ventilation air flow in surrounding areas since the air that would typically be delivered to room #9 is redirected elsewhere. This redirected air can help lead to occupant discomfort in surrounding spaces, which results in guests choosing to restrict supply air flow in their living spaces as well. Thus, the problem is compounded. This was the case in the men's facility during our visit, as we noticed blocked or restricted supply vents in several other rooms in addition to room #9. Once updated ventilation systems are installed and balanced to introduce outdoor air into each space, restricting or blocking of supply vents and return grilles should be prohibited. If supply air blowing on room occupants is still an issue, supply vents designed to alter the air throw pattern while still providing the prescribed air flow could be chosen.

We also noticed that several bathroom and shower exhaust fans were not operational during our visit (see Table 3). To control humidity and odors, bathrooms and shower areas should exhaust more air than the AHU is supplying. This will maintain these areas under negative pressure. Separate exhaust fans should be used to exhaust air directly outside at least 25 feet from any air intakes, there should be no recycling or re-entrainment of return/exhaust air from the bathrooms and shower rooms. For high occupancy public bathrooms, 50 cfm of exhaust per toilet/urinal is recommended. For private toilets in bathrooms intended to be occupied by only one person at a time, ASHRAE 62.1-2010 specifies that the exhaust ventilation should be 25 cfm if the exhaust fan is designed to operate continuously (the *Florida Building Code* only requires 20 cfm) or 50 cfm if the exhaust fan only operates during periods of occupancy (e.g., exhaust fan controlled by a wall switch). All bathroom and shower exhaust fans should be made functional with their exhaust rates verified for compliance with the 2010 *Florida Building Code*, and they should be operational any time the rooms are occupied. [Note: The kitchen hood exhaust system was not evaluated at the time of the NIOSH site visit due to ongoing meal preparation activities. This exhaust was reportedly paired with its own makeup air system. Neither of these systems is discussed within this report.]

While not a major concern from an airborne disease transmission standpoint, temperature and relative humidity (RH) affect the perception of comfort in an indoor environment. The perception of thermal comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperature. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. ANSI/ASHRAE Standard 55-2010: Thermal Environmental Conditions for Human Occupancy specifies conditions in which 80% or more of the occupants are expected to find the environment thermally acceptable [ANSI/ASHRAE 2010b]. Assuming slow air movement and 50% RH, the operative temperatures recommended by ASHRAE range from 68.5°F –76°F in the winter, and from 75.5°F – 80.5°F in the summer (see Table 4). The difference between the two temperature ranges is largely due to seasonal clothing selection. ASHRAE also recommends that RH be maintained at or below 65%. The U.S. Environmental Protection Agency recommends maintaining indoor relative humidity between 30–50% because excessive humidity can promote the growth of microorganisms [EPA 2012]. Temperature and RH levels were not recorded during our visit because the main guest spaces were generally unoccupied. Regardless, we recommend maintaining the indoor temperature and RH levels within the ranges established by ASHRAE to provide the most comfortable environment to guests at McDuff Campus. Meeting the 30–50% RH recommendation would be significantly easier if a dedicated outdoor air system is installed to introduce conditioned outdoor air to the shelter, as explained above.

Respiratory Separation Areas

Currently, McDuff Campus does not have areas set aside for separating guests suspected of having TB or other respiratory diseases from the remainder of the guest population. Rapidly identifying people with suspected TB disease and keeping them separated from others until appropriate medical evaluations and treatments are initiated is one of the most important elements in reducing or eliminating the spread of airborne disease. The men and women enrolled in the LifeBuilders program are full-time residents of McDuff Campus, so their backgrounds and medical statuses are known. This is not necessarily the case for guests staying in the women's overnight facility. Ideally, potential or suspect TB-positive cases would be identified during the intake screening process conducted at the New Life Inn, but, inevitably, some cases may slip through the screening process. As such, we strongly recommend identifying an area in the women's overnight facility that can be used for respiratory separation when needed. It is important to recognize that respiratory separation is not an alternative to medical evaluation. Rather, it is proposed to be a temporary holding area for guests awaiting transport for medical evaluation. It may also be used to house guests exhibiting signs of respiratory distress without having disease. When respiratory separation is not required, the area can be used for normal guest housing or other purposes.

A respiratory separation area is not intended to be equivalent to an airborne infection isolation (AII) patient room found in hospitals and other healthcare settings. However, it can be designed using some of the same protective concepts, namely negative room pressure and elevated ventilation rates. The respiratory separation area should be maintained under negative pressure relative to the adjacent spaces. This means that air from outside the respiratory separation area should migrate inwards into the respiratory separation area and not in the opposite direction. This is easily maintained by exhausting more air from the respiratory separation area than is being supplied. Operable windows, either within the respiratory separation area or in adjacent areas, should not be allowed to interfere with this intent. Negative pressure helps reduce the potential that any guest housed in the respiratory separation area with active TB disease (or any other disease where airborne infection is a concern) could expose other healthy individuals in adjacent areas. In addition to maintaining negative pressure, all return air from the respiratory separation area should preferably be exhausted directly outside. In no circumstances should air from the respiratory separation area be allowed to re-infiltrate the building or go back through the AHU without first having passed through a high-efficiency particulate air (HEPA) filter.

For true AII rooms in healthcare facilities, the CDC and the FGI recommend a differential pressure of >0.01 inches of water gauge (2.5 Pascals [Pa]) across the closed door between the isolation area and adjacent areas [CDC 2005b; FGI 2010]. Although the minimum pressure difference needed for maintaining air flow into a room is quite small (about 0.001 inches of water gauge), the higher prescribed pressure differential is easier to measure and maintain as the pressure in surrounding areas changes due to the opening and closing of doors, ventilation system fluctuations, and other factors. The FGI and CDC also recommend a total of 12 ACH through the isolation room (CDC allows 6 ACH for existing AII rooms) and at least 2 ACH of fresh outdoor air. True AII rooms are designed to house individuals with confirmed respiratory disease. A respiratory separation area at McDuff Campus would not be used to house guests with confirmed disease, so it would not be necessary to meet the strict air flow and differential pressure requirements detailed above. However, knowledge of the AII design strategies could be useful in designing a respiratory separation area. It is vastly more important to establish a negative pressure area that can be used for respiratory separation than it is to focus on the respiratory separation area meeting quantitative ventilation requirements.

During our visit, we identified family sleeping rooms #3 and #4 as areas that might be converted to effective respiratory separation areas. At least one of these rooms should be upgraded to serve this purpose. All four of the family sleeping rooms receive and return air to AHU Women-2, and in addition to the family bathroom, the family sleeping rooms are the only areas served by AHU Women-2. One or more of these rooms could be converted for respiratory separation by 1) installing a solid, sealed ceiling in place of the existing drop ceiling or ensuring the walls for the selected room extend to the hard ceiling above the current drop ceiling, 2) installing a new exhaust fan through the outside wall of each selected room to provide the required exhaust air flow, and 3) installing tight-closing dampers (or some other mechanism) to completely seal all existing air returns from each selected room to AHU Women-2. Choose an exhaust fan that is capable of maintaining the room under negative pressure relative to the adjacent corridor with minimal noise. These fans could be mounted directly in the wall or on the roof with ductwork running through the wall and up to the fans on the outside of the women's overnight facility. It is imperative that exhaust air from these new fans is directed away from all future AHU air intakes and gathering areas outside the building.

For the spaces selected for respiratory separation, the newly installed return air dampers should be sealed to prevent air from inside the room returning to AHU Women-2. The new exhaust fan should also be activated to maintain the space under negative pressure. For the majority of the time, when respiratory separation is not required, the room can be used as normal by shutting down the exhaust fan and reopening the return air dampers back to AHU Women-2. While it would be prudent to verify prior to any system renovations, AHU Women-2 should be able to self-balance if the return air grille from one of the suggested family sleeping rooms is blocked (when the room is used for respiratory separation). If not, additional ventilation modifications may be required to ensure that AHU Women-2 has an adequate supply of return air during periods when the rooms are simultaneously used for respiratory separation (and the normal return air paths from the rooms are blocked). To provide the AHU with the required return air flow, an alternative return air duct/damper system could be installed to pull air from an adjacent space. Care should be taken when choosing the alternative air return location so undesirable pressure relationships and air flow patterns do not result when the system is in operation.

For any respiratory separation area, a written plan for testing and operating the space is recommended. At McDuff Campus, a detailed written plan should be developed for the rapid conversion of the room from standard family sleeping area to use for respiratory separation. The plan should include contingency plans for moving the guests currently housed in the space to other locations, steps for cleaning and refurnishing the area for separation purposes, and step-by-step procedures for shelter staff to follow to effectively initiate respiratory separation.

All respiratory separation areas should be visually tested daily to ensure negative pressure is being maintained while the area is occupied for separation purposes. Testing can be done cheaply and easily with tissue flutter strips or smoke tubes. The results of the testing should be documented each day when in use. When the room is being used as a standard family sleeping room, it should be tested a minimum of once per month to ensure proper operation in the event it would be needed for respiratory separation.

Auxiliary HEPA Filtration

The higher the dilution ventilation rate within a given respiratory separation area, the faster the room air will be cleared of existing airborne pathogens. In order to increase effective ventilation within a separation area, in-room HEPA filtration units may be used. These units may be portable or permanently-mounted somewhere within the room. Some models can be ceiling mounted, which could reduce the potential for tampering. If such units are used, their placement and discharge orientation must be selected, installed, and maintained carefully to maximize room air mixing effectiveness without disrupting the desired flow of air into the respiratory separation area.

One unique use of portable HEPA filtration units is through ventilated headboards. The *ventilated headboard* is a NIOSH-developed technology that consists of lightweight, sturdy & adjustable aluminum framing with a retractable plastic canopy sheeting that can extend over the pillow area of a cot, mat or bed. Low-velocity airflow into the canopy is created using a high-efficiency fan/filter exhaust unit. This local control technique allows for near-instant capture of any aerosol originating from the patient while simultaneously providing air cleaning to the entire room. NIOSH engineers are available to provide additional information or to assist in the selection and acquisition of ventilated headboards.

Respiratory Protection

During an outbreak of airborne infectious disease, there could be instances when staff members or volunteers find themselves in close contact with guests suspected of being infectious. One example would be a van driver transporting overnight female guests to McDuff Campus from the City Rescue Mission sister shelter across town. Ideally, these cases would be identified during the administrative screening process. When these circumstances cannot be avoided, it is wise to consider the availability of respiratory protection to protect staff and volunteers. A particularly noteworthy circumstance would be a dentist providing urgent dental care to patients with suspected or confirmed TB disease in the McDuff dental clinic. In those instances, respiratory protection (at least an N95 particulate filtering facepiece respirator) should be worn by the dentist performing the procedures.

The first step toward the implementation of respirator use is to develop a document that clearly outlines a formal respiratory protection program. The Occupational Safety and Health Administration (OSHA) Respiratory Protection standard (29 Code of Federal Regulations [CFR] 1910.134) outlines the requirements for comprehensive respiratory protection programs. In accordance with 29 CFR 1910.134, a written Respiratory Protection Program, with an identified program administrator, is required for any facility that requires employees to wear respirators. The program must include training, medical evaluations, and respirators at no cost to employees or staff required to wear respirators on the job. Initial fit testing by a trained individual is required for all employees that will potentially wear a respirator. Annual fit testing is required after that, with additional fit testing upon major changes to the facial features of the respirator user (i.e. major weight gain/loss, change in facial hair, scarring, etc.).

To comply with applicable OSHA regulations regarding respiratory protection, we recommend that the shelter create a written respiratory protection program as outlined in 29 CFR 1910.134, appoint a program administrator, and initiate training and initial fit testing for employees. Many online resources exist to assist in the development of a respiratory protection program. OSHA has published a Respiratory Protection informational booklet online (http://www.osha.gov/Publications/OSHA3079/osha3079.html) and a more detailed Small Entity Compliance Guide for the Revised Respiratory Protection Standard (http://www.osha.gov/Publications/3384small-entity-for-respiratory-protection-standard-rev.pdf) to explain all parts of an appropriate respiratory protection program and how to comply. The Small Entity Compliance Guide also contains a sample respiratory protection program in Attachment 4 that can be used as a model program. The Washington State Department of Labor and Industries has also developed a user-friendly, fillable template that is helpful in developing a respiratory protection program at http://www.lni.wa.gov/Safety/Basics/Programs/Accident/Samples/RespProtectguide2.doc.

The DCHD, Florida Department of Health, local healthcare facilities or fire/ambulance stations can potentially assist with training and fit testing the employees required to wear respirators. Alternatively, qualitative fit testing kits (Bitrix™) can be purchased for around $200.00. When paired with a trained and competent fit test administrator (see CFR 29

1910.134), these kits would allow cost-effective, on-site fit testing annually.

Conclusions

Since the increase in cases of TB disease in 2010, McDuff Campus has taken significant steps to improve the administrative controls at the shelter. The shelter has developed important lines of communication with DCHD, and improved staff training and awareness of TB symptoms. Identifying guests with symptoms of TB disease or those listed on the DCHD target screening lists will help further reduce the potential for future cases of TB disease and bring the ongoing outbreak under control. Having consistent protective strategies upon suspect case identification is also important. While enhanced administrative controls are now in place, there is no written ICP established at the complex, and McDuff Campus administrators are encouraged to promptly coordinate with DCHD and the Florida Department of Health to establish one.

From an environmental control perspective, we inspected eight AHUs servicing the administration building, the women's overnight sleeping facility, and the men's facility. The preventive maintenance program in place is managed by the current facilities manager. The units appeared to be adequately maintained and were operational at the time of the NIOSH visit, although there were some with improper filter configurations and one containing standing water. There was no written preventive maintenance or O&M plan for the shelter AHUs.

None of the AHUs at McDuff Campus were providing fresh outdoor air to the occupied spaces, as required by the 2010 *Florida Building Code* and ASHRAE guidelines. Given the number of guests served at the shelter complex and the close proximity of guests to one another in most of the occupied spaces, it is important that these spaces are receiving adequate amounts of outdoor air. In addition to alleviating odors and better maintaining occupant comfort, outdoor air serves to dilute infectious aerosols, such as *M. tuberculosis* droplet nuclei responsible for TB transmission. With renovations, the existing AHUs might be made to provide the necessary outdoor air, or they could be augmented with the installation of new, dedicated outdoor air systems to provide the necessary outdoor air. A knowledgeable HVAC engineer should be consulted to discuss options for introducing outdoor air to the shelter complex. At the same time, consideration should be given to improving the air flow patterns in various living and sleeping areas throughout the complex. Once these changes have been implemented, other ventilation equipment and/or supplemental ultraviolet germicidal irradiation systems could be investigated if additional environmental controls are desired.

During our visit, McDuff Campus did not have an area set aside for separating guests suspected of having TB or other respiratory diseases from the remainder of the guest population. While this may not be critical in areas housing the men and women enrolled in the LifeBuilders program, the background and medical status of every woman seeking overnight shelter in the women's overnight facility is unknown. Therefore, it would be prudent to modify an area in the women's overnight facility for use as a respiratory separation area in the event an overnight guest presented with symptoms of respiratory infection. When respiratory separation is not required, the area could be used for normal guest housing.

For instances where improvements to administrative and environmental controls do not sufficiently mitigate the risk for disease transmission, respiratory protection might be necessary. There was no formal respiratory protection program in place during our visit, but such a program should be implemented at the shelter. Having this program in place will provide additional protection to McDuff Campus staff and volunteers working in close proximity to guests with suspected TB or other airborne diseases. Any respirator use at the shelter should be covered by an OSHA-mandated respiratory protection program.

Administratively, a positive approach is being taken toward reducing the likelihood of future TB transmission at McDuff Campus. However, the ventilation systems clearly need some attention to further reduce the risk. While ventilation systems and other environmental control systems cannot guarantee prevention of future TB disease transmission, improving the environmental controls will reduce the potential for airborne disease transmission, along with providing better indoor air quality throughout each building. The following recommendations are aimed at improving the overall infection control program at McDuff Campus, with emphasis on improvements to the existing environmental controls so they meet all applicable standards and guidelines.

Recommendations

Based on our assessment of environmental controls at McDuff Campus, we have developed the following list of recommendations, in order of priority:

1. Continue to improve and enhance the TB administrative controls at the complex and develop a written Infection Control Plan.

    - Continue working with the DCHD to screen campus staff, volunteers, and guests for TB disease.
    - With input from DCHD, develop specific procedures for handling a suspected or confirmed case of TB disease.
    - Continue educating staff and volunteers on the signs and symptoms of TB disease so they can readily identify suspect cases and implement established precautions.
    - Consider displaying informational posters about TB signs and symptoms to educate guests.
    - Consider displaying signs encouraging proper cough etiquette and hand hygiene.

- Develop a formal written TB Infection Control Plan. Seek guidance and input from DCHD and the Florida Department of Health. The plan should include:
    - All aspects of the TB infection control program and associated responsibilities, especially those functions requiring coordination with other agencies, such as the local and state health departments
    - The improved administrative controls put in place at McDuff Campus since the beginning of the TB outbreak
    - Input from ventilation staff and/or guests tasked with servicing ventilation systems. Obtaining input from ventilation maintenance staff serves to strengthen the environmental control section of the plan while giving maintenance staff additional insight into the ventilation requirements for reducing or preventing airborne disease transmission.
    - Schedule for updating and revising the ICP

2. Introduce the required amounts of fresh outdoor air to all occupied spaces.

- There are multiple options that can allow adequate outdoor air to be supplied to the various campus buildings. All options, including the associated capital, maintenance, and annual operating costs should be considered. Work with a reputable ventilation or engineering contractor familiar with the current *Florida Building Code*, ASHRAE, FGI, and CDC guidelines to select the best option for McDuff Campus.
- Improve air flow patterns within all occupied spaces, particularly the women's overnight bunk area and family sleeping rooms. Air flow patterns should provide effective ventilation and temperature control while minimizing the number of people that air travels across before returning to the AHU.
- Determine and fix the cause of the standing water inside AHU Men-2. Develop a monitoring strategy to prevent further occurrences of water buildup within the unit.

3. Improve filtration efficiency in all AHUs. Select higher efficiency filters (higher MERV ratings) for use in each AHU, as long as the new filters do not adversely impact the required air flow delivery capacity of the AHUs.

4. Modify at least one family sleeping room in the women's overnight facility for use as a respiratory separation area.

- Choose a reputable ventilation or engineering design contractor that is familiar with current *Florida Building Code*, ASHRAE, FGI, and CDC guidelines and recommendations. While there are various ways to develop a respiratory separation area, it should include the following:

- Ensure that all supply and return ductwork for AHU Women-2 is intact and sealed. Install tight-sealing return dampers on each return from the selected family sleeping room to eliminate return air flow when the space is used for respiratory separation. Ensure that supply air diffusers provide good air mixing and air flow patterns in each selected room.
- Design and install an auxiliary exhaust system that enables the respiratory separation area to be maintained under negative pressure when housing guests for separation purposes. One approach to this requirement would be to select and install an exhaust fan directly through the outside walls of the room. The fan can be mounted through the wall itself or mounted on the roof with ductwork through the wall to the fan.
- Install the highest efficiency air filters in AHU Women-2 that will still allow adequate air flow to meet the AHU's conditioning requirements. Adjust and balance the system as necessary to ensure proper air flows at all times when each selected room is individually or collectively used for respiratory separation and normal purposes. Ensure that adequate outdoor air is supplied to each space at all times (see Recommendation 2 above).
- Develop a detailed written plan for the conversion of the selected family sleeping room(s) from normal housing functions to use for respiratory separation. The plan should include:
    - Procedures for moving the guests currently in these areas to other locations
    - Procedures for cleaning and refurnishing the areas for separation purposes, and step-by-step procedures for staff to follow to start the exhaust fan, close the return air dampers, and test for negative pressure
    - Measures for preparing the areas for back-to-back occupants requiring separation
    - Procedures for cleaning and returning the areas to normal use after the need for respiratory separation has passed
- Operate the new systems as designed and according to the written plan. The respiratory separation area should be visually tested with smoke tubes or flutter strips daily to ensure negative pressure is being maintained while the room is occupied for separation. When the room is being used for normal purposes, it should be tested monthly to ensure proper operation in the event they would be needed for

respiratory separation. The results of all pressure testing should be documented.

5. Ensure the dental clinic is ventilated appropriately. The clinic should be provided with at least 6 total air changes per hour (ACH) and at least 2 ACH of fresh outdoor air. Additionally, if one does not already exist, an exhaust fan should be installed to maintain the clinical space under negative pressure any time dental procedures are being performed. If nitrous oxide is used as an analgesic/anesthetic gas in this clinic, NIOSH engineers can provide additional guidance on special design precautions that apply to its safe storage, delivery and recovery upon request.

6. Develop and implement an OSHA respiratory protection program in accordance with 29 CFR 1910.134. To meet the OSHA requirements, you must:

    - Designate a program administrator who is qualified by appropriate training or experience to administer or oversee the program and conduct the required program evaluations.
    - Provide respirators, training, and medical evaluations at no cost to employees or staff required to wear respirators on the job.
    - Develop a written program with worksite-specific procedures when respirators are necessary or required by McDuff Campus. The written respiratory protection program needs to include:
        - Respirator types and proper respirator selection
        - Required medical evaluations for employees prior to respirator use
        - Procedures for initial and annual respirator fit testing
        - Instructions for proper respirator use
        - Information on appropriate respirator maintenance and care
        - Initial and yearly training requirements for respirator users
        - Procedures for evaluating the effectiveness of the respiratory protection program
    - Update the respiratory protection program as necessary to reflect changes in workplace conditions that affect respirator use.

7. Repair existing bathroom exhaust fans or install new ones. Ensure that air is being exhausted from each bathroom and shower facility and that each area is under

negative pressure, in accordance with the 2010 *Florida Building Code* and ASHRAE requirements. Ensure that all exhaust air from bathrooms and shower facilities is exhausted directly outside and that no return air from bathrooms is recirculated back to an AHU or entrained in the outdoor air entering any current or future AHU.

8. After all of the ventilation systems are updated and functioning properly, develop a comprehensive, written HVAC O&M plan. The O&M Plan should include:

- Preventive maintenance schedules and all regularly scheduled maintenance tasks (filter changes, fan belt inspections, etc.) and who is responsible for conducting each task
- Written procedures for each maintenance task to ensure the work is done properly each time, regardless of who performs the work
- Training requirements for maintenance staff
- A method for logging maintenance activities for each AHU
- A method for updating or revising the O&M Plan as procedures or systems change

Outline of Future NIOSH Involvement

This report will serve to close out NIOSH Technical Assistance at McDuff Campus. However, we understand that the work outlined in the recommendations above will take several months to complete and will represent a significant investment of time and financial resources. As the work proceeds, NIOSH could assist by:

- Reviewing any Requests for Proposal developed to initiate the bidding process
- Reviewing any bids received in response to Requests for Proposals for technical content
- Providing technical assistance related to any environmental control strategies

It is not necessary for NIOSH to be on-site during any ventilation renovations. Yet, as projects are initiated, we can assist you by reviewing:

- Proposed modification strategies for outdoor air introduction or respiratory separation area designs
- Preliminary design schematics or equipment selection documents
- Air flow testing and balancing reports

- Final project documents, including as-built drawings, sequences of operations, and proper equipment set points

Once the renovations are complete, if additional NIOSH assistance is desired or warranted, the request for technical assistance can be reopened.

References

ANSI/ASHRAE (American National Standards Institute/American Society of Heating, Ventilating and Air-Conditioning Engineers) [2007]. Method of testing general ventilation air-cleaning devices for removal efficiency by particle size. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers. Standard 52.2-2007.

ANSI/ASHRAE [2010a]. Ventilation for acceptable indoor air quality. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers. Standard 62.1-2010.

ANSI/ASHRAE [2010b]. Thermal environmental conditions for human occupancy. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers. Standard 55-2010.

ASHRAE/ASHE (ASHRAE/American Society for Healthcare Engineering) [2008]. Ventilation of health care facilities. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers. Standard 170-2008.

Barry MA, Wall C, Shirley L, Bernardo J, Schwingl P, Brigandi E, Lamb GA [1986]. Tuberculosis screening in Boston's homeless shelters. Public Health Rep 101(5):487-498.

CDC (Centers for Disease Control and Prevention) [1985]. Drug-resistant tuberculosis among the homeless—Boston. MMWR 34:429-431.

CDC [1992]. Prevention and control of tuberculosis among homeless persons (ACET). MMWR 41(RR-5):001.

CDC [2003a]. Tuberculosis outbreak in a homeless population—Portland, Maine, 2002-2003. MMWR 52(48):1184-1185.

CDC [2003b]. TB outbreak among homeless persons—King County, Washington, 2002-2003. MMWR 52(49):1209-1210.

CDC [2005a]. Tuberculosis transmission in a homeless shelter population—New York, 2000-2003. MMWR 54(06):149-152.

CDC [2005b]. Guidelines for preventing the transmission of Mycobacterium tuberculosis in health-care settings, 2005. MMWR 54(RR-17):1-141.

CDC [2006]. Prevention and control of tuberculosis in correctional and detention facilities: Recommendations from CDC. MMWR 55(RR-9):1-54.

EPA (US Environmental Protection Agency) [2012]. The inside story: A guide to indoor air quality (http://www.epa.gov/iaq/pubs/insidestory.html). Date accessed: February 22, 2013.

FGI (Facility Guidelines Institute) [2010]. Guidelines for design and construction of health care facilities. Chicago, IL: American Society for Healthcare Engineering of the American Hospital Association.

Flanders Corporation [2011]. Pre Pleat 40 LPD low pressure drop MERV 8 pleated filter, product bulletin PB700-1211.

ICC (International Code Council, Inc.) [2011]. Florida building code 2010: Mechanical (chapter 4, ventilation). Country Club Hills, IL: International Code Council, Inc.

Knopf SA [1914]. Tuberculosis as a cause and result of poverty. J Am Med Assoc 63(20):1720-1725.

McAdam JM, Brickner PW, Scharer LL, Crocco JA, Duff AE [1990]. The spectrum of tuberculosis in a New York City men's shelter clinic (1982-1988). Chest 97:798-805.

NIOSH [2013]. NIOSH alert: preventing occupational respiratory disease from exposures caused by dampness in office buildings, schools, and other non-industrial buildings. By Martin M, Cox-Ganser J, Kreiss K, Kanwal R, Sahakian N. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2013-102 (http://www.cdc.gov/niosh/docs/2013-102/pdfs/2013-102.pdf). Date accessed: February 22, 2013.

Nolan CM, Elarth AM, Barr H, Saeed AM, Risser DR [1991]. An outbreak of tuberculosis in a shelter for homeless men: A description of its evolution and control. Am Rev Respir Dis 143:257-261.

Slutkin G [1986]. Management of tuberculosis in urban homeless indigents. Public Health Rep 101(5):481-485.

Table 1. General air-handling unit (AHU) information

NIOSH AHU Identifier	Physical Location of AHU (building/floor)	Location Served by AHU[A]	AHU Manufacturer[B]	AHU Model Number[B]	Proper Filter Configuration in AHU[C,D]	Actual Filter Configuration in AHU[B,D,E]
AHU-1	Central Mechanical Room (Administration Building/1st Floor)	Entire 1st Floor of Administration Building	Carrier	40RR034	(6) 20 × 25 × 2 and (2) 16 × 20 × 2	*(8) 20 × 25 × 2
AHU-2	Central Mechanical Room (Administration Building/3rd Floor)	Entire 2nd Floor of Administration Building	Carrier	40RR028	(6) 20 × 25 × 2 and (2) 16 × 20 × 2	*(12) 16 × 20 × 2
AHU-3	Central Mechanical Room (Administration Building/4th Floor)	Entire 3rd Floor of Administration Building	Carrier	40RR028	(6) 20 × 25 × 2 and (2) 16 × 20 × 2	*(12) 16 × 20 × 2
AHU-4	Central Mechanical Room (Administration Building/4th Floor)	Entire 4th Floor of Administration Building	Carrier	40RR028	(6) 20 × 25 × 2 and (2) 16 × 20 × 2	*(12) 16 × 20 × 2
Women-1	Women's Overnight Facility - Above Laundry Room	Women's Overnight Bunk Areas	Trane	TWE090A300EL	(3) 16 × 25 × 1	Grille[F]
Women-2	Women's Overnight Facility - Above Family Bathroom & Showers	Women's Overnight Family Areas	Trane	TWE042C14FCD	(1) 20 × 20 × 1	Grille[F]
Men-1	Men's Facility - Mechanical Room Beside Shower Room in Hallway 2	Men's Facility - Rooms off Hallways 1 and 2	Trane	TWE090A300CA	(3) 16 × 25 × 1	(3) 16 × 25 × 1
Men-2	Men's Facility - Outside Main Entrance to Men's Facility	Men's Facility - Rooms off Hallways 3 and 4	Carrier	Unknown[G]	Unknown[G]	(6) 16 × 20 × 2

[A] May not represent all locations served by the AHU
[B] Information taken during visual inspection of AHU
[C] Information gathered from product data specific to each AHU model published by respective AHU manufacturer
[D] Value in parenthesis represents the number of filters, dimensions are width × height × depth in units of inches
[E] Entries preceded by an asterisk (*) represent actual filter configurations that differ from published proper filter configurations. Differences could be due to incorrect filter size(s) being installed or because the AHU manufacturer modified the AHU model size/filter recommendation as the product was updated.
[F] It could not safely be determined if filters were installed in these AHUs during the NIOSH visit. However, return air filters were in place at each return air grille into the ceiling plenum.
[G] Labels and stickers on this AHU were missing or faded, so they could not be read.

Table 2. Applicable outdoor air supply flow rates, minimum exhaust air flow rates, and default occupancy densities from the *2010 Florida Building Code* and ASHRAE Standard 62.1-2010[A]

Occupancy Category	People Outdoor Air Flow Rate (cfm/person)[B]	Area Outdoor Air Flow Rate (cfm/ft^2)[C]	Minimum Exhaust Air Flow Rate[D]	Default Occupant Density (#/1000 ft^2)[E]
Barracks/Dormitory Sleeping Areas	5	0.06	—	20
Bedrooms/Living Rooms	5	0.06	—	10
Office Spaces	5	0.06	—	5
Conference Rooms	5	0.06	—	50
Multipurpose Assembly Spaces	5	0.06	—	120
Reception Areas	5	0.06	—	30
Break Rooms[F]	5[F]	0.12[F]	—	50[F]
Central Laundry Rooms[F]	5[F]	0.12[F]	—	10[F]
Occupiable Dry Storage Rooms[F]	5[F]	0.06[F]	—	2[F]
Occupiable Liquid/Gel Storage Rooms[F]	5[F]	0.12[F]	—	2[F]
Unoccupiable Storage Rooms[G]	—	0.12[G]	—	—
Lobbies/Prefunction Spaces	7.5	0.06	—	30
Lecture Classrooms	7.5	0.06	—	65
Computer Labs	10	0.12	—	25
Dining Rooms	7.5	0.18	—	70
Central Kitchens	7.5[F]	0.12[F]	0.7 cfm/ft^2 [C]	70
Public Bathrooms	—	—	50 or 70 cfm/toilet and/or urinal[H]	—
Private Bathrooms	—	—	25 or 50 cfm[I]	—
Shower Rooms[G]	—	—	20 or 50 cfm/shower head[G,J]	—

[A] Requirements published in: *2010 Florida Building Code*: Mechanical (Chapter 4, Ventilation). International Code Council, Inc., Country Club Hills, IL (2011) and American National Standards Institute (ANSI)/American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Ventilation for Acceptable Indoor Air Quality, Standard 62.1-2010. ASHRAE, Atlanta, GA (2010). In nearly all cases, the *2010 Florida Building Code* has adopted ventilation recommendations directly from ASHRAE Standard 62.1-2010.
[B] cfm/person = cubic feet per minute (also commonly shown as ft^3/min) per person typically in the occupied space
[C] cfm/ft^2 = cubic feet per minute (also commonly shown as ft^3/min) per square feet of occupied space
[D] Mechanical exhaust should be released directly outdoors at least 25 feet away from air intakes. Recirculation of exhaust air back into the building should be avoided.
[E] #/1000ft^2 = number of people per 1000 square feet of occupied space. These values are typical occupant densities in spaces that are useful for building/HVAC system design. If actual occupant densities are known, they should be used instead of these default values.
[F] Requirements are only published in ASHRAE Standard 62.1-2010. No directly corresponding values appear in the *2010 Florida Building Code*.
[G] Requirements are only published in the *2010 Florida Building Code*. No directly corresponding values appear in ASHRAE Standard 62.1-2010.
[H] Provide the higher rate when periods of heavy use are expected to occur (e.g. prior to guests leaving in the morning). If periods of heavy use are not anticipated, the lower rate may be used.
[I] These rates are for bathrooms intended for use by one person at a time. If exhaust fans are operated continuously, the lower rate may be used. If exhaust fans are operated intermittently (e.g., fans activated by a light switch), the higher rate should be used.
[J] If exhaust fans are operated continuously, the lower rate may be used. If exhaust fans are operated intermittently (e.g., fans activated by a light switch), the higher rate should be used.

Table 3. Total air delivered by ventilation systems, occupant densities, and recommended outdoor air flow

Space[A]	AHU Serving Space	Return Flow from Space (cfm)[B]	Supply Flow into Space (cfm)[B]	Approximate Area of Space (ft^2)[C]	Typical Occupants in Space[D]	Occupant Density (#/1000 ft^2)[D,E,F]	Recommended Outdoor Air Flow (cfm)[B,G]
1st Floor – Main Administration Building							
Assembly/Dining Room	AHU-1	550	3265	2980	60	20	478.8/968.4[H]
Hospitality Room	AHU-1	0[I]	585	790	12	15	107.4
Medical - Reception	AHU-1	None[J]	230	195	2	10	21.7
Medical - Exam Room 1[K,L]	AHU-1	None[J]	70	90	2	22	15.4
Medical - Exam Room 2[K,L]	AHU-1	<30[I]	350	125	2	16	17.5
Medical - Supply Storage[K]	AHU-1	None[J]	315	255	0	0	30.6
Medical - Laboratory	N/A	None[J]	None[M]	85	1	12	10.1
3rd Floor – Main Administration Building							
Room F1	AHU-3	None[J]	<60[I,N]	195	2	10	21.7
Room F2	AHU-3	None[J]	250	195	2	10	21.7
Room F3	AHU-3	None[J]	295	195	2	10	21.7
Sitting Area off Room F3	N/A	None[J]	None[M]	80	2	*25	14.8
Room F4	AHU-3	None[J]	170	195	2	10	21.7
Room F5	AHU-3	None[J]	400	195	2	10	21.7
Room F6	AHU-3	None[J]	220	195	2	10	21.7
Phoebe Room	AHU-3	None[J]	340	195	2	10	21.7
Room F8	AHU-3	None[J]	210	195	2	10	21.7
Room F9	AHU-3	None[J]	340	195	2	10	21.7
Room F10	AHU-3	None[J]	340	195	2	10	21.7
Sitting Area off Room F10	N/A	None[J]	None[M]	80	2	*25	14.8
Room F11	AHU-3	None[J]	255	190	2	11	21.4
Room F12	AHU-3	None[J]	210	185	2	11	21.1
Room S1	AHU-3	None[J]	705	600	2	3	46.0
Room S2	AHU-3	None[J]	500	585	2	3	45.1
Room S3	AHU-3	None[J]	520	590	2	3	45.4
Room S4	AHU-3	None[J]	635	590	2	3	45.4
Priscilla Powder Room	N/A	<30[I,O]	None[M]	90	N/A[P]	N/A[P]	N/A[P]

Table 3 (continued). Total air delivered by ventilation systems, occupant densities, and recommended outdoor air flow

Space[A]	AHU Serving Space	Return Flow from Space (cfm)[B]	Supply Flow into Space (cfm)[B]	Approximate Area of Space (ft^2)[C]	Typical Occupants in Space[D]	Occupant Density (#/1000 ft^2)[D,E,F]	Recommended Outdoor Air Flow (cfm)[B,G]
Fellowship Room	AHU-3	None[J]	940	685	3	4	56.1
Laundry Room	AHU-3	None[J]	400	130	1	8	20.6
Shower Room	N/A	Obs[Q]	None[M]	80	N/A[P]	N/A[P]	N/A[P]
Bathroom	N/A	Obs[Q]	None[M]	80	N/A[P]	N/A[P]	N/A[P]
Exercise Room	AHU-3	None[J]	780	600	1	2	92.0
RA Office	AHU-3	None[J]	400	185	1	5	27.2
Women's Clothing Room off RA Office	AHU-3	None[J]	400	380	1	3	50.6
4th Floor – Main Administration Building							
Room 435	AHU-4	None[J]	765	570	10	18	109.2
Room 441	AHU-4	None[J]	635	590	10	17	110.4
Room 443	AHU-4	None[J]	670	585	10	17	110.1
Room 445	AHU-4	None[J]	750	600	10	17	111.0
Large Computer Room	AHU-4	None[J]	550	590	10	17	170.8
Small Computer Room	AHU-4	None[J]	80	145	2	14	37.4
Library	AHU-4	None[J]	210	175	2	11	31.0
Women's Overnight Facility							
Overnight Bunk Area/Reception/Entry	Women-1	2125	1705	1865	42	*23	321.9
Overnight Bathroom & Showers	Women-1	0[I]	270	325	N/A[P]	N/A[P]	N/A[P]
Family Sleeping Room #1	Women-2	40	205	130	3	*23	7.8
Family Sleeping Room #2	Women-2	0[I]	230	130	3	*23	22.8
Family Sleeping Room #3	Women-2	0[I]	170	130	3	*23	22.8
Family Sleeping Room #4	Women-2	35	220	130	3	*23	22.8
Family Area Hallways	Women-2	1055	210	160	0	0	19.2
Family Bathroom & Showers	Women-2	0[I]	270	195	N/A[P]	N/A[P]	N/A[P]

Table 3 (continued). Total air delivered by ventilation systems, occupant densities, and recommended outdoor air flow

Space[A]	AHU Serving Space	Return Flow from Space (cfm)[B]	Supply Flow into Space (cfm)[B]	Approximate Area of Space (ft^2)[C]	Typical Occupants in Space[D]	Occupant Density (#/1000 ft^2)[D,E,F]	Recommended Outdoor Air Flow (cfm)[B,G]
Men's Facility							
Bedroom 1	Men-1	None[J]	75	145	2	14	18.7
Bedroom 2	Men-1	None[J]	115	145	2	14	18.7
Bedroom 3	Men-1	None[J]	60	145	2	14	18.7
Bedroom 4	Men-1	None[J]	160	135	2	14	18.1
Bedroom 5	Men-1	None[J]	40[R]	145	2	14	18.7
Bedroom 6	Men-1	None[J]	60[R]	145	2	14	18.7
Bedroom 7	Men-1	None[J]	230	145	2	14	18.7
Hallway 1 Bathroom	Men-1	0[I]	110	155	N/A[P]	N/A[P]	N/A[P]
Bedroom 8	Men-1	None[J]	85	145	2	14	18.7
Bedroom 9	Men-1	None[J]	0[I,R]	145	2	14	18.7
Bedroom 10	Men-1	None[J]	Obs[S]	145	2	14	18.7
Bedroom 11	Men-1	None[J]	70	145	2	14	18.7
Bedroom 12	Men-1	None[J]	70	145	2	14	18.7
Bedroom 13	Men-1	None[J]	160	145	2	14	18.7
Hallway 2 Prayer Room	Men-1	None[J]	70	90	1	11	10.4
Hallway 2 Shower Room	Men-1	0[I]	130	155	N/A[P]	N/A[P]	N/A[P]
Recreation Room	Unknown[T]	None[J]	325	520	2	4	41.2
Bedroom 14	Men-2	None[J]	115	215	2	9	22.9
Bedroom 15	Men-2	<30[I]	Obs[S]	215	2	9	22.9
Bedroom 16	Men-2	0[I]	215	235	2	9	24.1
Lounge Between Hallways 3 & 4	Men-2	760	260	535	2	4	42.1
Hallway 3 Bathroom	N/A	None[J]	None[M]	DNM[U]	N/A[P]	N/A[P]	N/A[P]
Bedroom 17	Men-2	0[I]	Obs[S]	155	2	13	19.3
Bedroom 18	Men-2	0[I]	Obs[S]	155	2	13	19.3
Bedroom 19	Men-2	0[I]	120	155	2	13	19.3

Table 3 (continued). Total air delivered by ventilation systems, occupant densities, and recommended outdoor air flow

Space[A]	AHU Serving Space	Return Flow from Space (cfm)[B]	Supply Flow into Space (cfm)[B]	Approximate Area of Space (ft^2)[C]	Typical Occupants in Space[D]	Occupant Density (#/1000 ft^2)[D,E,F]	Recommended Outdoor Air Flow (cfm)[B,G]
Bedroom 20	Men-2	0[I]	175	150	2	13	19.0
Bedroom 21	Men-2	None[J]	140	205	2	10	22.3
Bedroom 22	Men-2	None[J]	85	205	2	10	22.3
Bedroom 23	Men-2	None[J]	65	205	2	10	22.3
Hallway 4 Bathroom	N/A	None[J]	None[M]	200	N/A[P]	N/A[P]	N/A[P]
Weight Room	N/A	None[J]	None[M]	340	1	3	60.8

[A] May not represent all locations served by the AHU
[B] cfm= cubic feet per minute (also commonly shown as ft^3/min)
[C] ft^2 = square feet
[D] Occupant numbers estimated by visual observation during NIOSH visit
[E] #/1000 ft^2 = number of occupants per 1000 ft^2 of occupied floor space. Calculated by dividing the number of typical occupants in the space by the approximate area of the space and multiplying by 1000
[F] Entries preceded by an asterisk (*) represent spaces where the actual occupant density likely exceeds the default occupant density presented in Table 2.
[G] Calculated based on recommendations published in: American National Standards Institute (ANSI)/American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Ventilation for Acceptable Indoor Air Quality, Standard 62.1-2010. ASHRAE, Atlanta, GA (2010) and the *2010 Florida Building Code*: Mechanical (Chapter 4, Ventilation). International Code Council, Inc., Country Club Hills, IL (2011). In nearly all cases, the *2010 Florida Building Code* has adopted ventilation recommendations directly from ASHRAE Standard 62.1-2010.
[H] ASHRAE Standard 62.1-2010 and the *2010 Florida Building Code*: Mechanical (Chapter 4, Ventilation) provide separate outdoor air recommendations for assembly spaces and dining rooms. Both numbers are reported here (assembly space/dining area).
[I] A TSI Accubalance Plus, Model 8373, was used to determine air flow measurements. The instrument is unable to accurately read volumetric air flow rates less than 30 cfm. Reading could be anywhere between 0 and 30 cfm. In these cases, ventilation fog was used to visually determine if any air was flowing through the vent/grille. When there was visual confirmation of air flow, the result was reported as < 30 cfm. When air flow could not be verified visually, the result was reported as 0 cfm.
[J] There was/were no return grille(s) in this space.
[K] A partial wall exists between the two medical exam rooms and the medical storage space, so these areas could be considered one space. They were left separate in this table because of their functions.
[L] Areas where medical examinations and/or procedures are performed should be maintained under negative pressure compared to adjacent areas (i.e., more air should be exhausted from the space than is supplied to the space). This space was not under negative pressure during the NIOSH visit.
[M] There was/were no supply vent(s) in this space.
[N] There were two supply vents in this space. Visually, both appeared to be supplying air but less than the TSI Accubalance Plus, Model 8373 could measure (see Footnote I).
[O] This area was equipped with a switch activated exhaust fan designed for intermittent use when the space is occupied.
[P] N/A = not applicable. Neither ASHRAE Standard 62.1-2010 nor the *2010 Florida Building Code* include outdoor air recommendations for restrooms, bathrooms, and shower facili ties. Instead, for public bathrooms, the recommendation is 50 cfm of exhaust from the space per toilet or urinal when periods of heavy use are not expected. ASHRAE 62.1-2010 does not specifically address ventilation for showers. However, the *2010 Florida Building Code*: Mechanical (Chapter 4, Ventilation) specifies 50 cfm of exhaust air from the space per shower head when the exhaust system is designed to operate intermittently (e.g., exhaust fan connected to light switch) or 20 cfm per shower head for exhaust systems designed to operate continuously. Water closet and shower exhaust may be made up entirely of transfer air from adjacent spaces (i.e., no direct supply air to the space is required) and only a maximum of 10% of the exhaust air is permitted to be recycled.
[Q] Obs = obstructed. Air flow measurements could not be taken because the exhaust grille(s) were obstructed. Exhausts were determined to be working via ventilation fog testing.
[R] Cardboard was covering or partially covering the supply vent. The cardboard was not removed during the NIOSH visit.
[S] Obs = obstructed. Air flow measurements could not be taken because the supply vent(s) were obstructed by furniture, storage boxes, shelves, etc.
[T] It was not determined which AHU(s) in the Men's Facility supplied air to the recreation room.
[U] DNM = did not measure. Physical dimensions were not recorded for this space.

Table 4. ASHRAE indoor relative humidity and temperature recommendations[A]

Relative Humidity	Winter Temperatures[B]	Summer Temperatures[B]
30%[C]	69.5°F to 77.0°F	75.5°F to 81.5°F
40%	69.0°F to 76.5°F	75.5°F to 81.0°F
50%[D]	68.5°F to 76.0°F	75.0°F to 80.5°F

[A] Adapted from: American National Standards Institute (ANSI)/American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Thermal Environmental Conditions for Human Occupancy, Standard 55-2010. ASHRAE, Atlanta, GA. (2010)

[B] Applies to occupants wearing typical summer and winter clothing, with a sedentary to light activity level

[C] Humidity levels below 30% may cause irritated mucus membranes, dry eyes, and sinus discomfort.

[D] The U.S. Environmental Protection Agency recommends maintaining indoor relative humidity below 60% and ideally in a range from 30% to 50% to prevent mold growth.

Figures

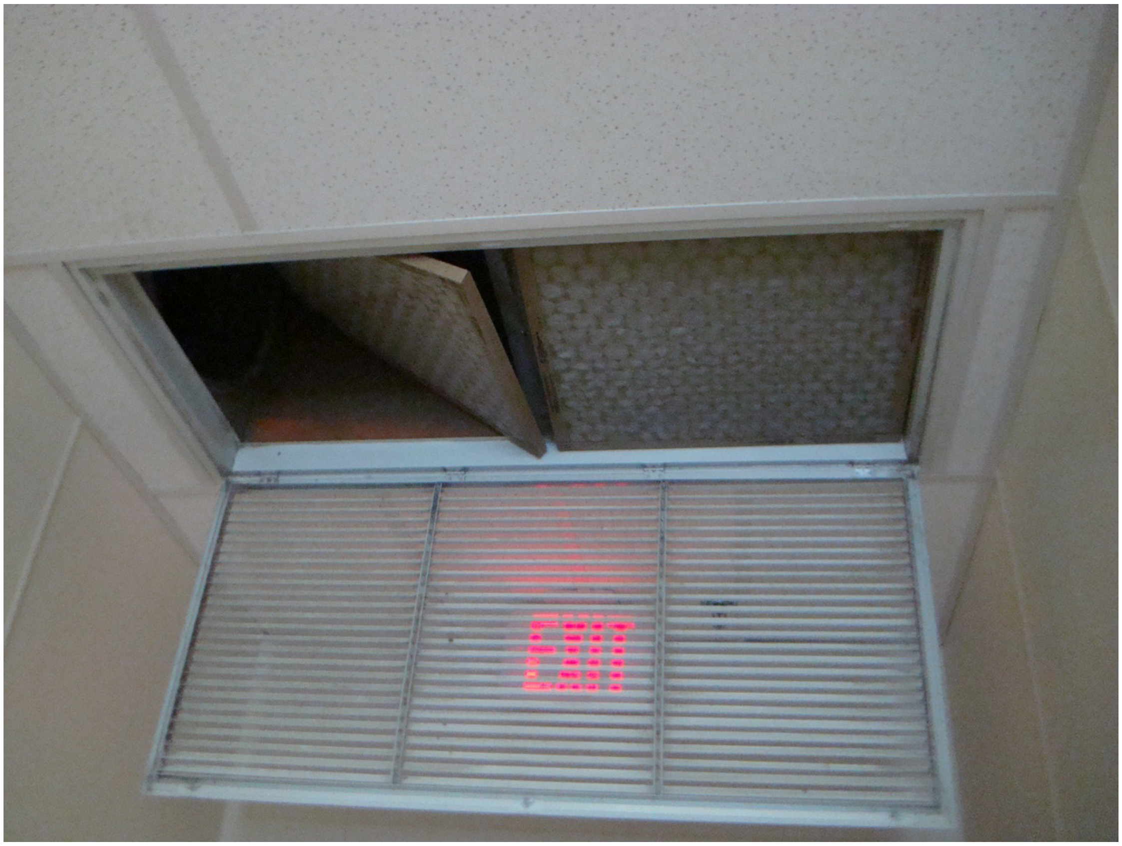

Figure 1. Return air grille leading to the AHU serving the women's overnight bunk area (Women-1). Air flow from the fan creates significant filter bypass.

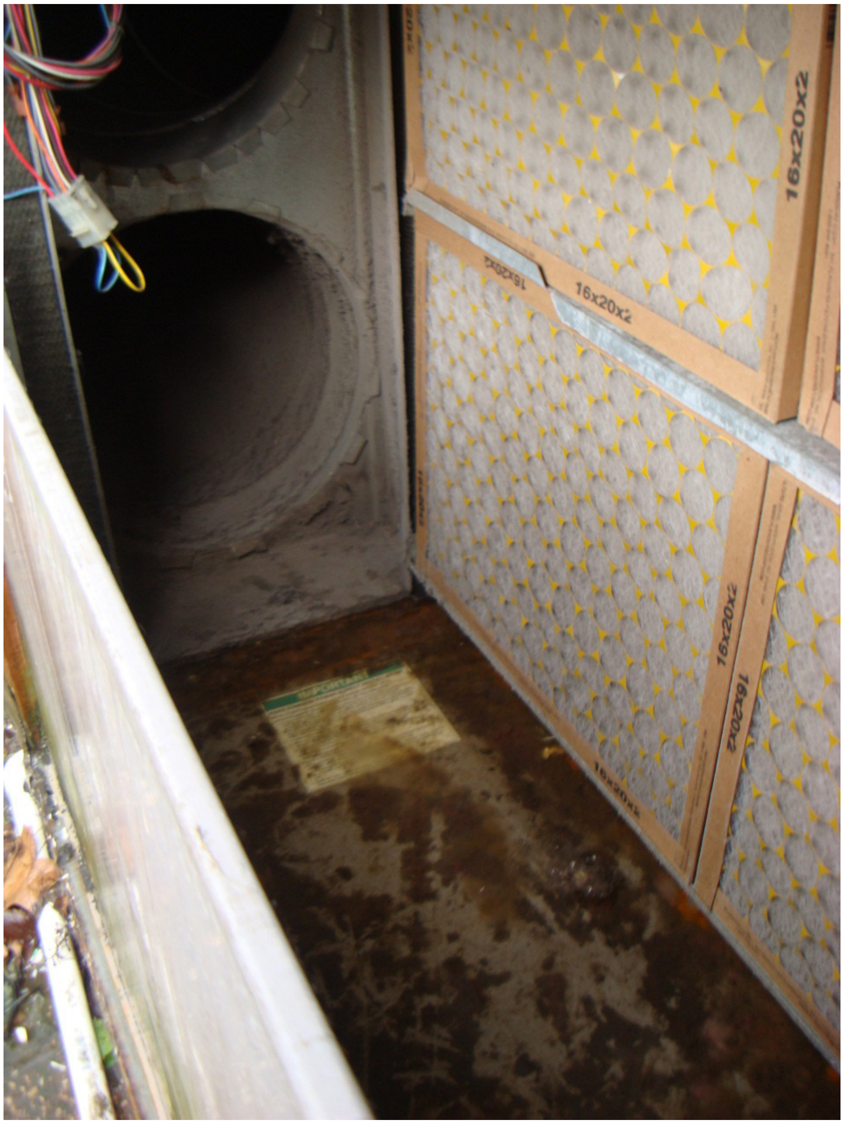

Figure 2. Standing water and apparent microbial growth in the drain pan of AHU Men-2.

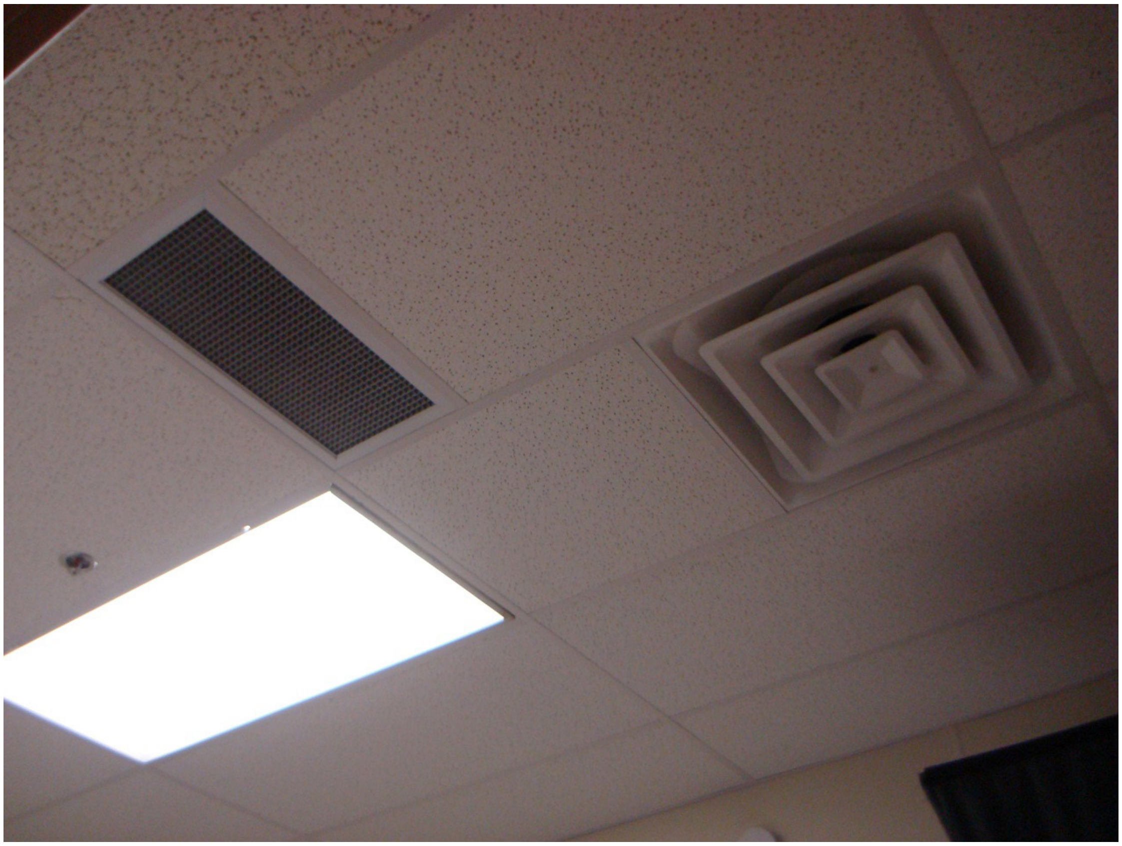

Figure 3. Supply vent and return grille in ceiling of family sleeping room #1 in the women's overnight facility. The close proximity of the supply to the return can result in short-circuiting of air, where supply air is immediately pulled into a return grille without providing any useful ventilation.

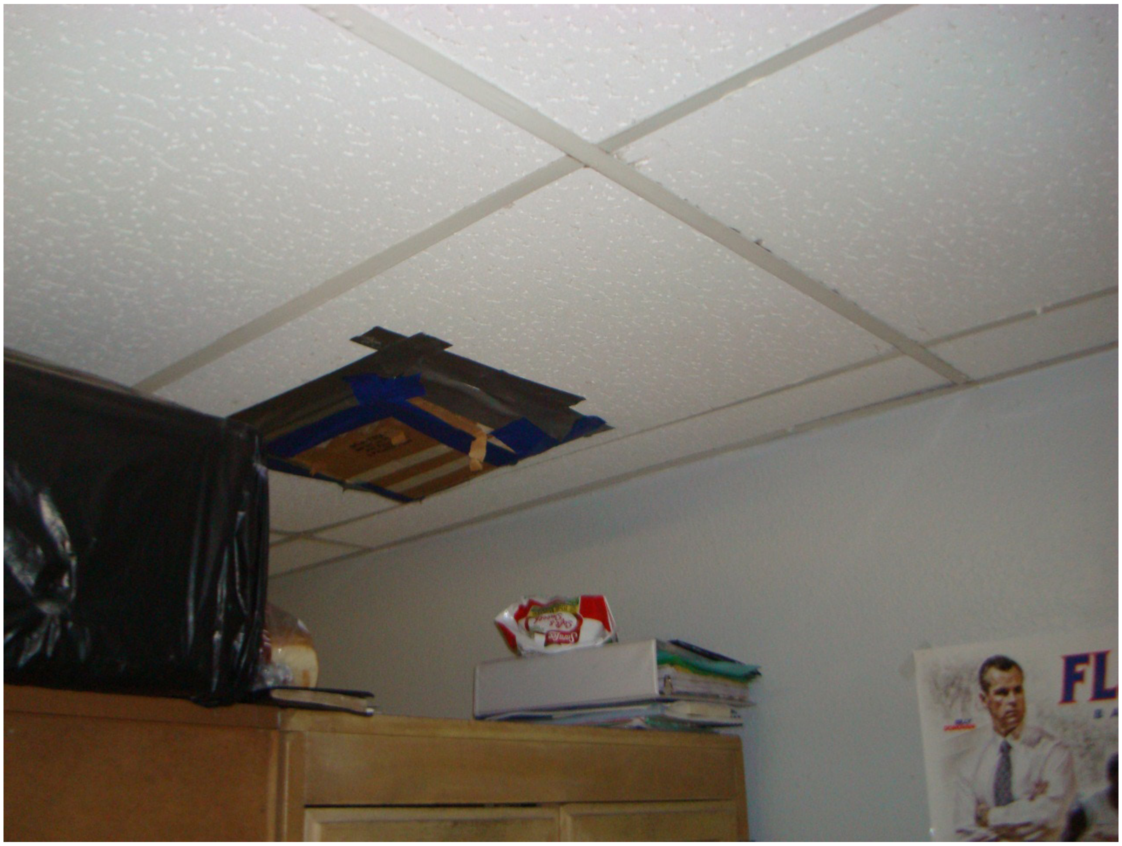

Figure 4. Supply vent covered with cardboard and tape in room #9 of the men's sleeping area.

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The Health Hazard Evaluation Program investigates possible health hazards in the workplace under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6). The Health Hazard Evaluation Program also provides, upon request, technical assistance to federal, state, and local agencies to control occupational health hazards and to prevent occupational illness and disease. Regulations guiding the Program can be found in Title 42, Code of Federal Regulations, Part 85; Requests for Health Hazard Evaluations (42 CFR 85).

Acknowledgments

This report was prepared by Stephen B. Martin, Jr., R. Brent Lawrence, and Michael C. Beaty of the Field Studies Branch (FSB), Division of Respiratory Disease Studies (DRDS) and Kenneth R. Mead of the Engineering and Physical Hazards Branch, Division of Applied Research and Technology. Desktop publishing was performed by Tia McClelland (FSB/DRDS).

Availability of Report

Copies of this report have been sent to representatives from City Rescue Mission–New Life Inn, DCHD, the Florida Department of Health, CDC/NCHHSTP/DTBE, and the OSHA Regional Office.

This report is available at http://www.cdc.gov/niosh/hhe/reports/pdfs/2012-0264-3182.pdf.

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