Evaluation of Environmental Controls at a Homeless Shelter (City Rescue Mission–New Life Inn) Associated with a Tuberculosis Outbreak – Florida

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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–New Life Inn, a local homeless shelter with epidemiological links to an ongoing tuberculosis outbreak.

What NIOSH Did

- We visited City Rescue Mission–New Life Inn on August 20, 2012.
- We met with representatives from the Duval County Health Department and City Rescue Mission–New Life Inn 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–New Life Inn 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 no filter or improper filter configurations installed, and others had condensate leakage.
- 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–New Life Inn 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 shelter ventilation systems to provide adequate fresh outdoor air to all occupied spaces using a strategy compatible with existing system capacities.
- Strategically reposition supply and exhaust grill locations to improve air flow patterns in occupied spaces, particularly in the three large guest sleeping areas.

- Install the highest efficiency air filter possible that is consistent with the proper operation of each air-handling unit.
- Modify at least one area of the shelter for use as a respiratory separation area, when necessary.
- 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 all bathroom exhaust fans.
- Develop and implement a written operation and maintenance plan for shelter 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
HEPA	High-efficiency particulate air
FGI	Facility Guidelines Institute
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
UV	Ultraviolet
UVGI	Ultraviolet germicidal irradiation

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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–New Life Inn homeless shelter in August 2012, we collected physical and ventilation measurements in all key areas of the facility. We focused on areas where shelter 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.

The ventilation systems in place could have contributed to airborne disease transmission among shelter guests. With the exception of condensate leakage from a few AHUs, the units appeared sufficiently maintained to be 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.

NIOSH investigators conducted an assessment of environmental controls in the City Rescue Mission–New Life Inn, a homeless shelter 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.

Since the TB outbreak began, City Rescue Mission–New Life Inn 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 in the shelter 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 or treatment could be obtained. We also recommend developing a written infection control plan, HVAC operation and main-

tenance plan, and a written respiratory protection program. Having these plans/programs in place will help the shelter under normal operating conditions, and especially during 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–New Life Inn. 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–New Life Inn

The New Life Inn serves as the "front door" to various programs and services offered by City Rescue Mission. It provides sleeping areas for men only, and consists of a main three-story brick building with an adjacent single-story brick/stucco annex. Both buildings are equipped with central HVAC systems. The first floor of the main building houses a reception area, laundry facility, large kitchen, and dining area capable of seating 60-70 guests comfortably. The second floor is comprised of staff offices on the northern side while the southern side has one barracks-style sleeping area with 24 bunks to house men in the City Rescue Mission work program. There are also three smaller transition rooms, each with 4 bunks, used to house work program guests preparing to leave the shelter and transition out on their own. The third floor has two large barracks-style sleeping areas with restroom and shower facilities for each. The sleeping area on the north side is equipped with 60 beds (30 bunk beds) for men in the initial three months of the City Rescue Mission LifeBuilders program. The south sleeping area has 67 beds for use by overnight and emergency services guests. Overnight guests may stay at the shelter a maximum of seven days per month, and longer stays are possible if space is available.

In addition to feeding the guests that sleep at the shelter, an additional 100–400 men and women eat breakfast and dinner there each day through the Mission's food program. Between 10–12 staff members work at New Life Inn during the day, and two staff members are present each night. The shelter is typically full throughout the year, but the number of overnight guests increases during periods of bad weather. During periods of high occupancy, the dining room on the first floor and/or the annex building are used as overflow sleeping areas for 100 or more guests.

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 New Life Inn and two of the three other homeless facilities to be visited during the week were in attendance. At the conclusion of the opening meeting, we traveled directly to the City Rescue Mission–New Life Inn. After we unloaded our ventilation equipment, the shelter administrator provided a tour of the facility and explained the various programs and general flow of shelter guests.

After the tour, we began taking physical and ventilation measurements in all key areas of the facility. We focused on areas where New Life Inn guests typically congregate or spend significant amounts of time. The dining/assembly area (1st floor), work program sleeping area (2nd floor), and the LifeBuilders program and overnight sleeping areas (3rd floor) were the areas of primary concern. However, we took measurements throughout the entire facility.

We recorded the make and model number of all nine air-handling units (AHUs) providing supply air to the facility, 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 appropriate air capture hood. 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 New Life Inn administrator on August 20, 2012 to discuss our general findings from the day's assessment. A formal closing meeting for our on-site response to the technical assistance request for all four of the 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 Control

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 New Life Inn, it was apparent that limited TB administrative controls were in place at the shelter 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 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, New Life Inn frequently provides services to large numbers of guests in very close proximity to one another. This is particularly the case in the congregate sleeping areas on the second and third floors, along with the ground floor dining room during meals and when the space is used to house overflow guests. Even the best ventilation systems are incapable of preventing the spread of disease between guests 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 shelter 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 New Life Inn 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 at New Life Inn, including the areas served by each unit, is provided in Table 1. Of the nine AHUs, units from five different manufacturers are installed throughout the shelter, and the units range in size and age. Each of the AHUs supply air to occupied spaces through uninsulated, galvanized steel supply ducts. Return air flows back to the units through a combination of ducted returns, ceiling plenums, and holes in the doors/walls to the mechanical spaces. None of the AHUs delivered fresh outdoor air into the buildings.

With the exception of the Annex, the mechanical spaces housing the AHUs were clear and free of clutter. All AHU air filters were changed just prior to the NIOSH visit. As shown in Table 1, AHU-1 did not have a filter installed in the unit itself. Four other AHUs had filter sizes/configurations that differed from manufacturers' recommendations. While these filters provided some filtration, the level was uncertain as the deviation from intended design provides ample opportunity for filter failure and bypass. On the day of our visit, all of the AHUs were operational and capable of maintaining temperature set points and air flow. However, there were some issues with controlling condensate from the cooling coils. AHU-1 on the first floor was dripping substantial amounts of condensate onto the floor of the mechanical room (Figure 1). Similarly, AHU-6 on the second floor was dripping condensate inside the mechanical room, including inside the return air ductwork of the AHU (Figure 2). Finally, the drain pan on AHU-8 (third floor) was completely full of water and was overflowing into the mechanical space (Figure 3). The excess moisture resulting from these condensate leaks is a recognized contributor to the development of microbial growth of public health concern [NIOSH 2013]. Proper slope of mechanical room floors, condensate pans, and clean unobstructed drain lines that route condensate into mechanical room floor drains should eliminate these moisture accumulation problems.

Filtration

All of the ventilation filters used at New Life Inn 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.

Ultraviolet Germicidal Irradiation (UVGI) Units

AHU-3, providing supply air to the dining/assembly area on the first floor, had a Fresh-Aire (Jupiter, Florida) ultraviolet (UV) disinfection system installed inside. This UV system is designed solely to kill or inactivate bacteria and mold growing on the coil and other exposed surfaces. While these UV units work to keep coils and surfaces clean, it is important to note that they are not designed to kill or inactivate microorganisms suspended in the airstream as it moves through the AHU. The system was noticeably working to keep the coil clean, and should continue to be used to avoid microbial buildup that is associated with indoor air complaints, dampness-related asthma, and upper respiratory symptoms [NIOSH 2013]. UV lamps should be replaced annually or when they burn out, whichever comes first.

While there are labels affixed on the outside of AHU-3 stating clearly that UV lamps are inside, CDC recommends additional safety devices when in-duct UV fixtures are used [CDC 2005b]. First, there should be a small viewport or window installed in each AHU access panel so maintenance personnel can see when the lamps are on or burned out. The blue glow through the window, while harmless, also serves as a reminder that the lamps need to be powered down before opening the access panels. Along with the viewport, a safety switch should be installed on each access panel to power down the lamps when the access panels are removed. Otherwise, forgetting to power down the AHU and opening the access panels could easily result in unnecessary UV exposures to workers. In humans, UV may be absorbed by the outer surfaces of the eyes and skin. Short-term overexposure may result in photokeratitis (inflammation of the cornea) and/or keratoconjunctivitis (inflammation of the conjunctiva). More details on UVGI installation, operation, and maintenance can be found in ASHRAE, NIOSH, and CDC documents [ASHRAE 2012; NIOSH 2009; CDC 2005b, 2006].

Any time that UVGI fixtures are installed inside AHUs, care needs to be taken to protect all nonmetallic surfaces exposed to UV energy. Synthetic filter material, such as that in the Flanders Pre Pleat 40 LPD filters used in all New Life Inn AHUs, is highly susceptible to UV degradation and should not be used in AHUs where the filters are in direct line-of-sight of the UV lamps [ASHRAE 2012]. If degradation of the synthetic filters is noticed, a switch to fiberglass filters is recommended. Fiberglass filter material does not degrade with exposure to UV energy, although some binding materials holding the fibers together can still be degraded. A reputable ventilation filter manufacturer could help select appropriate fiberglass filters for use around UV, if necessary. In addition to ventilation filters, all other nonmetallic materials, such as seals, gaskets, fan belts, and electrical wiring insulation, may be degraded by UV energy. These materials should be protected with foil tape or metal guards, if necessary. If any degradation becomes evident inside the AHU, the degraded material should immediately be replaced with new material that is properly shielded from the lamps or has been tested to be UV-resistant.

Preventive Maintenance

The ventilation system preventive maintenance program at New Life Inn was coordinated by the facilities manager. With the exception of the condensate issue, all of the AHUs were fairly clean and appeared to be adequately maintained. The facilities manager informed us that the ventilation filters are changed at least quarterly. 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 help 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 help 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.

Ventilation Measurements and Indoor Air Quality

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 New Life Inn. 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 of the shelter 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 we 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, all of the offices on the first and second floors with high densities are typically only occupied by one person. In these cases, the occupant densities are high simply because the offices are smaller than typical office spaces. However, the two sleeping areas on the third floor show high occupant densities because many people actually sleep in close proximity to one another. The work program sleeping area on the second floor is also close to exceeding the default occupant density value. 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 New Life Inn were delivering fresh outdoor air into the building. With one exception, the AHUs were not installed in a way that would allow them to easily bring outdoor air into the buildings. Some AHUs may not have the tempering capacity to incorporate the introduction of outdoor air. If such capacity is available, introducing outdoor air through the AHU would require some modifications, as well as increased annual energy costs. However, it is important to ensure that all occupied spaces in New Life Inn are receiving adequate amounts of fresh 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.

Two common approaches could be employed by New Life Inn 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 shelter would be to install a dedicated outdoor air system. This would involve installing a completely new AHU with ductwork extending to all occupied spaces of the main building. The same strategy could be applied for the Annex with a separate dedicated outdoor air system for that space. This new AHU should be sized to provide adequate outdoor air flow for the entire main building (approximately 2500–3000 cfm) while also providing the entire capacity to temper and dehumidify this outdoor air. The 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 the entire main building. Regardless of how it is accomplished, the major advantage of the dedicated outdoor air system is that it 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 system 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 shelter. At the same time, consideration should be given to optimizing air flow patterns, particularly in the three large sleeping areas, to reduce the potential of airborne disease transmission between guests. While even the best ventilation system cannot guarantee prevention of 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. One way that air flow patterns could be improved in these areas is to supply all air (fresh and recirculated) above the center 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 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. This arrangement should also alleviate concerns with short-circuiting of air, where supply air is immediately pulled into a return grille without providing any useful ventilation. 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 also noticed that virtually none of the bathroom exhaust fans were 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 whenever 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 68.5–76°F in the winter, and from 75.5–80.5°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 empty. We recommend maintaining the indoor temperature and RH levels within the ranges established by ASHRAE to provide the most comfortable environment to guests at New Life Inn. 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, New Life Inn 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. As such, we strongly recommend identifying an area 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 FGI recommend a differential pressure of $\geq$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 airflow 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 air changes per hour (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 New Life Inn 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 the three transition housing rooms on the second floor as areas that might be converted to effective respiratory separation areas. One of these transition rooms should be upgraded to serve this purpose. All of the transition rooms receive and return air to AHU-4, and they are the only areas served by AHU-4. One 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 the 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 the selected room to AHU-4. Choose an exhaust fan that is capable of maintaining the room under negative pressure relative to the adjacent corridor with minimal noise. The fan could be mounted directly in the wall or on the roof with ductwork running through the wall and up to the fan on the outside of the shelter. It is imperative that exhaust air from the new fan is directed away from all future AHU air intakes and gathering areas outside the shelter. Given that these rooms are located on the second level of the shelter, this should not be difficult.

For the space selected for respiratory separation, the newly installed return air dampers should be sealed to prevent air from inside the room returning to AHU-4. 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-4.

While it would be prudent to verify prior to any system renovations, AHU-4 should be able to self-balance if the return air grille from only one transition room is blocked. If additional respiratory separation areas are desired, the remaining transition rooms on the second floor could also be converted for this purpose. However, additional ventilation modifications may be required to ensure AHU-4 has an adequate supply of return air during periods when multiple rooms are simultaneously used for respiratory separation (and the normal return air paths from the rooms are blocked). To provide AHU-4 with the required return air flow, an alternative return air duct/damper system could be installed to pull air from an adjacent space. This alternative return air system would only be used when multiple transition rooms are simultaneously used as respiratory separation areas. 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 New Life Inn, a detailed written plan should be developed for the rapid conversion of the room from standard housing 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.

The respiratory separation area 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 housing unit, 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 a guest to a medical facility for TB testing. 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. 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 29 CFR 1910.134), these kits would allow cost-effective, on-site fit testing annually.

Conclusions

Since the increase in cases of TB disease in 2010, New Life Inn 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 shelter, and New Life Inn administrators are encouraged to promptly coordinate with DCHD and the Florida Department of Health to establish one.

From an environmental control perspective, the nine AHUs at the shelter are models from five different manufacturers and are of various sizes and ages. The preventive maintenance program in place is managed by the current facilities manager. The units appear to have been adequately maintained and were fully operational at the time of the NIOSH visit, although some had improper filter configurations and condensate containment and drainage problems that need to be addressed. There was no written preventive maintenance or O&M plan for the shelter AHUs.

None of the AHUs at New Life Inn 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 by shelter 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 qualified HVAC engineer should be consulted to discuss options for introducing outdoor air to the shelter. 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.

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 New Life Inn 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 New Life Inn. 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 the shelter. The following recommendations are aimed at improving the overall infection control program at New Life Inn, 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 New Life Inn, we have developed the following list of recommendations, in order of priority:

1. **Continue to improve and enhance the TB administrative controls at the shelter and develop a written Infection Control Plan.**
    - Continue working with the DCHD to screen shelter 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 shelter 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 New Life Inn 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 shelter. 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 New Life Inn.
   - Improve air flow patterns within all occupied spaces, particularly the three large sleeping areas. 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 condensate leaks with AHU-1, AHU-6, and AHU-8. Develop a monitoring strategy to prevent further occurrence of condensate buildup within the mechanical rooms.
   - After the condensate issue in AHU-1 is resolved, install a proper filter in that unit, which serves the registration/lobby area of the first floor. The filter through the door into the mechanical room housing AHU-1 can stay in place to provide additional air filtration if desired, but a filter is needed in the AHU itself to protect against aerosols generated within or leaking into the mechanical space.

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 transition room on the second floor into 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-4 is intact and sealed. Install tight-sealing return dampers on each return from the selected transition 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 exhaust fans directly through the outside walls of the rooms. The fans can be mounted through the walls themselves or mounted on the roof with ductwork through the walls to the fans.
- ○ Install the highest efficiency air filters in AHU-4 that will still allow adequate airflow 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 transition 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. When in use, 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. **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 the employer. 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.

6. **Repair all 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 F*lorida 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.

7. **Install additional safety features on the existing in-duct UV systems to meet CDC recommendations.** In addition to the labels currently on the outside of the AHUs, the following should be done:

    - Install a viewport or window in the AHU so maintenance personnel can see when the lamps are on or burned out.
    - Install a safety switch on the AHU access panel that automatically powers down the lamps when the access panels are removed.

- Ensure that nonmetallic surfaces exposed to direct or reflected UV energy are properly shielded with foil tape or metal guards to prevent material degradation.

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, UV lamp changes, 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 New Life Inn. 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.

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Tables

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

NIOSH AHU Identifier	Physical Location of AHU (floor/building)	Main Location Served by AHU (floor/building)[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 (1st floor/main building)	Registration/Lobby, Laundry Area (1st floor/main building)	Goodman	AR61-1	(1) 20 × 24 × 1	*None[F]
AHU-2	Southeast Corner Mechanical Room (1st floor/main building)	Kitchen, Kitchen Office (1st floor/main building)	International Comfort Products	FSM2X6000A	(1) 20 × 24 x 1	(1) 20 × 24 × 1
AHU-3[G]	Southeast Corner Mechanical Room (1st floor/main building)	Dining/Assembly Area (1st floor/main building)	Carrier	40RUQA08A2A6A0A0A0	(4) 16 × 24 × 2	*(4) 20 × 25 × 2
AHU-4	West Mechanical Room (2nd floor/main building)	All Transition Rooms (2nd floor/main building)	Trane	TWE036C14FB0	(1) 20 × 20 × 1	*(1) 20 × 25 × 1
AHU-5	West Mechanical Room (2nd floor/main building)	All Administration Offices/Areas (2nd floor/main building)	York	NAMB-FD20AC	Unknown[H]	(1) 20 × 22 × 1[H]
AHU-6	Southeast Corner Mechanical Room (2nd floor/main building)	Work Program Sleeping Area (2nd floor/main building)	International Comfort Products	FSM2X6000A	(1) 22 × 24 × 1	*(1) 20 × 24 × 1
AHU-7	Central Mechanical Room (3rd floor/main building)	Lifebuilders Program Sleeping Area (3rd floor/main building)	Trane	TWE090D300AA	(3) 16 × 25 × 1	(3) 16 × 25 × 1
AHU-8	Southeast Corner Mechanical Room (3rd floor/main building)	Overnight Sleeping Area (3rd floor/main building)	Carrier	40RMQ008--B611HC	(4) 16 × 24 × 2	(4) 16 × 24 × 2
AHU-9	Mechanical Room (annex)	All Locations (annex)	Trane	TWE120A100EL	(4) 16 × 25 × 1	*(4) 20 × 24 × 1

[A] May not represent all locations served by the AHU
[B] Information collected 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] No filter was installed in the AHU during the NIOSH visit. One 25 × 25 × 2 filter was installed in the door leading into the mechanical room housing AHU-1.
[G] This AHU is equipped with a Fresh-Aire in-duct UV system that may provide some inactivation of airborne pathogens as they pass through the irradiated zone. The effectiveness of the UV system could not be determined during the NIOSH visit.
[H] Manufacturer product literature for this AHU could not be found online or through a York dealer. Thus, the proper filter configuration could not be determined.

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 ventila tion 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 Building							
Registration/Lobby	AHU-1	Door[H]	790	620	8	13	77.2
Registration Office	AHU-1	Door[H]	100	85	1	*12	10.1
Laundry Area	AHU-1	Door[H]	400	450	1	2	59.0
Kitchen	AHU-2	0[I,J]	490	765	4	5	121.8
Kitchen Office	AHU-2	190	95	95	1	*11	10.7
Dining/Assembly Area	AHU-3	2130	2865	1755	60	34	405.3/765.9[K]
2nd Floor – Main Building							
Transition Room #1[L]	AHU-4	140	340	300	2	7	28.0
Transition Room #2[L]	AHU-4	155	< 30[I,M]	300	2	7	28.0
Transition Room #3[L]	AHU-4	70	300	300	2	7	28.0
Shelter Administrator's Office	AHU-5	None[N]	185	145	1	*7	13.7
Additional Glass Office	AHU-5	None[N]	170	150	1	*7	14.0
Reception Area	AHU-5	Door[H]	285	215	2	9	22.9
Conference Area	AHU-5	Door[H]	145	275	4	15	36.5
First Conference Area Office	AHU-5	Door[H]	90	115	1	*9	11.9
Second Conference Area Office	AHU-5	Door[H]	140	115	1	*9	11.9
Large Corner Office/Storage Area	AHU-5	Door[H]	200	215	1	5	17.9
Large Storage Area	AHU-5	Door[H]	75	130	0	0	15.6
Small Storage Area	AHU-5	Door[H]	45	55	0	0	6.6
Men's Room Off Conference Area	N/A[O]	< 30[I]	None[P]	25	N/A[Q]	N/A[Q]	N/A[Q]
Women's Room Off Conference Area	N/A[O]	< 30[I]	None[P]	25	N/A[Q]	N/A[Q]	N/A[Q]
Work Program Sleeping Area	AHU-6	295	955	1355	24	18	201.3
Work Program Bathroom/Showers	N/A[O]	0[I]	None[P]	255	N/A[Q]	N/A[Q]	N/A[Q]

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]
3rd Floor – Main Building							
LifeBuilders Program Sleeping Area	AHU-7	1230[R,S]	1610	2475	60	*24	448.5
LifeBuilders Program Bathroom/Showers	N/A[O]	0[I]	None[P]	280	N/A[Q]	N/A[Q]	N/A[Q]
Overnight Sleeping Area	AHU-8	1200[S]	1205	2205	67	*30	467.3
Overnight Bathroom/Showers	N/A[O]	0[I]	None[P]	190	N/A[Q]	N/A[Q]	N/A[Q]
Annex							
Entrance/Registration/Clothing Storage	AHU-9	Wall[T]	300	585	8	14	75.1
Seating/Gathering Area	AHU-9	Wall[T]	1160	790	70	89	397.4

[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] There were no return grilles. All air returning to the AHU passed through a grille in the door, cracks around the closed door, and various openings/leaks within the mechanical room structure. These air flows could not be measured accurately during the NIOSH visit.
[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] Does not include air pulled from the area by kitchen exhaust hoods. Air flow measurements through exhaust hoods were not taken.
[K] 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).
[L] Transition rooms were equipped with their own private bathrooms, but there were no separate bathroom exhaust systems. ASHRAE Standard 62.1-2010 and the *2010 Florida Building Code*: Mechanical (Chapter 4, Ventilation) specifies 25 cfm of exhaust air per toilet. This exhaust air 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.
[M] Cardboard was covering the supply vent. The cardboard was not removed during the NIOSH visit.
[N] There was/were no return grille(s) in this space. Only supply vent(s) was/were present.
[O] N/A = not applicable. Ventilation systems were properly designed to not supply air to this space.
[P] There was/were no supply vent(s) in this space. Only return grille(s) was/were present.
[Q] 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.
[R] Includes flow through the grille in the door into the mechanical room housing AHU-7
[S] Return grilles in this area were caked with dust and dirt. They should be cleaned periodically.
[T] There were no return grilles. All return air passed through holes in the wall and around the door into the mechanical room housing AHU-9. These air flows could not be mea sured accurately during the NIOSH visit

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. AHU-1 in the central mechanical room on the first floor of the shelter. The photograph shows standing water and apparent microbial growth due to condensate from the AHU leaking onto the floor of the mechanical room.

Figure 2. AHU-6 in the southeast corner mechanical room on the second floor of the shelter. The photograph shows condensate and debris in the return air plenum under the AHU.

Figure 3. AHU-8 in the southeast corner mechanical room on the third floor of the shelter. The photograph shows a drain pan overflowing with condensate, which is covering the floor of the mechanical room.

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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).

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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/2012-0155-3180.pdf.

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