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Exposure to Human Waste from Spills while Servicing Aircraft Lavatories: Hazards and Methods of Prevention

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Abstract: Workers service the lavatories of commercial aircraft approximately 11 million times per year in the United States and may have exposure to the spectrum of pathogenic viruses, bacteria and parasites potentially found in human waste. An industrial hygiene walk-through of the workplace was conducted by an interdisciplinary occupational health and safety team, and lavatory waste operators and supervisors and the process was observed. Exposure to untreated waste can occur through dermal, ingestion, and inhalation in quantities ranging from droplets to large spills. Several engineering and administrative measures were advised to minimize worker exposure, including the effective locking of a critical valve, and a mechanism for communicating valve locking problems.

Key words: Aircraft lavatories, Human waste exposure, Occupational health, Health hazard evaluation

Introduction

The Bureau of Transportation Statistics reports that in 2007 over 11 million flights departed from US airports[1)]. Following essentially every landing, lavatories are serviced, with the waste transferred from airplanes to other waste disposal pathways. Individuals who service the lavatories of commercial aircraft may have exposure to the spectrum of pathogenic viruses, bacteria and parasites potentially found in human waste. The unintentional ingestion of lavatory contents could occur following a splash exposure to the face or through hand-to-mouth contact after hand exposure. This route of exposure could result in enteric infections. Exposure to the eyes, respiratory tract, and skin wounds could result in ocular, respiratory, or dermal infection. In theory, open wounds could be a portal of entry for infections typically transmitted by the percutaneous route.

The health risks of airplane lavatory waste exposure have not been characterized, and even case reports of illness following exposure have not been reported. A case with skin, nose, and mouth exposure to a large lavatory spill was seen in an airport-based university occupational health clinic. We viewed that case as a "sentinel event" and, together with the employer of the exposed worker, conducted an evaluation to identify measures that may prevent future exposures.

Methods

Hazard characterization

The medical literature was reviewed. PubMed was queried using search terms (aircraft or airline or airplane) with (lavatory or wastewater or sewage or infection or noise). Abstracts were reviewed, and relevant English language papers were read. The citations of those papers and publications citing them were reviewed as well.

Process description and identification of current preventive efforts

An interdisciplinary occupational health team comprised of the treating occupational physician, a Certified Industrial Hygienist, and a mechanical engineer visited the worksite at a large international airport. Workers and supervisors who provided verbal consent to be inter-

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viewed were observed through all phases of servicing lavatories of several aircraft. Workers and their supervisor were interviewed and asked: 1) to describe the tasks involved in servicing the lavatories; 2) whether they have ever experienced a "lav spill"; and 3) if they have any suggestions for preventing lavatory spills.

This research was reviewed by the UIC Institutional Review Board and granted an exemption.

Results

Hazard characterization

Microbial

A variety of gram negative bacteria have been identified in cultures of bulk samples of aircraft lavatory waste[2]. Waste fluid containing "blue water" deodorizer contained *Morganella morganii, Providencia rettgeri*, and *Proteus penneri*, but not *Salmonella spp*. or *E. coli*. This suggests some disinfectant properties of the deodorizer. The bacteria identified are not considered to be significant causes of gastrointestinal illness, though they can cause urinary tract infections. Enteroviruses have been identified in seven of sixteen (44%) samples of aircraft lavatory waste international flights landing in the US[3]. Samples were found to contain echovirus 7, echovirus 13, echovirus 33, coxsackievirus B2 and coxsackievirus B5. Echoviruses and coxsackieviruses can infect the central nervous and cardiac systems, particularly in neonates. Transmission in the setting of wastewater treatment has not been reported.

Chemical

Endotoxin, also known as lipopolysaccharide, is a component of the cell walls of gram negative bacteria. Exposure to workplaces with high concentrations of endotoxin has been linked to a variety of acute symptoms[4, 5]. Endotoxin has been measured in wastewater treatment plants[6, 7], but levels related to aircraft lavatory service have not been reported. The fact that aircraft lavatory service takes place outdoors likely allows for significant dilution of endotoxin concentrations.

While some aircraft use tap water to flush toilets, others use a blue deodorizing liquid. The deodorizing liquid contains ammonium compounds[8]. While these can be an irritant, the fact that exposure takes place outdoors likely reduces airborne concentrations to a relatively low level.

Physical

Other potential occupational hazards for these operators are a function of working on an active runway. Aircraft engines are noisy, so hearing protection is required when the operators are servicing aircraft while engines are running (noise dosimetry is advised to determine if a comprehensive hearing conservation program is required[9–11]. In addition to engine noise, operators should be aware of hot exhaust from the aircraft engine. Ambient environmental hazards of extreme cold, high heat and humidity, and sun exposure should be accounted for in a health and safety program. Finally, since this workplace is an active runway, traffic hazards exist from many different types of cars and trucks, powered industrial vehicles, and aircraft.

Current practices

Training and organization of work

Operators are trained on the job over the course of three days, shadowing an experienced waste operator. The new operator is approved by a supervisor to work independently after he or she is observed performing the waste removal tasks and is verbally quizzed on the tasks to ensure the job is performed correctly and safely. The contracted company that hosted our visit organizes the work in two shifts, with three employees per shift. Some overtime work is performed at the end of the second shift if aircraft are delayed in their arrival. A high turnover rate of operators was noted.

The waste removal process

The waste removal process begins when the operator approaches the aircraft in a powered industrial vehicle (PIV) equipped with the removal apparatus (hose, pump, and holding tank), and parks the PIV a few meters from the aircraft. The operator then opens a waste service panel on the fuselage (Fig. 1), and uses a handle to open the waste port covering (Fig. 2). A hose from the removal apparatus is attached to the waste port on the aircraft, and is secured with a threaded fastener (Fig. 3). The operator then initiates waste flow by pulling a t-shaped handle (Fig. 2) that opens a flap in the toilet to open the system to assist in flow of the waste. Next a toggle is activated (Fig. 2) which opens a valve (Figs. 4a–c) at the waste port on the aircraft to permit waste flow into the attached hose; a mechanical pump assists in the removal. The

Fig. 1. Access panel to aircraft waste port.

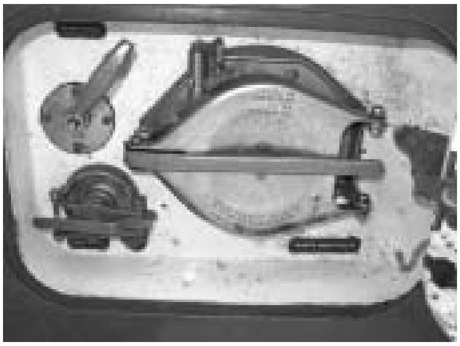

Fig. 2. Waste port and controls.

Fig. 3. Operator connecting hose from waste removal vehicle to aircraft waste port.

operator aids the pumping action by periodically lifting the hose so waste continues to flow into the vehicle holding tank. When all of the waste has been removed, the operator pushes the t-handle in to close off the flap in the toilet. The threaded fastener that secures the hose to the waste port is released by turning counterclockwise. The operator then wipes, as necessary, the inner diameter of the waste port and wipes off the valve area to ensure there is no waste that would prohibit a proper seal and closure. Finally the handle is used to simultaneously close the valve on the waste port and the waste port cover (Figs. 4a–c). For certain aircraft models, a supply hose is attached to a separate port to re-fill the lavatory deodorizing fluid used to flush the toilet; other models use the potable water system, which is loaded onto the aircraft at a different location. The waste service panel on the fuselage is then closed and service is complete. The entire service process takes three to seven minutes. In the course of observing lavatory service on several aircraft, it was clear that droplet splashes occur downwind of the waste port valve when it is opened. The exact number and locations of the panels varies across specific aircraft models.

The principl control strategy in place is the attempt to make the waste removal process a completely enclosed system. In theory, the operator never has contact with the waste because of the closed removal system, but the actual execution of the task does permit a few distinct opportunities for the closed system to become compromised.

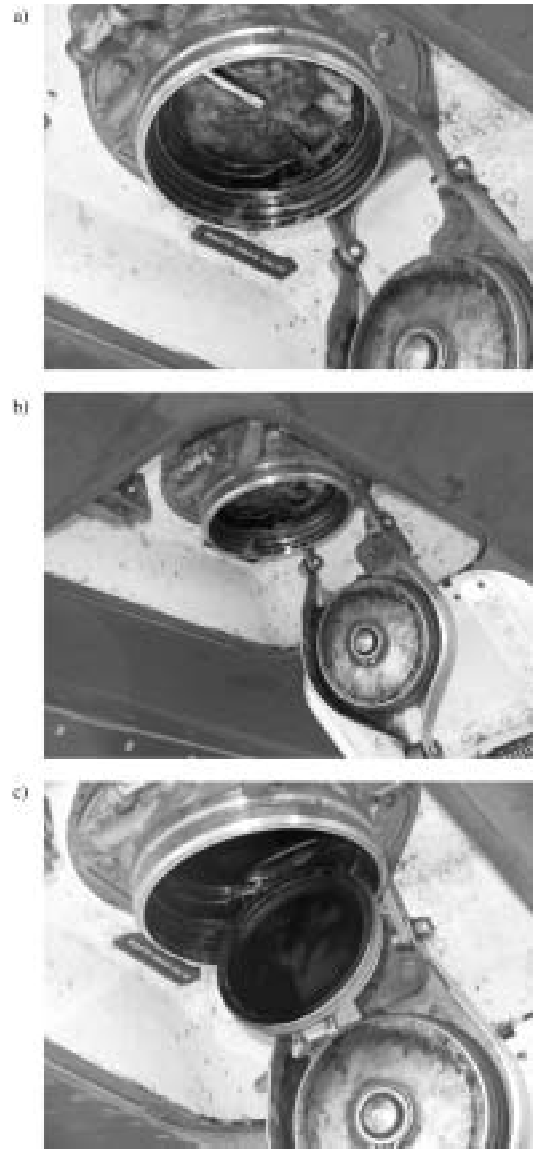

Fig. 4. a) the port handle in the open position, b) the valve in the closed position before the waste removal hose is attached, and c) the valve in the open position after the hose is removed.

Causes of spills

Mechanical factors

One cause of spills appears to be a mechanical failure of the waste port locking system, and seems to occur in two ways. One type of mechanical failure is caused when an obstruction that does not permit the waste port valve to be locked into place upon completion of servicing the tank. Operators cited waste (toilet paper, solid waste) from the holding tank may be left on the interface between the port and valve cover, prohibiting a properly sealed closure. Another reported type of mechanical failure can occur if the valve mechanically does not lock into place, suggesting a mechanical failure of the spring controlled system rather than a physical obstruction. Both types of mechanical failure of the waste port locking system should be apparent when lavatory tank service is being done. A mechanical factor that is independent of the valve mechanism relates to the pumping of the waste from the aircraft lavatory tank. If the pumping hose is not securely fastened to the waste port (Fig. 3), the hose connection may fail once material begins to flow. The weight of the waste flowing into the hose will simply pull the improperly attached hose away from the aircraft port. Any material in the hose will be lost to the ground, and this leaves all of the remaining material in the aircraft holding tank free to flow out of the tank.

Organization of work

The operators cited work-related behaviors that are associated with the organization of the work. "Working too fast" when many planes need to be serviced and "not paying attention" during the servicing were identified as factors contributing to spills. Failing to make sure the hose was properly secured to the aircraft before initiating pumping was identified as an outcome of the operator's attention failure. The operators also identified their failure to properly position themselves to avoid possible exposure (should a leak occur) as a function of failing to pay attention. While we only observed the task performed for smaller aircraft (where the waste port is 1 to 2 m off the ground), it seems likely that the operator is more vulnerable to significant exposure with increasing size of the aircraft, both in terms of volume of waste and because the work is performed nearly directly overhead.

Current preventive efforts

Personal protective equipment

Heavy rubber gloves, covering the hands or half-arm, were used by all workers; some workers chose to use a latex or cotton glove liner underneath. Face shields are provided and are to be used during tasks where splashes or spills may occur. However, adherence to the face shield policy varied among the workers observed.

Discussion

The research team applied principals of safety engineering and industrial hygiene to expand upon worker suggestions and to develop additional approaches to exposure prevention and risk reduction. These findings were discussed with workers and supervisors and additional feedback was obtained from them.

The primary cause of spills and subsequent exposure is mechanical in nature and is related to the design and maintenance of the valve locking system and interface with the waste removal apparatus. Engineering solutions are generally the preferred means of preventing exposure to workplace hazards, as they are independent of behavioral factors. We outline potential engineering solutions and suggest some additional administrative and personal protective equipment control strategies to prevent or minimize exposure.

Training

Formal training involving the supervisor and the experienced worker is necessary for the new employee. An ideal training program should be comprised of performance of job tasks, associated hazards and means of prevention. The worker's understanding should be verified in some meaningful evaluation before on-the-job training may begin. Supervisors and operators should have the opportunity to discuss the different work pace demands of the job and how best to address them so that the work is accomplished both safely and efficiently. Adoption of these skills and knowledge should be assessed again before the individual is permitted to work independently.

Key safety elements for operator training include attention to wind direction and body positioning relative to the waste port. Attention to wiping the waste port free of debris before closure will help assure proper closure of the valve and help prevent a spill at the aircraft's next servicing. The lavatory door inside the aircraft should be locked by the flight crew or maintenance team to prohibit use of the lavatory during servicing.

A clear and formal reporting mechanism should be in place so the operators and supervisors know whom to contact in the event of a spill. This includes both the acute management of the exposed operator as well as for the identification and possible removal of aircraft from service so a mechanical malfunction may be addressed.

Ensuring that the waste removal hose is properly connected to the aircraft waste port is critical in the prevention of spills. Training the operators to be mindful of ensuring proper threading of the hose to the port will assist in prevention.

Vaccination

Vaccination is an effective means of preventing hepatitis A virus (HAV) transmission. HAV is transmitted by the fecal-oral route and in theory could be transmitted through sewage. The CDC notes[12)] that confirmed transmission of hepatitis A among wastewater workers in the US has not been reported, and that hepatitis A vaccine is not recommended for wastewater workers. However, there is potential benefit, with little downside, to HAV vaccination. The primary mode of transmission for hepatitis B virus (HBV) is percutaneous (such as with a needle), not by splash exposures or ingestion. The Centers for Disease Control and Prevention (CDC) does not list occupational contact with wastewater as an indication for vaccination[13)].

Maintenance

Proper maintenance of the locking mechanism is essential. The spring loaded toggle switch that controls the opening of the valve must be properly maintained to ensure it is free from debris and is properly functioning. The lever locking system that forces the waste port valve into place upon completion of waste removal must also be properly maintained.

Personal protective equipment

The personal protective equipment (PPE) currently available to workers, when properly used, likely affords them significant protection. Appropriate administrative measures should be employed to make adherence to PPE requirements universal.

The operators are currently required to use a face shield when performing tasks where splashes may occur. Splashing is a risk throughout the entire task of waste removal as well as the re-filling of the liquid deodorizer tank. The authors recommend that goggles be used in conjunction with face shields to prevent splashing into the eyes, nose and mouth[14, 15)].

Operators currently use heavy rubber outer gloves with an optional latex or cotton (lightweight or heavy winter) as a glove liner. The heavy gauge is justified since the gloves must be durable for the tasks performed. If latex gloves are utilized, selection of a powder-free glove has been recommended to minimize allergy risk[16)]; other options exist, such as specific grades of nitrile gloves.

Long pants and long shirtsleeves should be required. Further, a uniform laundry service should be provided; alternatively, operators should wash their work clothes separately from other family member laundry[17–19)]. Work clothes should be changed during shift if there is known contamination with waste[20)]. If facilities are available, the operator should be given the option to shower before leaving their shift. These combined efforts will minimize contamination transfer to the operator's vehicle and home.

Our observations in context

The potential exposure to infectious microbial hazards (including HAV and HBV) has been noted. An additional acute irritant hazard may exist with exposure to the lavatory tank deodorizer fluid. Further, intercontinental travel presents the opportunity to import otherwise rare and non-endemic disease. With each commercial flight there is a potential lavatory spill and opportunity for transmission of infection, which begs the question, what is the frequency of the near miss? That is, our university occupational health clinic is likely to only see patients where a significant exposure has occurred. We do not know the frequency with which failure of the waste port closure mechanism or the hose attachment occurs but the operator manages to avoid direct exposure.

We have identified some of the contributing factors to spills while servicing aircraft lavatories and have suggested some potential methods of prevention. Our suggestions focus around proper maintenance of the aircraft waste port, hazard identification and prevention training for workers, and use of personal protective equipment for splash prevention and isolation from waste. The best strategy likely includes components from engineering controls, administrative controls, and PPE.

During conversations with the operators and supervisor, we learned of instances of repeated problems with malfunctioning waste port equipment with the same aircraft, even after a request to the airline maintenance for servicing had been made. One operator reported that maintenance did not take the operator seriously when he reported a malfunctioning valve. After our walk-through, the supervisor suggested that she arrange a meeting with maintenance personnel from the airline they support, and we completely support this course of action. This is principally a mechanical issue with the mishap isolated to the accessing of the waste port; optimizing the maintenance of these systems is likely to eliminate the potential for spill.

This research began as a health hazard evaluation following the treatment of a worker who had sustained a spill in an airport-based academic occupational health clinic. As such, the research was limited to walk-throughs in several terminals in a single airport. It is likely that current practices and preventive measures vary to some degree by employer, and we were not able to characterize that variability. The collaboration by a concerned employer and a multi-disciplinary academic occupational health research team was effective in developing an array of potential preventive measures.

Further investigation into the frequency of spills, the cost of follow-up treatment, and the risk of infection is warranted. Depending on the acceptance of risk and cost-benefit analysis, a complete re-design of the manner in which the aircraft waste port interfaces with the removal apparatus may be justified and subsequently demanded of aircraft design engineers. Future studies might also include evaluations of the effectiveness of the interventions suggested here. The application of environmental microbiology methods to this setting would be useful in developing a more comprehensive understanding of the hazards. This could also promote the development of deodorizing solutions that have greater antimicrobial properties.

Conclusion

To the authors' knowledge the characterization of lavatory operator tasks, associated potential hazards, and suggested methods of prevention have not been reported in the literature. Workers around the US are potentially exposed to an array of pathogenic organisms thousands of time per day. A multi-tiered approach to preventing exposure includes training, engineering solutions and PPE. Developing effective control strategies could help protect these workers and also some in other professions where exposure to human waste may occur, such as sewage system maintenance and operations personnel. Investigation by a multidisciplinary occupational health team is a valuable means of evaluating hazards and developing control strategies. This problem highlights the need for multi-tiered control strategies for the prevention of occupationally-related disease.

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