American Journal of Infection Control ■■ (2017) ■■-■■

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major Article

Environmental and body contamination from cleaning vomitus in a health care setting: A simulation study

Linh Phan MS, Yu-Min Su MS, Rachel Weber BS, Charissa Fritzen-Pedicini MSPH, Osayuwamen Edomwande, Rachael M. Jones PhD * for the CDC Epicenter Prevention Program

School of Public Health, University of Illinois at Chicago, Chicago, IL

Key Words:
Environmental service workers
health care
fluorescein
infectious diseases

Background: Environmental service workers may be exposed to pathogens during the cleaning of pathogen-containing bodily fluids.
Methods: Participants with experience cleaning hospital environments were asked to clean simulated, fluorescein-containing vomitus using normal practices in a simulated patient room. Fluorescein was visualized in the environment and on participants under black lights. Fluorescein was quantitatively measured on the floor, in the air, and on gloves and shoe covers.
Results: In all 21 trials involving 7 participants, fluorescein was found on the floor after cleaning and on participants' gloves. Lower levels of floor contamination were associated with the use of towels to remove bulk fluid ($\rho = -0.56$, $P = .01$). Glove contamination was not associated with the number or frequency of contacts with environmental surfaces, suggesting contamination occurs with specific events, such as picking up contaminated towels. Fluorescein contamination on shoe covers was measured in 19 trials. Fluorescein was not observed on participants' facial personal protective equipment, if worn, or faces. Contamination on other body parts, primarily the legs, was observed in 8 trials. Fluorescein was infrequently quantified in the air.
Conclusions: Using towels to remove bulk fluid prior to mopping is part of the recommended cleaning protocol and should be used to minimize residual contamination. Contamination on shoes and the floor may serve as reservoirs for pathogens.

In health care settings, patients with infectious diseases release pathogen-containing bodily fluids (eg, vomitus, diarrhea, respiratory secretions) and otherwise shed pathogens into the environment, which may result in health care–associated infections (HAIs) among other patients and health care personnel. Pathogen contamination of environmental surfaces in patient rooms has been widely documented[1,2] and is thought to be specifically associated with HAIs.[3] Therefore, cleaning of environmental surfaces to remove pathogens is recommended to prevent HAIs.[4]

There remains a knowledge gap about the exposures of environmental service workers (ESWs) to pathogens in health care settings. Cleaning requires ESWs to be in close, and potentially prolonged proximity, to infectious agents. Most research involving ESWs in health care settings has focused on improving the quality of cleaning, particularly with respect to terminal room cleaning,[5] not on infection risks. To begin to understand the exposures of ESWs to pathogens during cleaning in health care settings, we performed a simulation study in which ESWs were recruited to clean simulated vomitus in a room-scale chamber. Herein, we describe contamination in the environment and on workers' bodies associated with cleaning simulated, fluorescein-containing vomitus. Elsewhere, we have described the environmental surface and body contacts of the participants.[6]

METHODS

Details of the experimental simulation approach are provided elsewhere.[6] Briefly, participants with experience in hospital cleaning were recruited and asked to clean 200 mL of simulated vomitus

* Address correspondence to Rachael M. Jones, PhD, School of Public Health, University of Illinois at Chicago, 2121 W Taylor St (M/C 922), Chicago, IL 60612.
E-mail address: rjones25@uic.edu (R.M. Jones).
Funding/support: Supported by the Centers for Disease Control and Prevention Epicenter Program through cooperative agreement U54CK000445, and the UIC Epicenter for Prevention of Healthcare Associated Infections.
Conflicts of interest: None to report.

0196-6553/
https://doi.org/10.1016/j.ajic.2017.10.003

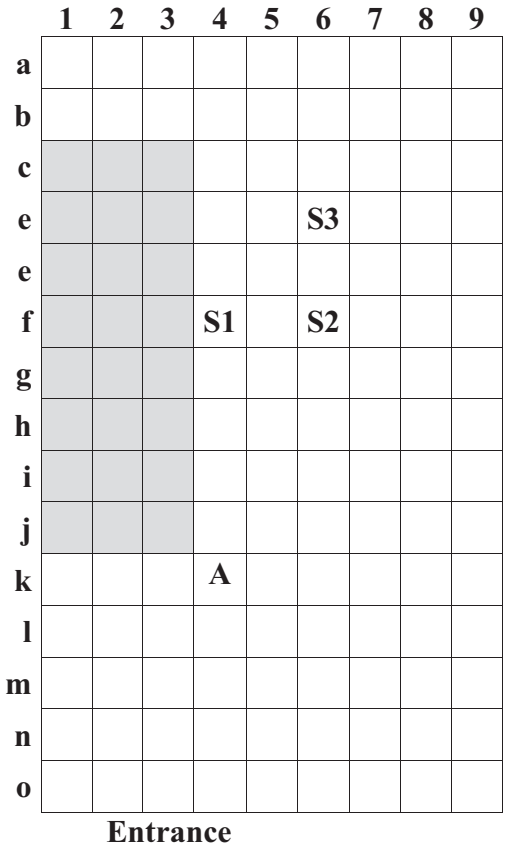

Fig 1. Layout of the room-scale chamber. Shaded boxes indicate location of the gurney. S1, S2, and S3 denote locations of floor sampling; A denotes location of air sampling.

in a room-scale chamber (2.5- × 4.5- × 2.4-m high). The chamber floor was marked into a grid (30.5 × 30.5-cm grid, or 929 cm^2), labeled by row (a-o) and column (1-9) (Fig 1). Simulated vomitus was a mixture of protein powder, water, sodium phosphate, and fluorescein powder (10^6 μg/L).[7] Four experimental conditions were used: (1) low viscosity vomitus poured on the side of the gurney, (2) high viscosity vomitus poured on the side of the gurney, (3) low viscosity vomitus poured on the floor, and (4) high viscosity vomitus poured on the floor. Vomitus was poured near grid square f4 (Fig 1). Participation involved a 2-hour time commitment and was incentivized with a $40 gift card. The University of Illinois at Chicago Institutional Review Board approved this study (protocol no. 2015-0990).

Environmental contamination of the chamber, indicated by the presence of fluorescein, was qualitatively measured under black light and described by the maximum radius and area contaminated before and after cleaning. Fluorescein was quantitatively measured at 3 prespecified locations (grid squares f4, f6, and d6, Fig 1) by swabbing each area with a Sponge Stick (3M, Minneapolis, MN). Fluorescein was measured in the air near the site of contamination, 70 cm above the floor at grid square k4, using a 5-stage Sioutas cascade impactor, with 37- and 25-mm PTFE filters (SKC, Eighty Four, PA) and an air flow rate of 9 L/min.

Body contamination of the participant was qualitatively measured under black light before and after doffing personal protective equipment (PPE). Observations were recorded separately for the palm, fingers, and back of the right and left glove and hand; the sole and top of the right and left shoe cover and shoe; the eye and forehead area; the mouth and nose area; the goggles or face shield (if worn); and the mask or respirator (if worn). Visible contamination at each location was recorded as the number of spots <1 and 1-3 cm in diameter, and percentage of the surface area contaminated by spots >3 cm in diameter. In tabulating total percent surface area visibly contaminated, each spot <1 cm in diameter was equated with 1% surface area, whereas spots 1-3 cm in diameter were equated with 2% surface area. The total surface area visibly contaminated was categorized by percent of surface area as none, low (>0% and ≤25% of the area contaminated), medium (>25% and ≤50%), and high (>50%).

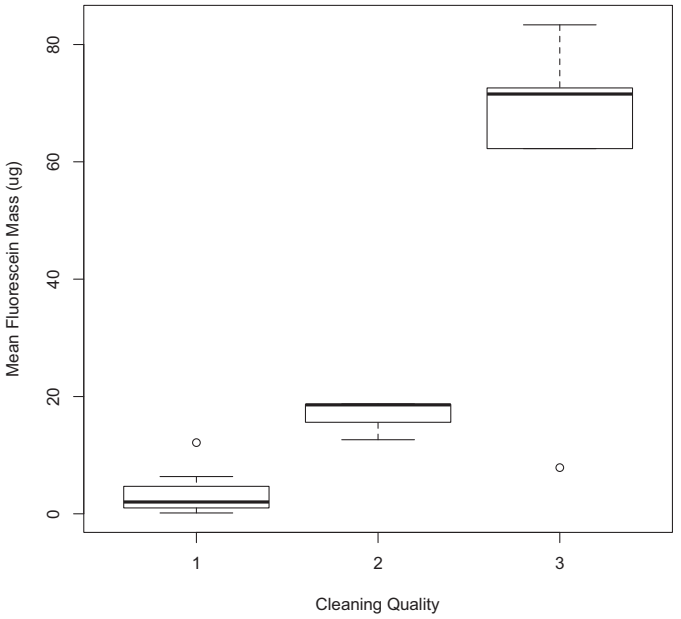

Fig 2. Increased cleaning quality is associated with decreased residual fluorescein contamination on the floor.

Fluorescein was extracted for quantification by agitation of the sampling device with sodium phosphate buffer and measured in triplicate using a Trilogy bench-top fluorometer (Turner Designs, San Jose, CA). The average value is reported. The fluorometer was calibrated to report fluorescein concentration (μg/L) using a 5-point calibration curve, with quality criterion $R^2 > 0.99$. The limit of detection (LOD) was 0.038 μg/L. The fluorescein concentration in buffer (μg/L) was converted to mass concentration per surface area (μg/cm^2) for Sponge Sticks, to mass concentration per air volume (ng/m^3) for air filters, and to total mass for gloves and shoe covers (μg).

Between trials, plastic sheeting on the chamber floor was replaced, and the absence of visible contamination verified under black light. Blank trials, in which participants performed cleaning activities without simulated vomitus, were used to verify the absence of fluorescein in the chamber. Quality control also included the analysis of blank sampling media (filters, Sponge Sticks, gloves, and shoe covers). Sponge Sticks were found consistently to have some fluorescent component, equal to 1.08 μg fluorescein (additional information is available online at https://indigo.uic.edu). As a result, the floor contamination data reported have been blank corrected. Air sampling filters were found contaminated on the day of 2 experimental trials (3-A1 and 3-A2). As a result, the results of these trials were excluded from analysis and the packages of filters discarded. Experimental blanks were elevated (but <5 μg) on the day of experimental trials 4-A1 and 4-A2; therefore, these data were blank corrected.

Results have not been corrected for sampling and extraction efficiencies, but the method performance was quantified (Supplementary materials). Briefly, sampling and extraction