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Brief Report

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Simulation Based Ambulance and Crew Decontamination Advise During COVID-19 Pandemic

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This study involved a simulation of transportation and basic life support on ambulances carrying coronavirus disease 2019 (COVID-19) patients, using a specially modified mannequin. The mannequin used can spew a fluorescent solution from its mouth to simulate the droplets or vomitus made by the patient and can be detected using ultraviolet light illumination. We determined that the most frequently contaminated areas of an ambulance in the driver's cabin are the left front door's outer handle, driver's handler, gear lever, and mat. The most frequently contaminated area in the rear patient's cabin is the rear door, rear door lining, and handle over the roof. The most frequently contaminated areas before the removal of personal protective equipment (PPE) are the lower chest to the belly area, bilateral hands, lower rim of the gown, and shoes. After the removal of PPE, traces of fluorescence were observed over the neck, hands, and legs. We therefore suggest taking a bath immediately after PPE removal.

Key words: *simulation, ambulance, ambulance crew, decontamination, COVID-19*

Introduction

Since the outbreak of coronavirus disease 2019 (COVID-19) in late 2019, daily medical practices have changed significantly. The current pandemic has reiterated the importance of proper personal protective equipment (PPE) usage, standard precautions, maintenance of social distance, and hand hygiene.

It is of utmost importance to adopt measures to prevent fomite-borne transmission of COVID-19, especially in health care settings; thus, environmental decontamination strategies are needed. Emergency medical service (EMS) systems constitute the first line of health care workers that deal with patients who may have COVID-19. Therefore, proper PPE use and environmental decontamination are mandatory to ensure personnel safety and prevention of transmission.

The United Kingdom government had published "COVID-19: Guidance for Ambulance Trust,"[1] which was last updated on April 11, 2020. The Taiwan Centers for Disease Control and National Fire Agency also published guidelines for the transportation of COVID-19 patients by the EMS system on April 13, 2020.[2] Both these guidelines mentioned decontamination of all exposed surfaces using a chlorine-based solution at 1,000 ppm. Taiwan's guidelines also mention decontamination of surfaces that are in contact with blood, vomitus, body fluid, urine, or feces, using a chlorine-based solution at 5,000 ppm.

However, information on possible contaminated areas in ambulances and EMS personnel remains lacking. Therefore, we conducted a high-fidelity simulation with a specially modified mannequin to determine the most frequently contaminated areas of the ambulance and EMS personnel.

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Methods

This study is part of a simulation hosted by the Ditmanson Medical Foundation Chia-Yi Christian Hospital and the Fire Bureau of the Chia-Yi City Government. The aim of the simulation is to determine the ability to transport COVID-19 patients using the EMS in Chia-Yi City and the ability to handle COVID-19 patients in the emergency department of the hospital.

This simulation was conducted using a specially modified mannequin. This mannequin was created using an intubation mannequin attached with an agricultural manual-pressured herbicide sprayer. The nozzle of the sprayer was placed in the mouth of the mannequin, which could spread a pre-mixed colorless fluorescent solution, to simulate droplets or vomitus from COVID-19 patients (Fig. 1). The pressured sprayer could hold 7.5 L of fluids with a maximal flow rate of up to 1.5 L/min. The flow rate could vary with pressure. During the drill, we used approximately 3 L of a pre-mixed fluorescent solution in 30 minutes, and the flow rate was approximately 0.1 L/min in this simulation. Ultraviolet (UV) light with a wavelength of approximately 395 nm was used for illumination to identify the most contaminated areas, which could be focused on during decontamination.

Two experienced emergency technicians (EMTs) were involved in this simulation; one was an EMT-P (paramedic) and the other was EMT-2. The scenario of the simulation was a confirmed COVID-19 patient requesting EMS due to shortness of breath and weakness at home, who then suffered a cardiac arrest during transportation.

In accordance with the current local EMS guidelines, the PPEs for EMTs dealing with COVID-19 patients are class-C protection suits, N95 masks, goggles, face shields, gowns, three layers of gloves, and shoe covers. In addition, EMTs in our city would put face masks on patients using any O_2 supplying modality. In our simulation, the EMT-P used a non-rebreathing mask along with a face mask to the patient at the time of contact with the patient and all the way to the hospital. He also performed chest compression only for basic life support (BLS) once the cardiac arrest manifested. BLS was performed for 10 minutes in the ambulance. The total exposure time of EMTs was approximately 30 minutes from contact with the patient to handover of the patient to the hospital. Ambulance settings are shown in Fig 2.

After handing over the patient to hospital and before removing PPE, we illuminated the EMTs with UV light at a wavelength of approximately 395 nm.

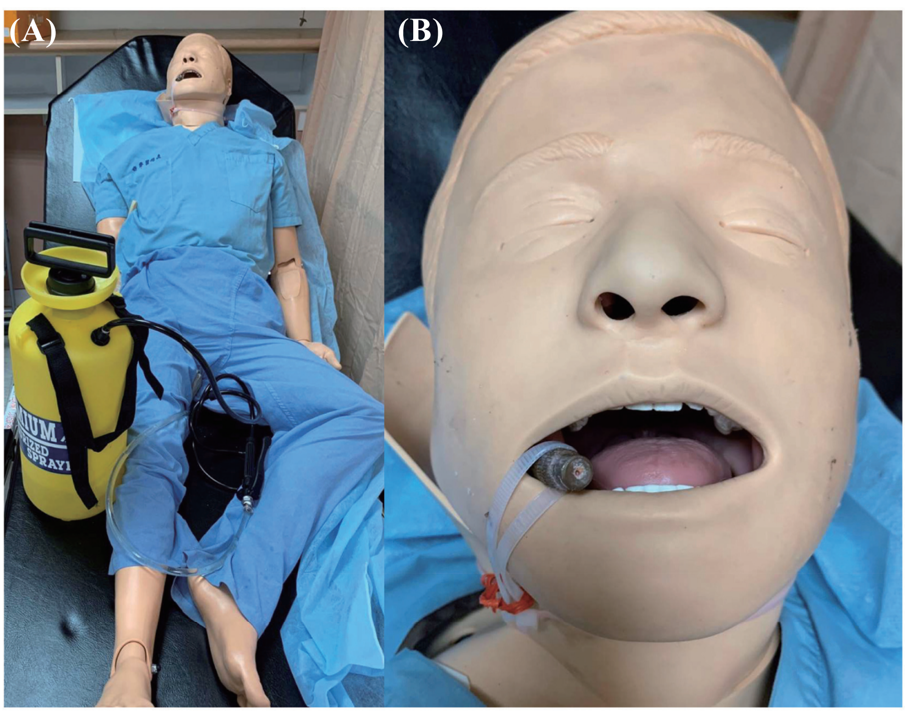

Fig. 1. Setting of the mannequin. (A) The whole set includes a manual-pressured herbicide spreader and an intubation mannequin. (B) Spreading nozzle in the mouth and the fixation method.

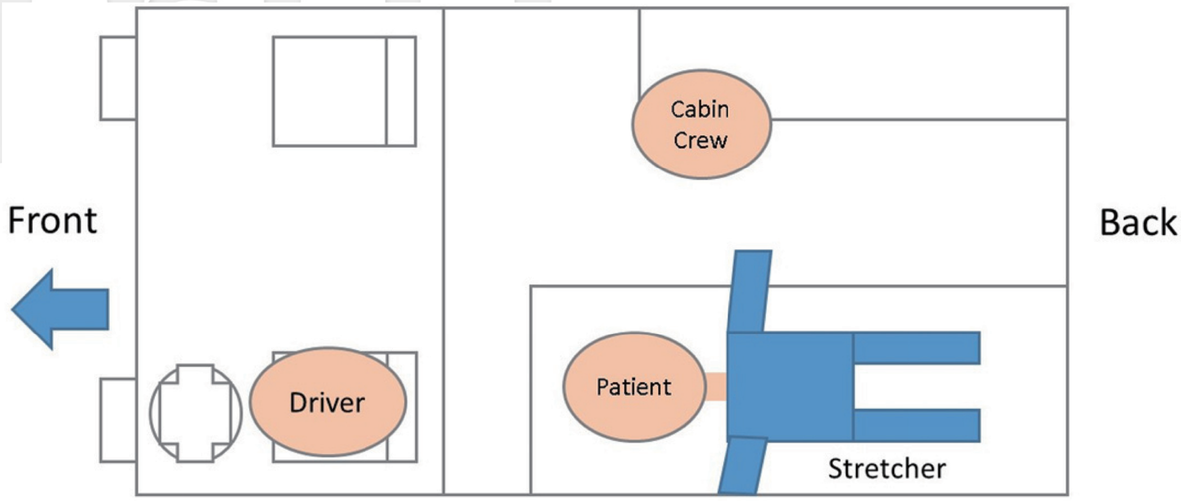

Fig. 2. Setting of the cabin inside the ambulance.

After PPE removal following the standard procedure, we re-illuminated the EMTs to check if any contamination persisted. We also illuminated the ambulance to determine the most frequently contaminated areas.

Results

With respect to the contamination of the personnel (Fig 3), the most frequently contaminated areas before PPE removal were the lower chest to belly area, bilateral hands, lower rim of the gown, and shoes. After PPE removal, traces of fluorescence persisted over the neck, hands, and legs. Prominent differences between the amount and areas of contamination of the driver and the cabin crew were observed. With respect to the driver, the most frequently contaminated areas were the hands, lower rim of the gown, and shoe cover. Conversely, the most frequently contaminated areas for the cabin crew were the hands, lower chest to belly area, lower rim of the gown, and shoe cover. The level of contamination of the cabin crew was also much more prominent than that of the driver. We think that this difference is attributable to the nature of their roles. The cabin crew is responsible for contacting the patient, providing a mask, and administering emergency care, while the driver is mainly involved in controlling the stretcher and driving the ambulance.

With respect to the ambulance (Fig 4), the most frequently contaminated areas in the driver's cabin were the left front door's outer handle, driver's handler, gear lever, and mat. The most frequently contaminated areas in the rear patient's cabin were the rear door, rear door lining, and handle over the roof. The driver's cabin was found to be less contaminated than the rear cabin.

Discussion

By using a fluorescent solution and UV light, we demonstrated that most frequently contaminated surfaces of an ambulance and on EMS personnel. During our simulation, we noted that despite carefully following standard procedures to remove the PPE, traces of fluorescence persisted on the clothing or skin of a person. We recommend taking a bath and changing clothes after the removal of PPEs. In addition, with respect to ambulance decontamination, the door handles, driver's handler, gear lever, mat, and handle over the roof of the patient's cabin must be routinely sanitized as these are the most frequently contaminated areas. Besides, the level of contamination is proportional to the time of exposure to the patient. Under proper circumstances and patient conditions, the EMS crew should be in the driver's cabin to reduce the time of exposure.

Although the specially modified mannequin could simulate the presence of droplets and vomitus, our study has some limitations. First, owing to the limited range of the spreading nozzle, aerosol distribution could not be accurately simulated. Second, owing to the limited range of movement of the nozzle, it is likely that over-contamination occurred in our study. Third, owing to the nature of fluorescence, our

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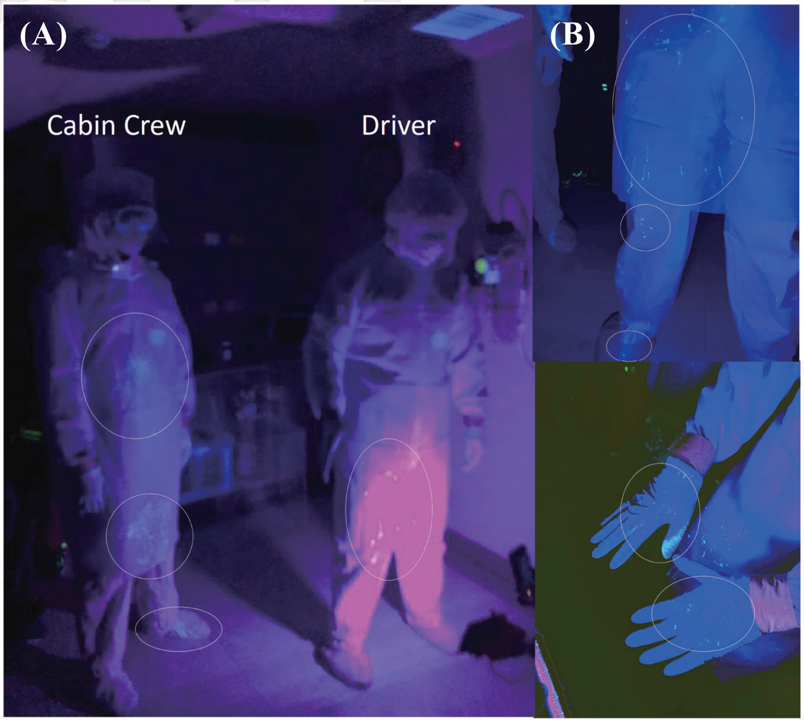

Fig. 3. Contaminated areas of the crew before personal protective equipment removal. (A) Different contaminated areas on the driver and cabin crew. (B) Driver's contaminated lower rim of the gown. (C) Driver's hand.

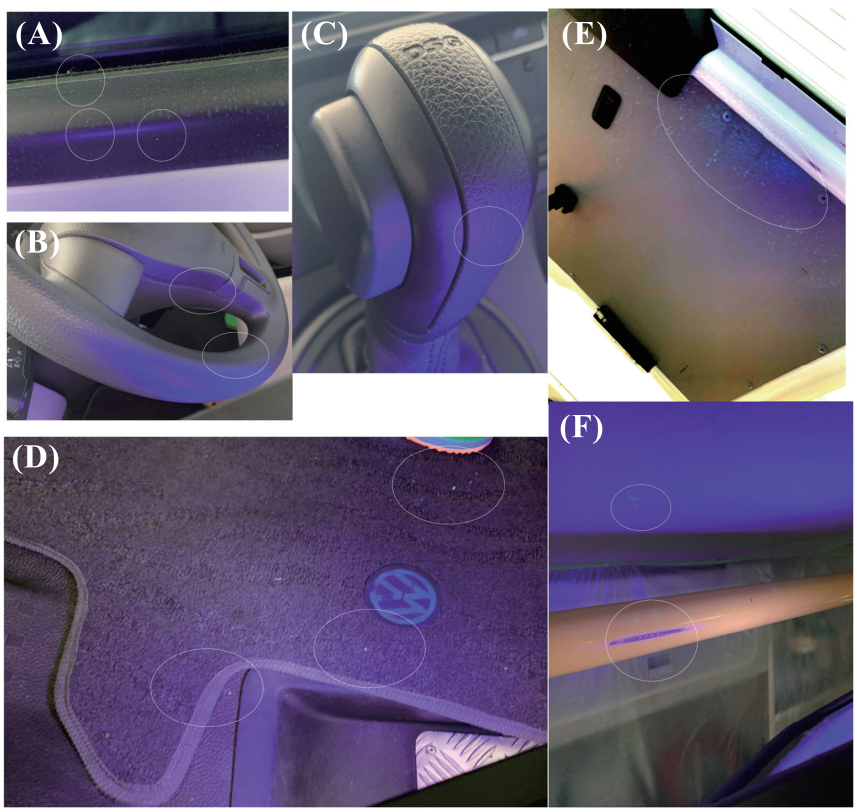

Fig. 4. Contaminated surfaces in the ambulance. (A) Driver's door handle. (B) Handler. (C) Gear lever. (D) Mat. (E) Rear door lining. (F) Handle over the roof.

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daily cleaning methods (including alcohol and chlorine-based solutions) could not effectively remove contamination; therefore, the effect of the hand sanitizing procedures could not be demonstrated in our simulation. This study provides a preliminary method for studying environmental contamination; future detailed studies should be conducted.

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Conflicts of Interest Statement

There is no conflics of interest.

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