Potential Exposure to Ebola Virus from Body Fluids due to Ambulance Compartment Permeability in Sierra Leone

Megan L. Casey, RN, BSN, MPH;[1,2,3] Duong T. Nguyen, DO;[1,2] Barrie Idriss;[4] Sarah Bennett, MD, MPH;[2,5] Angela Dunn, MD, MPH;[1,2] Stephen Martin, PhD, PE[3]

1. Epidemic Intelligence Service, Centers for Disease Control and Prevention (CDC), Atlanta, Georgia USA
2. Sierra Leone Ebola Response Team, Centers for Disease Control and Prevention (CDC), Atlanta, Georgia USA
3. Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention (CDC), Atlanta, Georgia USA
4. Bombali District Health Management Team, Sierra Leone Ministry of Health and Sanitation, Makeni, Bombali, Sierra Leone
5. Division of Foodborne, Waterborne, and Environmental Diseases, National Center for Emerging & Zoonotic Infectious Diseases, Centers for Disease Control and Prevention (CDC), Atlanta, Georgia USA

Correspondence:
Megan Casey, RN, BSN, MPH
Epidemic Intelligence Service Officer
National Institute for Occupational Safety and Health
Division of Respiratory Disease Studies
Surveillance Branch
Mailstop HG900
1095 Willowdale Road
Morgantown, West Virginia 26505 USA
E-mail: ydg7@cdc.gov

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CEN: European Committee on Standardization
NFPA: National Fire Protection Association
PPE: personal protective equipment

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Abstract

Introduction: Prehospital care, including patient transport, is integral in the patient care process during the Ebola response. Transporting ill persons from the community to Ebola care facilities can stop community spread. Vehicles used for patient transport in infectious disease outbreaks should be evaluated for adequate infection prevention and control.

Problem: An ambulance driver in Sierra Leone attributed his Ebola infection to exposure to body fluids that leaked from the patient compartment to the driver cabin of the ambulance.

Methods: A convenience sample of 14 vehicles used to transport patients with suspected or confirmed Ebola in Sierra Leone were assessed. The walls separating the patient compartment and driver cabin in these vehicles were evaluated for structural integrity and potential pathways for body fluid leakage. Ambulance drivers and other staff were asked to describe their cleaning and decontamination practices. Ambulance construction and design standards from the National Fire Protection Association, US General Services Administration, and European Committee on Standardization (CEN) were reviewed.

Results: Many vehicles used by ambulance staff in Sierra Leone were not traditional ambulances, but were pick-up trucks or sport-utility vehicles that had been assembled or modified for patient transport. The wall separating the patient compartment and driver cabin in many vehicles did not have a waterproof seal around the edges. Staff responsible for cleaning and disinfection did not thoroughly clean bulk body fluids with disposable towels before disinfection of the patient compartment. Pressure from chlorine sprayers used in the decontamination process may have pushed body fluids from the patient compartment into the driver cabin through gaps around the wall. Ambulance design standards do not require a waterproof seal between the patient compartment and driver cabin. Sealing the wall by tightening or replacing existing bolts is recommended, followed by caulking of all seams with a sealant.

Conclusion: Waterproof separation between the patient compartment and driver cabin may be essential for patient transport vehicles in infectious disease outbreaks, especially when chlorine sprayers are used for decontamination or in resource-limited settings where cleaning supplies may be limited.

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Introduction

The 2014-2015 outbreak of Ebola Virus Disease has been unprecedented in its duration and spread. Over 28,000 confirmed, probable, and suspected cases of Ebola have been reported in the West African countries of Guinea, Liberia, and Sierra Leone from March 2014 through September 2015.[1] Health care workers have been affected heavily with a case-fatality of 58% (513/881) as of September 2015.[1] Possible risk factors for Ebola infection in health care workers include inadequate infection prevention and control procedures; staff shortages; limited numbers of safe transport vehicles for patients and corpses; incorrect triage or recognition of potential Ebola in patients and corpses; and delayed laboratory diagnosis.[2]

Prehospital care is integral to the patient care process during the Ebola response as removing ill persons from the community can stop the spread of infection. Prehospital care refers to all of the components necessary to move the patient from the point of injury or illness to a place of care.[3] Prior to the current Ebola outbreak, prehospital care in West Africa largely was informal, with either no existing prehospital care system or a rudimentary system.[3] Building a prehospital care infrastructure in Sierra Leone has included procuring vehicles for patient transport, obtaining personal protective equipment (PPE), and training ambulance staff on infection control. Ambulance staff varied by location but generally included drivers, driver assistants, nurses, and ambulance maintenance personnel. Recommended full PPE required for ambulance staff includes two pairs of gloves, a gown or coverall, apron, goggles or face shield, face mask, and rubber boots or shoe covers.[4]

Ambulances of use during the Ebola response are of varying makes, models, age, and working condition; they are purchased or donated from multiple sources. Many vehicles used by ambulance staff are not traditional ambulances, but are pick-up trucks or sport-utility vehicles that have been assembled or modified for patient transport. These vehicles are often necessary because traditional ambulances cannot transverse unpaved roads and rough terrain.

Vehicles transporting patients with suspected or confirmed Ebola should have two distinct compartments in order to isolate the patient compartment from the driver cabin.[4] The driver cabin is considered the clean zone and PPE is not required. The patient compartment is considered the dirty/contaminated zone, requiring full PPE and regular decontamination.[4] The degree of separation between these areas varies greatly depending on the vehicle. Neither US nor European ambulance standards require that the wall separating the driver cabin and the patient compartment be waterproof.[5-7] The following report details a case of Ebola in an ambulance driver that may have resulted from body fluid exposure that passed from the patient compartment around the separating wall into the driver cabin.

Report

In July 2014, a 34-year-old man began work as an ambulance driver transporting Ebola patients in Tonkolili District, Sierra Leone. His job duties included patient transport and general maintenance of the ambulance, including cleaning and decontamination. He received training in infection prevention and control, including PPE donning and doffing and ambulance cleaning and decontamination.

After 10 weeks of work, he was cleaning the driver cabin for the first time. He was not wearing PPE because the driver cabin was considered a clean zone. This driver kept small sealed plastic bags of water behind the driver's seat on the floor. While cleaning, he took a bag of water off the floor, opened it with his teeth, and poured the water over his head, drinking a small amount in the process. The driver subsequently noticed that the floor behind the driver's seat in the driver cabin was wet with pools of what appeared to be vomitus and feces. He surmised that these fluids came from the patient compartment of the ambulance because no ill patients or staff had been in the driver cabin.

In the days after this cleaning event, the driver experienced body aches, which he attributed to long hours sitting in the ambulance, and some difficulty swallowing. Five days after cleaning the ambulance, he developed vomiting and diarrhea and self-presented to an Ebola holding center where he was admitted and tested positive for Ebola. He was transferred to an Ebola Treatment Unit, where he was treated for two weeks and then discharged.

Before his illness, the driver described no direct patient contact; all patients he transported were able to enter the ambulance themselves or with assistance from a nurse that often accompanied him. In addition, he reported no contact outside of his work with Ebola patients, such as family or community members.

After learning about this ambulance driver and his possible source of infection, a convenience sample of 14 vehicles used to transport patients with suspected or confirmed Ebola in Sierra Leone was assessed. The walls separating the patient compartment and driver cabin in these vehicles were evaluated for structural integrity and potential pathways for body fluid leakage. Ambulance drivers and other staff were asked to describe their cleaning and decontamination practices. The separating wall between the patient compartment and driver cabin was often comprised of sheet metal bolted to the floor and walls of the ambulance and did not have a waterproof seal around the edges. Staff responsible for cleaning and disinfecting ambulances often did not remove bulk body fluids with disposable towels before disinfecting with chlorine sprayers. Body fluids remained in the patient compartment during chlorine disinfection. Pressure from chlorine sprayers used in the decontamination process could push body fluids in the patient compartment through gaps around the separating wall into the driver cabin.

In response, a thorough decontamination of the patient compartment and the driver cabin was recommended for any of the 14 ambulances that had potential pathways for body fluid leakage. Following decontamination, replacing missing bolts and tightening loose bolts was also recommended, followed by the use of a sealant, such as epoxy, to create a waterproof barrier around the wall between driver cabin and patient compartment. Ambulance staff were reminded to inspect the sealant periodically and to remove bulk body fluids in the patient compartment with disposable towels while wearing full PPE before decontaminating vehicles with a strong (0.5%) chlorine solution.

Discussion

This investigation of the ambulance driver's risk factors for Ebola identified a possible exposure to body fluids in the driver cabin of his ambulance. Although it cannot be certain that this exposure led to his infection, his experience highlights a potential risk factor that impacts patient transport during Ebola response. For Ebola response ambulances in West Africa, body fluids in the patient compartment should be cleaned using disposable towels or pads before applying a strong (0.5%) chlorine solution to disinfect.[4] The removal of visible body fluids is essential to the disinfection procedure. The presence of high organic loads found in body fluids rapidly decreases the concentration and effectiveness of chlorine solutions and the concentrated body fluid mass may shield pathogens from full exposure to the disinfectant solution. However, the availability of disposable towels and pads in West Africa is limited, and this step is often not completed adequately.

While high-pressure cleaning and decontamination of the ambulance is not recommended,[4] chlorine sprayers can produce force capable of moving body fluids, especially when used at close range. If the wall separating the patient compartment and driver cabin is not sealed properly, body fluids could be pushed from the

patient compartment through gaps around the wall into the driver cabin.

Available ambulance construction and design standards from the National Fire Protection Association (NFPA; Quincy, Massachusetts USA), US General Services Administration (Chicago, Illinois USA), and European Committee on Standardization (CEN; Brussels, Belgium) were reviewed. In the US, the national ambulance design standard has been the KKK-A-1822 specifications established by the US General Services Administration.[5] Originally intended to provide specifications for federal ambulance purchases, the lack of any other national standards has resulted in KKK-A-1822 being the default ambulance design and construction standard in the US. In 2013, the NFPA released the *Standard for Automotive Ambulances* (NFPA 1917). The NFPA 1917 incorporates many of the KKK-A-1822 elements along with performance tests for various ambulance components.[6]

In Europe, the CEN released a standard called CEN 1789, which "specifies requirements for the design, testing, performance, and equipping of road ambulances used for the transport and care of patients."[7] The standard applies to ambulances constructed and operated in the 29 European countries that are members of the CEN.

While the US and European standards all provide some level of detail on the design of the ambulance, there are no requirements for the wall between the patient compartment and driver cabin to be waterproof. The only testing that is required is an external wash test to assure that ambulances are waterproof from the outside.[6] Given that the wall is not designed to be waterproof, no internal wash test is required to ensure that fluids cannot leak from the patient compartment into the driver cabin. Given that there is no standard requiring a waterproof wall in traditional ambulances, the finding that assembled or modified ambulances had no waterproof barrier between the patient compartment and the driver cabin is not surprising.

During an Ebola outbreak, where the patient compartment is regularly disinfected and washed, waterproof separation between the patient compartment and driver cabin is essential. An internal wash test could be performed using a regular garden hose sprayed into the patient compartment. If there is leakage from the patient compartment into the driver cabin, sealant can be applied around the separating wall. However, in some vehicles, additional reinforcement may be necessary if the wall is found to be unstable. If the separation wall is not waterproof, the ambulance driver should wear PPE and decontaminate the driver cabin until the separating wall is modified to be waterproof. This inspection, subsequent reinforcement, and sealing are low-cost and easily performed in low-resource settings.

Conclusion

A case of Ebola infection in an ambulance driver may have been associated with exposure to Ebola patient body fluids leaking from the patient compartment into the driver cabin. Ambulances used in Ebola response should be tested for waterproof separation of the patient compartment and the driver cabin and remedied, if necessary, with low cost measures. Waterproof separation between the patient compartment and driver cabin is essential for vehicles used for patient transport in infectious disease outbreak response, especially when chlorine sprayers are used for decontamination or in resource-limited settings where cleaning supplies may be limited.

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