Strategies and Considerations for the Deployment of EMS Personal Protective Equipment in Response to an Ebola Outbreak

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Introduction

Emergency Medical Services (EMS) providers are on the front line of delivering critical care to public citizens reporting illness, injury, or duress. Despite EMS personnel putting their health and safety at risk during routine operations, the emergence of an Ebola outbreak has increased concern that EMS providers may not be properly protected.

Despite recognition that the current Ebola outbreak may be one of the worst healthcare crises modern EMS has faced, no definitive strategy has been developed to address the appropriate deployment of EMS resources. Personal Protective Equipment is the only barrier that stands between an EMS provider and a potentially deadly disease. Previous studies have shown that as many as 80% of EMS providers would be reluctant to respond to calls for help if the appropriate protective gear was not readily available (Mackler, Wilkerson, & Cinti, 2007; Trainor & Barsky, 2011). Concerns about the refusal to treat suspected pandemic diseases may indicate, that without the proper PPE, deployment strategy, and training, the medical community runs the risk that emergency medical services will not be available to suspected Ebola patients. To ensure both the safety of EMS providers and the quality of care provided by these personnel, PPE deployment strategies, funding, and training will require significant consideration to meet the demands of the nation during an Ebola outbreak.

Current Situation

Ebola, previously known as Ebola hemorrhagic fever, is a rare and deadly disease caused by infection with one of the Ebola virus strains. The disease can cause illness in humans and nonhuman primates (monkeys, gorillas, and chimpanzees). Ebola was first discovered in 1976 near the Ebola River in what is now the Democratic Republic of the Congo. Until recently, outbreaks have only appeared sporadically in Africa (Steward, 2006).

The ongoing Ebola outbreak was first identified in March of 2014 in Guinea, now having become the largest Ebola outbreak on record. The disease has since been reported in at least seven countries with the vast majority in Liberia, Guinea, and Sierra Leone. Due to a number of factors, there have been sporadic but small reports of cases in four other countries (to include the US) associated with citizens being repatriated or travel of persons from Liberia, Guinea, and Sierra Leone.

As of November 2014, two individuals have been identified as infected by the Ebola virus in the United States after having traveled abroad. An additional two healthcare workers have been infected after

having cared for a patient that had a history of foreign travel. Additionally, at least three more Ebola patients have been treated in the US after having been evacuated from abroad.

It is important to note, in almost all seven cases above, prehospital EMS providers were involved in the primary treatment, evaluation, or inter-hospital transport of the patient. Despite media reports to the contrary, the true healthcare provider first-contacts have been prehospital EMS personnel. Since the onset of the current outbreak, domestic EMS has cared for hundreds of suspected Patient Under Investigation – Ebola (PUI-Ebola) patients that meet the general Ebola screening criteria. Every PUI-Ebola patient is treated as though they have the disease until confirmed otherwise by laboratory tests.

How Ebola Is Transmitted

Ebola Virus Disease (EVD) enters the patient through mucous membranes, breaks in the skin, or injection. Patients with Ebola generally have abrupt onset of fever and symptoms typically 8 to 12 days after exposure (incubation period for current outbreak has a mean of approximately 9 to 11 days) (Aylward & Barboza, 2014). Initial signs and symptoms are nonspecific and may include fever, chills, and malaise. Due to these nonspecific symptoms, particularly in early stages, EVD can often be confused with other more common infectious diseases such as malaria, typhoid fever, meningococcemia, and other bacterial infections (e.g., pneumonia) (Aylward & Barboza, 2014).

Patients can progress from the initial non-specific symptoms after about 5 days to develop gastrointestinal symptoms such as severe watery diarrhea, nausea, vomiting, and abdominal pain. Other symptoms such as chest pain, shortness of breath, headache or confusion, may also develop. Bleeding is not universally present but can manifest later in the course as petechiae, ecchymosis/bruising, or oozing from venipuncture sites and mucosal hemorrhage. Frank hemorrhage is less common in the current outbreak ("Interim Guidance for Emergency Medical Services (EMS) Systems and 9-1-1 Public Safety Answering Points (PSAPs) for Management of Patients with Known or Suspected Ebola Virus Disease in the United States," 2014).

Patients with more fatal progressions of the disease usually develop more severe clinical signs early during infection and die typically between days 6 and 16 of complications including multi-organ failure and septic shock. In non-fatal cases, patients may have a fever for several days and improve, typically around day 6.

Emergency Medical Services' Response to Ebola

Goals and Objectives for EMS:

In order to establish preparedness standards, one must first define the expectations and responsibilities of the response agencies involved. As it relates to EMS' role in treating suspected or confirmed Ebola, the following strategic goals and objectives could be established:

Strategic goal: To provide safe and timely emergency medical care to suspected Ebola patients and transport to the most appropriate facility for definitive care.

Objective 1: Protect prehospital care providers by providing them with the training and equipment necessary to safely treat and transport a PUI-Ebola patient.

Objective 2: Provide appropriate prehospital emergency medical care to PUI-Ebola patients.

Objective 3: Safely and expeditiously transport PUI-Ebola patients to the most appropriate facility for definitive and extended care.

Personal Protective Equipment (PPE) Requirements

Current CDC guidelines do not differentiate between hospital-based and prehospital healthcare providers. The principles set forth attempt to prevent the spread of the Ebola virus by providing a barrier between the medical provider and blood or bodily fluids of a person who is sick with Ebola or with objects that have been contaminated with the virus. The CDC currently recommends that all healthcare workers don PPE with full body coverage that leaves no skin exposed ("Guidance on Personal Protective Equipment To Be Used by Healthcare Workers During Management of Patients with Ebola Virus Disease in U.S. Hospitals, Including Procedures for Putting On (Donning) and Removing (Doffing)," 2014).

The strategy previously described is not novel to the prehospital care provider. However, the CDC recommendation of total encapsulation is a departure from the typical standard precautions practiced everyday by EMS (Mistovich & Karren, 2010). Instead of utilizing fully-encapsulating equipment, providers are trained to utilize barriers that protect areas of the body that have a high probability of exposure (i.e. gloves, eye protection, and masks).

Personnel Requirements

The CDC guidelines further dictate that there are specific staffing requirements above and beyond the normal scope to which EMS providers are accustomed. According to the most recent CDC recommendations, aside from the principal care providers, it is recommended that an additional trained provider be present to monitor the donning and doffing of PPE to ensure safe practices and procedures are followed ("Guidance on Personal Protective Equipment To Be Used by Healthcare Workers During Management of Patients with Ebola Virus Disease in U.S. Hospitals, Including Procedures for Putting On (Donning) and Removing (Doffing)," 2014). The non-provider safety officer must also be wearing appropriate PPE with the expectation that they may need to handle infectious materials or assist providers with the donning or doffing of equipment.

For any given EMS call related to an Ebola patient, a minimum of three personnel will be required to care for the patient:

- 1 primary healthcare provider will accompany the patient throughout treatment and transport.
- 1 secondary healthcare provider will assist with movement of the patient and drive the ambulance to the destination facility.
- 1 PPE safety officer will assist the two providers with both donning and doffing of equipment at the origin and destination locations.

Additionally, many patients will require as many as four additional support staff in the field to assist with extrication and movement of the patient to the ambulance.

Because most healthcare provider contamination occurs during the PPE doffing process, some jurisdictions may prefer to implement a fourth mandatory crewmember for suspected Ebola patients. The fourth crewmember serves as a driver of the ambulance and is restricted from all contact with the patient. This alternative staffing model allows the two aforementioned care providers to remain in a single set of PPE throughout treatment and transport to the hospital. However, the alternative method does not relieve the need for a designated safety officer and requires an additional staff member to be available at all times. Service agencies will need to balance the cost of an additional crewmember and added risk reduction against the cost of a single set of additional PPE.

PPE Cost

There is no single solution to meet the PPE guidelines set forth by the CDC. Like any other piece of equipment, the fundamental principles and objectives of the requirements can be met while having the option of adding various capabilities. For example, PPE can be reinforced by the manufacturer to withstand extreme weather in the prehospital environment that would not be otherwise expected in a hospital setting. Additionally, agencies have the option of exceeding the minimum PPE standards if they believe there are realized benefits. For example, an agency may elect to procure PPE that is capable of protecting a provider from an Ebola patient, but also designed for more extreme hazardous materials environments.

Medical personnel must be protected when in direct contact with the patient, their blood, other bodily fluids and/or excretions. The primary purpose of the provider is to deliver emergency medical to the patient and maintain a supportive role during transport to the hospital. The PPE ensemble described below requires specialized training and respiratory fit testing as well as precise donning and doffing procedures.

The two tables below describe an example of the cost to EMS for caring for an Ebola patient. The first table describes the initial cost for reusable capital purchases needed for every provider that will be expected to care for a PUI-Ebola patent. The second table details the expendable equipment required per patient per provider. The figures were extracted from recent vendor quotes to local EMS jurisdictions in the National Capital Region.

PPE Item	Manufacturer	Quantity	Gov't Contract Pricing
SCBA or APR Mask	Scott • AV 3000 Sureseal	1	$295.00/ea.
	MSA • Ultra Elite	1	$410.00/ea.
	Avon • C50	1	$510.00/ea.
	Average Capital Investment Cost Per Provider		$405.00

PPE Item	Manufacturer	Quantity	Gov't Contract Pricing
Manufacturer Specific P-100 Filter (40mm)	Manufacturer specific to mask	1 ea.	$25.00/ea.
Level C Coverall w/ Incorporated Footie	Dupont • Tychem SL	1 ea.	$33.00/ea.
	Kappler • Zytron 200	1 ea.	$41.00/ea.
	Lakeland • Chemmax 2	1 ea.	$32.00/ea.
Rubber Boot Cover	Various	1 pair	$27.00 to $63.00/pair
Latex Free Exam Gloves	Various	1 pair	$0.24/pair
Outer Glove	Various	1 pair	$6.00 to $11.00/pair
Duct Tape	Various	1 roll	$2.90/roll
	Operational Cost of One Set of Expendable Equipment Per Provider		$143.14

Strategy for Estimating Cost

The realized cost to the EMS service will be largely dependent on two factors, the deployment strategy utilized to distribute equipment (detailed in *PPE Deployment Strategies* below), and the number of suspected Ebola patients encountered by EMS personnel. At a minimum, the formulas below can be used to estimate the costs to an EMS agency.

Direct Relationship Capital Investment Formula

Number of Providers Expected to Provide Care = R
Average Capital Investment Cost Per Provider (Reusable PPE) = L

R x L = Total Capital Investment for Reusable PPE*

*While 29 CFR 1910.1030 allows for the sharing of reusable respirator facemasks, this formula assumes staff do not share respiratory PPE. Many departments have limited the use of shared respirators due to infection control concerns (Peplau, 2004).

Expendable PPE Operational Costs Formula

Number of Predicted PUI Ebola Patients Encountered by the Agency = E
Cost of One Set of Expendable Equipment per Provider = P
Average Support/Extrication Staff Per PUI-Ebola Call = S

E x (5P + S x P) = Minimum Total Operational Cost for Expendable PPE*

*This formula assumes that two providers (Safety Officer and Driver) will drive vehicles and therefore be required to don and doff two sets of PPE per patient.

The expected preparedness level will continue to be a moving target as the situation evolves. The most volatile variable in the preparedness formulas above is the expected number of PUI-Ebola patients the EMS agency is expected to encounter. EMS agencies should expect to continuously reassess and revise their preparedness levels as the disease spread progresses. EMS agencies must coordinate with public health officials, epidemiologists, and emergency management officials to better understand the threat and identify the optimum preparedness levels.

PPE Deployment Strategies

Presented with the challenges of the current Ebola situation, local jurisdictions have been forced to develop PPE deployment strategies to best distribute equipment in a manner that balances the demand with the availability. Two general strategies have surfaced in the prehospital environment to cope with the increased demand for the necessary equipment.

Focused Resource Deployment

The Focused Resource Deployment (FRD) strategy attempts to maximize efficiency of limited quantities of resources over a large coverage area. FRD consolidates needed specialty equipment and personnel into a single or limited response asset that is capable of supporting a distributed service area. The FRD strategy is utilized in similar low-density/low-demand public safety services such as hazardous materials, explosive ordinance disposal/bomb squad, and Advanced Life Support services.

Appropriate use of the FRD strategy may include the following assumptions:

- Requests for the assets will be extremely limited in comparison to the overall call volume for emergency services.
- Distribution of the equipment to common response assets is cost-prohibitive.
- Personnel involved in the mission require specialized training above and beyond that of common emergency response assets.

Many jurisdictions in Maryland have adopted the FRD strategy as a first-step towards preparing for a potential Ebola outbreak. These jurisdictions have provided extra training to pre-identified Ebola care-providers and invested in advanced PPE beyond the scope of what is carried on an ambulance. The

agency expectation is that this specialized asset will be requested for the specific task of caring for and transporting PUI-Ebola patients.

Perhaps the most appealing characteristic of FRD is its limited cost factor. FRD allows jurisdictions to stand up a needed specialized asset with limited initial investment and ongoing operational costs that are mostly correlated with the demand for the service (i.e. replacement of equipment that has met its end of service life is limited in comparison to a Distributed Resource Deployment strategy).

While the FRD strategy is effective at providing services to a large population base with low call volume for the assets, the strategy limits the agency in being able to respond to widespread demand for the assets. In light of the current Ebola situation, the FRD strategy will remain adequate as long as the numbers of infected persons remains limited in comparison to the overall demand for 911 services. However, in the event of a wide-spread outbreak, the FRD strategy can become quickly overwhelmed and unable to accomplish the goals set forth in the above section.

Distributed Resource Deployment

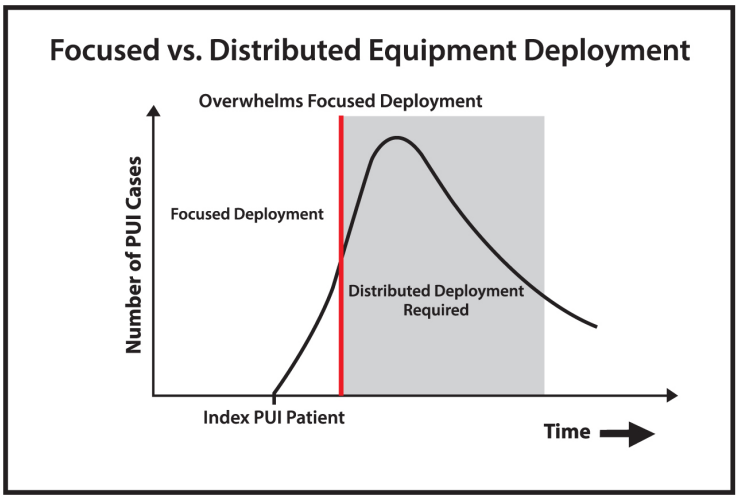
The Distributed Resource Deployment (DRD) strategy maximizes availability of resources by mass-allocation and training of equipment through common response units and personnel. DRD provisions needed equipment and personnel over a wide geographic area and attempts to ensure the capability is available to as many response units as possible. The DRD strategy is utilized in similar high-density/high-demand public safety services such as Automated External Defibrillators and fire extinguishers.

Appropriate use of the DRD strategy may include the following assumptions:

- Requests for the assets will be common or are required on a time-sensitive basis.
- Widespread availability of the equipment outweighs the cost associated with provisioning.
- Training on use of the equipment will be provided to all response personnel.
- Use of the equipment is an expectation of response personnel's regularly assigned duties and capabilities.

According to a recent survey conducted by MIEMSS, no jurisdictions in Maryland have adopted a DRD strategy in response to a potential Ebola outbreak. Jurisdictions have conducted both risk and gap analyses and identified that a DRD strategy would not provide significant benefit until a more definitive threat of a wide-spread Ebola outbreak exists.

The DRD strategy is effective at providing the most access to a large population base. However, due to the nature of the distributed strategy, initial capital implementation costs can be extremely high and cost-prohibitive. Additionally, ongoing operational costs are not directly associated with usage as equipment may not utilized before the end of service life. The graph below demonstrates how estimated number of PUI-Patients can impact PPE deployment strategy considerations. It should be noted that the incidence of suspected Ebola patients is simplified in the curved representation below.



As it pertains to the current Ebola situation, the DRD strategy will likely not be cost effective as long as the numbers of infected persons remains limited. However, in the event of a wide-spread outbreak, the DRD strategy will have to be implemented as rapidly as possible to deal with the influx of demand for the specialty resources.

Deployment Summary

The two distribution strategies enable service providers to identify a solution that best meets their needs given the risks presented by a potential or active Ebola outbreak. However, consideration will need to be given as to when a modification of strategy is required. While the focused distribution may be cost-effective it can quickly become ineffective at providing the necessary equipment if the call volume for suspected Ebola patients increased.

Summary

PPE distribution and training will be necessary for the EMS community to effectively respond to PUI-Ebola patients. The FRD strategy currently adopted by many Maryland jurisdictions will continue to provide additional training and advanced PPE to pre-identified Ebola-care providers. This will limit initial investments and operational costs while still meeting the specialized needs for patient care. Should the number of PUI-Ebola patients steadily increase, however, this strategy will quickly diminish resources and reduce the ability of EMS personnel to meet the growing needs of the community. The threat of an outbreak will then require the DRD strategy to be immediately deployed.

The above analysis does not address all costs incurred by PPE deployment. The costs associated with training methods, additional hours for personnel training and individual fit-testing will vary by jurisdiction. Possible training simulations and exercises will also require additional time and expense. These costs, however, are not without benefit. If the threat of an outbreak develops, providing additional PPE to the EMS community will be crucial for the continuation of care to the public.

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