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Major Article

A pilot survey of the U.S. medical waste industry to determine training needs for safely handling highly infectious waste

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Background: The recent Ebola outbreak led to the development of Ebola virus disease (EVD) best practices in clinical settings. However, after the care of EVD patients, proper medical waste management and disposal was identified as a crucial component to containing the virus. Category A waste—contaminated with EVD and other highly infectious pathogens—is strictly regulated by governmental agencies, and led to only several facilities willing to accept the waste.

Methods: A pilot survey was administered to determine if U.S. medical waste facilities are prepared to handle or transport category A waste, and to determine waste workers' current extent of training to handle highly infectious waste.

Results: Sixty-eight percent of survey respondents indicated they had not determined if their facility would accept category A waste. Of those that had acquired a special permit, 67% had yet to modify their permit since the EVD outbreak. This pilot survey underscores gaps in the medical waste industry to handle and respond to category A waste. Furthermore, this study affirms reports a limited number of processing facilities are capable or willing to accept category A waste.

Conclusions: Developing the proper management of infectious disease materials is essential to close the gaps identified so that states and governmental entities can act accordingly based on the regulations and guidance developed, and to ensure public safety.

BACKGROUND

During the 2014-2016 West Africa Ebola outbreak, the development of best practices and research surrounding Ebola virus disease (EVD) care and management were primarily focused on health care workers. However, as the U.S. medical community, and specifically high-level isolation units, began to successfully treat individuals with EVD, nonclinical aspects of EVD care were recognized as equally important in containing the virus and minimizing occupational risks. After the care of EVD patients, the Nebraska Biocontainment Unit identified proper medical waste management and disposal as a crucial component and point of consideration for U.S. health care facilities treating EVD patients.[1] An international hazard analysis of critical control points for EVD also emphasized that waste generated from the care of an EVD patient should not be disregarded as a potential transmission route.[2]

Medical waste produced through routine patient care is classified as category B or regulated medical waste per U.S. Department of Transportation (DOT) federal regulations in tandem with state medical waste regulations; therefore, medical waste processing varies

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from state to state. The DOT dictates the regulations for transport of category B infectious substances or regulated medical waste, which can be handled by most waste facilities and landfills throughout the nation so long as the waste is contained in leak-proof, properly marked packaging.[3] However, waste contaminated with EVD and some other highly infectious organisms is categorized as category A infectious substances.[4] Solids contaminated with category A infectious substances are regulated by government agencies, including the DOT, Centers for Disease Control and Prevention, U.S. Department of Labor's Occupational Safety and Health Administration, and Environmental Protection Agency, which does not typically regulate medical waste.[4] Minimum criteria are required of facilities to accept category A waste for ultimate disposal. This includes category A agents (UN2814) such as Crimean-Congo virus, *Yersinia pestis*, and EVD that must be handled and transported under stringent federal regulations and procedures dictated by the DOT Hazardous Materials Regulation (49 CFR Parts 171-180) when transported by air, rail, highway, or water.[4] The Nebraska Biocontainment Unit suggested that EVD medical waste management planning should incorporate detailed processes on how to safely handle and remove category A waste from the medical facility, including considerations for increased operational planning and financial burdens.[1]

Specifically, if category A waste contaminated with EVD is not treated via incineration or autoclaving onsite at the point of generation to inactivate or entirely remove the virus, a DOT special permit must be obtained and special category A packaging that meets the regulatory federal requirements for packaging of the DOT and Pipeline and Hazardous Materials Safety Administration must be used to transport it from the health care facility.[1,4] If off-site inactivation is required, medical facility and local government leadership, approved waste transportation and treatment facilities willing to accept the waste, state and local health departments, environmental agencies, and other units must collectively work to ensure that waste movement is compliant with inter- and intrastate regulations. The ultimate disposition of the category A waste at the off-site facility must also take into account residuals produced from inactivation.[4] Interim planning guidance has been issued as of January 2017, but there is not a mandatory nationwide industry standard established which dictates that all medical waste facilities must be ready to handle category A waste.[4]

As a result of the distinct complexity and regulatory framework for the management and disposal of medical waste contaminated with EVD, only a small number of U.S. waste processing facilities were willing to accept EVD waste.[5-8] This limited capacity not only presented logistical barriers but also raised concerns about waste worker preparedness to handle category A regulated infectious waste. Furthermore, few peer-reviewed articles specifically pertaining to the United States focus on the safe handling of category A waste or tangentially relate to highly infectious waste treatment[9-11]; those that do discuss category A waste, in Europe, do not follow the same classification system as the United States.

This pilot survey was administered to determine if medical waste facilities across the United States were currently prepared to handle or transport category A waste, to assess waste workers' extent of training pertaining to highly infectious disease (HID) mitigation and management, and to thereby suggest worker training can be supplemented or restructured to improve occupational safety and bolster worker preparedness to properly manage highly infectious waste in the future.

MATERIALS AND METHODS

This pilot survey's structure was adapted from high-level isolation unit checklists developed by the European Network for Highly Infectious Diseases[12] but modified and expanded with input from a panel of medical waste subject matter experts. We adapted a similar structure to conduct a survey in the death care sector.[13] In the fall of 2016, this medical waste gap-analysis survey was distributed via Qualtrics Software Version 2016.17 (Qualtrics, Provo, UT) (Institutional Review Board exemption Indiana University Kuali Coeus no. 1607534532). Two surveys were developed—one at the lead-supervisor-management level (lead) and the other at the worker-employee level (worker) and divided into 3 sections: (1) demographics; (2) industry-specific questions on comfortability and willingness to encounter HID scenarios, and current policies and procedures in place to address category A waste; and (3) levels of knowledge, training, resources, and personal protective equipment (PPE) to address HID scenarios. Sections 1 (9 questions) and 3 (6 questions) were identical in the lead and worker pilot surveys, with the only discrepancy being the directive pronoun. Section 2 at the lead level was 63 questions, whereas section 2 at the worker level was only 4 questions because the former asked detailed questions on organizational waste policies and procedures. Survey participants were able to select the link to which survey they felt was more appropriate—worker or lead. The survey predominantly consisted of multiple choice questions, lending the ability to provide qualitative responses where appropriate. Descriptive statistics were deliberately used given this being a pilot survey and the smaller sample size.

National medical waste organizations (Stericycle, Inc, Healthcare Waste Institute, Larson-Miller Medical Waste Disposal Service, and Republic Services) requested their waste facilities throughout the nation to disseminate the anonymous Uniform Resource Locator survey links to employees. Two follow-up e-mails were sent to solicit further participation; the survey links were closed after 105 days.

RESULTS

A total of 31 pilot surveys at the lead level and 19 at the worker level for a total of 50 were initiated and collected. All questions were voluntary, and skip patterns on questions leading to subquestions were used throughout; hence, response rates varied from 10%-78% (lead) and 5%-63% (worker), with a respective pilot survey completion rate of 58% and 47%.

Demographics

Self-reported position-titles for workers included the following: dispatcher (25%), field service administrator (17%), operator (17%), account manager (17%), and other (24%); the most common self-reported titles for leads included manager (facility, transportation, account, district operations, etc) (42%), supervisor (general, plan, or transportation) (25%), vice president (general or operations) (17%), and other (17%). Additional respondent demographics are offered to readers on request.

Lead-specific questions pertaining to industrial demographics, current operations, and existing protocols

Half of lead respondents (11/22) had transportation operations with >25 vehicles and 91% (20/22) had multistate operations. Over half of leads (52%, 12/23) indicated that their organization had a mail back program, 39% (9/23) did not, and 9% (2/23) were in the process of developing one. Of those with a mail back program, waste is sent to an owned facility (50%, 6/12), waste is sent to an owned facility but transferred to another treatment facility (33%, 4/12), and waste is sent to an entirely separate treatment facility (17%, 2/12). More than three-quarters of leads (78%, 18/23) had permitted treatment operations; 88% have an autoclave (15/17), 29% have an

Table 1
Reported percentages of lead perceptions of worker willingness versus worker actual self-reported willingness to encounter potential highly infectious waste scenarios

Respondent level	Very willing	Somewhat willing	Neither willing nor unwilling	Somewhat unwilling	Very unwilling
Lead response	32	14	18	23	14
Worker response	50	8	17	0	25

incinerator (5/17), and 12% (2/17) use a macerator or chemical processes. All lead respondents (21/21) indicated that their treatment technology did not require preshredded waste, and most did not (90%, 19/21) have postshredding operations. Almost all (95%, 20/21) posttreated waste (ie, after incineration or autoclave treatment) went to a sanitary landfill, 10% (2/21) went to a municipal solid waste combustor or waste to energy, and 5% (1/21) was recycled or recovered.

Sixty-eight percent of leads (15/22) indicated that their facility had not determined if they would accept highly infectious materials, whereas 14% (3/22) indicated the discussion was ongoing. From those who had made the determination to accept highly infectious materials (18%, 4/22), 75% (3/4) had already contacted their state regulatory agencies to ensure their facility has a permit sufficient to accept those materials, but 67% (2/3) had yet to modify their permit.

Of the aforementioned leads that had verified permits with state regulatory agencies, all (3/3) had also reported contact with state health department about special requirements to handle and transport category A infectious substances. Two out of 3 had tested their treatment process with selected-mandated packaging systems for EVD and other highly infectious waste. All (3/3) had developed a process plan (ie, testing during treatment event) and worked with their final disposal facility on how posttreated waste will be accepted. Two out of 3 lead respondents had a team of trained individuals to perform the processing operation for highly infectious waste, and all (3/3) had established a maintenance plan for pre-, during, and postoperations. One out of 3 lead respondents had a contingency facility or plan if their operation was interrupted.

Less than half of lead respondents (48%, 10/21) did plan to use a third party for treating received highly infectious waste; of those, 80% (8/10) have confirmed with the third party that category A waste will be accepted and have vetted treatment processes. Nine out of 10 have also confirmed packaging requirements in accordance to their state's medical waste regulations.

Less than half of lead respondents with on-site treatments (43%, 9/21) had been asked by their customers if their organization could be a backup operation for highly infectious waste; 57% said no or that it was not applicable (12/21). However, more than half with on-site treatment (56%, 9/16) had been asked by their customers if their facility would be willing to accept treated (ie, autoclaved) highly infectious waste on site as overpacked regulated medical waste.

Thirty-eight percent of leads (8/21) determined their organization will transport highly infectious waste. Of those that said they would transport highly infectious waste, 75% (6/8) have training materials prepared for generators on how to properly package the waste. When all worker respondents were asked if they have ever been trained on how to transport and process category A waste, 42% (5/12) reported yes. Regarding accepting category A waste at their facilities, 48% (10/21) of leads said their organization would; of those who stated yes, 7 of 10 have mechanisms in place for treating category A waste (ie, incinerator). However, for those with a treatment facility, 63% (10/16) said their state would not allow them to treat EVD waste. When workers were asked if their organization had protocols and a contract in place for handling and transporting category A waste, 42% (5/12) marked yes, 3 marked no, and 4 marked I do not know. Of the respondents that said they plan to use a third-party treatment facility that has confirmed it will accept EVD waste, 100% (12/12) stated the third-party facility had specific packaging requirements.

Sixty-seven percent of lead respondents (14/21) were familiar with the DOT special permit (SP) to transport large volumes of EVD waste; 29% (6/21) already held the DOT SP. For those without the DOT SP, 47% (7/15) had the required information prepared and ready to submit to the DOT in case of an EVD or HID emergency. Of those that held the DOT SP, 83% (5/6) had inventory of SP-compliant containers types and packaging material to be used and a security plan.

Eighty-three percent (5/6) had worked with health care facility customers anticipating highly infectious patients on how their organization will manage waste from the transportation operations (ie, other ambulances that may not be affiliated with the hospital). Five out of 6 had also contacted local law officials to discuss options for transport through their state, what those requirements will entail, and what driver teams will be trained to properly manage the highly infectious material during transport. When asked if their facility had an emergency response plan in place in the event of an accident or spilled materials, 86% (18/21) of lead respondents marked yes and 81% (17/21) had an emergency response company capable of responding 24 h/d, 7 d/wk. Of those respondents that had an established relationship with an emergency response company, 41% (7/17) had worked with the company to identify the routes that will be taken in the event of an accident.

As a potential transporter of category A waste, 40% (6/15) of leads said they had trained their employees on the specifics of handling such waste and 33% (5/15) had training in development. Of the 10 of 21 leads who plan to accept and transport category A waste, 40% already had the appropriate packaging in inventory. Fifty percent of lead respondents (10/20) stated they had training materials prepared for their generators on how to properly package category A waste.

Industry-specific perceptions of willingness and comfortability to handle highly infectious waste, HID knowledge, and PPE

To determine perceptions of willingness and comfortability to handle potentially highly infectious waste, leads were asked how they thought workers would respond and workers were asked to self-report on the aforementioned (Tables 1 and 2).

Given there was no clear pattern in Tables 1 and 2, percentage differences between the lead and worker response were not calculated.

To determine the current level of HID knowledge, pilot survey respondents were asked where they received up-to-date information about HIDs (Table 3). Other sources included internal resource teams, internal regulatory and compliance division, communication with other waste companies, and company-appointed individuals. Pilot survey respondents were also asked to mark routes of exposure for select HIDs. Incorrectly marked routes are displayed in Table 4. Moreover, only 50% (2/4) of leads and 33% (1/3) of workers knew that severe acute respiratory syndrome was transmissible via droplets.

When asked if their organization had mandatory orientation prior to workers being allowed to encounter a potential highly infectious scenario, 83% (5/6) of workers and 59% (10/17) of leads marked yes. When asked if workers had to successfully demonstrate

Table 2
Reported percentages of lead perceptions of worker comfortability versus worker actual self-reported comfortability to encounter potential highly infectious waste scenarios

Respondent level	Very comfortable	Somewhat comfortable	Neither comfortable nor uncomfortable	Somewhat uncomfortable	Very uncomfortable
Lead response	18	36	9	18	18
Worker response	17	17	8	25	33

Table 3
How pilot survey respondents receive up-to-date information on HIDs

Source of HID information	Leads (n = 18)	Workers (n = 9)
Government Web site (ie, CDC)	56	33
Industry's primary national organization Web site (ie, Solid Waste Association of North America)	56	11
Peer-reviewed journals	17	0
Newspapers or online articles	22	44
Television, radio, podcasts	0	33
Coworkers or word of mouth	17	56
Other	22	22
Do not receive updated HID information	11	0

NOTE. Values are presented as percentages. Respondents could select multiple options; hence, column totals are >100%.
CDC, Centers for Disease Control and Prevention; *HID*, highly infectious disease.

Table 4
Incorrectly marked routes of exposure for select HIDs

Marked routs of exposure	Leads	Workers
EVD as airborne	46 (6/13)	33 (2/6)
Anthrax as human-to-human contact	27 (3/11)	20 (1/5)
Botulism as human-to-human contact	25 (1/4)	33 (1/3)
Pneumonic plague as airborne	67 (2/3)	67 (2/3)

NOTE. Values are % (n/N).
EVD, Ebola virus disease; *HID*, highly infectious disease.

competence (ie, demonstrating procedural skills) prior to working in potential highly infectious waste scenarios, 100% (3/3) of workers marked no, whereas 25% (2/8) of leads did. One of 3 worker respondents indicated they had to undergo periodic retraining for highly infectious waste, whereas 70% (7/10) of leads indicated workers had to undergo periodic retraining. Regarding whether their organization conducted just-in-time training prior to personnel potentially handling highly infectious waste, 50% (4/8) of workers marked yes, whereas only 38% (5/13) of leads did; 37.50% (3/8) of workers and 31% (4/13) of leads did not know if just-in-time training was conducted. Additional discrepancies between work and lead responses on identical pilot survey questions are noted in Table 5.

DISCUSSION

Although this is a pilot survey, it underscores overall gaps in the medical waste industry to handle and respond to waste contaminated with category A infectious substances, in light of the EVD outbreak, and highlights disconnects between lead and worker perceptions of readiness to encounter such scenarios. Furthermore, this pilot study affirms reports that a limited number of waste processing facilities are capable or willing to accept category A infectious substances.

To determine current operations and existing protocols, pertaining to category A waste, lead respondents were asked a series of detailed questions to ascertain industrial demographics. Of those with a transportation operation, >90% (20/22) covered multistate operations. Additionally, more than three-quarters (18/23) of leads had permitted treatment operations that used an autoclave, incinerator, physical, or chemical processes for the waste, indicating the capacity to properly inactivate category A waste at their facility so that it is no longer deemed infectious.[4]

Of the limited number of respondents who had determined they would accept category A waste, only 75% of those respondents had contacted their appropriate regulatory agencies to ensure their facility has a permit to accept those materials, and contacted the state health department about special requirements to handle and transport highly infectious waste. Most states at the time of the EVD outbreak had no separate regulations on the management and treatment of HID waste because most states had never encountered this scenario and had not contemplated this in their rule making or statutory processes. Additionally, because regulations on the management and disposal of normal regulated medical waste vary from state to state, logistical challenges arise for organizations operating in multiple states, further complicating the situation. Interstate movement of the category A waste may result in circuitous rerouting around states that will not allow category A waste to enter because of misunderstanding of many state agencies and political entities.[4] Although there was no specific regulatory or statutory restriction, governor's offices and regulatory agencies used their given authority to stop the entry of the waste through their states, often citing safety as the reason to limit commerce, such as the EVD waste blocked from entering Louisiana in 2014.[14] Although the DOT issued SP intended to show these materials were safe to transport across all states (because DOT Hazardous Materials Regulation is preemptive), the special hypersensitivity to the situation led to rerouting of the waste.

Nearly 50% of leads stated their organization would be willing to accept category A waste and had the appropriate protocols, and nearly 30% of leads reported having the DOT SP to transport large volumes of EVD waste. Moreover, >80% of lead respondents had an emergency response plan in place of the event of an accident and an emergency response team capable of 24 h/d, 7 /wk response in the event of an incident that occurred during highly infectious waste transport. Despite these preparations, 63% of respondents said that their state would not allow their organization to transport pretreated EVD waste. In the event of another HID incident such as the EVD outbreak, this could result in issues efficaciously and swiftly responding to the outbreak. Limiting or prohibiting category A waste transport or disposal will undoubtedly increase the complexity for waste generators—including hospitals, ambulances, and decontamination or cleanup facilities—to safely and properly dispose of waste in a timely manner. Ultimately, this will result in the need for storage capacity for holding wastes that increase in volume, will result in waste having to travel longer distances for treatment and disposal creating greater safety risk during transport (accidents, incidents of tampering, and security), and will increase costs across all fronts. As other companies see these restrictions, they may be less willing to take these types of waste. The greater the restrictions and scrutiny, the less willing transport and treatment facilities will be likely to participate.

When leads were questioned on their perceptions of how willing and comfortable their workers would be to handle highly infectious waste, there were discrepancies with self-reported worker willingness and comfortability to handle highly infectious waste. On the extremes of the Likert scale, 20% more workers reported being very willing to handle highly infectious waste than leads

Table 5
Worker versus lead responses to select questions on perceived existing protocols, procedures, and resources

Select survey questions	Worker	Lead
Organization does not have procedures for health monitoring after workers encounter infectious substances, regardless of exposure status	100 (4/4)	78 (7/9)
Awareness of the availability of an employee assistance program for those who might encounter HIDs situations	100 (6/6)	62 (8/13)
Protocols-procedures are established at organization for the selection of differing PPE ensembles depending on risk of contact with a HID	100 (5/5)	91 (10/11)
Strategies in place for implementing and monitoring the correct use of PPE	75 (6/8)	86 (12/14)
Organization does not have protocols for maximum shift time allowed in PPE	57 (4/7)	50 (6/12)
Organization has procedures established to monitor employee adherence to proper hand hygiene	29 (2/7)	71 (10/14)

NOTE. Values are % (n/N).
HID, highly infectious disease; *PPE*, personal protective equipment.

perceived; however, 10% more workers were very unwilling than leads perceived (Table 2). Alternatively, 20% more leads perceived workers to be somewhat comfortable handling highly infectious waste, and more workers reporting they would be very uncomfortable (approximately 15% more than leads perceived) handling highly infectious waste (Table 3). The hesitance and discomfort to work with highly infectious waste could be tied to a lack of knowledge and training related to HIDs provided to workers. Category A waste that is properly packaged in compliance with DOT requirements or inactivated poses no risk to the transporter to the ultimate waste disposal facility.[4]

Continuing in the vein of current levels of HID knowledge and training of the pilot survey respondents, although over half of leads used government Web sites or their national organization's Web site for up-to-date information, >70% of workers relied on coworkers, word-of-mouth, or company-appointed individuals to convey them information, introducing possibilities for miscommunication, education that is not comprehensive, or misinformation. This emphasizes the importance of more in-person trainings within facilities. Moreover, there was a large discrepancy between workers and leads when asked if workers had to successfully demonstrate competence of skills or procedures prior to working in potential highly infectious waste scenarios, with 75% more workers than leads reporting that they were not required to do so. Trainee demonstration is crucial to the successful completion of training and to improve occupational safety and health outcomes.[15]

Additionally, workers and leads were asked about PPE and hand hygiene. Twenty percent more workers than leads reported their organization did not have procedures for health monitoring after workers encountered infectious substances regardless of exposure status; however, nearly 40% more workers than leads thought there was an employee assistance program (EAP) available to them even though not as many leads indicated their organization had an EAP. Regardless of exposure, health monitoring and surveillance is crucial to assess the physical and mental state of workers prior to, during, and after increased occupational demands and logistics involved with handling and transporting category A waste; making the existence of an EAP widely known is also instrumental for maintaining worker emotional and physical well-being. More workers than leads (approximately 10% difference) stated their organization did not have protocols-procedures for maximum shifts in PPE nor strategies in place for monitoring correct PPE usage. Not having policies on maximum shift times in PPE can create physiologic and psychologic distress for the worker.[16]

Finally, >70% of workers and leads stated there were no procedures established at their organization to ensure compliance with proper hand hygiene. This highlights a lack of basic infection control practices or potential misunderstanding of handwashing application related to the management of HIDs, even though it is emphasized in the DOT EVD waste planning guidance for handling solid waste contaminated with category A infectious substances.[4]

Waste operations perform a quiet but vital daily function by safely removing regulated medical waste, transporting it, and treating it to render it noninfectious for proper ultimate disposal; highly infectious waste can be done the same way. Of course, additional precautions should be taken, including adequate validation of processes and training of employees.

Our study has its limitations. The sample size of this pilot survey is not generalizable to the entire medical waste industry; there is need for greater participation in a larger study to determine overall industry preparedness to mitigate and manage highly infectious waste risks. Additionally, because of the sample size, more complex statistical methods were not used. Furthermore, selection bias is possible because of the voluntary nature of the survey, and the high nonresponse rate may indicate organizations that do not intend to accept highly infectious waste and therefore disregarded the survey. The greatest response rates appear to be in regions that had facilities that accepted the waste during the EVD outbreak. Moreover, although survey links were distributed by medical waste organizations, the survey was developed and had logos of an external entity, which typically elicits lower response rates.

CONCLUSIONS

On the surface, this pilot survey indicates the lack of preparedness and national capability to properly handle and transport category A waste and the need for proper planning for the future. Willingness for organizations to manage this waste and properly preparing for such events will be critical for the future. The implications of having unprepared, uninformed workers can have widespread consequences if category A waste is not properly contained or handled, such as not only compromising the safety and health of the worker, but also the communities through which that waste is transported. The pilot survey was beneficial in that it highlights the gaps in preparedness in this industry; however, the sample size is limited because of few organizations having any experience with category A waste. In some cases, some organizations made their own determination not to provide services, whereas others were prohibited by their state and local agencies. The rapid change in information and the lack of transmission of information during this time could also have led to the low response. Fortunately, this is also because of the limited number of U.S. patients and incidents that occurred.

These preliminary findings indicate that future success of management of HID waste will require additional forethought on the part of all parties and further planning to proceed now. Workers and leads will need to be provided materials, support, and training to ensure the safe management of these wastes. These tools will need to be developed by industry experts, organizations, and the government. Developing the proper management of HID materials now is essential to close the gaps identified in this study so that states and governmental entities can act accordingly based on the regulations and guidance developed, and so the safety of the public

is assured. Coordination of efforts and communication of decisions to the waste workers will be key.

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