RESPOND

EMERGING PANDEMIC THREATS PROGRAM

ENVIRONMENTAL MITIGATION AND MONITORING REPORT (EMMR)

7/18/2014

JULY 2014

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PERIOD COVERED: NOVEMBER 2013-SEPTEMBER 2014

Program Title:	**RESPOND Emerging Pandemic Threats Program**
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Contents

ACRONYMS

Action EMMP or A-EMMP	Action Environmental Mitigation and Monitoring Plan
Action EMMR or A-EMMR	Action Environmental Mitigation and Monitoring Report
BMPR	Best Management Practice Review
EA or EIA	Environmental Assessment or Environmental Impact Assessment
EDD	Environmental Due Diligence
EMMP	Environmental Mitigation and Monitoring Plan
EMMR	Environmental Mitigation and Monitoring Report
EMS	Environmental Management System
EPT	Emerging Pandemic Threats Program
ER	Environmental Review
Framework EMMP	EMMP for a category of actions
IEE	Initial Environmental Examination (and Threshold Decision)
M&E	Monitoring and Evaluation
MEO	Mission Environmental Officer
Project EMMP or P-EMMP	Project Environmental Mitigation and Monitoring Plan
SOW	Standard of Work
TAMIS	Technical and Administrative Management Information System

EXECUTIVE SUMMARY

This report covers project actions to achieve or surpass environmental compliance with the Initial Environmental Examination and Threshold Decision (IEE) for the RESPOND project, as planned in the project Environmental Mitigation and Monitoring Plan (EMMP).

SUMMARY OF ENVIRONMENTAL REVIEW AND MITIGATION MEASURES

To date, overall environmental review and mitigation measure metrics include:

- Funding component (i.e., grant, direct assistance) environmental reviews created: 283 out of 285 funding components (99%)
- Reviews with actions requiring risk mitigation/monitoring: 0 (0% of total)
- Most common closed action that required mitigation: Training with content to be determined.

DISCUSSION OF ISSUES

The EMMP has been updated with revised actions/issues, best practice reviews (to resolve uncertainties on the best approaches to environmental mitigation for particular RESPOND activities) and an environmental workshop session, which can be used in RESPOND training to raise awareness of environmental risks and mitigation measures.

RESPOND has developed a strong approach to environmental mitigation and monitoring, including an updated EMMP, consistent environmental review/monitoring/reporting process across regions, a database used for data collection/reporting, training of regional staff, development of content for an environmental workshop session, and identification of opportunities for best practice reviews.

With the conclusion of the period of performance for the RESPOND Project approaching, the priority is to ensure that all funding activities have undergone a thorough review for potential environmental risk and that mitigation measures are implemented in cases where potential risks are identified. Any new activities that are initiated after the generation of this report will undergo the same procedure of environmental risk analysis and mitigation before implementation. All related environmental forms will be saved in the RESPOND TAMIS.

SUMMARY OF ENVIRONMENTAL REVIEW AND MITIGATION MEASURES

This section reports the number of project funding components and actions reviewed and the mitigation measures implemented.

Definitions:

- Funding component: grant, direct assistance
- Action: specific kind of project action that is part of the funding component

FUNDING COMPONENTS

To date, 285 funding components have been created. In terms of environmental reviews/screening conducted, 99% have been properly completed (Table 1.) Review/screening forms are in Annex 2.

Table 1: Status of Funding Component Reviews

Status	Funding Component Reviews	Percent of total	Comments
Pending Certification	2	1%	Funding component not reviewed yet, scope being defined
In Progress	0	0%	Form certified, open actions
Complete	283	99%	Form certified, all actions closed
Total	285	100%	

Of the 283 reviewed funding components (status of *In Progress* or *Complete*), 13% have potential environmental issues (Table 2.)

Table 2: Funding components with potential issues

Status	Funding Component Reviews	Percent of total	Comments
No potential issues	247	87%	Funding components with risk category 1 or 2 actions
Potential issues	36	13%	Funding components with risk category 3 or 4 actions
Total	283	100%	

ACTION RISK CATEGORIES

USAID uses the following categories of environmental (including impact on the human population) risk:

• Category 1: No risk of negative impact following USAID categories of actions or "categorical exclusion."

• Category 2: Insignificant risk of negative impact, but not categorical exclusion.

• Category 3: If best practices and mitigation measures followed, no significant negative impact; otherwise, some impact is possible.

• Category 4: Potential risk of significant negative impact or "positive determination."

Although training events are normally Category 1 (categorical exclusion), USAID guidance indicates that if the actions that are treated in the training events will themselves incur risk of negative impacts, then the training event should be treated as requiring mitigation measures or should be classed as Category 3, negative determination with conditions.

Of the funding components that have been reviewed/certified (i.e., In Progress or Complete), 11% of the component actions have had potential environmental issues identified, which require mitigation/monitoring steps (Table 3.)

Table 3: Action Risk Categories

Risk Category	Actions	Percent of total	Comments
1	148	38%	Categorical exclusion
2	201	51%	Negative determination
3	43	11%	Negative determination with conditions
4	0	0%	Positive determination
Total	392	100%	

OPEN ACTIONS

At the time of the last EMMR in October 2013, there were 23 Open Actions pertaining to ongoing RESPOND activities. All outstanding Open Actions have been completed or closed, and there are no more Open Actions remaining.

CLOSED ACTIONS THAT REQUIRED MITIGATION/MONITORING

Table 5: Closed Actions requiring mitigation/monitoring

Action Type	Actions	Percent of total	Comments
Training with content to be determined	4	50%	1/4 – Training Materials were reviewed and there were no potential adverse environmental issues identified. 2/4 - Closed due to activity/funding cancelled. 1/4 – InCEF Ebola educational video. A thorough assessment was conducted, and there is no expected environmental impact from the training knowledge. The video content/material does not need refinement/adjustment for environmental concerns. See Environmental Action form for details (P-TUFKSA-001).
Training/enabling workers in response techniques that expose workers	1	12.5%	Closed due to activity/funding cancelled.

to infectious disease			
Training on dart gun use	1	12.5%	Closed due to activity/funding cancelled.
Training on animal immobilization methods	1	12.5%	Closed due to activity/funding cancelled.
Other	1	12.5	Closed due to activity/funding cancelled.
Total	8	100%	

At this time, there have been two Environmental Assessments completed (See P-TUFKSA-001 and P-DAIKLA-004).

DISCUSSION OF ISSUES

ISSUES WITH FUNDING COMPONENTS AND ACTIONS

The RESPOND work to date can be summarized by two types:

- No environmental concerns – 87% of the funds have been provided for multi-sectoral stakeholder meetings, planning, updates, general collaboration, or training with no risk;
- Potential environmental concerns – 13% of the funds have been provided for work where there could be environmental risks, which require mitigation measures/monitoring/assessment. However, half (50%) of the concerns have been related to training content that has not been determined yet. As the funding paid for the development of the content/material, it was not possible to review it prior to funding, so the thorough environmental review was completed when the content/material was developed.

36 funding components (out of 283) have been for activities where there could be a potential environmental issue (13%) These components were used to support, among other activities, the outbreak response efforts in Uganda, Wildlife Vet training in Thailand, and Wildlife Investigation and Livestock Disease (WILD) Trainings in DR Congo, Rwanda, and Gabon. As the project moved into year 5, the number of activities with potential environmental concerns continued to decrease as the work became more driven by university network development.

Grantees would be well served to understand the general concepts of environmental risk and mitigation, as well as USAID policies. The RESPOND approach has been to develop a general environmental training method for participating partners and professionals that will allow partners to develop their own analysis of environmental risk and mitigation. This will make responses to outbreaks better and will allow partners or grantees to conform to USAID environmental policy. Several issues that response professionals identified as requiring more attention are in the process of review to develop additional training materials. These are the disposal of waste in remote areas, disposal of carcasses and associated issues (or, following an integrated approach, reduction in the number of carcasses), reduction in impact on affected human populations (livelihoods issues) and reduction of the cost of resistance to necessary public health measures.

ISSUES WITH THE EMMP

In general, the project environmental management system is acting as proposed in the project EMMP to review funding components for conformity to USAID policy and enhance the capacity of partners to plan better responses. Continuing the EMS is indicated and the challenges for coming years is to develop and implement required training materials and circulate the materials developed, after USAID has the opportunity to review them. The EMMP was updated in Year 2 with:

- New/revised actions/issues in the training, procurement and outbreak response annexes, updated as the project progresses;
- Best practice reviews: as detailed in the EMMP, the RESPOND team has identified five areas that have either inconsistent or unavailable information/references related to proper environmental mitigation measures and approach. The areas include:
    - Experience and best practices for medical waste disposal in remote areas lacking health infrastructure ("remote" referring to areas that do not have access to health facilities and standard facilities for disposing medical waste);
    - Experience and best practices for disposing of wildlife and domestic animal carcasses after culling;
    - Experience and best practices when outbreak responses affect livelihoods;
    - Experience and best practices when outbreak responses engender passive or overt resistance; and
    - Experience and best practices of countries adopting habitat modification to control vectors. STTA for environmental/social issues as needed during implementation.
- Environmental workshop session: a workshop session was developed to highlight and raise issues environmental risks and mitigation related to the RESPOND scope. The scalable session can be inserted/modified for existing training courses/programs or it can be used as a standalone workshop, 1-2 days in length.
- Implement environmental workshops using the materials developed; disseminate the results of the best practice reviews to practitioners.

SUCCESS STORIES AND NARRATIVES

The RESPOND project has put together a solid approach to environmental mitigation and monitoring, due to the valued expertise/guidance from DAI environmental compliance advisor Steve Romanoff (of DAI.) His valuable insight and direction have helped the RESPOND project understand and respect the value of environmental mitigation/monitoring, as well as establish and implement a consistent, effective approach and process across the regional offices.

To date, accomplishments include:

- EMMP – The RESPOND EMMP describes the methodology used by the project across offices, potential environmental issues and mitigation measures inherent in RESPOND work, best practice review opportunities and an environmental workshop session;

- Process – The RESPOND team developed an environmental mitigation/monitoring approach that tied into the existing regional office/M&E structure. The M&E team is responsible for the overall approach; however the technical team members are responsible for ensuring that the proper consideration/screening occurs, as well as any identified mitigation measures are addressed;
- TAMIS - The DAI database TAMIS is used to collect, maintain and report the environmental information. An integrated screening form was developed in TAMIS to include the initial screening/risk categorization, as well as the identification of related actions, potential issues, mitigation measures, monitoring indicators, etc. While the project administrative staff members initiate the screening, through their grant and direct assistance documentation, it is sent to the technical lead and related M&E Officer to complete. Upon completion/certification, the form then resides with other forms of similar status (In Progress, Complete), available for future updates/review. Finally, the database allows for full exporting to support the annual report development, as well as summary views of the data to support decision making/reporting;
- Training – Environmental mitigation/monitoring introductory training occurred in all regional offices in the first half of 2011. While each office received the overview of the requirements and process, the M&E Officers went through more detailed training to understand the process/TAMIS steps;
- Environmental workshop session – In order to support the requirements that environmental consideration be properly addressed in our work, a workshop session was developed to be used in RESPOND implementation. The workshop can be a complementary session to an existing training or as a standalone session;
- Best Practice Reviews – In the course of compiling the EMMP in 2011, five issues were identified that require additional consideration/research. The M&E team addressed one high priority issue, best management practices for waste disposal from disease outbreak responses at remote sites, by developing and completing a comprehensive report on the subject in late 2011 and early 2012. See Annex 2 for the publication.

ANNEX 1. BEST PRACTICE REVIEW SOW

Project Headquarters
PROPOSED ACTIVITIES

Personnel	Team leader -Sally Lahm (30 days) Team coordinator - DAI TBD (15 days) Practitioner expert –TBD (10 days) Environmental Compliance and EIA Expert - Steven Romanoff (8 days) Training materials specialist –TBD (10 days)
RESPOND Position	STTA – Environmental Mitigation and Monitoring Best Practice Review
Proposed Dates	November 7, 2011 – December 31, 2011
Country	U.S. - Bethesda
Y2 Sub-activity (-ies)	N/A

BACKGROUND:

USAID awarded DAI a cooperative agreement to establish a coordinated and comprehensive program designed to minimize the impact of specific newly emergent diseases of animal origin, which pose a significant threat to human and animal health and development. RESPOND is one of five projects in the larger Emerging Pandemic Threats Program designed to strengthen the human capacity of countries to respond to outbreaks of emerging diseases of animal origin in a timely and sustainable manner.

Practitioner review of environmental compliance issues to prepare the RESPOND Environmental Mitigation and Monitoring Plan (EMMP) showed that experience and best practices for medical waste disposal in remote areas with minimal or no health infrastructure ("remote" referring to areas that do not have access to adequate health services and standard facilities for disposal of medical waste) needed to be further explored to harmonize materials, focus on specific concerns in remote locations, review best management practices (BMPs), and identify key issues and mitigation measures. Practitioners understand the problem and manage it by varied means, but do not have consistent and standardized BMPs to guide their response. This review will use publications, written documents and oral reports of practitioners, to be included in project training events and contingency planning.

PURPOSE:

The Best Management Practices Review will provide state-of-the-art summary of issues related to waste disposal during outbreak responses, provide reference materials for national RESPOND partners, provide training materials for use by RESPOND or others, disseminate knowledge of relevant BMPs to project partners and the wider practitioner community. In doing so, it will meet objectives of RESPOND and of USAID environmental regulations, which require continual review of environmental issues of concern to augment training materials.

TEAM:

The team will be comprised of:

Team Leader (S. Lahm)	30 days
Team manager/analyst (TBD)	15 days
Practitioner Expert (TBD)	10 days
Environmental Compliance and EIA Expert (S. Romanoff)	8 days
Training Methods and Materials Expert (TBD)	8 days

The RESPOND M&E Manager and technical staff who understand issues of waste disposal related to outbreak response and risks of environmental impact will provide RESPOND Implementing Partner quality assurance.

USAID will be asked to review the draft report, final report, and educational materials, as well as any changes to the project EMMP that result from this activity.

TASKS:

Team Lead:

1. Conduct research related to waste disposal issues resulting in an annotated bibliography and reference collection on waste disposal during outbreak response in remote areas, covering medical waste and waste generated by outbreak response workers, but not culling waste which is the subject of a separate BMP review.
2. Develop a report that summarizes results, key issues, BMPs and mitigation measures with attached training materials suitable for modification and use in RESPOND training events; review that report with project staff and national practitioner stakeholders.

3. Prepare a summary publication for distribution or journal publication.
    a. Best management practice review (BMPR)
        i. Specify concepts for review (including but not limited to BMP, relevant standards, waste generated during outbreak response, sanitation issues of concern in remote areas, mitigation) and priority areas for BMPR;
        ii. Review published (paper or internet), institutional ("gray publications"), and unpublished documents on waste disposal during outbreak responses in remote areas;
        iii. Convene video-conference panel of project experts with experience in outbreak responses in remote areas and conduct individual interviews; Output: identification of cases for in-depth review, practical or environmental issues, potential mitigation measures, methods for field visits (for M&E) and proposals for use of results;
        iv. Further research and review cases by communications with practitioners;
        v. Review issues with USAID health and environmental experts;
        vi. Visit 3 cases to generate original information on responses, environmental issues, and impact;
    b. Report and materials development
        i. Prepare draft report including review of practical measures, specification of issues, identification of priorities, draft mitigation measures and draft educational materials;
        ii. Convene video conference panel of project experts to discuss draft report; summarize minutes of the review.
        iii. Revise report including 1) analysis; 2) proposed mitigation measures; 3) proposal for educational materials;
        iv. Prepare educational materials to include 1) annotated bibliography with reference (non-copyrighted or with permission) materials; 2) PowerPoint presentation suitable for inclusion in training events for country officials and experts; 3) printed materials suitable for distribution to officials and local experts; 4) assessment suitable for dissemination via peer-reviewed publication;
        v. Prepare templates for practitioners to use in assessing and responding to outbreaks and plans to include results in RESPOND activities that will build capacities of practitioners;
        vi. Propose adjustments to the RESPOND Environmental Mitigation and Monitoring Plan (EMMP) to include BMPs;
    c. Communication

i. Maintain weekly contact with M&E Manager, providing updates on progress, issues faced, etc.

Team coordinator:

1. Management
   i. Manage team plan/schedule;
   ii. Oversee report/materials development, formatting, templates, etc.;
   iii. Providing regular updates to the M&E Manager and team;
   iv. Support the team with scheduling calls/meetings;
2. Best practice review
   i. Provide written materials and reports on outbreak response practices for waste disposal in remote areas; contribute literature and written reports and training materials;
   ii. Participate in interviews as requested by the BMPR team leader;
   iii. Provide written sections and support the research activities conducted by the best practice review team as required by the BMPR team leader.
3. Report and materials development
   i. Review created report/materials, provide feedback, edit as needed.

Practitioner Expert:

1. Provide subject matter expertise on waste disposal during outbreak response efforts. Help surface existing material and generate new data, based on past experiences, case studies, what has worked, etc.

Environmental Compliance and EIA Expert:

1. Become familiar with the SOW for the BMPR, as well as project documents on objectives, activities and environmental management;
2. Participate in practitioner interviews and case studies applying social science techniques;
3. Formulate recommendations for mitigation measures and best practices that comply with the RESPOND Initial Environmental Examination, the RESPOND Environmental Management

System and practitioner recommendations (as determined by the BMPR team); incorporate results in the RESPOND environmental management system;

4. Contribute to the report and supporting materials summarizing findings development and anticipate in formulation of training materials;
5. Otherwise support the best practice review team research related to waste disposal issues at the request of the team leader.

Training materials specialist:

1. Review team compiled report and supporting references;
2. Determine appropriate training approach/methodology for topic/materials, taking into account existing RESPOND environmental workshop sessions and adult learning perspective;
3. Develop training presentation and supporting materials;
4. Develop facilitator's guide;
5. Collaborate with the team.

DELIVERABLES:

#	Deliverable	Deliverable Due
1	Report including analysis, discussion of issues, proposed mitigation measures, proposal for educational materials, template for assessing and responding to outbreaks using BMPs.	Dec. 31, 2011
2	Educational materials: annotated bibliography, training presentation, printed or electronic materials for distribution, peer-review publication	Dec. 31, 2011

ANNEX 2. BEST PRACTICE REVIEW REPORT – WASTE DISPOSAL

USAID
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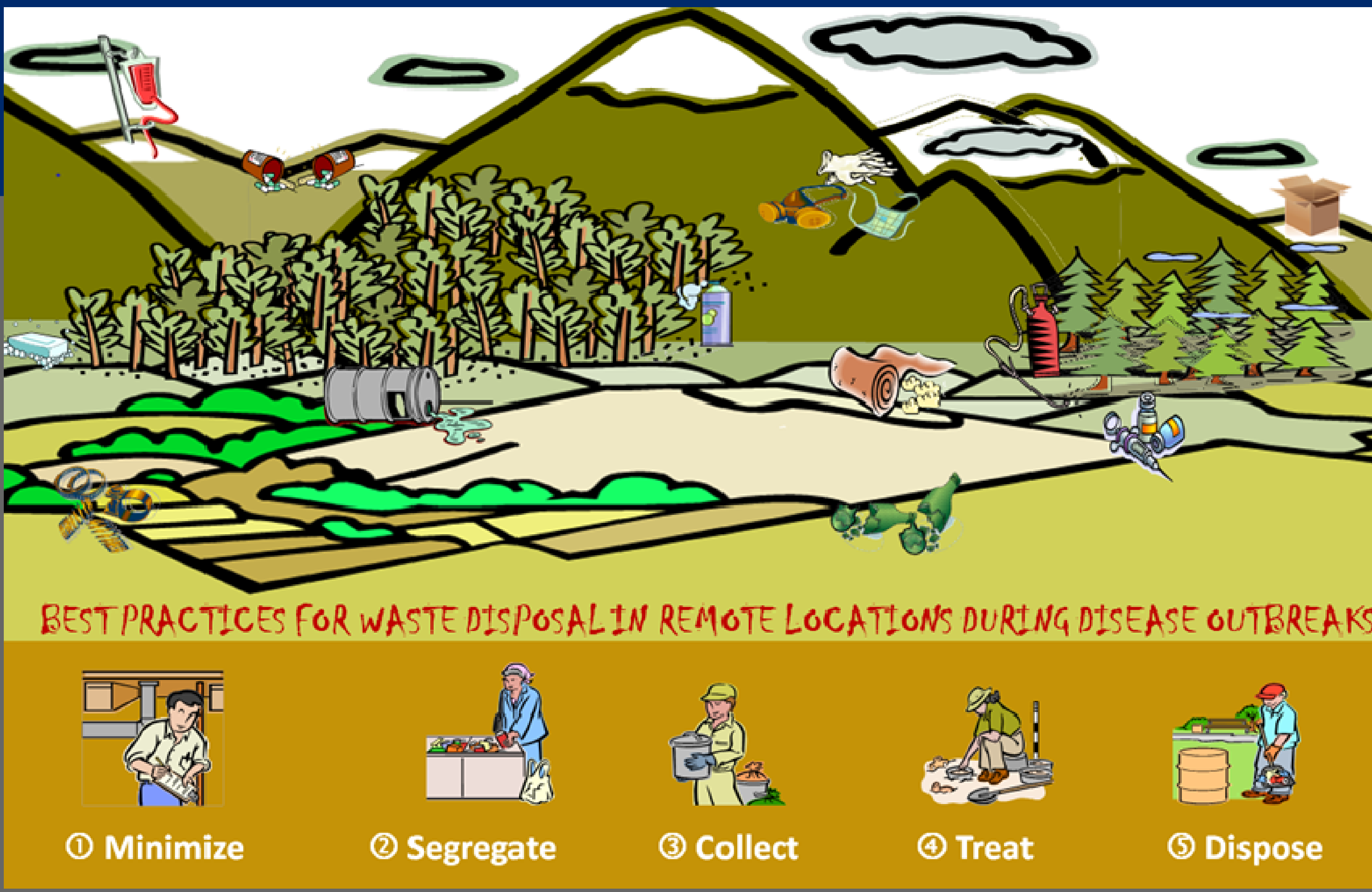
USAID RESPOND

BEST MANAGEMENT PRACTICES REVIEW FOR WASTE DISPOSAL FROM DISEASE OUTBREAK RESPONSE AT REMOTE SITES



FEBRUARY 2012

This publication was produced for review by the United States Agency for International Development. It was prepared by DAI.

RESPOND

BEST MANAGEMENT PRACTICES REVIEW FOR WASTE DISPOSAL FROM DISEASE OUTBREAK RESPONSE AT REMOTE SITES

Program Title:	**RESPOND**
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Award Number:	**GHN-A-00-09-00015-00**
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Date of Publication:	**February 2012**
Author:	**Sally A. Lahm, Ecology & Environment with**
	Introduction by Steven Romanoff, DAI
	Executive Summary by Danny Macri, DAI
	Supplemental by Thomas Hale-Kupiec, Department of Global Health, George Washington University, Washington DC
	Training Materials by Roberta Talmage, TRG

CONTENTS

ABBREVIATIONS

CDC	Centers for Disease Control and Prevention
DDT	dichlorodiphenyltrichloroethane
ENCAP	Environmentally Sound Design and Management Capacity-building for Partners and Programs in Africa
ERU	Emergency Response Unit
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
GAR	Global Alert and Response Department of WHO
GEF	Global Environment Fund
HBV	hepatitis B
HBC	hepatitis C
HCW	health care waste
HCF	healthcare facility
HIV	human immunodeficiency virus
HF	hemorrhagic fever
HPAI	haemophilus parainfluenzae
IDSR	Integrated Disease Surveillance and Response
IHR	International Health Regulations
IPC	Infection Prevention and Control
MSF	Medecins Sans Frontiers
OECD	Organisation for Economic Co-operation and Development
OIE	World Organisation for Animal Health,
PCB	polychlorinated biphenyl
POPs	persistent organic pollutants
PPE	personal protective equipment
PIC	prior informed consent
PVC	polyvinyl chloride

SARS	Severe Acute Respiratory Syndrome
SBC	Secretariat of the Basel Convention
UN	United Nations
UNEP	United Nations Environment Program
UNICEF	United Nations Children's Fund
USAID	U.S. Agency for International Development
VHF	viral hemorrhagic fevers
WHO	World Health Organization

EXECUTIVE SUMMARY

The World Health Organization and World Animal Health Organization have developed standards for waste management and disposal practices during the course of disease outbreaks. In developing countries, implementing safe and efficient waste management procedures can be problematic, especially in geographically remote areas, given limited availability of resources. The USAID RESPOND Project was designed to improve the capacity of countries to respond to outbreaks of emergent zoonotic diseases that pose a serious threat to human health. It follows that guidance on managing and disposing of waste generated during outbreak response should be provided to mitigate impacts to human, animal and environmental health. This Best Practice Review describes the roles and responsibilities of outbreak investigation and response team members, identifies types of health care waste that would likely be generated during disease outbreaks, explains health risks and environmental impacts of waste disposal, and details best practices and adaptive management procedures for treating and disposing of health care waste in remote areas. It has been written to guide USAID RESPOND Project staff, partners and outside practitioners on methods to properly dispose of waste in ways that reduce risks of further transmission and mitigate adverse environmental impact when working in remote areas.

The Introduction to the BPR frames the need for more guidance on how to dispose of medical waste during disease outbreaks in remote areas or in areas with small clinics. In the project's Initial Environmental Examination, USAID noted that though many activities would not have adverse impacts on the environment, there would be activities that could have indirect impacts such as training professionals in outbreak response methods that could generate hazardous and highly hazardous waste material. As a result, USAID requires the project to work with implementing partners to support training on best management practices for waste disposal. The introduction contains feedback from practitioners on the obstacles faced when trying to properly dispose of waste, how they adapted to those conditions, whether there were institutional and cultural factors that affected waste disposal processes, and whether there is an adequate need for training and more information on the subject. Based on this response the Introduction concludes by framing the review as responding to these needs by particularly emphasizing waste disposal management guidance in remote rural settlements with no health facility or only a small clinic, and no immediate access to urban centers.

This BPR begins by elucidating the importance of the issue of waste management in Chapter 2. It explains that the implications of medical waste disposal are most alarming in less economically developed countries. Though these countries produce less waste they tend to have weaker enforcement of regulations, higher population growth rates, lack of understanding and technology to address the dangers of healthcare waste, and insufficient financial and human resources to do so. This is especially prevalent in rural and remote areas. For example, at distant disease outbreak sites in resource-poor countries, mobile response teams must work under conditions in which infrastructure and amenities to support emergency healthcare interventions are less likely to be available.

Chapter 3, Definition and Classification of Types of Healthcare Waste, notes that all waste generated by healthcare facilities and response teams is considered healthcare waste. The majority of these wastes are not hazardous. The categories of waste that can have significant negative health and environmental effects if disposed of improperly include infectious (dressings, gowns, instruments), pathological (tissue or body fluids), sharps (needles), pharmaceutical (expired, unused, or contaminated), and chemical

wastes, in addition to solvents and pressurized containers. Depending on the pathogenic nature of the disease, the duration of the outbreak, and the numbers and types of response personnel, supplies and equipment needed, large volumes of waste can potentially be generated during investigation and response efforts.

The key international agreements and several underlying principles that form the basis for safe management of healthcare waste are explained in Chapter 4, International Agreements, Conventions and Regulatory Principles Regarding Healthcare Waste. The key agreements are the Basel, Rotterdam, and Stockholm Conventions. They respectively regulate transboundary movement of hazardous waste, require countries to be informed and provide consent for certain hazardous waste and pesticides to cross international borders, and promote the reduction, elimination (when possible) and management of the persistent organic pollutants produced from waste disposal. The agreements support a set of tenets which should be observed at all levels of healthcare waste disposal procedures. They are the Polluter Pays Principle (those who pollute must clean up), the Precautionary Principle (waste is hazardous until shown otherwise), the Duty of Care Principle (any person handling or managing waste is responsible for its disposal), and the Proximity Principle (disposal should take place as close to source as possible). This chapter also describes other international codes of practices and organizations that administer and promote policies and technical guidelines on management of healthcare waste and disease surveillance and response.

Chapter 5, Sources of Waste, identifies the key personnel required for conducting investigation and response activities during a disease outbreak. They are discussed in relation to their roles and required equipment and materials as examples of the volume and types of waste materials likely to be generated during disease outbreaks The teams include: the Disease Surveillance and Epidemiology Team which monitors and reports disease outbreaks; the Outbreak Investigation Team, which assesses outbreaks and begins resource mobilization; the Laboratory Services Team, which collects and analyzes specimens; the Clinical Case Management Team, which administers human and animal medical care; the Infection Prevention and Control and Hygiene and Sanitation Teams, which collaborate to ensure the implementation of adequate infection control and sanitation measures; the Social Mobilization Team, which ensures that affected communities receive adequate and accurate information about the outbreak; the Logistics/Personnel Deployment Team, which is responsible for planning transportation and mobilizing personnel; and Diverse Research Specialists who conduct varied investigations and work with response teams.

Chapter 6, Risks and Impacts of Healthcare Waste, identifies the risks associated with healthcare waste and their potential impacts on the environment and public health if not disposed of properly. The chapter details the risks of healthcare waste by the waste categories identified in Chapter 3. These risks do not just have impacts on medical staff and waste handlers but also on the wider public, animals and habitats through exposure at disposal sites, contamination of water and soil, and chemical pollutants in the air. Vectors such as rodents and insects can be hosts to pathogenic microorganisms and aid in their survival.

Chapter 7, Best Practices for Management of Healthcare-Associated Waste at Small Rural Medical Facilities and Remote Disease Outbreak Sites, advises on best practices for management of healthcare waste and on the roles and responsibilities of healthcare personnel and any persons likely to be in contact with waste. Following "minimal observance" standards is recommended, noting that "doing something is better than doing nothing." These standards are minimization, generation, segregation, codification, collection and on-site transportation, on-site storage in a secure location, treatment, and disposal of the waste. Emphasis is placed on the importance of personal protection equipment and appropriate training for waste handlers, as well as segregating different waste types, especially separating hazardous and infectious waste from non-hazardous to avoid potential cross contamination. Also discussed is the importance of contextual adaptive planning. Mitigation measures must consider local conditions including the state of the existing waste management system, the institutional capacity, the human resources available, and the costs of the different waste management options in relation to the financial status of the national health service and rural health centers.

Chapter 8, Diseases of Special Concern: Hemorrhagic Fevers presents options to control and contain the infection/contamination of Viral Hemorrhagic Fevers (VHFs) among the most lethal diseases which include Ebola and Marburg. These diseases require absolute isolation of patients and strict implementation of infection prevention and control measures because the risk of transmission to health workers and within communities is high. This chapter presents a selection of recommendations proposed by the CDC, WHO and various public health specialists in regard to aspects of fundamental Infection Prevention and Control and waste management measures, and burial of human remains, as well as response coordination and management during VHF epidemics. It also identifies manuals for VHF control measures in rural health facilities.

As a complement to the research review, selected practitioners with experience in outbreak investigation and response were asked to participate in a survey to identify practical adaptive measures and principal problems encountered in the field concerning waste disposal and related topics. The survey results are presented in Chapter 9, Best Practices for Waste Management at Disease Outbreak Sites: Results of a Practitioner Questionnaire Survey. Most respondents were aware of the standard recommended methods of WHO and OIE for waste management yet many noted that some developing countries do not have national waste management plans, or they are not applied, for diverse reasons including lack of government support, infrastructure and funding.

As such, meeting these international standards remains problematic. Nonetheless, on-site adaptive waste management and disposal is practiced and is effective in preventing and controlling further infection and contamination. In the most resource-poor situations, the basic methodology consists of performing triage on accumulated waste, disinfecting infectious waste, and burning/incinerating and/or burying the waste according to category. Questionnaire respondents provided examples of waste management and disposal methods employed during outbreaks of specific diseases of humans and animals, constraints on the implementation of waste management during outbreaks, and issues of concern related to burial and waste disposal.

In regard to large-scale animal disease outbreaks, local environmental characteristics such as soil type and content, and the height of the water table are amongst the factors which affect the time and effort required to complete the task of animal carcass disposal. Response teams must also be aware of socio-cultural issues, the impact of their actions on livelihoods, food, and water sources. The need for rapid diagnostic interventions, essential equipment, and continual dialog and communication within and exterior to affected communities during outbreaks were also noted..

Chapter 10: Conclusions and Recommendations reminds readers of the simple means and methods described in the preceding chapters which are both recommended and have proven to be effective in preventing and controlling infection at rural healthcare facilities and remote outbreak sites. Until the necessary funding, technical expertise and new technologies are widely available, many countries will continue to rely on basic waste segregation, disinfection, incineration or burning, and pit burial for disposal of healthcare waste. WHO fundamental principles for defining safe and effective healthcare waste management practices and basic actions to implement them are provided, as well as three associated reference guides for planning and management of healthcare waste, disposal methods for different healthcare waste categories, and safe burial of human remains and related culturally sensitive topics.

This BMP also includes several other annexes which can be consulted for direct guidance on healthcare waste management, mitigation and disposal method options.

The contents of this BPR have been adopted for training. The training materials can be found in Supplements 2, 3, 4 and 5.

CHAPTER 1: INTRODUCTION

The RESPOND project, financed by USAID as part of its Emerging Pandemic Threats Program, aims to improve the capacity of countries in high-risk areas to respond to outbreaks of emergent zoonotic diseases that pose a serious threat to human health. It began in October 2009 with a mandate to strengthen training and educational programs, and to provide support to governments, universities and civil society to improve capacity to respond to zoonotic and emerging infectious disease outbreaks.

This document reviews best management practices (BMPs) for disposing of waste generated by outbreak response teams working in remote areas. It identifies risks attendant on outbreak investigation and response activities in remote areas and the mitigation measures to prevent negative impacts. It evolved from the environmental review process created for RESPOND as a USAID-funded project.

Screening for environmental issues is a normal procedure for any USAID project. In this case, normal review for RESPOND activities found a need for standards and practices for teams working in the very remote and difficult environments where zoonotic diseases are often found. Project technical staff identified a need for guidance, training materials and support for practical issues in such atypical contexts.

USAID reviews projects for potential environmental impacts prior to deciding to finance the activity, providing guidance in an Initial Environmental Examination (IEE). Implementing partners, like DAI and other participants in RESPOND, are expected to continue reviewing their activities for potentially negative environmental impacts and to avoid, prevent, reduce, mitigate or offset such impacts. Identifying and using standard and feasible best practices to avoid negative impacts is part of that process.

Much of RESPOND's activities, comprising training and technical assistance, have very limited direct environmental impact. USAID notes that,

> Many of the RESPOND activities do not have direct adverse environmental impacts, as they entail technical assistance, information, education, communication, training, research, community mobilization, planning, management, and outreach activities.

But USAID also tasks RESPOND to look at indirect impacts. Among the potential indirect impacts cited which could arise from implementation of activities after training are the following:,

> Training professional and paraprofessional health care workers in methods that result in the generation and disposal of hazardous or highly hazardous medical waste (e.g. basic and emergency obstetric care techniques, administration of injectables, HIV or TB testing, malaria diagnosis, etc).

The project IEE notes the risks from "… improper handling, storage and disposal of the waste generated in these facilities or activities can spread disease through several mechanisms." It reviews general, hazardous and highly hazardous healthcare wastes. It goes on to conclude,

> If a project's training activities for professional health workers or community health workers involve techniques that would generate and require disposal of hazardous or highly hazardous waste, the Implementing Partners shall be required to include training in or ensure that the

training curriculum covers best management practices concerning the proper handling, use, and disposal of medical waste, including blood, sputum, and sharps.

As appropriate, the implementing partners will work with facility, local, regional and/or national officials, to implement and apply appropriate best management practices which incorporate appropriate health and safety measures and environmental safeguards, including proper disposal of medical waste in accordance with international norms as described by the WHO in "Safe Management of Wastes from Healthcare Activities." National policies and laws should also be considered, although most countries follow WHO Guidelines.

The requirement for RESPOND when doing training in methods that could result in the generation, and need for disposal, of hazardous and highly hazardous medical waste, is the following:

When USAID provides support to programs that enable workers it accepts that indirect impacts may occur. By training workers in response techniques and processes, USAID also must consider the potential indirect impacts such as the exposure, generation and disposal of infectious and hazardous waste.

When providing training on activities that could cause the exposure and generation of hazardous and highly hazardous medical waste, including blood, the partner must provide information and training on how to manage exposure, decrease the generation of hazardous materials and waste, and how to properly dispose of that waste.

Consequently, RESPOND is expected to include training about best management practices to address risks of waste accumulation during outbreak responses. The World Health Organization and World Animal Health Organization (OIE) have identified standards for waste management and medical waste disposal to observe during disease outbreaks, and USAID resources (the ENCAP Africa web site, for example) offer guidance for handling waste during small-scale healthcare initiatives, such as rural health posts or clinics, mobile clinics, urban clinics and small hospitals, and community health worker activities.

RESPOND project staff met to review environmental aspects of the project's activities. The staff, with field experience, identified risks and mitigation measures appropriate for project activities based on guidance, their own experience in the field and their training.

In spite of the guidance from USAID, WHO, and the OIE, implementing safe and efficient waste management procedures in remote areas of developing countries can be problematic. given limited resources available to outbreak response teams.

- Outbreak responses sometimes occur in remote areas that lack healthcare facilities, communications infrastructure, sewage systems or potable water systems. Indeed, where the outbreak involves contact between humans and wild animals, it is least likely to occur in areas with health and other infrastructure. And daily, intense contact between domestic animals and humans is common in many such rural areas, though market towns and urban facilities are also places of frequent contact.

- Outbreak responses are often transitory efforts. A team may enter a zone, do its work and depart in a matter of days or weeks. There may be no permanent healthcare program in the area at all. They may have no opportunity to construct incinerators or some kinds of disposal facilities. Such teams may generate their own waste that is not specifically medical, and that waste may bring risk to local people.

- Outbreak response may generate atypical waste streams. If segregation and relocation of a population is part of the outbreak response, the risks faced by refugees become part of the risk of the response. Culling large numbers of domestic or wild animals creates a huge issue of sanitary disposal.

The literature on waste in medical facilities, reviewed in this document, commonly puts the facility in a context of a typology of settlements: urban, peri-urban, rural and, rarely, remote rural, though the last category may concern clinics in remote rural areas, indicating that the remoteness of the area is not extreme. Surveys may cover regional hospitals, hospitals, clinics and small-scale clinics. Environments may be cited by climate, vegetation or special features, like presence of forest. This review is intended to emphasize remote rural settlements with no health facility or only a small clinic, and no immediate access to urban centers.

Medical waste is only part of the problem during outbreak response in remote areas. The risks attendant on outbreak response may include general waste generated by the outbreak response team. Popular or business resistance to culling, conflict about the proper response, and impact on livelihoods or diet are not restricted to remote areas, but remote areas are often characterized by strength of traditional cultural practices and economic marginality that exacerbate issues for waste disposal.

After the major issues concerning the provision of healthcare and managing associated waste in remote areas were identified, the next step was to review special issues of outbreak response in remote areas by reviewing literature and reference materials and by checking the degree to which field practitioners identified relevant issues.

PRACTITIONERS VIEWS ON WASTE DISPOSAL

DO PRACTITIONERS RECOGNIZE THE ISSUE OF WASTE DISPOSAL IN REMOTE AREAS DURING OUTBREAK RESPONSES?

To test the relevance of the issue, the BMP Review team reached out to practitioners and outbreak investigators. Queries went to 18 professionals in the fields of public health, veterinary medicine and biological sciences; 11 responded. All have experience in outbreak investigation or response. Seven work at African institutions, 2 in U.S. institutions, and 2 in a USAID-financed international program.

The participation of these practitioner-professionals illuminates the conditions under which actual responses to zoonotic disease occur. Themes in the practitioners' statements do confirm the need for discussion and guidance for remote and extreme circumstances. Other themes pertain to work in marginal conditions generally, not just geographically remote areas. These results are reported in more detail in Chapter 9, but some items are prominent .

WHAT CONSTRAINING FACTORS IN REMOTE AREAS DO PRACTITIONERS RECOGNIZE?

The practitioners do adapt medical waste disposal to environmental, economic, and logistical conditions in remote areas, such as

- lack of incinerators or facilities for disposal of medical waste,
- lack of equipment for excavation,
- lack of general waste collection, resulting in accumulation of waste in public areas,,
- lack of hospital or clinic facilities for isolation of patients,
- lack of supplies used for waste disposal that are available in urban areas and which may be difficult to obtain in remote areas, including gloves, soap, clean water, disinfectant, quick lime, formaldehyde, fuel, chemicals to disinfect soil or PPE for those tasked with burial,
- excessive distances to urban areas and delays in transporting samples from rural areas for diagnosis, with the risk that "damage can become enormous before they are ready to intervene," and
- natural factors most relevant in remote areas, such as depth of soil, rockiness, risk of fires, predators or scavengers, To adapt to scavengers, they noted use of deep trenches, quick burial, spraying with formaldehyde, and treatment with quick lime.

HOW DO PRACTITIONERS ADAPT TO THESE CONDITIONS IN REMOTE AREAS?

They do. For example, the practitioners cited several incineration techniques that are appropriate, or not, in particular environments: using old tires and diesel ("Every ranch/farm has old tires waiting to be taken away."), mobile incinerators (which may be limited by cost or local capacity), metal drums manufactured locally for burning, construction of simple incinerators, and on-farm composting as ways to mitigate risks of incineration or opposition to transport of carcasses. On the other hand, they noted very good facilities in some less marginal (geographically and economically) areas, such as large incinerators capable of disposing of cattle with attendant risks of transporting and possibly butchering infected carcasses.

DID PRACTITIONERS CITE UNEXPECTED ISSUES?

The practitioners also cited issues arising from human behavior that may be associated with geographic remoteness, or may be associated with marginality or poverty, such as occurs in a refugee camp. More than one practitioner cited instances when buried carcasses of dead/culled birds were exhumed by people for food; another noted that even if sharps are buried, "local population may dig them up after team leaves to try to use materials," (hence need for sharps containers); another noted the need to cap and close pits to prevent human and animal disturbance. Hunger and deprivation are the context of such behavior, and there is a "problem of awareness in order to get [local people] to adhere to the logic of the destruction of carcasses, which corresponds to the loss of food for a population often faced with malnutrition and /or hunger."

INSTITUTIONAL FACTORS IN WASTE DISPOSAL?

Institution strengthening is core to RESPOND. Several practitioners cited clear responsibilities and guidance for waste disposal in remote areas. But others cited unclear responsibilities, lack of personnel and varying capacities of the parties responsible for waste disposal, for example when less-than-capable farmers are expected to dispose of waste and carcasses. One practitioner noted that supervisory capacity is required for proper waste disposal:

> There were times when the vet services did not properly supervise euthanasia and burial of carcasses. Burial pits were barely 3ft and improperly euthanized birds escaped from the shallow pits.

Others noted that institutional commitment by local government was not always clear. Budget is a part of institutional commitment: “Without money, recommendations for remote areas are speculative waste. Without money, you can do nothing.” Another cited lack of budget for waste management.

CULTURAL FACTORS IN WASTE DISPOSAL.

Another unexpected theme of the responses was the importance of local norms and cooperation. It would not be true to claim that only remote areas are culturally conservative. But traditional cultures are often found in such areas. Practitioners cited issues arising from strong adherence to cultural practices and norms:

- Several respondents noted that disposal of human remains is problematic due to local cultural practices.

  “Many communities have traditional behaviors with burial that disposal during outbreaks may violate; these include traditional bathing of persons after death, need to wrap corpse traditionally in a cotton cloth (while outbreak teams need to prevent bathing to avoid contamination in an outbreak like cholera or hemorrhagic fever), and objections to burying a deceased person in a “body bag” which is not traditional.”

- One cited lack of information on local practices, and a need for training on how to handle cultural issues.

- Another noted that traditional practices or conditions offer limited protection in the burial or disposal of carcasses, so that a whole family or even the whole village or the room or the hospital may become contaminated, including all health care staff, paramedics and other emergency services such as sanitation.

Adjacent human presence affects the choice of method and locations for waste disposal; such as sources of drinking water, a refugee camp or a resettlement area. One practitioner noted that when burying large numbers of cattle, there is a real risk of blood and other waste fluids getting into the ground water and, by association, into peoples’ drinking water.

IS THERE A NEED FOR TRAINING AND WRITTEN GUIDANCE FOR DISPOSAL OF WASTE FROM DISEASE OUTBREAK RESPONSE IN REMOTE AREAS?

Yes, and the special issues of remote areas should be treated, but training needs should address marginality and cultural differences more broadly, as well as waste treatment generally. Several practitioners noted a need for staff training. Some noted application of WHO or other standards, and one cited government procedures, others cited a need for training: “the aspect of waste management is forgotten in outbreak management.... At supervisory level, in the fight against the disease, we have no expertise in waste management.” One cited lack of written guidance or standards for local staff covering waste disposal. Another noted lack of information on the different disposal methods and how to do a proper disposal. Clearly, personnel are not properly trained in waste disposal in many developing countries. Novelty is part of the problem, said another -- rapid response teams (RRTs) may be responding for the first time and may lack knowledge of practices. One cited specific training for health workers in refugee camps and resettlement areas in infection control, PPE use and disposal, waste disposal, and respectful and proper disposal of corpses.

Several also called for better written material. One cited lack of appropriate information on waste management due to lack of staff training. Another asked for "written materials distributed that there be in addition some information which could be used locally to inform the local population about how to avoid risk of becoming ill...." Another suggested that the project

> "Provide educational materials in appropriate language (English, French, Portuguese) to be available for use and accessible to print and distribute when outbreaks happen in remote areas. If resources exist, may be useful to have printed material for illiterate persons."

There were several with ideas about how to deliver information. One cited lack of outreach was cited as an issue; he

> "did not see any concern regarding issues with waste disposal mainly because the population was not aware that these activities were taking place. The governments had the information and did not publicize the events."

Another called for education in schools. Local practices and communications practices are the way to get messages out, such as use of local "town criers" or radio. One asked for "materials for the local health authority – and THEY would explain hazard avoidance to the local population." Another suggested that responders adapt methods to prevailing literacy skills (e.g. composting for low-literacy populations).

The practitioners experience with actual outbreak responses confirms the staff identification of a need for a BMP Review to support clear training and planning for work in remote areas. There is also clear need for training on waste disposal in economically and culturally distinct areas more generally.

THIS BMP

The goals of this BMP are to comply with USAID environmental policy to review potential impacts of project activities, address indirect impacts, generate guidance on how to dispose waste generated from an outbreak response to mitigate health or environmental impacts arising from outbreak responses and further RESPOND's overall goals of strengthening outbreak response through training.

This review does not replace WHO or USAID standards. Rather, it is intended to facilitate their application in environments where there are special conditions and to address issues raised by technical staff and practitioners.

It has been written to guide USAID RESPOND Project staff, partners and outside practitioners on how to properly dispose of waste in ways that reduce risks of further transmission and mitigate adverse environmental impact when working in remote areas. Following the needs identified by project experts and practitioners, the BMP Review puts the issues of remote areas in a wider context of medical waste disposal, explains health risks and environmental impacts of its disposal, and identifies best practices and adaptive management procedures for treating and disposing of health care waste in remote areas.

The review is accompanied by training materials suitable for use with national response programs as part of RESPOND's support for those programs. The success of this BMP review will be in the use and results of the training that it supports to improve outbreak response.

Future BMP Reviews will address other issues identified as risks for outbreak response, including issues specific to culling, how to address cultural aspects during outbreak response and impacts on livelihoods.

The contents of the review are described in the executive summary.

CHAPTER 2: IMPORTANCE OF THE ISSUE OF HEALTHCARE WASTE DISPOSAL

The generation and disposal of medical waste from hospitals and other healthcare facilities is a global and growing menace. It is particularly alarming in less economically developed countries which may have higher human population growth, a lack of awareness about the health hazards of medical waste, inadequate management and control practices, and insufficient technological training and financial resources to ensure responsible planning and management of medical waste products (Prüess et al. 1999; WHO HCW Policy August 2004).

Other major contributing factors contributing to increased risk include inappropriate regulations regarding medical waste, weak enforcement where regulations do exist, and the need for clarity concerning responsibility for processing and disposal of medical waste, as well as shortages in staff and inadequate resources to bring to bear on the problem. The general benefits of health care are reduced when medical waste is not properly managed, and can result in negative impacts on the health and well-being of human and domestic animal populations, wildlife, and environments (EnvironQuest 2007).

The World Health Organization (WHO) defines all waste generated by healthcare facilities, medical research facilities, and health laboratories as healthcare waste. The waste products are classified into two categories: general healthcare waste, which is comparable to domestic waste (i.e. low or non-risk), and hazardous waste, which has the potential to pose a variety of health risks (Prüess et al 1999; WHO Core Principles October 2007).

Medical waste may contain diverse hazardous materials, such as infectious waste, anatomical and pathological waste, obsolete or expired chemical products and pharmaceuticals, radioactive materials, and disposable or unusable medical equipment. Traditional options for disposal of healthcare waste have been limited to autoclaves and retorts, chemical disinfection, burial, open dumping, or incineration, with the latter option often resulting in incomplete waste destruction, inappropriate ash disposal, and emissions of dioxins, furans and other toxic air pollutants (Diaz et al. 2005; Hamoda et al. 2005; Murthy et al. 2011).

Developed countries generally produce substantially more healthcare waste and resulting pollution than other countries with more limited healthcare infrastructure, waste disposal planning and waste management capacity (Table 2.1).

TABLE 2.1 COMPARISON OF HEALTHCARE WASTE GENERATION IN EIGHT COUNTRIES

Average number of kilograms of waste generated per patient per day.

Country	kg/patient/day
Saudi Arabia	1.1
France	1.3
Iran	2.7

Country	kg/patient/day
Nigeria	2.7
United Kingdom	3.3
Canada	4.1
Spain	4.4
United States	4.4

Adapted from: Sawalem et al. 2008

Low income countries produce less healthcare waste compared to middle income and highly industrialized countries mainly due to differences in lifestyles, standards, economic status, availability of disposable medical supplies, and availability of medical treatment facilities (Table 2.2; [EnvironQuest 2007; Murthy et al 2011; Sawalem et al 2008].)

TABLE 2.2 COMPARISON OF HEALTHCARE WASTE GENERATION BY INCOME LEVEL

Daily range of healthcare waste generated per kilogram by patient.

National Income Level	kg/patient/day
High income countries	
- all medical waste	1.1 – 12.0
- hazardous medical waste	0.4 – 5.5
Middle income countries	
- all medical waste	0.8 – 6.0
- hazardous medical waste	0.3 – 0.4
Low income countries	
- all medical waste	0.5 – 3.0
- hazardous medical waste	0.05 – 0.15

Adapted from: EnvironQuest 2007

On a global basis, ranging from small rural clinics to large urban facilities, substantial volumes of healthcare waste are produced annually during normal healthcare activities, public health and natural disaster response efforts, and immunization campaigns. Medical facilities in 20 regions in Tanzania produced 12-14 tons of clinical waste per day, comprised of 12210 kg/day in hospitals and 1795 kg/day in health centers (UNEP-SBC/WHO 2005). Results from a WHO assessment conducted in 2002 revealed that from 18% to 64% of healthcare facilities in 22 developing countries did not use proper waste disposal methods (WHO Fact sheet N°281; October 2011).

In some less economically developed countries, the volume of healthcare waste generation in urban areas can approach those of developed countries, but there is relatively little accumulation at rural care health centers (Table 2.3). The latter are critically important as sentinel facilities for disease outbreak surveillance, investigation and first response, yet they are often understaffed, ill-equipped, and lack safe disposal technology.

TABLE 2.3 COMPARISON OF WASTE GENERATION BY HEALTHCARE FACILITY TYPE IN FIVE COUNTRIES

Average number of kilograms of waste generated per patient per day

Facility Type	kg/patient/day

Facility Type	kg/patient/day
Nigeria	
- University Hospitals	6.4
- General Hospitals	3.1
- State Hospitals	1.1
- Rural Healthcare Centers	0.2
India	
- Urban hospitals	6.2
Kuwait	
- Urban hospitals	3.8
- Rural Healthcare Centers	0.04
Libya	
- Urban Hospitals	1.3
- Rural Healthcare Centers	0.9
Iran	
- Rural Healthcare Centers	0.1

Sources: Hamoda et al. 2005; EnvironQuest 2007; Sawalem et al. 2008; Mesdaghinia et al. 2009; Murthy et al. 2011.

There is little information on the volume of hazardous and non-hazardous waste materials generated during disease outbreak investigations and response efforts in urban, peri-urban or more isolated rural areas. At more distant disease outbreak sites, the essential infrastructure and financial and technological resources required to undertake safe disposal of infectious waste are less likely to be available. Self-contained mobile teams must arrive with food, medical and other treatment and operational equipment, materials and products, as well as portable lodging and subsistence equipment for often large investigation and response teams comprised of several sub-units (WHO-AFRO/CDC 2001).

For example, during a mass immunization campaign for measles in six West African countries in 2001, seventeen million children were vaccinated, resulting in nearly 300 metric tonnes of injection equipment waste. Disposal options were planned and strictly implemented at local and regional levels to safely dispose of this huge volume of waste. (WHO Fact sheet N°281; October 2011: www.who.int/mediacentre/factsheets/).

The majority of waste generated from healthcare activities is not more dangerous than regular household waste, such as paper, packaging, food and debris, **although no waste products are completely and totally harmless**. Some types of healthcare waste represent a higher risk to health, including infectious waste (15% to 25% of total healthcare waste) among which are sharps waste (1%), body part waste (1%), chemical or pharmaceutical waste (3%), and radioactive and cytotoxic waste or broken thermometers (less than 1%) (WHO HCW Policy August 2004).

Where healthcare waste management is limited, substandard practices and poor supervision can expose health workers and the public to toxic effects of wastes generated from healthcare facilities. The results of a survey of six hospitals in northern Nigeria indicated that there was no separation of waste materials into hazardous and non-hazardous products and all mixed waste materials were placed in general containers stored at collection points in open spaces for days to weeks. The waste containers were thus subject to weather extremes and scavenging by animals and humans, while chemical, pharmaceutical, and human waste were observed in nearby drainages connected to rivers and streams (Ndidi et al. 2009).

Similar conditions on a smaller scale may prevail at rural medical care facilities. Disease outbreak sites in remote areas with little infrastructure and few amenities are particularly vulnerable to contamination from medical and other waste generated during outbreak investigations and response. Thus, applied waste management is imperative.

CHAPTER 3: DEFINITION AND CLASSIFICATION OF HEALTHCARE WASTE

The World Health Organization (WHO) defines healthcare waste as "the total waste stream (solid and liquid) from health-care establishments, research facilities and laboratories." In addition, health-care activities in minor or scattered locations, including health-care provided at home may also generate substantial health-care waste. 75% to 90% of the waste of health-care providers is general waste, comparable to domestic waste, and mostly comes from the administrative and housekeeping functions of the establishments. This general waste may also include waste from the maintenance of the premises of a healthcare facility. The remaining 10% to 25% is hazardous health-care wastes which may create a variety of health risks" (Prüess and Townsend 1998; Prüess et al. 1999). Healthcare waste is generated during activities of both human and veterinary medicine.

The categories and definitions of healthcare waste are described in the following sections and summarized in Table 3.1. (Source: Prüess et al. 1999, Chapter 2, pp. 2-8).

INFECTIOUS WASTE

Waste classified as "Infectious" is suspected to contain pathogens (bacteria, viruses, parasites, or fungi) in sufficient concentration or quantity to cause disease in susceptible hosts. This category includes:

- Cultures and stocks of infectious agents from laboratory work;
- Waste from surgery and the autopsies of patients with infectious diseases (e.g. tissues, and materials or equipment that have been in contact with blood or other body fluids);
- Waste from infected patients in isolation wards (e.g. excreta, dressings from infected or surgical wounds, clothes heavily soiled with human blood or other body fluids);
- Waste that has been in contact with infected patients undergoing haemodialysis (e.g. dialysis equipment such as tubing and filters;
- Disposable towels, gowns, aprons, gloves, and laboratory coats;
- Infected animals from laboratories;
- Any other instruments or materials that have been in contact with infected persons or animals.

Note: Infected "sharps" are a subcategory of infectious waste described separately.

Cultures and stocks of highly infectious agents, waste from autopsies, animal bodies, and other waste items that have been inoculated, infected, or in contact with such agents are called **highly infectious waste**.

PATHOLOGICAL WASTE

Pathological waste consists of tissues, organs, body parts, human fetuses and animal carcasses, blood, and body fluids. Within this category, recognizable human or animal body parts are also called **anatomical waste**. This category should be considered as a subcategory of infectious waste, even though it may also include healthy body parts.

TABLE 3.1 CATEGORIES OF HEALTHCARE WASTE

Waste Category	Description and Examples
Infectious waste	Waste suspected to contain pathogens (e.g. laboratory cultures, waste from isolation wards; tissues [swabs]; excreta; contaminated lab equipment/supplies);
Pathological waste	Human tissues or fluids (e.g. body parts; blood and other body fluids; fetuses)
Sharps	Sharp waste (e.g. needles; infusion sets; scalpels; knives; blades; broken glass)
Pharmaceutical waste	Waste containing pharmaceuticals (e.g. pharmaceuticals that are expired/unused
Genotoxic waste	Waste containing substances with genotoxic properties (e.g. waste containing cytostatic drugs)
Chemical waste	Waste containing chemical substances (e.g. laboratory reagents; film developer; disinfectants)
Waste with high content of heavy metals	Batteries; broken thermometers containing mercury; blood pressure gauges, etc.
Pressurized containers	Gas cylinders; gas cartridges; aerosol cans
Radioactive waste	Waste containing radioactive substances (e.g. unused liquids from radiotherapy, diagnostic radioisotopes or laboratory research; contaminated glassware, packages)

Source: Prüess et al 1999.

Genotoxic and radioactive treatment and related waste are unlikely to be used at small rural healthcare facilities and at disease outbreaks sites in remote areas. However, they are considered major categories of healthcare waste and thus are included in the following brief descriptions of all categories presented in Table 3.1.

SHARPS

Sharps are items that could cause cuts or puncture wounds, including needles, hypodermic needles (including those attached to syringes, scalpel and other blades, knives, infusion sets, saws, broken glass, and nails. Whether or not they are infected, such items are usually considered as highly hazardous health-care waste as they are often the cause of occupational risk to health workers (e.g. due to unintentional needle-stick injury).

PHARMACEUTICAL WASTE

Pharmaceutical waste includes expired, unused, spilt, and contaminated pharmaceutical products, drugs, vaccines, and sera that are no longer required and need to be disposed of appropriately. The category also includes discarded items used in the handling of pharmaceuticals, such as bottles or boxes with residues, gloves, masks, intravenous (IV) bottles, connecting tubing, and drug vials, including multi-use vials.

GENOTOXIC WASTE

Genotoxic waste is highly hazardous and may have mutagenic, teratogenic, or carcinogenic properties; thus raising serious safety problems, both inside hospitals and after disposal. This category should be given special attention. Genotoxic waste may include certain cytostatic drugs (see below), vomit, urine, or feces from patients treated with cytostatic drugs, chemicals, and radioactive material for cancers.

Cytotoxic (or antineoplastic) drugs, the principal substances in this category, have the ability to kill or stop the growth of certain living cells and are materials used in chemotherapy of cancer. They play an important role in the treatment of various neoplastic conditions but are also finding wider application as immunosuppressive agents in organ transplantation and in treating various diseases with an immunological basis.

Cytotoxic wastes are generated from several sources and can include the following:

- contaminated materials from drug preparation and administration, such as syringes, needles, gauges, vials, packaging; outdated drugs, excess (leftover) solutions, drugs returned from hospital wards;
- urine, feces, and vomit from patients, which may contain potentially hazardous amounts of the administered cytostatic drugs or of their metabolites and which should be considered genotoxic for at least 48 hours and sometimes up to 1 week after drug administration.

CHEMICAL WASTE

Chemical waste consists of discarded solid, liquid, and gaseous chemicals, for example from diagnostic and experimental work and from cleaning and disinfecting procedures. Chemical waste from health care may be hazardous or nonhazardous. In the context of protecting health, it is considered to be hazardous if it has at least one of the following properties:

- toxic;
- corrosive (e.g. acids of $pH < 2$ and bases of $pH > 12$);
- flammable;
- reactive (explosive, water-reactive, shock-sensitive);
- genotoxic (e.g. cytostatic drugs).

Nonhazardous chemical waste consists of chemicals with none of the above properties, such as sugars, amino acids, and certain organic and inorganic salts. The types of hazardous chemicals used most commonly in maintenance of healthcare facilities and the most likely to be found in waste are discussed in the following paragraphs.

FORMALDEHYDE

Formaldehyde is a significant source of chemical waste in healthcare facilities. It is used to clean and disinfect equipment (e.g. haemodialysis or surgical equipment), to preserve specimens, to disinfect liquid infectious waste, and in pathology, autopsy, dialysis, embalming, and nursing units.

PHOTOGRAPHIC CHEMICALS

Photographic fixing and developing solutions are used in X-ray departments.

The fixer usually contains 5-10% hydroquinone, 1-5% potassium hydroxide, and less than 1% silver. The developer contains approximately 45% glutaraldehyde. Acetic acid is used in both stop baths and fixer solutions.

SOLVENTS

Wastes containing solvents are generated in various departments of a hospital, including pathology and histology laboratories and engineering departments. Solvents used in hospitals include halogenated compounds, such as methylene chloride, chloroform, trichloroethylene, and refrigerants, and non-halogenated compounds such as xylene, methanol, acetone, isopropanol, toluene, ethyl acetate, and acetonitrile.

ORGANIC CHEMICALS

Waste organic chemicals generated in health-care facilities include:

- disinfecting and cleaning solutions such as phenol-based chemicals used for scrubbing floors, perchlorethylene used in workshops and laundries;
- oils such as vacuum-pump oils, used engine oil from vehicles (particularly if there is a vehicle service station on the hospital premises);
- insecticides, rodenticides.

INORGANIC CHEMICALS

Waste inorganic chemicals consist mainly of acids and alkalis (e.g. sulfuric, hydrochloric, nitric, and chromic acids, sodium hydroxide and ammonia solutions). They also include oxidants, such as potassium permanganate ($KMnO_4$) and potassium dichromate ($K^2Cr_2O_7$), and reducing agents, such as sodium bisulfite ($NaHSO_3$) and sodium sulfite (Na_2SO_3).

WASTES WITH HIGH CONTENT OF HEAVY METALS

Wastes with a high heavy-metal content represent a subcategory of hazardous chemical waste, and are usually highly toxic. Mercury (Hg) is a heavy metal, and wastes are typically generated by spillage from broken clinical equipment but their volume is decreasing with the substitution of solid-state electronic sensing instruments (thermometers, blood-pressure gauges, etc.). Whenever possible, spilled drops of mercury should be recovered. Cadmium waste comes mainly from discarded batteries. Certain "reinforced wood panels" containing lead are still used in radiation proofing of X-ray and diagnostic departments. A number of drugs contain arsenic, but these are treated here as pharmaceutical waste.

PRESSURIZED CONTAINERS

Many types of gas are used in health care and are often stored in pressurized cylinders, cartridges, and aerosol cans. Many of these, once empty or of no further use (although they may still contain residues), are reusable, but certain types, notably aerosol cans, must be disposed of.

Whether inert or potentially harmful, gases in pressurized containers should always be handled with care; containers may explode if incinerated or accidentally punctured.

MOST COMMON GASES USED IN HEALTH CARE

Anaesthetic gases: Nitrous oxide and volatile halogenated hydrocarbons (such as halothane, isoflurane, and enflurane), have largely replaced ether and chloroform.

Applications include: in hospital operating theatres, during childbirth in maternity hospitals, in ambulances, in general hospital wards during painful procedures, in dentistry, for sedation, etc.

Ethylene oxide: Applications: for sterilization of surgical equipment and medical devices, in central supply areas, and, at times, in operating rooms.

Oxygen: Stored in bulk tank or cylinders, in gaseous or liquid form, or supplied by central piping. Application: inhalation supply for patients.

Compressed air: Applications: in laboratory work, inhalation therapy equipment, maintenance.

RADIOACTIVE WASTE

Radioactive substances used in health care and generating waste include solid, liquid, and gaseous materials contaminated with radionuclides. Ionizing radiations cannot be detected by any of the senses and, other than burns, which may occur in exposed areas, usually cause no immediate effects unless an individual receives a very high dose.

MODIFICATIONS TO THE WHO CLASSIFICATION OF HEALTHCARE WASTE IN PRÜESS ET AL. 1999

The United Nations Environmental Program (UNEP) further subdivided two categories of healthcare waste (HCW) as described below for practical and public health safety purposes, in accordance with the Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal (UNEP-SBC 2003; UNEP-SBC/WHO 2005) and to further support the Precautionary Principles stated in Prüess et al. (1999):

- Non-Health Care Waste:
- recyclable waste;
- non-biodegradable waste;
- other non-risk waste; and
- Infectious and highly infectious waste:
- Infectious waste;
- Highly infectious waste.

International agreements, conventions and principles concerning healthcare waste treatment and disposal will be discussed in Chapter 4.

TYPES OF WASTE GENERATED DURING DISEASE OUTBREAK INVESTIGATION AND RESPONSE

Public health or veterinary medical emergencies, whether resulting from a natural disaster or an acute disease outbreak, require immediate response. Depending on the location of the event, the nature of any pathogenic agent involved, and the country's level of preparedness and planning, multi-disciplinary response teams ideally should be prepared on local, national and international levels to mobilize resources from emergency equipment and material stockpiles such as those shown in Table 3.2 (WHO/CDC 2010).

TABLE 3.2 KEY STOCK ITEMS FOR OUTBREAK RESPONSE.

Essential Stock items for Responding to Outbreaks				
Drugs	**Disinfectants, Insecticides and Rodenticides**	**Supplies**	**Vaccines**	**Equipment**
Benzyl penicillin	**Disinfectants**	Auto-disable syringes	Meningitis vaccines AC	Body bags
Ciprofloxacin	2% Chlorine	Auto-disable syringes	Meningitis vaccines ACW135	Buckets
Diazepam	Bleach	Bed nets	Meningitis vaccines Conjugated	Camping kits
Doxycycline	Calcium hypochlorite	Personal Protective Equipment (see Annex 4D)	Cholera vaccines	Candles
Drugs for supportive care	Cresol	Laboratory supplies (see Annex 4C)	Tetanus anatoxin	Computer
Erythromycin	Sodium hypochlorite	Mosquito nets	Yellow fever	Containers
Nalidixic acid	**Pesticides**	Nasogastric tubes 2.7 mm OD, 38 cm	Other vaccines	Cook-ware
Oily chloramphenicol	Cypermethrin	Nasogastric tubes 5.3 mm OD, 50 cm		Diesel
Oral rehydration salts	Malathion	Needles		Front lamp
Paracetamol	Permethrin	Intravenous giving sets (different sizes)		GPS
Penicillin V	**Rodenticides**	Teaspoons		Kerosene lamp
Rehydration fluids:	Brodifacom	Sprayers (pump and fogger)		Lab: see annex 5a
Ribavirin	Bromadione			Lamps
Ringer lactate				Maps
Streptomycin				Paraffine
Tetracyclin				Phones
Trimetroprim-sulfamethoxazole				Plastic sheets
				Power generator
				Radio
				Sprayers

Source: WHO/CDC (2010) Technical Guidelines for Integrated Disease Surveillance and Response, Second Edition, p. 159.

A discussion of the potential environmental and human health impacts from use of the disinfectants, insecticides and rodenticides listed column 2 in Table 3.2 is presented in Supplement 1. Key Environmental Contaminants used in Disease Outbreak Response.

If the emergency event occurs in a geographically remote area, which often have minimal basic health infrastructure, equipment, and appropriate supplies, or in an impoverished or disaster-affected peri-urban or urban area, response teams must be prepared to arrive on the scene self-contained in terms of having adequate organization and resources, including food, transport, medical and sanitation supplies, pharmaceuticals, infection control items, personal protective equipment, vector control products and equipment, and basic accommodations. The specific expertise and amounts and types of equipment and supplies needed vary according to the pathogenic agent known or suspected to be at the outbreak event site, as well as the nature of preexisting items available onsite or in pre-positioned stockpiles (Debay and Duale 2000; United Republic of Tanzania Ministry of Health 2004; WHO/FAO/OIE 2008; WHO 2009a.

Mobile laboratories are increasingly standard components of outbreak investigation and réponse teams. If local laboratory facilities and equipment are inadequate or non-existent at disease outbreak sites, the ability to safely perform accurate and rapid preliminary diagnostic tests helps to promptly identify the infectious cause of the outbreak and facilitates the implementation of appropriate a nd effective infection prevention and control measures while waiting for confirmation from national or international laboratories which are often located considerable distances from disease outbreak sites in remote areas. This contributes to the reduction of the life-cycle of an outbreak (WHO/CDC 2010).

In summary, the descriptions of the numerous types of healthcare waste indicate that there is great potential for the generation of large volumes of hazardous and non-hazardous waste during outbreak investigation and response efforts, even in geographically remote areas. This will be discussed in detail in Chapter 5 following a brief introduction to the international agreements, conventions and principles regarding healthcare waste in Chapter 4.

CHAPTER 4: INTERNATIONAL AGREEMENTS, CONVENTIONS AND REGULATORY PRINCIPLES REGARDING HEALTHCARE WASTE

This chapter provides a brief description of the major international agreements, conventions and regulatory principles related to the use, management, transport and disposal of hazardous waste, including healthcare waste, and related technical documents. Persons engaged in international assistance to other countries during outbreak response should be aware of the responsibilities implied in these agreements and principles. At the level of rural medical facilities and remote outbreak sites, basic practices to achieve safe management, control and disposal of hazardous waste can provide essential protection.

INTERNATIONAL AGREEMENTS AND REGULATORY PRINCIPLES

Three international agreements and several underlying principles, outlined below, form the basis for safe management of hazardous waste, including healthcare waste, and associated public and environmental health issues. These principles should guide improvements in healthcare waste practices through the formulation and implementation, by ministries of public health and environment of signatory countries, of national legislation, policy documents, and technical guidelines for the management, control, and disposal of healthcare and other hazardous waste.

THE BASEL CONVENTION ON THE CONTROL OF TRANSBOUNDARY MOVEMENTS OF HAZARDOUS WASTES AND THEIR DISPOSAL

The Basel Convention, a global agreement adopted in 1989 and ratified by more than 150 member countries, concerns transboundary movements of hazardous waste, also applicable to healthcare waste, and addresses the problems of management and disposal of hazardous waste. (Secretariat of the Basel Convention No. 97/012. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, 1998 and Decisions Adopted by the First [1992], Second [1994] and Third [1995] Meetings of the Conferences of the Parties [September 1997]: http//:www.basel.int).

The Basel Convention is administered by the United Nations Environment Programme (UNEP). The Secretariat in Geneva, Switzerland supports the implementation of the Convention and related agreements, provides assistance and guidelines on legal and technical issues, and conducts training on the proper management of hazardous waste. The Convention entered into force on 5 May 1992.

Signatory countries accept the principle that the only legitimate transboundary shipments of hazardous waste are exports from countries that lack the facilities or expertise to dispose safely of certain wastes to other countries that have both facilities and expertise. Exported waste should be labeled according to the UN recommended standards. **Healthcare-related waste is amongst the categories of hazardous wastes.**

The key objectives of the Basel Convention are:

- to minimize the generation of hazardous wastes in terms of quantity and hazard level;
- to dispose of hazardous wastes as close to the source of generation as possible; and
- to reduce the movement of hazardous wastes.

The principal focus of the Basel Convention during its first decade was the control of the transboundary movement of hazardous wastes and the development of criteria for "environmentally sound management" of such wastes to protect human health and the environment by minimizing hazardous waste production whenever possible and controlling the "life-cycle" of such wastes from production to storage, transport, treatment, recovery and disposal. The more recent emphasis of the Convention is on "full implementation of treaty commitments, promotion of the environmentally sound management of hazardous wastes and minimization of hazardous waste generation".

The Basel Convention covers hazardous wastes that are explosive, flammable, poisonous, infectious, corrosive, toxic, or eco-toxic. The categories of wastes and the hazardous characteristics are described in Annexes I to III of the Convention. Lists of specific wastes characterized as hazardous or non-hazardous are in Annexes VIII and IX.

The export of hazardous wastes from member states of the Organisation for Economic Co-Operation and Development (OECD) to non-OECD countries (Decisions II/12 and III/1) is also prohibited. The Basel Convention website is http//:www.basel.int.

There are currently no international conventions regulating transfer of pharmaceutical products across frontiers. However, expired or spoiled pharmaceuticals are considered as hazardous waste and as such, **if transferred across frontiers**, become regulated and subject to the Basel Convention on the Transboundary Shipment of Hazardous Wastes. This involves prescribed procedures to obtain permission to cross international borders along the transit route prior to actual transport.

THE ROTTERDAM CONVENTION ON THE PRIOR INFORMED CONSENT PROCEDURE FOR CERTAIN HAZARDOUS CHEMICALS AND PESTICIDES IN INTERNATIONAL TRADE

The Rotterdam Convention**,** adopted in 1998, is a direct result of the alarming increase in the production and trade of chemicals during the past 30 years, the menace of hazardous chemicals and pesticides, and the vulnerability of many countries to monitor the import and use of these products. UNEP and the UN Food and Agriculture Organization (FAO) jointly provide the Rotterdam Convention Secretariat, which is located in Geneva and in Rome

Although the UNEP and the FAO developed the Prior Informed Consent (PIC) procedure in the 1980s as part of voluntary codes of conduct and information exchange systems. The Rotterdam Convention entered into force 24 February 2004. It requires a mandatory PIC procedure for 30 hazardous pesticides and 11 industrial chemicals. The Convention website is www.pic.int.

THE STOCKHOLM CONVENTION ON PERSISTENT ORGANIC POLLUTANTS

The Stockholm Convention was adopted in 2001 in response to the urgent need for global action to protect human health and the environment from Persistent Organic Pollutants (POPs). These are highly toxic and persistent chemicals that remain intact in the environment for long periods and bio-accumulate in living organisms. POPs have worldwide distribution and use with detrimental environmental impacts. The Convention entered into force 17 May 2004.

Countries signatory to the Stockholm Convention agree to:

- reduce or eliminate the production and use of all intentionally produced POPs (industrial chemicals and pesticides) into the environment;
- minimize and ultimate eliminate, where feasible, the discharge of unintentionally produced POPs such as dioxins and furans; and
- manage and dispose of POP stockpiles in a safe, efficient and environmentally sound manner.

Dioxins and furans, which are released into the atmosphere as byproducts of the incineration of hazardous healthcare waste, will be discussed in detail in Chapter 6.

The Stockholm Convention allows continued use of the pesticide DDT for disease vector control until safe, affordable and effective alternatives are in place. It obliges each Party using DDT to develop an Action Plan, including for implementation of alternative products. Countries must also make determined efforts to indentify, label and remove polychlorinated biphenyl (PCB)-containing equipment from use by 2025 with disposal no later than 2028.

The Convention also restricts the import and export of POPs to specific exceptional cases and requires that they not be transported across international boundaries without consideration of relevant international rules, standards and guidelines. The Stockholm Convention website is www.pops.int.

The three conventions together provide an international framework governing the environmentally sound management of hazardous chemicals throughout their life cycles.

The Basel, Rotterdam and Stockholm Conventions address the technical assistance needs of developing countries. The Basel Convention (Article 14) and the Stockholm Convention (Article 12) provide for regional centers for training and technology transfer. There are 13 Basel Convention Regional Centers and a Technical Cooperation Trust Fund.

The Stockholm Convention (Articles 13 & 14) establishes a “financial mechanism”, to be operated by the Global Environment Facility on an interim basis. “Enabling activities” such as the development of National Implementation Plans are a key initial GEF focus. The Rotterdam Convention (Article 16) provides for technical assistance between Parties for the development of infrastructure and the capacity to manage chemicals

PRINCIPLES RELATED TO HEALTHCARE WASTE MANAGEMENT

As complements to the three conventions described above, it is recommended that the following principles be considered during the development of national legislation or regulations governing healthcare waste management (Prüess et al.1999).

POLLUTER PAYS PRINCIPLE

This objective of this principle is to recognize that polluters should pay for negative impacts on the environment as an incentive to produce less waste and manage it well. It implies that all producers of waste are legally and financially responsible for the safe and environmentally sound disposal of the waste they produce, as well as for accidental pollution.

It also attempts to assign liability to the party that causes the pollution. Accordingly, if the pollution results from poor healthcare waste management, the healthcare facility is responsible. If the pollution results from poor standards at the treatment facility, the healthcare facility could be held jointly accountable for the pollution with the treatment facility. Healthcare waste service providers can also be held responsible.

PRECAUTIONARY PRINCIPLE

The Precautionary Principle addresses health and safety protection. It assumes that waste is hazardous until shown to be otherwise and that, under conditions of uncertain risk, it should be assumed that the risk is significant and all precautionary measures should be taken to protect health and safety.

DUTY OF CARE PRINCIPLE

The Duty of Care Principle stipulates that any person organization handling or managing hazardous substances or related equipment is ethically responsible for the safe and appropriate use and disposal of the waste. Accordingly, the healthcare facility is responsible for the containment, handling and disposal of waste materials and products.

PROXIMITY PRINCIPLE

This principle recommends that treatment and disposal of hazardous waste take place at the closest possible location to its source in order to minimize the risks involved in its transport. According to a similar principle, any community should recycle or dispose of the waste it produces, inside its own territorial limits.

HEALTHCARE FACILITY (HCF) CODE OF PRACTICE

The HCF waste management code of practice plays a critical role in the overall waste management system. This document describes the standards and procedures for the hospital or clinic based on the type of equipment used. It also describes the roles and responsibilities of each staff group members. The code of practice forms the baseline document against which the waste management system of the HCF can be monitored.

WORLD HEALTH ORGANIZATION (WHO) POLICIES AND CORE PRINCIPLES

WHO provides several policy, management and advocacy tools to minimize the risks that the improper management of healthcare waste pose to healthcare workers, patients, waste handlers, communities and the environment, and to facilitate the development and sustained maintenance of health-care waste management systems. These include a policy paper on safe health-care waste management (2004) and core principles for achieving safe and sustainable management of health-care waste (2007). WHO has also developed a handbook on the safe management of healthcare waste (Prüess et al.1999), a policy document to facilitate the elaboration of a national plan of action on healthcare waste management (UNEP-SBC/WHO 2005), as well as specific guidelines for the safe management of particular categories of medical waste, such as solid health-care waste (WHO 2005), syringes (WHO fact sheet 2006) and mercury-containing equipment.(WHO fact sheet 2011).

CORE PRINCIPLES FOR ACHIEVING SAFE AND SUSTAINABLE MANAGEMENT OF HEALTH-CARE WASTE

These core principles were developed during the International Health Care Waste meeting hosted by WHO in Geneva in 2007. They require that all entities associated with financing and supporting health-care activities should provide for the costs of managing health-care waste. This is the duty of care. Manufacturers also share a responsibility to take waste management into account in the development and sale of their products and services.

In keeping with the Core Principles, WHO recommends the following:

- Governments
- allocate a budget to cover the costs of establishment and maintenance of sound health-care waste management systems;
- request donors, partners and other sources of external financing to include an adequate contribution towards the management of waste associated with their interventions;
- implement and monitor sound health-care waste management systems, support capacity building, and ensure worker and community health.
- Donors and partners
- include a provision in their health program assistance to cover the costs of sound healthcare waste management systems.
- **Non-governmental organizations**
- include the promotion of sound health-care waste management in their advocacy;
- undertake programs and activities that contribute to sound health-care waste management.
- The private sector
- take responsibility for the sound management of health-care waste associated with the products and services they provide, including the design of products and packaging.
- All concerned institutions and organizations
- promote sound health care waste management;
- develop innovative solutions to reduce the volume and toxicity of the waste they produce and associated with their products;
- ensure that global health strategies and programs take into account health-care waste management.

Source: Safe Healthcare Waste Management. WHO Core principles for achieving safe and sustainable management of health-care waste. 2007. WHO Department for Public Health and Environment Assessing and Managing Environmental Risks to Health; http//:www.healthcarewaste.org.

WHO activities are oriented by the following guiding principles concerning healthcare waste and management:

- preventing the health risks associated with exposure to healthcare waste for both health workers and the public by promoting environmentally sound management policies for health-care waste;
- supporting global efforts to reduce the amount of noxious emissions released into the atmosphere to reduce disease and defer the onset of global change;
- supporting the Stockholm Convention on Persistent Organic Pollutants (POPs);
- supporting the Basel Convention on hazardous and other waste; and
- reducing the exposure to toxic pollutants associated with the combustion process through the promotion of appropriate practices for high temperature incineration.

Source: WHO Safe Health-care Waste Management Policy Paper. August 2004. WHO Department for Public Health and Environment Assessing and Managing Environmental Risks to Health; http//:www.healthcarewaste.org.

INTERNATIONAL CODE OF CONDUCT ON THE DISTRIBUTION AND USE OF PESTICIDES

The International Code of Conduct on the Distribution and Use of Pesticides, developed by the Food and Agriculture Organization of the United Nations (FAO), is the worldwide guidance document and a framework for the management of pesticides for public and private entities engaged in, or associated with, the distribution and use of pesticides, **including pesticides used for public health purposes**. Although the Code is not legally binding, it is designed to provide standards of conduct and to serve as a point of reference for sound pesticide management practices, in particular for government authorities and the pesticide industry.

(Web site: http://www.fao.org/agriculture/crops/ corethemes/ theme/pests/pm/code/en).

INTERNATIONAL TECHNICAL GUIDELINES AND HEALTH REGULATIONS

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

Following the adoption of Council Recommendation C(2004)100 in 2004 on Environmentally Sound Management of Waste, OECD member countries reinforced the implementation of this legal Act by issuing a practical Guidance Manual for governments and waste treatment facilities. All elements of the Recommendation C(2004)100 are explained in detail, as well as the different core performance criteria which characterize environmentally sound management of waste, through various means (such as technical, financial, regulatory), including heath care-associated waste. Waste management practices applied in certain member countries are presented as examples.

INTEGRATED DISEASE SURVEILLANCE AND RESPONSE

In September 1998, representatives of Member States met at the WHO 48th Regional Committee for Africa in Harare, Zimbabwe and passed Resolution AFRO/RC48/R2, therefore adopting integrated disease surveillance as a regional strategy for early detection and response to priority communicable diseases for the African region. The term Integrated Disease Surveillance and Response (or IDSR) was subsequently adopted to emphasize the strong association between surveillance and response. The first edition of the IDSR Technical Guidelines was widely adopted and adapted throughout the African region (WHO/CDC 2001). Management of healthcare waste is a core element.

INTERNATIONAL HEALTH REGULATIONS

The International Health Regulations (IHR) was adopted on 23 May 2005 by the Fifty-eighth World Health Assembly in Geneva, Switzerland through Resolution WHA58.3. The IHR entered into force on June 15, 2007. The IHR is a legally binding instrument conceived to help protect countries from the international spread of emerging and re-emerging diseases and other public health emergencies without interfering with international traffic and trade. A key element of the IHR is the strong recommendation to strengthen core capacities of national health systems in terms of surveillance, control, prevention and response to public health emergencies of international concern through partnerships and collaboration. The original scope of the IHR has expanded from cholera, plague and yellow fever to all public health emergencies of international concern, including infectious diseases, chemical agents, radioactive materials and contaminated food. A second edition of the IHR was published in 2008 (WHO 2008a).

IMPLEMENTATION OF THE IHR THROUGH IDSR

The goals of IDSR to strengthen the capacity and resources of national health systems for effective and timely surveillance, investigation, confirmation, reporting and response from district to national levels are highly complementary to those of the IHR, The updated second edition of the IDSR Technical Guidelines (WHO/CDC 2010) provides the structure, human resources, tools, technical guidance and operating procedures for proper implementation of the IHR core components concerning trans-boundary public health security, including issues concerning hazardous medical waste.

CHAPTER 5: SOURCES AND GENERATION OF HEALTHCARE WASTE

The preceding chapter outlined several international agreements, protocols and principles designed to address the global burden of waste generated by science, industry and medicine, including healthcare waste and associated byproducts of disease outbreak investigation and response efforts and other public health emergencies. The IDSR and IHR are significant developments towards improved international collaboration on human, animal and environmental health emergencies of public concern. They add layers of both simplification and complexity to disease surveillance and outbreak response by calling for efficient use of scarce resources through collaboration, and by adopting an holistic approach which requires an increase in the numbers of health volunteers and multi-sectoral professionals active in field surveillance and at emergency events. .

As a consequence of increased emphasis on integrated and collaborative surveillance from community to district, national and international levels (WHO 2008a; WHO/CDC 2010), there is general recognition that surveillance for various diseases involves similar functions, processes, and personnel, and that interdisciplinary action and collaboration are required to effectively address threats to human, domestic animal, wildlife and environmental health through efficient utilization of human and material resources (i.e. One Health). This implies the involvement of diverse actors in disease surveillance, outbreak investigation, infection control and prevention, and outbreak response at any given time, from community relay health workers to district wildlife officers, agriculture and forestry extension agents, veterinarians, nurses and doctors, scientists, and professional non-governmental organizations.

IDSR is still at varying levels of organization and implementation in African countries. The results of a June 2010 self-assessment questionnaire on IDSR implementation administered to the 45 Member States in the African region indicated that 43 of the 45 responding countries had designated national surveillance structure and identified IDSR priority diseases or conditions, but only 24 countries had functioning operations command and control centers to coordinate and monitor public health emergencies. Amongst the 4386 districts surveyed in the 45 countries, 80% lacked epidemic management committees, more than 50% did not have rapid response teams, and many had inadequate capacity in terms of logistics and communications for effective surveillance and response (WHO/CDC 2010).

This indicates that most of the personnel, materials and equipment needed to conduct investigations and response to disease outbreaks in sub-Saharan African countries must necessarily originate from outside outbreak sites and that district level surveillance efforts need support, training and appropriate materials for effective community-based surveillance and first response to disease outbreaks.

In regard to generation of waste materials, small health clinics, rural dispensaries, and primary health care centers in geographically remote areas of many countries often lack the technology and knowledge to appropriately manage, treat and dispose of infectious and non-infectious waste (Diaz et al. 2005; Hamoda et al. 2005; Mesdaghinia et al. 2009). Therefore, sanitary and hygienic conditions can deteriorate rapidly when large mobile emergency response teams of volunteers and professionals converge where lodging, food, clean water and options for disposal of medical and personal waste are minimal.

As seen in Chapter Two, urban and peri-urban hospitals in many less economically developed countries do not employ management practices or lack the appropriate knowledge and equipment for environmentally safe disposal of waste. For example, in a survey of hospitals in India, infectious materials comprised 30 to 35% of all waste, most of which was mixed with other waste materials before disposal (Table 5.1; Goddu et al. 2007).

TABLE 5.1. PERCENT COMPOSITION BY WEIGHT OF HOSPITAL HEALTHCARE WASTE IN INDIA.

Waste category	% of total composition by wt.
Bandages, linen and other infectious waste	30 – 35
Plastics	7-10
Disposable syringes	0.3-0.5
Glass	3-5
General Waste	40-45

Source: Goddu et al. 2007

Depending on the nature of the pathogenic agent causing a disease outbreak, the amount of infectious waste generated during outbreak investigation and response in rural areas can be expected to be of similar or greater value than that indicated in Table 5.1. For the purposes of this review, no references were located containing quantified amounts of waste materials and products generated by emergency response teams during outbreak response efforts. The key personnel required for a comprehensive outbreak response are discussed in the following section in relation to their roles and equipment and materials needs in order to provide a perspective on the types and amount of waste potentially generated from their activities during the life cycle of an outbreak or epidemic.

COMPOSITION OF OUTBREAK INVESTIGATION AND RESPONSE TEAMS

The key components of Disease Surveillance, Investigation and Response Teams include:

- Disease Surveillance and Epidemiology;
- Outbreak Investigation;
- Laboratory Services;
- Clinical Case Management;
- Infection Control and Prevention;
- Social Mobilization;
- Hygiene and Sanitation
- Logistics/Personnel Deployment; and
- Diverse Research Specialists

For example, during an epidemic of Marburg Haemorrhagic Fever in Angola in 2005, the outbreak investigation and response team included “epidemiologists, medical anthropologists, infection control specialists, barrier-nursing trainers and supervisors, risk communications and behavioral change experts, sanitation technicians and engineers, information and data managers, laboratory technicians, and many other categories of health and public health experts”.

(United Nations Office for the Coordination of Humanitarian Affairs 2005, page 5)

DISEASE SURVEILLANCE AND EPIDEMIOLOGY TEAM

WHO and the IDSR Technical Guidelines emphasize the importance of strongly developed community-based surveillance systems to identify and report known and perceived public health problems, including rumors. In this system, community members are trained in surveillance methods to identify and report events in the community that have public health significance to the nearest health facility or directly to district authorities. Surveillance-trained individuals in rural health facilities and district offices are appointed as community liaison officers to maintain a functioning surveillance network from community to district to provincial and national levels.

The responsibilities of the community-based disease surveillance network are to report:

- Immediately-reportable diseases, conditions and events;
- Summary information for epidemic- and pandemic-prone diseases;
- Routine summary information for other diseases of public health importance

(Source: WHO/CDC 2010, page 61)

District level healthcare staff work with community health workers to conduct surveillance for the detection of public health problems of concern to their communities. Vigilance is emphasized to include events or threats, such as clusters of disease patterns or rumors of unexplained illness or deaths, in the reporting system.

District and community-level surveillance teams are comprised of public healthcare workers and persons such as community leaders, community health workers, traditional healers, and birth attendants who conduct outreach activities in inaccessible and isolated areas about the priority diseases and conditions under surveillance in a given area.

Members of Surveillance teams may assist district public or veterinary health personnel in the collection, storage and transport of specimens, and thus would be trained in the proper use of PPE (e.g. masks, gowns, gloves), and under ideal conditions, would have PPE materials available onsite. Community health workers/volunteers would also be active in the Investigation and Social Mobilization teams to be described in the following sections.

An example of the roles and responsibility of the Surveillance and Epidemiology Team personnel working in the 2005 epidemic of Marburg haemorrhagic fever in Angola is described below:

- Establish an active surveillance system to detect any cases in the community;
- Organize a mobile team structure to respond to alerts, identify cases, and follow-up contacts for 21 days;

- Provide cash incentives for local active surveillance teams;
- Train health care workers, surveillance officers and data managers in all provinces of Angola for surveillance, investigation of alerts, sample collection, and mobilization of response;
- Provide operation support to maintain the field laboratory and testing facilities, and ensure rapid transfer of samples for analysis;

• Provide sustained international technical support for epidemiological investigation, training, surveillance evaluation, and outbreak response activities.

(Source: United Nations Office for the Coordination of Humanitarian Affairs 2005)

OUTBREAK INVESTIGATION TEAM

In most countries, districts have the overall responsibility for investigating outbreaks. In a functioning surveillance system, a district-level public health emergency management committee would alert members of the district Epidemic or Rapid Response Team and begin mobilization of resources for investigating a given report. The district coordinator for the disease or event being investigated would be included in the Investigation Team, as well as any other relevant staff who have already been identified and trained to be part of the Rapid Response Team. The general protocol and strategy for proceeding from the disease surveillance to outbreak investigation phase is demonstrated in the following example.

“A community surveillance informant hears of several cases of acute watery diarrhea with vomiting in the community. The informant suspects cholera and reports the rumor to the local health facility and to the district level heath officer. Members of the Rapid Response Team (RRT) travel to the community to verify and investigate the possible outbreak, and, based on the investigation results, implement control and prevention measures”. (Source: WHO/CDC 2010; page 125).

District-level public health emergency management committees are comprised of local technical and non-technical members from health and other sectors. Their role is to develop and oversee the implementation of emergency preparedness strategies, action plans, and procedures for emergency events, including disease outbreaks and detection of other emergency public health events or hazards. The mobilization and control of supplies for response and district emergency stockpiles is also their responsibility.

Where no district emergency management committees exist, Rapid Response Teams will be comprised of district, provincial and national level experts who join community and district surveillance teams at the suspected outbreak site to conduct investigations.

The types and amounts of medical materials and equipment needed depend on the nature of the suspected pathogenic agent. In general, supplies will be needed to collect laboratory specimens from suspect cases of humans or animals, to undertake other biological or entomological surveys, and for travel, food, accommodations and communications, as determined by on-site conditions. For extremely infectious and lethal diseases, such as viral haemorrhagic fever or avian influenza, the following equipment should be available for the personal protection of all staff investigating a suspected case.

TABLE 5.2 RECOMMENDED LIST OF PERSONAL PROTECTIVE EQUIPMENT FOR ALL STAFF INVESTIGATING A SUSPECTED CASE OF ANY VIRAL HAEMORRHAGIC FEVER OR AVIAN INFLUENZA.

Composition of one set of PPE	WHO Deployment Kit
1 surgical gown	100 surgical gowns
1 coverall	100 coveralls
1 head cover	100 head cover
2 pairs of goggles	50 pair of goggles
1 pair of rubber gloves	100 pairs
1 mask N95	200 pieces
1 boot cover*	0
1 box 50 pairs of examination gloves	800 pairs of examination gloves
1 plastic apron re-usable	20 pieces
1 pair of gum boots	20 Gum boots
1 hand sprayer	2 of 1.5 litres each
1 Back sprayer	1 back sprayer of 10-12 litres
specimen containers	
Scotch of tapes	3 rolls
Anti fog for goggles	3 bottles
Chlorine	
N.B: chlorine and gum boots can be purchased locally * Not essential	

(Source: WHO/CDC 2010, p. 125)

The investigation team is responsible for transmitting the relevant information to the authorities throughout the investigation, and on its completion, to allow the appropriate decisions to be taken. An adequate supply of PPE and other necessary materials and equipment must thus be available to allow the time necessary to undertake a thorough investigation and initiate preliminary response actions. The investigation team is the first defense against a disease outbreak and should not go into the field under-equipped.

In the case of an outbreak of Yellow Fever, a Viral Haemorrhagic Fever (VHF) the investigating Rapid Response teams must be multidisciplinary and should include an epidemiologist or public health officer, a laboratory technician,, a clinician, an environmental health officer, veterinary or wildlife management experts and other experts based the specificity of the outbreak. It is important to include health personnel from the local and district levels because they are knowledgeable of local customs and conditions and will be responsible for initiating response efforts. Representatives of the community and local authorities should also be involved to facilitate good relations (WHO 2008b).

LABORATORY SERVICES

Mobile laboratories are increasingly standard components of outbreak investigation and response teams. Rural hospitals and health clinics often have laboratory equipment, but the age and condition of the equipment may preclude use for emergency purposes, or the laboratories may lack the necessary supplies such as microscope slides, reagents, and test tubes. Laboratory technicians on outbreak investigation missions can either collect specimens onsite and return to reference laboratories for analyses, or in most favorable conditions, transport sufficient equipment and materials to assemble onsite micro-laboratories.

During an outbreak of Ebola Sudan Haemorrhagic Fever in Uganda, a temporary field screening laboratory provided immediate screening of blood samples for preliminary diagnoses, while awaiting confirmation from a reference laboratory in South Africa. The use of a mobile laboratory with appropriate equipment during the outbreak demonstrated the utility of establishing regional and sub-regional laboratories, as well as more available and appropriate tools for simpler screening in the interest of long-term surveillance programs (Okware et al. 2002).

In the case of a suspected Yellow Fever case or outbreak, one or more properly equipped laboratory technicians should be part of the investigation team to undertake the following critical tasks:

- Development of a protocol for analysis of specimens;
- Collection of specimens and transport to the reference laboratory;
- Analysis of specimens;
- Analysis of captured mosquitoes;
- Evaluation of new diagnostic tools (possibly)

(Source: WHO 2008b)

Annex 1 presents a list of essential supplies and equipment used in disease outbreak investigations by laboratory technicians as an example of the types of waste which may be generated at a disease outbreak site by investigating laboratory technicians.

CLINICAL CASE MANAGEMENT TEAM

Following the investigation of the rumor or reported outbreak, the Investigation Team would propose appropriate strategies and control measures, coordinate rapid response actions with partners and other agencies, and initiate the implementation of the proposed control measures before preparing a detailed investigation report. Members of the Investigation Team, especially clinicians, often remain at disease outbreaks sites to work with the Clinical Case Management team members in human and animal medical care and with Infection Control and Prevention personnel.

The total number of clinicians and other persons involved in response to a disease outbreak depends on the nature of the public health emergency, the pathogenic agent involved, the geographic spread of the event, the number of confirmed and suspect cases and contacts, and the available financial and material resources. Accordingly, Rapid Response Teams may be supported by a wide range of specialists such as social and biological scientists, medical and emergency non-governmental organizations, and other national and international volunteer organizations.

The medical supplies and equipment listed in Table 5.2 above and in Table 3.2. in Chapter 3, include a variety of drugs, disinfectants and insecticides, as well as rodenticides, vaccines, diverse medical supplies, protection materials, and medical, laboratory, scientific, office and camping equipment. They are required to support patient care, related efforts in outbreak response, and accommodate teams. If an isolation ward is compulsory, whether in a tent or an existing structure, as in the case of Viral Haemorrhagic Fevers, additional medical staff, supplies and equipment would be required. **Example: Avian and Human Influenza Prevention and Control Project, Palestine**

- The United Nations Development Program and the World Bank provided funding and expertise for Palestine to undertake an environmental assessment and develop an environmental management plan for the West Bank and Gaza in the interest of outbreak preparedness for Human and Avian Influenza.
- Rapid Response and Culling Team members were identified within the Ministry of Agriculture and other government services. These were determined to be:
- the director of the Veterinary Department as chair of the Team;
- the manager of the Poultry Section within the district Department of Agriculture office;
- other local staff (one or more) to be nominated by the Director of Veterinary Service and Animal Health;
- representatives of the relevant stakeholders at the governorate level;
- Environment Quality Authority (EQA) employees (regulatory authority for environmental issues) to assist in site selection and monitor the carcass disposal process;
- culling teams, to include representatives of the EQA.

The roles and responsibilities of the Rapid Response and Culling team are:

- to identify the infected farms and disposal sites;
- to select a date and pre-inform farmers;
- to complete the culling and carcass disposal according to international standards.

(Source: Musleh 2007.)

INFECTION PREVENTION AND CONTROL TEAM

Healthcare-associated, or nosocomial, infections occur worldwide at all levels of development, causing frequent morbidity and mortality. Outbreaks of nosocomial infection in hospitals may result in the transmission of disease from patients or staff to other patients, visitors and members of local communities.

Ducel et al. (2002; page 4) define nosocomial infections as "infections acquired during hospital care which are not present or incubating at admission. Infections occurring more than 48 hours after admission are usually considered nosocomial".

In regard to emerging infectious diseases such as SARS, Viral Haemorrhagic Fevers, Avian Influenza, and the threat of pandemic influenza, the role of efficient infection control and prevention in healthcare settings, and especially during outbreak response, is critical for prevention and control of disease spread. The role of healthcare facilities as amplifiers of outbreaks resulting in increased numbers of cases is well documented. A considerable proportion of nosocomial infections is preventable and many low cost infection control and prevention interventions have been proven to be effective (WHO 2009b).

Humans, both patients and medical and other staff, are the primary agents of healthcare-associated infection, and may function as:

- the main reservoir and source of microorganisms;
- the main transmitter, notably during treatment; and
- the receptor for microorganisms, thus becoming a new reservoir.

(Source: Ducel et al. 2002; page 7).

Infection Prevention and Control (IPC) is also a major challenge in communities when suspect and contact cases are under surveillance and culturally and emotionally sensitive issues such as separation of family members, availability of clean water, sewage and excreta disposal, and safe burial practices must be monitored and addressed. IPC trained specialists work with the Surveillance, Social Mobilization, and Hygiene and Sanitation Teams to implement infection control and risk mitigation measures such as:

- Maintenance of standard infection control precautions, appropriate selection and use of antiseptics and techniques for clinical procedures;
- Application of protocols for sterilization and disinfection of clinical materials, isolation precautions and outbreak management;
- Training health-care workers in IPC procedures;
- Assessment of compliance with IPC practices;
- Assurance of procurement of adequate supplies;
- Establishment of isolation wards for highly infectious diseases (Ebola and other haemorrhagic fevers, Cholera, Severe Acute Respiratory Syndrome [SARS], etc.)
- Ensuring health staff access to safety and personal protective measures for any infectious diseases (e.g. haemorrhagic fevers and SARS);
- Evaluation of the potential for disease spread from treatment centers, isolation wards, suspect cases, and contacts within affected communities and to surrounding communities;
- Development of infection prevention educational messages and practical measures to transmit to households and communities in outbreak-affected areas and surrounding communities;
- Coordination and collaboration with the Hygiene and Sanitation Team and other outbreak response personnel on the management and disposal of waste generated during outbreak investigation, response and research activities.

(Source: WHO 2009a; 2009b).

SOCIAL MOBILIZATION

Effective risk communication is a core element of managing disease outbreaks. Human behavior is often the major determinant of outbreak emergence, transmission and amplification. Therefore, understanding and modifying human behavior is vital to outbreak and epidemic prevention, response and management.

The Global Alert and Response Department (GAR) of WHO promotes social mobilization and communications interventions as one of the core pillars for successful outbreak alert, readiness, response and control. In the event of a real or potential threat, communicating guidance, calming fears, and encouraging cooperation may be the most critical and effective public health tool, especially at remote outbreak sites where there may be few resources, delays in direct interventions and limited treatment options (WHO 2010).

> Social Mobilization teams should begin communication activities in affected communities without delay after public health problems have been identified. The teams are comprised of individuals from varied sources, including international and government agencies, local and district community leaders and volunteers, and national and international non-governmental organizations. They play important roles in vaccination campaigns, case management, active community surveillance and vector control..

Risk behavior communications and monitoring for adherence to standard health and safety measures within affected communities and outbreak teams are the primary responsibilities of Social Mobilization teams. The contents of educational messages developed and conveyed include the following subjects:

- Monitoring suspect cases and contacts;
- Case management at home;
- Use of protective clothing;
- Isolation precautions;
- Disinfecting surfaces, clothing and equipment;
- Disposing of bodies safely.

(Source WHO 2010)

The Social Mobilization Team also works closely with community health workers, the Infection Control and Prevention Team and the Hygiene and Sanitation Team to develop other practical and appropriate community education messages on various topics, such as:

- How to recognize disease symptoms and seek help from medical staff;
- The importance of hand-washing for disease prevention ;
- Safe handling of food;
- Safe disposal of human waste;
- Conservering and storing clean drinking water; and
- Reducing exposure to mosquitoes and other insect vectors of diseases

(Source: Howard 2002).

For outbreaks of Ebola and Marburg Haemorrhagic Fevers, large numbers of Infection Control and Prevention and Social Mobilization personnel are required to manage the potential for widespread infection within the affected communities and to surrounding communities. Person to person transmission of these viruses occurs by direct contact with infected body fluids such as blood, sweat, saliva, semen, vaginal fluids, urine, and sputum, or through direct inoculation by contaminated instruments such as needles, pins, razors blades, etc. Nosocomial transmission through contaminated needles and syringes has been well documented (CDC/WHO 1998).

During an epidemic of Marburg HF in Angola in 2005, the United Nations made an international appeal for funding for vital emergency medical services, as well as the continuing public awareness campaign. Social Mobilization teams were engaged in the following activities to manage human risk behavior and contain the geographic spread of the disease:

- Providing the general public with information about the disease, its symptoms and methods of prevention;
- Addressing the concerns and fears of health care workers;
- Disseminating information amongst children about the disease and actions they can take to ensure they and their families stay healthy;
- Addressing cultural customs of corpse management in order to reinforce the idea that the bodies of those affected by the disease must be immediately buried, omitting in such cases traditional funeral rites requiring contact with the body;
- Providing information on the management of suspected cases, empowering people with the knowledge of what to do if a suspected case is encountered.

(Source: United Nations Office for the Coordination of Humanitarian Affairs 2005)

RESEARCH SPECIALISTS

Scientists and subject matter experts are often engaged to work with the different sub-components of outbreak response teams. For vector-borne diseases, such as hanta viruses, leptospirosis and Dengue and Yellow Fevers, the services of biologists and entomologists, respectively, are needed for the design of appropriate interventions to reduce exposure to the offending vectors, rodents and mosquitoes, through behavior modification and control of the vector populations. Some examples of specialists' roles in outbreak investigation and response follow.

Entomologist

A WHO training manual for investigation of Yellow Fever outbreaks (WHO 2008b) includes an entomologist in the Investigation Team to assume the following responsibilities and should be fully equipped with the items in Table 5.3:

- Developing the entomological investigation protocol;
- Identification and capture of vector species (adults and larvae);
- Evaluation of entomological risk indicators;
- Determination of the modes of transmission; and
- Recommending vector-control measures adapted to the situation.

TABLE 5.3 ESSENTIAL ENTOMOLOGICAL SCIENTIFIC EQUIPMENT NEEDED TO INVESTIGATE SUSPECTED YELLOW FEVER OUTBREAK IN MOSQUITO POPULATIONS

Capture of adults	Collection of immature mosquitoes	Identification and transport
Data collection forms		
Tubes for haemolysis		Magnifying glass
Cloth bags	Corks	Entomological tweezers
Carded Cotton	Scoop	Petri box
Pocket lamp	Enamel pan	Refrigerated table
Batteries	Flexible transparent siphon	Electrical generator
Bulbs	Pipettes with	Fuel for the generator
Mouth or mechanical sucking tube	Plastic cups	Nitrogen bottle + nitrogen or dry ice
	WHO ovitrap	Nunc tubes (1.8 ml)
	Bamboo slivers	Fine-tipped indelible marker pens
		Index for identifying mosquitoes
		Filter paper
		Alcohol

(Source: WHO 2008b; page 71).

The actual vector control measures would be applied by the Sanitation and Hygiene Team. The entomologist would also work with the Social Mobilization Team to prepare community education on the proper use of bed nets, methods of environmental management and other mosquito prevention strategies, and how to avoid mosquito bites.

Wildlife Biologist

In the case of outbreaks of leptospirosis, Lassa Fever or other rodent-born diseases, biologists design and implement investigation protocols to identify and capture the rodent vector species. The biological scientist would collaborate with the district wildlife and/or vector control officer and the Social Mobilization and Hygiene and Sanitation Teams to create and launch a community education campaign regarding risk behaviors for infection, with possible applied control measures to reduce rodent populations in the community by means of home sanitation methods, contact avoidance behaviors, and use of chemicals and traps. The ecological, meteorological and other environmental conditions preceding the outbreak would be studied. For Haemorrhagic Fever outbreaks, biologists and veterinarians interview members of the affected community before undertaking wildlife capture and sampling missions to determine the source species of the outbreak. Adequate protection via use of thick plastic gloves, heavy clothing, boots and filter masks during capture procedures is required, and full PPE ensembles (gown, apron, gloves, and respirator with filter) are obligatory during dissection and sampling.

If hanta viruses or other rodent-borne haemorrhagic fever viruses are implicated, biologists and associated workers take precautions against aerosol and direct contact infections during capture of rodents. Rubber or plastic gloves and respirators are worn when handling rodents. Persons collecting traps wear gloves and disinfect all traps and processing equipment daily (Dennis et al. 1999).

Social, Medical and Biological/Ecological Anthropologists

During outbreak investigation and response efforts, social and medical anthropologists may work with community health workers, traditional medicine practitioners, and medical staff to complete verbal autopsies and identify risk behaviors by understanding local socio-cultural practices such as:

- Traditional healing practices and beliefs/perceptions of illness and death;

- Taboos and specific acceptable/unacceptable behaviors attributed to different social and gender subsets within the community; and
- Customs for preparation and burial of corpses;

Anthropologists also work with biologists, botanists and traditional medicine practitioners to understand the local/regional ethnozoology, pharmacopoeia, and use of animals and plants in traditional medicine and certain rites. This knowledge is valuable for management of socio-cultural aspects of the outbreak.

Hygiene and Sanitation Team

The members of this team coordinate their activities with those of the Social Mobilization and Infection Control and Prevention Teams. As mentioned in preceding sections, these three teams coordinate and collaborate on the following tasks which benefit all of the outbreak response team members, as well as the affected community:

- clean drinking water supply and containers;
- general hygiene and sanitation issues;
- safe burial practices;
- mechanical application of vector control measures;
- proper disposal of infectious and other waste; and
- coordination and implementation of routine disinfection (reusable materials, equipment, waste materials before disposal, etc.)

(Source: Prüess and Townend 1998; Ducel et al. 2002; United Republic of Tanzania, Ministry of Health 2005)

The Hygiene and Sanitation Team is responsible for the implementation of the measures necessary to assure the services listed above. For example, to assure safe disposal of human excreta to avoid secondary infections due to contact with contaminated substances, members of this team will inspect the area of the affected community for human waste disposal methods. If unsafe practices are found, community education on sanitation practices is conducted and the Team will work with the community to construct latrines appropriate for local conditions. This team also monitors hygiene and sanitation conditions and takes appropriate actions at the outbreak treatment center and associated facilities, the accommodation and waste disposal sites of the diverse outbreak responders, the equipment and materials disinfection stations, and the healthcare waste disposal area.

Logistics/Deployment of Personnel

This team ensures appropriate and adequate logistics, transportation and supplies for the duration of an outbreak by means of adequate logistical planning to use transport in the most efficient ways, and by monitoring the effectiveness of the logistics system and delivery of essential supplies and materials throughout the outbreak.

Assuring the reliability of mobile communications amongst teams during the outbreak and supplying additional equipment, if needed, is also the responsibility of the Logistics Team, as well as to procure and install communications equipment, computers and other hardware for data analyses and reporting.

Transportation support is critical for surveillance and social mobilization activities. Vehicles, motorcycles, and bicycles must be procured, maintained and repaired during the life cycle of an outbreak or epidemic. Air service links with provincial, national and international organizations is also provided by the Logistics Team.

(Source: United Nations Office for the Coordination of Humanitarian Affairs 2005)

ADDITIONAL ACTORS IN OUTBREAK RESPONSE

In addition to the diverse medical staff and other personnel from district, provincial and national agencies, and non-governmental organizations, a major outbreak or epidemic will involve a number of international institutions. During a Marburg HF epidemic in Angola in 2005, the following organizations had personnel present at the outbreak site in the northern province of the country, as well as in the capital, Luanda:

- WHO, UNICEF: leading and coordinating the international response;
- World Food Programme and other UN agencies;
- US Centers for Disease Control and Prevention;
- Medecins Sans Frontiers-Spain (MSF)
- MSF-Holland;
- MSF-France.

(Source: United Nations Office for the Coordination of Humanitarian Affairs 2005).

DURATION OF OUTBREAK RESPONSE EFFORT

Depending upon the extent of the outbreak and the pathogenic agent involved, response personnel are required to continue monitoring convalescent, suspect and contact cases for a period of time equivalent to the maximum incubation period. At some point during the outbreak life cycle, it will be determined that some team members can leave the outbreak site, while others remain as monitors. For Haemorrhagic Fevers (HF), that period of time is 21 days. Accordingly, at least some team members remain at the outbreak site for 21 days after the last exposure date. Outbreaks may take days, weeks, or months to resolve, resulting in a potentially enormous amount of waste materials generated by the members of the various investigation and response teams, as well as the patients, community health workers, and community members. An extensive epidemic of Ebola Sudan HF in Uganda in 2000-01, which lasted for 4.5 months, registered 425 cases with 224 deaths and involved 160 outbreak response team members (Table 5.4).

TABLE 5.4. NUMBER AND ROLES OF MOBILE OUTBREAK RESPONSE TEAM MEMBERS IN GULU DISTRICT, UGANDA, DURING OUTBREAK OF EBOLA SUDAN HF (N = 160)

Outbreak Response Mobile Team Members	Role	No.
Police	Medical	5
Uganda People’s Defense Force	Medical	5
Action Contre la Faim (Action Against Hunger)	Medical	13
District Directorate of Health Sciences	Medical	23
International Committee of the Red Cross	Volunteers	50

District Directorate of Health Sciences	Volunteers	64
TOTAL		160

(Source: Lamunu et al. 2004.

As noted in Table 5.4, volunteers comprised the majority of responders, including the International Federation of Red Cross and Red Crescent Societies (IFRC), to the Ebola Sudan HF outbreak in Uganda. The following section provides an example of the services offered by this international relief organization.

The IFRC has several categories of Emergency Response Units (ERU) which can be deployed at short notice for public health and disaster emergencies. An ERU is a team of trained technical specialists which employ pre-assembled standardized equipment sets. They are designed to be self-sufficient for one month and can operate for up to four months. ERUs provide specific support or direct services when local facilities are either destroyed, overwhelmed by need, or do not exist.

There are seven basic types of ERU.

- Basic Health Care: provides immediate health care for up to 30,000 people. The unit can provide basic outpatient services, maternal-child health, community health outreach, immunization and nutritional surveillance. It has a 20-bed capacity.
- Logistics: coordinates and provides immediate support to the incoming relief supply line, including customs clearance, warehousing, transportation and support to other ERUs. It also tracks incoming relief goods.
- Water and Sanitation: three water and sanitation modules are available, according to the volume of water, quality of water needed, the number of beneficiaries and locations.
- Referral Hospital Facility: a first-level referral hospital, or field hospital, which provides essential surgical and medical care for up to 250,000 people. It can treat 120–150 inpatients;
- IT and Telecommunications: re-establishes local communications networks and connects field operations and the secretariat in Geneva to ensure the smooth flow of information and operational coordination;
- Relief: supports a National Society to carry out relief assessments and assists in setting up relief distributions and camps. It works closely with the logistics ERU;
- Base Camp: provides living and working accommodation for Red Cross staff engaged in emergency operations. It offers tented accommodation, toilets and showers, recreational facilities, a kitchen, offices, administrative, and IT/communication and coordination facilities in locations where these are not available.

(Source: http//:www.ifrc.org)

CHAPTER 6: RISKS AND IMPACTS OF HEALTHCARE WASTE: AN OVERVIEW

As seen in the preceding chapters, appropriate management and disposal of healthcare waste remains a significant challenge in many countries. Healthcare services are expanding in developing countries together with the amount of waste generated and the consequential menace to human, animal and environmental health due to inadequate technological and financial resources to manage waste (Harhay et al. 2009).

Healthcare and general waste are often combined, and either disposed of in municipal waste facilities or dumped illegally. Open burning during incineration and widespread deficiencies in the operation and management of small-scale medical waste incinerators result in incomplete waste destruction and inappropriate ash disposal and dioxins emissions (United Nations Human Rights Council 2011).

The category of medical waste that is most widely recognized is contaminated sharps (needles, scalpels, blades, glass, etc.). Needle-stick injuries and reuse of infected sharps expose healthcare workers and communities to blood-borne pathogens, including hepatitis B and C viruses and Human Immunodeficiency Virus (HIV), as well as zoonotic and other diseases circulating during outbreaks (e.g. Lassa Fever, leptospirosis, yellow fever, SARS, cholera, Ebola HF).

Large numbers of people are potentially at risk of injury and/or contamination through accidental exposure to healthcare waste, including medical personnel, patients, workers in support services linked to healthcare facilities and waste disposal facilities, recyclers, scavengers and the general public. Domestic and wild animals and the environment are also affected directly and indirectly.

For example, four people died from acute radiation syndrome and 28 suffered serious radiation burns in 1988 as a result of the improper disposal of radiotherapy treatment equipment in Goiânia, Brazil. Similar accidents occurred in Algeria in1978, in Morocco in 1983, and Mexico in1962 and 1983. Low-level chronic exposure to some hazardous substances contained in medical waste or produced by its incineration may lead to slow-progressing but fatal diseases, including several forms of cancer. (Source: United Nations Human Rights Council 2011).

When all healthcare waste is combined (potentially infectious, office, general, food, construction debris, hazardous chemical materials) and transported for disposal in often unsecured dumps, the mixed waste as a whole becomes both potentially infectious and potentially hazardous (chemical). Those who handle the waste are at greatest risk (health workers, waste handlers and scavengers). The risk to the general public is secondary and occurs in three ways:

- accidental exposure from contact with wastes at disposal sites;
- exposure to chemical or biological contaminants in water; and
- exposure to chemical pollutants (e.g., mercury, dioxin) from incineration of the wastes.

. The wastes contain mercury and other heavy metals, chemical solvents and preservatives (e.g., formaldehyde) which are know carcinogens, and plastics (e.g., PVC) which when combusted produce dioxins and other pollutants which pose serious human health risks not only to workers but to the general public through food supplies.

(CGH Environmental Strategies, Inc. 2002)

RISKS ASSOCIATED WITH HAZARDOUS HEALTHCARE WASTE

Exposure to hazardous healthcare waste can result in disease or injury. The hazardous nature of healthcare waste may be due to one or more of the following characteristics:

- it contains infectious agents, including contaminated sharps;
- it is genotoxic or cytotoxic;
- it contains toxic or hazardous chemicals or pharmaceuticals;
- it is radioactive; and
- it contains sharps.

All individuals exposed to hazardous healthcare waste are potentially at risk, including those within healthcare facilities that generate hazardous waste, and those outside these sources who either handle such waste or are exposed to it as a consequence of careless management. They include:

- Medical staff: doctors, nurses, sanitary staff and hospital maintenance personnel;
- In- and out-patients receiving treatment and their visitors;
- Support services workers such as laundries, waste handling and transportation;
- Workers in waste disposal facilities;
- Inappropriate or inadvertent end-users such as scavengers and customers in secondary markets for reuse (i.e. households, local medical clinics, etc.)
- The general public, especially children playing with items they find in unsecured waste outside medical facilities.

(Source: Prüess et al. 1999; UNEP-SBC 2003).

OCCUPATIONAL AND PUBLIC HEALTH RISKS

Healthcare workers are not only at risk of acquiring infections, but also of being a source of infection to patients, communities, and the environment. Therefore, patients and healthcare workers need to be protected and employ infection control and prevention measures. This is also true for communities and their immediate environment at disease outbreak sites.

Inadequate packaging of wastes causes many injuries and infections when medical and supporting staff and sanitary workers handle waste materials. In that respect, sharps are considered as one of the most dangerous categories of waste. Syringe needles and other sharps left outside of, or in overfilled, safety boxes cause many injuries, and recycling scavengers may handle untreated and inappropriately disposed infectious waste at dump sites (Wenzel et al. 2008)

Dumping healthcare waste in unsecured areas can have major adverse effects on the public. Recycling and reuse of surgical gloves, gauze, and syringes is a serious problem in some developing countries. The sale of recovered drugs is also a major risk to public health.

WHO estimated that, in 2000, injections with contaminated syringes caused:

- 21 million hepatitis B virus (HBV) infections (32% of all new infections);
- two million hepatitis C virus (HCV) infections (40% of all new infections); and
- at least 260 000 HIV infections (5% of all new infections).

(Source: WHO *Health-care waste management*; Fact sheet N°281; October 2011).

The WHO developed a number of information tools to raise public awareness of the risks associated with the unsound management and disposal of hazardous medical waste and on the measures to eliminate or mitigate these risks, including fact sheets on health-care waste management, wastes from healthcare activities, and injection safety: WHO, *Health-care waste management*, fact sheet No. 281, October 2004;

WHO, *Core principles for achieving safe and sustainable management of health-care waste,* 2007; WHO, *Injection safety*, fact sheet No. 231, 2006.

Lessons from SARS, a Viral Zoonotic Disease.

The emergence of Severe Acute Respiratory Syndrome (SARS) in China in 2002 proved to be a great challenge for modern medicine owing to the potential for the virus to be transmitted by several means. The outbreak of SARS was not recognized until February 2003, resulting in a pandemic with a crude mortality rate of 10% and considerably higher mortality in certain locales. The etiology is a novel coronavirus especially capable of transmission in health facilities. Fifty percent of the victims were healthcare workers. SARS virus spreads mainly via large droplets, requiring close contact for transmission. However, it is possible that airborne transmission can occur and because the virus occurs early in the bloodstream, transfusion or sharps-related infections are also possible. Healthcare workers who refused to used masks properly while managing SARS patients were more likely to become infected than those who used the masks properly. In addition, because the virus is shed in the stool for about 30 days and can survive in the environment for 1 to 4 days, it is thought that the environment plays an important role in transmission. (Wenzel et al. 2008, pp. 306-07).

DIRECT AND INDIRECT RISKS VIA THE ENVIRONMENT

The disposal of healthcare waste in uncontrolled areas can have a direct environmental effect by contaminating soils and underground waters. Air can also be polluted if there is an inadequate filter process during incineration of waste materials.

The role of vectors such as rodents and insects in the survival or spread of pathogenic microorganisms in the environment should also be considered in regard to management of healthcare waste within and outside healthcare facilities. Vectors such as rats, flies, and cockroaches feed or breed on organic waste and are well known passive carriers of microbial pathogens. Their populations may increase dramatically where there is mismanagement of waste (Prüess et al. 1999; UNEP-SBC/WHO 2005)

Human feces may contain a range of disease-causing organisms, including viruses, bacteria and eggs or larvae of parasites. Therefore, the management and control of human fecal waste from patients, all medical facility and outbreak-associated personnel, and disease outbreak-affected communities is also a priority (Wisner and. Adams 2002).

CHARACTERISTICS AND HAZARDS OF WASTEWATER FROM HEALTH CARE

Wastewater from healthcare facilities may contain various potentially hazardous components, discussed in the following paragraphs. Ground and surface water can be contaminated by biological and chemical substances as a result of poorly sited and designed latrines, septic and wastewater systems and waste pits. Contamination can occur through overland flow into surface waters, seepage into ground water, or by direct disposal into waterways (Wisner and Adams 2002; USAID Bureau for Africa, ENCAP Africa Project 2009). Some of the following hazards posed by wastewater from large medical facilities are also applicable to small rural health centers and to disease outbreak sites in rural areas, especially if large, geographically dispersed response teams are managing an outbreak involving large numbers of confirmed suspect and contact cases.

MICROBIOLOGICAL PATHOGENS

Enteric pathogens, such as bacteria, viruses, and helminthes which are easily transmitted in water, may have high prevalence in healthcare wastewater. This is particularly challenging during outbreaks of diarrheal disease.

HAZARDOUS CHEMICALS

Small amounts of chemicals from cleaning and disinfection operations are regularly discharged into sewers and other local water sources.

PHARMACEUTICALS

Unknown quantities of pharmaceuticals are discharged into sewers and other water sources from hospitals and clinics and during disease outbreaks and other public health events, such as large-scale vaccination campaigns during epidemics.

RADIOACTIVE ISOTOPES

Small amounts of radioactive isotopes are discharged into sewers by oncology departments at hospitals.

RELATED HAZARDS

In some developing and industrializing countries, outbreaks of cholera are periodically reported. Sewers of the healthcare facilities where cholera patients are treated are not always connected to efficient sewage treatment plants, and sometimes municipal sewer networks may not even exist. Although links between the spread of cholera and unsafe wastewater disposal have not been sufficiently studied or documented, they have been strongly suspected, for instance during outbreaks in Democratic Republic of the Congo and Rwanda, and during the 1991- 92 cholera epidemic in southern South America. Little information is available on the transmission of other diseases through the sewage of healthcare facilities. (Prüess et al. 1999; UNEP-SBC/WHO 2005; United Nations Human Rights Council 2011).

COLLECTION AND DISPOSAL OF WASTEWATER

Sewage is greatly diluted in developed countries, where water use is commonly high. Under these conditions, effluents are treated in municipal treatment plants and generally pose no significant health risks. In many developing countries, discharge of untreated or inadequately treated sewage to the environment poses major health risks where there is no connection to municipal sewage networks. In addition, the toxic effects of any chemical pollutants contained in wastewater on the active bacteria of the sewage purification process may generate other hazards (Prüess et al. 1999; USAID Bureau for Africa, ENCAP Africa Project 2009)

RISKS ASSOCIATED WITH SPECIFIC CATEGORIES OF HEALTHCARE WASTE PRODUCTS, HUMAN REMAINS, AND ANIMAL CARCASSES

INFECTIOUS WASTE

Infectious waste may contain a great variety of pathogenic micro-organisms which may infect the human body. The pathogens contained in the waste may infect the human body through the following pathways:

- absorption through a crack or cut in the skin (injection);
- absorption through the mucous membranes; and
- by inhalation and ingestion.

Concentrated cultures of pathogens and contaminated sharps (in particular syringe needles) are probably the waste items that create the most acute human health hazards. Pathological waste (body tissues, organs, body parts, human fetuses, animal carcasses, liquid waste blood, plasma, coagulated factors, and body fluids) is among the most dangerous category of infectious waste owing to its potential of transmitting life-threatening diseases such as AIDS, viral hepatitis, typhoid fever, meningitis, rabies, Lassa and Ebola HF (Table 6.1). (Prüess et al. 1999; UNEP-SBC 2003).

Disposable materials and equipment are also sources of potentially infectious waste. These items are commonly used in hospitals, health centers and in field treatment centers during disease outbreaks. These include**:** disposable items contaminated with excreta and other body fluids (dressings, gowns, masks, gloves, etc.); containers with blood products, intravenous tubing, emptied peripheral dialysis fluid bags, intravascular access devices introducers, culture dishes, microbiological slides and cover slips, test tubes, vials, vacutainers, etc. (Wenzel et al. 2008).

TABLE 6.1 EXAMPLES OF INFECTIONS CAUSED BY EXPOSURE TO HEALTHCARE WASTES, CAUSATIVE ORGANISMS, AND TRANSMISSION VEHICLES

Type of infection	Examples of causative organisms	Transmission vehicles
Gastroenteric infections	Enterobacteria, e.g. *Salmonella*, *Shigella* spp.; *Vibrio cholerae*; helminths	Faeces and/or vomit
Respiratory infections	*Mycobacterium tuberculosis*; measles virus; *Streptococcus pneumoniae*	Inhaled secretions; saliva
Ocular infection	Herpesvirus	Eye secretions
Genital infections	*Neisseria gonorrhoeae*; herpesvirus	Genital secretions
Skin infections	*Streptococcus* spp.	Pus
Anthrax	*Bacillus anthracis*	Skin secretions
Meningitis	*Neisseria meningitidis*	Cerebrospinal fluid
Acquired immunodeficiency syndrome (AIDS)	Human immunodeficiency virus (HIV)	Blood, sexual secretions
Haemorrhagic fevers	Junin, Lassa, Ebola, and Marburg viruses	All bloody products and secretions
Septicaemia	*Staphylococcus* spp.	Blood
Bacteraemia	Coagulase-negative *Staphylococcus* spp.; *Staphylococcus aureus*; *Enterobacter*, *Enterococcus*, *Klebsiella*, and *Streptococcus* spp.	
Candidaemia	*Candida albicans*	Blood
Viral hepatitis A	Hepatitis A virus	Faeces
Viral hepatitis B and C	Hepatitis B and C viruses	Blood and body fluids

(Source Prüess et al, 1999, page 21).

HUMAN REMAINS AND ANIMAL CARCASSES

Dead or decayed human bodies do not normally pose a risk of communicable disease epidemic or a serious health hazard after natural disasters, unless they are polluting water sources with fecal matter, or are infected with cholera, plague or typhus, in which case they may be infested with the fleas or lice that spread plague or typhus (WHO-CD and SEARO 2005; Wisner and Adams 2002)

In the case of outbreaks of viral hemorrhagic fevers (VHF), if patients die, the risk of transmission is high in health facilities, for those involved in burials, and in communities, because the bodies and body fluids of deceased VHF patients remain contagious for several days after death. Family and community members are also at risk from burial practices which require touching and washing the body (CDC/WHO 1998).

The transmission risk of VHFs in the health care and laboratory setting is well documented. During the 1995 Ebola haemorrhagic fever outbreak in Kikwit, Democratic Republic of the Congo, one fourth of the cases were healthcare staff. The virus is transmitted during direct, unprotected contact with a VHF patient or with a deceased VHF patient. The virus is also transmitted during unprotected contact with VHF infectious body fluids or contaminated medical equipment and supplies, or as a result of an accidental needle-stick. The exposed person carries the virus back to the community. Transmission continues if there is direct person-to-person contact or any unprotected contact with infectious body fluids. (CDC/WHO 1998; WHO Ebola haemorrhagic fever Fact sheet N°103, provisional revision: September 2007).

Domestic and wild animal carcasses can also be major potential sources of infection. For example, mortality in wild animal populations was an order of magnitude greater than that of humans during a series of Ebola HF epidemics in Gabon and Republic of Congo from 1994-2003. Most of the index human cases had direct physical contact with the remains of dead animals they found immediately prior to their illness (Lahm et al. 2007).

SHARPS AND NEEDLES

All sharp objects that could cause a cut or puncture, whether infectious or not, are potentially hazardous, including hypodermic needles, suture needles, injector tips, scalpels, lancets, knives, blades, razors, pipettes, and broken glass. Owing to the double risk of injury and disease transmission, sharps are considered the most hazardous category of medical waste for medical staff and communities. They may not only cause cuts and punctures but also infect wounds with agents previously contaminating them. Syringe needles are of particular concern because they constitute an important part of the sharps and are often contaminated with the blood of patients. (Johannssen et al 2000)

The main diseases of concern are infections transmitted by subcutaneous introduction of the pathogenic agent such as viral blood infections. Health workers are exposed to blood and other body fluids in the course of their work at healthcare facilities and field outbreak sites. They are at risk of infection with blood-borne viruses and highly lethal pathogens such as filoviruses .The risk of infection depends on the prevalence of disease in the patient population and the nature and frequency of exposures.

Occupational exposure to blood can result from:

- *percutaneous injury*--needle-stick or other sharps injury;
- *mucocutaneous injury*--splash of blood or other body fluids into the eyes, nose or mouth; and
- *blood contact* with non--intact skin.

Needle-stick injury is most common form of occupational exposure to blood and the most likely to result in infection. The most common causes of needle-stick injury are:

- two-handed recapping; and
- unsafe collection and disposal of sharps waste.

(Source: WHO *Health Care Worker Safety Aide Memoire* 2011)

The lack of sufficient financial resources drives many health-care facilities to reuse objects and materials contaminated by blood or body fluids, such as syringes, needles and catheters. In some cases, these products are simply rinsed in water between injections. In other cases, used medical products are sold to waste recyclers and then reprocessed and sold back to medical facilities or the public without proper sterilization. (United Nations Human Rights Council 2011)

The reuse of unsterilized syringes and needles exposes millions of people to infections. As much as 40 per cent of injections are given with syringes and needles reused without sterilization, and in some countries this proportion is as high as 70 percent. (WHO, *Wastes from health-care facilities*, fact sheet No. 253, 2007;

WHO, *Injection safety*, fact sheet No. 231, October 2006).

CHEMICAL AND PHARMACEUTICAL WASTE

As stated in Chapter 3, hazardous chemical waste is defined as being any substance, liquid or solid, with at least one of the following properties: explosive, flammable, toxic, corrosive, locally chafing, reactive or genotoxic (carcinogenic, mutagenic, teratogenic) including cytotoxic drugs. All containers contaminated by these substances are also considered to be hazardous (Prüess et al.1999).

PHARMACEUTICAL WASTE

Pharmaceutical waste is potentially hazardous and is defined as being all pharmaceutical products, drugs, drug residuals and therapeutic chemicals that have been returned from wards; have been spilled; are outdated, contaminated, or are to be discharged because they are no longer required. Particular attention should be given to these wastes in the segregation process, as they may otherwise be resold by waste pickers (Ibid.).

Many chemicals and pharmaceuticals used in healthcare are hazardous chemicals. Injuries from chemicals occur when the skin, the eyes, or the mucous membrane of the lung come into contact with flammable, corrosive or reactive chemicals, such as formaldehyde or other volatile chemicals. Other chemical and pharmaceutical products may have toxic effects by means of acute or chronic exposure. Intoxication can result from absorption of the products through the skin or the mucous membranes, or from inhalation or ingestion.

Remains of hazardous chemicals and pharmaceuticals are found in biomedical and healthcare waste after their use or when they are no longer required. The most common injuries are burns. (United Nations Human Rights Council 2011).

DISINFECTANTS

Disinfectants are used in considerable quantities, especially during epidemics, and thus represent a particularly important group of hazardous chemicals, since they are often corrosive. Exposure to and physical contact with cleaning chemicals can cause eye, nose and throat irritation, skin rashes, headaches, dizziness, nausea and sensitization.

Disinfectants used in healthcare and emergency response such as ammonium compounds, phenols and bleach are registered with the United States Environmental Protection Agency (US EPA) as pesticides. These toxic chemical are used for routine surface cleaning and disinfection. Health effects from long-term exposure to quaternary ammonium compounds include asthma and hypersensitivity syndrome (Health Care Without Harm, *Cleaning Chemical Use in Hospitals* fact sheet, June 4, 2004).

Discharged chemical residues may have toxic effects on the operation of biological sewage treatment plants or on the natural ecosystems of water courses. Pharmaceutical residues may have the same effects, as they may include antibiotics and other drugs, heavy metals such as mercury, phenols and derivatives, and other disinfectants and antiseptics (United Nations Human Rights Council 2011).

In most developing countries, chemical and pharmaceutical wastes are either disposed of with the rest of municipal waste, or sent to cement kilns for burning.

Incineration is often regarded as the safest option to dispose of obsolete pharmaceuticals in developing countries. Most small-scale medical waste incinerators are not equipped with the complex air pollution devices needed to keep dioxin emissions to the levels recommended by the Stockholm Convention.

A significant amount of chemicals and pharmaceuticals is also disposed of through healthcare wastewater. In countries where no wastewater treatment facilities exist, effluents from healthcare facilities are discharged directly in rivers and other water courses, and risk contaminating surface and groundwater resources used for drinking and domestic purposes (WHO *Health-care waste management*, fact sheet No. 281, October 2004; WHO C*ore principles for achieving safe and sustainable management of health-care waste,* fact sheet 2007).

PESTICIDES

As seen in Table 3.2 in Chapter 3, disease outbreak response efforts may require the use of a wide variety of disinfectants, rodenticides and insecticides, depending on the nature of the pathogenic agent involved and its transmission cycle.

"A pesticide product is a mixture of chemicals used to kill, repel or otherwise control insects, weeds, rodents, fungi or other pests. Pesticides include insecticides, herbicides, fungicides, rodenticides, and other products active against pests. Pesticide products are formulations of a number of different materials, including active and "inert" ingredients, as well as contaminants and impurities. In addition, pesticides, when subject to various environmental conditions, break down into other materials known as metabolites, which are sometimes more toxic than the parent material". (Source: Owens 2003, page 4).

> The US EPA states that, "By their very nature, most pesticides create some risk of harm to humans, animals, or the environment because they are designed to kill or otherwise adversely affect living organisms."
>
> (Source: United .States.Environmental Protection Agency (EPA). 2002. What is a Pesticide? Office of Pesticide Programs.http://www.epa.gov/opp00001/whatis.htm).

Individual pesticides have varying levels of toxicity. Typical symptoms that can result from an acute pesticide exposure include nausea, diarrhea, headache, seizures dizziness, aching joints, mental disorientation, inability to concentrate, vomiting, convulsions, skin irritations, flu-like symptoms and asthma-like problems. Acute poisoning and low-level pesticide exposure over a period of time may result in chronic health effects, including cancer, birth defects, genetic damage, neurological, psychological and behavioral effects, blood disorders, chemical sensitivities, reproductive effects, and abnormalities in liver, kidney, and immune system function. Many insecticides, herbicides and fungicides are linked to certain types of cancer, especially those of the lip, stomach, and prostate, as well as leukemia, lymphatic cancers, and multiple myeloma (Owens 2003).

The inert ingredients of pesticides are also hazardous chemicals. Pesticide formulations contain a majority of so-called "inert" ingredients, while the amount of active ingredient is much smaller. Inert agents comprise the largest percentage of ingredients in a pesticide product as the solution, dust, or granule in which the active ingredient is mixed. **Many inert ingredients are petrochemical solvents such as acetone, fuel oil, toluene and other benzene-like chemicals**. They may not be chemically, biologically or toxicologically inert, can be more toxic than the active ingredient, and/or be an active ingredient in another pesticide product (Ibid.)

OBSOLETE PESTICIDES

Obsolete pesticides stored in leaking drums or torn bags, can directly or indirectly affect the health of anyone who comes into contact with them. During heavy rains, leaked pesticides can seep into the ground and contaminate the groundwater. Poisoning can occur through direct contact with the product, inhalation of vapors, drinking of contaminated water, or eating of contaminated food. Other hazards may include the possibility of fire and contamination as a result of inadequate disposal such as burning or burying (Health Care Without Harm; http//:www.noharm.org).

CYTOTOXIC OR GENOTOXIC WASTE

Cytotoxic or genotoxic products include any drug that inhibits or prevents the function of cells. They would be more apt to be used in large hospitals or specialized treatment facilities, but the particularly high risks they pose for human, animal and environmental health merit some discussion. The severity of health hazards due to handling or disposal of cytotoxic waste is dependent upon the combined effect of the substance's toxicity and the extent of exposure to the material. Exposure occurs mainly by means of inhalation of dust or aerosols, skin absorption, and ingestion of food accidentally in contact with cytotoxic (antineoplastic) drugs, chemicals, waste, or with the secretions of chemotherapy patients, and ingestion as a result of bad practice, such as mouth pipetting (UNEP-SBC/WHO 2005).

Many cytotoxic drugs are extremely irritant and have harmful local effects after direct contact with skin or eyes. They may also cause dizziness, nausea, headache, or dermatitis. Special care in handling genotoxic waste is imperative as any discharge of such waste into water courses or the general environment could have disastrous ecological consequences for the flora and fauna of local ecosystems, and for local human communities (Prüess et al.1999; United Nations Human Rights Council 2011).

MERCURY WASTE

Mercury is another hazardous product common in healthcare owing to its prevalent use in literally hundreds of different devices. It is most concentrated in diagnostic devices such as thermometers, blood pressure gauges and, and esophageal dilators. It is also found in other sources such as fluorescent light tubes and batteries. It is a potent neurotoxin that can have several adverse effects on the central nervous system in adults, increase the risk of cardiovascular disease and cause kidney problems, miscarriage, respiratory failure and even death. (Johannessen et al.2000).

The release of elemental mercury occurs during spillage from broken thermometers or leaking equipment. In many developing countries, there is no clean-up protocol for mercury spills, resulting in inadequate cleaning, segregation and management of mercury waste. Inhalation of mercury vapors may cause damage to the lungs, kidneys and the central nervous system of those who are exposed to it (Prüess et al. 1999; UNEP-SBC 2003).

Many developed countries have banned or severely restricted the use of medical devices containing mercury, owing to their adverse effects on human health and the environment. Thermometers and sphygmomanometers containing mercury continue to be widely used in many developing countries. Some healthcare institutions in industrialized countries decommission their old mercury-containing instruments and donate them to institutions in developing countries, where mercury waste may, in many cases, be either incinerated with infectious waste or treated as municipal waste. Without healthcare waste management systems and the replacement of mercury-containing devices, the total amount of mercury released into the environment by all types of healthcare facilities in developing countries is expected to increase in the future (WHO, *Replacement of mercury thermometers and sphygmomanometers in health care: technical guidance*, May 2011).

Improper disposal of elemental mercury may result in long distance dispersal and eventual deposit on land and water, where it reacts with organic materials to form methyl mercury, a highly toxic organic substance. This type of mercury affects the nerves and the brain at very low levels and bio-accumulates in the aquatic food chain. The main source of human exposure to this form of mercury derives from the ingestion of contaminated fish and seafood. Even at very low levels, methyl mercury can cause severe, irreversible damage to the brain and nervous system of fetuses, infants and children (United Nations Human Rights Council 2011).

RADIOACTIVE WASTE

As mentioned in Chapter 3, radioactive products and materials would not likely be used at rural medical facilities and during outbreak response in remote areas. Nonetheless, a summary description of the dangers of exposure to radiation from medical procedures will be presented in this section.

Exposure to all levels of radiation is considered to be associated with some risk of carcinogenesis. Radioactive materials cause harm through both external radiation by means of approaching them or handling them, and via intake into the body. The degree of harm depends on the amount of radioactive material present or taken into the body and on the type of material. Exposure to radiation from high-activity sources, such as those used in radiotherapy, can cause severe injuries, ranging from superficial burns to early fatalities. Nuclear medicine radioactive waste is much lower in activity and is therefore unlikely to cause as much harm (UNEP and Secretariat of the Basel Convention 2003).

The type and extent of exposure determines the type of disease caused by radioactive waste. Symptoms can range from headache, dizziness, and vomiting to much more serious problems such as deleterious impacts on genetic material. Handling of highly active sources may cause severe injuries such as superficial burns and destruction of tissue and may result in early death. Low activity radiation hazards may result from contamination of external surfaces of containers or improper mode or duration of waste storage. The majority of radioactive waste generated by health-care establishments is classified as "low level" waste. **In some developing countries, a lack of knowledge and instruction regarding the risks, management, and safe disposal of radioactive materials may result in dangerous conditions at health facilities** (Prüess et al. 1999; United Nations Human Rights Council 2011).

DIOXINS AND FURANS

Risks to human, animal and environmental health from dioxin and furan emissions can be common during use of inefficient rudimentary incinerators and burn pits to destroy waste at small rural medical facilities and at remote disease outbreak sites.

The majority of small-scale medical waste incinerators used in developing countries do not employ any air pollution control devices or other equipment necessary to meet modern emission standards established in the Stockholm Convention on Persistent Organic Pollutants, since this would increase greatly costs for their construction and operation (UNEP-SBC/WHO 2005).

An assessment of small-scale medical waste incinerators in developing countries showed widespread deficiencies in the design, construction, siting, operation and management of these units. **The poor performance of the incinerators resulted in low burning temperatures and consequential incomplete waste destruction, as well as high amounts of ash disposal and dioxin emissions as much as 40,000 times higher than the emission limits established by the Stockholm Convention**. The small-scale incinerators also released significant amounts of other hazardous pollutants through gaseous emissions, fly and bottom ash, and occasionally through wastewater. Pollutants released include heavy metals (such as arsenic, cadmium, mercury and lead), acid gases, carbon monoxide and polycyclic aromatic hydrocarbons (Batterman 2004).

Medical waste contains a high proportion of polyvinyl chloride (PVC), a chlorinated plastic that is used in containers for blood, catheters, tubing and numerous other applications. PVC releases polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (dioxins) when burned. These substances are part of a family of 210 persistent organic pollutants that are unintentionally formed and released from a number of industrial and incineration processes, including medical waste incineration, as a result of incomplete combustion or chemical reactions. (CGH Environmental Strategies, Inc. 2002)

Dioxins are a known human carcinogen. Chronic lymphocytic leukemia, soft-tissue sarcoma, non-Hodgkin's lymphoma and Hodgkin's disease have been linked to dioxin exposure. There is further evidence of a possible association with liver, lung, stomach and prostate cancers. Short-term high-level exposure may result in skin lesions and altered liver functions, while low-level exposure to dioxins may lead to impairment of the immune system, the nervous system, the endocrine system and reproductive functions. Fetuses and new-born children are most sensitive to exposure (Health Care Without Harm, *What's Wrong With Incineration* fact sheet, 15 October 2002; United Nations Human Rights Council 2011).

HEALTHCARE AND COMMUNITY-ASSOCIATED WASTE POSING HEALTH RISKS AT DISEASE OUTBREAK SITES

HUMAN WASTE

Human feces may contain a range of disease-causing organisms, including viruses, bacteria and eggs or larvae of parasites. The microorganisms contained in human feces may enter the body by means of:

- contaminated food, water, eating and cooking utensils; and
- contact with contaminated objects.

Diarrhea, cholera and typhoid are spread in this way and viral haemorrhagic fevers may also remain highly virulent in fecal matter. During disasters and public health emergencies, insects, particularly some fly species, are attracted to waste materials and the accumulation of feces generated by higher human population densities. This increases the risk of transmission of trachoma, dysentery and intestinal worm infections at outbreak and natural disaster sites. Feces in water courses may also increase the risk of infections with the intestinal form of schistosomiasis.

Urine is relatively harmless, except in areas where the urinary form of schistosomiasis occurs. This parasitic infection is similar to the intestinal form, but the parasite species in question resides in the veins around the bladder and its eggs are excreted in urine. In this regard, response teams arriving at outbreak sites are at risk if either species of schistosomiasis is present in local waterways. Communities may be at risk if outbreak response team members are infected and contaminate local water courses (Wisner and Adams 2002).

SULLAGE

Sullage is defined as wastewater from kitchens, bathing places and laundries or general clothes-washing areas. It can contain disease-causing organisms, particularly from soiled clothing in the case of extremely contagious diseases such as Ebola and Marburg HF. Waste or wash/cleaning-water from patient treatment centers at outbreak response sites is considered to be infectious or highly infectious waste, depending on the disease-causing organism involved.

The greatest overall health hazard of sullage is when it forms pools of organically polluted water in poorly drained places which may be used as breeding sites for *Culex* mosquitoes. This genus of mosquitoes transmits some viruses as well as the parasitic disease lymphatic filariasis. Mosquitoes that transmit malaria do not breed in polluted water. Accordingly, sullage generated from kitchen and laundry items used by patients, response teams, suspect and contact cases, and local community members during disease outbreaks are potentially hazardous for the reasons mentioned above. This includes wastewater from general activities at temporary bathing sites, as well as washing/rinsing potentially contaminated surfaces (furniture, equipment, vehicles used as ambulances and for burials, etc.) (Ibid.) Therefore, response team personnel should not bathe, wash clothing, other materials or equipment, or throw wastewater in local streams and rivers.

GENERAL SOLID WASTE

Solid waste in the form of discarded food, cloth, medical dressings, packaging and obsolete materials and equipment are attractive to rodents, dogs, cats and commensal animals, which may transmit parasites and other disease-causing organisms amongst each other and to response teams and affected communities. Unused or discarded buckets, tires and other receptacles brought by response teams may fill with rainwater and serve as breeding sites for *Aedes* mosquitoes which transmit Yellow Fever, Chikungunya Virus and Dengue Fever.

In summary, there is a multitude of risks and associated occupational, environmental, biological (flora and fauna) and community-related hazards linked to waste materials from health facilities and outbreak response venues. The collection, treatment, management, disposal and monitoring of these potential hazards, from infectious, chemical and pharmaceutical waste to wastewater, excreta, sullage and general solid waste, is a challenge for healthcare facilities of all sizes, and for varying numbers of outbreak response personnel working at sites with often minimal amenities.

Examples of best practices for the management and disposal of healthcare and associated waste at resource-poor rural medical facilities and remote sites where disease outbreaks often occur will be discussed in detail in Chapter 7.

CHAPTER 7: BEST PRACTICES FOR MANAGEMENT OF HEALTHCARE-ASSOCIATED WASTE AT SMALL RURAL MEDICAL FACILITIES AND REMOTE DISEASE OUTBREAK SITES

It is well-documented that open dumps are frequently used for land disposal of solid wastes in many developing countries, including healthcare waste. This disposal method is hazardous for public and environmental health (Diaz et al. 2005; Harhay et al. 2009). Unsafe management of healthcare waste occurs at all levels of society and economy, and has many contributing underlying factors (education, resources, infrastructure, and politics). It is most intense and conspicuous in rural communities and remote areas where emerging and other disease outbreaks often occur.

In this chapter, best practices for management of healthcare waste, will be discussed in the context of small rural medical facilities and more remotely-located areas without health centers, the types of locale and conditions in which many zoonotic and infectious disease outbreaks occur. Standards for “minimal observance” of healthcare waste management will be described in detail, as well as the roles and responsibilities of healthcare-associated personnel in understanding and implementing simple and effective measures for infection control and prevention and safe management of waste from routine medical activities and disease outbreak response.

The application of “minimal practices” contributes to the reduction of health risks associated with inappropriate medical waste management. Although guidelines exist for more developed settings, improvised waste management strategies have been documented to be successful in resource-poor locales. Where more advanced technology and methods of waste treatment and disposal are lacking, the “minimal practices” concept is recommended by WHO (Prüess 1999). In Southeast Asia, for example, small rural medical facilities succeeded in effectively disposing of waste using no- to low-cost minimal procedures which prevented scavenging and the transmission of common and emerging infectious diseases (Cole 2000).

The investment in terms of time, finances and political will to develop appropriate and sustainable low-technology solutions for healthcare waste management in less economically developed nations and even poorer in-country regions requires international support over the long term. In the short term, training and education in minimal, achievable practices to improve healthcare waste management and disposal in countries such as Brazil have resulted in rapid and remarkable improvement (Blenkharn 2005). The principle of "doing something is better than doing nothing" is important, and underlies any effort to initiate a system for the management of healthcare waste (Prüess 1999).

BACKGROUND ON RURAL HEALTHCARE FACILITIES

Small rural healthcare facilities play a vital role in public health by treating the sick, reporting suspected or actual outbreaks, and educating communities in infection prevention, childbirth preparation, and maternal child care. **Rural primary healthcare centers are the front line of defense against epidemics.** They may range in size from a territorial or sub-district hospital of 25 beds or less staffed by one or two doctors and some nurses, to a health clinic with a full-time nurse and a few beds, or one- or two-room health posts and dispensaries in more remote locations with a full or part-time nurse or community health worker who treat or advise out-patients only.

In addition, a nurse, doctor, or mobile health team may visit periodically from a larger facility nearby to provide other services (childhood immunization, family planning, laboratory diagnostics, etc) (USAID ENCAP Africa Project 2009).

Healthcare waste management planning must consider local conditions, the safety of the medical staff, associated workers and communities, and local environmental criteria. Small healthcare facilities, typically primary healthcare centers, health posts, and dispensaries, produce limited quantities and types of hazardous healthcare wastes, mainly sharps, infectious waste and some pharmaceuticals (Table 1). Primary health care centers mainly deliver medical care to outpatients. On occasion, they may participate in large-scale immunization programmes or response to local disease outbreaks. In the latter case, they may serve as the headquarters for outbreak investigation and response teams.

At these small facilities, where human and financial sources are limited, a set of well defined and implemented practical measures can ensure that waste materials are properly and safely controlled. The management of waste at this level is usually done by the doctor or nurse in charge; thus responsibility is clearly defined (WHO 2005).

TABLE 7.1 APPROXIMATE PERCENTAGE OF WASTE TYPE PER TOTAL WASTE AT PRIMARY HEALTHCARE CENTERS IN DEVELOPING COUNTRIES.

Type of Waste	% total
Non-infectious	80
Pathological and infectious	15
Sharps	1
Chemical or pharmaceutical	3
Pressurized cylinders, broken thermometers, etc.	<1

Adapted from: WHO Management of Solid Health-Care Waste at Primary Health-Care Centres. A Decision-Making Guide. 2005

TRAINING AND EDUCATION IN WASTE MANAGEMENT

Although national legislation for sound management of healthcare waste may exist in a given country, implementation at the level of rural primary care centers is often problematic and inadequate. In contrast, methods of safe management and disposal of waste materials at disease outbreak sites, where a considerable amount of hazardous medical waste may be generated rapidly, must be practical and adapted to local conditions, yet rigorously applied to achieve a high level of infection prevention and control in the affected communities and surrounding human and natural environments.

Technical as well as organizational issues must be considered in the design of waste management systems for rural medical facilities and outbreak teams, **with the main objective of protecting health by eliminating as many risks as possible**. Combinations of waste management methods may be used. WHO recommends the following topics to be addressed in the development of a healthcare waste management system for primary healthcare centers. This is also applicable to outbreak response teams:

- training of concerned personnel;
- clear attribution of responsibilities;
- allocation of human and financial resources;
- insightful development and implementation of best practices regarding handling, storage, treatment and disposal;

The key element is that personnel must be well trained and motivated to ensure that these simple practices are consistently implemented. The choice of sustainable management and disposal options are recommended to be made according to:

- Context and needs;
- Availability;
- Affordability;
- Environment-friendliness;
- Efficiency;
- Worker's safety;
- Prevention of the re-use of disposable medical equipment (e.g. syringes);
- Social acceptability

(Source: WHO 2005, pp. 4-5).

To achieve the desired outcome, an Infection Control Officer should be selected as the person responsible for the implementation and monitoring of waste management in a given facility, whether it is a primary care center, health outpost, or dispensary. In the simplest cases, this will be the doctor, nurse, or other health worker in charge. At disease outbreak sites, this is the responsibility of the Infection Prevention and Control personnel within the Outbreak Investigation and Response Team, as discussed in Chapter 5.

The Infection Control Officer should be responsible for all training related to the management and disposal of healthcare waste, and for ensuring that staff at all levels are familiar with the waste management plan and of their own responsibilities and obligations in this regard. Since the range of healthcare services offered will differ according to facility type and circumstances (i.e. outbreak), the guidelines should be prioritized on the most frequent and/or risky practices such as injection safety and invasive procedures. (Pruess et al.1999).

As discussed in Chapter 5, the functions of Infection Prevention and Control personnel in outbreak response or at medical facilities include: maintenance of standard precautions for hygiene, sterilization and disinfection of medical materials; early disease detection and monitoring of precautionary measures such as use of PPE; outbreak management; establishing aseptic techniques for clinical procedures; guiding waste management procedures; and training healthcare and associated staff. Management of healthcare waste is an integral part of hygiene and infection control (WHO 2009b).

> "Healthcare waste management is first of all a *management* issue before being a technical one and therefore completely depends on the *commitment* of the entire staff within healthcare facilities. This dedication will only be possible if people are first of all properly *trained* and made aware of the risks that this particular type of waste poses. Training is a crucial aspect to successfully upgrade healthcare waste management practices. The overall aim of training is to develop awareness of the health, safety, and environmental issues. It should highlight the roles and responsibilities of each actor involved in the management process of the healthcare waste (Duty of Care Principle in Chapter 4). It is therefore important to make sure the curricula of medical and para-medical staff include this important public-health issue"
>
> (Source: UNEP-SBC/WHO 2005, p.7).

UNEP-SBC/WHO (2005) and WHO (2005) recommend separate but equal training programs in medical waste management for the following categories of personnel:

- healthcare facility managers and administrative staff responsible for implementing regulations on healthcare waste management;
- medical doctors; nurses and assistant nurses;
- cleaners, porters, supporting staff, and waste handlers;
- waste handlers and waste pickers.

In addition, local authorities, communities and schools should be informed of the risks to public health related to healthcare waste.

The staff healthcare waste management education programme should contain

- information on, and justification for, all aspects of the waste management policy;
- information on the role and responsibilities of each staff member in implementation of policy and practices;
- technical instructions, relevant for the target group, on the application of waste management practices;
- information on monitoring techniques; and
- a display of written instructions for personnel.

(Source: Ibid.)

Ducel et al. (2002) highly recommend Infection Control and Safety Training, including management of waste, for all healthcare-associated personnel. These include administrators/managers, physicians, nursing staff, and other health care workers, clinical microbiology, pharmacy, central supply, maintenance, housekeeping, food service, laundry service, training services, hygiene and sanitation service. Many of these personnel categories apply to large hospitals, but will also be present at larger rural health centers and district hospitals, as well as outbreak response teams involved in epidemics.

HYGIENE AND PROTECTION OF PERSONNEL HANDLING WASTE

HYGIENE OF PERSONNEL

Basic personal hygiene is a priority for reducing the risks that occur from handling healthcare waste. Washing facilities should be made available to people handling healthcare waste at collection, storage, treatment and disposal facilities.

Cleaning is one of the most basic measures for the maintenance of hygiene. Hand hygiene is the primary preventive measure because **hands are the most frequent vectors of nosocomial infections**. Thorough hand washing with adequate quantities of clean water and soap removes more than 90% of micro-organisms encountered on the hands. Cleaning must be carried out in a standardized and rigorous manner for 20-30 seconds.

IMMUNIZATION

Ideally, all staff handling healthcare waste should be offered appropriate immunization, including hepatitis A, B and tetanus.

PERSONAL PROTECTION

Healthcare-associated personnel who are responsible for collecting and transporting medical waste should wear the following personal protective clothing:

- Suitable heavy-duty gloves when handling waste containers;
- Safety shoes with covers or in thick rubber boots to protect the feet against the risk of contamination or of containers being accidentally dropped;
- Plastic apron or leg protectors.

(Source: UNEP-SBC/WHO 2005)

In addition, all personnel treating patients or handling highly infectious waste infected with certain highly pathogenic agents are required to wear thick plastic gloves, boots, a filter-equipped mask or respirator, a plastic apron and a gown or full ensemble. (See Annex 2: Diseases with Special Requirements for Infection Prevention and Waste Management).

MINIMAL OBSERVANCE OF HEALTHCARE WASTE MANAGEMENT

Waste materials that are generated within a healthcare facility or during outbreak response should ideally follow an appropriate and well-identified “stream” from their point of generation until their final disposal. This stream is composed of several steps that include: minimization, generation, segregation, codification, collection and on-site transportation, on-site storage, offsite transportation (optional), treatment, and disposal of the waste products (Pruess et al. 1999; UNEP-SBC/WHO 2005) as illustrated in Figure 7.1.

STEP 0. MINIMIZATION OF WASTE

Waste minimization essentially involves changes in management and behavior to prevent and reduce waste generation. The need for ecologically-oriented approaches to waste management is increasingly being recognized. Ideally, this should begin with the procurement process by giving preference to less harmful products and replacing toxic or disposable items with reusable or alternative products, consistent with standards for hygiene and patient safety.

A noticeable reduction in waste volume can be achieved only if disposable products already in use are evaluated for their necessity. In principle, disposables such as linen (including covering sheets), instruments and equipment (scissors, scalpels, forceps) and various containers should be replaced by reusable products and durable alternatives.

The amount of waste generated can be noticeably reduced if the amount of associated packaging is considered in the selection of products. Packaging materials should not exceed the minimum necessary to meet transportation, storage, hygiene and sterility requirements. Relevant waste management efforts should be addressed in relation to procurement by administrators of packaged products (UNEP-SBC 2003).

FIGURE 7.1 SYNOPSIS OF HEALTHCARE WASTE MANAGEMENT STREAM

step	location	healthcare waste stream	key points
0		*waste minimization*	*purchasing policy; stock management; recycling of certain types of waste…*
1	in medical unit	**generation**	
2		**segregation at source**	*one of the most important steps to reduce risks and amount of hazardous waste*
3	in health facility	**collection + on-site transport**	*protective equipment; sealed containers; specific easy to wash trolleys*
4		**on-site storage**	*lockable easy to clean storage room; limited storage time of 24-48 hours*
5		**on-site treatment / disposal**	*adequate storage room; limited time of max 48 hours*
6	outside of health facility	**off-site transport**	*appropriate vehicle and consignement note; HCF is informed about final destination*
7		**off-site treatment / disposal**	*appropriate vehicle and consignement note to ensure…*

Source: UNEP-SBC/WHO 2005: Preparation of National Health-Care Waste Management Plans in Sub-Saharan Countries Guidance Manual, p.13).

Waste minimization can be achieved most effectively through a number of activities on the part of medical, managerial and administrative staff through characterization of the waste produced, identification of waste prevention and reduction opportunities, implementation, and education and training. Some examples of waste prevention and source reduction methods include:

- Purchasing reductions: selection of supplies that are less wasteful or less hazardous;
- Prevention of wastage of products, e.g. in nursing and cleaning activities;

- Frequent ordering of relatively small quantities rather than large amounts at one time, especially applicable to unstable products;
- Use of the oldest batch of the product first;
- Use of all the contents of each container;
- Checking the expiration date of all products at time of delivery;
- Substitution of less toxic materials;
- Recycle or reuse items not directly used for medical care (paper, cardboard, glass, plastic wrappings, etc.)

Note: The reuse of equipment has almost disappeared due to the marketing of single use items and the need to prevent the spread of nosocomial diseases, particularly medical items such as syringe needles (Ibid.).

STEP 1. GENERATION OF WASTE

Medical activities generate waste that should always be discarded **at the point of use** by the person who used the item to be disposed of. The quantity of waste generated should always be minimized and precautions must be taken during their handling.

> "All staff who produce healthcare waste should be responsible for its segregation, and should therefore receive training in the basic principles and practical applications of segregation. Waste is generated by a large number of personnel, many of whom are directly involved with care of patients, often in conditions of urgency. Management of the waste generated in such circumstances may thus seem to be of little importance. Training should make staff aware of the potentially serious implications of the mismanagement of waste for the health of waste handlers and patients, provide them with an overall view of the fate of waste after collection and removal …, and teach them the importance of proper segregation of the different categories of waste. If no separation of wastes takes place, the whole mixed volume of healthcare waste must be considered as being infectious."
>
> (Source: Prüess et al.1999, p. 162)

STEP 2. SEGREGATION, CODIFICATION/LABELING AND CONTAINMENT OF WASTE

Segregation

Segregation is the key to effective biomedical and healthcare waste management. When performed correctly, it reduces the quantity of hazardous wastes requiring special attention and treatment and thereby ensures that the correct disposal routes are taken, personnel safety is maintained, and environmental harm is minimized

Segregation must take place at the point and time of generation and must be carried out by the person generating the waste, for example when an injection is given and the needle and syringe are placed in a waste container, or when packaging is removed from supplies and equipment, in order to secure the waste immediately and avoid dangerous secondary sorting. It should be undertaken on the basis of the types of waste listed in the definitions for biomedical and healthcare waste as seen in Chapter 3.

For routine medical activities at rural healthcare facilities, waste materials should be separated mainly into the following categories: sharps, infectious non-sharps and non-hazardous waste similar to household waste. **Suitable latex gloves must always be used when handling infectious waste.** Protection measures required for handling highly infectious waste will be discussed in other sections of this document.

Non-hazardous waste (e.g., paper) can possibly be recycled/reused. Non-infectious biodegradable organic wastes (e.g., food waste) can be composted and then used on-site (Pruess et al. 1999; UNEP-SBC 2003; UNEP-SBC/WHO 2005).

Codification and Labeling

Codification is a color-coded system which defines the containers in which waste must be stored after segregation. WHO recommends identifying healthcare waste categories by sorting the waste into color-coded and well-labeled bags or containers; for example, yellow or red for infectious waste, brown for chemical and pharmaceutical waste, and black for non-infectious waste.. Segregating waste using a simple three bin waste disposal system at small healthcare facilities and remote outbreak sites minimizes the amount of waste that needs to be buried in the waste pit and reduces the risks of injuries from sharps.

The application of a color coding system enables immediate identification of the hazards associated with the type of healthcare waste that is handled or treated. All the specific procedures of healthcare waste segregation, packaging and labeling should be explained to the medical and support staff and displayed on charts on the walls near the waste containers that should be specifically suited for each category of waste. Outbreak response teams will have appropriately colored plastic bags displaying the international biohazard symbol, with red bags indicating highly infectious materials. **If different colored bags are not available, use thick garbage bags clearly labeled for specific types of waste and placed close to points of generation.**

Owing to the nature of the potentially highly pathogenic agents involved, outbreak investigation and response teams are expected to rigorously apply the following WHO recommended color coding and containment system, or similar alternatives, for waste management.

TABLE 7.2 WHO-RECOMMENDED COLOR CODING FOR BIOMEDICAL AND HEALTH-CARE WASTE AS AN EXAMPLE OF A COLOR-CODING AND CONTAINMENT SYSTEM

Type of Waste	Container color and label	Type of Container
Highly infectious	Yellow, marked "HIGHLY INFECTIOUS"	Strong, leak-proof plastic bag(s) or container
Infectious or pathological	Yellow	Double plastic bags or container
Sharps	Yellow, labeled "SHARPS"	Puncture-proof container
Chemical or pharmaceutical	Brown	Plastic bags or container
Radioactive*	--------	Labeled lead box
General waste	Black	Plastic bag

Adapted from UNEP-SBC 2003, p. 25.

* Radioactive waste is mainly generated only in large hospitals.

Containment of waste

As seen in Table 7.2, the segregated waste materials should be placed in specific types of colored or well-marked containers. Improperly handled and stored sharps represent a significant hazard to the staff members responsible for collecting and managing wastes. Special, dedicated containers made of plastic or cardboard are available in some locations for storing used sharps. If such safety boxes are not available, other types of containers that can serve to contain sharps are sealed cardboard boxes and used plastic bottles.

Another type of safety box is designed to remove used hypodermic needles from their syringes without risk to the user, and to serve as a safe storage vessel. Needle removers can extract and blunt needles. Removed needles should be safely stored within a closed container which can be emptied or disposed in a sharp pit once three quarters full. Mutilated syringes can then be treated as an infectious waste. Other alternatives for sharps containers, as well as practical methods for containment/isolation of waste disposal sites in rural/remote areas, can be found in Annex 3.

Non-sharps should be stored in closed containers. Appropriate types of containers for their collection include plastic bags with closures, plastic bags placed in metal receptacles, and plastic containers with lids. A larger container can then be used to store the waste bags when they are full (WHO 2005).

STEP 3. COLLECTION, STORAGE, AND ON-SITE TRANSPORT

Waste should be collected daily. General waste may be stored in convenient places that facilitate collection, but hazardous healthcare waste should be stored in a secure closed place with restricted access and protection, as much as possible, from rodents, birds and insects. Waste should not be stored close to patients or where food is prepared (Prüess et al.1999; UNEP-SBC/WHO 2005).

The basic criteria for safe collection and transportation of waste are: segregation of infectious and non-infectious waste and the use of sharps containers to dispose of needles right after injection. **Infectious waste must be decontaminated before transportation to final disposal**. Household bleach, at the appropriate concentrations (0.5% chlorine solution), can be used to disinfect sharps and other wastes. For safety and efficacy, disinfection procedures must be followed precisely and carefully**, but this disinfection does not render sharps safe for reuse**. It only serves to reduce the risk from accidental exposure to sharps prior to treatment or disposal (WHO 2005).

Small amounts of chemical or pharmaceutical waste may be collected together with infectious waste. Large quantities of obsolete or expired pharmaceuticals should be stored and returned to the pharmacy for disposal, if possible. Other generated pharmaceutical waste, such as spilled or contaminated drugs, or packaging containing drug residues must **not** be returned owing to the risk of contamination of the pharmacy. It must be deposited in the correct container at the point of generation (Ducel et al. 2002).

If present, large quantities of chemical waste must be packed in chemical-resistant containers and removed by authorities/response teams from outbreak sites to be sent to specialized treatment facilities and be disposed of elsewhere. **Pressurized containers may be collected with general health care waste once they are completely empty, provided that the waste is not destined for incineration** (Ibid).

STEP 4. ON-SITE STORAGE OF WASTE

As stated in Step 3, infectious health care waste should be stored in a secure place with restricted access. **In general, the maximum time of storage before disposal of infectious waste should not exceed 24 hours at primary healthcare facilities with limited resources.** (WHO 2005). **This also applies to remote disease outbreak sites.**

Under other circumstances, WHO recommends that infectious waste should be disposed of within the following time periods:

- Temperate climate: maximum 72 hours in winter maximum; 48 hours in summer;

- Warm climate: maximum 48 hours during the cool season; maximum 24 hours during the hot season.

(Source: Prüess et al. 1999, p. 170).

STEPS 5 AND 6. ON-SITE TREATMENT/DISPOSAL OR OFF-SITE TRANSPORT

Methods of Waste Treatment

The choice of an appropriate technology for treatment and disposal of waste depends on a range of local circumstances, including the state of the existing waste management system, the institutional capacity, the human resources available, and the costs of the different options in relation to the financial situation of the national and local health sector (Johannessen 2000).

Treatment modifies the characteristics of the waste. Treatment of wastes mainly aims at reducing direct exposure of humans to less dangerous levels, at recovering recyclable materials, and at protecting the environment. For wastes from primary healthcare centers and remote outbreak sites, the main aim is to disinfect infectious waste and to destroy disposable medical devices, in particular used syringe needles, which should not be reused, or at least to render them inaccessible or sterile (WHO 2005). Some types of predisposal treatment methods are discussed below.

Chemical Disinfection

Chemical disinfection is used routinely in healthcare to kill microorganisms on medical equipment. This method can also be used to treat healthcare waste. Infectious waste must be decontaminated before transportation to final disposal. Chemicals (mostly strong oxidants like chlorine compounds, ammonium salts, aldehydes, and phenolic compounds) are added to the waste to kill or inactivate pathogens. This is most suitable for treating liquid wastes such as blood or sewage. Solid and highly hazardous waste and sharps normally should be segregated, shredded and milled prior to the application of the chemical reagents. The shredding and milling technology requires special treatment of hazardous wastewater streams. (Johannessen 2000). The latter technology would obviously not be available in rural areas or at remote outbreak sites.

Disinfection with Bleach

Household bleach, at the appropriate concentrations (0.5% chlorine at 1:10 solution), can be used to disinfect sharps and other wastes. Outbreak response teams will usually have a range of stronger disinfectant products for use, but bleach is highly effective. Disinfection procedures must be followed carefully to be effective, whether using simple bleach solution or other products (Prüess et al. 1999; WHO 2005).

Encapsulation of needles

Needles removed or cut from the syringes occupy little space. Large quantities of needles can be collected in hard puncture proof or alternative containers. When the container is three quarters full, wet concrete can be added to the container to permanently encapsulate the needles. Once the needles have been encapsulated, the block containing the needles can be disposed of in a burial pit. Single use needle removers can also be disposed of in a similar manner.

Inertization of waste

This predisposal treatment method involves rendering hazardous waste products such as pharmaceuticals "inert" by mixing them with cement before disposal in order to minimize the risk of leakage of toxic substances contained in the waste. This method cannot be used on infectious healthcare waste (WHO 2005).

Handling and transport of waste

Containers of hazardous healthcare waste should be sealed after treatment and before on-site disposal or prior to loading on to a vehicle for transport off-site. **It is strongly recommended**, **for safety reasons, that healthcare centers applying minimal waste management programmes in areas without adequate treatment facilities should dispose of hazardous healthcare waste within their own premises** (Ibid; WHO 2005). This implies that the treatment, incineration and burial of waste, as well as the location of burial pits, should be in the vicinity of the healthcare center or outbreak patient treatment area to assure control and monitoring, but not in too close proximity to cause concerns for contamination of patients and staff. Burial of human bodies associated with outbreaks of highly pathogenic diseases will be discussed in detail in Chapter 8.

Medical waste bags serve as the primary barriers between waste and the persons handling the waste. Gloves and personal protective equipment appropriate for the category of waste handled should be worn. Waste bags should be securely tied and not shaken, squeezed, compacted, or crushed to make space to add more waste. The bags should be carried by their necks away from the body, not lifted or held by the bottom or sides, and they never should be thrown into receptacles or onto the ground. (U.S. Army Center for Health Promotion and Preventive Medicine 2009).

The transport of general waste must be carried out separately from the collection of hazardous infectious materials to avoid potential cross contamination or mixing of these two main categories of waste. The collection should follow specific routes to reduce the passage of accumulated waste through patient-occupied or clean areas.

If vehicles are used to transport infectious waste, they should be free of sharp edges, easy to load/unload by hand and to clean and disinfect, and be fully enclosed to prevent spillage on facility premises or on the property during transportation. Normally, these vehicles should not be used for other purposes (UNEP-SBC/WHO 2005).

Annex 4 lists suitable treatment and disposal options for different categories of waste.

STEPS 7 AND 8. OFF-SITE TREATMENT AND DISPOSAL

If a rural primary healthcare center has a vehicle and is located within reasonable transportation distance on serviceable roads to a district hospital that operates a legally approved modern waste treatment facility, it could possibly transport infectious wastes there. **Such scenarios are likely to be rare** (WHO 2005).

However, the situation also depends on the arrangements that could be explored for transporting the waste. For example, if supplies are transported to the healthcare center from a district hospital, it could also be planned to transport the waste back to that district hospital for treatment. As noted above, medical centers and outbreak teams in remote areas without access to modern waste disposal facilities must organize and operate their own waste treatment systems using available resources and multiple technical options for sharps, infectious and non-infectious wastes.

Under circumstances involving disease outbreaks, treatment and disposal of infectious waste materials should occur as close as possible to the patient treatment center, while disposal of general solid waste products from healthcare, equipment and various teams' living quarters could be evaluated for reuse, recycling, or any appropriate and environmentally-acceptable disposal method (Prüess 1999; UNEP-SBC/WHO 2005).

Refer to Annex 3 for local alternatives to control access to waste disposal areas. Annex 5 presents a decision-making scenario for waste management options at rural medical centers without access to modern waste disposal facilities. This scenario would also apply to remote disease outbreak sites. Scenarios for urban and peri-urban sites with/without access to modern disposal facilities can also be found in WHO (2005).

METHODS OF WASTE DISPOSAL

Autoclaving. This method involves steam heating of waste material in an enclosed container at high pressure. Small autoclaves are common for sterilization of medical equipment, but a waste management autoclave can be a relatively complex and expensive system and require a high level of operation and maintenance support. Preparation for autoclaving requires waste segregation to remove unsuitable material and shredding to reduce individual pieces to an acceptable size (Johannessen 2000). Large autoclaves for this purpose would not be available at rural clinics or transported to remote disease outbreak sites.

Incineration. As discussed in Chapter 4, medical waste incinerators release a wide variety of pollutants into the air depending on the sophistication of the incinerator and the composition of the waste. These pollutants include particulate matter such as fly ash; heavy metals, acid gases, carbon monoxide, and organic compounds. Pathogens can also be found in the solid residues and in the exhaust of poorly designed and badly operated incinerators. In addition, the bottom ash residues are generally contaminated with leachable organic compounds, such as dioxins, and heavy metals, and have to be treated as hazardous waste (Batterman 2004; Emmanuel 2007).

The trend in many industrialized countries is to move away from incineration towards alternative technologies that do not produce any dioxins. The financial and infrastructure resources needed to purchase, install, and operate these technologies are substantial. In developing-world settings, emission testing is not readily available and is expensive. Determination of dioxins and furans is more difficult. Samples must be shipped for analysis in Europe or the United States.

Some developing countries such as the Philippines and major cities like New Delhi and Buenos Aires have banned or put a moratorium on incinerators. However, the opposite trend is happening in other developing countries in Africa and Asia, with hundreds of incinerators being installed, often with inadequate or no air pollution control. In many cases, these incinerators are brought in through loans or grants from official development aid or international aid agencies (Emmanuel 2007).

> **United Nations Development Programme, GEF Global Healthcare Waste Project**
>
> The Global Environmental Facility (GEF) is funding a healthcare waste management global demonstration project involving the United Nations Development Programme, World Health Organization, Health Care Without Harm, and governmental and non-governmental organizations in eight countries (Argentina, India, Latvia, Lebanon, Philippines, Senegal, Tanzania, and Vietnam). The objective of the project is to demonstrate and promote best practices and technologies for healthcare waste management in order to reduce healthcare waste and decrease and eventually eliminate environmental releases of dioxins and mercury from health care waste incineration.
>
> This involves development and demonstrations of low cost and appropriate locally manufactured technologies for rural areas based on international competition, training and education in best environmental practices and alternative technologies, and building institutional capacity including waste management systems. For further information, see: www.gefmedwaste.org and www.noharm.org.

Incineration is thus most often the method of choice, especially in remote rural areas where simple oil drum and brick incinerators, or burn pits, are commonly used for healthcare waste disposal. This would also be the case during outbreak response activities in remote areas. Residual ashes should be buried as hazardous waste. Annex 6 presents an overview of the types, cost and effectiveness of incinerators and other options for treatment and disposal of healthcare waste under different socio-economic conditions.

Pressurized containers must never be incinerated as they may explode, causing injury to workers and/or damage to equipment. Aerosol cans are not generally recyclable and should be buried in pits or landfills together with general waste. Many undamaged pressurized gas containers, however, may be easily recycled, and should be returned to their original supplier for refilling. (Prüess et al.1999).

Burial of Hazardous Waste. In remote locations, safe burial of waste on healthcare center premises is sometimes the only viable option. A specially constructed small burial pit can be prepared for healthcare waste only. The pit should be 2m deep and filled to a depth of 1-1.5m. Each load of waste should be covered with a soil layer 10-15cm deep. Chloride of lime may be placed over the waste if coverage with soil is not possible. In case of a disease outbreak involving especially virulent pathogens (such as the Ebola virus), both chloride of lime and soil cover should be added. Stronger disinfectants, if available, may be added to each soil layer. Access to this area should be restricted and closely supervised by the responsible staff to prevent scavenging by humans and animals (CDC/WHO 1998; Prüess et al.1999).

To avoid risks of health and of environmental pollution, some basic rules to apply regarding on-site disposal follow:

- waste burial pits should be sited at least 30 meters from any water source;
- access to the disposal site should be restricted to authorized personnel only;
- the burial boundary should be lined with a material of low permeability (e.g. clay), if available;
- only hazardous healthcare waste should be buried;

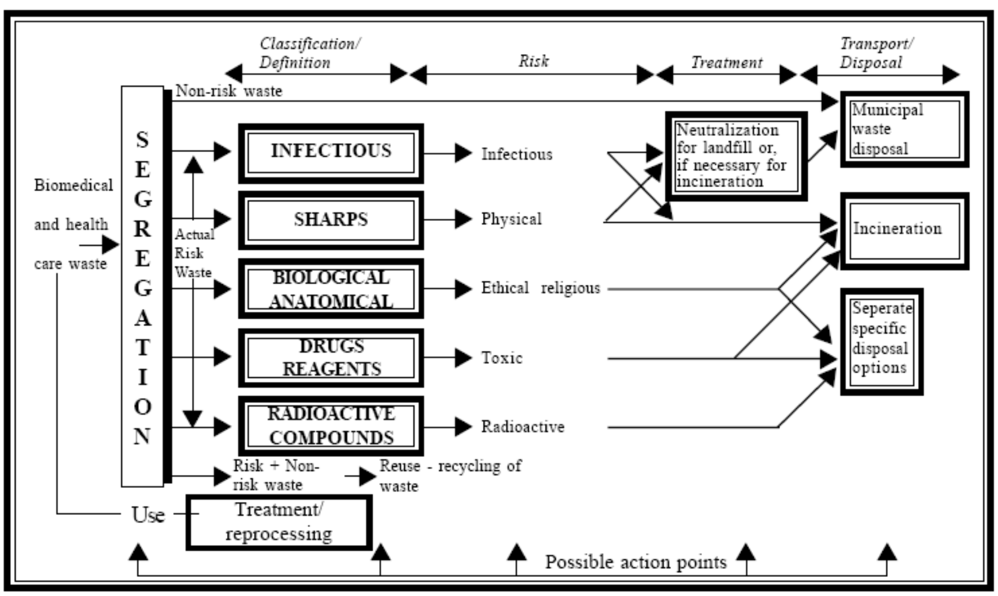
- large quantities (over 1 kg) of chemical wastes should not be buried at the same time; burial should be spread over several days;
- burial pit sites should be managed in the same way as landfills, with each layer of waste being covered with a layer of soil to prevent development of odors and infestation by rodents and insects (Prüess et al.1999).

Burial of human remains and animal carcasses, and their corresponding socio-cultural and economic implications, will be discussed in Chapter 8 on Viral Haemorrhagic Fever outbreaks and in Chapter 9 on the results of an outbreak investigation and response practitioner questionnaire survey.

For additional information on options for waste disposal methods, see Annex 6 for an overview of treatment and disposal methods. More detailed information on these topics is available in Prüess et al. 1999; Johannessen 2000; UNEP-SBC 2003; Batterman 2004; UNDP-SBC/WHO 2005; WHO 2005; and USAID ENCAP Africa Project 2009. Annex 7 presents a list of options for disposal of unwanted pharmaceuticals during and after public health and other types of emergencies.

The recommended ideal process for management of different waste categories, their associated risks, and basic treatment and disposal methods are illustrated in Figure 7.3. As discussed earlier, radioactive compounds would not normally be used at rural health clinics or disease outbreak sites in remote areas.

FIGURE 7.3 HEALTHCARE WASTE MANAGEMENT STRATEGY
(Source: UNEP-SBC 2003, p.3).



SANITATION: WASTEWATER ISSUES

Without proper management, wastewater generated by medical centers and outbreak response teams could contaminate surface water, groundwater, soil, and food by the excreta, chemicals and pathogens they contain. This could result in increased disease transmission associated with excreta (diarrheal, parasitic, etc.), higher infant mortality, reduced economic productivity, other health problems from the use of water contaminated with chemicals and other substances, and degradation of terrestrial and aquatic habitats (USAID ENCAP Africa Project 2009).

Possible causes of wastewater contamination in this situation include:

- failure to use cleaning, washing/bathing and sanitation facilities;
- disposal of excreta or wastewater directly on land or into surface water without adequate treatment;
- improper siting of cleaning, washing/bathing sanitation facilities near water supplies;
- inadequate protection of groundwater;
- improper operation of cleaning, washing/bathing and sanitation facilities;
- failure of cleaning, washing/bathing and sanitation facilities due to lack of maintenance; and
- improper use of wastewater in food production.

In addition, pools of stagnant water form an excellent breeding place for disease vectors such as mosquitoes that carry malaria. They can also increase transmission of water-related diseases, especially when the wet spots are clogged or contaminated with solid waste or excreta (Ibid).

In many emergency situations, it may be judged that the quantity and nature of the wastewater produced do not present a health risk sufficient to justify control activity. In others, efforts to limit the production of wastewater may be sufficient to keep the problem under control. In many situations, however, specific measures are needed to dispose of wastewater.

The simplest technique to control non-infectious wastewater is to construct a “soakaway” (or soakage pit). This is an excavation at least 1.25 meters deep and 1.25 meters wide, filled with stones, that allows water to seep into the surrounding ground. It is sealed from above by an impermeable layer (oiled sacking, plastic or metal) to discourage insect breeding. Wastewater is fed by pipe into the center of the pit (Wisner and Adams 2002).

In emergencies, soakaways may consist simply of pits filled with small stones or gravel into which wastewater is directed. As long as the level of the water in the pit does not rise above the top of the ground, insect breeding is minimal. Soakaways can only dispose of a limited amount of water because they provide a relatively small area of soil surface for infiltration. Infiltration trenches, which are commonly used for disposing of the effluent from septic tanks, overcome this problem through a series of parallel trenches in which perforated pipes are laid in a bed of gravel (Ibid.).

Proper and effective measures to contain, control, and dilute or disinfect hazardous wastewater containing chemicals, body fluids and other pathological waste in a system separate from general wastewater must be taken.

LOCATION OF EMERGENCY SANITATION FACILITIES

The subject of the selection, siting and management of sanitation facilities in relation to waste disposal will be discussed briefly.

Healthcare establishments should ideally be connected to a sewage system. Where there are no sewage systems, technically sound on-site sanitation should be provided, such as the simple pit latrine, ventilated pit latrine, and pour-flush latrine. In temporary field hospitals during disease outbreaks, other options such as chemical toilets may also be considered. In addition, convenient washing facilities (with clean water and soap available) should be available for patients, personnel, and visitors in order to limit the spread of infectious diseases within the healthcare establishment (Prüess et al.1999).

Latrines should be sited at least 30 meters from any water source. If the water extraction point is upstream of the latrine, the distance can be reduced provided that the groundwater is not extracted at such a rate that its flow direction is turned towards the extraction point (Franceys et al. 1992).

In heavily-fissured rock this distance may have to be increased substantially. Because fecal and chemical pollution tend to disperse downslope from their source, latrines should be sited downhill from any groundwater source, particularly if the bottom of the latrine is less than 2 meters above the water table. Latrines should be sited no more than 50 meters from users' shelters, to encourage their use, but sufficiently far away (at least 6 meters) to reduce problems from odors and pests (Wisner and Adams 2002).

Additional information on design, siting criteria, and construction of a variety of sanitation facility types at rural healthcare centers and in emergency conditions can be located in Franceys et al. 1992; Pruess et al. 1999; Wisner and Adams 2002; and USAID ENCAP Africa Project 2009.

CHAPTER 8: DISEASES OF SPECIAL CONCERN: HAEMORRHAGIC FEVERS

As indicated in Chapter 7, infection prevention and control measures (IPC) combined with safe waste management and disposal practices are key components of disease outbreak response activities and routine healthcare practices, especially in rural medical facilities which often serve as sentinels for disease outbreaks.

This chapter will focus on measures necessary to control and contain the spread of infection/contamination during outbreaks of Viral Haemorrhagic Fevers (VHFs), among the most lethal of the diseases of special concern listed in Annex 2 in Chapter 7.

The most recognized VHFs worldwide are the 5 subspecies of Ebola Viral Haemorrhagic Fever: Ebola Zaïre, Ebola Sudan, Ebola Reston, Ebola Côte d'Ivoire, and Ebola Bundibugyo, which, with the 1 species of Marburg Haemorrhagic Fever, comprise the filoviruses of the family Filoviridae. Ebola Reston is not known to cause illness in humans, but is fatal for some species of monkeys (WHO 2009c; CDC Filovirus Fact Sheet, 5 May 2010).

The two species of Ebola and Marburg VHF are serologically, biochemically, and genetically distinct. Marburg virus was first isolated in 1967 during an outbreak in Europe. Ebola virus emerged in 1976 during two simultaneous outbreaks in southern Sudan and northern Zaire, now Democratic Republic of the Congo. The most recent Ebola subspecies discovered, Bundibugyo, emerged in a rural area of western Uganda in 2007 (MacNeil et al. 2010).

Outbreaks of the Ebola and Marburg viruses have steadily increased in frequency in sub-Saharan African countries since their discovery. Human mortality during the Ebola and Marburg VHF epidemics in 12 African countries between 1976 and 2007 ranged from 24% to 90%, and averaged 67% mortality for the 18 Ebola outbreaks and 78% for the 8 Marburg outbreaks (Allaranga et al. 2010).

The blood, urine, vomit, feces, pus, sperm and saliva of patients affected by VHFs are all infectious. The risk of transmission to health workers and community members is high during the provision of health care and preparation for burial of the deceased. Around 9% of reported cases of Ebola and Marburg infections were healthcare workers (Ibid.). Strictly applied infection prevention and control measures and rigorous management of infectious and other waste materials associated with outbreaks of these VHFs are thus of high priority.

Yellow Fever, and the 4 Dengue viruses which cause Dengue Fever and Dengue Haemorrhagic Fever, are also VHFs known to cause widespread and often long-term epidemics in sub-Saharan and Latin American countries, and in Asia, tropical Africa, Indian Ocean islands, the Caribbean and the Americas, respectively (WHO 1997; WHO 2008b; CDC Viral Hemorrhagic Fevers Fact Sheet: www.nc.cdc.gov). Both diseases are transmitted through the bites of infected mosquitoes of the genus *Aedes*. There are many other types of VHFs such as Omsk VHF, Crimean Congo HF and a suite of rodent-borne Arenaviruses which will not be discussed in this chapter. For further information, see the following and related references: CDC Crimean-Congo Haemorrhagic Fever Fact Sheet and Arenavirus Fact Sheet: www.nc.cdc.gov; WHO Dengue fact sheet N°117 March 2009; WHO Yellow Fever fact sheet N°100 January 2011; WHO Marburg haemorrhagic fever fact sheet revised December 2011; and for Ebola Reston VHF: WHO 2009c.

.A demonstration of the highly infectious nature of VHFs is illustrated in the following description of WHO-recommended additional infection control precautions during patient care for diseases with specific modes of transmission.

"Highly virulent diseases **such as haemorrhagic fevers**, in which several routes of transmission are implicated, require absolute (strict) isolation of patients and implementation of the following Infection Prevention and Control measures:

- individual room, in an isolation ward if possible;
- mask, gloves, gowns, cap, eye protection for all entering the room;
- hygienic hand washing at entry to and exit from the room;
- incineration of needles, syringes;
- disinfection of medical instruments;
- incineration of excreta, body fluids, nasopharyngeal secretions;
- disinfection of linen and reusable medical clothing;
- restrict visitors and staff;
- daily disinfection and terminal disinfection at the end of the stay;
- use of disposable (single-use) equipment;
- appropriate transport and laboratory management of patient specimens".

(Source: Ducel et al. 2002, page.45).

Table 8.1 presents a selection of recommendations proposed by the CDC, WHO and various outbreak response teams and public health specialists in regard to aspects of VHF case management and fundamental IPC measures in rural settings, as well as response coordination and management during VHF epidemics. The joint CDC/WHO manual (1998) addresses the use of VHF infection prevention and control measures to reduce the transmission of VHFs in rural health facilities or any health facility with limited resources, based on experience during Ebola and Marburg VHF outbreaks in African countries.

The WHO (2008c) document provides a summary of interim infection control recommendations for clinical and non-clinical healthcare-related personnel providing direct and non-direct care to suspected or confirmed VHF patients, pending further updates. The additional references include publications on management of clinical cases, solid and liquid waste, and burial of human remains, and vector control practices from actual outbreaks of Ebola, Marburg and Dengue VHFs. Included in Table 1 is mention of the efficacy of a decentralized system for local disposal of medical waste in rural areas of Indonesia with transport limitations and long distances between health centers and existing incinerators, but adequate land available for incineration, burning and/or burying waste materials (PATH 2005b).

TABLE 8.1. A SELECTION OF GENERAL AND FIELD REPORT RECOMMENDATIONS FOR INFECTION PREVENTION AND CONTROL DURING OUTBREAKS OF VIRAL HAEMORRHAGIC FEVERS. OUTBREAK LOCATIONS AND ASSOCIATED REFERENCES ARE IN PARENTHESES FOLLOWING EACH RECOMMENDATION.

VHF IPC* Issue	General IPC and Management Recommendations	Outbreak Response Report IPC Recommendations/Comments
General Personal Protection	For patient care, wear double gloves, disposable impermeable gown, waterproof apron over non-impermeable gown, medical mask and goggles or face shield, closed resistant shoes (e.g. boots). (WHO 2008c). --------------------------------------- All healthcare staff and workers, non-clinical support staff, all laboratory and support staff, burial teams, and family members who care for VHF patients must wear PPE. (CDC/WHO 1998).	Reduce the risk of contamination of health care workers, burial teams, hygiene and sanitation teams and all supporting staff by the proper use of PPE and enforcement of universal IPC measures (Gabon, Congo-Nkoghe et al. 2004, 2005, 2011; Congo-Boumandouki et al. 2005; Formenty et al.2005. -- Health workers and those at risk of infection (burial and skin biopsy teams, care takers) should be provided with adequate protective materials (masks, gloves, plastic aprons, boots and head wear). (Uganda-Lamunu et al. 2003).
Isolation Center Management	Employ standard hand hygiene practices before and after patient care, after removal of PPE, and after touching potentially contaminated surfaces; no movement of VHF-isolation staff to other clinical areas (WHO 2008c). --------------------------------------- Use sprayer/bucket/shallow pan with 1:100 bleach solution for disinfecting boots; place a towel soaked in 1:100 bleach solution on the floor for staff to stand on when removing boots; use a separate bucket/pan of 1:100 bleach solution for disinfecting gloved hands (CDC/WHO 1998). --------------------------------------- Cover patient mattresses or sleeping mats with plastic sheeting to protect against contamination; the plastic can be easily cleaned and disinfected if contaminated with infectious body fluids. (CDC/WHO 1998).	Outbreak isolation centers are stigmatized and called “houses of death” by affected communities; people refuse medical care there after epidemics; isolation centers should be rehabilitated after epidemics (furniture repair, painting, etc.) accompanied by psychological, social, and health education programs in the communities (Gabon and Congo-Formenty et al. 2004). -- Poor attention to infection control was a common observation in many rural health units. Proper management of hospital waste must be taken more seriously than before; the principle of isolation of cases proved useful but sometimes gave false confidence to health workers; it was not unusual to detect occasional new cases in the general wards; risk assessment and intensive sensitization about risks to healthcare and supporting staff are vital (Uganda-Okware et al. 2002). -- Epidemics are rapidly controlled once healthcare workers put in place protective measures while treating their patients (Allaranga et al. 2010).
Contaminated Sharp Objects	Limit use of needles and other sharps as possible; never recap used needles, remove used needles by hand, or re-use syringes or needles; put used sharps in	Handle needles and other pointed/sharp instruments with care ; do not recap syringes, place them in waste containers; (Gabon-Nkoghe et al. 2004)

VHF IPC* Issue	General IPC and Management Recommendations	Outbreak Response Report IPC Recommendations/Comments
	puncture-resistant containers to ¾ full only (WHO 2008c) -- Limit invasive procedures to reduce number of injectable medications; disposable needles and syringes should be used only once; if puncture-resistant containers are not available, use empty water, oil, or bleach bottles made with plastic or other burnable material; burn containers in incinerator or burning pit. (CDC/WHO 1998).	-- Orally-administered medications are preferable to injections to avoid potential for patient haemorrhaging during Ebola VHF outbreaks. (Gabon-Nkoghe et al. 2004). -- Limit all invasive procedures (injections, incisions, etc.) as much as possible to prevent haemorrhaging and reduce the number of contaminated sharps (Congo-Nkoghe et al. 2005).
Field Diagnostic Laboratory	Personnel handling specimens must wear gown, gloves, respirators and eye protection/face shields during aerosol-generating procedures; perform hand hygiene after PPE removal and contact with contaminated surfaces; place specimens in labeled non-glass leak-proof containers at handling areas; disinfect external surfaces of specimen containers before transport (e.g. 0.05% bleach at 1:100 solution). (WHO 2008c). -- When a VHF case occurs, limit work on VHF samples to one laboratory staff person who will do all testing of body fluids from patients; make sure the designated person knows when and how to use protective clothing and safely disinfect spills and waste. (CDC/WHO 1998).	Two deployed well-equipped field laboratory teams were invaluable in providing on-site diagnoses of suspect cases during triage and greatly improved the quality of the response to the outbreak; (Congo-Boumandouki et al. 2005). -- The availability of a temporary field laboratory helped with confirmation of cases within 24 hours; this facilitated the early isolation of non-cases from true cases, thus reducing risks of nosocomial infection; it also helped to identify non-infectious patients and those eligible for discharge (Uganda-Okware et al. 2002).
Cleaning, Disinfection, and Vector Control Methods	Clean then disinfect contaminated surfaces and objects with standard detergents and disinfectants; do not spray clinical areas with disinfectants; wear full PPE when cleaning heavily soiled surfaces; put soiled linens in marked leak-proof bags or buckets at site of use; burn linen if safe cleaning and disinfection are not possible. (WHO 2008c). -- Viruses causing VHF are very sensitive to disinfectant bleach solution; use 1:10 bleach solution to disinfect excreta and bodies; use 1:100 bleach solution to disinfect surfaces, medical equipment, patient bedding, reusable protective clothing before laundering, for rinsing gloves between contact with patients, for rinsing gloves, apron, and boots before leaving patient rooms, and for disinfecting contaminated waste for disposal; scrub contaminated items with soap and clean water before disinfection; if autoclave or steam sterilizer	Use bleach (sodium or calcium hypochlorite), 70% alcohol solution, boiling, or autoclave for disinfection; use bleach of 5% initial concentration in a solution of 1:100 to disinfect soiled gloved hands, walls, floors, bedding, and mattresses; depending on the material to disinfect, wait from 30 seconds to 30 minutes for complete disinfection, followed by washing with clean water and soap. (Gabon-Nkoghe et al. 2004). -- Cover mattresses with plastic sheeting, if possible; disinfect and burn mattresses heavily soiled with infectious liquid waste (Gabon-Nkoghe et al. 2005a). -- Emergency control measures during Dengue Fever outbreaks are mainly based on large-scale applications of insecticides; the most effective means of vector control is environmental management to reduce human-vector

VHF IPC* Issue	General IPC and Management Recommendations	Outbreak Response Report IPC Recommendations/Comments
	not available, boil items in water for 20 minutes to kill VHF. (CDC/WHO 1998).	contact via improved water supply and storage methods, better solid waste management, and modification of man-made larval habitats (WHO 1997).
Waste Management	Waste should be triaged for safe handling; put tissue and body fluids in labeled sealed containers for incineration; put all sharps and tubing in puncture-resistant containers near place of use; collect solid, non-sharp medical waste in leak-proof bags and covered bins; wear gloves, gown and boots to handle solid infectious waste. (WHO 2008c). -- Discard used gloves and used disposable gowns and masks in a bucket for disposal of contaminated waste; provide containers with 1:100 bleach solution for collecting infectious waste in clinical areas; disinfect spills of infectious body fluids and remove with cloth soaked with 1:100 bleach solution; dispose of body fluids waste (secretions and excretions) and liquid washing-waste in sanitary sewer or pit latrine for VHF cases; place containers of 1:100 bleach solution in patient rooms to collect infectious waste, contaminated items, and non-reusable supplies that will be burned.(CDC/WHO 1998).	Place infectious waste and one-use materials and instruments in container of 1:100 bleach solution; remove after 30 minutes and dry before burning ; use 1:10 bleach solution for excreta; spread solution around the area soiled by excreta, then remove waste with a mop cloth soaked in bleach and dispose in isolation unit latrine. (Gabon-Nkoghe et al. 2004) -- Healthcare workers from the local clinic and Red Cross volunteers were trained in protected care techniques, safe burial, and disinfection. The same team was responsible for hygiene in the isolation ward, safe burial, and disinfection of the houses of cases and fatalities (Congo-Nkoghe et al. 2011).
Final Disposal: Burn Pit or Incinerator	Prevent entry to pit by animals and humans; pit should be 2m-deep and filled to 1.5m; each waste load should be covered by 10-15cm of soil; incinerate solid waste only for short periods; put placenta and anatomical samples in separate pit;; wear gloves, gown, boots and facial protection; avoid splashing liquid waste. (WHO 2008c). -- Burning is recommended for disposal of non-liquid VHF-contaminated waste; burning waste in an incinerator or a pit is a safe and inexpensive disposal system; use fuel to accelerate burning and ensure destruction of all waste; burning is recommended for disposal of needles/syringes, used treatment materials/dressings, non-reusable protective clothing, laboratory supplies, and biological samples; if no latrine pit available, burn disinfected infectious waste and used disinfectants in pit; move waste frequently while burning to be sure all items burn completely; burning should be carried out at least daily; if using incinerator, bury ashes in pit; secure access to disposal site; close	Waste containers should be handled and transported only by persons responsible and trained for this work; they must wear appropriate PPE; waste should be transported exterior to the patient care zone and placed in an incinerator or pit; waste should be destroyed daily by burning with gasoline. (Gabon-Nkoghe et al. 2004) -- Small-scale incinerators work effectively in treating medical waste without causing environmental problems. Reliable transport without dedicated vehicles remains a challenge, especially for more remote health centers. Locally produced mini-incinerators offer good potential for waste destruction without transport for remote sites (Indonesia-PATH 2005b).

VHF IPC* Issue	General IPC and Management Recommendations	Outbreak Response Report IPC Recommendations/Comments
	pit when it can be covered by ½ meter of soil.(CDC/WHO 1998).	
Burial of Human Remains	Do not spray, wash, or embalm bodies; burial team should be in full PPE during body collection and placement in body bag; wrap remains in sealed leak-proof material; bury promptly. (WHO 2008c). -- Wear PPE recommended for patient isolation staff; use thick rubber gloves as the second pair of gloves; place body in body bag and close securely; spray body bag with 1:10 bleach solution; transport body to burial site promptly; the grave should be 2m deep; disinfect area of vehicle in which body was transported. (CDC/WHO 1998).	Dead bodies remain contagious for several weeks; explain the importance of rapid burial to families of deceased persons; burial teams must wear PPE; bodies and adjacent surfaces should be disinfected with 1:10 bleach solution, then placed in body bags sprinkled with sodium hypochlorite interiorly; allow families of deceased to practice burial customs without touching the bodies (Gabon-Nkoghe et al. 2004). --- Burial teams should respect IPC protocol while allowing permissible traditional funeral rites to occur and family members to be present at burial site, if possible (Congo-Boumandouki et al. 2005). --- Pay local artisans to make coffins for placement of body bags as additional IPC security measure (Congo-Boumandouki et al. 2005). --- Respect the social significance of burials, which must involve IPC practices, but should be organized as funereal ceremonies of respect for the dead; do not use transparent body bags; use stretchers to carry bodies; burials should be in public cemeteries, not behind homes or at medical centers; the risk of infection in families is higher when people die at home (Gabon/Congo Formenty et al. 2004). --- Burial teams were established for safe burial of the dead in a designated cemetery created for this purpose. This was necessary to avoid hazardous traditional practices such as cleansing the bodies of the deceased; burial in cemeteries away from home contradicted tradition and was only accepted after extensive counseling. (Uganda-Okware et al. 2002). -- Burial teams were comprised of volunteers from the army, police, hospital staff, District Directorate of Health Services staff, and the community; burial teams buried the dead in the community

VHF IPC* Issue	General IPC and Management Recommendations	Outbreak Response Report IPC Recommendations/Comments
		after taking skin snips and/or performing a cardiac puncture for laboratory confirmation (Uganda-Lamunu et al. 2003).
Socio-cultural Sensitivities: Contaminated Property of Patients and Other Issues	Decontaminate bedding, possessions, and residences of recovered and deceased patients; burn only if absolutely necessary, depending on the type and extent of contamination (CDC/WHO 1998; WHO 2008c).	Do not burn deceased persons' properties designated for grave site homage; disinfect well and place them in the coffin, or in or on top of the grave (Gabon/Congo Formenty et al. 2004; Congo-Boumandouki et al. 2005); -- The victims' personal belongings were burnt, and bush meat was forbidden, even though it was the main source of protein. Provision of alternative food sources during outbreaks might help to ensure that infection control measures are respected (Congo-Nkoghe et al. 2011).
Refusal of Hospitalization-Home Care of Sick Persons	If families assist with patient care, provide appropriate training, PPE, 1:100 bleach solution, and soap and water for designated caregiver to wash patient eating utensils; wash utensils, rinse in 1:100 bleach solution, let utensils air-dry; provide instruction to caregiver on hand-washing, decontamination of surfaces, careful laundering of clothes, bedding, and other home infection control measures such as isolating the sick person in a separate corner of the house. (CDC/WHO 1998).	A strategy of "reduction of risks of transmission at home" was adopted to allow for care and monitoring of patients at home whose families did not want to release them to hospital care. All IPC precautions were taken and PPE materials were supplied to minimize risks to families. **Home care should only be a strategy of exception** (Congo-Boumandouki et al. 2005). -- Local beliefs about infectious diseases and perceptions of health services in affected communities can constitute barriers to acceptance of hospitalization; although home care is not a good strategy to stop transmission, it must be allowed while working to convince families to release suspect cases (Gabon and Congo-Formenty et al. 2004). -- Family members who assist suspect cases at home should be informed of protection methods and provided with protection equipment (gloves, bleach) (Allaranga et al. 2010).

* Infection Prevention and Control

The practical guidelines and recommendations in Table 8.1 attest to the highly pathogenic and contagious nature of VHFs, and the associated high risk of person-to-person and nosocomial transmission, as well as risk from contaminated objects and materials. Management and disposal of waste generated during outbreaks of VHFs is extremely hazardous and requires strictly implemented personal protection practices, appropriate types and use of equipment, and meticulously applied waste collection, disinfection and disposal measures.

Nonetheless, the methods, materials and equipment used to control outbreaks of VHFs are fundamental to outbreak response protocols for many diseases. Treatment for VHFs is essentially supportive to the general symptoms, as no precise medications exist, and there are currently no vaccines available for public use. Aside from the standard PPE items, drugs and other medical supplies and equipment which would be used by healthcare staff during outbreaks, the other supplies mentioned are common low-cost items, such as household bleach, soap, water, cotton cloth, and plastic sheeting. The latter can replace plastic body bags if none are available and double or triple labeled garbage bags can replace color-coded bags if necessary. Infectious waste can be safely destroyed in simple brick or oil drum incinerators, or burn pits if the latter materials are not available, and toxic residual ashes should be covered with soil.

The waste disposal teams indicated in Table 8.1 were also responsible for disinfection of isolation wards, laboratory premises, private possessions and homes, as well as safe burial of human remains. These tasks all have associated risks and the socio-cultural connotations of burials must be addressed prior to, during, and after the burial process. Where home care occurs, families must be trained in daily use of PPE and disinfectants, and waste disposal teams would assure the disposal of these items.

If the basic step-by-step procedures are followed for disposing of contaminated waste, preparing bodies of deceased patients for burial, and preventing disease transmission through contact with suspect, confirmed and deceased patients, the persons responsible for the assurance of waste management, and by association, infection prevention and control beyond patient care centers, will securely fulfill their duties.

As a complement to the Best Practice measures for outbreaks of Viral Haemorrhagic Fevers discussed in the present chapter, the following chapter will focus on the results of a questionnaire survey administered to multi-disciplinary practitioners with experience in disease outbreak investigations and response.

CHAPTER 9: BEST PRACTICES FOR WASTE MANAGEMENT AT DISEASE OUTBREAK SITES. RESULTS OF A PRACTITIONER QUESTIONNAIRE SURVEY

As a complement to the bibliographic research undertaken on the topic of best practices for disposal of medical, hazardous and general waste products associated with routine and outbreak-related healthcare in remote areas, a questionnaire was developed for practitioners to identify practical adaptive measures and the principal problems encountered in the field during outbreaks (Annexes 8 and 10).

Eighteen professionals in the fields of public health, veterinary medicine, and the biological sciences were invited to participate in the questionnaire survey which was administered via electronic mail or verbally, depending on locations and circumstances. The eleven persons from four countries who were able to participate have experience in outbreak investigations and/or response and are engaged in the following professions:

- Veterinary Medicine
- Veterinary epidemiologist (3 persons);
- Veterinarian (2 persons);
- Veterinarian specialist in poultry (1 person).
- Human Health
- Physician/Epidemiologist (3 persons).
- Biological Sciences
- Wildlife biologist (1 person);
- Medical microbiologist (1 person).

The eleven respondents are associated with diverse institutions, organizations and programmes, including government ministries, universities and an international health-oriented project. The professional affiliations and corresponding number of respondents are presented in Table 9.1

TABLE 9.1. ASSOCIATIONS OF THE 11 QUESTIONNAIRE RESPONDENTS: NUMBER AND TYPE OF AFFILIATION AND NUMBER OF PERSONS PER AFFILIATED INSTITUTION, ORGANIZATION OR PROGRAMME.

No. of Associations	Affiliations of Questionnaire Respondents	No. of Persons
1	African government National Biomedical Research Laboratory	1
1	African government Ministry of Livestock Development	1
1	African government Ministry of Agriculture and Animal Health	1
1	African government Ministry of Public Health	2
2	African universities in two countries	2
2	United States universities	2
1	USAID-funded international health programme	2
Total 9		11

The eleven questionnaire respondents have considerable experience in disease outbreak investigation and response activities and have collaborated in the field with other team members as integrated components of coordinated outbreak control and management teams. As discussed in Chapter 5, these are comprised of surveillance, investigation, clinical case management, infection prevention and control, social mobilization, logistics, and hygiene and sanitation subcomponents. The respondents' collective field experience includes interventions in outbreaks of 23 diseases in six African countries, Canada, Great Britain, and the United States, as described in Table 9.2.

TABLE 9.2. QUESTIONNAIRE RESPONDENTS' EXPERIENCE IN OUTBREAKS OF 23 DISEASES: TYPES OF DISEASES IMPLICATED IN OUTBREAKS AND NUMBER OF RESPONDENTS WITH FIELD EXPERIENCE IN OUTBREAKS OF EACH TYPE OF DISEASE.

No. of Diseases	Diseases implicated in Outbreaks	No of Persons with experience
1	Acute Respiratory Infection	1
2	African Swine Fever	1
3	African Trypanosomiasis	1
4	Anthrax	1
5	Avian Influenza (Low pathogenic)	3
6	Avian Influenza (Highly pathogenic)	2
7	Cholera	3
8	Dengue Fever	1
9	Ebola Haemorrhagic Fever	2
10	Exotic Newcastle Disease	3
11	Foot & Mouth Disease	1
12	Infectious Laryngotracheitis	2
13	Marburg Haemorrhagic Fever	2
14	Meningococcal Disease	1
15	Measles	2
16	Monkeypox	3
17	Peste des Petits Ruminants	3

No. of Diseases	Diseases implicated in Outbreaks	No of Persons with experience
18	Rift Valley Fever	2
19	Salmonellosis	1
20	Shigellosis Dysentery	1
21	Typhoid Fever	1
22	Whooping Cough	1
23	Yellow Fever	3

The identities, opinions and comments of all respondents will remain anonymous in the following sections as a professional courtesy and to prevent conflicts of interest.

RESPONSIBILITY FOR WASTE MANAGEMENT DURING OUTBREAKS

Responses regarding the supervision of general waste management during outbreaks, including disinfection and disposal, varied according to the disease type (human or animal), local conditions, and financial and material circumstances. Three respondents involved in outbreaks in resource-poor countries stated that no one person or team was responsible for the proper disposal of all waste materials generated during outbreak investigation and response activities. For one of the latter, a small district hospital in a remote region was described as being totally unprepared to accommodate outbreak patients. It had no incinerator or isolation ward, was greatly lacking in PPE, and the hospital staff needed training in basic hygiene and sanitation practices. The stretcher on which one patient with an infectious disease was carried was left outside the facility to be touched and reused for other patients. In other circumstances, personnel of the government hygiene service or a designated nurse from the local medical facility or the outbreak response team were responsible for supervising and controlling waste management during outbreaks.

The scenario for infection prevention and waste management is more complicated for disease outbreaks involving humans because patients are either transported to the closest medical facilities which are modified for use during outbreaks or other structures may be used temporarily as isolation wards. This and the fact that large numbers of supporting staff may be involved create opportunities for the generation of large amounts of all kinds of waste and thus complicate management efforts in situations lacking strong coordination. In refugee camps, separate medical care tents are designated for multiple purposes. For example, during a cholera outbreak in a refugee camp, health teams employed and trained local workers to manage all waste materials.

For diseases involving animals, those afflicted are most often treated and/or disposed of onsite in breeding or housing facilities or in the field (pastures or in natural habitats), thereby avoiding the additional burden of contaminating other facilities. Respondents stated that government veterinary services in most countries were responsible overall for waste management during disease outbreaks and that usually a veterinarian and a veterinary technician supervised this task.

During Highly Pathogenic Avian Influenza (HPAI) epidemics involving large numbers of poultry, leaders of the culling/disposal teams were responsible for the destruction, disinfection and disposal of affected birds at breeding facilities, live markets and community residences. For Foot & Mouth disease epidemics in Great Britain, local district councils hired contractors to burn and bury the affected cattle, but in more recent years, these activities have been overseen by the military. Concerning Anthrax outbreaks in wild bison herds in Canada, either the National Park Authority or the Provincial Wildlife Department (inside or outside the park, respectively) was responsible for engaging firefighting teams to burn carcasses. The primary sign of Anthrax is sudden death, so the immediate problem is carcass disposal, getting herds out of fields where deaths occurred, and treating them with antibiotics to catch incubating infections or vaccinate them. Blood-contaminated bedding or soil must be collected and burned with carcasses or buried with them, preferably after chemical disinfection, so there was no actual problem with "general refuse".

RESPONSIBILITY FOR BURIAL OF HUMANS AND ANIMALS

Many factors and actors affect the selection of persons to be held responsible for safe burial of human remains and animal carcasses. In refugee camps in East Africa, the local public health and/or sanitary authority were responsible overall for the proper burial and disposal of deceased persons. In some countries where international medical non-governmental organizations (NGOs) intervene in disease epidemics, the National Red Cross or Medecins sans Frontières teams coordinate with national outbreak response teams to assure safe transport and burial of epidemic victims. Regarding cases of infectious but less lethal diseases such as Monkeypox, staff members from district or local medical facilities supervised and coordinated burials with families of the deceased to prevent continued infection by means of unprotected contact with dead bodies.

During Anthrax outbreaks in the United States, the ranch owners were responsible for disposal of carcasses. This caused difficulty if ranchers were not experienced in this task as carcasses were sometimes left to rot, leaving opportunities for birds and mammals to scavenge the infected carcasses. Preventing birds of prey, foxes, bears, wolves and coyotes from scavenging carcasses was also an important issue to address when burying cattle and bison which died from Foot & Mouth disease in Great Britain and Anthrax in Canada, respectively. As noted earlier, district councils hired contractors to dispose of cattle, and in later years, the military took charge of this task during Foot & Mouth disease outbreaks, and either the Canadian National Park Authority or the Provincial Wildlife Department assured destruction and burial of affected bison

In contrast, farmers, herders, and communities, in coordination with local veterinary agents, were held responsible for the burial of cattle, camels, sheep and goat carcasses from outbreaks of Rift Valley Fever, Peste des Petits Ruminants, African Swine Fever, and African Trypanosomiasis in some African countries, often with minimal available financial and technical resources. In Nigeria, where Veterinary Services Rapid Response Teams were formed with international aid to combat large-scale HPAI epidemics, the associated culling and disposal team(s) carried out this task.

Financial aid is available in most developed countries for assistance in disasters and medical emergencies. During a large epizootic of Exotic Newcastle Disease in the United States in 1971-73, in which the disease was confirmed to be airborne, entire poultry sheds were gassed after which the dead birds and litter were removed and buried, followed by the cleaning and disinfection of the buildings. The operations were coordinated by state and federal governments. The eradication program severely disrupted the operations of many poultry producers and increased the prices of poultry and poultry products to consumers

WASTE MANAGEMENT PLANNING FOR DISEASE OUTBREAKS

Most of the respondents expressed awareness of the standard recommended methods and protocols of the WHO and/or the OIE (World Animal Health Organization) for waste management and disposal at small rural healthcare and veterinary facilities and during disease outbreaks. They emphasized the importance of respecting the rules of bio-security by wearing PPE, collecting waste and performing triage according to the nature of waste materials, placing waste in different receptacles/ containers, and transporting waste for other treatment before disposal. For those working in the most resource-poor and remote conditions, the basic methodology to prevent infection and manage healthcare waste was described as the following, founded on 3 key actions:

- Wear appropriate PPE, boots and thick gloves;
- Separate and disinfect infectious waste with bleach solution; and
- Incinerate and bury the waste.

Despite having knowledge of international standards and protocols for waste management, some developing countries do not have national waste management plans and procedures, or the plans may exist but they are not applied. In one case, a respondent said that international standards did not yet exist in the 1980s when he was involved in outbreak investigation and response activities in 3 African countries, so there was no written plan to follow, but basic triage, disinfection and incineration or burial of waste were accomplished.

Sometimes the problem stems not from lack of training, but mainly from a lack of the necessary financial support from governments to fulfill the needs for PPE, disinfectants, waste containers, and simple locally fabricated oil drum or brick incinerators. In West Africa, an internationally-funded HPAI project had a medical waste/carcass disposal manual as well as an environmental waste management manual consistent with WHO standards.

One respondent frankly stated that outbreak waste management planning and implementation in complete accordance with WHO and OIE standards was more often not the norm for developing countries, unless there was substantial international aid and intervention, but following the basic 3-action methodology outlined above is the goal. A second respondent declared that international waste management standards are followed more or less, according to local conditions, in non-developing countries.

In summary, applying waste management plans, if developed, according to WHO/OIE standard international regulations, including waste minimization, segregation, collection, transport, storage, and disposal for all categories of liquid and solid waste materials remains problematic for routine medical care and emergencies in many less economically-developed countries which continue to rely on international financial and technical assistance for all forms of human and animal emergency medical care.

ON-SITE ADAPTIVE WASTE MANAGEMENT AND DISPOSAL PRACTICES

According to the respondents, myriad factors including the type of disease implicated, the availability of appropriate supplies, equipment and trained personnel, and the social, economic and ecological conditions at outbreak sites all affect the decisions about, and subsequent approaches to, waste management (Table 9.3).

The extremely sensitive issue of obtaining approval of burial pit and grave site locations from communities and local authorities was raised in relation to Cholera epidemics in refugee camps, where infection control and hygiene issues were a priority, but neglect of the local context and customs could be costly in terms of local cooperation and effectiveness of outbreak control and management.

In regard to highly virulent and infectious diseases such as VHFs, and the less lethal Monkeypox, the basic waste strategy utilized was to segregate the different wastes to the greatest degree possible in different bags, place sharps in separate closed containers, disinfect all infected waste and place it in a deep pit, then burn and cover the ashes with a layer of soil. If fuel is not available for burning, put dry leaves and grass on the waste and light a fire. Thus, separation of waste materials, decontamination, and burning were cited as the most effective and practical means of preventing and controlling infection in resource-poor areas.

TABLE 9.3. EXAMPLES OF METHODS OF WASTE MANAGEMENT AND DISPOSAL EMPLOYED DURING OUTBREAK INVESTIGATIONS AND RESPONSE, IN RELATION TO LOCAL CONDITIONS AND SPECIFIC DISEASES.

Disease implicated in Outbreak	Specific Management Practices employed during/after Investigations and Response
Cholera in refugee camps	Ensure that burial sites are approved by administrative and traditional authorities and that graves and buried contaminated waste are not adjacent to water supplies and sources.
Viral Haemorrhagic Fevers, Typhoid Fever, Shigellosis	Basic waste disposal strategy: triage all waste in separate bags, with sharps in some kind of closed separate containers, dig a deep pit; place the waste in the pit, burn it, cover each ash layer well with soil.
Viral Haemorrhagic Fevers, Monkeypox	Basic waste disposal strategy: collect the waste; disinfect the infectious waste; incinerate the waste in a place prepared for this purpose (a pit doused with gasoline or if not available, place dry wood and leaves on top and light fire; prevent access of people and animals to the pit; when the pit is ¾ full, and after all incineration of waste, close the pit with sufficient soil.
Respiratory infections, Measles, H_1N_1 Influenza	After investigations and research, used triage method to separate waste materials into different garbage bags; the local sanitation team burned and buried the bags.
Foot & Mouth Disease and Anthrax in Domestic and Wild Animals	The actual strategies employed depend on the status of local facilities to assist in interventions, availability of fuel and digging equipment, quality and depth of soil (rocks, clay, etc.) and climatic factors. The primary aim is to dispose of carcasses by burning and placing contaminated bedding and soil on top of burning carcasses. There are usually not enough chemicals to disinfect soils. Secondary response: bury carcasses at least 2m deep; it is suggested to use chloride of lime to cover carcasses, but agricultural lime is too often used. At all times, discourage wild scavengers from opening carcasses.
Avian Influenza, Peste des Petits Ruminants, African Trypanosomiasis	During/after epidemiological investigations, the management of waste concerned mainly destruction of specimen collection materials by disinfection and burial, plus burning used PPE.
African Swine Fever, Peste des Petits Ruminants	Waste management activities mainly focused on carcass disposal by burning and burial with no concerted efforts at decontamination of litter, garbage, animal housing, etc. Available funding, supplies and equipment were inadequate for these outbreaks.
Highly Pathogenic Avian Influenza (HPAI)	For HPAI-infected developing countries, burial of dead poultry was the disposal method of choice, followed by burning carcasses. This was not always done under any guidelines and many did not take the height of the water table into consideration. In the United States, in-house composting and transport of birds to renderers

Disease implicated in Outbreak	Specific Management Practices employed during/after Investigations and Response
	and landfills were common.
Highly Pathogenic Avian Influenza	The waste management and disposal options depended on the locations of HPAI outbreaks. Where water tables were low, burial was used for poultry carcasses. In regions with high water tables, especially in riverine areas, open air burning was employed. Generally, the methods used were: onsite burial of carcasses, open air burning, and use of local incinerators (mostly near live bird markets).

Managing carcass disposal during outbreaks of diseases involving medium to large-sized domestic and wild animals such as Foot & Mouth Disease and Anthrax proved to be challenging in many respects. Local environmental characteristics such as soil type, presence of rocks, and the height of the water table affect the time and effort required to complete the task of carcass disposal. Other factors include the availability of personnel, tools and/or machinery for digging sufficiently deep and large pits, and disinfectants and fuel to complete treatment and disposal. The minimal procedures to achieve the task were described as burning carcasses and associated potentially contaminated soils and bedding in pits, bury the carcasses, and prevent wild scavengers at all times from access to the carcasses. This could also include domestic carnivorous animals such as dogs and cats.

The main focus for waste management during outbreaks of African Swine Fever and Peste des Petits Ruminants in pigs, sheep and goats in rural areas where appropriate funding, supplies and equipment were inadequate was to dispose of the carcasses as quickly as possible by burial, preceded by disinfection, if possible. There often was little to no disinfectant for decontaminating soils, animal litter, and associated materials. The essentials were accomplished with what was available.

In developing countries affected by HPAI, dead poultry were most often disposed of via burial in deep pits, followed by open-air burning in pits and lastly use of local incinerators which were mainly near live bird markets.

The importance of considering local environmental variables was learned in one African country after large numbers of chickens were buried at lowland sites with high water tables and/or adjacent wetlands, resulting in the contamination of surrounding surface areas and water sources. In the latter cases, it was later decided to employ open-air burning, as it was not possible to transport large numbers of birds to other areas for disposal. The in-house composting method for poultry carcasses, as used in the United States, is not yet used in most developing countries during HPAI epidemics mainly due to lack of heavy equipment to periodically turn the composting birds and safety concerns for people and animals scavenging carcasses.

CONSTRAINTS ON THE IMPLEMENTATION OF WASTE MANAGEMENT AND DISPOSAL DURING DISEASE OUTBREAK INVESTIGATIONS AND RESPONSE

The eleven respondents mentioned numerous constraints, not only on the implementation of waste management and disposal during outbreaks, but also on general preparedness for outbreak investigation and response. These constraints relate to seven major topics: overall government support for disease outbreaks, national planning and budgeting, infrastructure, supplies and equipment, personnel issues, affected communities, and ecological and climatic factors (Table 9.4).

GOVERNMENT SUPPORT

Health in general may not a high priority for some governments, resulting in a perceived lack of initiative to undertake national public health preparedness assessments and establish or improve corresponding surveillance and reporting networks, and essential teams, equipment and supplies. Even less attention may be given to the importance of supporting disease outbreaks in domestic and wild animals.

PLANNING AND BUDGETING

There outbreak management plans exist, the waste management and disposal component is not considered a priority or there may be insufficient funds to support a realistic budget for waste management. Consequently, some countries have little expertise in this topic and rely on national and international relief NGOs to contend with waste disposal during outbreaks. In addition, insufficient or even no funds may be allocated to reimburse farmers for the destruction of poultry during HPAI epidemics and for livestock following outbreaks of diseases such as African Swine Fever, Peste des Petits Ruminants, and Anthrax.

INFRASTRUCTURE

Conditions at many rural health centers are poor in terms of structural quality, hygienic and sanitation amenities and practices, and essential equipment and supplies for purposes of routine medical care, as well as potential disease outbreaks. The methods and means of waste disposal at many of these facilities are rudimentary at best, posing significant risks for underreporting of potentially serious cases, possible flare-ups of nosocomial infections, and incapacity to implement indispensable first response efforts, or provide enabling environments for arriving outbreak investigation and response teams.

TABLE 9.4. MAJOR ISSUES CITED AS CONSTRAINTS TO EFFECTIVE INVESTIGATION AND MANAGEMENT OF DISEASE OUTBREAKS, INCLUDING MANAGEMENT AND DISPOSAL OF WASTE.

Subject of Concern	Constraints to Safe Waste Management and Disposal
Government Support for Outbreaks	a) The government does little in terms of preparation and waits for exterior partners such as the CDC, WHO and OIE to intervene technically and financially when disease outbreaks occur; b) Absence of government engagement in supporting epidemiological investigations for disease outbreaks in animals;
Planning and Budgeting	a) Waste management is forgotten in epidemic management planning in some countries, resulting in little national expertise on this subject; b) There is no budget for management of waste materials during outbreak response. It is most often taken charge of by NGOs assisting in response; c) There is often inadequate or no reimbursement of farmers for destruction of animals and burying carcasses after confirmation of Avian Influenza and other animal diseases in developing countries.
Infrastructure	a) Rural health centers are dilapidated and poorly maintained in terms of hygiene and sanitation for routine medical care as well as response to local disease outbreaks;

Subject of Concern	Constraints to Safe Waste Management and Disposal
	b) There is a general lack of essential infrastructure such as basic simple incinerators for eliminating waste in rural areas.
Supplies and Equipment	a) Complete PPE kits, disposable gloves and masks were in short supply in refugee resettlement areas with populations of 200,000 and 500,000 persons, as well as the means to safely dispose of the materials; b) Limited and sometimes non-existent quantities of materials and equipment necessary for waste management; c) Absence of portable containers to conserve clean water and a chronic absence of disinfectants at outbreak sites; d) No waste disposal bins and incinerators; e) Availability of fuel, other burning medium or alternatives for disposal. To dispose of large animals, fuel or old tires must be available. In some areas, where there are no trees, carcasses are decomposed under heaps of lime, and bones are recovered 9 months later; f) Necessary equipment not available or too expensive to buy/rent for digging pits/trenches, turning over bird carcasses for composting, etc.
Personnel Issues	a) Many medical personnel are well-trained but poorly equipped and insufficiently motivated; b) Healthcare personnel do not have appropriate information or are not properly trained in waste disposal techniques in many developing countries; c) Main constraints: lack of information on different disposal methods and how to safely effectuate disposal after deciding on burial or burning; d) Insufficient attention to recommended practices: e.g. euthanasia and burial of animals must be rigorously performed and supervised to avoid animal suffering and assure that animals are buried at recommended depths and not in shallow pits vulnerable to scavenging/contamination.
Affected Communities	a) Lack of training and technical support for farmers/ranchers on burying carcasses of medium to large-sized animals; b) Inadequate sensitization and information for communities is the basis for opposition and reticence during epidemiological investigations; c) Inadequate public awareness of importance of waste disposal.
Ecological and Climatic Factors	a) Animal carcasses cannot be safely burned during drought or fire risk, especially in dense scrub; b) Delays between digging pits and burial of animals cause risks. Burial must occur promptly after digging pits to prohibit scavengers tearing carcasses and increasing environmental contamination. If there is a delay in the burial process, spraying with formaldehyde, as a last resort, discourages carnivores, but it must be done immediately; c) Local habitat features/conditions must be carefully considered to avoid errors such as burying animals in high water table areas.

SUPPLIES AND EQUIPMENT

All respondents cited chronic insufficiency, and sometimes non-existence, of essential supplies and equipment for medical care as well as waste management, including PPE, disinfectants, bags/bins/containers for waste materials, portable containers for clean water, and incinerators or the materials to construct them onsite (oil drums, bricks, cement, etc.). Using old tires as a burning medium where fuel supplies were reduced or depleted was considered an option owing to the necessity of destroying Foot & Mouth disease- infected carcasses despite the environmental consequences of burning tires, and lime had to be used to decompose cattle carcasses where neither wood nor adequate fuel were available.

PERSONNEL ISSUES

While medical personnel may be well-trained, they are often poorly equipped and insufficiently motivated both financially and materially. This is a common problem in government health facilities of all sizes, but is especially remarkable in rural areas. Other respondents mentioned that healthcare personnel are inadequately or not trained in waste disposal techniques and/or do not have manuals or information at-hand to guide them in simple and effective waste segregation, treatment and disposal procedures. Also, where well-trained personnel exist, they may be lax in supervising or completing procedures such as assuring the complete destruction and safe burial of HPAI-infected poultry to prevent escapes, animal suffering and further contamination to other animals and humans.

AFFECTED COMMUNITIES

The need for public education and sensitization, both generally, and at the community level, were cited as major constraints to undertaking outbreak investigations, safely disposing of infected materials, animals, and human remains, and safeguarding human, animal and environmental health against risks of contamination. Reticence and opposition towards investigation and response teams manifested by affected communities could be reduced by educational outreach Veterinarians stated that training and information for farmers and communities affected by disease outbreaks in domestic animals are also scarce.

ECOLOGICAL AND CLIMATIC FACTORS

Critical to proper waste management, and especially to options for disposal, is the attention which must be given to ecological and climatic factors. As discussed in previous sections, local hydrography, soil type, climatic regime, vegetation and potential for contamination of other animals and humans are amongst the factors to consider, and can be potential constraints to, the implementation of safe waste management and disposal. Delays in completing the entire process in a timely manner can have repercussions resulting in the creation of new links in the chain of disease transmission.

RECOMMENDED ON-SITE ADAPTIVE MEASURES/METHODS TO IMPROVE OR SIMPLIFY MANAGEMENT OF WASTE IN RESOURCE-POOR RURAL AREAS

The respondents were asked to describe any adaptive management measures and/or methods they would recommend as practical and feasible in situations of scant material resources, amenities and infrastructure from their experience in disease outbreaks. Their varied and candid responses primarily concern two major topics and associated subtopics. These emphasize the value of basic instruction and information, as well as how the control and disposal of waste, cadavers and animal carcasses can be accomplished while minimizing contamination risks for ecosystems, animals and humans and respecting fundamental practices recommended by international health organizations.

- Training, Education and Materials
- Waste disposal cannot be addressed unless people are trained to perform the minimal practices recommended to safely manage and dispose of waste materials. Train healthcare workers in Infection Prevention and Control, proper use and disposal of PPE, simple and effective waste disposal techniques, and proper and respectful burial practices, including burial of humans when body bags are absent. This is often the case when there is no CDC or WHO presence at outbreaks;

- Training is simple, is not necessarily expensive, and is irreplaceable in terms of achieving best practices Train healthcare workers in proper disposal of sharps or effective methods to blunt needles because local people dig up buried items for reuse or sale;
- Provide educational materials to local health and other authorities on the risks of exposure to used healthcare supplies and equipment;
- Provide the minimum materials to assure essential and secure waste management;
- Provide basic education and materials for healthcare workers on risk avoidance and reporting of illness/deaths with focus on particular diseases such as Cholera, Ebola HF, Monkeypox and a summary of risk factors and simple infection prevention interventions;
- Provide basic hygiene and sanitation education in schools where outbreaks often or are likely to occur;
- Provide educational materials in appropriate languages for communities. Develop printed illustrated materials for illiterate persons.
- Treatment and Disposal of Waste
- Careful control and inventory of healthcare waste is simple and can be easily organized and undertaken, as can their safe and ecological elimination. It is not difficult for workers to understand why burning certain waste presents a danger of contamination for humans and animals;
- Burn the waste thoroughly in an incinerator or pit fire as hot as possible. In case there was physical contact with the waste, immediately wash hands with water and soap, or if there is no soap, use ashes;
- The simplest method is to bury the waste residue well after thorough burning;
- Prior experience in large animal culling and disposal is the best management. The easiest burn technique in difficult circumstances is to use old tires and diesel. Mobile incinerators have been used but are expensive. Suitably large permanent incinerators can work well, but dead animals must be transported for necropsy and dismembered before burning in incinerators, with risks for contamination;
- Construction of local incinerators (fixed or mobile) is a good option for rural areas;
- Best method for poultry that is amenable to adaptation in resource-poor communities is composting. Small-scale composting requires minimal use of equipment and resources. The process is straightforward and people with poor literacy skills can be easily trained;
- With HPAI, there is currently an initiative to develop locally fabricated metal waste and carcass disposal containers, with connection for gaseous euthanasia and then incineration. The units must be mobile so they can be hauled by vehicles from one village to another. They may be adaptable for small ruminants and pigs;

ISSUES OF CONCERN RELATED TO BURIAL AND WASTE DISPOSAL

The respondents were asked to identify any issues of concern raised by members of outbreak-affected or neighboring communities in regard to proper burial of infected deceased persons or animals or disposal of contaminated waste. Their responses concerned four major topics and demonstrate:

- why local socio-cultural and economic contexts must be included in planning and management of outbreak response;
- why rapidity in terms of diagnosis and first response are vital, and
- how communications or the lack thereof, can enhance, hinder and/or conceal efforts to control the more disturbing aspects of burial of the dead and elimination of infectious materials.

SOCIO-CULTURAL ISSUES

- One of the most common and complicated problems involves complaints about disrespect for traditional burial preparations and practices and desecration of the dead by placing deceased persons in body bags. Addressing this issue is one of the most important tasks of the Social Mobilization team during outbreaks, as are the following two subjects ;
- Families of victims do not want their dead relatives to be deprived of specific time-consuming rituals and cleansing before burial and they object to the method of transporting cadavers to burial sites in body bags and the refusal by medical teams to allow burial of the dead adjacent to homes of the deceased, especially when persons die far from their places of origin;
- Outbreak-affected farmers and communities ask why bury animal carcasses and how are they supposed to do it without appropriate tools and compensation? These concerns lead to the following issue of concern.

LIVELIHOODS, FOOD AND WATER

- Problem of sensitization of communities to understand and accept the logic of the necessity to destroy domestic animals and their carcasses which results in loss of food for people often confronted with hunger and/or malnutrition;
- Difficulty of completing the process of animal destruction and disposal to its end, thereby preventing people from reclaiming or exhuming livestock and poultry carcasses for consumption or sale;
- Careful attention must be given to the location of water sources when disposing of large numbers of cattle or other livestock. There is a risk of blood and waste fluids contaminating drinking water and people alarmed at seeing “red water”.

NEED FOR RAPID INTERVENTIONS AND ESSENTIAL EQUIPMENT

- Dangerous delays may occur after epidemiological investigation and before diagnosis. There is a huge need for mobile field laboratories with rapid tests. If there are delays of several days to weeks for results from the capital or foreign countries, the extent of infection and contamination of humans, animals and the environment can be enormous before the teams are ready to intervene. Those persons tending to the sick, burying the dead, and handling waste are at high risk;

- For infectious viruses such as Ebola HF and Monkeypox, the diagnosis must be timely and the sick must be isolated from their families and other sick persons already hospitalized. Otherwise, owing to traditional practices or limited conditions of protection during burial or disposal of carcasses, entire families and villages or hospital wards can be infected, including the healthcare personnel and other intervention teams such as hygiene and sanitation responsible for burials and disposing of waste materials from victims;
- Burial teams often have insufficient amounts of PPE, soap, clean water, and disinfectants available for their use and are thus highly vulnerable to infection.

COMMUNICATIONS DURING OUTBREAKS

- During disease outbreaks in livestock and poultry, communications must be handled carefully and expertly. Make sure that local journalists are properly briefed and allowed access, but not to euthanasia and disposal sites. The public needs to be informed and to know what to monitor in their own animals;
- Where HPAI outbreak events were publicized in developed countries, people were concerned with transportation of culled birds to landfills before in-house composting methods were adopted;
- In many developing countries, there are no waste disposal concerns because most people are not aware of the epidemics. Governments did not publicize the events to avoid situations of panic and/or flight from affected regions/areas.

DISCUSSION OF QUESTIONNAIRE SURVEY RESULTS

The last topic, communications, is of critical importance not only for conveying information to affected and surrounding communities, the general public and the media, but also within and amongst the subcomponents of outbreak investigation and response teams. The daily updates and coordination communications given by the outbreak response coordinator to team leaders must be heeded and accepted by all team members to prevent continued transmission within communities or new cases in outbreak team personnel, and to avoid conflicts and ethical or socio-cultural crises. There have been cases in which outbreak investigation and response efforts were halted by leaders of affected communities who forced teams to withdraw from epidemic sites due to improper and unethical behavior of team members.

Where disease outbreaks in wildlife populations preceded or were concurrent with outbreaks in human communities, as in Ebola VHF epidemics in Central Africa, waste management and disposal teams may be responsible for disinfecting and burying animal carcasses close to villages as a means of discouraging people from scavenging carcasses and becoming infected (Lahm et al. 2007). People may scavenge wild animal carcasses or hunt and trap during Ebola VHF epidemics, despite interdictions by health authorities, if alternative sources of protein are not provided during the life cycle of the outbreak.

In like manner, as noted above in the “Livelihoods, Food and Water” section, waste management personnel must also be vigilant for poultry and livestock owners who may attempt to exhume their buried infected animals for consumption or sale. The carefully planned siting of animal burial pits in regard to the location of water sources is also of great consequence, as is obtaining approval for the location of human burial sites.

Finally, and comparable to the experience and recommendations presented in the previous chapter on VHF epidemics, the results of the questionnaire survey indicate that the following measures continue to be the Best Practices for disposal of waste associated with disease outbreaks in remote areas until new technology, funding and other resources are provided:

- training in basic waste management and disposal methodology;
- accessibility and correct usage of minimum necessary materials for personal protection and containment of waste; and
- adherence to the minimization, segregation, collection, disinfection and disposal protocol terminating in burning and burial according to waste category.

CHAPTER 10: CONCLUSIONS AND RECOMMENDATIONS

The preceding chapters have presented information, guidance, results from analyses of assessments, and professional observations and opinions from field practitioners which demonstrate that healthcare-associated waste, as well as its management, at any kind of medical facility or outbreak response event has potential risks for human, animal and environmental health. This document describes recommended "Best Practices" for managing and disposing of this waste with the viewpoint that the "Best Practices" approach to dealing with the problem will help protect human, animal and environmental health. Under the most challenging circumstances, for example in remote locations where infrastructure and amenities are rudimentary to non-existent, minimal standards for waste management and disposal have proven to be effective in preventing and controlling infection using simple means and methods such as:

> "Until countries in transition and developing countries have access to Health Care Waste Management options that are safer to the environment and health, incineration may be an acceptable response when used appropriately. Key elements of appropriate operation of incinerators include effective waste reduction and waste segregation, and placing incinerators away from populated areas…" (Source: WHO August 2004).

- systematically segregating all solid and liquid waste;
- digging latrines and waste disposal pits of recommended dimensions for disposal of liquid and solid infectious waste;
- wearing gloves, footwear and personal protective equipment appropriate for the type of waste handled;
- regularly washing hands with soap and clean water or using an alcohol-containing hand sanitizer;
- decontaminating infectious waste and reusable equipment with disinfectants such as appropriate-strength bleach solutions; and
- adhering to safe and practical waste collection, storage, burning and burying procedures;
- In total, follow the management process of the healthcare waste "stream": minimize, generate, segregate, label, collect, store, transport, treat, and dispose.

While many developed countries have greatly reduced or eliminated exposure to toxic pollution from incineration of healthcare waste by adopting new technology, numerous countries lack the resources and/or expertise to develop and implement national plans, policies and legislation on this subject and purchase new equipment. They thus remain dependent on comparatively inefficient small-scale incinerators for waste disposal. As seen in Chapters 8 and 9, burning solid waste in simple incinerators and waste disposal pits is a necessary and critical practice during outbreak response, provided that total incineration has been accomplished and that residual toxic ashes are buried.

The WHO Health Care Waste Management website (www.healthcarewaste.org) offers four basic principles for defining management practices to ensure that healthcare waste is properly and safely dealt with, as well as four basic actions to attain this goal. These measures can provide "significant health protection” at small rural healthcare facilities as well as in conditions of outbreak response in remote resource-poor areas.

BASIC PRINCIPLES OF HEALTH CARE WASTE MANAGEMENT

- Burying hazardous Health Care Waste in a waste pit is better than uncontrolled dumping;
- Reducing the amount of hazardous waste by segregation is better than having to cope with large volumes of mixed waste;
- Good stock management of chemicals and pharmaceuticals not only reduces waste quantities but also saves purchase costs;
- Proper identification of waste packages warns healthcare personnel and waste handlers about their contents.

FOUR BASIC ACTIONS FOR A MINIMAL HEALTH CARE WASTE MANAGEMENT PROGRAMME

1). **Training** health care staff is the basis for a systematic and coherent waste management programme;

2). **Segregating** waste using a simple three bin waste disposal system will help minimize the amount of waste that needs to be buried in the waste pit and reduce the risks of injuries from sharps:

- Sharps should be disposed of in safety boxes or alternative containers such as plastic bottles, etc. Use of needle cutters is an effective way of making sure syringes are not reused;
- Infectious waste should be discarded into a plastic bin that will then be emptied each day into the pit and cleaned on a regular basis.
- Non-hazardous waste can be disposed of in the local waste stream.

3). **Managing** the waste treatment/ disposal system properly: Even a simple pit requires some attention such as making sure that a small layer of earth is put on top of each load of healthcare waste.

4). **Informing** the local population:

- officials from the local authority should be informed about the measures taken … to reduce the overall public health and environmental risks;
- provide some basic information to both teachers and pupils in the local school(s) to raise awareness about the risks related to healthcare waste should help to prevent children playing/scavenging around/in the waste pit.

Three short reference guides provide recommendations for essential planning and management of the healthcare waste “stream” at remote outbreak sites (Annex 10), disposal methods for different healthcare waste categories (Annex 11) and issues related to safe burial of human remains and associated culturally sensitive topics which must be addressed during outbreak response efforts (Annex 12).

ANNEX 1. CHECKLIST OF LABORATORY SUPPLIES

(Source: Technical Guidelines for Integrated Disease Surveillance and Response, WHO/CDC 2010; page 120).

Checklist of Laboratory Supplies For Use In An Outbreak Investigation And For Standard Safety Precautions When Collecting And Handling All Specimens

_____ Pieces of bar soap and bleach for setting up hand-washing stations
_____ Supply of gloves
_____ Safety boxes for collecting and disposing of contaminated supplies and equipment

For collecting laboratory specimens:

Blood
_____ Sterile needles, different sizes
_____ Sterile syringes
_____ Vacutainers
_____ Test tube for serum
_____ Antiseptic skin disinfectant
_____ Tourniquets
_____ Transport tubes with screw-on tops
_____ Transport media (Cary-Blair, Trans-Isolate)

Blood films (malaria)
_____ Sterile or disposable lancet
_____ Glass slides and cover slips
_____ Slide box

Respiratory specimens
_____ Swabs
_____ Viral transport medium

Cerebral spinal fluid (CSF)
_____ Local anaesthetic
_____ Needle and syringe for anaesthetic
_____ Antiseptic skin disinfectant
_____ Sterile screw-top tubes and tube rack
_____ Microscope slides in a box

Appropriate personal protection equipment (PPE) (for all EPR diseases such as VHF, suspected avian influenza, etc.)

_____ Trans-Isolate transport medium
_____ Latex kit
_____ Gram stain
_____ May Grunwald Giemsa Kit

Stool
_____ Stool containers
_____ Rectal swabs
_____ Cary-Blair transport medium

Plague
_____ Gram stain kit
_____ Rapid diagnostic test (dipstix AgF1)
_____ Cary-Blair transport

If health facility has a centrifuge:
_____ Sterile pipette and bulb
______ Sterile glass or plastic tube, or bottle with a screw-on top

For packaging and transporting samples:
____ Cold box with frozen ice packs or vacuum flask
_____ Cotton wool for cushioning sample to avoid breakage
_____ Labels for addressing items to lab
_____ Labels for marking "store in a refrigerator" on outside of the shipping box
_____ Case forms and line lists to act as specimen transmittal form
_____ Marking pens to mark tubes with patient's name and ID number (if assigned by the district)

ANNEX 2: DISEASES WITH SPECIAL WASTE HANDLING AND MANAGEMENT REQUIREMENTS

Special requirements must be imposed on the management of these wastes from the viewpoint of infection prevention inside the healthcare establishments. Double bags or containers made of strong and leak-proof material are used for the collection of these wastes within health-care establishments.

Special requirements regarding the collection and management of hazardous infectious wastes must be imposed whenever waste is known or, on the basis of medical experience, expected to be contaminated by causative agents of the diseases listed below and when this contamination gives cause for concern that the disease might spread. The list comprises diseases which make particular demands on infection prevention when the following factors are taken into account:

- associated risk of infection (contagiousness, infection dose, epidemic potential);
- viability of the pathogen (infection capacity/infectiousness);
- route of transmission;
- extent and nature of the potential contamination;
- quantity of contaminated waste;
- severity and treatability of the disease that might be caused.

(Source: UNEP-SBC 2003, p. 18).

The wastes belonging to this group may occur in the context of diagnosis and treatment of patients suffering from the following diseases:

INFECTIOUS DISEASES AND ASSOCIATED EXCRETIONS REQUIRING SPECIAL WASTE MANAGEMENT PRACTICES

Infectious Diseases requiring Special Infection Prevention and Waste Management Practices	Associated Pathogen-containing Excretions as Potential Sources of Contamination
Acquired immunodeficiency syndrome (AIDS)	Blood
Viral hepatitis	Blood, feces
Creuzfeld-Jacob disease, Transmissible spongiform encephalopathy	Tissue, cerebrospinal fluid
Cholera	Feces, vomit
Typhoid fever/paratyphoid fever	Feces, urine, bile
Enteritis, dysentery, enterohaemorragic Escherichia coli-induced hemolytic uraemicsyndrome	Feces
Active tuberculosis	Respiratory tract secretions, urine, feces
Meningitis, encephalitis	Respiratory tract secretions, cerebrospinal fluid
Brucellosis	Blood
Diphtheria	Respiratory tract secretions, secretions from infected wounds
Leprosy	Secretion from nose/infected wounds
Anthrax	Respiratory tract secretions, secretion from infected wounds
Plague	Respiratory tract secretions, secretion from infected wounds

Infectious Diseases requiring Special Infection Prevention and Waste Management Practices	Associated Pathogen-containing Excretions as Potential Sources of Contamination
Poliomyelitis	Respiratory tract secretions, feces
Q Fever	Respiratory tract secretions, feces
Glanders	Respiratory tract secretions, secretion from infected wounds
Rabies	Respiratory tract secretions
Tularemia	Pus
Viral haemorrhagic fevers, including hantavirus-induced renal and pulmonary syndromes	Blood, respiratory tract secretions, semen, secretion from infected wounds, urine, feces, saliva

Adapted from UNEP-SBC/WHO 2003, pp. 18-19

ANNEX 3. LOCAL WASTE MANAGEMENT ALTERNATIVES FOR SHARPS SAFETY CONTAINERS AND CONTROLLING ACCESS TO WASTE TREATMENT AND DISPOSAL AREAS

(Source: WHO 2005, page 41)

LOCAL ALTERNATIVES FOR CONTAINMENT OF HAZARDOUS WASTE: SHARPS SAFETY BOXES

- Cardboard safety boxes made to WHO/UNICEF standards manufacture locally;
- Safety boxes made from available cardboard, folded and taped at site;
- Reusable plastic bucket with round hole cut in plastic lid (works best with sharps disposal in cement-lined pits;
- Various reusable plastic containers (medicine jars, empty detergent/disinfectant containers, empty cooking oil containers, etc.) with holes cut in them (works best with sharps disposal in cement-lined pit);
- Locally manufactured metal box with a hole on top for syringe disposal and pull away bottom for emptying box in cement-lined pit;
- Empty metal cans;
- Empty plastic bottles.

LOCAL ALTERNATIVES TO CONTROL ACCESS TO WASTE TREATMENT AND DISPOSAL AREAS

- Chain-link fence;
- Scrap metal fence (corrugated iron sheets);
- Wood fence;
- Living fence (trees, bushes, cactus…);
- Thorn fence;
- Grass or sisal fences.

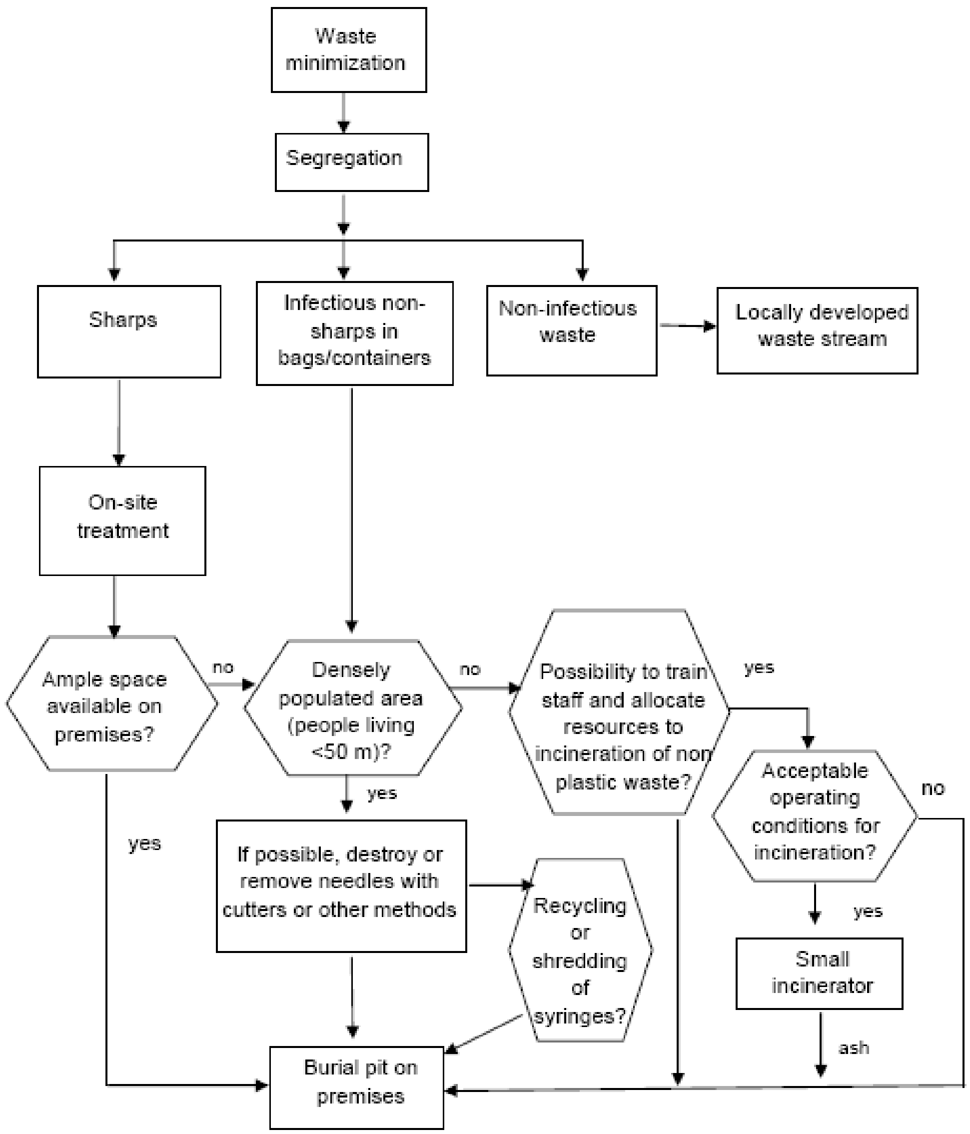
ANNEX 4. COMPARISON OF DISPOSAL AND TREATMENT METHODS APPROPRIATE FOR DIFFERENT CATEGORIES OF HEALTHCARE WASTE

(Source: WHO 2005, page 16).

[1] Low temperature incineration (<800°C) and any other form of burning (drum, pit, open space etc.) remains the last option for infectious waste in emergency situations when no alternative treatment is available, e.g.: during acute outbreaks of communicable diseases.

Technical options	Non Plastic Infectious waste	Anatomical waste	Sharps	Pharmaceutical waste	Chemical waste
ON SITE					
Waste Burial	Yes	Yes	Yes	Small quantities	Small quantities
Sharp pit	No	No	Yes	Small quantities	No
Encapsulation	No	No	Yes	Yes	Small quantities
Inertization	No	No	No	Yes	No
Low T° burning (. < 800°C)[1]	Yes	Yes	No	No	No
Med T° burning (800 – 1000°C)	Yes	Yes	Yes	No	No
High T° burning (.> 1000C°)	Yes	Yes	Yes	Small quantities	Small quantities
Steam autoclave	Yes	No	Yes	No	No
Microwave	Yes	No	Yes	No	No
Chemical	Yes	No	Yes	No	No
Discharge to Sewer	No	No	No	Small quantities	No
OFF SITE					
Sanitary landfill	Yes	No	No	Small quantities	No
Other methods				Return expired drugs to supplier	Return unused chemicals to supplier

ANNEX 5. DECISION-MAKING SCENARIO FOR WASTE MANAGEMENT OPTIONS AT A RURAL PRIMARY HEALTHCARE CENTER IN AN AREA WITHOUT ACCESS TO A LEGALLY APPROVED MODERN WASTE TREATMENT OR DISPOSAL FACILITY.



Also applicable to remote disease outbreak sites with few amenities and limited infrastructure (Source: WHO 2005, p. 30).

ANNEX 6 CHARACTERISTICS OF DIFFERENT OPTIONS FOR TREATMENT AND DISPOSAL OF INFECTIOUS AND SHARPS HEALTH CARE WASTES

(Source: WHO 2005; pp. 17-26).

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
Waste Burial Pit sides covered with a low permeability material, covered and fenced. The pit should be sealed with cement once it is full or at least the last 50cm should be filled with compacted soil and the area identified.	▪ Low tech ▪ Simple ▪ Adequate for small quantities of waste ▪ No atmospheric pollution (non burn technique)	▪ Requires space available ▪ Does not disinfect waste ▪ Might be a risk to community if not properly buried ▪ Potentially easy access to non-authorized personnel ▪ No volume reduction ▪ May fill up quickly ▪ Potential soil and water pollution	▪ Correct segregation of waste ▪ Depth of ground water ▪ Size ▪ Lining of pit ▪ Impact of rainy season	▪ According to pit size	Low construction cost Low cost of cement
Cemented sharp pit Pit well covered with a narrow access for sharps. Should be filled with cement once full.	▪ Low cost ▪ Simple ▪ Adequate for large quantities of needles ▪ No atmospheric pollution (non burn technique)	▪ Space availability ▪ Does not disinfect waste ▪ No volume reduction ▪ Potential soil and water pollution	▪ Correct segregation of waste ▪ Depth to ground water ▪ Depth, size ▪ Design	▪ Needles: 1 million in $1m^3$ ▪ Needle + syringes: 30 000 in $1m^3$	Construction cost: approximately US$50 /$1m^3$ Low cost of sealing material

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
Encapsulation A process in which full safety boxes or disinfected needles are placed within high-density plastic containers or metal drums. When the containers are full, an immobilizing material such as plastic foam, sand, cement or clay is added. Once dry the containers are sealed and disposed of in landfill sites or waste burial pits.	▪ Low tech ▪ Simple ▪ Prevents needle reuse ▪ Prevents sharp related infections / injuries to waste handlers / scavengers ▪ No atmospheric pollution (non burn technique)	▪ Requires space availability ▪ No volume reduction ▪ Does not disinfect waste ▪ Potential soil and water pollution	▪ Correct segregation of waste ▪ Sealing method	▪ About 3000 needle-syringes in a 200 l drum.	▪ Low cost of equipment: plastic containers or metal drums ▪ Low cost of immobilizing material
Inertization Mixing of waste with cement before disposal in order to minimize the risk of leakage of toxic substances contained in the waste	▪ Simple ▪ Safe ▪ May be used for pharmaceutical waste ▪ No atmospheric pollution (non burn technique)	▪ Not applicable to infectious health care waste.			Cost of cement only

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
Low Temperature burning[2] (< 400°C) Open air burning of waste in pits, drums, open - brick enclosures on the ground, single chamber incinerator. Waste residues and ashes are buried.	▪ Reduction in waste volume and weight ▪ No need for highly trained operators ▪ Relative high disinfection efficiency	▪ May require fuel, dry waste to start burning ▪ Incomplete combustion ▪ May not completely sterilize ▪ Potential for needle stick injuries since needle are not destroyed ▪ Toxic emissions (i.e. heavy metals, dioxins, furans, fly ash) poses a threat to health and violate environmental health regulations ▪ Emits heavy smoke and has potential fire hazard ▪ Production of hazardous ash containing leachable metals, dioxins and furans may pollute soil and water ▪ Produces secondary waste	▪ Correct segregation of waste ▪ Waste moisture content ▪ Combustion chamber filling ▪ Temperature / residence time ▪ Maintenance & repairs	▪ 100 to 200 kg / day ▪ Drum: ▪ 5 to 10kg/day	Purchase price of single chamber incinerator: up to US$1,000

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
Medium Temperature burning[3] (800 – 1000°C) Relatively high-temperature burning (i.e. above 800°) reduces combustible waste to incombustible matter and results in a very significant reduction of waste volume and weight. The high temperatures attained via incineration ensure full combustion and sterilization of used needles. Incineration produces a small amount of ash and waste material that must be buried.	▪ Reduction in waste volume and weight ▪ Reduction in infectious material ▪ Prevents needle reuse ▪ Achieves complete sterilization of contaminated wastes	▪ May require fuel or dry waste for start up and maintenance or high temperatures ▪ Possible emission of toxic emissions (i.e. heavy metals, dioxins, furans, fly ash) poses a threat to health and violate environmental health regulations ▪ Potential heavy smoke ▪ Production of hazardous ash containing leachable metals, dioxins and furans may pollute soil and water ▪ Requires trained personnel to operate ▪ Potential for needle stick injuries since some needles may not be destroyed	▪ Correct segregation of waste ▪ Moisture content in wastes ▪ Filling of the combustion chamber ▪ Achieving Temperature / residence time ▪ Maintenance & repairs ▪ May require fuel ▪ Population density in the nearby community ▪ Requires trained staff for operation and maintenance	▪ 10 kg to 50kg / hour	Purchase price of incinerator: US$1,000-15,000

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
High Temperature burning (> 1000C°)	▪ Complete combustion and sterilization of used injection equipment ▪ Reduced toxic emissions ▪ Greatly reduces volume of waste	▪ Expensive to build, operate and maintain ▪ Requires electricity, fuel and trained personnel to operate ▪ Possible emission of toxic emissions (i.e. heavy metals, dioxins, furans, fly ash) poses a threat to health and violate environmental health regulations unless pollution control devices are installed ▪ Production of hazardous ash containing leachable metals, dioxins and furans may pollute soil and water	▪ Correct segregation of waste ▪ Moisture content in wastes ▪ Filling of the combustion chamber ▪ Achieving Temperature / residence time ▪ Maintenance & repairs ▪ May require fuel ▪ Requires trained staff for operation and maintenance	▪ 50 kg to 500 kg / hour	Purchase price of incinerator: US$50,000-100,000 Running costs: Fuel

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
Rotary Kiln A rotating oven with a post-combustion chamber. High T° burning (1200 – 1600 °C)	▪ Adequate for infectious waste, most chemical waste and pharmaceutical waste. ▪ Very effective at high temperatures ▪ Reduces significantly volume and weight	▪ Not for pressurized containers, waste with high heavy metal content ▪ Require skilled staff to operate	▪ Correct segregation of waste ▪ Moisture content in wastes ▪ Achieving Temperature / residence time ▪ Maintenance & repairs ▪ Operation and equipment cost are high ▪ Energy intensive ▪ Requires trained staff	▪ 0.5 to 3 tonnes/hour	Purchase price: approximately US$350,000 Running costs: approximately US$15,000 per year for energy and maintenance
Needle remover The used needle is inserted into a device which cuts or pulls the needle off from the syringe. Various designs available ranging from manual pliers (not recommended) to manually enclosed boxes (needle poppers).	▪ Prevents needle re-use ▪ Inexpensive models available (some can be made locally) ▪ Drastically reduces volume of most dangerous types of waste, i.e. contaminated needles ▪ Plastic syringes can be recycled after disinfection ▪ Easy to operate	▪ Splash back of bodily fluids may pose a significant risk to operator and contaminate working areas ▪ Some models require electricity ▪ Needles and syringes are still infectious ▪ Breaks down ▪ Needles may point out of the receiver underneath ▪ Safety profile not established	▪ Correct segregation of waste ▪ Needle cutter should be designed in such a way that they do not allow "splash back" of bodily fluids ▪ Should be easy to operate ▪ Reduces occupational risks to waste handlers and scavengers ▪ Need to be used in conjunction with another waster disposal technique (e.g. burial pit)	▪ Blade life: 200 000 cuts	Purchase price: US$2-80

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
Needle destroyer The needle is inserted into a closed box and makes contact with an electrical device that destroys it. Ashes are stored in an attached container. Various models are available commercially.	▪ Almost completely destroys the needle ▪ Plastic syringes can be recycled after disinfection ▪ Small ▪ Complete disinfection of the entire needle	▪ Requires electricity ▪ A sterile piece of the needle remains attached to the syringe	▪ Correct segregation of waste ▪ Requires electricity ▪ Maintenance of the electrical contacts	▪ Results It takes 2 seconds to destroy one needle	Purchase price: US$100- 150
Steam autoclave Waste is added to a large autoclave where a combination of heat and pressure sterilizes the waste. Various commercial models are available. In some countries locally made autoclaves are available.	▪ Sterilizes many types of waste such as used injection equipment ▪ Low adverse environmental impact ▪ Facilitates plastic recycling ▪ When combined with shredding reduces waste volume and can safely be handled as municipal solid waste ▪ Low operating cost	▪ Requires electricity ▪ Medium to high capital cost ▪ Requires well-trained staff for operation and maintenance ▪ May emit volatile organics in steam during depressurisation and opening of chamber ▪ Not suitable for all waste types ▪ Waste appearance unchanged ▪ Waste weight unchanged ▪ Requires further treatment to avoid reuse (e.g. shredding) Resulting sterile waste still needs to be disposed off	▪ Correct segregation of waste ▪ Temperature / pressure ▪ Requires electricity ▪ Steam penetration ▪ Waste load size ▪ Treatment cycle length ▪ Chamber air removal	▪ 12kg / day to 90kg / hour	Purchase price: US$500-50,000 Running costs: Electricity

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
<u>Microwave</u> Micro organisms are destroyed by the action of microwaves that rapidly heat the water contained within the wastes.	▪ Significant volume reduction ▪ Waste made unrecognizable ▪ No liquid discharge	▪ High investment cost ▪ Increased waste weight ▪ Not suitable for all waste types ▪ Potential contamination of shredder, exposure to pathogens ▪ Uncharacterised air emissions	▪ Correct segregation of waste ▪ Waste characteristics ▪ Moisture content of wastes ▪ microwave source strength ▪ Duration of microwave exposure ▪ Extent of waste mixture	▪ 40 kg/day to. 250 kg/h	Purchase price: US$70,000-500,000 Running costs: Electricity
<u>Chemical treatment</u> Treatment of wastes with chemical disinfectants e.g. bleach (sodium hypochlorite 1% solution)	▪ Simple ▪ Relatively inexpensive ▪ Disinfectants widely available	▪ Disinfectants may be corrosive and need to be handled safely ▪ Proper concentrations must be used for specific lengths of time to ensure adequate disinfection ▪ No waste volume reduction ▪ Environmental health concerns when disinfectants are disposed of ▪ Uncharacterised air emissions	▪ Correct segregation of waste ▪ Chemical concentration ▪ Temperature and pH ▪ Chemical contact time ▪ Waste/chemical mixing ▪ Requires availability of disinfectants ▪ Requires further treatment / disposal e.g. encapsulation, burial, etc.	▪ High performance	Cost of disinfectant only

Technical options on site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
Shredding After autoclaving, the wastes are often added to a mechanical shredder to reduce their volume. Various commercial locally-made models are available	▪ Reduces waste volume ▪ Facilitates plastic recycling ▪ After autoclaving the waste can be safely handled as solid municipal waste	▪ Requires electricity	▪ Correct segregation of waste ▪ Requires electricity	▪ 50kg to X tonnes /hour	Cost of shredder: If locally made grain mill, then low cost; Up to US$100,000 for a 4t/hour-capacity shredder
Syringe melter Used syringe needles are placed inside a metal pot which is heated in a specially designed oven. The syringes melt and form a cake that can be disposed of as solid waste. Commercial models are not widely available	▪ Prevents needle reuse / scavenging ▪ Sterilizes the used syringes and needles ▪ Treated waste handled as solid waste ▪ Greatly reduces volume wastes	▪ High electricity consumption ▪ May emit localized air pollutants (needs a well-ventilated working area) ▪ Scarce availability of commercial models	▪ Correct segregation of waste ▪ Requires electricity		High use of electricity

Technical options off site	Strengths	Weaknesses	Decisive factors	Performance	Cost information
<u>Sanitary landfill</u> Wastes are disposed of in the ground at a landfill site. Landfills are specifically designed to prevent wastes from contaminating the environment. Public access to the landfill is restricted. Trained staff manages the wastes at the site. Landfill is a supervised facility as opposed to as open / unregulated dumping of wastes.	▪ Controlled adverse environmental impact ▪ Final disposal wastes away from the healthcare facility	▪ Requires organized transportation ▪ Requires good operation and maintenance to prevent environmental health risks	▪ Correct segregation of waste ▪ Needs a secured transport to landfill site, especially if the waste is still infectious or not encapsulated / mutilated ▪ Landfills must be properly designed to prevent environmental health risks	▪ Depends on space availability	Costs vary between settings
<u>Plastic recycling</u> Plastic syringes are reprocessed for the production of other plastic products (buckets, benches, etc.)	▪ Creates income generating opportunities Environmentally friendly ▪ Used syringes are turned into useful products	▪ Needles or needles parts need to be removed ▪ Contaminated syringes need to be disinfected prior to recycling ▪ Requires sustained demand for recycled plastics ▪ Requires established infrastructure for recycling plastic products	▪ Requires established recycling industry willing to acquire recycled plastics ▪ Requires markets for products made from recycled plastics		Purchase price of thermoplast: approximately US$15,000

ANNEX 7: DISPOSAL METHODS FOR PHARMACEUTICALS DURING AND AFTER EMERGENCIES

Adapted from: Prüess et al.1999, page 16.

Disposal Method	Types of Pharmaceutical	Comments
Return to donor or manufacturer, transfrontier transfer for disposal.	All bulk waste pharmaceuticals, particularly antineoplastics.	Usually not practical – plus transfrontier procedures may be time consuming.
High temperature incineration with temperatures greatly in excess of 1200^{o} C.	Solids, semisolids, powders, antineoplastics, controlled substances.	Expensive.
Medium temperature incineration with two-chamber incinerator with minimum temperature of 850^{o} C. Cement kiln incineration.	In the absence of high temperature incinerators, solids, semi-solids, powders. Controlled substances.	Antineoplastics best incinerated at high temperature.
Immobilization		
Waste encapsulation	Solids, semi-solids, powders, liquids, antineoplastics, controlled substances.	
Inertization	Solids, semi-solids, powders, antineoplastics, controlled substances.	
Landfill		
Highly engineered sanitary landfill	Limited quantities of untreated solids, semi-solids and powders. Disposal of waste pharmaceuticals after immobilization preferable. PVC plastics.	
Engineered landfill	Waste solids, semi-solids and powders, preferably after immobilization. PVC plastics.	
Open uncontrolled non-engineered dump	As last resort untreated solids, semi-solids, powders – must be covered immediately with municipal waste. Immobilization of solids, semi-solids, powders is preferable.	Not for untreated controlled substances.
Sewer	Diluted liquids, syrups, intravenous fluids, small quantities of diluted disinfectants (supervised).	Antineoplastics, and undiluted disinfectants and antiseptics not recommended.
Fast-flowing watercourse	Diluted liquids, syrups, intravenous fluids; small quantities of diluted disinfectants (supervised).	Antineoplastics, and undiluted disinfectants and antiseptics not recommended.
Burning in open containers	As last resort, packaging, paper, cardboard.	Not acceptable for PVC plastics or pharmaceuticals.
Chemical decomposition	Not recommended unless special chemical expertise and materials available.	Not practical for quantities over 50 kg.

ANNEX 8. QUESTIONNAIRE: MANAGEMENT AND METHODS OF WASTE DISPOSAL DURING OUTBREAK INVESTIGATIONS AND RESPONSE EFFORTS

NAME:

PROFESSION:

INSTITUTION/ORGANIZATION:

1) Have you worked in disease outbreak investigation, response and/or research outside of urban areas, or in urban areas lacking appropriate health facilities and sanitation infrastructure?

2) Which disease(s) was/were implicated in the outbreak(s) or research?

3) Which of the following components of the response to the disease outbreak were you involved in? (Yes/No):
- Disease surveillance,
- Outbreak investigation,
- Clinical management of infected/ill persons or animals,

- Infection control and prevention

- Social mobilization,
- Logistics, personnel deployment
- Field research

4) Was there any team member responsible for supervising the proper disposal of waste materials (waste management)? (If YES, who?):

5. Which person(s) or team was responsible for the proper burial and disposal of persons or animals who/which died during the outbreak(s)?

6) Are you aware of the WHO/OIE standard recommended methods for waste management and disposal during a disease outbreak?

7) During your outbreak response experience(s), was a waste management plan employed according to WHO standard international regulations, including waste segregation, collection, transport, storage, disposal, minimization and reuse for all categories of liquid and solid waste materials?

8) Can you describe the methods of waste management and disposal used during the outbreak response experience(s), in relation to local conditions and the specific diseases?

9) Please describe any lack of infrastructure, resources or personnel that prevented proper disposal of waste during the outbreak under investigation, or for any other reasons.

10) Can you recommend on-site adaptive management methods or tools which could be used to improve or simplify standard methods for waste disposal during disease outbreak investigations and response in rural areas with few or no resources or amenities?

11) Were there any issues of concern in the affected or neighboring communities in regard to proper burial of infected deceased persons or animals or disposal of contaminated waste?

ANNEXE 9. QUESTIONNAIRE : GESTION ET METHODES D'ELIMINATION DE DECHETS DES ENQUETES EPIDEMIOLOGIQUES ET LA RIPOSTE AUX FLAMBEES DES MALADIES

Nom:
Profession:
Établissement / organisme:

1) Avez-vous travaillé dans l'investigation des flambées des maladies, la riposte et / ou la recherche en dehors des zones urbaines, ou dans les zones urbaines manquent d'installations sanitaires appropriées et des infrastructures d'assainissement?

2) Quelle(s) maladie (s) a (ont) été impliqué dans la flambée(s) ou la recherche sur le terrain?

3) Lequel des éléments suivants de la réponse à l'épidémie de maladie avez-vous été impliqué? Oui / Non:
- La surveillance des maladies, -
- Enquête épidémiologique, -
- Prise en charge clinique des personnes ou des animaux infectées / malades,
- Contrôle des infections et la prévention -
- La mobilisation sociale,
- Logistique, le personnel du déploiement
- La recherche sur le terrain

4) Y at-il un membre de l'équipe chargée de superviser l'élimination appropriée des déchets (gestion des déchets)? (Si oui, qui?):

5). Quelle personne (s) ont été responsable de l'enterrement correcte des personnes décédées et/ou l'élimination des carcasses des animaux morts lors de l'épidémie(s)?

6) Etes-vous conscient de la norme et des méthodes de l'OMS recommandées pour la gestion et l'élimination des déchets lors d'une éclosion de maladie?

7) Au cours de votre expérience de la riposte, était un plan de gestion des déchets mis en œuvre selon la norme OMS règlements internationaux, y compris la séparation des déchets ainsi que la collecte, le transport, le stockage, l'élimination, la minimisation et la réutilisation pour toutes les catégories de déchets liquides et solides?

8) Pouvez-vous décrire les méthodes de gestion des déchets et d'élimination utilisée pendant l'expérience de riposte (s), par rapport aux conditions locales et les maladies spécifiques?

9) S'il vous plaît, décrire tout le manque d'infrastructures, de ressources ou de personnel qui ont empêché l'élimination adéquate des déchets lors de l'épidémie à l'étude, ou pour toute autre raison.

10) Pouvez-vous recommander des méthodes de gestion adaptative sur place ou des outils qui pourraient être utilisés pour améliorer ou simplifier les méthodes standards pour l'élimination des déchets au cours

des enquêtes d'une maladie et la riposte aux flambées dans les zones rurales avec peu de ressources ou d'équipements?

11) Y-at-il des questions d'intérêt dans les communautés touchées ou voisines en matière d’enterrement ?

ANNEX 10. RECOMMENDED MEASURES FOR MANAGEMENT OF HEALTHCARE-ASSOCIATED WASTE PRIOR TO TREATMENT AND DISPOSAL AT REMOTE DISEASE OUTBREAK SITES

Prior to the Treatment and Disposal of waste, planning for management of the “waste stream” at the outbreak site should proceed according to the following steps:

- **Minimize**: reduce the volume of waste by using oldest materials first, use all contents of each container and recycle/reuse items such as paper, cardboard;
- **Generate**: waste should be discarded **near/at the point of use by the user**;
- **Segregate**: Planning should include that waste will be separated into the following basic categories by the person(s) generating the waste and placed in clearly labeled plastic bags or containers for each of the main waste types:
- Infectious;
- Highly infectious;
- Sharps;
- Pharmaceutical;
- Chemical; and
- General non-infectious refuse.
- **Collect**: Personnel responsible for collecting/handling medical waste should wear protective clothing and footwear (rubber boots, mask, heavy gloves, gown/apron).
- Bags/containers should be securely closed and handled in the following manner:
- Carry bags by their necks away from the body, hold and carry containers firmly and away from the body;
- Do not lift or hold bags by the bottom or sides;
- Do not throw bags or containers into receptacles or on to the ground.
- **Transport**: Waste should be removed daily. General waste should be transported separately from hazardous and infectious waste to avoid cross-contamination or mixing the wastes. Other measures for safe transport include:
- Follow specific routes of waste transport to avoid passage of waste through patient-occupied and clean areas;
- If vehicles are used for transport of infectious waste, they should be:
- Free of sharp edges;
- Easy to load and unload by hand;

- Cleaned and disinfected after each use.

Precautionary Measures for Preparation, Use and Maintenance of Waste Burial Pits:

- The bottom of the waste pit should be at least 2m above the local water table;
- The waste pit should be at least 30m away from water sources (streams, etc);
- The pit should be 2m deep and filled to a depth of 1-1.5m, then closed with soil;
- Each load of waste should be covered with a soil layer of 10-15cm depth;
- Place chloride of lime over the layers if soil cover is not possible;
- During outbreaks of highly virulent pathogens (e.g. Ebola VHF), both lime and soil cover should be added or stronger disinfectants may be added to each layer;
- Large quantities of chemical waste (>1kg) should not be buried simultaneously, and should be spread into different layers over several days;
- Access to the burial pit should be restricted and supervised to prevent scavenging.

ANNEX 11. RECOMMENDED TREATMENT AND DISPOSAL METHODS FOR DIFFERENT CATEGORIES OF HEALTHCARE-ASSOCIATED WASTE FROM OUTBREAK SITES IN REMOTE AREAS WITHOUT ACCESS TO MODERN WASTE DISPOSAL FACILITIES

Categories of Healthcare-associated Waste	Chemical Disinfection (e.g. bleach solution)	Encapsulation	Inertization with cement or clay (if possible)	Low T ° burning* (<800°C)	Medium T ° burning* (800 – 1000 °C)	Burial in waste pit	Place in Isolation Ward latrine
Solid infectious waste (dressings, PPE, etc.)	Yes	No	No	Yes	Yes	Residue and ashes	No
Liquid infectious waste (e.g. excretions/secretions, washing-wastewater)	Yes	No	No	No	No	No	Yes
Sharps (syringes, glass, scalpel blades, etc.)	Yes	Yes, (cut or blunt needles)	No	Yes	Yes	Yes	No
Anatomical waste	Yes	No	No	No	No	Yes	No
Pharmaceutical waste	No	No	Yes	No	No	Small quantities	No
Chemical waste (e.g. disinfectants, insecticides.)	No	No	No	No	No	Small quantities	No
General non-infectious waste (packaging, paper)	No	No	No	Yes, if not reusable	Yes, if not reusable	Yes, if not reusable	No
Used supplies/equipment (e.g. batteries, aerosol cans)	No	No	No	No	No	Yes (or removal)	No

* Treat waste residues and ashes from low/medium burning in oil drum/brick incinerators or open air pits as toxic waste. Bury in pit.

ANNEX 12. RECOMMENDATIONS FOR SAFE BURIAL PRACTICES IN LOCAL SOCIO-CULTURAL CONTEXTS

Aspects of Burial	Recommended Procedures
Consultation in the community	Consult with local traditional and religious authorities and other prominent persons regarding local customs for preparation of corpses, burial practices, and rituals.
Training of teams for safe burial of the dead	Personnel responsible for burying human remains must receive specific training for this task, including how to interact with families of deceased persons while maintaining infection prevention/control
Burial site selection	Burials should be in designated cemeteries, not at homes or medical centers; obtain authorization for burial sites from local authorities.
Preparation of grave for burial	Explain the importance of rapid burial to families of deceased persons. Graves should be 2m deep and 30m from water sources . ***(See Note)**;
Personal protection	Personnel handling bodies should wear PPE: double or thick gloves, gown or full ensemble, apron, surgical mask, eye protection, closed shoes (thick rubber boots)
Preparation of bodies for burial	Bodies and adjacent surfaces should be disinfected with 1:10 bleach solution and wrapped in sealed leak-proof material (e.g. body bag or plastic sheeting). Do not use transparent body bags.
Transport of bodies for burial	Pay local artisans to make coffins for body bag transport or carry body bags on stretchers or similar platforms, if possible; If no coffin, disinfect surface where body bag rested after removal.
Burial process	Bury bodies as promptly as possible, but respect social significance by permitting some traditional funeral rites and family members to be present at burial site, if conditions allow.
Grave site homage objects	Do not burn deceased persons' properties designated for grave site homage; disinfect well and place in coffin, or in or on top of graves.
Contaminated property and possessions	Decontaminate bedding, possessions, and residences of recovered and deceased patients; burn only if absolutely necessary, depending on the type and extent of contamination
Post-burial decontamination	Burial team should follow the standard decontamination protocol with disinfectant and hand-washing after burial proceedings, including safe removal and proper disposal of personal protective equipment (PPE).

*Note: Ebola and other viral hemorrhagic fevers, as well as infectious diseases such as cholera, can be transmitted in locations where the body of a patient who died following infection is washed or prepared by family members before burial. Health workers should communicate with local leaders and explain to families the potential risk of physical contact with the body or bodily fluids, including during preparation for burial. Reinforce the importance of hand hygiene to prevent infection being transmitted through physical contact, or during subsequent food preparation. Health workers and transport personnel need to demonstrate respect for the body of any deceased patient(s) at all times.

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WASTE IN RURAL, PERIURBAN AREAS

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PLANNING FOR WASTE MANAGEMENT

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> This paper reviews the historical accusation that the risk of "disinfection byproducts" led to suspending chlorinization in Peru, resulting in cholera epidemic. The paper rejects that history but argues the plausibility of the accusation indicates need to weight different risks to choose best mitigation measures.

Alago, Aylin Zeren and Gunay Kocasoy. 2008. "Improvement and modification of the routing system for the health-care waste collection and transportation in Istanbul." Waste Management 28(8). 1461–1471.

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P. Hanumantha, Rao. 2008. "Report: Hospital waste management -- awareness and practices: a study of three states in India" Waste Manag Res 26(3): 297-303.

> This article assesses awareness of hospitals, nursing homes and private medical practitioners in both rural and urban areas on medical waste disposal procedures within two states of India. It finds that hospital staff were usually the best informed though dumping medical waste on roadsides near hospitals is still common.

Bdour, A., B. Altrabsheh, N. Hadadin, and M. Al-Shareif. 200776. "Assessment of medical wastes management practice: A case study of the northern part of Jordan." Waste Management 27(6): 746–759.

> This study surveyed medium and large healthcare facilities in Irbid City, Jordan to assess procedures, techniques and methods for handling medical waste. The study shows that the city's facilities have practices lower than the developed world. It explains a statistical model used to determine significant factors on waste generation which can be applied elsewhere.

Jang, Yong-Chul, Cargro Lee, Oh-Sub Yoon, and Hwidong Kim. 2006. "Medical waste management in Korea." Revista De Enfermeria Barcelona Spain 80(2): 107-115.

> With increased role of environmental regulatory agencies and waste generators, this paper describes current management practices for the management of medical waste generation, segregation, transportation and disposal in Korea. It notes that even with regulations that require air pollution control devices many waste incinerators can still emit toxins given high level of plastic materials in medical waste if they are properly operated.

Abdulla, Fayez, Hani Abu Qdais, and Atallah Rabi. 2008. "Site investigation on medical waste management practices in northern Jordan." Waste Management 28(2): 450–458.

> This article reports on waste management practices in hospitals in northern Jordon. It finds that though incinerator is the most commonly used practice, none of the incinerators at hospitals visited met domestic standards. Likewise segregation of waste and discharge of liquid waste is not conducted properly. It recommends more training and capacity building.

Da Silva, C.E., A.E. Hoppe, M.M. Ravanello, and N. Mello. 2006. "Medical wastes management in the south of Brazil." Waste Management 25(3): 315-317.

> This article reports on medical waste management, segregation, generation, storage and disposal practices in one of Brazil's states. The results show that management practices did not conform with domestic legislation though most complied with waste segregation procedures.

Chiang, Chow F, fung C. Sung, Fang H. Chang, and Ching T. Tsai. 2006. "Hospital Waste Generation During an Outbreak of Severe Acute Respiratory Syndrome in Taiwan." 2006. Infect Control Hosp Epidemiology 27(5): 519-522.

> This article describes how the amount of medical waste increased during and outbreak. In this case, the article investigates this during a SARS outbreak in Taiwan.

BEHAVIOR MAY CREATE RISK VIA INTERMEDIATE VARIABLES: GENERAL WASTE, NOSOCOMIAL INFECTION, POOR SANITATION, RESETTLEMENT

Heukelbach,Jörg, Fabíola Araújo Sales De Oliveira, Lígia Regina Sansigolo Kerr-Pontes, and Hermann Feldmeier. 2001. "Risk factors associated with an outbreak of dengue fever in a favela in Fortaleza, north-east Brazil." Tropical Medicine and International Health 6(8): 635-642.

> This article takes an investigative epidemiological approach to uncovering the causes of an dengue outbreak in north-eastern Brazil. The study identifies the risk factors of contracting dengue including uncovered receptacles and trash and the possible starting point of the breakout being an uncovered water tank. This case reiterates the importance of waste control during outbreaks and how trash (like containers) response teams leave behind can affect dissemination of disease vectors.

Hayes, John M., Endid Garcia-Rivera, Roberto Flores-Reyna, Floria Suarez-Rangel, Tito Rodriguez-Mata, Rene Coto-Portillo, Rafael Baltrons-Orellana, Elmer Mendoz-Rodriguez, Betty Fuentes De Garay, Juan Jubis-Estrada, Rolando Hernandez-Argueta, Brad J. Biggerstaff, and Jose G. Rigua-Perez. 2003. "Risk Factors for Infection During A Severe Dengue Outbreak in El Salvador in 2000." Am. J. Trop. Med. Hyg. 69(6): 629–633.

> This article reports a large dengue-2 outbreak being attributed to the presence of discarded cans, plastic containers, and tire casings in a community. It notes that cleanup campaigns directed towards tires and solid waste likely to have the most impact on reducing dengue infection.

Appleton, Jenny and Mansoor Ali. 2000. Healthcare or Health Risks? Risks from Healthcare Waste to the Poor." Accessed on 23 January 2012. http://www.lboro.ac.uk/well/resources/well-studies/full-reports-pdf/task0326.pdf

> Though this article focuses on risks associated with healthcare waste in general, it does highlight that if many time adverse environmental and human impact on disposed healthcare waste is not always the result of improper disposal. Certain groups may scavenge through waste and contract or transmit disease. Table 3 of the report identifies waste pickers and recycling industry (including waste sellers) may go through waste for economic benefit.

NOSOCOMIAL DISEASE TRANSMISSION

Liu, Jien-Wei, Sheng-Nan Lu, Shun-Sheng Chen, MD, Kuender D. Yang, Meng-Chih Lin, Chao-Chien Wu, Peter B. Bloland, Sarah Y. Park, William Wong, Kuo-Chien Tsao, Tzou-Yien Lin, and Chao-Long Chen. 2006. "Epidemiologic Study and Containment of a Nosocomial Outbreak of Severe Acute Respiratory Syndrome in a Medical Center in Kaohsiung, Taiwan." Infect Control Hosp Epidemiology. 27(5): 466-472.

> This paper investigates the dynamics of SARS transmission, the magnitude of SARS outbreak and impact on the immediate community in the setting of a large medical center in Taiwan. Given limitations on being able to quickly diagnose the disease the paper finds grouping individuals by liklihood of SARS infection important to reduce further transmission.

SANITATION IN RURAL AREAS

Tumwine, James K., John Thompson, Munguti Katui-Katua, Mark Mujwahuzi, Nick Johnstone, and Ina Porra. 2003. "Sanitation and hygiene in urban and rural households in East Africa." Int J Environ Health Res. 13(2): 107-15.

> This study highlights how the presence and quality of hygiene and sanitation facilities can affect disease transmission, a potential intermediate factor between outbreak response and outcomes using Kenya, Tanzania and Uganda as a case study.

Ells, Michael D. And Christopher A. Monz. 2011. "The consequences of backcountry surface disposal of human waste in an alpine, temperate forest and arid environment." Journal of Environmental Management 92(4): 1334-1337.

> This paper investigates the efficacy of the smear method of human waste disposal in alpine, temperate and arid environments to determine minimize health and environmental impacts. It finds that it is most effective in arid and alpine environments and recommends that it should only be used when there is little possibility for contact by other visitors.

Knappett, Peter S.K., Veronica Escamilla, Alice Layton, Larry D. McKay, Michael Emch, Daniel E. Williams, R. Huq, J. Alam, Labony Farhana, Brian J. Mailloux, Andy Ferguson, Gary S. Sayler, Kazi M. Ahmed, and Alexander van Geen. 2011. "Impact of population and latrines on fecal contamination of ponds in rural Bangladesh." Science of the Total Environment 409(17):3174-82.

> This paper analyzes the source of pond water fecal contamination –human or livestock-which is used for hygiene in rural Bangaldesh. It found that humans were typically the dominant source and that there was a high correlation between latrines with visible effluent or open withs with pond water contamination.

Harvey, Peter. 2002. *Emergency sanitation : assessment and programme design*. Loughborough: WEDC.
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> This book provides guidelines on how to design simple to complex latrines and what environmental factors need to be considered for siting.

RESETTLEMENT

Jagai, Jyotsna S., Jeffrey K. Griffiths, Paul H. Kirshen, Patrick Webb, and Elena N. Naumova. 2010. "Original Contribution Patterns of Protozoan Infections: Spatiotemporal." EcoHealth 7(1): 33-36.

> This article shows a relationship between density of cattle and human protozoan infections. If a response changes the density of cattle, it may have consequences for human health.

Nath, K.J. 2003. "Home hygiene and environmental sanitation: a country situation analysis for India." International Journal of Environmental Health Research 13(1): S19 – S28.

> This study outlines perceptions and practices in personal hygiene and levels of sanitation and associated health risks. It recommends integrated action for improving hygiene behavior and access water and sanitation.

RISK OF CULTURE CLASH IN OUTBREAK RESPONSE

Gurley, Emily S, Shahana Parveen, M Saiful Islam, M Jahangir Hossain, Nazmun Nahar, and Nusrat Homaira. "Family and community concerns about postmortem needle biopsies in a Muslim society." BMC Medical Ethics 12(10): 1-11.

This article discusses under which circumstances families in Bangladesh would agreed and would not agree to consent to biopsies of family members to determine the causes of death. The research team interviewed families who were affected by the Nipah virus during 2004-2008.

CARCASS DISPOSAL

Gwyther, Ceri L., A. Prysor Williams, Peter N. Golyshin, Gareth Edwards-Jones, and David L. Jones. 2011. "The environmental and biosecurity characteristics of livestock carcass disposal methods: A review." Waste Management 31 (2011): 767–778.

This article assesses potential environment impacts and risks associated with disposal of livestock mortalities. It argues that alternative technologies may be the most environmentally sound and efficient method for carcass disposal in light of EU legislation aimed to minimize the spread of infectious disease and on farm pollution.

Watanabe, Osamu, Jun Ishii,Takahisa Kitagaki, Hirokazu Okawa, Hitomi matsumoto and Mamoru Kameyama. 2010. "Logistical Study in Hyogo Prefecture on Disposal of Poultry Carcasses Infected with Highly Pathogenic Avian Influenza Virus to Prevent Infection Spreading to Other Flocks." J. Vet. Med. Sci. 73(5): 573–581, 2011.

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Delgado, Joao, Phil Longhurst, Gordon A.W. Hickman, Daniel M. Gauntlett, Simon F. Howson, Phil Iving, Alwyn Hart, and Simon J.T. Pollard. 2010. "Intervention Strategies for Carcass Disposal: Pareto Analysis of Exposures for Exotic Disease Outbreaks." Environ. Sci. Technol. 44: 4416–4425.

This paper presents sources of exposure to human health, animal health, and wider environmental health during carcass disposal. To minimize threats the paper presents risk mitigation and control measures.

Wilkinson, K.G. 2007. "The biosecurity of on-farm mortality composting." Journal of Applied Microbiology 102: 609-618.

This article conducts a review and assesses risk and security of composting as an method of carcass disposal during disease outbreak. It identifies current practice is and studies as well as additional research needed.

Jacobson, Kurt H., Seunghak Lee, Debbie McKenzie, Craig H. Benson, and Joel A. Pedersen. 2009. "Transport of the Pathogenic Prion Protein through Landfill Materials." Environ Sci Technol. 43(6): 2022–2028.

This paper examines how animal carcasses and associated waste affected from Transmissible spongiform encephalopathies (TSEs, prion diseases) outbreaks can be transported and what type of soils used in landfills can best contain the disease.

Chena, Shui-Jen, Lien-Te Hsieha, and Shui-Chi Chiub. 2003. "Emission of polycyclic aromatic hydrocarbons from animal carcass incinerators." The Science of the Total Environment 313: 61–76.

This article studies the levels of polycyclic aromatic hydrocarbons (PAHs) emitted from incinerators in a hog farm, livestock disease control centre and from a medical waste incinerator. The study concluded that the hog farm and livestock disease control centre incinerators emitted more PAHs than did the medical waste incinerator.

TECHNOLOGY FOR WASTE DISPOSAL (AND RISKS)

Rogers, David E.C., and Alan C. Brent. 2006. “Small-scale medical waste incinerators – experiences and trials in South Africa.” Waste Management 26: 1229-1236.

This article reviews incinerators in remote rural primary health care clinics. It identifies issues, a methodology and need for special consideration of remote areas.

Huang , Chin-Ming, Wan-Fa Yang, Hwong-Wen Ma, and Yii-Ren Song. 2006. “The potential of recycling and reusing municipal solid waste incinerator ash in Taiwan.” Waste Management 26(9): 979-987.

This article examines potential of recycling byproduct of incinerator ash for metals and other base materials which can be used for cement additives or road base.

Olsen, Jaran Strand. Tone Aarskaug, Ingjerd Thrane, Christine Pourcel, Eirik Ask, Gisle Johansen, Viggo Waagen, and Janet Martha Blatny. 2010. “Alternative Routes for Dissemination of Legionella pneumophila Causing Three Outbreaks in Norway.” Environ. Sci. Technol.44(22): 8712–8717.

This paper finds that treatment ponds were in the Fredrikstad/Sarpsborg communities of Norway in 2005 and 2008 were responsible for amplifying and disseminating L Pneumophila strains. It emphasizes the need for preventative action against release of wastewater containing human pathogens.

SUPPLEMENT 1: KEY ENVIRONMENTAL CONTAMINANTS USED IN DISEASE OUTBREAK RESPONSE

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Within the scope of disease outbreak emergency investigation and response activities, a substantial amount of both medicinal waste and associated hazardous and general waste (including disinfectants, pesticides, rodenticides, and other resulting materials) may be generated. The remote generation of healthcare-associated hazardous wastes within a confined area can result in an array of environmental health problems. Excessive buildup of these compounds can impact soil, air, or water sources in innumerable ways. Taken from the WHO/CDC Technical Guidelines for Integrated Disease Surveillance and Response (2010), the major Disinfectants, Insecticides, Rodenticides and other potential hazardous products recommended as essential stock items for outbreak response have undergone specific risk assessments. From these data, individually tailored risk management of these compounds is presented as a guide for mitigation of these potential problems.

DISINFECTANTS

According to the WHO/CDC Technical Guidelines for Integrated Disease Surveillance and Response (2010), five major disinfectants are recommended as fundamental for outbreak response. All of these pose significantly different health impacts in terms of their environmental health impact and toxicological impact. The most significant disinfectants posing environmental hazards include 2% chlorine, bleach, calcium hypochlorite (also known as chlorinated lime powder), cresol, and sodium hypochlorite. Other major disinfectants include 1% chlorine solution and 1-2% phenol solution. (WHO/CDC 2010)

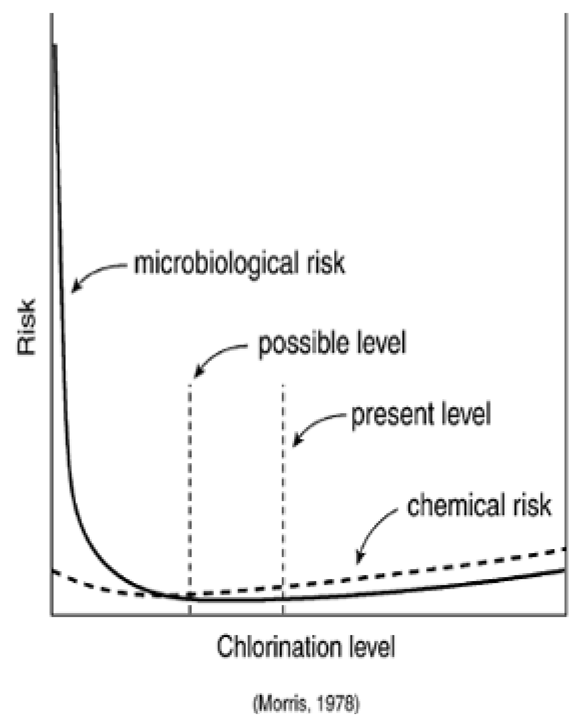

Figure 1– The Inverse Relation between Risk and Chlorination Level. Note how chemical risk tends to stay constant over chlorination level deviations.

HYPOCHLORITES AND ASSOCIATED ENVIRONMENTAL TOXINS

Chlorinated water products are mandated as essential for responding to disease outbreaks. Chlorine has long been known as an agent of water disinfection. Figure 1 illustrates the reduction of risk with the increase of chlorination to a plateau and the constant threat of chemical contamination with these products. Figure 2 illustrates the effectiveness of Chlorine as a disinfectant for the removal of Typhoid from water in the United States. The IDSR Guidelines present methods on "how to make 1:10 and 1:100 chlorine solutions from household bleach and other chlorine products". (WHO/CDC 2010) Generally, chlorine is found in the diatomic form of Cl_2, yet here, chlorination really suggested hydrogen-chlorine chemicals. Not only is "The active ingredient in household bleach is sodium hypochlorite, or NaClO," (Kaneski & Boraas, 2012), but sodium hypochlorite is the active ingredient found in the categories of 1-2% chlorine bleach solution, bleach, and sodium hypochlorite. Calcium Hypochlorite will also be discussed, as this chemical contains twice the amount of hypochlorite per mole of cation.

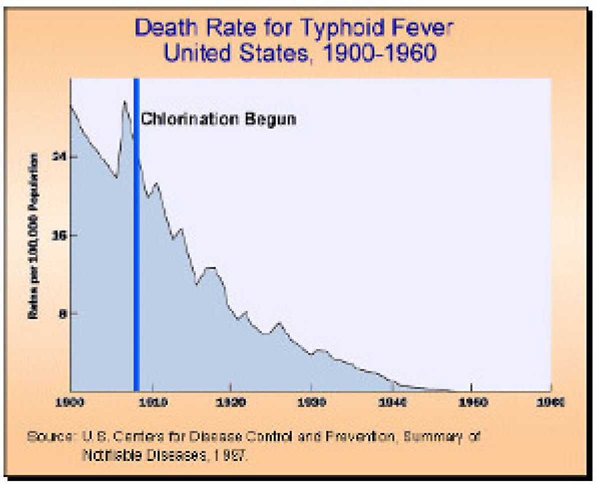

Figure 2 - Chlorination and Disease Reduction

This figure illustrates the direct correlation between introduction of chlorination to drinking water supply and reduction in the death rate of *Salmonella typhi* (*S. typhi*), a waterborne disease.

Bleach, in the WHO/CDC (2010) document, denotes the blanket of chemicals with an active ingredient of hypochlorite (ClO^- or derivatives thereof). Specifically, these solutions are primarily used to ensure "disinfection […] from outbreaks of waterborne infectious and parasitic diseases". (EPA 1994) In the two methods of preparation of disinfectant products for outbreak response in rural areas, the stronger disinfectant (1:10 solution in a bleach to water ratio) is noted for the disinfection of "Excreta, Cadavers and Spill of Infection body fluids" whereas weaker disinfectants (1:100 solutions in a bleach to water ratio) are utilized for gloved hands, bare hands and skin, floors, clothing, equipment, and bedding" (Ibid.). As suggested here, the use of various amounts of hypochlorite dictate varying degrees of polarity.

NaClO is a useful oxidizing agent, yet "the solid is not stable," resulting in the decomposition in to the anionic form, ClO^-. (Lenntech 2011b) This anion then reacts to form any number of active compounds. Depending on the environment, ClO^- can decompose to form Chlorine anions known as Cl^-, which can produce the diatomic form of Chlorine, Cl_2, (House 2008), the molecule can oxidize to create chlorine-oxygen containing

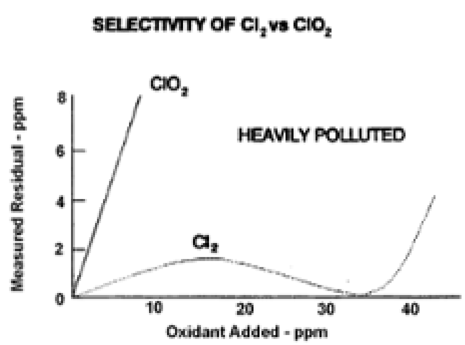

Figure 3 – Selectivity of Chlorination Compounds

This figure illustrates that ClO_2 is a more selective oxidizing agent than Cl_2. Chlorinated agents have various reactivity due to varietal electronic stability. (Lenntech 2011a)

compounds including hypochlorite, chlorite, chlorate, and perchlorate, (Kaneski & Boraas, 2012) the molecule can combine with protons to form any number of acids, the molecule can combine with oxygen and protons to form hypochlorous acid, chlorous acid, chloric acid, or perchloric

Table 1 - Disinfection Biproducts and Detection Limits (UNEP 2000).

DBPs	Analytical method	APHA[a] method	Minimum detection limit (µg/litre)	Major interferences	References
THMs	MTBE extraction Pentane extraction	– 6232B	0.4 0.1	None	AWWARF (1991)
HAAs	Salted MTBE extraction and derivatization with diazomethane	6233B	0.5–1.0	None	AWWARF (1991)
HANs	Pentane extraction	6232B	0.05	None	Koch et al. (1988)
Cyanogen chloride	MTBE extraction	6233A	0.5	None	AWWARF (1991)
Chloramine	Derivatization with 2-mercaptobenzothiazole	–	–	None	Lukasewycz et al. (1989)
Haloketones[b]	Pentane extraction	6232B	0.2	None	Krasner et al. (1995) AWWARF (1991)
Chloral hydrate	MTBE extraction	–	0.5	None	AWWARF (1991)
Aldehydes	Extraction with hexane and derivatization with PFBHA	–	1.0	PFBHA sulfate	Sclimenti et al. (1990)
Bromate	Ion chromatography (H_3BO_3/NaOH)	4500	2.0[c] 0.2	Cl^-	Siddiqui et al. (1996a) Krasner et al. (1993) Weinberg et al. (1998)
Chlorate	Ion chromatography (H_3BO_3/NaOH)	4500	5	Cl^-, acetate	Siddiqui (1996)
Chlorite	Ion chromatography ($NaHCO_3$/Na_2CO_3)	4500	10	Cl^-, acetate	AWWARF (1991)
TOC	UV/persulfate or combustion	5310	200	Metals	APHA (1995)

[a] American Public Health Association.
[b] Sum of 1,1-DCPN and 1,1,1-TCPN.
[c] 1.0 µg/litre with high-capacity column.

acid, the molecule can combine with an amine to become a chloroamine, or combine with another Oxygen to form Chlorine dioxide. (WA-DOH 2011 and NIH, 2011) Perhaps the most toxic of all chlorine byproducts occurs when chlorine comes in to contact with phenol. **When combined, the electrophilic chlorine will naturally substitute with the hydrogen molecules of Phenol to create PCP or DDT, which can stay remain in an environment for as long as 5 years.** More information on this deadly molecule will be presented later, after explaining the subsequent toxicology. (NIH, 2011)

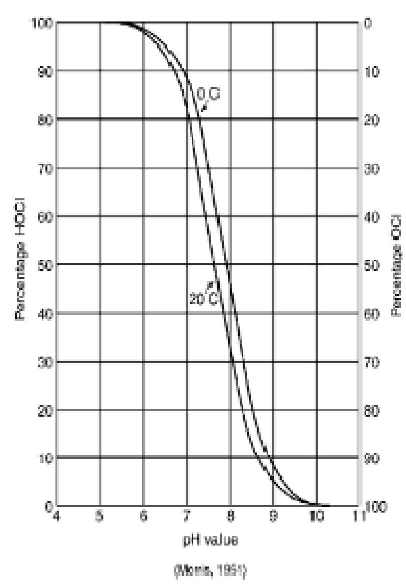

Figure 4 - Effect of Variable Temperature on pH; This figure illustrates how deviation of temperature (i.e. different environments) can impact the solubility, and therefore reactivity of these various compounds. Here, higher temperatures cause more

The varieties of products also show a variance in electrochemical properties. This number of products poses a significant problem, as mitigation measures of one byproduct will not solve the potential for removal of another product. The variance of activity from the different products is alluded to in Figure 3, suggesting that some of these products are quite dangerous, and react often, while others are fairly inert, and seldom react. In Figure 3, one notes removal of diatomic chlorine from a heavy polluted site (denoting high chemical activity), whereas Chlorine dioxide (ClO_2) would not react with heavy pollution, and therefore remain contaminating a waste site for long periods of time regardless of the mitigation chemical used. Therefore, different and highly specific removal techniques must be utilized for each of the chemical byproducts listed above.

For less active products, such as ClO_2, differential filtering processes should be utilized for environmental removal. Specifically, the EPA noticed this problem of multiple chlorination byproducts after the issuing of the Safe Drinking Water Act of 1986. The agency contracted out a chemical company, named Novatek, to "develop analytical methods and instrumentation for the accurate determination of low level concentrations of chlorite ion and chlorate ion resulting from the generation and/or use of chlorine dioxide in the purification of drinking water." (EPA,1990). They had aimed to "1. Improve analytical methodology and instrumentation; 2. Removal of [byproducts by using appropriate chemistry." (EPA, 1990) Specifically, this was accomplished via "develop[ment of] analytical methods and instrumentation for the accurate determination of low level concentrations of chlorite ion and chlorate ion […] and […] develop technology for the removal of chlorite ion from drinking water by using appropriate oxidation-reduction chemistry." (EPA, 1990). Using similar mitigation techniques and products, this could also be accomplished for the removal of hazardous chemicals from a remote site. This being said, these chemicals must all be individually assessed in order to dictate how and in which manner to accomplish this. Therefore, individual data on the environment, and therefore what byproducts are being produced in an area, becomes a germane topic of discussion. A list of detection methods for DBP are listed above in Table 1.

<u>Environmental Factors</u>. The impact of different environments on reaction speed is imperative to the creation of the alternative byproducts. As shown in Figure 4, temperature plays a significant role on reaction (Figure 4 shows a nearly 20% deviation in proton disassociation of the different temperature graphs when pH is set at 7.5). Temperature, pH, levels of Sodium Hypochlorite, waste site chemical medium, weather conditions, and other contaminants can all play a huge role in what the ClO^- will produce. (UNEP, 2000) One aspect of this association is level of Hypochlorite anion present. A mole of $Ca(ClO)_2$, also known as chlorinated lime powder, will produce twice as much anion of ClO^- as sodium hypochlorite. This primarily is based on the electrochemical charge, therefore allowing Calcium to be associated with more anion per a mole of cation, when compared to Sodium. This would account for a different equilibrium and therefore different level of byproduct produced.

Various health effects occur after exposure to sodium hypochlorite. This chemical, also because of its reactivity and variable nature based on the surrounding environment cause a plethora of potential problems. The EPA suggests:

> Effects of chlorine on human health and the environment depend on how much chlorine is present and the length and frequency of exposure. Effects also depend on the health of a person or condition of the environment when exposure occurs. Human health effects associated with breathing or otherwise consuming small amounts of chlorine over long periods of time are not known. They are currently under investigation. […] Laboratory studies show that repeat exposure to chlorine in air can adversely affect the immune system, the blood, the heart, and the respiratory system of animals […] and causes environmental harm at low levels. Chlorines are especially harmful to organisms living in water and in soil. (EPA 1994)

The EPA also notes Lithium hypochlorite (an isoelectronic structure to Sodium hypochlorite):

> has been shown to be highly corrosive, placing it in Toxicity Category I (indicating the highest degree of acute toxicity) for both eye and skin Irritation It is moderately acutely toxic in acute oral and dermal toxicity studies, placing it in Toxicity Category III for oral toxicity and Toxicity Category IV for dermal toxicity. Studies on human use of lithium-containing drugs, including chronic use, have not shown any reason for concern over continued human exposure to lithium following its use as a pesticide. The medicinal exposures are at a much higher level than that which results from the compound's pesticide uses (EPA, 1993)

In terms of toxic impacts of the substance, much is known about the exposure. :

> People are exposed to sodium hypochlorite by inhalation of aerosols. This causes coughing and a sore throat. After swallowing sodium hypochlorite the effects are stomach ache, a burning sensation, coughing, diarrhea, a sore throat and vomiting. Sodium hypochlorite on skin or eyes causes redness and pain. After prolonged exposure, the skin can become sensitive. **Sodium hypochlorite is poisonous for water organisms. It is mutagenic and very toxic when it comes in contact with ammonium salts. […] Sodium hypochlorite is a dangerous and corrosive substance. While working with sodium hypochlorite, safety measures have to be taken to protect workers and the environment.** Sodium hypochlorite should not come in contact with air, because that will cause it to disintegrate. (Lenntech, 2011b)

Despite Sodium Hypochlorite's reactivity, though, this product shows no potential for carcinogenicity: "There is inadequate evidence for the carcinogenicity of hypochlorite salts in experimental animals. No data were available from studies in humans on the carcinogenicity of hypochlorite salts. Overall evaluation: Hypochlorite salts are not classifiable as to their carcinogenicity to humans (Group 3)." (NIH, 2011) Similarly, "No mutagenic effects were seen in a battery of studies" (EPA, 1993) using lithium hypochlorite. These data are correlated with Table 2. Here, one is able to note various Dose-Response relationships to the frequency of bleach use. Acute effects seem to show stronger signals of correlation, whereas chronic impacts tend to approach a null correlation.

TABLE IV. Associations between the frequency of bleach use and allergic diseases, respiratory symptoms, and BHR

	Frequency of bleach use			
	Less than 1 d/wk (n = 1267)	1 to 3 d/wk (n = 669)	4 to 7 d/wk (n = 350)	*P* for linear trend
Ever asthma	0.93 (0.72-1.21)	0.88 (0.62-1.23)	1.30 (0.86-1.96)	.61
Nasal allergies or hay fever	0.76 (0.64-0.91)	0.76 (0.60-0.97)	0.91 (0.66-1.25)	.07
Ever eczema or skin allergy	1.25 (1.06-1.47)	1.12 (0.89-1.41)	1.07 (0.80-1.44)	.32
Allergic symptoms* triggered by contact with animals	0.87 (0.70-1.08)	0.71 (0.51-0.99)	0.93 (0.59-1.46)	.16
Allergic symptoms* triggered by contact with house dust	0.90 (0.74-1.08)	0.75 (0.58-0.97)	0.93 (0.66-1.30)	.15
Allergic symptoms* triggered by contact with trees/grass/flowers/pollen	0.70 (0.58-0.83)	0.76 (0.60-0.97)	0.96 (0.69-1.33)	.09
Wheeze	1.01 (0.82-1.24)	1.00 (0.76-1.31)	1.24 (0.88-1.74)	.40
Nocturnal shortness of breath	0.73 (0.52-1.03)	1.09 (0.74-1.59)	1.38 (0.88-2.16)	.21
Chronic cough	0.75 (0.54-1.04)	1.19 (0.81-1.76)	1.49 (0.94-2.37)	.11
Symptom score (ratio of the mean score)†	0.88 (0.76-1.02)	1.06 (0.89-1.27)	1.37 (1.11-1.68)	.02
BHR‡	1.06 (0.79-1.42)	1.03 (0.70-1.50)	1.30 (0.82-2.06)	.38

OR and 95% CI relative to those who never used bleach (n = 1340), adjusted for sex, age, smoking status (fixed), and study center (random).
*Cough, wheeze, chest tightness, shortness of breath, runny or stuffy nose or sneezing, and/or itchy or watering eyes.
†Sum of the answers (0 = no, 1 = yes) to 5 symptoms in the last 12 months (wheeze with breathlessness, woken up with chest tightness, attack of shortness of breath at rest, attack of shortness of breath after exercise, woken up by attack of shortness of breath).
‡Methacholine dose of 1 mg or less causing a 20% fall in FEV_1.

Table 2 – Note that Chronic impacts are insignificant, whereas acute toxicity maintains variable levels. (Zock, 2009)

This being said, a number of carcinogenic byproduct problems become associated with Chlorine. Chloroform, a long known carcinogen, is formulated through the interaction of chlorine and drinking water. In humans, a number of observational studies have associated chlorinated drinking-water consumption with a slight increase in bladder, rectal, and colon cancer; however it is not clear how much, if any, of the cancer increase was caused directly by chloroform exposure, as these studies did not incorporate the disinfection byproducts of chlorination in to the assessment of these elevated cancer rates. (EPA, 2001 and Frumkin, 2010) Therefore, carcinogenicity of the indirect impact of this array of disinfectants has yet to be determined.

In terms of waste, as noted earlier, sodium hypochlorite seems to present an acute environmental impact of a potentially deadly nature. The good aspect to this is that because of its acute method of action, bioaccumulation of NaClO will not persist in hazardous waste sites. The major problem here, though, is that various chemicals' byproducts can persist based on the variable environmental conditions. (UNEP, 2000) **These products are the cause of concern, and necessity for quick removal. In terms of management, one needs to ensure the disposal of bleach products is not into environmentally sensitive areas. Excess bleach should be kept in airtight containers to allow for no environmental interaction. Due to the acute reactivity of this chemical, medical, biological, and chemical wastes mixed with bleach should never be allowed to burn** (burning would cause for an increase of chlorine gas, which is induces a much higher LC50 in rates when compared to oral administration. LC50 in rats for inhalation of chlorine gas is 15.9 mg/L for 5 minutes, 5.6 mg/L for 10 minutes, 2.0 mg/L for 30 minutes, 1.3 mg/L for one hour, as compared to LD50. Rat oral administration of 8.91 g/kg. (NIH, 2011) Similar LC50 measures are seen in mice and humans, thus dictating burned NaClO as a potential danger across species (NIH, 2011). This lack of burning will results both in a removal of potential for a disease to become airborne as well as a mitigation of environmental contaminants in the air. **Appropriate medical waste dispensing containers should be used for all forms of waste saturated in bleach, even in remote locations.**

The best compliance measure would stem from The Occupational Safety and Health Administration. OSHA notes that one should "**Keep locked up. Keep container dry. Keep away from heat. Keep away from sources of ignition. Keep away from combustible material. Do not ingest. Do not breathe gas/fumes/ vapor/spray. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment**. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as reducing agents, combustible materials, organic materials, metals, acids. Keep container tightly closed. Keep container in a cool, well-ventilated area. Separate from acids, alkalis, reducing agents and combustibles. Air Sensitive & sensitive to light. Store in light-resistant containers." (ISU, 2001) Though space is limited, **proper disposal of these materials must be necessary in order to prevent acute health impacts; proper removal should incorporate airtight containers, as to not allow NaClO to enter reservoirs of air, soil, water or other organisms**. In conjunction with the OSHA compliances of mitigation techniques to reduce environmental contamination of the multiple byproducts, **use of disinfectant should be limited only to contaminated items in need of sanitation**. All other uses should be limited to reduce potential contamination elsewhere. As bleaches and chlorines are generally used at the site of disinfection, and "the potential for transmitting disease is greatest at the point where waste is generated," (Frumkin, 2010) suggesting that used bleach should be separated from unused bleach, and both containers should be airtight.

ALCOHOLS, CRESOL AND PHENOLS

Alcohols. Unlike the complexity associated with NaClO, bleaches, chlorides, etc., alcohols pose a much different environmentally toxic impact. Alcoholic compounds (those denoted as having a constituent "–OH") have a much higher No Adverse Effect Level (NAOEFL), denoting in a higher safety, as higher concentrations denote no impact. Ethanol is not accumulated in the body. Dermal uptake of ethanol is very low. (International Programme on Chemical Safety, 2004b) Environmental impact also shows this same trend:

> Ethanol is stable to hydrolysis but is readily biodegradable (74% after 5 days) and is not likely to bioaccumulate (calculated logBCF=0.5). Ethanol is not persistent in the environment. Fugacity-based modeling shows that ethanol released into the environment will become distributed mainly into air and water. Relative distributions between compartments based on an emission pattern of 1000:100:10 were 57 % in air, 34 % in water, and 9 % in soil. These predictions are supported by the limited data available on prevailing concentrations, which shows that ethanol has been detected in outdoor air and in river water. The total tropospheric half-life of ethanol is estimated to be 10-36 hours, with degradation due to hydroxyl, NOx and SOx radical-mediated photo-oxidation. As a volatile organic compound in the atmosphere, ethanol is a potential contributor to tropospheric ozone formation under certain conditions, however its photochemical ozone creation potential is considered to be moderate to low (40-45 relative to ethylene as 100). The aquatic toxicity data in fish, invertebrates, and algae indicate a low order of acute toxicity with LC50/EC50 values greater than 1000 mg/l. The most

sensitive species were algae Chlorella vulgaris with a 96hr EC50 of 1000 mg/l and the invertebrate Artemia Salina with a 24hr LC50 of 1833 mg/l. Valid chronic toxicity data are available for two trophic levels. The lowest reported NOEC for invertebrates is 9.6 mg/l (10 day reproduction) whilst for plants it is 280mg/l (7 day study). (International Programme on Chemical Safety, 2004b)

In conjunction with this, even with large organic cleanup impact, "Any organic wastes from manufacture are typically incinerated on site or disposed of via specialist waste contractors (CEFIC, 2003). It is possible that small, farm scale fermentation manufactures may not have such extensive emission controls but by their nature, volumetric emissions will be low and dispersed." (International Programme on Chemical Safety, 2004b) Therefore, since mitigation of threat is highly controlled with the alcoholic compounds, only two major issues should be noted. The first is the storage of alcohol would be of imperative value, as to ensure chemical spills are not generated. The second major aspect would be the potential bioaccumulation of phenolic compounds, or alcoholic compounds with a highly nonpolar steroid ring attached, as these could allow for the potential of environmental impact and exposure.

Material	Breakthrough time (hr)
Butyl Rubber	>8
Nitrile Rubber	>8
Viton	>8
4H (PE/EVAL)	>8
Neoprene	>4
Teflon	>4
Polyvinyl Chloride	Caution 1 to 4
Saranex	Caution 1 to 4
Natural Rubber	<1(*)
Polyethylene	<1(*)
Polyvinyl Alcohol	<1(*)

(*) Not recommended, degradation may occur

Table 3-Breakthrough times for alcoholic products to personal protective equipment (Department of Labor, 1994)

In terms of proper storage of alcoholic compounds, OSHA has made many dictations. The form of isopropyl alcohol was used here, as this is the most common form of industrial disinfectant used:

> Isopropyl alcohol should be stored in a cool, dry, well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's Hazard Communication Standard. Containers of isopropyl alcohol should be protected from physical damage and contact with air, and should be stored separately from strong oxidizers, acetaldehyde, chlorine, ethylene oxide, acids, and isocyanates. (US Department of Labor, 1994)

It is important to note that the storage of these compounds should also not be placed in any sort of flammable areas, as this could cause for combustion of these hazardous materials. Proper movement away from heated objects are required and necessary for the safety and health of all those involved. In conjunction, proper breathing apparatuses must be utilized for safe usage, to ensure that acute inhalation exposure does not occur. Figure 5 dictates the relation between utilization of breathing apparatus and time related to the permeation of these devices to environmental contaminants. These measures ensure the mitigation of environmental exposure of inhalation, which consists of the most viable route of exposure to these toxins.

In terms of outbreak response waste disposal, it must be noted that these disinfectants potentially containing pathogens cannot be burned, as to reduce potential for a contaminant to go airborne. Therefore, proper storage and labeling of contaminated products must be undergone, in order to ensure the removal of product in a safe and effective manner. In terms of reduction of waste disposal, if the disinfectant is known to not contain viable pathogen, it can be burned, assumed the burning area is a controlled flame far apart from any other potentially flammable material.

The other consideration is the phenolic compounds. Specifically, these compounds contain at least one hydroxyl group (-OH) and phenol group ($-C_6H_5$), which denote the two major areas. The phenol group contains the aromatic, nonpolar, electron-rich ring, allowing for a net stability of polar alcohol group. The aromatic structure provides a great stability to the molecule, and therefore, shows a grand stability in terms of a chemically conjugated structure. This "freedom" allows for electron freedom, and thus for π-orbial elections to cycle around the molecule with space allowing them a delocalized, or less constrained, structure. This cycling of the π-bond elections in conjunction with the stable ϭ-bond characteristics of these molecules allows for bonds to exert an overall bond order of ~1.5 for the molecule. This "electron freedom" and stabilization causes for these chemicals to remain fairly stable, since impacts of polar charges can therefore be "cycled" around the molecule, and thus miniaturized by the grand stability of these molecules. In terms of the physical chemistry, the 1s and 2 orbitals of these molecules are filled to completion. The deviations occur at the p-orbitals. Here, one would usually find $2p\pi_u$ orbitals filled, yet all other orbitals open for carbon shifting in this chemically conjugated cyclic stabilization. (Laidler, 2003) **These chemicals, therefore, generally have a low reactivity, which allows for bioaccumulation of the major chemical and respective metabolites**. Two major examples of these products are presented: Cresol and Phenol. Though others exist, Cresol is a certified and mandated WHO disinfectant, and phenol is considered the monomer of all other phenolic structures (including phenolic monomers, polyphenols, tannins).

<u>**Cresol**</u>. In terms of Cresol, 3 separate forms exist: ortho-cresol, meta-cresol, and para-cresol. All three are viably active agents, yet the most widely used is p-cresol. **Problems associated with these compounds are generally result from bioaccumulation of byproducts leading to cardiovascular disease and oxidative injury.** (Genome Alberta, 2009) Specific depositor-supplied cresol synonyms include 4-Methylphenol, p-cresol, 4-Cresol, 4-Hydroxytoluene, p-Methylphenol, p-Oxytoluene, p-Hydroxytoluene, p-Kresol, p-Toluol, para-Cresol, p-Cresylic acid, p-Methylhydroxybenzene, and over 150 other chemicals are designated (NIH, 2011). Specifically, the problem with Cresol results from the resultant reactions of the byproducts. When metabolized, p-Cresol yields p-cresyl sulfate in humans. (NIH, 2011) This can contain some major toxic implications. "p-Cresol sulfate is a small protein-bound molecule that is poorly cleared with dialysis and is often considered to be a uremic toxin. Uremic toxins include low-molecular-weight compounds such as indoxyl sulfate, p-cresol sulfate, 3-carboxy-4-methyl-5-propyl-2-furanpropionic acid and asymmetric dimethylarginine. It has been linked to cardiovascular disease and oxidative injury." (Genome Alberta, 2009) In terms of carcinogenicity of Cresol, it has been denoted as a "Level C- possible human carcinogen. The

basic of this claim relates to increased incidence of skin papilloma in mice in an initiation-promotion study. The three cresol isomers produced positive results in genetic toxicity studies both alone and in combination." (NIH, 2011) This being said, data remains limited for this classification, and both more animal and more human data needs collection in order to verify these findings.

According to the International Program for Chemical Safety, all three forms of Cresol have natural environmental safety precautions due to this toxicity in high doses:

> Personal protection: filter respirator for organic gases and particulates adapted to the airborne concentration of the substance. Chemical protection suit. Sweep spilled substance into containers; if appropriate, moisten first to prevent dusting. Carefully collect remainder, then remove to safe place. Do NOT let this chemical enter the environment. (International Programme on Chemical Safety, 2004a)

In conjunction, much information is denoted on the storage and usage of this chemical: "Separated from strong oxidants, food and feedstuffs. Store in an area without drain or sewer access. Provision to contain effluent from fire extinguishing." (International Programme on Chemical Safety, 2004b) Therefore, similar protocol in the waste mitigation and management should be used for Cresol as with other alcohols.

Phenols. Phenols constitute a number of biochemical materials, which comprise a wide range of products **including sanitation disinfectants** and consumer products such as wines. Phenols are metabolites created from Benzene for these commercial uses. Benzene products are known for their environmental issues, and therefore are not generally used directly as disinfectants; generally modified benzenes (the phenols) are utilized as disinfectant agents, which host their own slew of health issues:

> Benzene is an occupational and environmental toxicant. The major health concern for humans is acute myelogenous leukemia. To exert its toxic effects, benzene must be metabolized by cytochrome P450 to phenol and subsequently to catechol and hydroquinone. Previous research has implicated CYP2E1 in the metabolism of phenol. (Powley, 2001)

As they are naturally occurring chemical compounds, they generally can be metabolized from their larger chemical constituents in to their monomer form. This is then actively broken down and excreted:

> The cytochrome P450 isozymes involved in the metabolism of phenol were examined in hepatic and pulmonary microsomes utilizing chemical inhibitors of CYP2E1, CYP2B, and CYP2F2 and using CYP2E1 knockout mice [...] Although a small amount of phenol undergoes conjugation with glucuronic and sulfuric acids within one to two days of exposure, most is excreted unchanged in the urine[...] Phenols are subject to oxidative metabolism leading to ortho- and para-hydroxylated products. These metabolites are then transformed into equimolar amounts of two conjugates, sulfates and glucuronides (NIH, 2011)

In addition, other reported metabolites include hydroquinone, other quinones and other catechols. (NIH, 2011) The mechanism of action allows for phenol to act as "protoplasmic toxin that disrupts cell walls and denatures proteins. These properties promote rapid pulmonary and gastrointestinal absorption. Dermal absorption is rapid even through intact skin. High concentrations of Phenol disrupt the dermal barrier and penetrate the skin effectively." (NIH, 2011) The site of action of toxicology of phenols is highly researched and understood, as phenol has universal impact on human physiological function:

> In a case of lethal human phenol intoxication (a phenol-containing disinfectant was ingested), the phenol concentration in brain, kidney, liver and muscle was determined several hours after death. The concentration in the brain was highest, followed by the kidney; the concentrations in liver and muscle were half that in the brain. (NIH, 2011)

The phenolic compounds are considered to interfere with iron absorption by complex formation with iron in the gastro-intestinal lumen, making the iron less available for absorption. Much of this is believed to occur through the disruption of the coordination complex, yet this is still debated, as the extent to which different types of phenolic compounds of different size and chemical structure inhibit iron absorption. (Brune, 1989) Therefore, as noted: Phenol is toxic with a probable oral lethal dose to humans of 50-500 mg/kg […] Rapid absorption and severe systemic toxicity can occur after any route of exposure including skin. Death and severe toxicity are usually due to effects on the CNS, heart, blood vessels, lung, and kidneys. However, toxic manifestations may vary somewhat with the route. Observed effects from acute exposure may include: shock, delirium, coma, pulmonary distress, phenolic breath, scanty/dark urine, and death. Protracted or chronic exposure usually results in major damage to the liver, kidneys and eyes. Pigmentary changes of the skin have been noted. Consumption of water contaminated with phenol resulted in diarrhea, mouth sores, burning of the mouth, and dark urine. Phenol is highly caustic to tissues. Skin exposure results in pain, then numbness, blanching, severe burns, and eschar formation. Ingestion leads to burning of throat and severe gastrointestinal inflammation. Inhalation can result in pulmonary irritation and edema. (NIH, 2011)

The volatility of this chemical in relation to personal protective equipment is illustrated in Table 4. Changes to this molecule via dilution or other aspects change the impact of action on the human system: "Phenol is absorbed rapidly through the lungs and through the skin […] dilution of phenol may increase absorption and does increase toxicity." (NIH, 2011) Therefore, disruption of the properties of this chemical's medium of administration can potentially cause more harmful exposure pathways. This can lead to a compounding in the levels of acute or chronic effects. Therefore, disruption of these media should be avoided, and separate containers should be used for phenols. In terms of storage and disposal, phenols "should be stored in a cool, dry, well-ventilated area in tightly sealed containers […] protected from physical damage and ignition sources, and should be stored separately from strong oxidizers (especially calcium hypochlorite), acids, and halogens" (Department of Labor, 1994)

Table 4 -Breakthrough times for Phenol products to personal protective equipment (Department of Labor, 1994)

Material	Breakthrough time (hr)
Viton	>8
Saranex	>8
Barricade	>8
Chemrel	>8
Responder	>8
Neoprene	>4
Teflon	>4
4H (PE/EVAL)	>4
Butyl Rubber	Caution 1 to 4
Natural Rubber	<1(*)
Nitrile Rubber	<1(*)
Polyethylene	<1(*)
Polyvinyl Alcohol	<1(*)
Polyvinyl Chloride	<1(*)

(*) Not recommended, degradation may occur

In the event of a spill or leak involving phenol, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup has been undergone. This is not only due to the volatile nature of this chemical, but also the potential for spreading this compound to other susceptible organisms.

As the environmental impact of this chemical is universally detrimental, mitigation techniques must be carried out in order to ensure the proper techniques are present to reduce spills, remove threats of contamination, and contain the threat after it has been present. The methods of control via separation have already been noted. Also noted, "Significant differences have been demonstrated in the chemical resistance of generically similar PPE materials (e.g., butyl) produced by different manufacturers. In addition, the chemical resistance of a mixture may be significantly different from that of any of its net components." (Department of Labor, 1994), therefore indicating that the active phenol constituents must be examined in a holistic manner in order to determine the chemical's overall impact.

Within the scope of this project, this would require analysis of each potential phenolic disinfectant in a future outbreak response, so as to understand potential interactions with soils, humans, etc. Therefore, for future remote outbreak investigations and response, analysis of the proper dilution and removal of hazardous waste must be undergone prior to utilization of phenolic compounds. **As noted earlier, the utilization of the proper safety equipment and safe storage in a separate container for both used and unused products would prevent potential environmental contamination**. In conjunction, the removal of products by burning should only be undergone if:

- the phenolic chemical and contaminated materials are free of epidemiological impact;

- the chemical is able to be burned within a safe radius of other flammable materials/areas; and
- the chemical is safe and an environmentally viable candidate for burning.

All of these internal chemical factors need review, based on the information of the mixing differentiation provided by OSHA.

PESTICIDES:

According to the WHO-AFRO/CDC Technical Guidelines for Integrated Disease Surveillance and Response, three major pesticides are marked as essential in the scope of the project. Cypermethrin and Permethrin are two of these contained within one group (the pyrethroid insecticides) and Malathion is the third pesticide of interest.

CYPERMETHRIN & PERMETHRIN

Cypermethrin and Permethrin belong to a larger group of chemicals known as Pyrethrins. These chemicals are known by working through neurotoxic impact. This is majorly accomplished due to both the oxidative or esterative attack of these compounds. This all depends on the relative electron density of chemicals mentioned, with changes relative to isomer of these compounds used, but these two sites of action remain the site of action hallmark for these species. Depending on which area holds the higher electron density generally dictates the higher mode of action of these species. (Bear, 2008) "In the case of cypermethrin, the relative importance of an esterase attack as opposed to an oxidative one is more important than for permethrin" (NIH, 2011) **For the individualistic aspects, these chemicals should all be kept in separate containers.**

In terms of human impact: "The major degradation pathway of cypermethrin is hydrolysis of the ester linkage to yield ultimately 3-phenoxybenzoic acid and 3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylic acid. A minor degradative route is ring hydroxylation to give an alpha-cyano-3-(4-hydroxyphenyl)benzyl ester followed by hydrolysis to produce the corresponding hydroxycarboxylic acid. (NIH, 2011) These can be done ex vivo by adding filtered water to large quantities of these pesticides, and then disposing of them as phenols. **Therefore, if large standing quantities of these chemicals exist, adding clean water and then disposing of them as phenolic wastes generally allows for a safe, cost-effective handling mechanism in remote areas**. (Department of Labor, 2004)

In terms of usage, Pyrethrins with piperonyl butoxide are used for topical treatment of pediculosis (lice infestations), and many clinicians consider 1% lindane to be the pediculicide of choice. In terms of toxicology, these chemicals are generally non-fatal, yet Cypermethrin was the first pyrethroid to be reported as having caused a human fatality due to acute toxicity. In Greece a man died 3 hr after eating a meal cooked in a 10% cypermethrin concentrate used in error instead of oil. (NIH, 2011) In terms of carcinogenicity, Pyrethrins are classified as Group C Possible Human Carcinogens, which denote that not enough information is currently available to dictate that generic abnormalities occur with this chemical's sustained usage. (NIH, 2011)

In terms of impact, the general reason for toxicological mechanism is direct occupational use of this substance:

> Of the 573 cases, 229 were of occupational origin resulting from inappropriate handling of the chemicals such as spraying with higher concentrations than allowed, sustaining longer exposure durations than recommended, spraying against the wind, clearing stoppage of sprays by mouth and hands, spraying closer than every row of crops, or not wearing personal protective equipment. (Thangavelu, 2010)

Therefore, it is safe to assume this chemical, when used properly, generally mitigates most occupational exposure (and therefore human health impact). If used in aerosol or gaseous form, breathing apparatuses, similar to those in phenolic compounds, should be utilized. In conjunction, aerosol residues should be properly stored as not to contaminate other products. In terms of environmental mitigation:

- standing solid, semi-solid, or liquid reservoirs of pesticide should be added to large quantities of water and disposed as phenolic compounds; a
- all waste should be handled with care, as potential flammability can and does occur;
- any pathogenic waste should be diluted with sterile water, and placed in phenolic waste containers, and should not be burned for the potential of environmental contamination or pathogenic spreading; and
- deceased Aves or higher tropic level organisms should be monitored for elevated levels, though bioaccumulation is generally not an occurrence.

MALATHION

Malathion is contained under the larger umbrella of chemicals dictated as organophosphates. These compounds are more chronically toxic, and impact toxicology in a bioaccumulative manner. Acting on a similar mechanism, and therefore also discussed, are the more acutely toxic organosulfates. These chemicals are removed relatively quickly, and therefore more quickly removed from toxicological impact.

Organophosphates are the massive group of chemicals which contain a phosphate group linked with some organic constituents. The chemical Malathion has properties of both an organophosphate, and with the residual sulfate groups, contains sulfur toxicity impact. Phosphate, due to its unique valence structure, has the physical potential to form 5 bonds between different molecules. This allows for a highly electrophilic species of Phosphor, and therefore relatively unstable form. In the Malathion species, the phosophorous atom is linked to both oxygen and sulfur, which further allow for the electrophilic nature of this area. Even though this molecule is nonpolar, overall, though, the varied stability seen in this electronic structure suggests the relative propensity for this molecule to attack other chemicals (Bear 2008).

Because of this chemical's nonpolar nature, it readily crosses the blood-brain barrier, and is able to impact cholinesterase. The polar regions of the molecule are able to "rapidly hydrolyzed, and thereby inactivated, by cholinesterase. When cholinesterase are inhibited, the action of endogenously released acetylcholine at cholinergic synapses is potentiated. Cholinesterase inhibitors are widely used clinically for their potentiation of cholinergic inputs to the gastrointestinal tract and urinary bladder, the eye, and skeletal muscles; they are also used for their effects on the heart and the central nervous system." (NIH, 2011). The good news is that these chemicals do take a while to absorb through the skin, **yet these chemicals seem to persist for long periods of time: Organic phosphorous insecticides are absorbed by the skin, as well as by the respiratory and GI tracts. Absorption by the skin tends to be slow, but, because the insecticides are difficult to remove, such absorption is frequently prolonged**. Skin absorption is somewhat greater at higher temperatures (NIH, 2011) and therefore other factors such as pH, environmental substituents, and other chemical associations play a role in these chemical's environmental toxicology.

The conversion of many organophosphates with a P=S group to P=O is another instance of activation by mixed function oxidase resulting in an increase in toxicity. This process explains the greater toxicity of metabolites like paraoxon, malaoxon, fenitrooxon, etc than that of their parent compounds. These chemicals are converted by the P450 cytochrome, and generally are converted in the liver. (NIH, 2011) Ex vivo, these chemicals should be individually evaluated due to the individualistic aspects of these chemicals, and therefore mitigation should be done for each of these chemicals on the individual inorganic constituents. **Therefore, individual mitigation methods must be used for different chemicals.** For environmental removal, toluene is suggested as a solvent removing agent. (Department of Labor, 2004) This should only be used for solid, semi-solid, or liquid waste in the environment. Due to problems of dermal and inhalation absorption, proper handling equipment (eyewear and dermal protection) must be worn. In conjunction, proper storage separate from other contaminated products must be accomplished in order to allow for a lack of mixing. **As this is an insecticide, and because of potential for bioaccumulation, the chemical should be examined in higher tropic organisms (such as Aves) in order to monitor potential threats.**

Organosulfates are the second class of interesting chemical. Sulfur here, like Phosphate, has the ability to overcome the traditional rules of bonding formation, and can form up to 6 bonds. As these chemicals, are generally similar to the electron formation and individuality of the Phosphate molecules, each individual molecule holds a similar individualistic impact from intermolecular and intermolecular forces. This chemical does not hold as much chronic toxic impact due to the propensity of sulfur not to hold the maximum potential bonds (12 individual bonds tend to make sulfur too neucleophilic, and therefore center too much magnetic tension and strain on the bonded nucleus and the associated nuclei of the various bonds). In conjunction, this results in a generally negative charge on the sulfur molecule. This makes this chemical harder to exert chronic, neurotoxic impact, and therefore acute impact of this chemical is a more likely mechanism to be considered. (Bear, 2008) This chemical does have the potential for chronic impact, though, and should be ministered similar to organophosphates. Similar mitigation techniques should be used, therefore, in both the protection of those susceptible and the disposal and removal of this chemical.

RODENTICIDES: BRODIFACOM & BROMADIONE

According to the WHO-AFRO Technical Guidelines for Integrated Disease Surveillance and Response, two major rodenticides are marked as essential for use in disease outbreaks. Both are remarkably similar, and therefore grouped within the same topic of Brodifacom & Bromadione.

In remote areas, Rodenticides are highly useful agents in order to mitigate disease spread in rodent vectors. Specifically, these agents (Brodifacom and Bromadione) act as anti-coagulant species to induce failure of myocardial muscle. Bromadiolone, brodifacoum and coumatetralyl are generally found in unchanged and unmetabolized in rats, suggesting that these chemicals are active in their generic forms. The major (and only identified) metabolite of brodifacoum in bile was the glucuronide, which is found in the liver, not interacting in the mechanism of toxic impact. In conjunction liver metabolic pathways, a number of hydroxycoumarins are formed in the liver as nontoxic products. (NIH, 2011) The exact mechanism of action of these chemicals remains undetermined. The combination of chemicals generally remaining immobile in soil and the concept of *Henry's Law* (a compound does not volatize between water and soil), dictates that these rodenticides remain fairly inert in their environments, **providing optimal occurrence for bioaccumulation**. (NIH, 2011) The good news with these chemicals stems from their propensity for photo-degeneration. The better news is that humans are fairly resilient to exposure in controlled amounts. The bad news is that organisms generally recycle these inert molecules back in to their system before this process occurs. The worse news is that anti-coagulant treatments do not generally illustrate symptoms until major impacts have already occurred. **Therefore, mitigation of bioaccumulation of these compounds is a fundamental priority.**

The mitigation protocol must center on the controlled administration of rodenticides:

- First, this substance must be utilized within only a controlled area, in order to control the circulation of rodents;
- Next, all deceased organisms must be labeled as toxic waste, and disposed of properly;
- This toxic waste cannot be burned, as heavy amounts of carbon monoxide, bromide gas, and other highly toxic fumes can be released. In conjunction, a pathogen could go airborne, or these rodenticides could be released into the surrounding atmosphere;
- Therefore, separate and sealed medical waste must be used for these organisms as to ensure that no release of these chemicals can occur into the atmosphere for bioaccumulation (NIH, 2011).

In conjunction, the storage of this molecule follows stringent guidelines: "brodifacoum and formulations should be stored in sealed containers in locked, well-ventilated, dry areas away from frost, direct sunlight, and sources of heat and ignition. Keep products out of reach of children and unauthorized personnel. Do not store near food and animal feed." (NIH, 2011) Finally, outside monitoring must be done in order to mitigate the potential for bioaccumulation of chemical in higher organisms resulting in human consumption. Especially in remote areas, **regular monitoring of deceased Aves and other higher trophic organisms via mass spectrometer or other methods, allows a proper method of mitigation of chemical rodenticide for waste disposal in rodent vector hazardous waste disposal. Proper disposal of all infected organisms should not be near a water source, or buried, but rather in sealed, airtight containers**. (NIH, 2011)

OTHER CHEMICALS TO NOTE

Though many chemicals have been noted in the WHO-AFRO/CDC Technical Guidelines for Integrated Disease Surveillance and Response, other widely used materials have been listed following this order. The following are additional chemicals proposed by The Oregon Health Authority (The Public Health Sector of the state of Oregon). They have denoted these chemicals as environmental contaminants which cause "the most acute poisoning as well as any subacute illness or condition (dermatologic, ophthalmologic, or systemic) caused by, or suspected of being caused by, pesticide exposure. […] To be confirmed case, a case must have some specific laboratory indication of exposure and absorption, or a history and pattern of symptoms that are pathognomonic for exposure to the particular chemical." (Oregon Health Division 1995). The following are the results and associated explanations.

CARBAMATES & DITHIOCARBAMATES

These compounds are fully explained in the Malathion section. These chemicals exhibit reversible effects on the acetylcholinesterase enzyme, and therefore are more capable of acute impact, and therefore should be monitored in direct human interactions, as they do not have as much potential as organophosphates for bioaccumulation. For further information, please review the "Malathion" section of this report, as this contains information for both Organophosphates and organosulfates. Examples of to N-methyl carabamates include carbaryl (Sevin), propoxur (Baygon), oxamyl, and aldicarb (Temik) (Oregon Health Division 1995). Examples of generic carbamate and dithiocarbamates include benomyl, maneb, zineb, ziram, ferbam, thiram, and diallate. (Oregon Health Division 1995).

CHLOROPHENOXY COMPOUNDS

Chlorophenoxy compounds are noted as compounds "sometimes mixed into commercial fertilizer to control the growth of broadleaf weeds. Several hundred commercial products contain chlorophenoxy combinations. In some cases, the same name is used for products with different ingredients. Specifically, these commercial operations refer nearly specifically to crop herbicide use. "EPA determined that there is reasonable certainty that no harm to any population subgroup will result from aggregate exposure to 2,4-DB when considering dietary exposure." (Fishel, 2010) Examples include 2,4-D-MCPA, and MCPP (National Pesticide Information Center, 2009 and Oregon Health Division 1995). Therefore, it is reasonable to assume that this chemical should have little-to-no environmental toxicological in control quantities, and most likely remain outside of the scope of this outbreak waste mitigation investigation.

COUMADINS AND INDANDIONES (RODENTICIDES)

Coumadins and indandiones are contained within the massive group of Coumadin-derivatives possessing a 4-hydroxy group with a carbon at the 3 position of the columarin-base structure. These chemicals possess anticoagulant activity and are referred to as hydroxycolumarins. One example, Bishydroxycoumarin, is known for being the active ingredient responsible for this hemorrhagic disorder. Bishydroxycoumarin is formed when fungi in moldy sweet clover oxidize coumarin to 4-hydroxycoumarin, an anticoagulant, which allow for this chemical to exert it's toxic impact. The 4-hydroxy columarins species are primarily used as anticoagulants and rodenticides. Second-generation rodenticides (long-acting anticoagulants, such as brodifacoum) are characterized by their clinical effects and very long half-lives. These chemicals are highly lipid-soluble, and are both concentrated and are metabolized in the liver. For these reasons, bioaccumulation of these compounds can and do occur. Though not highly lethal in terms of chemical toxicology, these chemicals can exacerbate existing conditions by reducing the coagulate property of blood. (Katzung, 2009 and Thangavelu, 2010) Examples of these compounds include warfarin, pindone, diphacinone, zoocoumarin, and coumafuryl (Oregon

Health Division 1995). To mitigate this threat, similar protocols to the WHO-noted rodenticides should be undergone.

DIPYRIDYLS

Dipyridyls are herbicides generally used as pesticides. The most common and generically used form of dipyridyl is paraquat. Another less widely used form is diquat. These chemicals are actively used in occupational settings for the spraying of crops, and are known as oxidative stressors, due to their disruption of metabolic oxidation pathway activity. As these chemicals are regulated for use in only widespread agricultural practices, runoff can occur, yet this should not generally fall within the scope of this environmentally hazardous medical waste toxicology. Much of the data known about paraquat has only been obtained through the use of ingestion and inhalation studies, which still require more results for further confirmation. This chemical is quite highly regulated in industrial use (only allocated as a controlled substance), and therefore usage for an outbreak scenario would be highly unlikely due to its potentially fatal nature. (Hale-Kupiec & Zinsmeister, 2011 and Oregon Health Division, 1995)

NITROPHENOLIC AND NITROCRESOLIC HERBICIDES

These chemicals consist of nitrogen-phenolic and nitrogen-cresol compounds. For associated information on these compounds, please note the “Cresol and Phenols and Alcohols” section of this report. These chemicals’ variability present different reactive potential based on the specific chemical formula, as phenols react in a variable manner depending on solute, route of exposure, media in which the active agent is contained, and chemical structure. Examples include inoseb and dinocap (Karathane). (NIH, 2011 and Oregon Health Division 1995)

ORGANOCHLORINES

These chemicals consist of chlorine linked to organic materials. For associated information on these compounds, please note the “Hypochlorites & associated Environmental Toxins” section of this report to note the toxicology of associated products. This should be less reactive than most non-organic chlorinated products, as added carbon groups (in processes such as methylation) generally stabilize these species. These chemicals both tend to stay longer in the environment, as they are more stable, and also are not as quickly removed from the body, as they are more nonpolar. Examples include aldrin, chlordane, and dicofol (Kelthane) (Katzung, 2009 and Oregon Health Division, 1995)

ORGANOPHOSPHATES (INSECTICIDES)

These chemicals attack cells in a similar mechanism to N-methyl carabamates, yet attack the acetylcholinesterase in an irreversible manner. These therefore exert a more deadly impact, and should be monitored more closely than the N-methyl carabamate compounds. Mitigation techniques are the same as the carbamate groups. For further information, please review the “Malathion” section of this report, as this is a prime example of an Organophosphate. Examples include malathion, diazinon, dimethoate, azinphosmethyl (Guthion), chlorpyrifos (Dursban, Lorsban), and dichlorvos. (Oregon Health Division, 1995).

PENTACHLOROPHENOL (PCP), DICHLORODIPHENYLTRICHLOROETHANE (DDT) AND OTHER CHLORINATED PESTICIDES

These chemicals consist of 5 chlorines linked to a phenol group. Generally, these are found in wood preserving agents, and not generically found as an outbreak containment or outbreak migration cleanup. PCP is also known for easily dissolving in water, and can be created when chlorine agents are exposed to phenolic compounds. For associated information on these compounds, please note both "Hypochlorites and Associated Environmental Toxins" for information on problems with chlorine residual byproducts, and the "Alcohols, Cresol and Phenols" section of this report for direct problems with phenolic compounds. Due to the chlorine's nucleophilic nature, the chlorine species are generally more reactive in the outside environment, while the phenol molecule remains fairly inert. This will result in more chlorine byproduct due to the heightened interaction and therefore more coordination complexes with the chlorine exterior of this molecule. Also, the low phenolic interaction and multiple, chlorine bonds results in highly deadly chlorinated products which stay in the environment for prolonged period of time. This chemical is highly toxic. An example is sodium pentachlorophenate. (Bear, 2008 and Oregon Health Division, 1995) As noted by the NIH:

> If released to soil, pentachlorophenol is expected to have low to no mobility [...] this compound will almost entirely exist in the anion form in the environment and anions generally do not adsorb more strongly to soils containing organic carbon and clay than their neutral counterparts. Volatilization from moist soil is not expected because the acid exists as an anion and anions do not volatilize [...] pentachlorophenol does biodegrade but may require several weeks for acclimation. (NIH, 2011)

Due to its nature, PCP mitigation techniques should be taken quite seriously, and phenolic and chlorine reduction tactics should be undergone in order to remove this chemical from environmental areas.

More commonly known as **DDT**, this chemical holds a nearly identical problem to PCP. These chemicals hold nearly identical chlorine atoms per mole of solution, though PCP, due to increased aromatic structure, also tends to exhibit a longer environmental longevity. DDT is similarly naturally created with the combination of chlorinated and phenolic compounds together, and can be extremely toxic. This is due to the fact that this molecule exerts a relatively nonpolar effect, allowing for solubility across the blood brain barrier, while still having relatively polar molecules (chlorines) attached. Also, the added stability of multiple phenolic compounds cause for greater potential harm than PCP. In humans, the excretion method is relatively quick, yet minor quantities persist due to its chemical nature. Acute impact is similar: "Death is usually due to respiratory failure from medullary paralysis. In acute exposures, recovery is usually complete within 1-3 days, but sometimes weakness or paralysis and ataxia may persist for weeks." (NIH, 2011)

Therefore, bioaccumulation is a constant threat, and therefore mitigation techniques must be a constant operation in programs utilizing this chemical in remote areas. These chemicals hold direct relation to chlorination issues illustrated in the disinfection problem mitigation. As these chemicals contain constituent and active groups from these areas, specific focus should be given on mitigation techniques when using these compounds. **Deceased higher tropic organisms subject to these chemicals should be monitored to ensure that bioaccumulation of species is**

not occurring in vulnerable animal populations, as to ensure the passage does not occur over to human populations.

PYRETHRINS, PYRETHROIDS (INSECTICIDES)

These chemicals are contained within the Cypermethrin & Permethrin section of the pesticide analysis. Please note that associated chemicals include fenvalerate (Pydrin), permethrin (Ambush, Pounce), resmethrin (Synthrin), and cypermethrin (Ripcord). (Oregon Health Division 1995).

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SUPPLEMENT 2: BEST PRACTICES FOR WASTE DISPOSAL IN REMOTE LOCATIONS DURING DISEASE OUTBREAK TRAINING OBJECTIVES AND MATERIALS

SESSION OBJECTIVES

To raise awareness of the potential public health and environmental hazards that can result from improper waste disposal when responding to a disease outbreak.

MATERIALS

- Waste Disposal in Remote Locations_Facilitator Guide (ppt file with presentation slides and facilitator notes)
- Waste Disposal in Remote Locations_Participant Handbook (ppt file, 1/participant)
- Best Management Practices Review for Waste Disposal from Disease Outbreak Response at Remote Sites (pdf file, 1 participant)

If you do not have access to a computer and projector:

- Make a color, poster-sized copy of Waste Disposal in Remote Locations_Poster (ppt file)
- Create flipcharts of Slides 6 through 12.
- Present material from facilitator notes on other slides without visuals. Refer participants to the Participant Handbook as you cover the material.

Note: The PowerPoint presentation is an interactive presentation. Please review the Facilitator Guide notes before presenting the slides.

SUPPLEMENT 3: BEST PRACTICES FOR WASTE DISPOSAL IN REMOTE LOCATIONS DURING DISEASE OUTBREAK TRAINING FACILITATOR'S GUIDE

Emerging Pandemic Threats Program
PREDICT • RESPOND • PREVENT • IDENTIFY

USAID
FROM THE AMERICAN PEOPLE


Because following best practices in waste disposal can SAVE LIVES
In the middle of a response to a disease outbreak when we are trying to save lives, why are we even talking about waste disposal?!!

5 steps

in waste disposal to protect you, others, and the environment

5 simple steps

in waste disposal to protect you, others, and the environment

Step ①

MINIMIZE

Step ②

SEGREGATE

Step ③

COLLECT

Step ④

TREAT

Step ⑤

DISPOSE

Key concepts in waste minimization

- Purchase supplies with less packaging
- Purchase supplies that are less hazardous
- Order in smaller quantities
- Use the oldest first
- Use all the contents
- Check expiration date at time of delivery
- Recycle or reuse items not directly used for medical care

REMEMBER
to always take personal precautions when handling waste.

Personal Precautions

- Use PPE which can include:
  - Gloves
  - Gowns/Aprons
  - Mask
  - Eye Protection
  - Shoes
- Wash your hands thoroughly after handling all waste

Key concepts in waste segregation

- Divides waste into:
  1. Sharps
  2. Infectious non-sharps
  3. Non-hazardous
- Takes place at time of generation
- Carried out by the person generating the waste

Step ②

SEGREGATE

REMEMBER
to always take personal precautions when handling waste.

WHO Recommended color coding for medical waste...

Type of Waste	Container Color and Label	Type of Container
Highly infectious	Yellow, marked "HIGHLY INFECTIOUS"	Strong, leak-proof plastic bag or double bag
Infectious or pathological	Yellow	Double plastic bags
Sharps	Yellow, labeled "SHARPS"	Puncture-proof container
Chemical or pharmaceutical	Brown	Plastic bags or container
General waste	Black	Plastic bag

If colored bags are not available, make sure the bags are

Key concepts in waste collection

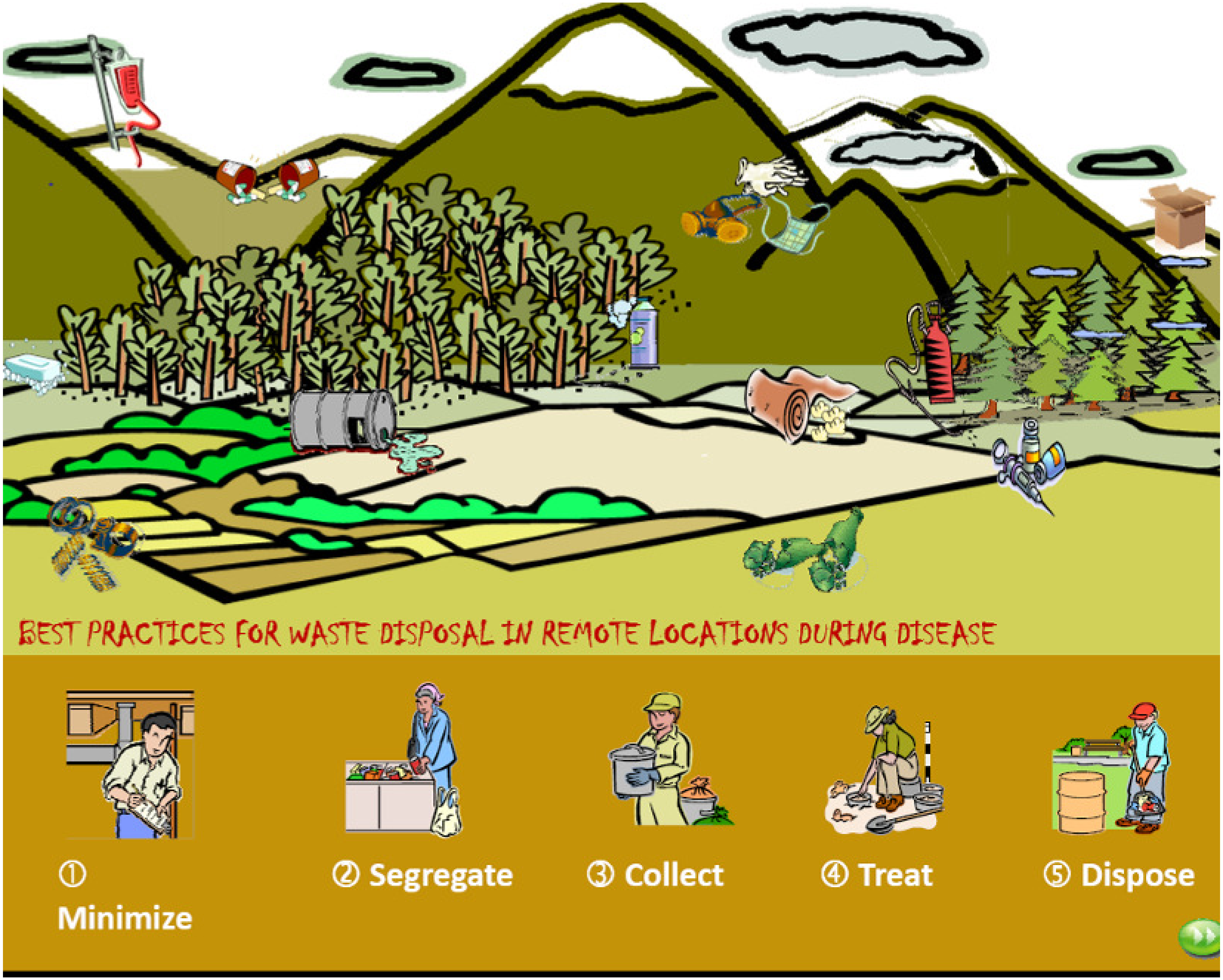
- Make sure waste is properly bagged or contained and closed
- Do not open, shake, squeeze, compact or crush the bags
- Bags should be carried by their necks and away from the body. Do not lift or hold the bag by the bottom or sides.
- Place bags carefully into proper receptacles or on the ground.

Key concepts in waste treatment

- Chemical disinfection
- Encapsulation of needles
- Intertization of waste
- Preparation for transport

Key concepts in waste disposal

- Solid infectious waste should be:
  - Incinerated
  - Buried
- Liquid infectious waste should be disposed in patient care latrines.


BEST PRACTICES FOR WASTE DISPOSAL IN REMOTE LOCATIONS DURING DISEASE
① Minimize
② Segregate
③ Collect
④ Treat
⑤ Dispose

DISINFECTANTS

What would you do?

① Minimize ② Segregate ③ Collect ④ Treat ⑤ Dispose

- Order in smallest quantities possible.
- Check expiration date.
- Use oldest first.
- Use all the contents before opening a new container.
- Small amounts of disinfectants may be collected and treated as infectious waste.
- Larger amounts of disinfectants need to be packed in chemical-resistant containers and removed from the remote outbreak sites.
- Pressurized containers may be collected with general health care waste once they are completely empty provided that the waste is NOT incinerated.

What would you do?

① Minimize ② Segregate ③ Collect ④ Treat ⑤ Dispose

BANDAGES, DRESSINGS

- Place in a strong, leak-proof plastic bag or container.
- Seal the bag or container.
- Store in a secured location.
- Incinerate or bury within 24 hours.

BLOOD, ORGANS, TISSUE

What would you do?

- Place in a strong, leak-proof plastic bag or container.
- Seal the bag or container.
- Store in a secured location.
- Incinerate or bury within 24 hours.

CARDBOARD, PAPER

What would you do?

- Try to purchase supplies with minimum packaging.
- If possible reuse or recycle.
- If not, store in a convenient place that facilitates collection.
- Dispose with non-hazardous waste.

CHEMICALS, CHEMICAL CONTAINERS

What would you do?

① Minimize ② Segregate ③ Collect ④ Treat ⑤ Dispose

- Order in smallest quantities possible.
- Check expiration date on chemicals.
- Use oldest first.
- Use all the contents before opening a new container.
- Small amounts of chemicals may be collected and treated as infectious waste.
- Larger amounts of chemicals need to be packed in chemical-resistant containers and removed from the remote outbreak site.
- Pressurized containers may be collected with general health care waste once they are completely empty, provided that the waste is NOT incinerated.
- Gas containers should be returned.

DETERGENTS

What would you do?

- Use all the detergent in the container.
- If possible, reuse (after washing thoroughly) or recycle container.
- If not, store container in a convenient place that facilitates collection.
- Dispose with non-hazardous waste.

MEDICINES, PHARMACEUTICALS

What would you do?

- Order in smallest quantities possible.
- Check expiration date on medicines.
- Use oldest first.
- Small amounts of unused or expired medicines may be collected and treated as infectious waste.
- Large quantities of unused or expired medicines should be stored in a secured area and removed from the outbreak site.

EQUIPMENT,
MAINTENANCE PARTS

What would you do?

① Minimize ② Segregate ③ Collect ④ Treat ⑤ Dispose

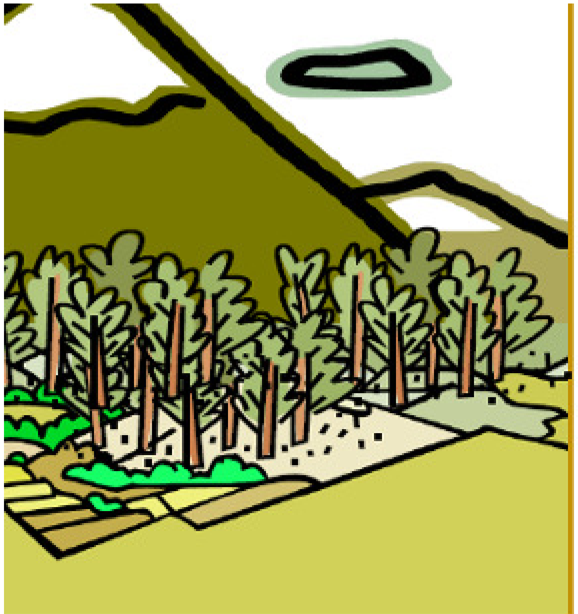
- Try to repair equipment.
- If possible reuse or recycle.
- If not, store in a convenient place that facilitates collection until it can be removed from the outbreak site.
- Dispose of small items with non-hazardous waste.

GLASS, PLASTIC

What would you do?

- Glass and plastic containers with nonmedical products:
  - Clean.
  - Recycle or reuse.

- Glass or plastic containers with medical products:
  - Disinfect.
  - Place in a strong, leak-proof plastic bag or container.
  - Incinerate or bury.



INSECTICIDES, RODENTICIDES

What would you do?

- Order in smallest quantities possible.
- Check expiration date.
- Use oldest first.
- Use all the contents before opening a new container.
- Treat as toxic waste. Small quantities can be buried. Large quantities should be removed from the outbreak site.
- Pressurized containers may be collected with general health care waste once they are completely empty, provided that the waste is NOT incinerated.

PPE

What would you do?

- If used to treat an infected patient, treat as infectious non-sharps.
    - Disinfect.
    - Place in double plastic bags or other container.
    - Seal the bags or container.
    - Incinerate or bury.
- If not used to treat an infected patient, treat as non-hazardous waste.
    - Clean and reuse, or
    - Dispose in a sealed plastic bag and dispose with general waste.

SHARPS, SYRINGES

What would you do?

① Minimize ② Segregate ③ Collect ④ Treat ⑤ Dispose

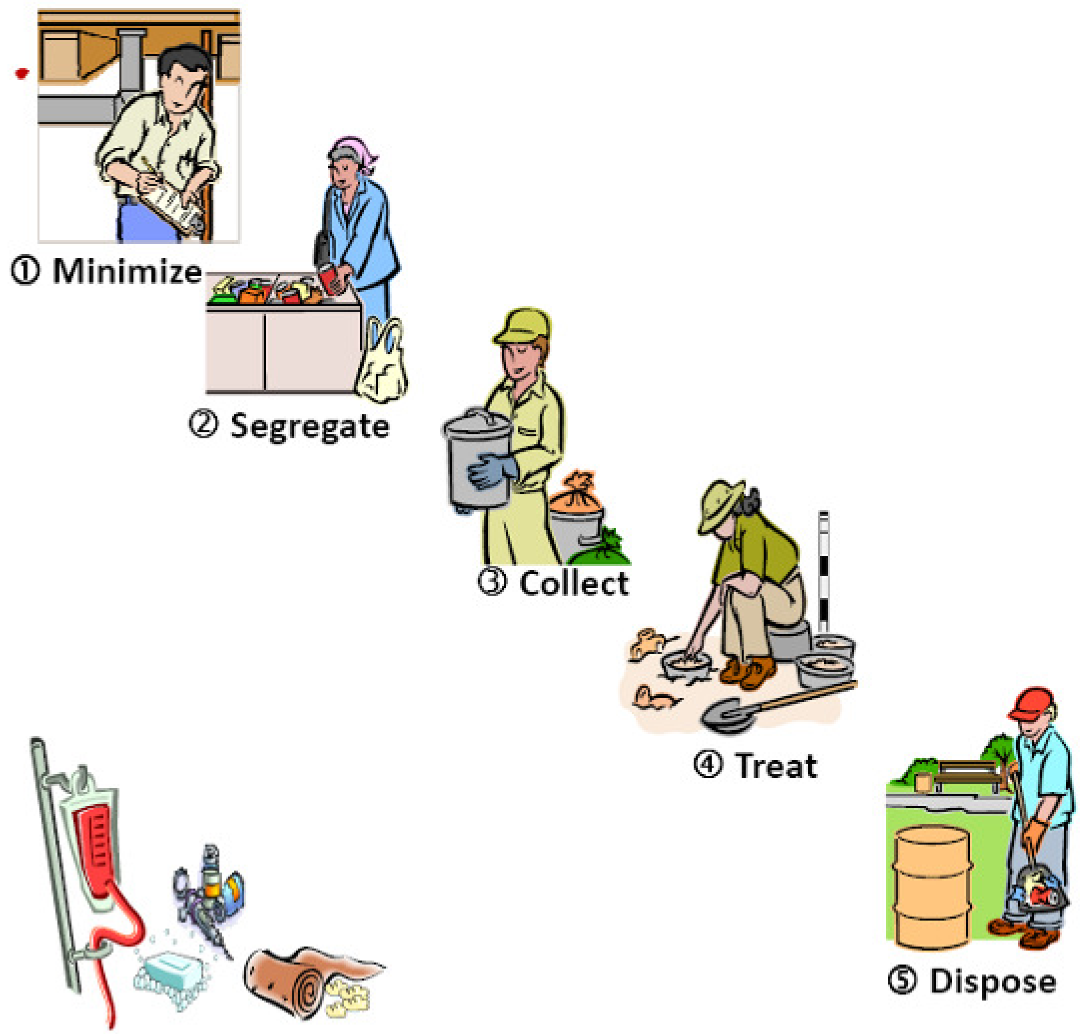
- Disinfect.
- No not recap or remove used needles by hand.
- Never reuse disposable syringes or needles.
- If possible, break needles and other sharps.
- Place in a sturdy container labeled "SHARPS."
  - Put used needles in point-first in the container.
  - Seal the container when it is ¾ full.
- Encapsulate, inertizse or bury.

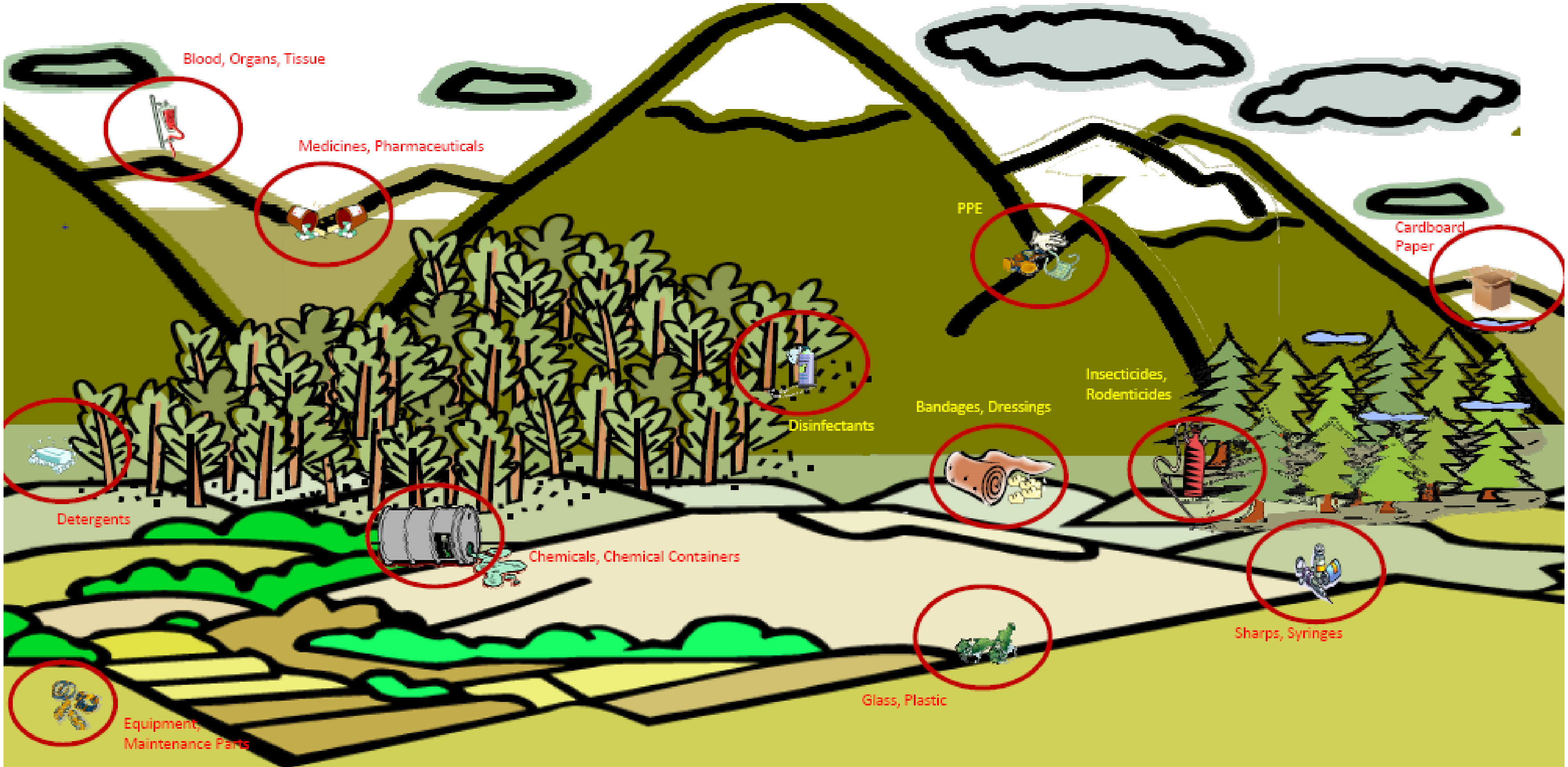
Share your experiences with waste disposal.

Describe a response you participated in and then describe the steps you took to properly dispose of the waste generated by the response.

SHARE YOUR EXPERIENCES

Describe key elements of each step. .





BEST PRACTICES FOR WASTE DISPOSAL IN REMOTE LOCATIONS DURING DISEASE OUTBREAKS

To learn more, read
"Best Management Practices Review for Waste Disposal from Disease Outbreak Response at Remote Sites "

SUPPLEMENT 4: BEST PRACTICES FOR WASTE DISPOSAL IN REMOTE LOCATIONS DURING DISEASE OUTBREAK TRAINING PARTICIPANT HANDBOOK


BEST PRACTICES FOR WASTE DISPOSAL IN REMOTE
LOCATIONS DURING DISEASE OUTBREAKS
Emerging Pandemic Threats Program
USAID

BEST PRACTICES FOR WASTE DISPOSAL IN REMOTE LOCATIONS DURING DISEASE OUTBREAKS

Notes on steps in waste disposal . . .


① Minimize


② Segregate


③ Collect


④ Treat


⑤ Dispose

When handling waste, always take personal precautions:

- Wear PPE which can include:
  - — Gloves
  - — Gowns or aprons
  - — Eye protection
  - — Masks
  - — Shoes
- Wash hands thoroughly after handling waste.

Type of Waste	Container Color and Label	Type of Container
Highly infectious	Yellow, marked "HIGHLY INFECTIOUS"	Strong, leak-proof plastic bag or double bag
Infectious or pathological	Yellow	Double plastic bags
Sharps	Yellow, labeled "SHARPS"	Puncture-proof container
Chemical or pharmaceutical	Brown	Plastic bags or container
General waste	Black	Plastic bag

If colored bags are not available, make sure the bags are very clearly labeled.

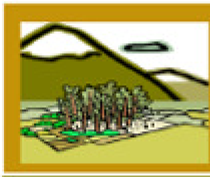
① Minimize

② Segregate

③ Collect

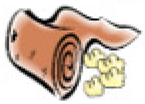
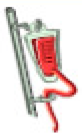
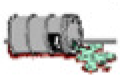
④ Treat

⑤ Dispose



BEST PRACTICES FOR WASTE DISPOSAL IN REMOTE LOCATIONS DURING DISEASE OUTBREAKS

Notes on proper disposal of…

 Disinfectants	 Medicines, Pharmaceuticals
 Bandages, Dressings	 Equipment, Maintenance Parts
 Blood, Organs, Tissue	 Glass, Plastic
 Cardboard, Paper	 Insecticides, Rodenticides
 Chemicals, Chemical Containers	 PPE
 Detergents	 Sharps, Syringes

BEST PRACTICES FOR WASTE DISPOSAL IN REMOTE LOCATIONS DURING DISEASE OUTBREAKS

If you created a new waste disposal scenario, please send a copy of your scenario to:

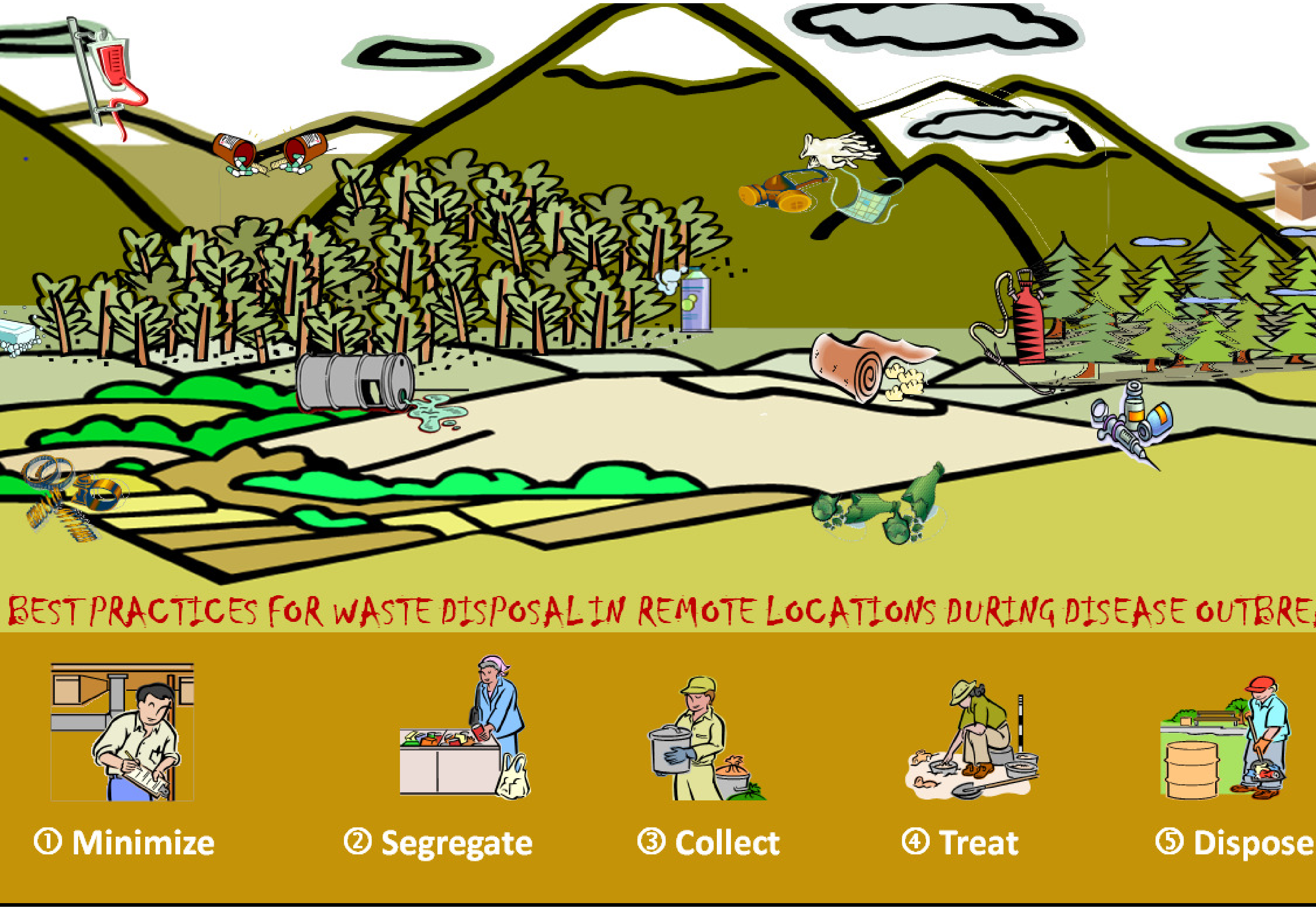
Steve Peck, Monitoring & Evaluation Manager
Project RESPOND
DAI
7600 Wisconsin Ave., Suite 200
Bethesda, MD 20814

Steve_Peck@dai.com
Telephone: 301-771-7797

Share your experiences with waste disposal. *Describe a response you participated in and then describe the steps you took to properly dispose of the waste generated by the response.*

① **Minimize** ② **Segregate** ③ **Collect** ④ **Treat** ⑤ **Dispose**

SUPPLEMENT 5: BEST PRACTICES FOR WASTE DISPOSAL IN REMOTE LOCATIONS DURING DISEASE OUTBREAK TRAINING POSTER


BEST PRACTICES FOR WASTE DISPOSAL IN REMOTE LOCATIONS DURING DISEASE
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ANNEX 3. ACTION EMMR