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ABSTRACT

ROBERT L. ODETTE. Survey of Infectious Waste Management Practices in Selected Acute Care Hospitals in the United States. (Under the Director of Dr. WILLIAM A. RUTALA).

In July 1987, 39% (200/519) of a survey of acute care hospitals throughout the United States responded to a comprehensive solid (infectious) waste questionnaire. The questionnaire was designed to identify infectious waste handling, treatment, and disposal practices in U.S. acute care hospitals. Survey responses were received from forty-three of the fifty states. Most hospitals (71%) have a written comprehensive hazardous waste management plan (includes infectious waste, low level radioactive waste hazardous chemicals, and cytotoxic waste). Only (38%) of the hospitals reported they have an EPA hazardous waste identification number.

Most hospitals (90%+) consider microbiological; human blood and blood products; pathological; and sharps (e.g., needles, scalpel blades) as infectious waste. This is consistent with the Centers for Disease Control (CDC) recommendation. Furthermore, most hospitals (79%) are in compliance with the CDC recommended treatment methods for these types of infectious waste.

EPA recommends that microbiological; blood and blood products; communicable disease isolation; pathological; contaminated sharps; and contaminated animal carcasses and body parts be designated as infectious waste. Furthermore, EPA has identified optional infectious waste categories as waste from surgery and autopsy; miscellaneous laboratory waste; dialysis unit waste; and contaminated equipment. For all the waste categories except contaminated equipment, most hospitals (80%+) considered these waste as infectious waste. However, only (26%) of the hospitals were in compliance with the EPA recommended treatment practices for all infectious waste categories. For the EPA infectious (less optional) waste categories 52% of the hospitals were in compliance with EPA recommended treatment methods.

It is hoped this information will be useful to regulators, decision makers, hospital administrators, and others as the debate on regulating infectious waste continues.

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CHAPTER I

PREFACE

The Resource Conservation and Recovery Act (RCRA) of 1976, as amended, directs the Environmental Protection Agency (EPA) to develop and evaluate solid waste management methods. This includes both hazardous as well as nonhazardous solid waste. Thus far, most regulatory attention has been devoted to the hazardous waste issue. However, EPA and others have found that defining with certainty all types of solid waste which may be hazardous is very difficult, if not impossible. Thus, the debate on infectious waste arises. Some believe it should be regulated as a hazardous waste while others strongly disagree. To date, EPA has largely left the matter up to the individual states to resolve and manage appropriately.

Environmentalists and others believe solid waste believed to be nonhazardous and/or not meeting the EPA definition of hazardous waste may possibly also harm the environment and possibly have adverse health affects. Decreasing availability of land suitable for sanitary landfills, elevated societal concerns, and economic considerations have all greatly impacted on our thinking on the disposing of our garbage and refuse i.e. the often forgotten bi-products of living. The paper focuses on a

specific subset of the solid waste disposal dilemma, namely infectious waste treatment/disposal practices in acute care hospitals.

Treat the Earth Well
It was not given to you by your parents
It was loaned to you by your children.
-Kenyan Proverb

CHAPTER II

INTRODUCTION

The disposal of solid waste has been a longstanding problem of man. In the 1970's primary environmental attention was directed toward air and water pollution. In the last twelve years, we have realized that improper disposal of solid waste may pose a health as well as an environmental hazard because it may affect air, land, and water quality. Thus, it is a cross media environmental pollutant.

In 1976, the Resource Conservation and Recovery Act (RCRA) was passed by Congress. RCRA tasked the Environmental Protection Agency (EPA) to develop and evaluate environmentally sound methods for solid waste management. RCRA established three goals:

1. To protect human health and the environment.
2. To reduce waste and conserve energy and natural resources.
3. To reduce or eliminate the generation of hazardous waste as expeditiously as possible.

Three interrelated programs were developed under RCRA in order to achieve its goals. These are:

1. Subtitle C, Hazardous Waste Program
2. Subtitle D, Solid Waste Program

3. Subtitle I, Underground Storage Tank Program

Section 1004(5) of RCRA defines hazardous waste as a "solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious (underlined for emphasis) characteristics may:

A. cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness; or

B. pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed."

In the last five years or so hospital solid waste disposal practices have come under closer public scrutiny. Disposal of infectious waste also commonly referred to as "red" bag waste or bio-hazard waste has specifically heightened public concern. Perhaps this may be at least partially due to the societal fears related to the present AIDS (Acquired Immune Deficiency Syndrome) epidemic. Risks associated with infectious waste, whether real or merely perceived, have had a tremendous impact on the health care industry.

Florence Nightingale said "It may seem a strange principle to enunciate as the very first requirement in a hospital that it should do the sick no harm." Litsky, 1972, expanded this thought by stating ". . . the hospital should likewise do the community no harm." Disposal of hospital waste may not only affect the patients and staff but also

may affect the community at large. This paper focuses on a specific subset of hospital solid waste, namely infectious waste.

On the federal level, infectious waste is not considered a hazardous waste. However, on the state or local level, infectious waste may or may not be considered a hazardous waste in terms of legislation.

An important step in evaluating any potential environmental problem is hazard identification. The problem must be clearly defined in order to proceed in a logical fashion. It is hoped this study will be useful in better defining the parameters of the infectious waste disposal dilemma.

CHAPTER III

LITERATURE REVIEW

Infectious Waste Designation

Categorizing hospital solid waste sources as infectious or noninfectious is often a controversial issue because there are no clear cut guidelines. Moreover, there is not an universally accepted definition for infectious waste. Regulatory agencies (both federal and state), individual hospitals and other medical institutions have varying perspectives and objectives which help mold their views on defining infectious waste.

EPA defines infectious waste as waste capable of producing an infectious disease. Furthermore, EPA states that certain factors are necessary for disease transmission to take place. These are:

A. presence of a pathogen of sufficient virulence
B. dose
C. portal of entry
D. resistance of host.

Thus, to meet EPA's parameters for designating a waste as infectious the waste must contain pathogens with sufficient virulence and quantity so that when a susceptible host is exposed, an infectious disease results. Persistence,

viability and multiplication are additional pathogenic factors which may affect disease transmission.

This was not EPA's initial agency response regarding the meeting of the perceived Congressional directive (RCRA), i.e. promulgating regulations for the handling/disposal of infectious waste. The Federal Register dated December 18, 1978, contained the proposed EPA hazardous waste regulations. Infectious waste was interpreted to be a hazardous waste because of the RCRA definition (plain meaning of the law) of hazardous waste. Instead of trying to characterize infectious waste, EPA chose to identify infectious waste by the generating source. Ten hospital areas were identified as being generators of infectious waste. The areas were:

1. obstetrics departments including patient rooms
2. emergency department
3. surgery department including patient rooms
4. morgue
5. pathology department
6. autopsy department
7. isolation rooms
8. laboratories
9. pediatric department
10. intensive care unit

EPA's rationale was these areas were most likely to generate waste containing pathogens. Furthermore, EPA

believed this approach could be enforceable while characterizing infectious waste (as done for certain hazardous waste) was not feasible nor enforceable.

A number of private organizations as well as state and federal agencies submitted formal responses to EPA proposed infectious waste regulations. Gordon et al. (1979) summarized the comments into five main areas. These were:

1. Cited the overly inclusive native of EPA's proposal designating hospital generating sources of infectious waste.
2. Cited lack of sufficient scientific evidence to support the proposed definition and sources of infectious waste.
3. Questioned the need and costs of treating the waste per proposed specification.
4. Opposed the extension of federal regulation into an area generally covered by state and/or local regulation (10th Amendment of the U.S. Constitution).
5. Felt that a thorough cost-benefit study was needed to assess the impact of the proposed regulations.

Faced with strong opposition EPA decided to defer action on the infectious waste issue and when the RCRA regulations were promulgated in 1980 infectious waste was not included as being a regulated hazardous waste.

In September 1982, EPA published Draft Manual for Infectious Waste Management. Once again, a significant amount of criticism was generated. For example, Mallison (1985) critiqued the draft and stated the recommended treatment method for certain categories of waste were unnecessary and/or inappropriate. Due to considerable

comments, EPA once again went back to the drawing board to further study the issue.

In May 1986, EPA published its current guidelines titled EPA Guide for Infectious Waste Management. While not an enforceable regulation, the guideline provides an insight into the agency's posture regarding the infectious waste treatment/disposal issue.

EPA recommends that six categories of hospital waste be considered infectious waste:

1. isolation waste
2. cultures and stocks of infectious agents and associated biologicals
3. human blood and blood products
4. pathological waste
5. contaminated sharps
6. contaminated animal carcasses, body parts, and bedding.

EPA considers isolation waste as waste generated by hospitalized patients who are isolated to protect others from communicable disease. An obvious flaw in this definition is patients with a communicable disease who are not hospitalized may also be generating potentially infectious waste. EPA recommends waste from patients with diseases considered communicable and requiring isolation, as defined by the Centers for Disease Control (CDC), should be considered as infectious. Garner (1983) published Guidelines for Isolation Precaution in Hospitals which

contains CDC's general recommendations for handling infectious waste from patients on isolation precautions.

EPA believes all cultures and stocks of infectious agents should be designated as infectious waste because of potentially high concentration of pathogenic organisms found in these materials. This point will be explored later during a discussion of the microbiological composition of hospital waste. Examples of waste included in this category are specimen cultures; culture dishes and devices used to transfer, inoculate, and mix culture; waste from production of biologicals; and discarded live and attenuated vaccines.

EPA considers all human blood and blood products including plasma, serum, and other blood components as infectious wastes. Blood soaked materials such as wound dressings are not necessarily an infectious waste as specified in the EPA guideline.

Pathological waste consists of tissues, organs, body parts, and body fluids that are removed during surgery and autopsy. EPA recommends all pathological waste be considered infectious because the health status of the waste source is usually unknown.

EPA considers all contaminated sharps as infectious waste. Sharps include such items as discarded hypodermic needles, syringes, pasteur pipettes, scalpel blades, and broken glass which has come into contact with infectious agents during patient care, or in laboratories. Sharps

present both a safety hazard as well as a disease transmission hazard. This will be discussed further during a review of risks associated with infectious waste.

Besides the aforementioned infectious waste categories, EPA has also identified four additional categories of hospital waste which may present hazard. EPA recommends each hospital determine whether or not these waste should also be managed as infectious waste. The optional waste categories are:

1. waste from surgery and autopsy
2. contaminated laboratory waste
3. dialysis unit waste
4. contaminated equipment

Examples of waste from surgery and autopsy include soiled dressings, sponges, drapes, lavage tubes, surgical gloves, drainage sets and underpads. Examples of contaminated laboratory waste include specimen containers, slides and cover slips, disposable gloves, laboratory coats and aprons. Dialysis unit waste include things such as tubing, filters, disposable sheets, towels, gloves, aprons and laboratory coats. Contaminated equipment includes any disposables which may have been contaminated with infectious agents.

Centers for Disease Control is another federal agency which has played a significant role in defining the infectious waste stream. Unlike EPA, CDC is not a

regulatory agency. However, CDC is an established authority in the area of infectious diseases including the management of infectious waste. CDC's opinion as to the most practical approach to infectious waste management is to identify hospital waste which pose a sufficient potential risk of infection during handling and/or disposal. CDC, based on highly suggestive clinical studies, recommends that microbiological, pathological, blood and blood products, and sharps be considered as potentially infective, thus warranting special handling and disposal (CDC, 1985). As previously mentioned, CDC recommends that infective waste from patients on isolation precautions should be handled and disposed of according to the current edition of Guideline for Isolation Precautions in Hospitals. CDC recommends every hospital develop a policy for management of waste from patients on isolation precautions. CDC presently recommends universal blood and body fluid precautions. All blood and body fluids should be handled as potentially infectious because the source status is often unknown (MMWR, Vol 36, 1987).

The Joint Commission on Accreditation of Hospitals (JCAH) is an independently, private organization which also has had some bearing on defining the infectious waste issue. While JCAH does not specifically delineate what is or is not an infectious waste, JCAH has set standards on the management of hazardous materials and wastes. Specifically,

JCAH Standard 15.6.3 states that "Policies and procedures are developed that include a process for identifying hazardous materials and wastes (e.g., toxic materials, infectious wastes, radioactive materials). . ." (JCAH, 1987). Each hospital is required to define exactly what it considers infectious waste. If the hospital policy is consistent with local or state regulations then it is likely to be acceptable.

Evaluating the Risks

Assessing the risks, if any, associated with management of infectious waste is an area which need further exploration. Questions as to whether health risks are solely occupational or affect the general public need to be resolved. Everyone agrees that certain categories of infectious waste, particularly sharps, present an occupational risk hazard to employees. Greible, 1974, showed how solid waste disposal practices were linked to a disease outbreak. This occurred in a hospital which had a hydropulping waste system. Pseudomonas and enteric bacilli were aerosolized from the grinding of hospital waste. These pathogens were responsible for a two-fold increase in the number of bacteremias. The infectious rate dropped upon closure of the hydropulping system.

In evaluating risks both potential health and environmental hazards must be considered. First, the health issue will be addressed followed by the environmental issue.

Three main categories of people are likely to be exposed to any potential hazards associated with infectious waste. These are:

1. Patients and personnel in health care institutions.
2. Personnel in organizations providing support services on a contract basis such as laundries and waste haulers/treaters/disposers.
3. Patients and personnel involved in home care or primary care (WHO, 1983).

Categories one and two may be considered largely an occupational setting whereas category three may be construed to reflect the general population. Evidence of infectious waste as an attributable factor for anyone acquiring an infection in the community is lacking.

However, the occupational setting is a different story. Hepatitis B is a serious infectious occupational health risk for health care professionals (Gestal, 1987). A great deal of literature has been generated on the risk of hepatitis B transmission to health care workers. Needlestick injuries are believed to account for many of these occupational acquired infections. Furthermore, needlestick injuries are often the result of employees handling needles carelessly. Moreover, the infectious disease currently creating the most anxiety for both hospital workers and the general public is AIDS. The AIDS virus when compared to other agents is not readily transmitted via needlestick in an occupational setting. CDC reports less than 1% of health care workers

who received a percutaneous exposure from a needlestick from an AIDS patient have seroconverted (MMWR, Vol. 36, 1987). Nevertheless, because of the severity of the disease, i.e. a fatal infection, street adherence to proper management of sharps is paramount. Other organisms, such as the hepatitis B virus, as stated above, are usually more concentrated and more easily transmitted. For example, approximately 1% of health care workers are positive for the hepatitis B surface antigen and 10% to 20% are positive for the antibody to the surface antigen, indicating past exposure (Patterson et al., 1985). Again, proper management of sharps can prevent unnecessary injuries thus decreasing the risk of disease transmission.

A great deal of work has been done in assessing the risk of handling infectious agents in microbiological research. Wedum, et al. in 1972 reviewed the literature and summarized the cases of laboratory-acquired infections in human beings. However, this data is of limited use in assessing the infectious waste risk in a clinical hospital setting. This data was derived from research laboratories where the organisms in the cultures are concentrated for ease of study. Common sense indicates that infectious waste from a research laboratory most likely presents a higher risk than infectious waste from an acute care hospital so extra care in handling the waste is warranted. The virulence of the organism, dose, and host factors such as

resistance all play a role in assessing health risk associated with infectious waste. Epidemiological evidence necessary for assessing risks is needed. Research is needed in measuring dose as well as exposure. This data is important for quantifying risks.

A limited amount of research has looked at the question regarding the microbiological content of hospital waste. Many believe hospital waste to be contaminated with pathogens which present health and environmental hazards.

Kalnowski, et al. (1983) conducted a microbiological study of hospital waste from a surgical department, nursing unit and intensive care unit. A comparison of the microbial load of these wastes to household refuse was conducted. They found the household waste to be more contaminated than the hospital waste.

Frost and Filip (1985) conducted a similar study. In general, they found refuse from medical consulting rooms had lower microbial counts when compared to municipal refuse.

Mose and Reinthaler (1985) also conducted a bacteriological analyses of hospital waste and household refuse. They found a wider range of bacteria in the hospital waste, however, consistent with the other studies the household refuse was more contaminated. In blood-drenched waste and serum samples 2% of all samples examined were anti-HB_c and anti-HB_e positive.

Gordon and associates (1979) also reported their findings on the microbial content of hospital solid waste. They isolated 34 genera and groups of bacteria and fungi from hospital solid waste. Twenty-seven out of thirty-four of these isolates are classified by CDC as class 1 etiologic agents. Furthermore, only seven pathogens of class 2 were isolated and no pathogens of any higher classes than two were reported. CDC class 1 etiologic agents are agents of no or minimal hazard to human or animal. Class 2 etiologic agents are agents of ordinary potential hazard. This class includes agents which may produce disease of varying degrees of severity from accidental inoculation or injection or other means of cutaneous penetration but which are contained by ordinary laboratory techniques. Class 3 agents involve pathogens which require special conditions for containment. Class 2 pathogens isolated from hospital waste in Gordon's study included Actinobacillus; Escherichia coli; Klebsiella; Moraxella; Salmonella; Staphylococcus auras; and the fungi Actinomycetes. No viruses or higher parasites have been isolated from hospital solid waste (Gordon et al., 1979).

Pathogens identified in solid waste from municipal waste by Gaby (1975) and Scarpino et al. (1979) included thirty-nine different genera and groups of organisms. Thirty of these isolates were classified as CDC class 1 etiologic agents and nine as CDC class 2 etiologic agents. All the aforementioned class 2 pathogens isolated from

hospital waste were also isolated from municipal solid waste except Actinobacillus sp. and the fungi Actinomycetes.

Similar studies have been conducted on municipal waste water. Gordon, 1979 reported that municipal waste water contains pathogens of higher virulence (Class 3) than either hospital solid waste and/or municipal solid waste.

Unfortunately, there is insufficient information, data, or relevant standards to determine the levels of microbiological contaminants (infectious dose) that might pose a health or environmental hazard. CDC states no environmental mode of HIV transmission has been documented (MMWR, Vol. 36, 1987). Nevertheless, no one has suggested infectious waste be handled in a manner inconsistent with accepted methods i.e. CDC and/or EPA recommendations.

Handling Infectious Waste

EPA (1986) recommends every hospital develop an infectious waste management plan which should include the following elements:

Designation of infectious waste
Handling of infectious waste

- Segregation
- Packaging
- Storage
- Transport and handling
- Treatment
- Disposal

Contingency planning
Staff training

Treatment and disposal concerns are close to the heart of the infectious waste health/environment hazard issue. After defining the infectious waste stream hospitals are faced with managing the waste to preclude harm to patients, staff, visitors, the community and the environment.

In looking for alternative treatment methods for managing infectious waste several concerns must be taken into account. These are:

1. Physical plant constraints -- space, traffic patterns, electricity and water, and accessibility.
2. Costs to purchase, operate and maintain treatment method.
3. Quantity and quality of the infectious waste stream.
4. Existing local/state regulations.

CDC, in general, recommends infectious waste be incinerated or autoclaved prior to disposal in a sanitary landfill. Bulk blood, suctioned fluids, excretions, and secretions may be carefully poured down a sanitary sewer drain. CDC also recommends use of sanitary sewer for disposal of other infectious waste capable of first being ground and then flushed into the sewer. CDC recommends disposable syringes with needles, scalpel blades, and other sharp items capable of causing injury should be placed intact into puncture-resistant containers located as close to the area in which they were used as is practical. To prevent needlestick injuries, needles should not be

recapped, purposely bent, broken, or otherwise manipulated by hand.

EPA recommends all infectious waste be treated prior to disposal. The purpose of treating the waste is to reduce any hazards which may be associated with infectious agents. Effective treatment is the destruction of pathogens. Incineration and steam sterilization are the two most frequently used treatments. However, EPA acknowledges there are other treatment techniques which may be useful. These include thermal inactivation, gas/vapor sterilization, chemical disinfection and irradiation. Appendix B contains the EPA recommended treatment techniques for specific types of infectious waste. EPA believes that infectious waste which has been effectively treated presents no biological risk. Treated waste may be mixed with and disposed of as ordinary (municipal) waste, provided the waste does not pose other hazards that are subject to Federal, State or local regulations. For example, cytotoxic contaminated waste or nuclear radiated waste products may require special handling.

Gordon (1979) found that if sanitary landfills are used for disposal of infectious waste then there is no risk to human health and the environment. Landfilling is considered a disposal not a treatment method. EPA presently recommends infectious waste first be treated prior to placement in a sanitary landfill.

As previously mentioned, incineration and steam sterilization are the most frequently used treatment techniques for infectious waste, therefore a closer look at these techniques is in order.

Incineration has been used for many years for treating infectious waste. It is reported that the first hospital waste incinerator was installed in 1981 at a New York hospital on West 17th street (Burchinal, 1973). Incineration burns combustible materials and converts the material into noncombustible residue or ash. About one-half of hospital waste is combustible (EPA, 1974).

Hospitals use pathological incinerators (Class VI) to incinerate all types of infectious waste. Incineration has proven to be particularly useful for pathological waste and contaminated sharps because it renders body parts unrecognizable and renders sharps unusable. However, incineration is not the panacea for the infectious waste disposal problem. As with all incineration operations there is concern for minimizing stack emissions.

Barbeito and Shapiro (1977) conducted a microbiological safety evaluation of a solid and liquid pathological incinerator. They found in order to prevent the release of viable micro-organisms to the atmosphere the operating temperatures for the primary chamber must be maintained at 1400°F and the secondary chamber at 1600°F.

There is a growing concern about emissions from pathological incineration. Murnyak and Guzewich (1982) reported that chlorine emissions from medical waste incinerators which burn waste with a high plastic content (i.e. hospital waste) may pose a potential environmental health hazard. They state the significance of the hazard depends on the quantity of chlorine emitted and the potential for human exposure.

Allen and associates (1986) found that hospital incinerators frequently exceed the particulate emission standard. This is not surprising because many hospital incinerators are not properly designed, maintained, or operated correctly. Personnel responsible for operation of the incinerators often are not adequately trained. At present, pathological incinerators are not subject to Federal regulations promulgated under the Clean Air Act or Resource Conservation and Recovery Act. However, several states do regulate emissions from hospital incinerators.

Steam sterilization (autoclaving) is also a common treatment technique for rendering infectious waste noninfectious. Time and temperature are the dependent factors which determine effective treatment via steam sterilization. Decontamination of the waste occurs primarily from steam penetration. Infectious waste with low density such as plastics and glass is more amenable to

autoclaving than infectious waste with a high density such as large body parts and bulk blood.

Rutala et al. (1982) showed that the transfer of heat was more efficient when smaller loads were run and stainless steel vice polypropylene containers were used and more importantly steam sterilization of microbiological waste requires extended exposure to ensure destruction of bacteria.

In a similar study, Lauer and associates (1982) found that a processing time of fifty minutes is adequate when waste is placed directly into a steel container with the addition of one liter of water or into an autoclavable waste bag (plus one liter of water), which is then placed into a steel container.

Both these studies showed that packaging and containerizing the waste are important factors in determining the efficacy of steam sterilization of infectious waste. In addition, the types of wastes as mentioned before, and the volume of the waste and its configuration within the treatment chamber also are crucial consideration regarding the reliability of autoclaving infectious waste.

EPA and others recommended that a monitoring method be used to ensure effective treatment. Bacillus stearothermophilus is frequently used as the biological indicator for monitoring steam sterilization.

Role of Government

To date, there are not any Federal regulations on the handling, treatment, or disposal of infectious waste. It appears EPA's position is that scientific evidence on the risk of harm to human health and the environment is needed before the arduous task of rulemaking is undertaken

Assessing risk is a difficult task. Lowrance (1976) stated ". . . a thing is safe if its risks are judged to be acceptable." Acceptable risks may vary from person-to-person, thus grasping the concept is somewhat slippery. Relating this to the issue at hand, i.e. infectious waste management, EPA has deferred the matter to the individual states for action or perhaps nonaction. Some states have chosen to regulate the treatment/disposal of infectious waste, while others have not taken any action. Table 1 shows a breakdown by states regarding their position on regulating infectious waste.

Table 1 shows that half the states regulate infectious waste disposal. A cost-benefit analysis is usually an integral part of any governmental regulatory undertaking. However, cost-benefit analysis on infectious waste disposal has been limited. Rutala (1985) showed how restricting the designation of the infectious waste stream solely to the four CDC recommended waste types (microbiological, pathological, blood, and sharps) can drastically reduce the cost a hospital expends for infectious waste treatment and

disposal. More research is needed on cost-benefit analysis applicable to infectious waste treatment/disposal.

The regulatory role is still evolving. Unfortunately, FEAR may be the catalyst for this evolution. More research regarding the assessment of risks associated with the management and disposal of infectious waste is needed. Cost benefits considerations should be included in present and future infectious waste management regulations.

TABLE 1

State Regulatory Status Pertaining to Management of Infectious Waste (I.W.).

Do Not Regulate I.W.		Regulate I.W.	
Alabama	Nevada	Arizona	New Hampshire
Alaska	New Mexico	California	New Jersey
Arkansas	Mississippi	Delaware	New York
Colorado	New Mexico	Florida	North Carolina
Connecticut	North Dakota	Georgia	Oregon
Indiana	Ohio	Hawaii	Pennsylvania
Kentucky	Oklahoma	Idaho	Rhode Island*
Louisiana	South Carolina	Illinois	Tennessee
Maine	Washington	Iowa	Texas
Michigan	Wisconsin	Kansas	Vermont*
Missouri	Wyoming	Maryland	Virginia
Montana	Utah	Massachusetts	West Virginia
Nebraska		Minnesota	

*I.W. regulated as a hazardous waste.

Adapted from: EPA Guide for Infectious Waste Management, May 1986.

CHAPTER IV

PROJECT GOAL AND OBJECTIVES

The overall goal of this project is to collect data on the handling, treatment, and disposal of solid (infectious) waste from acute care hospitals with the hope of determining the "norm" for hospital solid (infectious) waste disposal methods. Hopefully, this information will be useful in better defining the infectious waste disposal problem. Identifying the hazards, if any, is a first step in any risk analysis of a potential environmental health hazard.

To achieve the goal the following objectives were established:

- -Collect data on existing hospital solid (infectious) waste disposal practices.
- -Define the infectious waste stream.
- -Quantify the hospital solid (infectious) waste stream.
- -Compare prevailing infectious waste treatment/disposal methods to CDC and EPA recommendations.
- -Collect data on identified problems associated with the handling of infectious waste.

CHAPTER V

MATERIALS AND METHODS

In June 1987, a 12 page questionnaire, Appendix A, was mailed to 519 acute care hospitals throughout the United States. The sample was randomly selected from the membership registry of the American Hospital Association (AHA). AHA is basically an organization of hospitals and related institutions which has a membership of approximately 5,500 hospitals. Thus, the sample represents about ten percent of the membership population. Surveys were mailed to only hospitals which have a Service Classification Code of 10 which indicates a general medical and surgical, i.e. acute care hospitals.

Since most, if not all, hospitals have an infection control practitioner, this person(s) was asked to serve as the primary responder for compiling the requested information and the completion and return of the questionnaire.

The questionnaire contains questions concerning the collection, packaging, transport, storage, treatment, and disposal of hospital solid waste. Moreover, specific questions on infectious waste management are included.

The 200 returned surveys were manually coded, computer programmed utilizing SAS, and then subsequently analyzed.

CHAPTER VI

RESULTS

Characteristics of Responding Hospitals

Two hundred out of five hundred and nineteen hospitals (39%) completed and returned the solid waste survey. Of these, 33% had < 100 beds, 38% had 100-299 beds, 15% had 300-499 beds and 14% had 500+ beds. Completed surveys were received from 43 different states. Seventy-one percent (138/195) of the hospitals had a written comprehensive hazardous waste management plan (includes infectious waste, low level radioactive waste, hazardous chemicals, and cytotoxic waste). Furthermore, 92% (181/197) of the hospitals stated their facility has a written infectious waste management policy. Seventy-one of one-hundred eighty six responses (38%) stated their hospitals have an EPA hazardous waste identification number. One hundred forty-seven of one hundred ninety responses (78%) stated their respective states regulate the disposal of infectious waste. Caution is warranted in interpreting this finding because it is believed many respondents were unsure of this information. For example, there is a difference between statutory authority and having actual promulgated regulations on infectious waste treatment/disposal.

Defining the Infectious Waste Stream

Defining which hospital wastes are infectious or noninfectious is probably the most important element for developing a hospital infectious waste disposal policy. Information was solicited for whether specific waste categories were considered infectious or noninfectious waste and the treatment/disposal methods utilized for that respective waste category. Table 2 provides a summary of the findings. For example, more than 90% of the hospitals considered microbiological, blood and blood products, pathological, communicable disease isolation and sharps as infectious waste.

Quantity of Solid Waste Generation

One hundred and four (104) acute care hospitals generated an average of 22.6 pounds and a median of 14.22 pounds of solid waste/patient/day (± S.E 6.56). Furthermore, 103 hospitals generated an average of 2.17 pounds and a median of 1.25 pounds of infectious waste/patient/day (± S.E. .3). The average percent of the solid waste stream considered infectious was approximately 15% with a median of 11% for 108 hospitals (± S.E. 1.22).

Segregation, Packaging Collection, Transport, Storage

Ninety seven percent (97%) of the responding hospitals segregate infectious from noninfectious waste. The most common methods used are labeled or color coded bags (69%).

TABLE 2

Categories of Solid Waste Designated As Infectious/ Noninfectious

Waste Category	Infectious (%) Yes	No	*Treatment/Disposal Methods (%) I	SL	S	SEW
Microbiological [N=186]	92	8	60	11	40	3
Human blood and blood products (liquid, not contaminated items) [N=191]	91	9	58	12	25	23
Pathological (e.g. tissues, organs, body parts) [N=181]	94	6	92	4	4	2
Communicable disease isolation [N=196]	98	2	76	16	10	2
Sharps (e.g. needles, scalpels) [N=196]	98	2	79	16	14	0
Waste from surgery [N=183]	84	17	72	25	9	5
Waste from autopsy (morgue) [N=141]	92	8	82	9	6	12
Dialysis unit waste [N=97]	81	19	59	14	13	21
Miscellaneous laboratory waste (e.g. specimen container slides) [N=188]	85	15	62	20	26	2

Waste Category	Infectious (%) Yes	No	*Treatment/Disposal Methods (%) I	SL	S	SEW
Contaminated animal carcasses, body parts, and bedding [N=90]	84	16	81	2	2	0
Items contacting secretions, excretions [N=187]	68	32	58	32	11	6
Intensive care unit [N=186]	36	64	41	49	6	6
Emergency room waste [N=179]	41	59	41	47	6	5
Waste from surgical patient's room [N=185]	30	70	35	50	4	5
Waste from obstetrical patient's room [N=159]	28	72	31	52	5	6
Pediatric patient area waste [N=170]	21	79	26	58	3	5
Treatment and examination rooms [N=192]	26	74	28	54	2	5
All patient related waste [N=192]	21	79	26	55	4	10

*I=Incineration; SL=Sanitary Landfill; S=Steam Sterilization; SEW=Sewer

**Treatment/disposal method not equal to 100% because hospitals may use more than one method or insufficient data for some responses.

Use of labeled or color coded bags in combination with the use of physical separation, and/or special containers accounts for approximately the remainder (28%) of the hospital which segregate infectious and noninfectious waste. Approximately 3% of the hospitals utilize physical separation alone.

In approximately 77% of the hospitals, the housekeeping staff is solely responsible for collecting and transporting infectious waste to the treatment/storage/disposal site. Housekeeping staff in conjunction with maintenance personnel account for another 10%, with the remainder consisting of housekeeping staff in combination with nursing service, laboratory personnel, contractors and pharmacy personnel.

Ninety-seven percent of the hospitals (193/197) have a formal training program for employees who handle infectious waste including health and safety precautions.

Most hospitals (91%) use rigid, puncture-proof containers (plastic, glass) for collecting contaminated needles and syringes. Four percent (4%) use cardboard boxes. Approximately 5% still use needle choppers.

Thirteen percent (26/198) of hospitals use a gravity chute (vertical transfer) to transport solid waste within the hospital. Only 2% (3/199) of the hospitals use pneumatic chutes to transport waste within the hospital. One percent (1/198) of the hospitals utilize a hydropulping waste disposal system. A hydropulping waste disposal system

uses a grinder to first macerate the waste into a slurry, then pumps the slurry to a central extractor.

Infectious waste is stored prior to treatment/disposal in 81% (162/200) of the hospitals. Of these hospitals 56% stored infectious waste < 24 hours; 22% stored infectious waste 24-48 hours; 11% stored infectious waste 48-96 hours; the remaining 11% stored infectious waste $\geq$ 96 hours. Storage temperature of the waste was predominately (approximately 95%) at ambient temperature, whether the storage room was inside or outside the hospital. Only about 5% of the hospitals use refrigerated storage spaces for infectious waste.

Eighteen percent (36/198) of the hospitals infectious waste storage area was not separated from the point at which clean supplies enter the hospital.

Treatment/Disposal Solid Waste

Fifty-five percent (55%) of hospitals which segregate infectious from noninfectious waste use incineration solely for treating infectious waste. Another 18% treat infectious waste via incineration and/or sanitary landfill after rendering infectious waste noninfectious by steam sterilization. Another 11% use incineration in combination with other procedures such as placement in a sanitary sewer or sanitary landfill, and steam sterilization. Three percent (3%) of hospitals dispose of infectious waste in sanitary landfills without prior treatment. The remaining

(13%) consists of a combination of several treatment/disposal methods. Refer to Table 2 on pages 31 and 32 for a summarization of treatment methods for specific types of infectious waste.

Most hospitals which segregate infectious from noninfectious waste dispose of noninfectious waste (non-liquid) via placement in a sanitary landfill without prior sterilization (85%). Twelve percent (12%) treat noninfectious waste via incineration. The remaining hospitals (3%) dispose of noninfectious waste using several different methods.

Only 4.5% (9/200) of the hospitals surveyed responded they do not segregate their waste stream. Of these, 34% use incineration; 22% use incineration and/or sanitary sewer; 11% use incineration and/or sanitary landfill without sterilization; 11% use incineration and/or sterilization; 11% use sanitary landfill without sterilization; and the remaining 11% use sanitary landfill after incineration and/or sterilization.

Ninety-seven of the 200 hospitals (49%) reported they use a steam sterilizer for rendering infectious waste noninfectious before discarding. Sixty three percent (63%) of these conduct weekly biological monitoring of the autoclave operation; 23% conduct daily biological monitoring and 8%, 1% and 1% conduct biological monitoring on a

monthly, twice daily and bi-weekly basis, respectively. Four percent (4%) do not conduct biological monitoring.

Fifteen percent (15%) of these hospitals operate the steam sterilizer (autoclave) for 15 minutes; 47% operate the autoclave for more than 15 minutes but less than or equal to 30 minutes; 12% operate their autoclave for more than 30 minutes but less than or equal to 45 minutes; 17% operate their autoclave for more than 45 minutes but less than or equal to one hour; and finally, 9% operate their autoclave for more than an hour to sterilize infectious waste. Ninety-eight percent (98%) of the hospitals which autoclave infectious waste operate at a minimum temperature of 250° F.

Ten percent (19/186) of the hospitals use ethylene oxide and/or hot dry heat to treat infectious waste. Of these nineteen hospitals six (32%) use ethylene oxide, ten (52%) use hot dry heat, and three (16%) use a combination of the two.

Seventy percent (139/200) of the hospitals state they have or share an incinerator with another medical faculty. Of these, 69% (97/139) report the local/state authorities conduct on-site inspections of the incinerator operations. The primary regulatory monitoring mode appears to be a visual observation of the incinerator stack emission (50%). Ninety-six percent (70/73) of the responding hospitals operate their incinerators at or above 1200° F.

Seventy percent (120/172) of the hospitals report final disposal of solid waste is placed in a class A landfill; 8% (14/172) use a class B landfill; and the remaining 22% (38/172) were unsure of the landfill's classification.

Fifty-two percent (102/197) of responding hospitals grind-up solid waste (mostly garbage) and flush the waste to a sanitary sewer. Fourteen percent (11/102) grind up infectious waste and dispose the waste via a sanitary sewer.

Risks and Other Problems

Ninety-five percent (188/198) of the hospitals have a written policy for managing needlestick injuries. Only six percent (12/200) report they discard contaminated needles in a sanitary landfill without first sterilizing to render needles noninfectious. As previously stated, very few hospitals (< 5%) still use needle choppers.

Fourteen percent (26/182) of the hospitals reported problems with transporter and/or landfill operators refusing to accept treated infectious waste.

Five hospitals (2.5% or 5/193) reported problems related to infectious waste disposal (excluding needlestick injuries) in the past five years. Four explanations were provided and are listed below:

1. ". . . handling and disposal of liquid waste from suspect AIDS patients, disposal of antineoplastic waste after administration."

2. ". . . limited contractor and incinerator availability, needlestick and contact with potential HIV patients."

3. ". . . blood disposal."

4. ". . . bag strength in the past was poor causing breakage and leakage, bag over filling, lag time between collection of infectious waste and transport to incinerator, storage area not appropriate."

CHAPTER VII

DISCUSSION

Defining the infectious waste stream is a crucial building block in the development and implementation of an infectious waste management plan. Because there is no uniform definition of infectious waste, many different interpretations of what is or is not an infectious waste exist.

Table 3 provides a summary of the survey replies, comparing specific waste categories to both CDC's and EPA's recommendations on whether that waste category should or should not be considered infectious. As may be deduced from the table, the majority of hospitals (90%+) considered the CDC recommended infectious waste categories as infectious waste in their own institutions. Also, hospitals, in general, tended to extend their definition of the infectious waste stream to include EPA's recommendations for infectious waste (optional waste included) categories. This policy greatly increases the volume of waste considered infectious, therefore, the cost of infectious waste disposal likewise is significantly increased.

These findings are consistent with Rutala's study of the North Carolina hospitals in 1980. He found in his survey that 95% of North Carolina hospitals considered

TABLE 3

Types of Hospital Waste Designated as Infectious By CDC, EPA, And Survey Respondents

Source/Type of Solid Waste	CDC*	EPA*	Sample**
Microbiological	Yes	Yes	Yes (92%)
Blood and blood products	Yes	Yes	Yes (91%)
Communicable disease isolation	Yes/No+	Yes	Yes (98%)
Pathological	Yes	Yes	Yes (94%)
Sharps (e.g. needles)	Yes	Yes	Yes (98%)
Waste from surgery	No	Optional	Yes (84%)
Dialysis unit waste	No	Optional	Yes (81%)
Contaminated animal carcasses, body parts and bedding	No	Yes	Yes (84%)
Contaminated equipment	No	Optional	Yes (68%)
Miscellaneous laboratory waste	No	Optional	Yes (85%)

*CDC - Centers for Disease Control;
EPA - Environmental Protection Agency

**Percent of responding acute care hospitals that considered the waste infectious

+Dependent on Hospital Policy

microbiological waste as infectious; 86% considered blood and blood products as infectious; 97% considered communicable disease isolation waste as infectious; and 97% considered pathological waste as infectious. Rutala's study did not provide data on sharps. This study found that 92% of the hospitals considered microbiological waste as infectious; 91% considered blood and blood products as infectious; 98% considered isolation waste as infectious; 94% considered pathological waste as infectious; and 98% considered sharps as infectious waste.

Another important factor in designing a waste disposal plan is quantifying the amount of generated waste. Overall, these findings were fairly consistent with other studies. Rutala (1983) reported about 13 pounds of solid waste/ patient/day were generated in his survey of North Carolina hospitals. Furthermore, he found that infectious waste comprised 10.9% of the total solid waste stream. In this study, a median of about 14 pounds of solid waste/ patient/day was generated and approximately 11% of the total solid waste stream was infectious.

Many hospitals have little, if any, idea on the volume of total solid waste or infectious waste generated in their facility. It appears hospitals must develop a systematic plan to determine the volume of generated waste in order to provide necessary data for the development and implementation of a comprehensive waste management plan.

This information is necessary for conducting a valid cost analysis of waste disposal practices. A logical approach would be for each work site to keep a log of pounds of waste (solid and infectious) generated for a set time period such as a week. Hopefully, this data would provide not only information useful for quantifying solid waste generation but also may be useful in helping the hospital to evaluate methods to minimize the volume of solid waste generated.

Only 9% of the hospitals which autoclave infectious waste were holding the waste (> one hour) for a time sufficient to sterilize the waste per Rutala et al. (1982) and Lauer et al (1982) studies. This suggest that closer study of autoclaving infectious waste is needed. Perhaps CDC and EPA recommendations need to be revised to encompass necessary operating parameters for both steam sterilization and incineration.

Seventy-nine percent of the surveyed hospitals are treating their infectious waste (microbiological, blood, pathological, and sharps) in accordance with CDC recommendations. Table 4 provides a breakdown for each of the waste categories.

When communicable disease isolation waste is included with the above four mentioned waste categories 73% of the surveyed hospitals were treating these five categories of infectious waste per CDC recommendations. Table 5 summarizes this data.

TABLE 4

Survey Respondents Compliance with CDC Treatment/Disposal Recommendations for CDC Defined Infectious Waste Types

Type of Infectious Waste	CDC Recommendation**	Percent Hospital Compliance
Microbiological	S,I	97 (179/184)
Blood and blood products (liquid not blood contaminated items)	S,I, SEW	94 (178/190)
Pathological	I	92 (166/181)
Sharps (e.g. needles, scalpels)	S,I	90 (176/196)
Compliance with all of the above		79 (142/179)

*CDC - Centers for Disease Control
**Abbreviations: S = Steam Sterilization
I = Incineration
SEW = Sanitary Sewer

TABLE 5

Survey Respondents Compliance with CDC/EPA Treatment/ Disposal Recommendations for Five Types of Infectious Waste

Type of Infectious Waste	Percent Hospital Compliance
Microbiological	97 (179/184)
Blood and blood products (liquid not contaminated items)	94 (178/181)
Pathological	92 (166/181)
Communicable disease isolation	85 (164/192)
Sharps (e.g. needles, scalpels)	90 (176/196)
Compliance to all of the above	73 (132/181)

CDC - Centers for Disease Control
EPA - Environmental Protection Agency

Rutala (1980) found that about 67% of the North Carolina hospitals surveyed were treating infectious waste (microbiological, blood and blood products, communicable disease isolation, and pathological) in accordance with CDC recommendations. You may note Rutala's study and this one have different waste category grouping so as overall analysis is not possible. However, individual waste category comparisons are possible. For example, Rutala found that for microbiological waste (96% hospitals), blood and blood products (90% hospitals), communicable disease isolation (71% hospitals), and pathological (96% hospitals) were treating these waste per CDC recommendations. Likewise, this study's data , for treatment compliance, was 97%, 94%, 85%, and 92% for these same waste, respectively.

Fifty-two percent (52%) of the responding hospitals were treating microbiological, blood, pathological, communicable disease isolation, sharps and contaminated animal carcasses, body parts in accordance with EPA recommendations. These are the waste categories EPA recommends hospitals consider infectious. Table 6 provides a breakdown by each individual waste category.

When the infectious waste stream is expanded to include EPA's optional infectious waste categories (waste from surgery, waste from autopsy, dialysis unit waste and miscellaneous laboratory waste) the compliance rate drops to 26%. Table 7 summarizes this data.

TABLE 6

Survey Respondents Compliance With EPA Treatment/Disposal Recommendations for EPA Defined Infectious Waste Types

Type of Infectious Waste	EPA Recommendation	Hospital Compliance (%)
Microbiological	S, I, TI, C	97 (179/184)
Blood and blood products (liquid not contaminated items)	S, I, SEW, C	94 (178/181)
Pathological	I, SW, CB	92 (166/181)
Communicable disease isolation	S, I	95 (164/192)
Sharps	S, I	90 (176/196)
Contaminated animal carcasses or body parts	I, SW	85 (73/86)
Compliance to all of the above		52 (60/115)

*EPA - Environmental Protection Agency
**Abbreviations: S = Steam Sterilization
I = Incineration
TI = Thermal Inactivation
C = Chemical Disinfection (liquids)
SEW = Sanitary Sewer
SW = Steam Sterilization followed by incineration or grinding and flushing to sanitary sewer
CB = Cremation or burial

TABLE 7

Survey Respondents Compliance with EPA Treatment/Disposal Recommendations for EPA Defined Infectious Waste Types, Including Optional Infectious Waste Types

Type of Infectious Waste	EPA Recommendations**	Percent Hospital Compliance
Microbiological	S, I, TI, C	97 (179/184)
Blood and blood products (liquid not contaminated items)	S, I, SEW, C	94 (178/181)
Pathological	I, SW, CB	92 (166/181)
Communicable disease isolation	S, I	85 (164/192)
Sharps (e.g. needles, scalpels)	S, I	90 (176/196)
Waste from surgery	S, I	79 (143/182)
Waste from autopsy	S, I	87 (124/142)
Dialysis unit waste	S, I	70 (68/ 97)
Miscellaneous laboratory waste (e.g., specimen containers, slides)	S, I	82 (156/190)
Contaminated animal carcasses or body parts	I, SW	85 (73/ 86)
Compliance to all of the above		26 (30/117)

*EPA - Environmental Protection Agency
**Abbreviations: S = Steam sterilization
I = Incineration
TI = Thermal Inactivation
C = Chemical Disinfection for liquids only
SEW = Sanitary Sewer
SW = Steam sterilization followed by incineration or grinding
CB = Cremation or burial

The significance of the findings is that most hospitals in the survey are complying with CDC guidelines for 1) identifying certain categories of waste as infectious and 2) are treating these categories of waste in accordance with CDC/EPA recommendations.

About half of the hospitals were in compliance with EPA recommendations for treating infectious waste. When optional categories of infectious waste are included then the compliance rate drops to about one-quarter.

CHAPTER VIII

CONCLUSION

Management of infectious waste continues to be a problem for hospitals throughout the United States. Hospitals need to systematically develop and implement a comprehensive written solid waste management plan. A subpart of this plan should address infectious waste management. Foremost, hospitals, working with state/local regulatory authorities, need to clearly define the infectious waste stream. Steam sterilization and incineration appear to be best treatment methods for infectious waste. Through a systematic approach, hospitals should be able to minimize any risk to patients, staff, visitors, the public at large, and the environment. This effort should provide the hospital benefits such as reduced costs of waste disposal and decreased liability concerns which may be associated with improper or careless waste disposal practices.

CHAPTER IX

GENERAL RECOMMENDATIONS

Regulatory authority for infectious waste management should remain a state responsibility.

Hospitals should develop a comprehensive hazardous waste management plan.

Hospitals should minimize the generation of all categories of solid waste.

Hospitals should develop and implement a written policy on the management of infectious waste, covering all aspects from source generation to final disposal.

Hospitals must keep abreast on all federal, state, and local regulation applicable to solid waste disposal.

Hospitals should ensure employees required to handle infectious waste are provided with appropriate training.

Hospitals should implement a monitoring plan to ensure infectious waste is managed per hospital policy.

CHAPTER X

STUDY RECOMMENDATIONS

Hospitals should not use needle choppers for disposing of contaminated needles

Hospitals should obtain and EPA hazardous waste identification number.

Hospitals should quantify and qualify their volume of solid (infectious) waste generated.

CDC/EPA should research and publish recommended treatment specifications for the incineration and autoclaving of infectious waste.

Hospitals which autoclave infectious waste should ensure sterilization efficiency, including a minimum contact time of one hour at 250° F. at 15 psi.

Regulatory agencies should conduct more research in evaluating potential health risk associated with the disposal of infectious waste.

Cost-Benefit considerations should be an integral part of infectious waste regulations.

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BIBLIOGRAPHY

Allen, R.J., et al., "Air Pollution Emissions from the Incineration of Hospital Waste," Hazardous Waste Management, 36(5):829-831, July 1986.

Anderson, J., "A Total Waste Management System for Hospitals," Journal of Hospital Supply, Processing, and Distribution, 2(6):28-30, Nov/Dec 1984.

Barbeito, M.S., et al., "Microbiological Evaluation of a Large Volume Air Incinerator," Applied Microbiology, 16(3):490-495, March 1968.

Barbeito, M.S. and Shapiro, M., "Microbiological Safety Evaluation of a Solid and Liquid Pathological Incinerator," Journal of Medical Primatology, 6(5):264-273, 1977.

Budacki, T.J., "Hospitals and Hazardous Waste: A Risk Manager's Viewpoint," Hazardous Materials and Waste Management, May/Jun, 29-32, 1985.

Burchinal, J.C., "A Study of Institutional Solid Waste," N.T.I.S. PB 223 345, 1973.

CDC, "Recommendations for Preventing Transmission of Infections with Human T-Lymphotropic Virus Types III/ Lymphadenopathy-Associated Virus in the Workplace," MMWR 1985; 34:681-686, 691-695.

CDC, "Recommendations for Prevention of HIV Transmission in Health Care Settings," MMWR 1987; 36(25):3-17.

Cohen, R., "Occupational Biologic Hazards," Occupational Health Nursing, 20-24, Aug. 1980.

Conte, J., "Infection with Human Immunodeficiency Virus in the Hospital: Epidemiology, Infection Control, and Biosafety Considerations," Annals of Internal Medicine, 105:730-736, 1986.

Cross, F.L. and Noble, G. Handbook on Solid Waste Management. Westport:Technomic Pub. Co., 1973.

Environmental Protection Agency, Hospital Wastes, Pub. No. SW-129, 1974.

Environmental Protection Agency, EPA Guide for Infectious Waste Management, Pub. No. 530-SW-86-014, May 1986.

Federal Register, 43(243), dtd. Dec 18, 1978.

Garner, J.S. and Simmons, B.P. "CDC Guidelines for Isolation Precautions in Hospitals," Infection Control, 4(suppl):245-325, Jul/Aug 1983.

Garner, J.S. and Favero, M.S., Guidelines for Handwashing and Hospital Environmental Control, 1985, Atlanta: PHS, CDC, Pub. No. 99-1117, 1985.

Gates, P., "Infectious Waste Treatments," Executive Housekeeping Today, 8-10, Oct. 1985.

Gerbedine, J.L., "Transmission of Hepatitis B Without Transmission of AIDS by Accidental Needlestick," The New England Journal of Medicine, 312(1):56, 1985.

Gestal, J., "Occupational Hazards in Hospitals: Risk of Infection," British Journal of Industrial Medicine, 44:435-442, 1987.

Gordon, J.G., et al., "Disposal of Hospital Wastes Containing Pathogenic Organisms," N.T.I.S. A0-A084 913, Sept. 1979.

Greible, H.G., et al., "Chute Hydropulping Waste Disposal System: A Reservoir of Enteric Bacilli and Pseudomonas in a Modern Hospital," Journal Infectious Diseases, 130:602-607, 1974.

Hirsch, M.S., et al., "Risk of Nosocomial Infection with Human T-Cell Lymphotropic Virus III," The New England Journal of Medicine, 312(1):1-4, 1985.

Huisingh, D. and Miller, S.J., ed. Management of Toxic and Hazardous Substances, N.C. Board of Science and Technology, 134-151; 239-248; 249-257; and 258-272, 1987.

Iglar, A.F., et al., "Hospital Solid Waste Disposal in Community Facilities," N.T.I.S. PB 222-018, 1973.

Kalnowski, G., Wiegand, H., and Ruden, H., "The microbial contamination of hospital waste," Zbl. Bakt. Hyg. I (Abt Orig B), 178:364-379, 1983.

Kensett, R.S., "The disposal of hospital waste," Hospital Engineering, 39(3):4-8, 1985.

Kesner, B.T. and Ahrendsen, C.J., "Sources of Hazardous Waste in Hospitals," Hospitals Materials Management, 11(8):14-17, 1986.

Kuhls, T.L., et al., "Occupational Risk of HIV, HBV, and HSV-Z infections in Health Care Personnel Caring for AIDS Patients, "American Journal of Public Health, 77(10):1306-1308, 1987.

Lancianese, F.W., "Survey Probes Risk in a Complex Society," Occupational Hazards, 42(10):109-113, 1980.

Lauer, J., Battles, D.R., and Vesley, D., "Decontaminating Infectious Laboratory Waste by Autoclaving," Applied and Environmental Microbiology, 44(3):690-694, 1982.

Litsky, W., et al., "Solid Waste: A Hospital Dilemma," American Journal of Nursing, 72(10):1841-1847, 1972.

Mallison, G.F., "A Critical Review: EPA's Draft Manual for Infectious Waste Management," American Journal Infection Control, 13(1):45-46, 1985.

Mclean, A. and Lehmann, R., Managing Hazardous Wastes and Materials, J.C.A.H. (Monograph), 1986.

Möse, J.R. and Reinthaler, F., "Microbial Contamination of Hospital Waste and Household Refuse," Abl. Bakt. Hyg. I (Abt. Orig.), 181:98-110, 1985.

Murnyak, G. and Guzewich, D.C., "Chlorine Emissions from a Medical Waste Incinerator," Journal of Environmental Health, 45(2):83-85, 1982.

Oksenhendler, E., "HIV Infection with Seroconversion After a Superficial Needlestick Injury to the Finger," The New England Journal of Medicine, 315(9):582, 1986.

Patterson, W.B., et al., "Occupational Hazards to Hospital Personnel," Annals of Internal Medicine, 102:658-580, 1985.

Peterson, M. and Stutzenberger, F., "Microbiological Evaluation of Incinerator Operations," Applied Microbiology, 18(1):8-13, 1969.

Rhame, R., "In-hospital Needlesticks and Other Significant Blood Exposures to Blood from Patients with Acquired Immunodeficiency Syndrome and Lymphadenopathy Syndrome," American Journal of Infection Control, 12(3):69-75, 1984.

Rutala, W.A., "Cost-effectiveness application of the CDC Guideline for Handwashing and Hospital Environmental

Control," American Journal of Infection Control, 13(5):218-224, 1985.

Rutala, W.A. and Sarubbi, F.A., "Management of Infectious Waste from Hospitals," Infection Control, 4(4):198-204, 1983.

Rutala, W.A., Stiegel, M.M. and Sarubbi, F.A., "Decontamination of Laboratory Microbiological Waste by Steam Sterilization," Applied and Environmental Microbiology, 43(6):1311-1316, 1982.

Slavik, N., "How to Increase Efficiency Safety and Cost," Hospital Topics, Jan/Feb, 8-16, 1985.

Slavik, N., "Management Strategies for Chemical, Infectious and Radiological Wastes," Journal of Hospital Supply, Processing, and Distribution, 3(4):28-35, Aug 1985.

Top, F.H., "The Hospital Environment: A Crossroad for Infection," Archives of Environmental Health, 21:678-688, 1970.

Trost, M. and Filip, Z., "Microbiological Investigations on Refuse from Medical Consulting Rooms and Municipal Refuse," Abl. Bakt. Hyg. I (Abt. Orig. B), 181:159-172, 1985.

Tulis, J., "AIDS: Prevention and Control in the Laboratory and Healthcare Setting," North Carolina Medical Journal, 48(7):365-357, 1987.

Wedum, A.G., et al., "Handling of Infectious Agents," Journal of the American Veterinary Medical Association, 161(11):1557-1567, 1972.

World Health Organization. Management of Waste from Hospitals and Other Health Care Establishments, Report of a WHO Meeting 28 June - 1 July 1983.

Wright, M.R., "Safety and Environmental Issues with Waste Disposal in Hospitals," Hospital Engineering, 37:10-12, 1983.

40 C.F.R. Parts 260-265.

42 U.S.C. Section 6901 et sequel.

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APPENDICES

APPENDIX A

DISPOSAL OF SOLID WASTE

Disposal of Solid Waste from Hospitals (Please circle the correct response or fill in the correct response. Please do not use the blanks to the far left of each page, they are for computer coding).

FOR CODING ONLY

1. Does the hospital segregate infectious from non-infectious wastes?

1-4 (hosp)

a. yes
b. no (skip to question # 5)

2. If yes to question 1, how does the hospital segregate infectious from non-infectious wastes?

5

a. labeled or color-coded bags
b. physical separation
6 c. box, barrel
d. other (please specify):

3. If yes to question 1, how does the hospital dispose of infectious waste?

7-10

a. incinerator
b. sewer
c. sanitary landfill without sterilization
d. sanitary landfill after rendering infectious wastes non-infectious by sterilization
e. both a and d
f. other (please specify):

4. If yes to question 1, how does the hospital dispose of non-infectious solid waste?

11-12

a. incinerator
b. sewer
c. sanitary landfill without sterilization
d. other (please specify):

5. If no to question 1, how is all hospital waste disposed of?

13-14

a. incinerator
b. sewer
c. sanitary landfill without sterilization
d. other (please specify):

FOR CODING ONLY

6. If a steam sterilizer (autoclave) is used to render infectious solid waste non-infectious before discarding, how often is it checked with biological monitors?

15

a. daily
b. weekly
c. monthly
d. not checked
e. other (please specify):
f. autoclave not used for this purpose (proceed to question 9)

7. In reference to question 6, how long does the steam sterilizer operate and at what temperature?

16-17 a. length of time _____

18-20 b. temperature _____

8. Are holes punched in the top of all plastic bags just before autoclaving?

21

a. yes
b. no
c. not sure

9. Is a gas (ethylene oxide), hot air sterilizer or other sterilizing device used to render infectious solid waste non-infectious before discarding?

22

a. yes
b. no (proceed to question 11)

10. If yes to question 9, what kind of sterilizer is used?

23

a. gas (ethylene oxide)
b. hot air
c. both a and b
d. other (please specify):

11. (A.) Do local/state authorities (e.g. local health department, State EPA or State Solid and Hazardous Waste Management Group) conduct on-site inspections of the hospital incinerator?

24

a. yes
b. no
c. no hospital incinerator

FOR CODING ONLY

11. (B.) If yes to question 11A, what kind of monitoring is conducted by local/state authorities?

25

d. combustion gas analysis-CO, CO_2, O_2
e. particulates
f. organics-total hydrocarbons
g. inorganics-metal
h. biological agents
i. inspector does not monitor incinerator emissions
j. other (please specify):

12. (A.) Does the hospital perform self-monitoring of their incinerator's operation?

26

a. yes
b. no

(B.) If yes to question 12A, what kind of monitoring is conducted by the hosital?

27

c. combustion gas analysis-CO, CO_2, O_2
d. temperature
e. time
f. other (please specify):

(C.) If temperature is monitored where is the thermocouple positioned and what is the operating temperature?

28

g. thermocouple position: _____.
h. incinerators operating temperature: _____.

29-32

13. If waste is taken to a sanitary landfill, what is the landfill's rating?

33

a. class A - covered daily with earth and no deliberate burning
b. class B - covered three times per week with earth or wastes burned at site
c. class C - no covering with earth and a public health nuisance
d. not sure

14. Are solid wastes ground-up (e.g. garbage grinder) and flushed into the sanitary sewage system?

34

a. yes
b. no (proceed to question 16)

FOR CODING ONLY

15. If yes to question 14, what type of solid wastes are discarded by the sewer system?

a. garbage - wastes from preparation, cooking, and serving of food
b. infectious wastes (please specify):
c. both a and b
d. other (please specify):

35

16. How many pounds of solid wastes (both infectious and non-infectious) are produced in the hospital per day?

36-40

17. If yes to question 1, how many pounds per day of infectious wastes are generated (if you segregate waste)?

40-43

18. How many pounds per day of non-infectious wastes are generated?

44-48

19. How does your hospital discard disposable needles and syringes?

a. cardboard box
b. needle chopper
c. cardboard box and needle chopper
d. rigid, puncture-proof container (plastic, glass)
e. other (please specify):

49-50

20. After placing the needles and syringes in the container identified in question 19, how are they finally discarded?

a. incinerator
b. sanitary landfill without sterilization
c. sanitary landfill after sterilization
d. other (please specify):

51

21. Does your hospital have a written policy for managing needlestick injuries?

a. yes
b. no

52

Segregation of infectious and Non-Infectious Waste

22. Does the hospital consider the following hospital solid waste infectious? Please circle yes of no to the sources of solid wastes on the left and circle: I (incinerator), SL (sanitary landfill), S (sterilizer - gas, steam, hot air), or Sew (sewage) to the method used to discard the solid wastes. If a method of waste disposal is used that is not identified, please specify. If more than one method of waste disposal is used, identify all methods.

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_____ 53-59	a. microbiological	Yes	No	I	SL	S	Sew	Other (specify):
_____ 60-66	b. blood and blood products	Yes	No	I	SL	S	Sew	Other (specify):
_____ 1-4(hosp)	c. pathological (eg. tissues, organs, body parts)	Yes	No	I	SL	S	Sew	Other (specify):
_____ 5-11				I	SL	S	Sew	Other (specify):
_____ 12-18	d. communicable disease isolation	Yes	No	I	SL	S	Sew	Other (specify):
_____ 19-25	e. sharps (eg. needles, scapels)	Yes	No	I	SL	S	Sew	Other (specify):
_____ 26-32	f. wastes from surgery	Yes	No	I	SL	S	Sew	Other (specify):
_____ 33-39	g. wastes from autopsy (morgue)	Yes	No	I	SL	S	Sew	Other (specify):
_____ 40-46	h. dialysis unit wastes	Yes	No	I	SL	S	Sew	Other (specify):
_____ 47-53	i. micellaneous laboratory wastes (eg. specimen containers, slides)	Yes	No	I	SL	S	Sew	Other (specify):
_____ 54-60	j. contaminated animal carcases, body parts, and bedding	Yes	No	I	SL	S	Sew	Other (specify):
_____ 61-67	k. items contacting secretions, excretions	Yes	No	I	SL	S	Sew	Other (specify):
_____ 1-4(hosp)	l. intensive care unit	Yes	No	I	SL	S	Sew	Other (specify):
_____ 5-11	m. emergency room wastes	Yes	No	I	SL	S	Sew	Other (specify):
_____ 12-18	n. wastes from surgical patient's room	Yes	No	I	SL	S	Sew	Other (specify):

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o. wastes from obstetrical patient's room — Yes No I SL S Sew Other (specify): (26-32)

p. pediatric patient area wastes — Yes No I SL S Sew Other (specify): (33-39)

q. treatment and examination rooms — Yes No I SL S Sew Other (specify): (40-46)

r. all patient related wastes — Yes No I SL S Sew Other (specify): (47-53)

s. other (please specify): — Yes No I SL S Sew Other (specify): (54-60)

23. Does the hospital have a written infectious waste management policy?

a. yes
b. no
c. other (please specify):

(61)

24. Do hospital employees who handle infectious waste receive formal training in proper handling/disposal procedures?

a. yes
b. no
c. other (please specify):

(62)

Collection and Transport of Solid Waste

25. Who collects the wastes and transports it to on-site storage or processing sites?

a. housekeeping
b. other (please specify):

(63-64)

26. Are the wastebaskets leakproof?

a. yes, all wastebaskets are leakproff
b. most (greater than 50 per cent) are not leakproof

(65)

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27. Are the wastebaskets lined with impervious liners?

66

a. yes
b. no (proceed to question 29)

28. If yes to question 27, what are they lined with?

67

a. plastic bag
b. paper bag
c. other (please specify):

29. How frequently are wastes picked up?

68

a. three or more times per day
b. two times per day
c. daily
d. other (please specify):

30. Are transfer carts cleaned? The term "transfer carts" refers to the container used to trnsport wastes inside the hospital from wastebaskets directly into gravity chutes or for vertical transport by elevator to the outside storage container (or storage room).

69

31. If yes to question 30, how frequently are the transfer carts cleaned?

70

a. two times per day
b. daily
c. three times per day
d. weeks
e. other (please specify):

32. Are the transfer carts leakproof?

71

a. yes, all transfer carts are leakproof?
b. most (greater than 50 per cent) transfer carts are leakproof
c. most (greater than 50 per cent) transfer carts are <u>not</u> leakproof

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33. Is the solid waste taken to an outside storage container after pickup? The term "outside storage container" refers to a container stored generally in one location outside the hospital. With portable outside storage containers, waste is transferred to a collection vehicle by a lift mechanism. For detachable containers, a service truck hoists the container aboard when full, then returns it to the hospital after emptying. If your hospital employs a different transport mechanism for infectious and non-infectious solid waste, please indicate.

72

a. yes (proceed to question 35)
b. no

34. If no to question 33, what is done with the solid waste that is picked-up?

1-4 (hosp)

a. taken to incinerator
b. other (please specify):

5

35. Are gravity chutes (vertical transfer) used to transport solid wastes within the hospital?

6

a. yes
b. no

36. Are pneumatic chutes (vacuum source used to propel wastes through a large-diameter tube) used to transport wastes within the hospital?

7

a. yes
b. no

37. Do you have a hydropulping waste disposal system? A hydropulping waste disposal system uses a grinder to first macerate the wastes into a slurry, then pumps the slurry to a central extractor.

8

a. yes
b. no

38. Is the outside storage area for hospital waste separate from the point at which clean supplies enter the hospital?

9

a. yes
b. no
c. hospital uses a waste storage room or building

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39. Does the hospital's solid waste outside storage container have a compactor?

____ 10

a. yes
b. no
c. hospital does not use outside storage container (proceed to question 46)

40. How frequently is the area around the outside storage container cleaned?

____ 11

a. two times per day
b. daily
c. three times per week
d. weekly
e. other (please specify):

41. How frequently is outside storage container cleaned?

____ 12

a. two times per day
b. daily
c. three times per week
d. two times per week
e. weekly
f. never
g. unknown
h. other (please specify):

42. Is the outside storage container leakproof?

____ 13

a. yes
b. no

43. What response best describes the solid waste outside storage container used to collect wastes? If a different outside storage container is used for infectious solid waste, please indicate.

____ 14-15

a. small (2-4 cubic yards) portable container
b. medium (4-15 cubic yards) portable container
c. large (30-40 cubic yards) detachable containter
d. closed, leakproof trailer
e. open, leakproof trailer
f. none of the above (please describe container):

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44. Is the outside storage continer identified in question 43 also used to transport wastes to the final disposal site?

16

a. yes (proceed to question 46)
b. no

45. If no to question 44, please indicate how the solid waste is transported to to the disposal site.

17

a. solid waste is transferred from the outside storage container to a collection vehicle
b. other (please specify):

46. How frequently is the hospital solid waste hauled to the disposal site(s)? If the hospital segregates infectious and non-infectious solid waste and both are hauled from the hospital, please indicate frequency for both types of wastes.

18-19

a. two times per day
b. daily
c. three times per week
d. two times per week
e. weekly
f. other (please specify):

47. If infectious waste is stored prior to treatment/disposal, what is the maximum storage time and what is the storage temperature. Two answers are required for this question, that is, one for storage time and another another for temperature.

20-21

Storage Times

a. 24 hours
b. 24-48 hours
c. 48-96 hours
d. 96 hours

Temperature

e. room temperature (e.g. 20-25C)
f. outside temeperature (please specify): _____
g. refrigerated temperature (please specify): _____

48. Has there been an attempt by your transporter or landfill operator to refuse to accept treated infectious waste?

a. yes
b. no

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General Information

49. Type of hospital:

24

a. Community non-teaching
b. Community teaching
c. Government (city, state, federal)
d. Proprietary (non-government for profit)
e. University
f. Military
g. Other (please specify): _____

25-28

50. Hospital size-Number of Beds (licensed beds) _____

29-30

51. Hospital Location

Specify State _____ Zip Code _____ (optional)

52. Does your state regulate the disposal of infectious waste?

a. yes
b. no

31-32

53. How long has the respondent(s) been employed by the hospital?

33

54. Was the respondent(s) aware (before reading the cover letter) of the recently published EPA and CDC guidelines for handling infectious wastes from hospitals.

a. yes
b. no

55. Are you aware of any infection problems (excluding needlestick injuries) that have occurred in your hospital in the past five years involving disposal of infectious waste?

34

a. yes (please describe as completely as possible):

b. no

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35

56. Does the hospital have a Environmental Protection Agency (EPA) identification number for disposal of hazardous chemical waste?

a. yes
b. no

57. Does the hospital have a written comprehensive hazardous waste management plan (includes infectous waste, low-level radioactive wastes, hazardous chemicals and antineoplastic drug wastes).

36

a. yes
b. no
c. comments (if desired): _____

_____

58. If you wish to make additional comments about disposal of solid waste from your hospital, please use the space below:

_____

_____

_____

APPENDIX B

TABLE 1

RECOMMENDED TECHNIQUES FOR TREATMENT OF INFECTIOUS WASTE[a]

Type of Infectious Waste[b]	Recommended Treatment Techniques				
	Steam Sterilization	Incineration	Thermal Inactivation	Chemical Disinfection[c]	Other
Isolation wastes	X	X			
Cultures and stocks of infectious agents and associated biologicals	X	X	X	X	
Human blood and blood products	X	X		X	X[d]
Pathological wastes	X[e]	X			X
Contaminated sharps	X	X			
Contaminated animal carcasses, body parts, bedding:					
• carcasses and parts	X[e]	X			
• bedding		X			

a. The recommended treatment techniques are those that are most appropriate and, generally, in common use; alternative treatment technique may be used to treat infectious waste, if it provides effective treatment.
b. See Chapter 2 for descriptions of infectious waste types.
c. Chemical disinfection is most appropriate for liquids.
d. Discharge to sanitary sewer for treatment in municipal sewerage system (provided that secondary treatment is available)
e. For aesthetic reasons, steam sterilization should be followed by incineration of the treated waste or by grinding.