

PRELIMINARY RISK ANALYSIS APPLIED TO THE HANDLING OF HEALTH-CARE WASTE

S.M.L.Carvalho¹ and M.G.C.Silva^{2*}

¹Department of Chemical Engineering, Federal University of Pará,
UFPA, Zip Code 66075-900, Belém, PA - Brazil.

E-mail: sleao@feq.unicamp.br

²School of Chemical Engineering, State University of Campinas, P.O. Box 6066,
Zip Code 13083-970, Campinas - SP, Brazil.

E-mail: meuris@bla.feq.unicamp.br

(Received: March 5, 2002 ; Accepted: August 6, 2002)

Abstract - Between 75% and 90% of the waste produced by health-care providers no risk or is “general” health-care waste, comparable to domestic waste. The remaining 10-25% of health-care waste is regarded as hazardous due to one or more of the following characteristics: it may contain infectious agents, sharps, toxic or hazardous chemicals or it may be radioactive. Infectious health-care waste, particularly sharps, has been responsible for most of the accidents reported in the literature. In this work the preliminary risks analysis (PRA) technique was used to evaluate practices in the handling of infectious health-care waste. Currently the PRA technique is being used to identify and to evaluate the potential for hazard of the activities, products, and services from facilities and industries. The system studied was a health-care establishment which has handling practices for infectious waste. Thirty-six procedures related to segregation, containment, internal collection, and storage operation were analyzed. The severity of the consequences of the failure (risk) that can occur from careless management of infectious health-care waste was classified into four categories: negligible, marginal, critical, and catastrophic. The results obtained in this study showed that events with critical consequences, about 80%, may occur during the implementation of the containment operation, suggesting the need to prioritize this operation. As a result of the methodology applied in this work, a flowchart the risk series was also obtained. In the flowchart the events that can occur as a consequence of a improper handling of infectious health-care waste, which can cause critical risks such as injuries from sharps and contamination (infection) from pathogenic microorganisms, are shown.

Keywords: health-care waste, solid waste, risk analysis, PRA.

INTRODUCTION

According to WHO (1999) all individuals exposed to hazardous health-care waste are potentially at risk, including those within health-care establishments that generate hazardous waste and those outside these sources who either handle this waste or are exposed to it as a consequence of careless handling.

Infectious waste is suspected to contain pathogens (bacteria, viruses, parasites, or fungi) in sufficient concentrations or quantities to cause

disease in susceptible hosts. The main risk situation for humans is direct contact between the individual and the contaminated waste, especially in situations in which the pathogen may enter the organism. The presence of sharps in infectious waste may not only cause cuts and punctures but also infect these wounds if they are contaminated with pathogens; because of this double risk sharps are considered to be highly hazardous health-care waste (WHO, 1999).

Currently there is no definitive, quantitative analysis that can be used to determine whether a waste is “infectious” or not. Thus, infectious wastes

*To whom correspondence should be addressed

are segregated from other health-care waste because the infectious potential of the waste can not necessarily be determined by its appearance or the particular source of the item and its infectious nature may not be identifiable, and it is impractical and infeasible to test each item for pathogen content (type and quantity) (EPA, 1992).

Appropriate infectious health-care waste handling practices follow an operational flow that includes segregation, containment, internal collection, storage, transport (external collection), treatment, and final disposal. The number of these operations, as well as the terminology can vary from one author to another. The main objective of proper infectious solid-waste handling is to protect public health and the environment, while the system's performance demand is to ensure that there are no adverse effects on public health and the environment as a consequence of inadequate waste handling practices.

Safety has permeated all operations in health-care waste management. In the technical reports on the safety of health-care waste management operations great concern with the correct use of norms and standardized procedures can be observed. However, even in cases where management control is rigorous and resources are available, failures may occur (Ribeiro Filho, 1999).

The aspects related to disease transmission, degree of contamination, and occupational risk attributed to infectious health-care waste have been very controversial and they have frequently reflected antagonistic opinions; as a consequence divergent opinions have been reflected in all management operations for this waste. This fact can be evidenced by published work such as that of Rutula and Weber (1991), Byrns and Burke (1992), APCI (1992), Collins and Kennedy (1992), Rutula and Mayhall (1992), Ayliffe (1994), Monge (1997), and CEPIS (1997).

In the present work the preliminary risks analysis (PRA) technique was used to study a health-care establishment with relation to their handling practices for infectious wastes. The main objective of this methodology was to organize systematically failures of improper infectious health-care waste handling, severity of consequences, and corrective actions, among other information. The results of this analysis can be used to reduce the extent and impact of possible operational failures during infectious waste handling.

METHODOLOGY

The application of the PRA technique in this study was restricted to those health-care waste handling

practices carried out within the health-care establishment such as segregation, containment, internal collection, and storage. Transport (external collection), treatment, and final disposal are operations usually carried out by specialized companies or entities. The analysis was carried out in a health-care establishment where a health-care waste management program had been implemented. This establishment has about forty-three sources of generation of infectious waste and it produces about 120 kg of infectious waste per day. In Table 1 the steps of the PRA technique applied in this analysis are shown.

Thirty-six procedures were analyzed. They were distributed as follows: segregation (03), containment (11), internal collection (12), and storage (10). All procedures analyzed have been cited in national legislation (CONAMA, 1993), technical norms (ABNT 1993a, 1993b, 1993c), or technical guidelines (WHO, 1999 and CETESB, 1997). The aspects of the analysis included the following:

- a) The main human risk situation evaluated was direct exposure to untreated infectious waste, especially in situations in which a pathogen may enter the organism;
- b) The main groups of people that can be exposed and contaminated within the health-care establishment: health-care workers (medical doctors, nurses, health-care auxiliaries, and cleaning personnel), waste handlers, patients, and visitors;
- c) According to Who (1999), very few data are available on the health impacts of exposure to health-care waste and suspected cases of adverse health effects of health-care waste are not adequately documented with precise descriptions of exposure. Thus, this analysis was performed admitting that any source of infectious waste produces a waste with the potential to cause disease in a susceptible host;
- d) Severity of consequence was evaluated qualitatively using the following categories (De Cicco and Fantazzini, 1985): negligible (I), marginal (II), critical (III), and catastrophic (IV);
- e) Probability of occurrence was determined using the guidelines presented by FEMA (1993): Common (C) - expected to occur one or more times each year on average, Likely (L) - expected to occur at least once every 10 years on average, Reasonably Likely (RL) - predicted to occur between once every 10 years and once every 1,000 years on average, Unlikely (U) - predicted to occur between once every 100 years and once every 1,000 years on average, and Very Unlikely (VU) - predicted to occur less than once in 1,000 years;
- f) A sheet was used to organize information such as infectious health-care waste handling practice, procedures, possible failures, severity of

consequence, probability of occurrence, and corrective actions.

The risk series shows through a flowchart the events (risks) that may cause critical risks in the system. The risk series was elaborated from the initial, main, and critical risks.

RESULTS AND DISCUSSION

From the analysis of thirty-six procedures, eleven sheets of results were obtained. In Table 2 the results of only one procedure of the segregation operation are shown, as an example of the analysis carried out in this work. The results for probability of occurrence were obtained from observations carried out within the health-care establishment during the implementation of the operational procedures. Summarized results of the analysis are as follows:

- a) For the segregation operation, one event with a critical consequence (III) was determined to be common (C);
- b) The containment operation had twelve events with critical consequences (III), (about 80%). Of these critical events, about 60% were considered to be common (C);
- c) Five internal collection events with critical consequences (III) were determined to be common (C); and
- d) Three storage operation events with critical consequences (III) were considered to be common (C).

The results of the analysis suggest the need for prioritization of corrective actions for failures with critical consequences and the probability of common

occurrences. Proper containment of infectious waste, for example, ensures the formation of a barrier that renders safe the subsequent handling practices for infectious health-care waste.

The risk series was obtained considering the following risks: initial risks - failures in the handling of infectious waste classified as critical (III) due to the high potential for causing direct contact between humans and untreated infectious waste, main risks - direct exposure to untreated infectious waste, and critical risks - injuries from sharps and contamination by pathogenic microorganisms. Figure 1 shows the risk series obtained.

The risk series can be analyzed in terms of possible inhibitions, which can be applied to each event in the series. Analysis of this sequence enables those responsible for the waste management program to carry out control measures that minimize or interrupt the risk series.

In addition the following observations related to inadequate handling of infectious health-care waste were made:

Corrective actions used to prevent failures of health-care waste management practices require previous knowledge of the amount of infectious waste generated, sources of generation, and types of wastes. WHO (1999) suggests that studies to obtain this information should precede implantation of any health-care waste management program;

In this study training requirements for all people involved in the handling of infectious health-care waste were also seen as an essential step in achieving the goals of the infectious waste management program.

Table 1: Steps of the preliminary risks analysis technique applied in this work

PRA steps	Objectives	Means
1. Revision of known problems.	To revise problems known from similar systems.	Review of the literature.
2. Revision of the mission.	To revise the aims of adequate handling of infectious health-care waste. To revise the system's performance demand with relation to the handling infectious health-care waste. To revise operational procedures used in the handling of infectious health-care waste.	Legislation, review of the literature. Legislation, technical norms, and technical guidelines. Legislation, technical norms, and technical guidelines.
3. Determination of main, initial, and contributor risk (risk series).	To elaborate the risk series.	Results analysis and flowchart elaboration.
4. Revision of means for elimination risks control.	To revise compatible actions for elimination and control of failures (risks) according to the system's performance demand.	Results analysis.

Source: De Cicco and Fantazzini (1985).

Table 2: Results of the evaluation of infectious waste handling practices using the PRA technique. Example: Segregation operation.

System or subsystem: Health-care Establishment						
Handling practice: Segregation Operation						
Objective: Separation and Identification of the Waste.						
Date:						
Procedure	Failure	Detection method	Consequence	Severity of consequence	Probability of occurrence	Corrective actions
All wastes have to be contained in plastic bags or containers appropriately identified as close as possible to where they were generated.	*Containers distant from the source of generation of waste.	*Inspection at the source of generation of waste.	* Discourage a proper segregation of waste.	I	L	*To identify all the sources of generation of infectious waste and to locate as close as possible to them properly identified bags or containers.
	*Containers and plastic bags inadequately identified.	* Inspection at the source of generation of waste.	* Increase of the amount de infectious waste.	II	L	

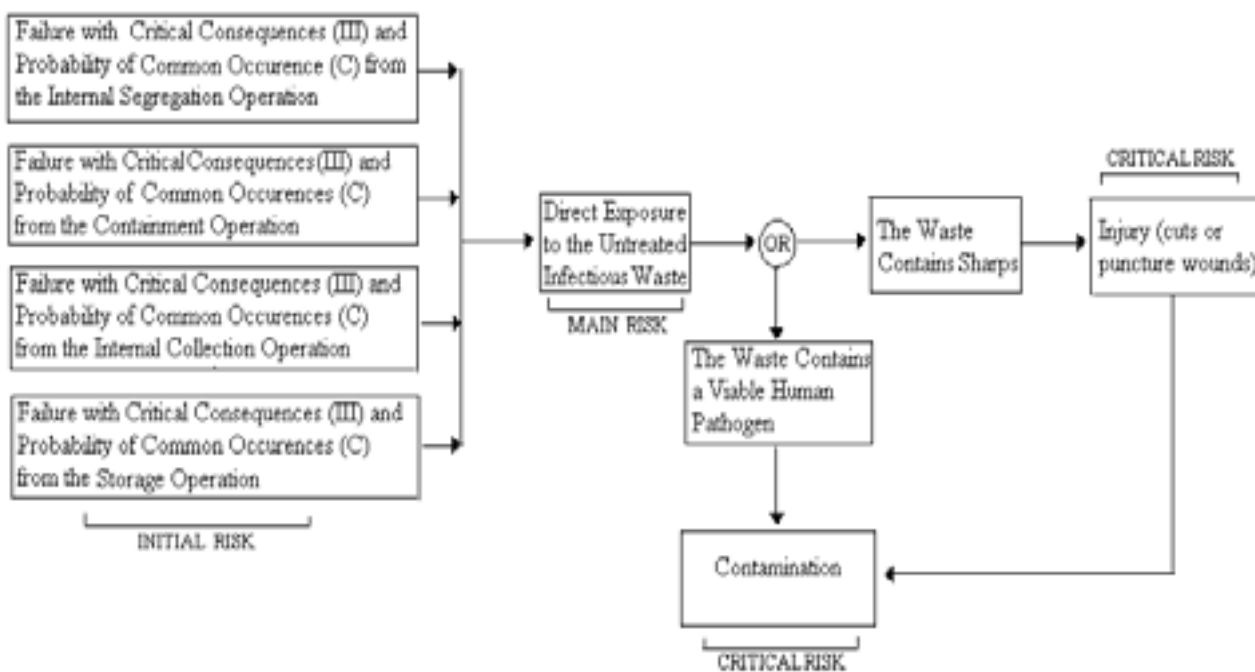


Figure 1: Sequence of events that can cause critical risk from inadequate handling of infectious health-care waste.

CONCLUSIONS

In many studies published in the literature on the topic of health-care waste several operational technical problems have been seen in the implementation of health-care waste management programs. Further, other difficulties such as preservation of the environment, public health safety, and economical implications tend to worsen the problems of the health-care waste management. Today health-care establishments are ever more in need of instruments that enable them to take decisions in order to make the handling of hazardous health-care waste safer and more appropriate.

The methodology used in the present work has been promising in this sense, since information obtained from it can aid in the prioritization of corrective actions, taking into account, for example, the hazardous potential of failures due to an inadequate implementation of operational procedures and the possible consequences for the system. In addition analysis of the risk series enables those responsible for the waste management program to implement control measures that minimize or interrupt the risk series. This methodology is currently being improved; thus, additional operational procedures will be incorporated into those that have already been studied and the methodology will be extended to other practices in the handling of infectious health-care waste.

ACKNOWLEDGMENTS

The authors acknowledge the technical and personal support received from the health-care solid waste management team at the State University of Campinas (Campinas, SP, Brazil) and the financial support received from CAPES and FAPESP for this research.

REFERENCES

- Associação Brasileira de Normas Técnicas (1993a). Rio de Janeiro, NBR 12.807; Resíduos de Serviços de Saúde: Terminologia. Rio de Janeiro: ABNT, 3 p.
- Associação Brasileira de Normas Técnicas (1993b), Rio de Janeiro, NBR 12.808; Resíduos de Serviços de Saúde: Classificação. Rio de Janeiro: ABNT, 2 p.
- Associação Brasileira de Normas Técnicas (1993c). Rio de Janeiro, NBR 10.809; Resíduos de Serviços de Saúde: Procedimento. Rio de Janeiro: ABNT, 4 p.
- The Association For Practitioners in Infection Control (APIC) (1992). Position Paper: Medical Waste (Revised). *Infect. Control Hosp. Epidemiol.*, 20, 73.
- Ayliffe, G.A.J. (1994). Clinical Waste: How Dangerous Is It? *Current Opinion In Infectious Diseases*, 7, 499.
- Byrns, G., Burke, T. (1992). Medical Waste Management - Implications for Small Medical Facilities. *Journal of Environmental Health.*, 55, 12.
- Companhia de Tecnologia de Saneamento Ambiental (CETESB) (1997). Resíduos de Serviços de Saúde. São Paulo: CETESB, 30p.
- Centro Panamericano de Ingeniería Sanitaria e Ciencia del Ambiente (CEPIS) (1997). Guia para el Manejo de los Recursos Sólidos en Centros de Atención de Salud. Lima: CEPIS, 58p
- Collins, C. H., Kennedy, D. A. (1992). The Microbiological Hazards of Municipal and Clinical Wastes. *Journal of Applied Bacteriology*, 73, 1.
- Conselho Nacional do Meio Ambiente (CONAMA) (1993). Resolução Nº 5 de 5 de Agosto de 1993. Ministério do Meio Ambiente.
- De Cicco, F., Fantazzini, M. L. (1985). Introdução à Engenharia de Segurança de Sistemas. 3 ed. São Paulo: FUNDACENTRO.
- Environmental Protection Agency (EPA). (1992). Model Guidelines for State Medical Waste Management. Washington, D.C.: Office of Solid Waste and Emergency Response, U.S. EPA, 30p.
- Federal Emergency Management Agency (FEMA) (1993). Handbook of Chemical Hazard Analysis Procedures. U.S. EPA, and U.S. DOT.
- Monge, G. (1997). Manejo de Resíduos em Centros de Atención de Salud. CEPIS: Organización Panamericana de Saúde OPS.
- Ribeiro Filho, V. O. (1999). Introdução ao Tratamento e Destino Final dos Resíduos de Serviços de Saúde. In *Curso: Tratamento e Destinação Final de Resíduos de Serviços de Saúde*. São Paulo: Associação Brasileira de Limpeza Pública (ABPL), 8.
- Rutula, W. A., Mayhall, C. G. (1992). Medical Waste. *Infect. Control Hosp. Epidemiol.*, 13, 38.
- Rutula, W. A., Weber, D. J. (1991). Infectious Waste - Mismatch between Science and Policy. *The New England Journal of Medicine*, 325, 578.
- World Health Organization (1999). Safe Management of Wastes from Health-care Activities. Edited by A. Pruss, E. Giroult, P. Rushbrook. Geneva, Switzerland.