Waste Management 34 (2014) 1324–1329

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Risk management for outsourcing biomedical waste disposal – Using the failure mode and effects analysis

Ching-Jong Liao, Chao Chung Ho *

Department of Industrial Management, National Taiwan University of Science and Technology, Taipei 106, Taiwan

ARTICLE INFO

Article history:
Received 14 October 2013
Accepted 17 March 2014
Available online 13 April 2014

Keywords:
Failure mode and effects analysis (FMEA)
Biomedical waste
Hospital waste management

ABSTRACT

Using the failure mode and effects analysis, this study examined biomedical waste companies through risk assessment. Moreover, it evaluated the supervisors of biomedical waste units in hospitals, and factors relating to the outsourcing risk assessment of biomedical waste in hospitals by referring to waste disposal acts. An expert questionnaire survey was conducted on the personnel involved in waste disposal units in hospitals, in order to identify important factors relating to the outsourcing risk of biomedical waste in hospitals. This study calculated the risk priority number (RPN) and selected items with an RPN value higher than 80 for improvement. These items included "availability of freezing devices", "availability of containers for sharp items", "disposal frequency", "disposal volume", "disposal method", "vehicles meeting the regulations", and "declaration of three lists". This study also aimed to identify important selection factors of biomedical waste disposal companies by hospitals in terms of risk. These findings can serve as references for hospitals in the selection of outsourcing companies for biomedical waste disposal.

1. Introduction

After the implementation of the National Health Insurance (NHI) system, hospitals have continually been improving the quality of medical treatment, and accepting more patients than before, thus resulting in an increased amount of workable hospital waste. Ho (2011) found that the amount of medical waste from disposable medical products has increased since the implementation of the NHI system. Among the hazardous waste types, the amount of infectious medical waste has increased at the fastest rate. In order for hospitals to handle such large amounts of medical wastes, they outsource registered waste treatment companies for transportation and disposal of wastes, which leads to a higher waste management cost for hospitals. According to medical statistics from the Ministry of Health and Welfare of Taiwan, the total wastes from regional hospitals reached 97,698 metric tons in 2011. Ordinary medical waste was reported to be 71,723 tons (73.4%), and an additional 25,975 tons were hazardous wastes. Cheng et al. (2009) conducted a study to evaluate the quantities of medical waste generated and the factors associated with the generation rate at medical institutions in Taiwan. The average waste generation rates ranged from 2.41 to 3.26 kg/bed/day for general medical wastes, and 0.19–0.88 kg/bed/day for infectious wastes. The total average quantity of infectious wastes generated was the highest in medical centers, or 3.8 times higher than that in regional hospitals (267.8 vs. 70.3 tons/year). Birpinar et al. (2009) found that the estimated quantity of medical waste from hospitals is about 22 tons/day and the average generation rate is 0.63 kg/bed/day. Recyclable materials are collected separately at a rate of 83%.

The World Health Organization (WHO) defines "healthcare waste" as waste produced in hospitals, research organizations, and laboratories. Among them, around 75–90% are non-risk or simply general healthcare waste, while the remaining 10–25% are hazardous waste insofar as they are waste that can cause human health hazards if touched or handled (Pruss et al., 1999). In North America, biomedical waste or hazardous medical waste accounts, on average, for 20% of medical waste (Weir, 2002). Patwary et al. (2009) suggested that mismanagement of medical wastes in developing countries may be a significant risk factor for disease transmission. Quantitative estimation of medical waste generation is necessary to estimate the potential risk and can serve as a basis for waste management plans. They used a statistically designed sampling of waste generation in a broad range of Health Care Establishments (HCEs), and indicated that the amount of waste produced in Dhaka is estimated to be 37 ± 5 ton per day. The amount of hazardous waste, as defined by the WHO guidelines, was 21%. The infectious/toxic and toxic

* Corresponding author. Address: 3F, No. 229, Beixin Road, Danshui District, New Taipei City 251, Taiwan. Tel.: +886 2 87878015; fax: +886 2 87876955.
E-mail address: ho919@pchome.com.tw (C.C. Ho).

http://dx.doi.org/10.1016/j.wasman.2014.03.007
0956-053X/

medical wastes accounted for 10% and 50% of the total hazardous medical wastes generated by the public cancer treatment and university hospitals, respectively (Komilis et al., 2012). Tudor et al. (2005) suggested that an important challenge to be overcome is the need to progress from the concept of 'waste management' to one of sustainable decision-making regarding resource use, including methods of waste minimization at the source and recycling.

According to the Taiwan Waste Disposal Act, institutions that produce medical waste must voluntarily dispose of it or outsource it to private waste disposal companies, hence, waste handling costs are unavoidable. Roberts (2001) indicated that because of the implementation of a "global budget system", both working hospitals and healthcare systems face financial problems. Thus, hospital administrators, in order to balance the quality of patient care and lower hospital operating costs, have outsourced non-essential tasks, including the handling of biomedical waste. This shows that waste produced by hospitals is being disposed by non-official methods, which often leads to great risks. Therefore, an objective selection method to choose a good biomedical waste disposal company for long-term security is especially important. This study examines the risks of outsourcing disposal of biomedical waste. Under such division of work, biomedical waste is produced by hospitals and the disposal is handled by professional companies. Hence, hospitals do not have to deal with biomedical waste, and can lower the operating cost. Such approach creates benefit effectiveness for the hospitals. However, the cost of waste handling is a concern of this study, and Ho (2011) suggested that the most important factor of selecting a waste handling company for infective waste is price. This study only explores the outsourcing risk of biomedical waste, and provides the references to decision-makers on outsourcing of biomedical waste.

Currently, waste management in hospitals is based on the waste disposal act. Although the management of biomedical waste disposal companies is effective, according to regulations, institutions that produce waste must be responsible for safe and proper waste disposal. Hence, when waste disposal management relies on outsourced companies and the waste is problematic, hospitals are still held responsible. Given this, hospitals should be extremely careful about the outsourcing risk of biomedical waste.

Morrisey and Browne (2004) suggested that most of the municipal waste models identified in the literature are decision support models, which, for the purposes of this research, are divided into three categories—those based on cost benefit analysis, those based on life cycle assessment and those based on multi-criteria decision making. Moreover, Morrisey and Browne (2004) suggest that even though a sustainable waste management model must consider environmental, economic and social aspects, no model so far has considered all three aspects in application. Most hospitals are concerned about economic factors, and biomedical waste disposal is based on market prices. Mere focus on price competition leads to the detriment of the social and environmental welfare. Therefore, hospitals must carefully evaluate risk-price tradeoffs in both short and long-run scenarios.

Taiwan has imposed a very strict set of laws and regulations concerning the production, disposal and processing of medical wastes. However, medical institutions may violate these laws unknowingly. The penalties for violation are insignificant, but the violation may damage the medical institutions' reputation. This study proposes suggestions to the hospital administrators regarding the selection of outsourced biomedical waste disposal company, in order to guarantee proper disposal and quality of medical service. As the hospitals are the producers of wastes, they also need to strengthen the management and examination of wastes, in order to lower the risks after outsourcing.

2. Literature

2.1. Biomedical waste and management

Garvin (1994) proposed that there appear to be hidden infection risks involved in supervising the disposal of medical waste. Medical wastes generally include controlled medical waste, biohazardous waste, isolation waste, biomedical waste, and potentially infectious waste. Hospital wastes include medical waste and biomedical waste (also known as controlled medical waste). Those classified as medical waste include infectious risk agents (Rutala and Weber, 1991).

According to the Standards for Defining Hazardous Industrial Waste, announced by the Environmental Protection Administration (EPA) of Taiwan, medical wastes include toxic drugs, needles/blades, pathological waste, discarded blood/plasma, and used surgical equipment, such as gauze. This can all be classified as 'biomedical waste', waste specifically generated from medical institutions. Infectious waste is also included in biomedical waste.

Narendra et al. (2013) studied biomedical wastes in various hospitals of Mysore City, and collected data on waste and disposal practices from personal observations. Moreover, assessment of knowledge, attitude and practice of working personnel were explored using questionnaire survey. The results revealed that there is a lack of knowledge and awareness regarding legislations on biomedical waste management even among qualified hospitals personnel. Patwary et al. (2012) conducted a study to determine whether fatalism is an important factor in explaining occupational accidents among medical waste operatives in Dhaka, Bangladesh. They found that most waste workers (95%) had experienced occupational accidents, mostly (75%) from used needles and other sharp objects. According to literature, workers handling biomedical wastes are in a high-risk work environment, and they need professional knowledge to deal with the biomedical wastes.

2.2. Failure Mode and Effects Analysis Application (FMEA)

FMEA is an advanced preventive analysis tool used in the process of the product or system and engineering design. The purpose of this study is to expand the application of FMEA technologies to the scope of project management in order to determine possible project quality failure methods in advance. The principles of FMEA are very simple. As Rasmussen (1985) observed, the complexity of a system is not an objective feature of the system, but rather a method, which may contain some defects in nature, that results in doubts and disputes. For example, the classification of the definition of risk is highly subjective and unconvincing, and a uniform format is not available in the FMEA analysis table (Fracica et al., 2006). Although this study identified many problems involved in the practical application of FMEA at early stages in development (such as incomplete data for the JCAHO risk coefficient) it is still able to produce subjective judgments of risk classification, a determination of failure modes, and so on, which are required later on.

Ebrahimipour et al. (2010) defined 'failure' in FMEA as any undesirable outcome, such as production loss, injury or accident, and define a 'customer' as someone or something that receives products or services. Gruber et al. (2006) mentioned that FMEA can also be used to improve patients' safety and medical quality. Zupa et al. (2006) suggested that FMEA can be applied to any procedure that might affect a patient's safety. Vannice and Wimmer (2007) used FMEA to improve chemotherapy-related management practices, reduce unusual events and improve chemotherapy management in order to ensure patient safety. Rogers and Hughes (2008) applied FMEA to the dispensing process and successfully