Risk Evaluation of Outsourced Biomedical Waste Disposal of Medical Institutions by Multi-criteria Decision Making Analysis to Improve Hospital Management Capability

M.S. Chen[1], C.C. Ho[2]

[1]Department of Healthcare Administration, College of Management and Healthcare, Oriental Institute of Technology, New Taipei, 22061, Taiwan, ROC

[2]Department of Public Administration, Nanfang College of Sun Yat-Sen University, Guangzhou, Guangdong, 510970, P.R. China.

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Presenting author email: tree1013@gmail.com

Introduction

As Taiwan has high quality medical care and hospital management capability, many nations in the Asia Pacific region learn from Taiwan. In order to continuously improve quality of medical service and make the public satisfy the medical and hygienic environment, while maintaining the high quality of medical care, hospitals also generate large amount of medical wastes. Hospitals must seek professional and cost-effective treatment companies to jointly treat such medical wastes and control costs. Among the medical wastes, the biomedical wastes account for the highest proportion.

According to the statistics provided by the Taiwan Environmental Protection Administration Executive Yuan's and Ministry of Health and Welfare, Taiwan's total hospital waste reached 120,000 metric tons in 2016. Ordinary medical waste was reported to be 91,000 tons (76%); 30,000 tons is classified as hazardous biomedical waste.

If the treatment process has slightest mistake, it will cause environmental pollution and biological hazards, which may seriously affect environment and soil. This study is aimed to provide considerations for medical institutions, policy makers and medical waste management units in selection of medical bio-waste treatment companies and establish a multi-criteria decision-making analysis model to assist the hospital waste management personnel to evaluate and select the outsourced suppliers for treatment and transport of wastes.

Material and methods

In this study, the analysis data required for the multi-criteria decision making model were collected from the wastes management personnel of the four hospitals in Taipei City (Taiwan) and managers of the medical waste treatment contractors. This study uses the three following tools. First, the FMEA was used to gather expert opinions in order to sort out and build up an evaluation criterion for selecting candidate waste disposal vendors. Second, AHP was applied to calculate factor weights. Third, TOPSIS was applied to determine the best biomedical waste disposal vendor.

- FMEA: the method was developed in the 1950s in response to the low level of reliability of oil pressure devices and the electrical devices of American fighter planes, which often resulted in plane crashes. The aircraft company Grumman was the first to apply the concept of FMEA to the fault analysis of the main control system of planes. It is a reliable technique for preventing defects and improving product safety and quality. The main function is to point out the design or system failure mode, explore the impact of system failure, provide qualitative or quantitative assessments, and employ the necessary corrective measures and preventive policies; it was not until recent years that hospitals began to use FMEA for improvement.
- AHP: this method can simplify a complicated question and solve it hierarchically with different perspective. Also, by its quantitative judgment and comprehensive evaluation through its context, it provides decision makers with sufficient information to make suitable decision as well as reduce the risk of making wrongful decisions. In the decision-making methodology of multiple targets and guidance, AHP is a simple and feasible method (Deng and Zeng, 1989). Plus, AHP is mainly used in situations of uncertainties where one needs to make decision based on multiple evaluation guidance (Saaty, 1980).
- TOPSIS: this method was employed in this study to establish the order of preference of the evaluation method. TOPSIS is one of the traditional ordering methods of the MCDM. Proposed by Hwang and Yoon (1981), it mainly applies methods developed by the concept of compromise solution. TOPSIS's basic hypothesis to characteristics is simple increasing or decreasing. Its concept of algorithm is to define positive ideal solution and negative ideal solution and then decide the optimal solution as closest to the positive ideal solution and farthest from the negative ideal solution according to Euclidean distance (Wang, 1999; Triantaphyllou and Lin, 1996).

Results

The evaluation model construction in this study can be dissected into three stages. The first stage uses FMEA to determine suitable selection criteria. The second stage applies AHP to decide the weight of each evaluation criterion. The third stage uses TOPSIS construction of selection mode. The study construction and part of data were collected from previous research data (Liao and Ho, 2014), and the results of advanced analysis with the TOPSIA method were as table 1.

Table 1. The scores of the experts evaluate value with the TOPSIS analysis Method

Item	A	B	C	D	max	min
Disposal permit time	0.51	0.58	0.35	0.53	0.58	0.35
Singular processing speed	0.62	0.48	0.46	0.41	0.62	0.41
Emergency management plans	0.46	0.54	0.35	0.61	0.61	0.35
Handling capacity	0.60	0.53	0.45	0.39	0.60	0.39
Handling method	0.56	0.45	0.39	0.57	0.57	0.39
Vehicular equipment complies with Laws and ordinances	0.50	0.53	0.36	0.58	0.58	0.36
Offers freeze-storage equipment	0.59	0.56	0.41	0.42	0.59	0.41
Offers equipment maintenance	0.62	0.53	0.44	0.38	0.62	0.38
Provides clearly marked sharp instrument receptacles	0.54	0.44	0.65	0.30	0.65	0.30
Alternate firm scope	0.59	0.49	0.45	0.46	0.59	0.45
Removal frequency	0.47	0.57	0.37	0.57	0.57	0.37
Vehicular dispatch capability	0.62	0.53	0.45	0.38	0.62	0.38
Disposal permit time	0.51	0.58	0.35	0.53	0.58	0.35

Collect the data form talble 1 and using TOPSIS Optimal solution to anylsis most preferential outsourcing vendor ranking. The first-place option was the most ideal medical waste disposal vendor in this study. The scores and order were vendor A (0.731) > B (0.610) > D (0.437) > C (0.366). According to the results of this case study, from the relative proximity of the above solution to the PIS, the preferential order of the vendors can be known as A > B > D > C; thus, vendor A was the most preferred candidate among the four.

Discussion and conclusions

Biomedical wastes generated from medical institutions are highly biohazardous substances. If they cannot be properly treated, they may cause serious environmental impact and may also harm hospital staff or patients. Taiwan has established strict biomedical waste ordinances and management system to avoid outflow or improper treatment of biomedical wastes. Most of Taiwan's hospitals entrust treatment of biomedical wastes to contractors for transport and treatment. This study provides a new multi-criteria model for decision making analysis as a method to help hospitals find the most suitable waste treatment companies. The study results can be used to improve hospital management capability, reduce probability of improper treatment of hospital medical wastes and minimize hazards to the environment and establish evaluation mechanism of hospital biomedical wastes treatment supplier as the basis for hospitals to select the suppliers.

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