Implementation of an Environmentally Friendly Approach of a Hospital–Practice of Medical Waste Disposal

Chiwei Chen

1 Professor, College of Economics and Management, Zhaoqing University
Zhaoqing, Guangdong 526061, China
E-mail: 3418221808@qq.com

Abstract. Gama Hospital is a well-known private hospital in Taiwan. In addition to medical treatment technology, hospital management and cost control are also excellent. Regarding the treatment of medical waste, one must consider the cost and also the environmental implications. Waste disposal, besides the inevitable treatment after its emergence, should be given more attention during the course of medical execution. In the practice of the hospital, the actual waste treatment cost was reduced. The main factor is that the hospital promotes a series of waste treatment education and training. In addition to medical personnel, patients and family members also participate in medical waste reduction and correct handling activities, successfully completing the hospital's waste reduction target and achieving sustainable environmental social responsibility.

1. Introduction
The World Health Organization (WHO) has pointed out that about 85 per cent of the total waste generated in medical activities is generally harmless waste, while the remaining 15 per cent is considered to be a hazardous substance of pollution, chemical or radioactivity [1]. Globally, 16 billion injections are made worldwide, but not all needles and syringes are properly treated after use, and in some cases, open burning of medical waste can lead to toxic air pollution emissions. The aim is to ensure that safe and environmentally harmless management measures for medical waste are in place to prevent adverse health and environmental effects.

Common problems with the disposal of medical waste are as follows: lack of awareness of health hazards associated with medical waste, inadequate training on waste disposal, lack of waste management and disposal systems, and low attention to this issue, as well as inadequate financial and human resources. In low and middle-income countries, there has been a significant reduction in the use of contaminated needles and syringes in recent years, partly due to efforts to reduce the reuse of syringes. In 2010, however, unsafe injections resulted in as many as 33,800 new HIV (Human Immunodeficiency Virus) infections, 1.7 million hepatitis B infections and 315,000 hepatitis C infections [2].

According to WHO statistics [3], each hospital bed in industrialized countries produces 0.5 kg of medical waste per day per bed, while in developing countries each bed produces 0.5-2.5 kg of medical waste per day. The United States of America produces about 2.6 million tons of medical waste each year. Therefore, each hospital should be particularly and continuously attentive about the generation and treatment of medical waste. The methods and data presented in this paper are the result of Gama Hospital’s case. Gama Hospital aims to make a minor contribution toward environmental friendliness and environmental sustainability.
2. Gama Hospital promoted medical waste treatment methods
Gama Hospital is a private hospital in Taiwan. In addition to its well-known medical technology, its hospital management and cost control are also excellent. Based on the high priority attached to the treatment of medical waste, Gama Hospital actively promoted the reduction of medical waste. The hospital set short-term and long-term goals. The short-term goal was to reach a specific reduction target, to be socially responsible for the sustainable environment, and to achieve environmental friendliness.

2.1. Classification of medical waste
Medical waste may be largely classified as general medical waste and hazardous medical waste which includes infectious, chemical, and radioactive waste. The WHO also listed common hazardous medical waste as follows [1]:
(1) Infectious waste: Waste contaminated by blood or other liquids.
(2) Pathological waste: Human tissues, organ fluids.
(3) Sharp ware: Needles, syringes and disposable scalpels.
(4) Chemicals: Solvents, disinfectants for laboratory preparation.
(5) Drugs: Expired, unused, and contaminated drugs or vaccines.
(6) Genetically toxic: High-risk, mutation-causing, teratogenic and carcinogenic.
(7) Radioactive waste: Radioactive nuclide-contaminated items.

2.2. The importance and purpose of infectious waste classification
The correctness of classification can affect the treatment process and cost, and due to the characteristics of the infectious waste, classification does not directly affect the safety of hospital workers, but may generate secondary environmental pollution. The purposes of improving treatment of infectious waste are as follows: to strengthen people's understanding of the correct classification of infectious waste, to achieve the effect of reducing the amount of infectious waste, and to reduce the cost of treatment of infectious waste.

The Bureau of Health of Taiwan, the Bureau of Environmental Protection of Taiwan, and other health administration offices of Taiwan have set clear standards for the determination and treatment of medical waste [4-8], and have requested all medical institutions to implement all related regulations in a firm and serious manner, as follows: waste classification, waste characteristics analysis, storage methods, adherence to labels, typical waste disposal, and identification of major sources.

Since the implementation of health insurance in Taiwan, the service amount of various medical institutions has increased and so has the amount of medical waste. The medical waste disposal costs have increased and the operating costs of hospitals have also increased. Gama Hospital will review the current treatment of medical waste and carry out feasible solutions to analyze its driving effect.

2.3. Analysis of the status of branches
The review plans of Gama Hospital include hospitals such as the Linkou, Kaohsiung, Keelung, Jiayi and Yunjianan Regional Hospitals, and will begin with the Jiayi Branch. From Table 1, it can be seen that the daily per bed in the Linkou Branch produces 0.45 kg of infectious waste, which is the smallest number among the branches, while the Jiayi Branch is the largest daily producer of infectious waste. In terms of general waste, the Linkou Branch produces the most at 2.83 kg per bed per day and the Keelung Branch produces the least at 1.87 kg per bed per day. In year A and B, the total amount of infectious waste in the Jiayi Branch was 194 tons and 223 tons respectively, compared with 594 tons and 566 tons for general waste.

| Branch                  | Infectious waste (kg/bed-day) | General waste (kg/bed-day) |
|-------------------------|-------------------------------|----------------------------|
| Linkou Branch           | 0.45                          | 2.83                       |
| Kaohsiung Branch       | 0.49                          | 2.18                       |
| Keelung Branch         | 0.52                          | 1.87                       |
| Yunjianan Regional Hospital | 0.52                       | --                         |
In year A, the infectious waste disposal cost at the Jiayi Branch was $502,869 (in this paper, currency unit used is NT$, New Taiwan Dollars; exchange rate of NT$ to US$: 30NT$=1US$) per month, and in year B was $537,372 per month (see Table 2), an increase of $34,503 per month. In general waste disposal, the monthly treatment cost in year A was $114,781, while the monthly cost in year B was $116,256 per month, an increase of $1,475 per month. From year A to B, the monthly processing cost increased $35,978.

| Waste types       | Year A (A)                      | Year B (B)                      | Cost difference (B) – (A) = C     |
|-------------------|---------------------------------|---------------------------------|-----------------------------------|
| Infectious waste  | $194,659 * $31/kg= $6,034,429   | $223,060 * $26.5/kg= $5,911,090 | $34,503/month                     |
|                   | $6,034,429/12= $5,911,090/11=   | $502,869/month $537,372/month   |                                   |
| General waste     | $593,694 * $2.23/kg= $1,377,370 | $566,334 * $2.26/kg= $1,278,815 | $1,475/month                     |
|                   | $1,377,370/12= $1,278,815/11=   | $566,334/month $116,256/month   |                                   |
| Total amount      | $617,650/ month $653,628/ month | $653,628/ month                 | $35,978/ month                   |

*Note: year B only collect 11 months of data

2.4. Analysis of the current problems of medical waste disposal

In order to deeply explore the source of problems arising from the cost of medical waste disposal in the Jiayi Branch, this paper uses a Cause and Effect diagram (Fishbone diagram) shown as Figure 1. In the diagram, both staff members and the families of patients are under-aware of the classification of medical waste, and staff treatment of infectious waste is not comprehensive. On the environmental aspect, the markings of medical waste sites are unclear. On the policy aspect, there is no audit of the misclassification of infectious waste, and no reward and punishment policy had been established.

**Figure 1.** Cause & Effect diagram of the incorrect disposal of medical waste
2.5. Improvement strategies

2.5.1. Environment aspect. Previous infectious waste collection spots in hospital were not clearly marked for infectious waste, resulting in classification errors in the handling of medical waste by staff or the family of the patients. The proposed solution is to place physical photographs next to trash buckets where infectious waste is placed to assist staff and patients' families in discarding infectious waste.

2.5.2. Policy aspect. The analysis of the medical waste treatment issues (in Figure 1) shows that the hospital has not yet formulated a reward and punishment policy for the treatment of medical waste. The corresponding proposal is to hold a competition "medical waste reduction and classification" and also offer rewards. In addition, a "medical waste classification audit team" was set up by 5S (Seiri, Seiton, Seiso, Seiketsu, Siesuke) audit members to conduct occasional spot checks on the classification of medical waste in each area of responsibility and to continuously assess performance [9].

2.5.3. Employees aspect. The staff of this branch are under-aware of the classification of medical waste, and the corresponding proposal is to carry out "medical waste classification and collection" education and training. In the case of the inaccuracy of the disposal of infectious waste, the proposed solution is to add "waste liquid collection tanks" to the care vehicles.

2.5.4. Patients and family members aspect. The patients and family members are also under-aware of the medical waste classification. The proposed solution is to strengthen the environmental introduction of admission, point out the location of the medical waste disposal rooms, and set up "medical waste disposal locations and direction maps" at the nursing station to assist the patients and their families to find the correct waste placement site. It also strengthens the importance of publicizing medical waste classification for patients and their families.

3. Results and analysis

3.1. Questionnaire

In order to examine the proposed alternatives and the effect of the implementation, the Quality Assurance Team of administration office designed a questionnaire for patients and family members and nursing staff respectively.

3.1.1. Patient and family questionnaire

(1) Were contaminants collected in the nursing station?
(2) Were the diapers thrown into the red trash buckets?
(3) Were cotton balls and cotton sticks thrown into the blue trash buckets?
(4) Were wipe paper and toilet paper thrown into the blue trash buckets?
(5) Were Styrofoam boxes thrown into the red trash buckets?
(6) Were flowers thrown into the blue trash buckets?
(7) Were masks thrown into the blue trash buckets?
(8) Were newspapers thrown into the recycling bins?
(9) Were polyethylene bottles thrown into the recycling bins?
(10) Was the kitchen waste thrown into the red trash buckets?

In response to the above-mentioned questionnaire, a survey was given before and after the medical waste publicity and education activities were conducted, and 18 patients and family members were interviewed before the event, including 8 men and 10 women, with a correct response rate of 74.4%. After the event, a total of 21 patients and family members were interviewed, including 6 men and 16 women, and the accuracy rate of answering the questionnaire was 93.3%, an increase of 25.4%.

3.1.2. Nursing staff questionnaire

(1) Were cotton sticks that are not contaminated with the blood and body fluids of infected people thrown into the red trash buckets?
(2) Were pots, urinals, and diapers used by non-infected patients thrown into the red trash buckets?
(3) Was medical waste after chemotherapy thrown into the red trash buckets?
(4) Were drain fluids in drainage bottles (bags) thrown into the red trash buckets?
(5) Were general Amp and Vial within 50ml thrown into the blue trash buckets?
(6) Were IV sets thrown into the blue recycling bins?
(7) Were general IV infusion bags after removing moisture and stickers thrown into the blue recycling bins?
(8) Were PVC empty bottles of preparations treated as general waste?
(9) Were polyethylene bottles and aluminum cans thrown into the yellow trash buckets?
(10) Was medical waste divided into general and infectious waste?

The accuracy rate of responses to the above-mentioned questionnaire by nursing staff before education and training was 84.3%, and the accuracy rate of answers after education and training was 95.8%, an increase of 11.5%.

3.2. Results of implementation

3.2.1. The statistics of medical waste amount. Ward waste measured 0.54 kg per bed per day before education and training activities, and 0.33 kg per bed per day after education and training activities. As a result, the daily amount of waste per bed decreased from 0.54 kg to 0.33 kg, a decrease rate of 38.9% (see Table 3).

Table 3. Statistics on infectious waste in wards

|                         | Before improvement actions (year B/11/01~year B/11/07) | After improvement actions (year C/01/01~year C/01/23) |
|-------------------------|---------------------------------------------------------|--------------------------------------------------------|
| Total weight (kg)       | 150                                                     | 76                                                     |
| Total bed-day amount    | 280                                                     | 231                                                    |
| Average weight per bed  | 0.54                                                    | 0.33                                                   |

*Note: C=B+1

3.2.2. Waste disposal cost
Monthly saving: $26.5 /kg * 1,271 bed-day * (0.54-0.33) kg/bed-day = $7,073/month
Yearly saving: $84,876/year

3.2.3. Differences between before and after improvement actions
(1) Increased awareness of medical waste classification among patients and family members, with a 25.4% increase in test scores.
(2) Increased awareness of medical waste classification among nursing staff, with test scores increasing by 11.5%.
(3) Reduced the amount of infectious waste in the wards from 0.54kg/bed-day to 0.33kg/bed-day, with a reduction rate of 38.9%.
(4) Increased the number of illustrated guidelines in wards and medical waste disposal rooms from 0 to 20.
(5) Increased the number of posters for the classification of waste in wards from 1 to 21.

4. Conclusion
After the education and publicizing of medical waste identification to medical staff, patients and family members in the Jiayi Branch, the awareness of nursing staff, patients and their families regarding medical waste was greatly improved, directly reducing the amount of infectious waste and reducing the cost of its treatment. As Gama Hospital has several branches in Taiwan, the hospital can promote a more comprehensive approach to reduce secondary pollution caused by improper handling of medical waste, so as to fulfill the social responsibility of environmental sustainability.
5. References

[1] World Health Organization 2018 Medical waste
   http://who.int/zh/news_room/fact_sheets/detail/health-care-waste

[2] Pe´pin J, Abou Chakra CN, Pe´pin E, Nault V, Valiquette L. 9 June 2014 Evolution of the global burden of viral infections from unsafe medical injections 2000-2010 PLoSOne 9(6): e99677

[3] Arterial Network 28 August 2018 How to dispose of 2 million tons of medical waste a year?
   http://m.huxiu.com/article/259830.html

[4] Environmental Protection Bureau of the Executive Council 2006 Medical waste disposal methods
   http://oaout.epa.gov.tw/law/LawContent.aspx?id=GL003544

[5] Chen W 2016 Biomedical waste management and disposal
   http://gao.sinica.edu.tw/ehsmd/ch/docu/education/20160824_sinica_Biowaste_print_pdf

[6] Lan Z 2000 Infectious medical waste treatment strategy and technology review Policy Research Foundation

[7] Cai Q 2001 The final report of the study of medical waste identification, classification and treatment guidelines Published by Environmental Protection Bureau of the Executive Council

[8] Review and regulations of the determination of the characteristics of infectious industrial waste 1998 Published by Environmental Protection Bureau of the Executive Council

[9] 5S-Seiri, Seiton, Seiso, Seiketsu, Shitsuke 17 November 2016 http://ncl.com.tw/world/250