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CASE REPORT

Estimation of Infectious Medical Waste Quantities on a Per-patient Basis: An Observational Study at a Hospital

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Abstract:

Introduction:

Infectious medical waste management in hospitals is very important. The potential impacts of infectious medical waste discharged from hospitals on populations and society are considered greater than those of general industrial waste. Therefore, the estimation of infectious medical waste discharged from healthcare facilities should be accurate. The present study reports the quantity of infectious medical waste discharged per ward per day per inpatient by weight.

Methods:

In medical wards, the digestive surgery ward discharged the most infectious medical waste. In addition, the digestive surgery ward had the highest quantity of infectious medical waste per day per inpatient. Infectious medical waste quantity estimates based on beds were lower than those based on inpatients, with minimum and maximum underestimates of 6% and 21%, respectively.

Results & Discussion:

Infectious medical waste discharged per patient per day was low in the outpatient department. The operating room and the emergency department discharged 10-fold more infectious medical waste than the wards. The operating room, the emergency department, and the clinical inspection department accounted for 60% of infectious medical waste discharged from hospitals.

Conclusion:

Notably, there are considerable differences among departments when evaluating hospital waste, particularly in hospitals with surgery and critical care departments, which is different in the case of evaluations based on bed counts.

Keywords: Infectious medical waste, Japanese, Hospital waste management, World Health Organization (WHO), Pathological waste, Healthcare Waste (HCW).

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1. INTRODUCTION

Every year, hospitals discharge large quantities of Healthcare Waste (HCW). In several countries, potential harm to the public from HCW has become a great source of concern for governments, medical practitioners, and civil societies. In addition, hospital management and medical staff are expected to take greater responsibility for the waste materials they produce in the course of medical care and related activities. Currently, indiscriminate and erratic handling and disposal of waste within healthcare facilities are widely recognized as sources of avoidable infections and are synonymous with public perceptions of poor standards of healthcare.

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The World Health Organization (WHO) [1] has classified HCW into seven categories: sharp waste, infectious waste, pathological waste, pharmaceutical waste, chemical waste, radioactive waste, and general HCW, which are further broadly classified into either hazardous HCW or nonhazardous HCW. Used or unused sharps (*e.g.*, hypodermic, intravenous, or other needles; auto-disable syringes; syringes with attached needles; infusion sets; scalpels; pipettes; knives; blades; broken glass) are referred to as sharp waste. Waste suspected to contain pathogens and that pose a risk of disease transmission (*e.g.*, waste contaminated with blood and other body fluids; laboratory cultures and microbiological stocks; waste, including excreta and other materials that have been in contact with patients infected with highly infectious diseases in isolation wards) is referred to as infectious waste. Human tissues, organs, or fluids (*e.g.*, body parts; fetuses; unused

blood products) are referred to as pathological waste. Pharmaceuticals that have expired or are no longer needed, items contaminated by or containing pharmaceuticals, and cytotoxic waste containing substances with genotoxic properties (*e.g*., waste containing cytostatic drugs often used in cancer therapy; genotoxic chemicals) are classified as pharmaceutical waste or cytotoxic waste. Waste containing chemical substances (*e.g*., laboratory reagents; film developer; disinfectants that have expired or are no longer needed; solvents; waste with high heavy-metal concentrations, *e.g*., batteries; broken thermometers, and blood-pressure gauges) is classified as chemical waste. Waste containing radioactive substances (*e.g*., unused liquids from radiotherapy or laboratory research; contaminated glassware, packages, or absorbent paper; urine and excreta from patients treated or tested with unsealed radionuclides; sealed sources) is referred to as radioactive waste. General HCW refers to waste that does not pose any particular biological, chemical, radioactive, or physical hazards.

Numerous researchers have reported HCW discharge amounts per bed. However, such estimates vary across countries [2, 3]. The lowest estimate is 0.08 kg per bed per day, and the highest estimate is 2.79 kg per bed per day [4]. Such differences could be attributed to differences in economic status among different countries. However, even at a similar economic status, there are differences in waste discharges per bed. Such differences could also be attributed to different definitions of HCW. For example, in Jordan, [5] a study has categorized infectious waste into isolation waste; cultures and stocks of infectious agents and associated biologicals; human blood and blood products; pathological waste; sharps; and animal carcasses, body parts, and bedding. In China, Yong *et al*. (2009) [6] grouped medical waste into tissues, infectious waste, sharps, chemical waste, and medicine waste. According to the United States Environmental Protection Agency [7] medical waste refers to all waste material generated by healthcare facilities, such as hospitals, clinics, physicians' offices, dental practices, blood banks, and veterinary hospitals/clinics, in addition to medical research facilities and laboratories. The definition, according to USEPA, includes, but not limited to, blood-adhered bandages, culture dishes and other glassware, disposed of surgical gloves, surgical instruments, needles (*e.g*., medical sharps), microbiological cultures, stocks, swabs used to inoculate cultures, and body tissues resected during surgery.

In Japan, infectious waste is classified as specially controlled waste. In addition, waste is classified into "infectious general waste" and "infectious industrial waste" depending on the materials discharged. Materials that contain infectious pathogens or are attached to bandages, absorbent cotton, gauze, or waste paper, or contain blood and are discharged from medical institutions are classified as infectious general waste. Materials that are discharged by medical institutions, such as alcohol, X-ray fixing solution, synthetic resin instruments, plastic gloves, injection needles, and ampoules, with potentially infectious pathogens are referred to as infectious industrial [8].

Another potential reason for the discrepancy in discharge amounts per bed is due to variations in discharges of patients based on their conditions and treatment sought in hospitals. For example, surgical, internal medicine, and psychiatric patients would emit varying amounts of infectious waste. Infectious medical waste management in hospitals is critical because infectious medical waste discharged from hospitals could affect populations and society in general to a greater degree than general industrial waste. Therefore, the accurate estimation of infectious medical waste discharged from healthcare institutions is critical. Therefore, in the present study, infectious medical waste discharged per ward per day per inpatient has been discussed.

2. METHODS

2.1. Study Location

Kindai University hospital is located south of Osaka prefecture, Japan. The hospital has 17 medical wards, 14 outpatient departments, and 929 hospital beds. The hospital has approximately 2,500 staff, including doctors, nurses, technical staff, and administrative staff.

2.2. Definition of Infectious Waste

In Japan, all medical waste is first separated into infectious and noninfectious waste. Three major criteria are applied when distinguishing infectious waste from noninfectious waste, as illustrated in (Fig. **1**). In Japan, the law categorizes as Infectious general waste and Infectious industrial waste [9], but in fact, many hospitals treat them together as Infectious medical waste which is categorized as Infectious industrial waste. In our hospital, all infectious waste discharged from the hospital is classified as Infectious medical waste.

2.3. Infectious Waste Container Counting and Data Collection

The person in charge of waste collection in each ward noted the name of the ward or department when discharging infectious medical waste disposal containers from each ward or department in the hospital. At the waste storage site in the hospital, the numbers of infectious medical waste containers discharged from each ward or department were counted according to the type of container. The data were collected for each ward or department. The numbers of hospitalized patients, outpatients, operations, and emergency reception cases were obtained from hospital data.

2.4. Data Analysis

All collected data were digitized. Statistical data analyses were conducted using SPSS (Statistical Package for Social Sciences) statistical software (Ver. 24, IBM Corp.).

3. RESULTS

The quantities of infectious medical waste discharged by medical wards are shown in Table **1**. Most of the infectious medical waste was discharged from the digestive surgery ward. The digestive surgery ward also had the highest number of infectious medical waste per day per inpatient (Table **1**).Infec-

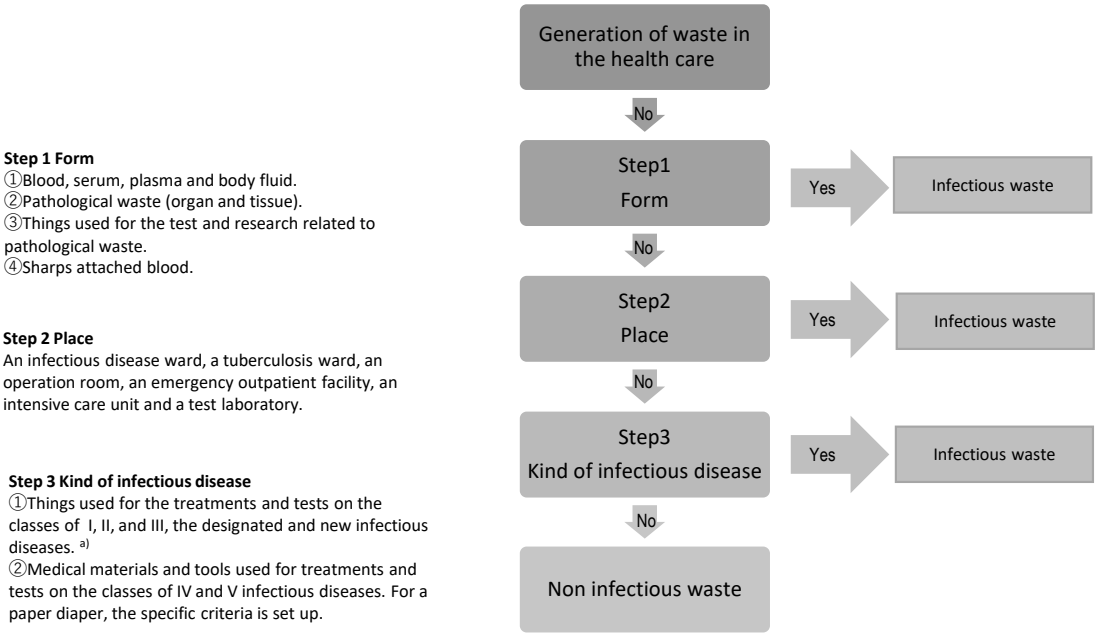

Fig. (1). Infectious waste assessment. (**a**) See reference for infection classification of Japan (National Institute of Infectious Diseases, 2018).

Table 1. Infectious medical waste discharges per day per in-patient hospital ward.

-	Total	Kg/day/bed (A)	Kg/day/in-patient (B)	Difference Between Patient Base and Bed Base. (Kg / day)	Percentage of Difference Between A and B.
Digestive Surgery	25,637	1.351	1.635	0.284	17%
Blood and Collagen Disease	22,295	1.072	1.249	0.177	14%
Cardiac Surgery	17,648	0.948	1.120	0.172	15%
Cardiology	12,582	0.783	0.851	0.068	8%
Pediatrics	12,201	0.796	1.003	0.207	21%
Otolaryngology	10,767	0.702	0.828	0.126	15%
Brain Surgery	9,969	0.635	0.744	0.109	15%
Urology	9,936	0.469	0.537	0.068	13%
Dermatology	9,480	0.618	0.660	0.042	6%
Respiratory and Allergic Internal Medicine	9,479	0.472	0.520	0.048	9%
Liver, Gall bladder and Pancreatic surgery	9,030	0.603	0.686	0.082	12%
Orthopedics	7,896	0.373	0.407	0.034	8%
Gastroenterology	7,493	0.348	0.394	0.047	12%
Delivery Part	7,088	0.511	0.599	0.088	15%
Ophthalmology	5,696	0.269	0.296	0.027	9%
Oncology	4,200	0.443	0.513	0.071	14%
Gynecology	3,947	0.270	0.327	0.056	17%

tious medical waste quantities based on patients and beds were different, ranging from 0.284Kg/day to 0.027Kg/day (Table**1**). In all wards, the infectious medical waste quantity per bed was lower than that per patient. In addition, the infectious medical waste quantity per bed was lower than that per inpatient. The minimum and maximum underestimates were 6% and 21%, respectively (Table **1**).

The quantities of infectious medical wastes that were discharged by the outpatient hospital department are shown in Table **2**. Among the outpatient departments, the dermatology department discharged most of the waste. Infectious medical waste discharge per patient ranged from 0.000 Kg/day/ outpatient to 0.102 Kg/day/outpatient (Table **2**). Oriental medicine does not generate infectious medical waste as it only

interrogates and gives medicine during treatment.

Table 2. Infectious medical waste discharges per day per out-patient hospital department.

-	Total	Kg/day/out-patient
Dermatology	3,420	0.080
Internal medicine	3,096	0.014
Dentistry	2,892	0.082
Surgery	1,968	0.034
Urology	1,482	0.060
Gynecology	1,278	0.058
Otolaryngology	1,218	0.046
Plastic surgery	942	0.102
Pediatrics	822	0.046
Orthopedics	458	0.009
Ophthalmology	414	0.008
Anesthesiology	399	0.041
Psychiatry	90	0.003
Oriental medicine	0	0.000

Infectious medical wastes discharged per day per event by the operation room and the critical care and clinical inspection departments are shown in Table **3**. The operating room and the emergency department had 10 times more infectious medical waste than the wards (Table **3**). The quantity of infectious medical waste discharged by the clinical inspection department could not be determined because waste from the inpatient department could not be distinguished from the outpatient department (Table **3**).

Table 3. Infectious medical waste discharges per day per case by department.

-	Total	Kg/case
Operating room	192,338	22.67
Critical care (emergency department)	62,832	15.54
Clinical inspection department	32,835	not available

4. DISCUSSION

In the present study, infectious medical waste discharge from each hospital department and per patient per day was reported, with the aim of finding an accurate method for the assessment of quantities of infectious medical waste discharged from hospitals. In addition, to the best of the author's knowledge, this is the first report of infectious medical waste discharges from hospital wards per inpatient.

The discharge of infectious medical waste according to the medical ward is as follows. Digestive surgery, blood and collagen disease, and cardiac surgery medical wards discharged large quantities of infectious medical waste. Such medical wards are likely to discharge large amounts of blood and body fluids. The amounts of infectious medical waste discharged per inpatient were also high in these three departments: 1.635 Kg/day/patient in the digestive surgery ward, which was the highest among the inpatient department wards. Conversely, in the ophthalmology ward, the infectious medical waste discharged per day per inpatient was as low as 0.3 Kg. Infectious medical waste discharges per bed were lower in every ward compared with the per-patient infectious medical waste discharges per day (Table **1**). Infectious medical waste quantities based on beds were lower than those based on inpatients. The most obvious difference in infectious medical waste discharge between patient base and bed base was 0.284Kg/day (Table **1**). Moreover, the estimation of infectious medical waste discharges on the basis of bed basis was underestimated by up to 21% compared to the inpatient basis (Table **1**). As expected, the results suggest that not all beds are occupied every day, and there are vacant beds as well. Because infectious medical waste is discharged by inpatients, the results indicated that estimates based on inpatients were more accurate than those based on beds.

In the outpatient department, infectious medical waste discharges were highest in the dermatology, internal medicine, and dentistry departments in that order, whereas infectious medical waste discharges per patient per day were highest in the plastic surgery, dentistry, and dermatology departments in that order. The results imply that such departments experience more hospital visits than hospitalizations. In addition, a large quantity of skin and blood waste is likely to be produced during outpatient treatment. The waste discharged by the plastic surgery department, which represents the highest amount of infectious medical waste per patient, which is 0.102 kg/day/outpatient. In any case, infectious medical waste in the outpatient department is considered to account for a small percentage of the entire hospital.

With regard to the surgery and emergency departments, infectious medical wastes discharged per case were 10-fold more than those of wards and 100-fold more than those of outpatient departments. The highest operating room was 22.67 kg/case. This is because, in the case of surgery or emergency, all waste is considered infectious waste (Fig. **1**, step 2). Therefore, these departments in Table **3** account for 60% of the infectious medical waste discharged from hospitals.

To compare the results of this study with those of previous studies, the total infectious medical waste from all departments was estimated to be 1.697 kg/day/bed. The finding was reasonable compared with the results of previous studies [10 - 12].

CONCLUSION

The present study provides an example taken from one hospital. University hospitals in Japan could have similar trends. However, in other countries, the definitions and separation strategies for infectious waste could be different. Therefore, researchers should be cautious when extrapolating the results. It is also important to note that most of the literature available has reported on the quantities of HCW on the basis of weight. Infectious waste ranges from relatively heavy material (such as blood, metal, and glass) to light material (such as plastic, cotton, and gauze). While assessing amounts of infectious medical waste, some medical material, such as cotton, gauze, and disposable plastics, could be underestimated in weight evaluations. In future, the author will investigate how the weight and volume of different waste components influence the assessment of infectious medical waste that are discharged

from healthcare facilities.

CONSENT FOR PUBLICATION

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CONFLICT OF INTEREST

The author declares no conflict of interest, financial or otherwise.

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