

## An Analysis of Waste Management in Hospitals

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Laws have been created over the years to curb the impact of wastes upon the environment. Hospital and medical wastes are an important part of environmental degradation, aggravated by the toxicity and health hazard they impose upon living beings, humans, and animals alike. This paper is an exploratory synthesis on research topics related to hospital management waste, as featured in 285 studies indexed on MEDLINE. The methodology applies bibliometric analysis to the main descriptors of publication types, year of publication, country, and journals. The paper uses the NLM Medical Subject Headings (MH) controlled vocabulary of biomedical terms and the EC/RN number classification of MEDLINE to classify the most recurrent research topics. Papers retrieved and the incidence of biomedical terms and EC/RN number combinations are described. The literature reviewed focuses mainly on methods and guidelines for the management of disposal of hospital wastes related to human health and on the environmental impact of hazardous substances and products. The phases of product segregation, packaging, storage, collection, transportation, and treatment are less researched than the routines and methods of waste disposal.

### 1. Introduction

Recent research have indicated strategies and techniques for waste disposal in hospitals (Yashasvi and Surjit, 2012) and there is a growing concern in devising new techniques for solid waste disposal in circuit board industry (through the use of enzymatic bioremediation as in Jadhav and Hocheng, 2015) and for solid disposal of non-biodegradable polymers (Roozbehani et al., 2015), among others. This concern with waste disposal represents a recent trend. At the beginning of the industrial revolution, little or no questioning existed about the unbridled consumption of existing nature reserves. The focus was to ensure the growth of the industry and enhance its economic relations with other institutions in national and international territories (Pajón, 2012). These attitudes were responsible for the spread and emergence of diseases among workers and the general population due to, respectively, the handling of and the exposure to waste without any protection. Over the years also numerous disasters occurred due to the uncontrolled use of natural raw materials and industrial waste, as well as to the dumping of homes and hospitals wastes in the environment without any treatment (Pajón, 2012).

One of the legal solutions to ensure economic growth without harming the environment was to regulate the treatment and disposal of all types of waste by signing laws and agreements in both national and international levels. To Martínez (2012), solid wastes in general can be classified according to the origin, the physic nature, the chemical composition, and the potential risks to the environment. Those generated by hospitals can have their own classification. In hospitals the waste can be considered dangerous due to features such as pathogenicity, toxicity, and reactivity. Specifically at these locations the challenge is to balance the quality of the service offered with the preservation of the environment (Pajón, 2012).

The medical literature has treated several research topics related to medical wastes extensively. This study seeks to contribute to research in this area, by providing taxonomy of the most currently encountered topics on the subject of hospital waste management. Biomedical terms and substance registration most commonly encountered in the medical literature provide a summary of main concerns or

the focus of hospital waste management. The following research questions (RQ) guide the remaining of this paper:

RQ1: How hospital wastes are defined in health regulations?

RQ2: Which research topics are usually associated with published studies in hospital medical wastes?

The paper is organized as follows. The next section presents the methodology used in the bibliographic review and bibliometric analysis. The third section presents the results. Concluding remarks, implications for practitioners, and directions for future research close the paper.

## 2. Methodology

The method of systematic literature reviews of Cooper (2010) is adopted, in seven steps. First, the objective of the study and research questions were defined. Second, Thomé et al. (2012; 2014) approach to study selection in systematic literature reviews is applied to the MEDLINE database. Studies were searched in MEDLINE with the following keywords in titles and abstracts: "hospital waste management." Consistent with Cooper (2010) recommendations, keywords were sufficiently broad to do not artificially limit the search and were sufficiently specific to do not bring articles not related to the objective of this review. The application of the keywords returned 285 studies. The complete list is available upon request to the corresponding author. Third, in the data gathering step, data were extracted from MEDLINE using BibExcel software (Persson et al., 2009). Fourth, data quality of primary studies is reputedly reliable as only studies published in peer-reviewed Journals were included. The fifth and sixth steps are analysis and interpretation. The analysis includes information related to publication types, year of publication, country, journals; the US-National Library of Medicine (NLM) medical subject headings (MH) controlled vocabulary of biomedical terms and the EC/RN number classification of MEDLINE. The EC/RN number includes the US Food and Drug Administration (FDA) Substance Registration System for Unique Ingredient Identifiers, the US Enzyme Commission (EC) system to designate a particular enzyme, and the US Chemical Abstracts Service (CAS) registry numbers. The taxonomy of most current research topics follows the NLM-MH classification. Co-occurrence of NLM-MH tags was analysed and graphically depicted as a network of related tags using Pajek (De Nooy et al., 2005). Step 7 is the presentation of the results.

## 3. Results

This section presents a definition of hospital wastes and the main descriptors of the studies selected and it provides evidences of association of NLM-MH terms based on the co-word occurrence analysis.

### 3.1 Defining hospital wastes

For a better understanding of the magnitude of this issue and its importance to the society, it is important to define hospital wastes first. We adopt here the official definition from the Brazilian health regulatory authorities. Hospital wastes include any input generated in hospitals from procedures and activities performed by these health institutions (Brasil, 2006). Generally speaking, these inputs can be divided into two large groups, according to Martínez (2012):

-- Common wastes – which are those generated not only in hospitals, but also at home. They can, in most cases, be recycled and reused without any damage to the health of the population, if properly managed; examples are papers and plastics.

-- Biomedical wastes – which are those generated directly from specific activities of hospitals. Due to the high risk of contamination they are considered dangerous to the health of the population and they need specific management, such as incineration.

In Brazil the wastes from health activities are classified into five groups (Brasil, 2006), namely:

Group A - it encompasses the components with possible presence of biological agents, by its characteristics of greater virulence or concentration it may present a risk of infection. Examples: plates and blades lab, carcasses, anatomical parts (members), tissues, and bags containing blood transfusion.

Group B - it contains chemicals that can present a risk to public health or to the environment, depending on its characteristics of flammability, corrosiveness, reactivity, and toxicity. Examples: drugs, seized laboratory reagents, and waste containing heavy metals.

Group C - any materials resulting from human activities that contain radionuclides in amounts in excess of the limits specified in the rules of elimination of the Brazilian National Commission of Nuclear Energy - CNEN, such as nuclear medicine services and radiation.

Group D - no biological, chemical, or radiological risk to health or the environment, which may be assimilated to household waste. Examples: leftover food and food preparation areas.

Group E - sharp or bladed materials that can scarify, such as razor blades razors, needles, glass ampoules, diamond tips, scalpel blades, lancets, and spatulas.

Due to the high degree of danger to the health of the population, such waste need specific management. The treatment process of these products already begins in the period in which they are generated and extend to their disposal. The steps in this process are segregation, packaging, storage, collection, transportation, treatment, and final disposal (Brasil, 2006).

### 3.2 Study descriptors

Figure 1 depicts the number of publications in hospital waste management per year.

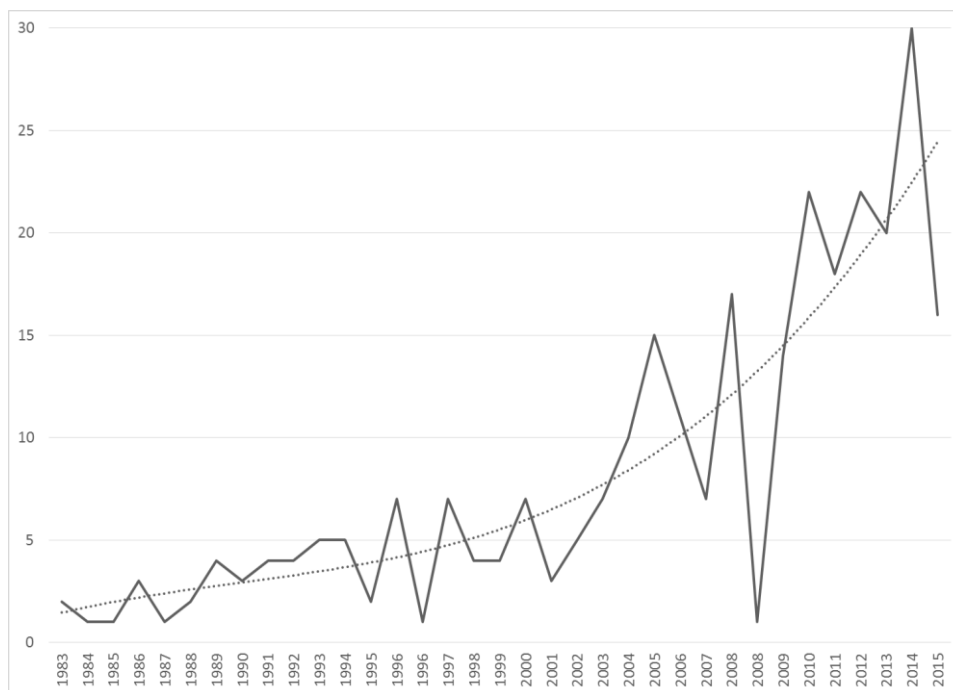


Figure 1: MEDLINE publications in hospital waste management per year

As seen in Figure 1, the first publication indexed on hospital waste management in MEDLINE dates from 1983. There is a constant trend upwards since then, following an exponential growth. Countries of publications appear in Table 1.

Table 1: Publications by country of origin

| Countries      | Frequency | Cumulative % | Countries | Frequency | Cumulative % |
|----------------|-----------|--------------|-----------|-----------|--------------|
| United States  | 97        | 35 %         | Japan     | 7         | 78 %         |
| United Kingdom | 70        | 60 %         | Spain     | 5         | 80 %         |
| India          | 26        | 70 %         | Pakistan  | 5         | 82 %         |
| Netherlands    | 8         | 73 %         | Brazil    | 5         | 83 %         |
| Canada         | 8         | 75 %         | Germany   | 5         | 85 %         |

Table 1 shows that eighty-five percent of the total number of publications came from research in eleven countries, with 70 % concentrated in the United States, the United Kingdom, and India.

The main Journals publishing on hospital waste management research worldwide are depicted in Table 2. The Journals Waste Management Research and Waste Management (NY) concentrate over half the number of publications. The international characteristics of research in this area (already noticed by the number of publications per country in Table 1) is further evidenced by the large array of regional and local publications depicted in Table 2 with substantive number of articles appearing in Journals for the Eastern Mediterranean region, India, and Latin America. Journals from Japan and Pakistan are also represented. Together, the Journals of Table 2 respond for over 70 % of the total number of publications.

Table 2: Journals publishing on hospital medical waste research

| Journals  | Publications | Cumulative % |
|---|--------------|--------------|
| Waste Management & Research                               | 24           | 20 %         |
| Waste Management (New York, N.Y.)                         | 18           | 34 %         |
| International Journal of Health Care Quality Assurance    | 5            | 38 %         |
| Eastern Mediterranean Health Journal                      | 4            | 41 %         |
| Hospital Materiel Management Quarterly                    | 4            | 45 %         |
| Indian Journal of Medical Microbiology                    | 4            | 48 %         |
| Revista Latino-Americana De Enfermagem                    | 4            | 51 %         |
| The Journal of Hospital Infection                         | 3            | 54 %         |
| Indian Journal of Public Health                           | 3            | 56 %         |
| Hospital Material Management                              | 3            | 59 %         |
| Rinsho Byori. The Japanese Journal Of Clinical Pathology  | 3            | 61 %         |
| BMC Health Services Research                              | 3            | 63 %         |
| American Journal Of Health-System Pharmacy                | 3            | 66 %         |
| Journal of Ayub Medical College, Abbottabad, Pakistan     | 2            | 67 %         |
| Social Science & Medicine                                 | 2            | 69 %         |
| Journal of The Academy Of Hospital Administration (India) | 2            | 71 %         |

Table 3: Frequency of occurrence of research topics in hospital waste management

| Subjects                                  | Occurrences | Subjects                      | Occurrences |
|---|-------------|-------------------------------|-------------|
| Humans sub-total                          | 153         | Demographics sub-total        | 86          |
| Waste disposal and management sub-total   | 143         | Male                          | 29          |
| Medical Waste Disposal/*methods           | 33          | Female                        | 29          |
| Medical Waste                             | 17          | Adult                         | 21          |
| Medical Waste Disposal                    | 16          | Aged, 80 and over             | 7           |
| Waste Management/*methods                 | 10          | Countries/Locations sub-total | 74          |
| Refuse Disposal/*methods                  | 10          | United States                 | 27          |
| Hazardous Waste                           | 10          | India                         | 16          |
| Waste Products                            | 10          | England                       | 10          |
| Waste Management                          | 9           | Developing Countries          | 8           |
| Hazardous Substances                      | 9           | Iran                          | 7           |
| Refuse Disposal                           | 6           | Cities                        | 6           |
| Safety                                    | 7           |                               |             |
| Medical Waste Disposal/*methods/standards | 6           |                               |             |
| Organizational issues sub-total           | 95          | Research Methods sub-total    | 95          |
| Guidelines as Topic                       | 19          | Questionnaires                | 28          |
| Efficiency, Organizational                | 16          | Cross-Sectional Studies       | 14          |
| Incineration                              | 12          | Data Collection               | 13          |
| Inservice Training                        | 8           | Costs and Cost Analysis       | 10          |
| Hospital Administration                   | 8           | Cost-Benefit Analysis         | 9           |
| Attitude of Health Personnel              | 8           | Retrospective Studies         | 8           |
| Conservation of Natural Resources         | 7           | Organizational Case Studies   | 7           |
| Time Factors                              | 6           | Models, Theoretical           | 6           |
| Risk Assessment                           | 6           |                               |             |
| Quality Assurance, Health Care            | 6           |                               |             |
| Organizational Policy                     | 6           |                               |             |
| Hospitals, University                     | 6           |                               |             |
| Public Health                             | 6           |                               |             |

### 3.3 Research Topics

The most recurrent research topics according to the NLM-MH taxonomy and the number of occurrences are displayed in Table 3. To ease the presentation, results were regrouped in the categories of hospitals for humans (as opposed to veterinary care), waste disposal and management, organizational issues, demographics, countries/locations, and research methods.

There is a clear concentration of research on human health wastes (as opposed to veterinary). Waste disposal and management methods and guidelines prevail, as well as the organizational issues of efficiency, incineration, and hospital management. The field is eminently practical and focused on waste disposal and its implication for human health and the environment, with little concentration on the phases of product segregation, packaging, storage, collection, transportation, and treatment. Most publications were classified by demographics (gender and age) and by country of origin. It is also worth to mention in Table 2 the prevalence of the research method of questionnaires. Cross-sectional studies prevail over retrospective data, with no mention of longitudinal studies. The focus on organizational case studies and costs and cost-benefit analysis attests the eminently practical and managerial orientation of the publications in this area.

Table 4 reports the classification of studies by EC/RN codes. Medical waste, waste disposal, products and hazardous products and substances top the list. Concerns with the environment are reflected by the frequency of research on air pollutants, soil, radioactive waste, and pollutant substances as Tetrachlorodibenzodioxin (a persistent environmental contaminant), nitrous oxide (a major greenhouse gas and air pollutant), and isoflurane anesthetic gas for dogs and horses.

Table 4: EC/RN classification of studies on hospital waste

| EC/RN Classification   | Frequency | EC/RN Classification                  | Frequency |
|------------------------|-----------|---------------------------------------|-----------|
| Medical Waste Disposal | 95        | Soil Pollutants                       | 3         |
| Medical Waste          | 44        | Particulate Matter                    | 3         |
| Hazardous Waste        | 16        | Metals, Heavy                         | 3         |
| Waste Products         | 11        | Pharmaceutical Preparations           | 2         |
| Hazardous Substances   | 11        | CYS9AKD70P (Isoflurane)               | 2         |
| Air Pollutants         | 6         | DO80M48B6O (Tetrachlorodibenzodioxin) | 2         |
| Dental Waste           | 5         | Solid Waste                           | 2         |
| Soil                   | 5         | K50XQU1029 (Nitrous Oxide)            | 2         |
| Radioisotopes          | 4         | Manure                                | 2         |
| Radioactive Waste      | 4         | Sewage                                | 2         |

The co-occurrence of most quoted biomedical terms is a measure of association or relatedness among similar concepts. Figure 2 depicts the most commonly associated terms. The size of the circles is proportional to the number of times the term is encountered in the different studies (the frequencies of Table 3).

Figure 2 delineates the research shape for both the substantive issue of hospital waste disposal management and the more prevalent research techniques used in the field. Studies are first classified as treating human health, as opposed to animal health. Humans relate in roughly equally sized circles with demographics (female, male), methods of medical waste disposal, use of questionnaires, and studies done in the United States. The association of the use of questionnaires with health knowledge, attitudes, and practice surveys is also worth noticing.

## 4. Conclusions

The review of the most common biomedical terms and substance classes used to index studies on medical wastes in MEDLINE database is illustrative of the substantive areas (health versus environment), most prevalent countries of studies (emphasizing the United States, the United Kingdom, and India), publishing Journals (over half on highly specialized literature – waste management Journals), and time trend showing a constantly growing relevance of the subject as measured by the number of yearly publications.

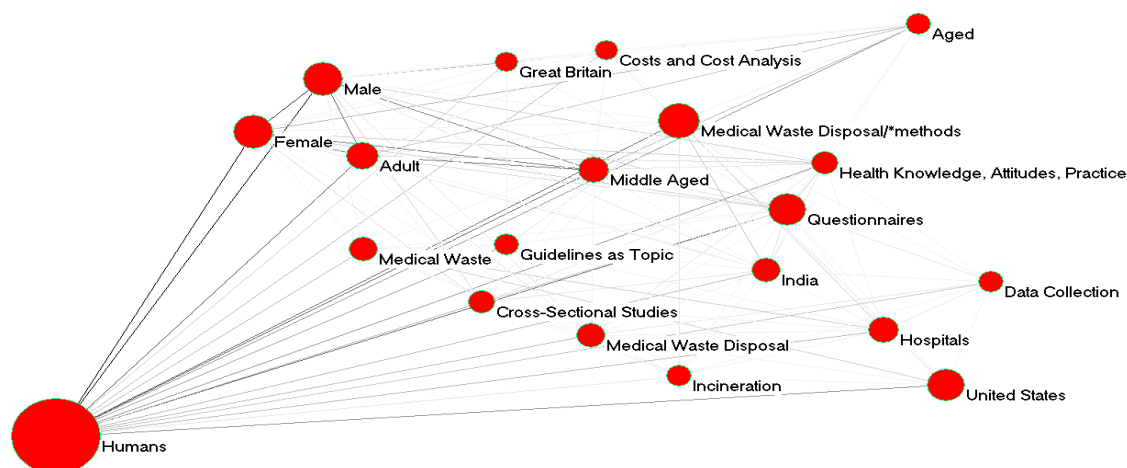


Figure 2: Co-occurrence of biomedical terms in the hospital waste management literature

The association among the biomedical terms shows a clear focus of the ongoing literature on the practical aspects of waste disposal management, related to human health, with clear concerns about the environmental impact of wastes. However, the phases of product segregation, packaging, storage, collection, transportation, and treatment are less researched than the routines and methods of waste disposal. This paper contributes to researchers in this area by outlining the conceptual shape of most frequently treated subjects. It equally contributes to practitioners in indicating the main management themes in hospital waste disposal and the sources of published material on the subject. The review of case studies evidencing the use of those management practices in specific contexts would be a natural extension of this research.

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