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## Quantitative Assessment and Statistical Analysis of Hospital Waste: Comparative Study of hospitals of Kolkata, India

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### Abstract:

*A survey was conducted to assess the quantum of hospital waste in eight government hospitals of Kolkata, West Bengal, India. A Waste Audit was conducted wherein the different categories of hospital waste generated was weighted. This not only provided a comprehensive scenario of the quantum of waste but also highlighted the loopholes within the waste management practice. There has been a paradigm shift from curative to preventive medicine and thus research on waste management is imperative. The problem of handling Hospital waste is a gigantic environmental threat, which is of growing concern, unless remedial steps are taken in right earnest and in time. Critical issues like ignorance of the WHO guidelines on treating and disposal of hospital waste, occupational hazards and illegal cycling of infectious waste needs to be addressed in order to develop a rational and safe waste management system.*

**Key words:** Hospital waste, waste audit, occupational hazards, illegal cycling

### Introduction

The Hospital Waste management crisis is yet to receive its much-needed attention. The danger though silent, looms over

an institution which stands to treat life-threatening diseases, which itself is metamorphosing as a vector of the same.

A large variety of infectious material is churned out in hospitals. However, compared to the municipal waste the quantity of Hospital waste is relatively low. Tracking of hazardous, contaminated medical waste is often complicated by a lack of available records on waste generation. This results from hospital waste being mixed with non-infectious municipal waste and from disposal of potentially hazardous waste into sewers.

Though the Bio-medical Waste (Management and Handling) Rules, 1998, has made it mandatory for all medical institutions to segregate medical waste and adopt different treatment options, the response has been lukewarm. A significant characteristic of the modern hospital is that it has been and will continue to be a rapidly changing institution. Not only are the diagnostic and treatment facilities drastically improving, but also they are witnessing an increase in the quantum of Hospital waste generated. Today, hospitals are facing fresh challenges in treating and disposing hospital waste.

## **Location and Selection of Study Area**

Once the greatest colonial city in the Orient, Kolkata was later reviled as a cauldron of poverty, dirt, and disease. Today, it ranks among the four major metropolis of India along with Delhi, Mumbai, and Chennai. The largest metropolis in India, Kolkata is a vibrant city on the move, volatile and unpredictable. A city just about ready to burst at the seams, Kolkata is home to more than 10 million people.

### **Criteria for selecting Samples**

- Since the study area is confined to the Kolkata Municipal Corporation (KMC) boundary, care was taken to select hospitals from the KMC
- The technique of Stratified Purposive Sampling was used in order to categorize the hospitals into stratas depending on their bed strength.
- The stratas developed are as follows;

**Table 1: Selected Hospitals and their Bed strength**

<b>NUMBER OF BEDS</b>	<b>SELECTED HOSPITALS</b>	<b>ACTUAL BED STRENGTH</b>
< 250	Bagha Jatin State General Hospital and School of Tropical Medicine	100 & 150
251 – 500	Vidyasagar State General Hospital and Lady Dufferin Victoria Hospital	256 & 274
501 – 750	Sambhunath Pandit Hospital and M.R.Bangur State District Hospital	560 & 600
> 751	Calcutta Medical College and Hospital and Nil Ratan Sarkar Medical College and Hospital	1718 & 1890

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All the selected hospitals are General Hospitals, which unlike Special Hospitals generate all the different categories of hospital waste. The chosen hospitals are located in wards, which boast a substantial population density as and are primarily in residential areas. This has aided the research to study the impact of infectious hospital waste on public health.

### **Objectives:**

The main objectives of the study are:

- (1) To examine the nature of the problem of Hospital waste
- (2) To undertake an inventory of the total quantum of infectious waste generated
- (3) To study the impact of patient days on the quantum of hospital waste

- (4) To examine the health hazards associated with handling of hospital waste

## **Hypotheses**

- A positive correlation exists between the patient days (total number of patients at the last day of each month) and the quantum of hospital waste generated.

## **Methodology and Database:**

Fundamentally the quality of research depends largely on a systematic methodology, which has to be adopted in order to achieve the stated objectives. The availability, authenticity and the extent of primary data form the crucial base of research.

Survey Method, which is concerned with the present scenario of waste management, was adopted in all the eight hospitals. This process involved description, recording, analysis and interpretation of the hospital waste management scenario that currently exists. This constitutes the backbone of this research, as it involved frequent visits to the hospitals, treatment plants, disposal sites and slums in proximity to the hospital. It also involved comparisons and attempts to discover the cause and effect relationship.

The most integral part of the research comprises of the primary data which was collected by frequent field visits, interviews of experts, observation method, spot photographs, which has made the work more authentic, novel and contributory.

The selected hospitals were visited frequently in order to observe, document and examine the generation, storage, transportation, disposal and treatment of hospital waste. Questionnaire survey was conducted in order to build a requisite database which provided conclusive evidence, on

various aspects of waste management, its treatment and disposal methods, awareness among the target groups, recycling of waste, etc. which in turn became a storehouse of information.

The primary and secondary data cannot be treated in watertight compartments, but have been seen as complimentary to each other. They are required to be processed, assimilated and analyzed. It has involved first treating parameters individually but later correlating them with other aspects whether quantitative or qualitative, which results in adequate synthesis of the data.

## **Methods of Ascertaining Correlation - Mathematical Methods**

**(i) Correlation Coefficient** – A precise quantitative measurement of the degree and direction of a linear correlation has been computed using Karl Pearson's Product Moment Formula.

### **Test of Significance of Correlation Coefficient**

#### **Analysis**

As shown in Table 2, the 'r' values have been computed for all the hospitals for two successive years, 2012 and 2013. The relationship between the total number of Patient Days and the quantum of Hospital Waste generated was positive for both 2012 and 2013, except for Nil Ratan Sarkar Medical College and Hospital and Bagha Jatin SG Hospital for 2013. This shows that this variable has a negative influence on the hospital waste generated, i.e. as Patient Days increases the Waste Quantum decreases.

The critical value of 't' at  $\alpha = 0.05$  at degree of freedom = 11 is 2.201. Since the calculated value of 't', is less than the table or critical value of 't', for all the

hospitals, except the above mentioned two hospitals we accept the Null hypothesis ( $H_0$ ) partially. These are the only two instances where  $H_0$  is rejected, thus committing a Type I error, whereby though the quantum of hospital waste generated increases with an increase in the patient days, the results for two hospitals for one year so otherwise. The two most probable reasons for explaining this feature would be:

- 1) The Daily Waste Output Register is not maintained regularly; hence the data on total hospital waste generated could be misleading.
- 2) Segregation is not carried out to its optimum level whereby the infectious hospital waste is dumped into black bags meant for general waste and hence not accounted for in the total hospital waste stream. Siphoning of commercially viable hospital waste items like syringes, surgical gloves, dressings, etc.

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<b>Table 2. Regression of the Patient Days on the Total Hospital Waste Generated</b>					
<b>Objective:</b> Establish a correlation between Patient Days and Hospital Waste. Regression is a means to find out how much of the variation in the dependant variable - 'Y' can be explained as a function of the independent variable 'X'					
<b>Null Hypothesis (H<sub>0</sub>):</b> The total Hospital Waste generated increases with an increase in the number of Patient days.					
<b>Methodology:</b> Coefficient of Correlation [Product Moment Formula by Karl Pearson]					
<b>Hospital</b>	<b>Regression Equation</b>	<b>Correlation Coefficient</b>	<b>R<sup>2</sup></b>	<b>Test of Significance (t)</b>	<b>Relationship</b>
<b><u>Nil Ratan Sarkar Medical College and Hospital</u></b>					
2012	Y= 82.04+0.04*X	R=. 157	R <sup>2</sup> =0.025	0.503	<b>Positive</b>
2013	Y= 3747.48+ - 0.05*X	R=. 412	R <sup>2</sup> =0.169	2.302	<b>Negative</b>
<b><u>Calcutta Medical College and Hospital</u></b>					
2012	Y= 1329.99+0.01*X	R=. 043	R <sup>2</sup> =0.002	0.550	<b>Positive</b>
2013	Y= 888.24+ 0.04*X	R=. 465	R <sup>2</sup> =0.217	1.663	<b>Positive</b>
<b><u>M.R.Bangur State District Hospital</u></b>					
2012	Y= 380.38+0.06*X	R=. 132	R <sup>2</sup> =0.017	0.202	<b>Positive</b>
2013	Y= 508.90+0.03*X	R=. 067	R <sup>2</sup> =0.004	0.327	<b>Positive</b>
<b><u>Sambhu Nath Pandit Hospital</u></b>					
2012	Y= 28.63+0.05*X	R=. 217	R <sup>2</sup> =0.047	0.703	<b>Positive</b>
2013	Y= 363.76+0.10*X	R=. 457	R <sup>2</sup> =0.209	1.626	<b>Positive</b>
<b><u>Lady Dufferin Victoria Hospital</u></b>					
2012	Y= 537.83+0.19*X	R=. 156	R <sup>2</sup> =0.024	0.354	<b>Positive</b>
2013	Y= 407.98+0.15*X	R=. 760	R <sup>2</sup> =0.577	2.182	<b>Positive</b>
<b><u>Vidvasagar State General Hospital</u></b>					
2012	Y= 1959.34+0.56*X	R=. 960	R <sup>2</sup> =0.921	- 5.630	<b>Positive</b>
2013	Y= 4043.28+0.92*X	R=. 874	R <sup>2</sup> =0.763	- 4.036	<b>Positive</b>
<b><u>School Of Tropical Medicine</u></b>					
2012	Y= 3334.88+1.14*X	R=. 424	R <sup>2</sup> =0.180	1.482	<b>Positive</b>
2013	Y= 5581.84+1.74*X	R=. 544	R <sup>2</sup> =0.295	2.051	<b>Positive</b>
<b><u>Bagha Jatin State General Hospital</u></b>					
2012	Y= 88.70+0.34*X	R=. 289	R <sup>2</sup> =0.083	0.126	<b>Positive</b>
2013	Y= 1415.53+ - 0.33*X	R=. 314	R <sup>2</sup> =0.098	2.339	<b>Negative</b>

\* 0.05 level of significance (Computed by author with aid of SPSS Version 13.0)

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Sl. No.	2012	2013	r = types	Actual Value		'r'	Range of 'r' value
				2012	2013		
1	Nil Ratan Sarkar Medical College and Hospital Calcutta Medical College & Hospital M.R.Bangur State District Hospital Lady Dufferin Victoria Hospital	Hospital M.R.Bangur State District Hospital	Very Low	0.157 0.043 0.132 0.156	0.067	± 0.1 to ± .19	
2	Sambhu Nath Pandit Hospital Bagha Jatin State General Hospital	Bagha Jatin State General Hospital	Low	0.217 0.289	0.314	± 0.20 to ± .39	
3	School of Tropical Medicine	Nil Ratan Sarkar Medical College and Hospital Calcutta Medical College & Hospital Sambhu Nath Pandit Hospital School of Tropical Medicine	Moderate	0.424  0.464 0.457 0.544	0.412	± 0.40 to ± .59	
4		Lady Dufferin Victoria Hospital	High		0.76	± 0.60 to ± .79	
5	Vidyasagar State General Hospital	Vidyasagar State General Hospital	Very High	0.96	0.874	± 0.80 to ± .99	

A wide variation is evident in Table 3, as the 'r' values range from a meagre 0.043 (Calcutta Medical College Hospital) to a very high of 0.960 (Vidyasagar SG Hospital) for the year 2012. In 2013, the lowest 'r' value is 0.067 (M.R. Bangur SD Hospital) whereas the highest is 0.874 (Vidyasagar SG Hospital). Thus, Vidyasagar SG Hospital shows a very high correlation between the variables for both the years. In the same year, Bagha Jatin SG Hospital and School of Tropical Medicine, both hospitals with low bed strength, showed less and moderate correlation i.e. 0.289 and 0.424 respectively.

## Regression Analysis between Patient Days and Total Hospital Waste Generated

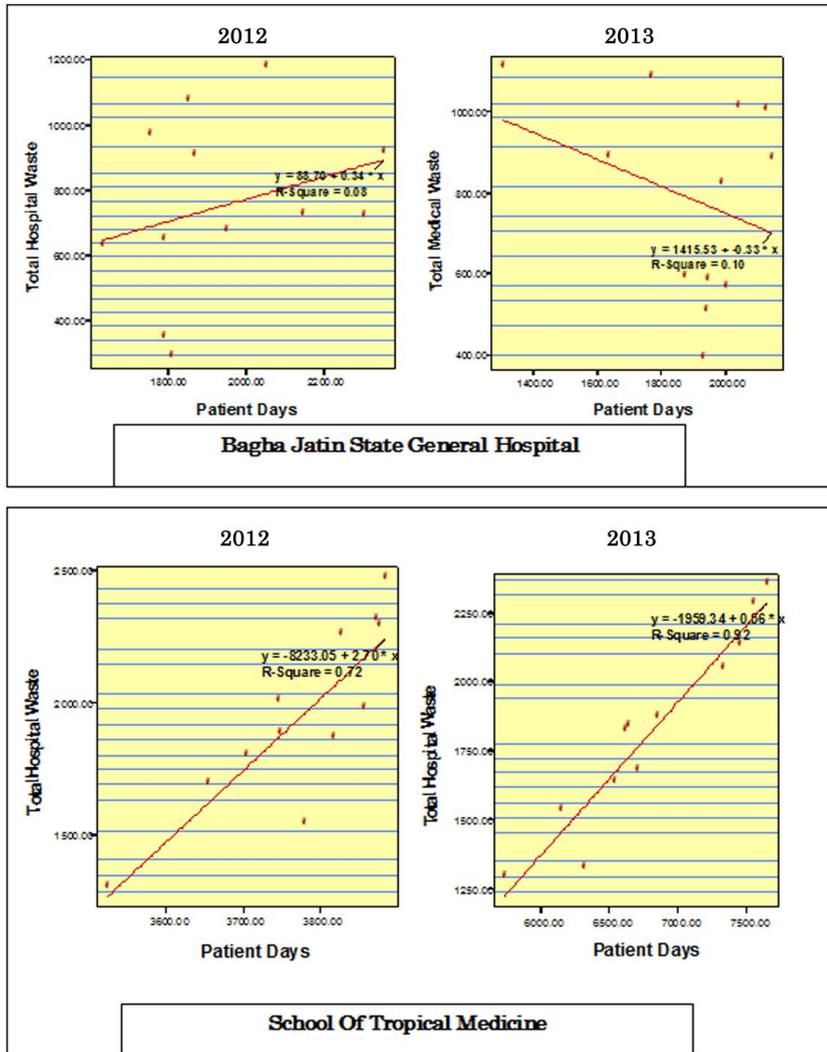
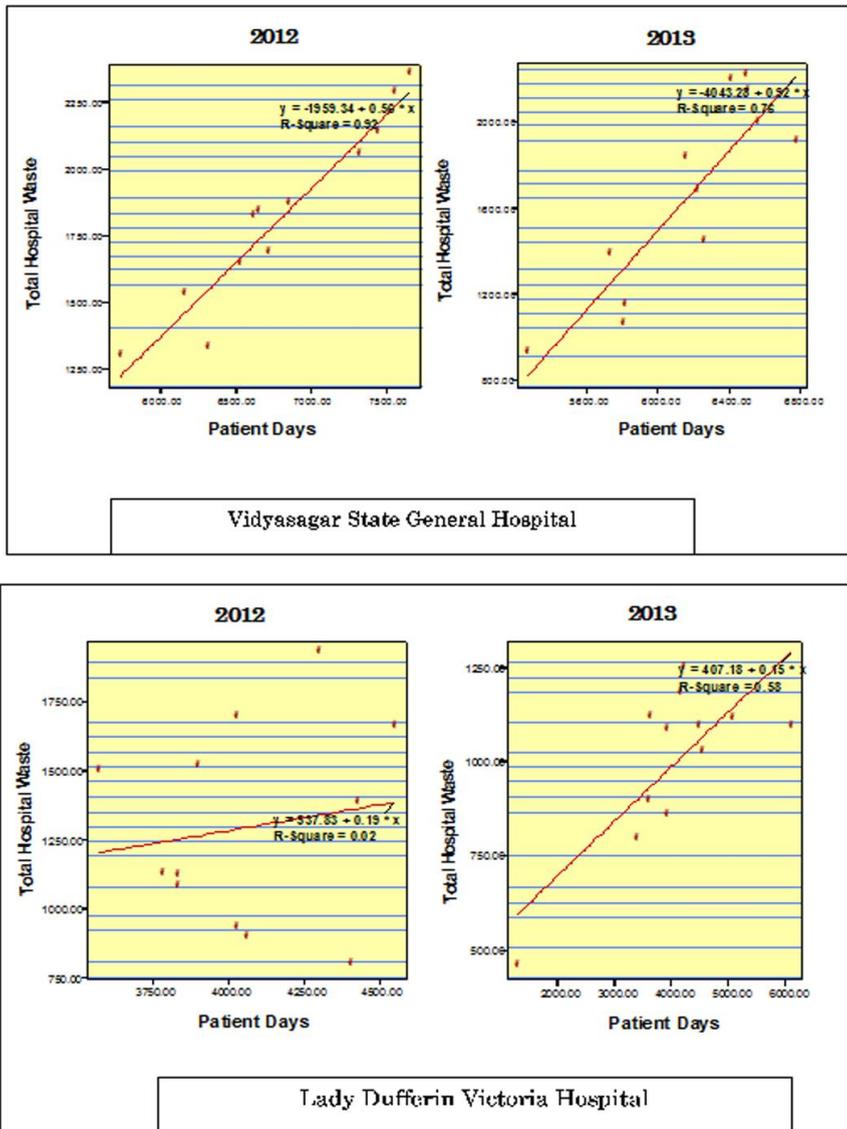


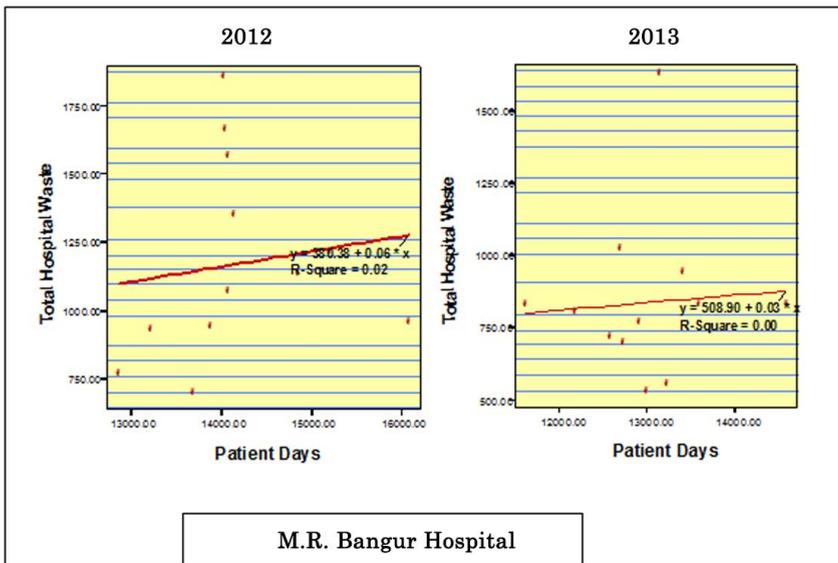
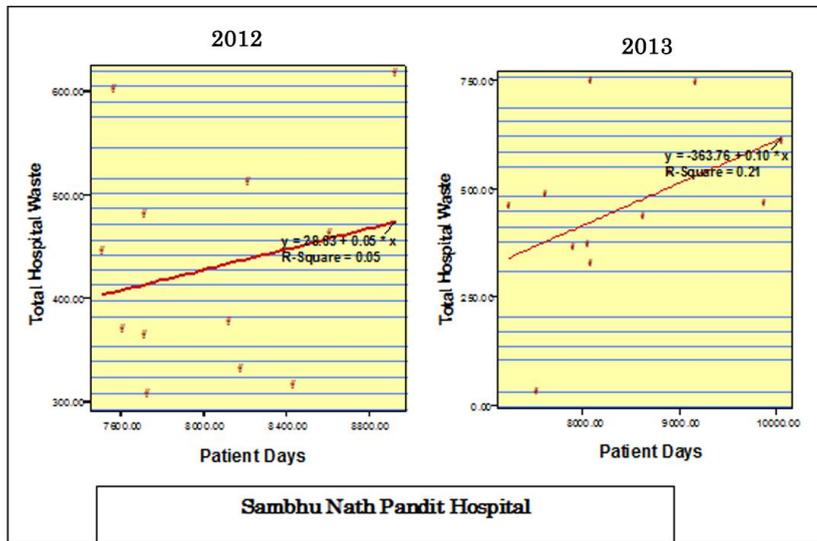
Figure: 1  
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## Regression Analysis between Patient Days and Total Hospital Waste Generated



**Figure: 2**  
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## Regression Analysis between Patient Days and Total Hospital Waste Generated



**Figure: 3**  
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## Regression Analysis between Patient Days and Total Hospital Waste Generated

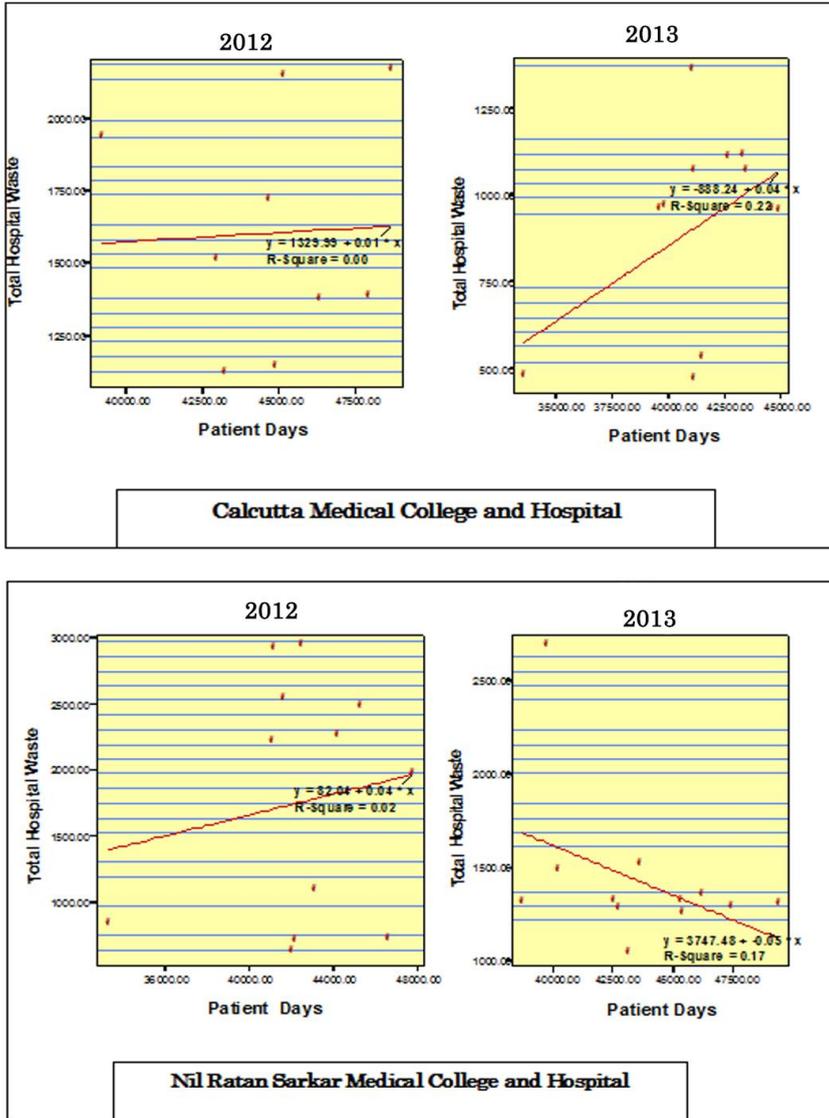


Figure: 4  
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**(ii) The Coefficient of Determination** – The Correlation coefficient, ‘r’, can be interpreted in terms of  $r^2$  which is called ‘Coefficient of Determination’. This may be called as the variance interpretation of  $r^2$ . When multiplied by 100 (expressed in terms of percentage) the coefficient  $r^2$  gives us the percentage of variance in Y, i.e. total Hospital Waste that is associated with, determined by, or accounted for by variance in X, i.e. Patient Days.

**Table 4: Values of Coefficient of Determination & Coefficient of Alienation for selected values of ‘r’**

Category	Hospital	Correlation Coefficient $r_{xy}$		Coefficient of Determination ( $r^2_{xy} \times 100$ )		Coefficient of Non-determination $k^2=1-r^2$		Coefficient of Alienation $k=\sqrt{1-r^2}$	
		2012	2013	2012	2013	2012	2013	2012	2013
Small	Bagha Jatin State General Hospital	0.289	0.314	8.35	9.86	0.917	0.902	0.958	0.95
	School of Tropical Medicine	0.424	0.544	18	29.59	0.82	0.705	0.986	0.84
Medium	Vidyasagar State General Hospital	0.96	0.874	92.16	76.39	0.079	0.237	0.281	0.487
	Lady Dufferin Victoria Hospital	0.156	0.76	2.43	57.76	0.976	0.423	0.988	0.65
Big	Sambhu Nath Pandit Hospital	0.217	0.457	4.71	20.88	0.953	0.791	0.976	0.889
	M.R. Bangur State District Hospital	0.132	0.067	1.74	0.45	0.983	0.996	0.991	0.998
Large	Calcutta Medical College & Hospital	0.043	0.465	0.18	21.62	0.998	0.783	0.999	0.885
	Nil Ratan Sarkar Medical College and Hospital	0.157	0.412	2.5	16.97	0.975	0.831	0.987	0.912

Computed by author

### Analysis:

Table 4.6, illustrates a high range of Coefficient of Determination of the selected eight hospitals. In Vidyasagar SG

Hospital 92.16% of the variance in Hospital Waste quantum has been accounted for by the variance in patient days (X scores). The same holds true for 2013 where 76.39% of the variance in Hospital Waste is associated with the variance in Patient Days. On the other hand, M.R.Bangur SD Hospital reveals that only 1.74% and 0.45% of the variance in Hospital Waste for 2012 & 2013 respectively, is associated with Patient Days and the remaining approximately 99% of the variations are due to other independent variables yet to be located.

Inversely, this proportion of the variance in hospital waste (Y) which is not associated or determined by the variance in Patient Days (X) is expressed as  $K^2$ , which is called '**The Coefficient of Non-Determination**'. Hence the Coefficient of Non Determination for M.R. Bangur SD Hospital is as high as 0.983 and 0.996 for 2012 & 2013 respectively. The situation is just for hospital for Vidyasagar SG Hospital where  $k^2 = 0.079$  and 0.237 for 2012 & 2013 respectively.

Another Index derived from the same is the '**Coefficient of Alienation**',  $k$ ,

$$k = \sqrt{1 - r^2}$$

while 'r' indicates the degree of relationship between two variables, the coefficient of Alienation indicates the degree of lack of relationship. Table 4.4 shows a high degree of relationship between patient days and quantity of Hospital Waste generated in 6 of the 8 hospitals under study. The Coefficient of Alienation shows a similar trend with hospitals like Calcutta Medical College and Hospital, Nil Ratan Sarkar Medical College and Hospital, M.R.Bangur SD Hospital, Sambhu Nath Pandit Hospital, Bagha Jatin SD Hospital and School of Tropical Medicine posing very high values of alienation for 2012 – 0.999, 0.987, 0.991, 0.976, 0.958 and 0.986 respectively. This indicates that the influence of patient days on the quantity of Hospital Waste generated is not very strong.

## Discussion and Findings

### Testing of Hypothesis

As per the Correlation Coefficient models the total quantity of hospital waste generated increased with an increase in the patient days. The hypothesis is accepted for all the hospitals except two hospitals for two successive years. The exceptions were N.R.S. Medical College and Hospital and Bagha Jatin Hospital for 2013, where the quantity of hospital waste generated decreased with an increase in the patient days, indicated by a negatively sloping regression line. The reasons for this exception were as follows:

- Segregation was not carried out efficiently, whereby infectious hospital waste was dumped in black bags meant for general waste. Hence, this was not accounted for in the total hospital waste stream, giving an erroneous figure of waste generated by the hospital.



- The Waste register was not maintained regularly and hence there existed a vacuum in data inventory.
- Commercially valuable hospital waste items like syringes, gloves and plastic IV bottles were siphoned from the hospital premises. Since these were illegally scavenged before being taken for final treatment and disposal, they were unaccounted for. The rag pickers living in the slums adjoining the hospitals engaged in collecting sharps, surgical gloves and dressings discarded from the orthopaedic departments in particular. These were then cleaned with naked hands

in ordinary buckets with water and repacked in new packets. It was evident from the questionnaire survey that they were not aware of the health implications of this illegal act. Due to constant handling of sharps their limbs bore injury marks which in the long run could lead to life threatening diseases like Hepatitis B and AIDS. Percutaneous injuries were the most common and frequent among health care workers, primarily from needles and other sharps. Highest rates of occupational injury were seen among the cleaning personnel, waste transporters (from wards to vat), nurses and scavengers. Two-thirds of the hospital waste was scavenged by rag pickers who were ignorant of the adverse health hazards. They showed visible signs of cuts and punctures from discarded sharps.



## **Recommendations**

- A separate wing, called Hospital Waste Management Cell, can be created in each of the hospitals, which would maintain an inventory of waste generated ward wise and the quantum sent for treatment and disposal.
- An Infection Control Committee should be established for imparting training. There is an urgent need to advocate for fresh legislation, which would incorporate occupational safety of health care workers. Their safety is compromised as they are exposed to HIV and Hepatitis due to irrational handling of hospital waste. Though the use of Personal Protective Equipment (PPE)

has been stressed on by WHO and the Waste Handling and Management Act, most of the hospitals do not practice it earnestly. Safety measures like preventive vaccinations and health insurance should be made mandatory in all medical institutions and form the backbone of all policy formulations.

- The civic authority should insist on proper hospital waste management as a pre-requisite to licensing health care set-ups (12-18 months). License should be renewed at specific intervals of time after reviewing and assessing the working of the system.
- Train personnel from regulatory bodies along with personal from the hospitals and clinics.
- Develop health education materials both print and electronic, like posters, books, booklets, films, videos, slides etc. A multipronged strategy needs to be developed and implemented regarding the optimum use of all education material. Audio-video screening sessions, field visits, situation analysis, problem solving, informal interactions and module based training along with self study should be incorporated in training programme and Awareness campaign.
- Train and certify operators to operate and maintain equipment used for disposal.

## **Conclusion**

Implementation of sustainable programmes for hospital waste management would greatly depend on the degree of responsibility, the stakeholders wish to assume in the above-mentioned areas. It is therefore crucial that every stakeholder including regulatory bodies, hospitals and other generators of hospital waste and above all public recognize their role and execute it with zeal in this crucial area of public health protection.

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