Monitoring knowledge, awareness and practices regarding hospital waste management - A comparison of government and private hospitals in Pakistan

Mustafa Ali 1, 2,\*, Wenping Wang2, Uzma Ashraf3, Nawaz Chaudhry3, Yong Geng1

1 School of Environmental Science and Engineering, Shanghai Jiao Tong University, Shanghai 200240, China.

2Department of Management Science & Engineering, Southeast University, Nanjing, P.R. China.

3College of Earth & Environmental Sciences, University of the Punjab, Lahore, Pakistan.

\*Corresponding Author

*Address -* School of Environmental Science and Engineering, Shanghai Jiao Tong University, Shanghai 200240, China. *Tel -* 008618652035014. *Email -* aliseunanjing@gmail.com

Abstract

Proper management of healthcare waste is a critical concern in many developing countries of the world. Rapid urbanization and population growth rates pose serious challenges to the existing healthcare waste management infrastructure in such countries. This study was aimed at monitoring the situation of hospital waste management in a major city of Pakistan. Simple random sampling was used to select 12 government and private hospitals. Field visits, physical measurements and questionnaire survey method were used for data collection. Information was obtained regarding hospital waste generation, segregation, collection, storage, transportation and disposal. Data Envelopment Analysis (DEA) was used to classify the hospitals on the basis of their relative waste management efficiencies. The weighted average total waste generation at the surveyed hospitals was discovered to be 1.53 Kg/patient day-1 of which 75.15% consisted of general waste and the remaining consisted of biomedical waste. Of the total waste, 24.54% came from the public hospital and the remaining came from the private hospitals. DEA showed that seven of the surveyed hospitals had scale or pure technical inefficiencies in their waste management activities. The public hospital was relatively less efficient than the private hospitals in these activities. Results of the questionnaire survey showed that none of the surveyed hospitals was completely following government rules regarding safe management of healthcare wastes. The current situation should be rectified in order to avoid environmental and public health risks.

Key Words

Infectious waste; clinical waste; hazardous waste; developing country; public health.

**Introduction**

Delivery of sound healthcare services is a challenge for many resource constrained countries of the world. Pakistan is also such a country with a poverty headcount ratio of 22.30% (Bank 2005). Its recent budget allocated a mere 0.28% of the expenditure to public healthcare services (Division 2014-15). Nonetheless this void in the healthcare services has been partly filled by private healthcare service providers. Some of these are supported by charitable institutions and hence provide an affordable alternative to public services. However, Pakistan also has the highest rates of population growth and urbanization in the region (Murtaza Haider 2014). This translates as an acute need for monitoring and expansion of local health care infrastructure in the rapidly burgeoning, yet neglected, secondary cities of the country. The aim of the present study is to determine the waste generation and handling thereof across different hospitals in a major city of Pakistan, Gujranwala. We also want to compare the hospital waste management (HWM) practices between the private and the government hospital in the city. Gujranwala lies in the central part of the Punjab province which is also the economic and political heartland of the country. Currently, it stands as the fourth most populated district of the country with a population growth rate of 3.49% (Mayors 2011) which makes it the fastest growing city in the country. Figure.1 shows the location of the city in the wider geographical setting.

[Insert Figure.1 here]

The healthcare facilities in this city cater to the needs of not only the residents of the city but also to more than five million people from neighboring villages and other parts of the district. Yet there is only one public hospital in the city to provide inexpensive treatment to the people. This deficiency in healthcare services is not just limited to basic amenities of treatment and infection control. Many ancillary activities also remain limited or non-existent. This also applies to the situation of healthcare waste management (HWM). Currently no incinerator is operational in the city for the treatment of medical waste. Therefore healthcare facilities in Gujranwala have to rely on a commercial firm for the collection and transportation of their medical wastes to another city before its final treatment. The arrangement is fraught with difficulties as the transportation and treatment costs eventually trickle down to the patients and contribute to environmental pollution (M. Ali et al. 2016a). Finally, published data exist regarding HWM practices in the city is limited. Research regarding HWM in this city can help discover shortcomings and devise policies for other similar cities. Most of the existing studies on the topic of hospital waste management in Pakistan are qualitative (M. Ali et al. 2016b), (Junaid Habib Ullah 2011). There have been relatively few studies to quantify waste generation across hospitals in the country. Moreover existing studies only give a broad overview of the existing waste management scenario without a detailed analysis. Constant monitoring and evaluation are necessary to quantify hospital wastes and to assess onsite waste management practices in the light of national regulations.

**Methodology**

The study was conducted across 12 hospitals in Gujranwala city in the period between November 2014 and March 2015. The list of hospitals in the city was obtained from the office of the Executive District Officer-Health. In all there were 48 hospitals in the city having a total of 2415 beds (M. Ali et al. 2016c). Thirty five of the total hospitals were located in the city’s four predominantly urban towns. Of these 12 hospitals were selected for the survey based on simple random sampling. These consisted of 11 private hospitals and the only government hospital in the city. The population of the hospitals in Gujranwala city included 5 large hospitals (>100 beds) divided across the 4 towns; 4 medium hospitals (50<beds<100) divided across 2 towns and 23 small hospitals (beds<50) divided across 3 towns. Our survey covered all 5 of the large hospitals, 2 of the medium hospitals and 5 of the small hospitals. The survey methodology consisted of physical weighing of the wastes with a digital balance along with determination of waste management practices using a standard questionnaire. The questionnaire was developed in accordance with the national regulations namely Hospital Waste Management Rules, 2005 (HWMR). The questions about waste management practices gathered information about staff trainings, use of safety equipment, waste records, waste collection, handling & storage and waste transportation among others. To initiate the survey, an introductory letter from the authors' institutions was presented and informed consent was taken from the hospital management. The questionnaire was addressed to the hospital manager and it was usually filled by the resident Medical Superintendent (MS) or a member of the waste management team. The responses were then compared with actual findings following 7-day inspection of each hospital. To calculate the waste generation rates, information regarding the no. of beds and ward wise patient occupancy was obtained from hospital records. Analysis of the results was carried out in SPSS v. 21. In order to measure the relative waste management efficiency of the private and the trust hospitals, Data Envelopment Analysis (DEA) was conducted using the software DEAP v.2.1. DEA is a non parametric data oriented technique for evaluating the relative efficiencies in a set of peers (Song et al. 2014). Following (Coelli 1996) the DEA model can be expressed as follows

Such that

and *i=*1,2,…,N

Where is a scalar that measures the efficiency of *i*th hospital; Y is the data of M outputs; X is the data of K inputs and is a vector of Nx1 constants.

The advantage of using DEA is that the calculations are not tied to units which helps avoid the use of a common scale (Kavurmaci and Ustun 2016). Moreover, in contrast to regression models, DEA optimizes the performance measure for each hospital relative to its peers (Clement et al. 2008). In the past, different studies have employed DEA to measure the efficiency of hospitals as units of production (Kawaguchi et al. 2014). Similarly DEA has also been used to measure the efficiency of municipal waste management (Khadivi and Ghomi 2012). However, to the best knowledge of the authors, this is the first time that DEA was used to measure the efficiency of hospital waste management in a South Asian country.

**Results & Discussion**

Waste Characterization

Hospital waste was sorted into two types, namely general and biomedical wastes. Biomedical waste consisted of all waste segregated for onward submission to a commercial firm for incineration and final disposal. It comprised, mainly, of empty plastic drips, used blood infusion bags, cotton swabs, dressings and plasters, syringes, used testing kits, laboratory sample containers, nosographic tubes and sharp boxes containing needles, broken vials, cut glass, etc. General waste consisted of all waste collected for landfilling at the local municipal waste dumping ground. The weighted average general and biomedical waste generated at the private hospitals were discovered to be 0.89 Kg/patient day-1 and 0.26 Kg/patient day-1 respectively. The weighted average general and biomedical waste generated at the public hospital were found to be 0.26 Kg/patient day-1 and 0.12 Kg/patient day-1 respectively. The weighted average total waste generation was 1.53 Kg/patient day-1 of which 24.54% was generated at the public hospital and the remaining waste was generated at the private hospitals. Moreover, 75.15% of the total waste was composed of general waste and the remaining consisted of biomedical waste items. These findings are similar to those of the World Health Organization in developing countries which conclude that around 10%-25% of healthcare waste in these countries is infectious (Yves Chartier 2013). Here, the units of Kg/patient day-1 have been used as more than one patient occupied a bed in some cases. Most of the waste at the public hospital was generated at the gynaecology ward followed by the surgical ward. Waste generation was minimum in the paediatrics ward. The findings are also similar to those discovered in other studies (Gupta and Boojh 2006). Similarly, total waste generation at another public hospital in the nearby city of Lahore was discovered to be 0.45 Kg/patient day-1 (Munir et al. 2014) which is again similar to our findings. In other countries, total hospital waste generation was found to be 1.3 Kg/patient day-1 in Libya (Sawalem et al. 2009), 1.29 Kg/patient day-1 in Turkey (Goren and Ozdemir 2011) and 1.22 Kg/patient day-1 in Greece (Sanida et al. 2010). Thus total waste generation from the hospitals included in our survey was slightly higher than that in other countries.

Waste management efficiency

For the DEA, the inputs consisted of no. of beds, no. of admitted patients/day, no. of outdoor patients and the number of sanitary workers at each hospital. The two outputs consisted of general waste and biomedical waste. The basic descriptive statistics for the inputs and outputs have been given in Table.1. Note that instead of the individual valuse for each of the hospitals the average, minimum and maximum values have been provided along with the standard deviation. This has been done to give a concise, yet holistic, picture of the variation in inputs and outputs across the hospitals. The outputs have been presented in the units of Kg/day. In case of the inputs occupancy represnts the no. of in-patients, OPD represents the no. of outdoor patients and sanitary represents the no. of sanitary workers at each hospital. Therefore with these variables, the hospitals resulting in the optimum amount of waste relative to the inputs would be considered most efficient. This is because such a hospital uses its inputs in the most efficient manner to manage its waste outputs.

[Insert Table.1 here]

The results of the DEA have been presented in Table.2. The table represents the technical, pure technical and scale efficiencies of each of the DMUs/hospitals. Technical efficiency referes to as how well a hospital utilizes the available inputs for the outputs and it can be measured in terms of constant returns to scale (CRS) as well as variable returns to scale (VRS). The CRS scores consider input/output configuration and as well as scale/size of operations in their measurements while VRS scores measure efficiency without considering scale (Avkiran 2001).  All efficiency values are represented as fractions rather than percentages. As such their values vary between 0 an 1. This notation has been followed based on standard practices (Ratkovic et al. 2012). In Table.2 abbreviations have been used such that symbol G represents the public hospital and the symbol P represents the private hospitals. Of these hospitals, the large hospitals are represented in Table.2 as G, P1, P2, P3, P4, the medium sized hospitals are represented by P5 and P6 and small hospitals are shown as P7, P8, P9, P10 and P11. Similarly, among the DMUs, P6, P8, P10 and P11 are specialized hospitals and the remaining are general hospitals.

[Insert Table.2 here]

From Table.2 it can be seen that hospitals P3, P4 and P9 were completely efficient having scale and pure technical efficiencies of 100%. Hospitals P6, P7 and P10 had relatively high scale efficiencies ranging from 82.1% to 98.9%. Hospitals P1, P2 and P8 had moderate scale efficiencies of 68.4%, 78.5% and 76.3% respectively. Hospitals G and P11 had a very low scale efficiency of 32% and 47.7% respectively. Similarly hospitals P2, P3, P4 and P7 had pure technical efficiencies ranging from 77.8% to 89.4% indicating poor waste management at these hospitals. All hospitals, except P2, P7 and P11, have 100% technical efficiencies. Note that Table.2 gives the efficiency scores of the individual hospitals as well as the average values of the technical, pure technical and scale efficiencies for all the hospitals in the second-last row. Similarly, the last row in Table.2 displays the number of hospitals considered to be efficient in each column. The results show that, on average, the technical efficiency of the hospitals under consideration was 79.4%. Thus nine of the surveyed hospitals turned out to be inefficient in their waste management activities. Furthermore, These results also show that most of the technical inefficiency was scale inefficiency (17.3%) while the remaining (4.0%) was pure technical inefficiency. This indicates that even though most of the inefficiency in HWM was due to the size of a hospital, inadequate management was also resulting in inefficiency. The size of a hospital has been discovered to influence HWM in other studies as well (Pant 2012). Finally, these results serve to show that the public hospital had a lower scale efficiency than the average private hospital. This was because private hospitals managed their inputs more productively for waste management.

Table.3 shows slacks in the variables of no. of beds, sanitary workers and outdoor patients on the input side and infectious waste on the output side. All of this serves to show that the waste management activities needed to be optimized at the public hospital to make them more efficient relative to the private hositals in the city. Further analysis of the waste management network (Mustafa Ali et al. 2016) at the public hospital is needed to identify the root cause of the inefficiency.

[Insert Table.3 here]

Knowledge & awareness

The results of the questionnaire survey have been displayed in Table.4 which clearly illustrates a variation in waste management practices at all the surveyed hospitals. It can be seen that none of the hospitals was completely following national regulations. For instance, HWMR require regular training for all personnel engaged in HWM activities. In our survey, we found that 75% of the private hospitals claimed to provide training to their employees on a monthly or quarterly basis. In the table, Q represents quarterly, M represents monthly and O represents only one training conducted at the hospitals for the staff. Similarly, management in 66.67% of the private hospitals claimed to have knowledge about HWMR; 41.67% of the private hospitals claimed to possess some guide regarding HWM and 66.67% private hospitals claimed to have a waste management plan. It can be seen that the situation was overall better in the public hospital as compared to many of the private hospitals. In other countries, a study in Iran discovered that 60% of healthcare facilities organize some kinds of training courses at least once a year (Askarian et al. 2004). Similarly in Istanbul, Turkey 98% of the hospitals organize courses for their waste collection personnel (Birpinar et al. 2009). In Jordan, 57% of the hospitals provided training to their support staff regarding HWM (Abdulla et al. 2008).

Table.4 also shows that the public hospital did not have any separate routes for biomedical waste transportation. It also lacked safety equipment for its waste collection staff. Moreover it did not maintain any waste generation records. The situation was similar in many of the private hospitals as only 25% provided safety equipment to their waste collection staff, none kept any waste generation records and only 25% had a separate route for waste transportation. Finally, only 41.6% of the private hospitals segregated their wastes at source and all but one disposed their wastes by incineration, as outsourced to a commercial company.

[Insert Table.4 here]

A 10-item multiple choice questionnaire was designed to gauge the awareness of the hospital staff regarding sound HWM practices. The questionnaire was designed using HWMR and distributed among the staff across all the surveyed hospitals. In total 167 responses were received from the private hospitals. The respondents included 114 nurses and 33 sanitary workers. Subsequent analysis revealed that 84% of the nurses and 37.5% of the sanitary workers at the private hospitals reported receiving regular trainings on HWM. Moreover, nurses answered 52.5% of the questions correctly while the percentage of correct answers for sanitary workers was 30.2%. Similarly 136 responses were received from the private hospitals. The respondents included 114 nurses and 22 sanitary workers. Subsequent analysis revealed that 100% of the nurses and 31.8% of the sanitary workers at the public hospital reported receiving regular trainings on HWM. Moreover, nurses answered 69.2% of the questions correctly while the percentage of correct answers for sanitary workers was 47.9%. The questionnaire is given in the Appendix.

**Conclusions**

Our study concludes that HWM practices across most of the surveyed hospitals did not confirm with national regulations. Waste segregation, transportation, storage and final disposal practices varied across the hospitals. The lone public hospital in the city was relatively inefficient in managing its wastes. Pathological items were also discovered in the general waste at some of the hospitals. This created difficulties in sorting general and medical waste items. Similarly, occupancy in some of the wards was greater than 100% in some cases which pointed towards a lack of resources for the patients. Lack of safety equipment for waste handlers was another issue discovered during the survey. Poor management of healthcare waste has also been reported in other resource constrained countries. The case of Pakistan merits special attention due to its relatively large population and high rates of urbanization. This makes it an issue which needs to be tackled urgently to avoid any crises.

A limitation of this study was that we only included hospitals in the survey. Other healthcare facilities such as clinics, laboratories, mother care units, basic health centers and rural health centers were not included. In the future the scope of this study can be broadened and subsequently used for comparison and benchmarking. This means that similar surveys can be conducted in other parts of the country and the wider regional setting. Once enough information is available, the findings can be used for public policy making geared towards constant monitoring and assessment of healthcare waste management.

**References**

Abdulla, F., Abu Qdais, H., & Rabi, A. (2008). Site investigation on medical waste management practices in northern Jordan. *Waste Manag, 28*(2), 450-458, doi:10.1016/j.wasman.2007.02.035.

Ali, M., Wang, W., & Chaudhry, N. (2016a). Application of life cycle assessment for hospital solid waste management: A case study. *Journal of the Air and Waste Management Association, 66*(10), 1012-1018, doi:10.1080/10962247.2016.1196263.

Ali, M., Wang, W., & Chaudhry, N. Comparing Administration of Hospital Wastes Using Social Network Analysis. In *MATEC Web of Conferences, 2016* (Vol. 68, pp. 14009): EDP Sciences

Ali, M., Wang, W., & Chaudhry, N. (2016b). Investigating motivating factors for sound hospital waste management. *Journal of the Air and Waste Management Association, 66*(8), 786-794, doi:10.1080/10962247.2016.1181686.

Ali, M., Wang, W., & Chaudhry, N. (2016c). Management of wastes from hospitals: A case study in Pakistan. *Waste Manag Res, 34*(1), 87-90, doi:10.1177/0734242X15616474.

Askarian, M., Vakili, M., & Kabir, G. (2004). Results of a hospital waste survey in private hospitals in Fars province, Iran. *Waste Manag, 24*(4), 347-352, doi:10.1016/j.wasman.2003.09.008.

Avkiran, N. K. (2001). Investigating technical and scale efficiencies of Australian Universities through data envelopment analysis. *Socio-Economic Planning Sciences, 35*(1), 57-80, doi:<http://dx.doi.org/10.1016/S0038-0121(00)00010-0>.

World Development Indicators (2005). The World Bank. <http://data.worldbank.org/country/pakistan>. Accessed 23 August 2015.

Birpinar, M. E., Bilgili, M. S., & Erdogan, T. (2009). Medical waste management in Turkey: A case study of Istanbul. *Waste Manag, 29*(1), 445-448, doi:10.1016/j.wasman.2008.03.015.

Clement, J. P., Valdmanis, V. G., Bazzoli, G. J., Zhao, M., & Chukmaitov, A. (2008). Is more better? An analysis of hospital outcomes and efficiency with a DEA model of output congestion. *Health Care Management Science, 11*(1), 67-77.

Coelli, T. (1996). A guide to DEAP version 2.1: a data envelopment analysis (computer) program. *Centre for Efficiency and Productivity Analysis, University of New England, Australia*.

Division, G. o. P.-F. (2014-15). Federal Budget - Budget In Brief.

Goren, S., & Ozdemir, F. (2011). Regulation of waste and waste management in Turkey. *Waste Manag Res, 29*(4), 433-441, doi:10.1177/0734242X10378887.

Gupta, S., & Boojh, R. (2006). Report: Biomedical waste management practices at Balrampur Hospital, Lucknow, India. *Waste Management & Research, 24*(6), 584-591, doi:10.1177/0734242x06068342.

Junaid Habib Ullah, R. A., Javed Iqbal Malik and M. Amanullah Khan (2011). Outcome of 7-S, TQM Technique for Healthcare Waste Management. *Journal of the College of Physicians and Surgeons Pakistan*.

Kavurmaci, M., & Ustun, A. K. (2016). Assessment of groundwater quality using DEA and AHP: a case study in the Sereflikochisar region in Turkey. *Environmental Monitoring and Assessment, 188*(4), doi:10.1007/s10661-016-5259-6.

Kawaguchi, H., Tone, K., & Tsutsui, M. (2014). Estimation of the efficiency of Japanese hospitals using a dynamic and network data envelopment analysis model. *Health Care Management Science, 17*(2), 101-112.

Khadivi, M., & Ghomi, S. F. (2012). Solid waste facilities location using of analytical network process and data envelopment analysis approaches. *Waste Management, 32*(6), 1258-1265.

The world’s fastest growing cities and urban areas from 2006 to 2020. (2011). <http://www.citymayors.com/statistics/urban_growth1.html>.

Munir, S., Batool, S. A., & Chaudhry, M. N. (2014). Characterization of hospital waste in Lahore, Pakistan. [Article]. *Chinese Medical Journal, 127*(9), 1732-1736, doi:10.3760/cma.j.issn.0366-6999.20132088.

Murtaza Haider, N. U. H., Nadeem Hussain and Atyab Tahir, Ahsan Iqbal, Michael Kugelman, Sania Nishtar, Farrukh Chishtie, and Jawad Chishtie, Mohammad A. Qadeer, Tasneem Siddiqui (2014). Pakistan’s Runaway Urbanization: What Can Be Done? <https://www.wilsoncenter.org/publication/pakistans-runaway-urbanization>.

Pant, D. (2012). Waste management in small hospitals: trouble for environment. *Environmental Monitoring and Assessment, 184*(7), 4449-4453, doi:10.1007/s10661-011-2276-3.

Ratkovic, B., Andrejic, M., & Vidovic, M. (2012). Measuring the efficiency of a healthcare waste management system in Serbia with data envelopment analysis. *Waste Manag Res, 30*(6), 635-638, doi:10.1177/0734242X11426172.

Sanida, G., Karagiannidis, A., Mavidou, F., Vartzopoulos, D., Moussiopoulos, N., & Chatzopoulos, S. (2010). Assessing generated quantities of infectious medical wastes: A case study for a health region administration in Central Macedonia, Greece. *Waste Management, 30*(3), 532-538, doi:<http://dx.doi.org/10.1016/j.wasman.2008.11.019>.

Sawalem, M., Selic, E., & Herbell, J. D. (2009). Hospital waste management in Libya: a case study. *Waste Manag, 29*(4), 1370-1375, doi:10.1016/j.wasman.2008.08.028.

Song, M. L., Wang, S. H., & Liu, W. (2014). A two-stage DEA approach for environmental efficiency measurement. *Environmental Monitoring and Assessment, 186*(5), 3041-3051, doi:10.1007/s10661-013-3599-z.

Yves Chartier, J. E., Ute Pieper, Annette Prüss, Philip Rushbrook, Ruth Stringer, William Townend, Susan Wilburn and Raki Zghondi (2013). Safe Management of Wastes from Health Care Activities (second ed.) World Health Organization, Geneva