

Interim Report of Health Care Waste Management System In Bir Hospital, Kathmandu



Technical Assistance:
Health Care Foundation Nepal
Health Care Waste Management Program



Technical Support:
Health Care Without Harm



Endorsed By:
World Health Organization



Implemented By:
National Academy of Medical Sciences
Bir Hospital

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1 Executive Summary

Bir Hospital, one of the largest in Kathmandu, long had problems managing its waste. Some of the staff had started segregation system in their wards but it was not effective because there was no institutional system. Management became concerned in the issue and requested assistance from Health Care Foundation Nepal (HECAF), who had already installed a non-incineration waste management system at the National Kidney Centre. HECAF in turn work with technical support from Health Care Without Harm (HCWH).

The main objectives of the program were to set up a sustainable, non-incineration waste management system and to eliminate mercury from the hospital.

First, HECAF gave sensitization seminars on health care waste management for top level officials and in-charges of the wards to create awareness on the current problems of health care waste. Secondly, a baseline assessment was carried out to identify failings in the existing system and quantify waste generation. The assessment concluded that 1.23kg waste was generated per bed per day. A health care waste management committee (HCWMC) was developed based on WHO guidelines and a waste coordinator selected. The Housekeeping in-charge was appointed as the waste management coordinator.

The Male Medical was chosen as a model ward to develop waste segregation, handling, and storage practices in collaboration with the staff, rather than imposing practices without consultation. Training was given to all staff of the ward before establishment of the system. Continuous monitoring was conducted from the system established date.

A transportation, collection and storage system was also set up. Housekeeping staff were appointed for waste transportation with full set of personal protective equipment and training provided. A disused mortuary building was converted into a waste treatment and storage centre, with autoclaves designated for treating infectious waste, which were validated by Health Care Without Harm.

During the first 8 months of the year 2068, around 33 tonnes of segregated waste was collected. Six tonnes (19%) was infectious, and was autoclaved. Almost 11 tonnes (34% of the total waste) was sold to recyclers, earning over 2,00,000 Nepalese rupees (US\$2400). Just less than one quarter of the waste is food waste, which can be composted or bio-digested and a bio-digestion plant is being installed for this purpose. When the system has been fully implemented, on the basis of 460 beds, it will handle over 84 tonnes of waste (including almost 16 tonnes of infectious waste) each year, and sell 29 tonnes of recyclables, worth almost US\$6000.

Now the final steps for the completion of the project will be the implementation of the waste management system in the Emergency, Haemodialysis and Outpatients Departments (OPD). The commissioning of a recently constructed bio-digestion plant will be completed. Its primary feedstock will be food waste from the wards but it should also be able to dispose of pathological waste from the operating theatres. Microbial tests will be run to confirm safe bio-digestion of the pathological waste. The gas produced from the bio-digestion plant is proposed to be supplied to the kitchen of Diet section.

Even before the project is complete, Bir has become a model center for the whole country. Visitors from 11 different hospitals around the Kathmandu valley, university, different

medical colleges, schools as well as the Health Minister, Ministers from MoLD have been to observe the treatment centre and operations on the wards. Requests for support in setting up cleaner waste management have already been received from different hospitals such as Norvic International Hospital, Kathmandu Model Hospital, Civil Service Hospital of Nepal, Om Hospital proving the value it has an inspiration to initiate the healthcare waste management system implementation in other hospital.

2 Acknowledgements

Any accomplishment requires the effort of many people and completion of this project is no exception. Health Care Foundation Nepal is deeply indebted and expresses sincere appreciation to WHO Nepal for endorsing and supporting the work at the oldest and biggest hospital of Nepal, Bir Hospital, for managing their health care waste safely.

Completion of this project would not been possible without commitment from the Bir Hospital itself. Grateful thanks are expressed to Ms. Ishwori Shrestha, former nursing director of Bir hospital for initiating discussion of health care waste management. We would like to express our special gratitude to Professor Dr. Buland Thapa, Director of Bir Hospital for his continuous moral and financial support to accomplish the task. He motivated staff to adopt the new established system of waste segregation which was fundamental to the success of the project. We are extremely grateful to Mrs. Sudha Baidhya, Acting Nursing Director of Bir Hospital for her hard work in establishing the system.

Completion of this project would be impossible without the endless support from Sarita Shrestha, In-charge Housekeeping Bir Hospital and the designated healthcare waste management coordinator. Our special thanks go to her for her dedication to the project even outside working hours. Finally, no waste management project can work without the efforts of the other staff of housekeeping and all the doctors, nurses and support staff who participated actively in this program during system implementation and continue to keep it running successfully.

Similarly, we would like to thank Ms Ruth Stringer, International Science and Coordinator, Health Care Without Harm for providing the technical support especially on autoclave validation, data management and project completion.

Bio-digestion is an exciting new aspect of the health care waste management system. For the construction of the bio-digestion plant, the financial support from Ministry of Local Development (MoLD), the Solid Waste Management and Resource Mobilization Center (SWMRC) and Biogas Support Program (BSP), Alternative Energy Promotion Center (AEPC) is greatly appreciated. We would also like to thank Rastriya Gobar Gas Company, Biogas consultants, for providing manpower and managing the construction of the bio-gas plant. Finally, we would like to thank Professor Amrit Karki for providing his invaluable expertise on biodigestion.

3 Abbreviations

WHO	World Health Organization
HCW	Health Care Waste
HCF	Health Care Facilities
NAMS	National Academy of Science
HECAF	Health Care Foundation Nepal
DOHs	Department of Health Services
HCWM	Health Care Waste Management
HCWMC	Health Care Waste Management Committee
IEC	Information, Education and Communication
HCWH	Health Care Without Harm
UNDP	United Nation Development Program
POPs	Persistence Organic Pollutants
OPD	Out Patient Department
HIV	Human Immuno- Deficiency Virus
ART	Antiretroviral Treatment
PEP	Post Exposure Prophylaxis
MoLD	Ministry of Local Development
SWMRC	Solid Waste Management and Resource Mobilization Center
BSP	Biogas Support Program
AEPC	Alternative Energy Promotion Center
ATSDR	Agency of Toxic Substances and Disease Registry

4 Introduction

“Healthcare waste is a by-product of healthcare that includes sharps, non-sharps, blood, body parts, chemicals, pharmaceuticals, medical devices and radioactive materials.” These are the wastes generated in the diagnosis, treatment or immunization of human beings or animals. It consists of both risk and non risk wastes (WHO guidelines, Pruess *et al.* 1999). These may be liquid or solid. The actual percentage of risk waste varies from 10-25 percent. The amount and categories of risk waste that health care facilities generate vary according to the services provided. This small percentage of waste carries a risk of infection and other health hazards. Poor management of HCW exposes healthcare workers, waste handlers and the community and environment to infections, toxic effects and injuries.

One of the main problems faced by the hospitals of Kathmandu Valley and the rest of Nepal is the problem of mismanagement of health care waste. There is an urgent need to deal with the issue. It is the ethical responsibility of management of hospitals and health care establishments to have concern for public health.

Until now, in Nepal, almost all the waste generated from the HCFs is treated as regular solid municipal waste. But some of the waste, including sharps (e.g. needles, razors, and scalpels), pathological waste, other potentially infectious waste, pharmaceutical waste, biological waste, and hazardous chemical waste requires special attention.

Some hospitals incinerate their waste. However, most of these operate at low temperature and have poor or no air pollution control, so they are highly polluting. Scavengers also seek out discarded medical waste including syringes, which are repackaged and sold- a highly dangerous trade.

Safe handling, segregation, storage, treatment and disposal of healthcare waste ensure mitigation and minimization of the concerned health risks involved through contact with the potentially hazardous material, and also in the prevention of environmental contamination.

5 Project Partners

5.1 Bir Hospital

Bir Hospital, the nation's oldest medical institute, was established in the year 1889 AD, and has been developed into the National Academy of Medical Sciences (NAMS). It has been contributing much towards the delivery of health care in the country. Every year, Bir Hospital admits almost 8,500 inpatients, deals with over 300,000 outpatients and treats over 60,000 accident and emergency cases. It has currently 460 beds. Beside a general medical service, Bir Hospital provides services in highly specialised areas like neurology, neurosurgery, cardiology, cardio-thoracic and vascular surgery, burn and plastic surgery, nephrology, urology, gastrointestinal surgery, gastroenterology, hepatology (separate unit) and radiotherapy. Bir Hospital, thus, provides services to the community in most medical and surgical specialty and super-specialties through emergency, outpatient and inpatient facilities. The majority of out-patient examination services and in-patient beds in Bir Hospital are free. This is the only tertiary referral centre in the country which provides such free services.

5.2 Health Care Foundation Nepal

Health Care Foundation Nepal (HECAF) has been working in the field of health care waste management since 1999, when it installed the first non-burn medical waste management system in the National Kidney Centre. Waste is segregated at source and infectious materials are disinfected in an autoclave. The system is partly funded by the sale of recyclables.

HECAF developed its Health Care Waste Management Program in 2007. The program is committed to managing Nepal's health care waste safely and to develop systems that can be implemented at the level of single facilities, entire cities, or nationwide.

HECAF works closely and in consultation with the Department of Health Services (DOHS) on capacity building, development of practical approaches in health care waste management (HCWM), in particular focusing on non-burn technologies; development of Information, Education and Communication (IEC) materials to support awareness raising and orientation on HCWM for the health sector and the general public.

Management of sharps in the health sector remains a serious concern for health sector staff and for final disposal. HECAF has earlier supported several hospitals and health facilities in applying good practice through the promotion of locally available needle destroyers and autoclaving using pressure cookers. HECAF is a member of Health Care Without Harm, an international network focusing on a healthy and environmentally friendly health care system, and works in close collaboration with them.

5.3 Health Care without Harm

Health Care Without Harm (HCWH) is an international coalition of hospitals, professional associations, and non-governmental organisations dedicated to implementing ecologically sound and healthy alternatives to health care practices that pollute the environmental and contribute to disease. Founded in 1996, HCWH now has offices in Europe, USA, Latin America and South East Asia, and 508 member organisations in 53 countries around the world. HCWH works closely with the World Health Organisation, UNDP and other international agencies.

Implementing safe and sustainable medical waste management, and substituting mercury and other toxic chemicals in medical practice are two core issues for HCWH. Other issues include climate and health, green and efficient buildings, green purchasing and pharmaceuticals.

HCWH provides technical support to HECAF in medical waste management at Bir Hospital, mercury substitution and other projects.

5.4 World Health Organization

The World Health Organization is the directing and coordinating authority for health within the United Nations system. WHO has been at the forefront of global efforts to improve healthcare waste for many years and publishes guidelines for the safe management of waste from healthcare activities. These guidelines have been used as the foundation for the practices used at Bir and other HECAF healthcare waste management projects. WHO has

endorsed HECAF and has supported HECAF work on health care waste management in Nepal. .

6 Concepts

6.1 Do No Harm Principle

Any hospital that does not treat its waste properly will harm the patients, staff, patients or environment. To *do no harm*, the hospital aims to manage waste safely from source to the final disposal, and also to reduce the toxicity of waste and other hazards associated with it. To do this, the waste is properly segregated, staff are trained to handle it safely and it is treated in an environment-friendly way by using non-burn technologies.

6.2 Non Burn Technology Promotion

Nepal is a signatory country of the Stockholm Convention on Persistent Organic Pollutants (POPs), therefore committed to non-burn technology. There are a number of alternatives to incineration, such as microwaving, dry heat and chemical disinfection. Out of these, autoclaving was chosen as it has no chemical discharges, is low cost, easy to maintain, and the technology is familiar to the hospital maintenance department. There are also many autoclave models on the market, making it easy to select one that is suitable for the needs of the hospital.

6.3 Project Management structure

The system has been developed through the participatory approach of all the staff of the hospital and HECAF team. The hospital staff are at the front for the development of the system and HECAF team have motivated them to accept the system. The HECAF and HCWH team has been providing technical support to the hospital.

For sustainability of the system the hospital needs a waste management committee. For the first time in the history of the hospital, a waste management committee has been established at Bir. The committee meeting meets regularly every month with extra meetings being called when necessary.

The hospital waste management committee includes: Director of the Hospital, Acting Nursing Director, Emergency In-charge, Section Officer, Medical Unit Department Head, Senior Sister Burn Ward, Account Officer, Medical Record Officer, Lab Technician, Radiographer, Senior Housekeeping In-charge , Medical Store In-charge, General Store In-charge. The hospital waste management committee is headed and chaired by the Director of Bir Hospital.

The hospital waste management coordinator is assigned as the member secretary of the committee. Similarly, the waste coordinators were appointed in each of the ward so that they can coordinate, supervise and monitor the waste management system in their respective wards.

The Housekeeping department is also playing a leading role in health care waste management in Bir Hospital. The Hospital has assigned Housekeeping department as focal unit for waste management of the hospital. In-charge of Housekeeping department is assigned as Hospital Waste Management Coordinator. The housekeeping staff coordinates with the hospital management, Hospital staff and HECAF for the smooth implementation of the health care waste management system in Bir Hospital.

6.4 Tricycle Model

In a tricycle, two rear wheels move together with front wheel. Similarly this project at Bir Hospital encompasses three main concepts e.g. waste management, safe injection and mercury free. Comparing these three concepts to the tricycle mechanism, waste management will take the lead as the front wheels and mercury free and injection safety will play the role of two rear wheels.

Once the waste system is being installed, the other two issues arise naturally. As the waste is being segregated, broken thermometers and blood pressure meters will be separated out. Since there is no safe way to dispose of them, the best solution is to substitute them for non-mercury alternatives. So, as each ward is taught about waste segregation, non-mercury medical devices are also introduced. Finally, to reduce the dangers from sharps waste on the wards, safe injection practices are being introduced by installing needle destroying and cutting instruments. Mercury free and safe injection practices goes along with the safe health care waste management in the hospital.

So if all these move together successfully means it moves sustainably as the tricycle. This is the tricycle model.

6.5 Participatory Approach

The safe Health Care Waste Management system in Bir Hospital is not only the work of the HECAF team. The system has been developed through a participatory approach. The nurses and other medical staff were fully involved in designing the medication trolley to suit them. The buckets in trolley are placed in the best position for staff to use as they work. Similarly decisions on waste management in wards are taken by the waste coordinator nominated by the respective ward staff.

As well as the medical staff, the maintenance department also participated in the creation of the medical waste management system, making much of the equipment, as described in the next section.

Even the security guards were involved; before the new system was in place, it was common for scrap dealers to come to the hospital in search of materials to sell to recyclers. The guards make sure that this no longer happens so that no potentially dangerous materials leave the site and the hospital does not lose valuable recyclables.

6.6 3R Principle (Reduce, Reuse, Recycle)

The purpose of the health care waste management program is to minimize the volume and toxicity of the healthcare waste. There are several measures that can be applied for the waste

minimization. 3R principle is one of them. HECAF has adopted the 3R principle as one of the principle of the safe health care waste management system in Bir hospital.

The waste is segregated at source by the medical staff and visitors. The segregation of waste at source minimises the amount of infectious waste and the amount of potentially recyclable waste that is rendered unusable through contamination. Substituting mercury also reduces the amount of hazardous waste that has to be stored or disposed of. Waste minimisation reduces the costs of waste treatment and disposal.

Scrap materials have been re-used to make medication trolleys and waste transportation trolleys and create the waste storage bays in the waste storage area. For instance, the waste transportation trolleys have been made from discarded patient trolleys, wheels and handles from discarded wheelchairs and an oxygen cylinder trolley. Similarly, the medication trolleys, with hoops for the waste bins, are designed from the old trolleys. The disused former mortuary has been converted into the treatment centre and adjacent waste dump site has been modified into the general waste collection area. The work has been done by the hospital engineers working from designs produced by HECAF and the ward staff.

The waste collected from the wards are segregated at source and in the recycling centre are further separated into different categories of plastic, paper, glass and metal, which are sold to scrap dealers for recycling.

7 Start-up

7.1 *Baseline Assessment*

A baseline assessment was also conducted in Bir Hospital from 7th November 2009 to 4th February 2010. Waste was weighed for 7 days and each and every bucket was assessed. During the process the waste handling practice from the point of segregation to final disposal was also assessed.

The baseline assessment found that Bir hospital generated around 330 kg wastes per day, equivalent to 1.23 kg/bed/day (HECAF, 2010). The waste was segregated by the HECAF team, who found that 25% of it was risk waste, in line with the normal figures reported by WHO. However, because it was not segregated at source, 78% was a mixture of risk and non-risk waste, which has to be treated as though all of it is risk waste. Hence the lack of segregation increased the amount of risk waste by a factor of three. This clearly indicated that proper waste management system from the segregation to disposal needed to be established.

7.2 *Sensitization*

A seminar on health care waste management was conducted in Bir hospital for top level officials and In-charges of the wards. This seminar focused on raising the awareness of the participants about the current problems of health care waste in the Kathmandu Valley, particularly in Bir Hospital, and making them realize the importance of proper management of health care waste. More than 50 participants attended the seminar. HECAF explained the

current problems of health care waste in Bir hospital such as lack of total system of waste management and lack of institutional framework. The majority of staff were trained by government and other organizations on waste management but still they didn't have a practical knowledge which is essential to successful implementation. They knew what to do but they did not know how to do it. HECAF presented some experiences from other hospitals. This seminar proved to be an eye opener for the top level management officials and nursing in-charges, who were motivated to establish a health care waste management system. The concept of institutional system was made clear and they were advised to create a health care waste management committee representing all departments according to WHO standards.

7.3 Field Office Set-up

A HECAF field office was set up for smooth facilitation during implementation of activities. As the Housekeeping Department is the focal point for medical waste management, the field office was set up there. The hospital management provided a room, necessary furniture, wireless internet connection etc. HECAF technical team is providing technical assistance from that office.

7.4 Model Ward

It is difficult to implement the healthcare waste management system in whole hospital at once; so a model ward was selected to test the system, get feedback from the staff and to make sure that they all approved the system before it was replicated to other wards.

7.5 Mercury in Hospital Environment

Mercury is a potent neurotoxin and nephro-toxin found in a variety of products. It affects the brain, liver and kidneys and can cause developmental disorders in children. Young children and developing fetuses are especially at risk (ATSDR 1999, WHO 2003, European Commission 2005). Mercury represents an occupational hazard for nurses, dentists and also hazards to patients and communities as well.

Mercury usage in healthcare industry is quite high and it can be found in products like fever thermometers, sphygmomanometers, lab chemicals, batteries, fluorescent lamps, dental filling etc. It is found in huge quantity in dental fillings or dental amalgams (HCWH 2002, Maxson 2004). Hence, health care professionals should be very careful in handling of these products as mishandling or mismanagement can lead to the mercury exposure.

Mercury spills in hospitals, clinics and labs, expose doctors and nurses, other health care workers and patients to elemental mercury. At normal room temperature significant amount of liquid elemental mercury after spillage vaporizes and remains in the atmosphere and can lead to exposure through inhalation. (ATSDR 1999, European Commission 2005, Toxics Link 2007). The severity of the exposure depends on air temperature, amount of mercury released, air flow and the body type of the individual being exposed.

So substitution of mercury containing product with the non mercury products, is the best way to minimize the hazards caused by mercury. The world is heading towards the mercury elimination and substitution.

However, at the start of the project at Bir, there was a low level of awareness about the hazards of mercury in the hospital environment. To demonstrate the problem, HECAF tested the level of mercury in hospital environment at Bir Hospital. Different samples of air, water, solid waste and soil were taken for testing the level of mercury and tested at Water Engineering and Training Pvt. Ltd.

The water samples were taken from the different sources including the main water supply of the hospital (borehole water), floor-wash of medical ward, floor wash of dental ward and the main outlet or drainage of the hospital. Solid waste samples were collected from the main disposal site of the hospital and the area behind the maintenance room, where the broken florescent lamps were dumped before. For the air sample, dental OPD, maintenance room and female medical ward were selected and air sample from the Director's room was also taken for the control sample.

The results of the concentration of mercury in air, water and solid waste samples are discussed below:

7.5.1 Air Samples

The mercury level was found to be highest in the Dental OPD (3.78 $\mu\text{g}/\text{m}^3$). It was not detectable in the Director's room. because the level was $<2 \mu\text{g}/\text{m}^3$. . The air temperature of the Dental OPD was found to be 26 degree Celcius. The highest level of mercury in the Dental OPD was due to the use of mercury amalgam with mercury content in the unit. The second highest was found in the Female Medical Ward (3.22 $\mu\text{g}/\text{m}^3$). The concentration of this unit is also very high; this is due to the maximum use of mercury thermometer in the ward by the staff as well as the students of various nursing college working there. The mercury concentration in the maintenance room was found to be 2.94 $\mu\text{g}/\text{m}^3$. The high concentration in this unit may be due to the damaged medical equipment such as blood pressure meters and fluorescent tubes being stored here.

7.5.2 Water Samples

The mercury level was found to be highest in the floor wash sample of the Dental Ward (0.045 mg/l) and lowest in the hospital inlet. Since no detectable amount of mercury was found in the inlet water, it was taken as a background reference level. The high concentration of mercury in the dental OPD is due to the fact of use of mercury in dental amalgams which is vaporized in the air and later falls down in the floor. The second highest level was found in the floor wash of the Female Medical Ward (0.015mg/l). The maximum use of thermometer in this ward is one of the reasons for the high value of mercury in the floor wash. The other was the drainage from the Pathological Laboratory (0.003mg/l). The concentration in the final outlet was found to be 0.0058mg/l. The concentration is found to be less than the one in the ward. This can be due to the dilution of the metal in the main drainage since it is the only drain for the whole waste water of the hospital which is flowing continuously.

7.5.3 Solid Waste Disposal Area Samples

The mercury concentration in the soil sample of the area near maintenance was found to be very high (2.72mg/kg). This is due to mercury containing fluorescent lamps being disposed of in this area. The mercury level in the solid waste sample was 0.21mg/kg. This is due to all the medical waste being disposed of in this particular site.

7.6 Waste Treatment Centre Design and Initiation

Infectious waste needs to be treated before disposal or recycling. There are lots of treatment options from chemical disinfection to microwave, but for the developing countries like Nepal, autoclaving is the best option which is environmental friendly, non-burn technology of health care waste management.

A facility was developed for separate storage of different types of waste, and for the treatment of infectious waste. The treatment centre has separate areas/rooms for: storage of infectious waste; infectious waste autoclaving. storage of general and recyclable wastes ; storage of consumables and a staff washroom. The layout is designed so that infectious and non-infectious waste are kept separate at all times; they are never in the same room and enter and leave the centre by different doors.

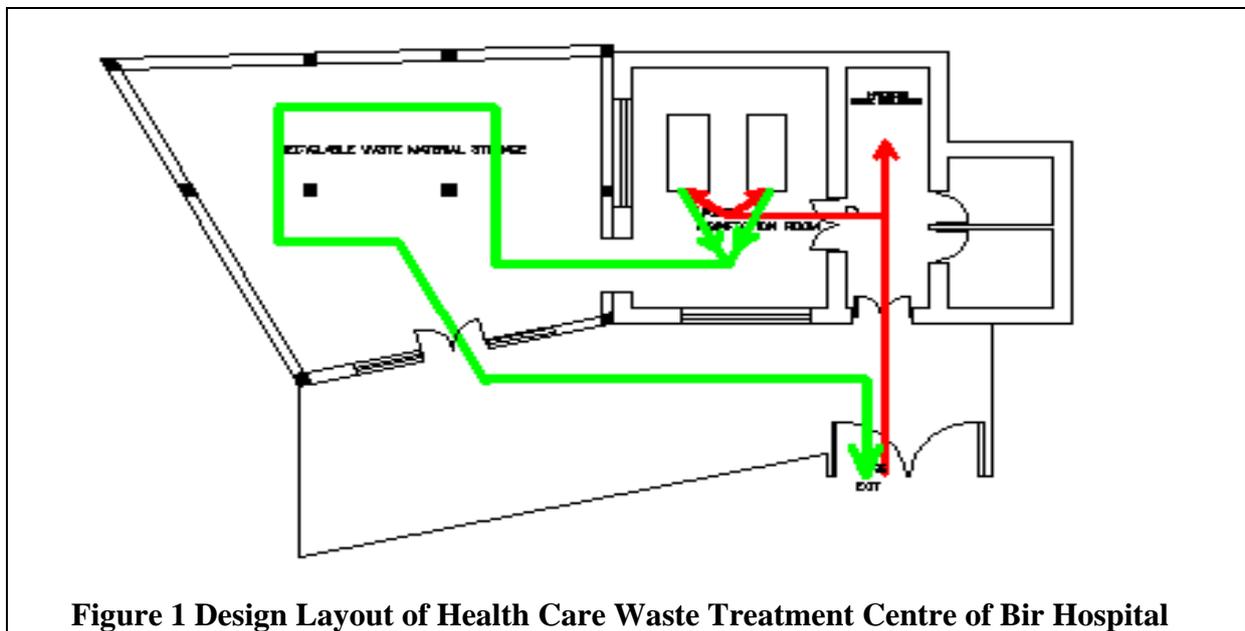


Figure 1 Design Layout of Health Care Waste Treatment Centre of Bir Hospital

7.7 Autoclave Validation

Although autoclaving is a well established medical waste treatment technology, they must be validated with the hospital waste before they can be used. In order to conduct experiment for autoclave validation, Ruth Stringer, International Science and Policy Coordinator, Health Care without Harm (HCWH) was requested by the World Health Organization to support HECAF to validate the autoclave installed in the hospital and conducted the several experiments. Different autoclave cycles and waste containment strategies were evaluated.

Efficacy of disinfection was tested by using chemical indicators (autoclave tape and integrators), and biological indicators (*Geobacillus stearothermophilus*) and procedures based on those recommended by the UNDP GEF global medical waste project (UNDP GEF 2010). Syringes were packed in metal dressing drums, with holes to allow steam to penetrate. Bags of infectious waste were placed in cotton bags. The autoclaves were gravity-fed models, so three pulses were used to ensure that the steam penetrated into the waste, followed by 30 minutes at 121°C sterilization temperature, and 15psi pressure.



Figure 2: Autoclaves used for Waste Disinfection

8 System Implementation

8.1 Waste Transportation

The wastes from the wards are transported to the treatment room in specially designed transportation trolleys. The risk and non risk waste are collected and transported in separate trolleys.

The trolleys have been designed and prepared by using materials found in the hospital, such as discarded patient trolleys, wheelchairs, gas cylinder trolleys etc, with the help of the housekeeping staff and maintenance engineers. The risk waste trolley contains red buckets and sharps containers while the non risk trolley contains blue buckets for bottles and cans, a black bucket for biodegradable waste, light green for unbroken glass and cotton bags are used for the collection of paper and plastic waste.

Staff wear masks, overalls, boots and gloves for their safety. They were also trained on its proper use and cleanliness.



Figure 6 Transportation of Non Risk Waste



Figure 7 Transportation of Risk Waste

8.2 Routine Operation of Autoclave

It is only one of two autoclaves is in operation. So, the hospital has retained the ability to disinfect all its waste, by conducting two runs per day in the operational autoclave. In the year 2068, almost 5550 kg of the infectious waste and 650 kg of syringes were autoclaved. Almost 6200 kg of risk waste had been disinfected. Similarly, the autoclave is being tested regularly.

It is recommended that after the initial validation of the autoclave, the testing frequency of the autoclave should be one in a week, or once a two week if the tests are consistently passed (UNDP GEF 2010). So, initially, the autoclaves were tested once a week. After the consistency in the results, the frequency is reduced to once in two weeks. To date, 100% passed tests reveal that the autoclave is working properly.

8.3 Data Collection and Reporting

Data collection and reporting is an important part of the project. It allows the waste management committee to track the progress of the project, and to set targets for continual improvements. This also includes waste tracking system which is important part of waste management. Proper recording of waste from generation point to the final disposal is essential. A gate pass system for the waste sales was .

Data collected include: amounts of waste of each type, sales of recyclable waste and income generated, amounts of waste autoclaved, autoclave maintenance.

Log books are used to record problems and unusual events, get feedback from the staff, including suggestions for improving the program. The log book has been maintained on a daily basis in order to record all the activities performed. The information regarding the waste generation was delivered to the ward members to show if there are segregation problems and also to motivate the ward staff for further successful continuation of the ward. Data are also regularly presented to the waste management committee.

During the first 8 months of the year 2068, around 33 tonnes of segregated waste was collected. Six tonnes (19%) was infectious, and was autoclaved. Almost 11 tonnes (34% of the total waste) was sold to recyclers, earning over 2,00,000 Nepalese rupees (US\$2400). Just less than one quarter of the waste is food waste, which can be composted or bio-digested.

This allows us to predict that, on the basis of 460 beds, when the system has been fully rolled out; it will handle over 84 tonnes of waste (including almost 16 tonnes of infectious waste) each year, and sell 29 tonnes of recyclables, worth almost US\$6000.

Waste generated	Infectious waste			Recyclable waste						Other wastes	
	Infectious kg	Syringes kg	Sharps (metal) kg	Sharps (glass) kg	Glass kg	Paper kg	Plastic kg	Metal kg	Bottles and cans kg	Bio-degradable kg	Wastage inc liquids kg
Total since project start	3475	403	28	178	2799	2456	1904	19	3799	5316	7598
Daily average	9.63	1.12	0.08	0.49	7.75	6.80	5.27	0.05	10.52	14.73	41.52
Maximum	35.09	4.24	4.40	2.15	26.87	39.74	20.57	1.76	52.11	79.22	122.27
Minimum	0.14	0.02	0.00	0.00	0.00	0.13	0.03	0.00	0.37	0.83	0.00

Waste sold					Income	
	Paper (kg)	Plastic (kg)	Glass (kg)	Metal (kg)	All recyclable waste (kg)	Value (Rs) per bed per day (Rs)
Total since project start	2463	3696	1671	157	7987	135569.48 3.149

Statistics	All wastes kg	Infectious waste kg	Recyclable waste kg	Biodegradable wastes kg	Total general waste kg	% infectious waste %	Number of beds monitored number	inf waste per bed per day kg	total waste per bed per day kg	% potentially recyclable %	% actually recycled %
Total since project start	20377	3906	11155	5316	16293	19%	43057	0.091	0.473	54.7%	39.2%

Up-to-the minute summary of waste received at the treatment centre and sold.

This form is calculated automatically from data in other sheets.

It has to be general categories only to allow flexibility in other parts of the worksheet

Note that the amounts received and sold will not match because: waste was collected before the project start

Some waste that was put in the recycling bins may not be usable,

but some of the infectious waste (eg plastic from syringes) may be recyclable after treatment,

finally, there will almost always be some waste in the centre waiting to be sold

It is protected to prevent data entry



Figure 3. Example of summary statistics for Bir.



Figure 4: Segregation System for Visitors



Figure 5: Segregation for Nursing Staff

As discussed earlier, the system was tested in a model before being rolled out across the rest of the hospital. The Male Medical Ward was chosen as the model ward. Before implementation, training on safe management of health care waste was organized with the motive of providing clear vision about the potential hazards of improper waste management practice and HCWM system with both the practical and theoretical knowledge. This training was organized for three different levels of the staff: nurses, housekeeping staff and support staff.

The wastes are segregated at source in the ward according to the types of the waste generated from the ward. The two main categories are risk and non-risk waste.

The buckets for non-risk waste- paper, plastic, bottle or cans and biodegradable wastes- are placed at the location that is accessible for all the staff, patients and their visitors. There is no need for buckets for risk waste at this location it is not generated by the visitors or the patients.

The infectious and other risk waste buckets are placed in a separate room or separate from the general waste buckets. The basic concept is that the infectious waste bucket should be separated from the general waste bucket so that there is no contamination. The location of the buckets may vary according to the structure and space availability in the ward.

The medication trolley with different coloured buckets has been designed by the nursing staff. The basic principal of the medication trolley with bucket is to segregate almost all of the waste generated during medication at source, even treating patients at the bedside. The trolley contains the buckets for paper, plastics, saline bottle, sharps metal, sharps glass, infectious waste. A needle destroyer is provided for destroying the needles and syringes are placed or segregated in “Syringe Only” bucket.

8.4 Mercury Substitution

HECAF is promoting mercury free health care in all its programs and train each ward in the use of digital thermometers at the same time as they are trained about medical waste management.

For this reason mercury thermometer in Bir Hospital has been replaced by the digital thermometer. Now, the hospital store section is also supplying digital thermometers instead of mercury thermometers in the whole hospital and many of the wards in the hospital are using digital thermometer.

On the occasion of 121th Anniversary of Bir hospital in 28th July, 2010, the Director of the Hospital Dr. Buland Thapa, committed to make Bir Hospital Mercury Free Hospital in his speech.

By the end of January, 2011, mercury thermometers had been completely phased out and mercury blood pressure monitors had also been replaced by aneroid ones in all sections except the Cardio Outpatient Department.

8.5 Injection Safety and Post Exposure Prophylaxis

Health care professionals, patients and community are prone to biological and physical hazards due to unsafe injection practices in health care facilities. Transmission of communicable diseases such as HIV, Hepatitis B and Hepatitis C are a great concern.

However, many workers were unaware of hazards related to their work.

The HECAF program has organized training program for nurses and support staff of the hospital on occupational safety. They were made aware about the different hazards related to

their work environment and the ways of protecting themselves from these hazards were also highlighted.

An injection safety program was also launched in Bir hospital. The concept of safe injection was made clear through the training and different types of needle destroyer were introduced. A workshop was organized at the Bir hospital in which, staff were committed to follow safe injection practice by signing the banner written with " I am Committed for Safe Injection".

Staff were trained in destroying needles immediately after use. Syringe hubs were also cut so that the syringes could not be used again. Closed and leak proof sharps containers were provided in each ward. Separately collected syringes are autoclaved to make them safe, shredded, and then only sent for recycling.

Addressing injection safety helps prevent the medical transmission of HIV and other blood-borne pathogens to patients and health care workers. Injection safety falls under the umbrella of health systems strengthening and encompasses safe medical injection, safe disposal of health care waste, and the provision of post-exposure prophylaxis (PEP) following occupational exposure to HIV.

So the full protection of the staff including waste management staff is the responsibility of the hospital. In this context, Bir hospital has started service of providing the post exposure prophylaxis for those who have occupational exposure.

An Antiretroviral Therapy (ART) clinic was inaugurated in 7th January, 2011. Experts from ART clinic in collaboration with health care waste management program of Bir have conducted awareness training for the senior nurses of the hospital. Now Bir has the provision of making PEP available at emergency for 24 hour. Some of the housekeeping staff has already been benefited from those services.

8.6 System Replication

Once the system had been tested on the model ward developed and agreed by all the staff now, it could be replicated. First of all the needed equipment was estimated and ordered. All the staff was adequately trained and oriented to the importance of health care waste management system before the system replication.

The first two wards for replication were the Male Surgical Ward and Post Operative. The system was implemented here in October 2010. As the replication proceeded, and staff became more familiar with the process, it was possible to replicate to several wards in a short period. In December 2010, 5 more wards and two non-medical units joined the system. Before system implementation, during training all the staff were properly trained and oriented about the importance of health care waste management system. This is more efficient and effective than training everyone at once, since it minimises the time between hospital staff receiving the training, and having to put it into practice. The HECAF staff also monitor the wards closely for several weeks after replication, so that any early problems are corrected without delay.

The second phase training was conducted for the staff of 5 wards including Sanjeevani and Receptionists was conducted on 29th November-3rd December, 2010, for both the nursing as well as support staff.

In 3rd phase of training, all the staff of all other remaining wards was trained 6th-17th March, 2011. This training did not include Out Patient Departments and Emergency. This training also includes both the nursing staff and support staff. Similarly the training included the session of Experience sharing of the Wards that has already health care waste management system implemented, so that the participants encouraged implementing and supporting the system which will enhance their attitude towards the system.

The Oncology ward system was implemented on its own, because of its special circumstances. The cytotoxic and cytostatic drugs which are used that needed to be denatured before disposal- as discussed earlier. In May and June, the system was replicated to four more wards and in July, 5 joined the system simultaneously.

9 Current Project Status

9.1 Successes

By July 2011 the system had been implemented in all the inpatient units except Operation Theatres. The establishment of the model ward and its replication took a long time, partly as the HECAF team work as volunteers, and are not available full time. But as the replication proceeded, now HECAF is able to replicate 6 wards at a time. Similarly all the staff of the hospital are positive and happy with the system.

9.1.1 Recycling and bio-digestion

Recycling is one of the significant parts of the non-burn environmentally friendly waste management as well as the best way for the waste reduction so it was promoted from the beginning of the establishment of the system. Materials recycled include: several grades of paper and plastic, glass vials and bottles, aluminium and steel.

Approximately 34% of the total waste is now recycled. A significant proportion of what remains is food waste, which makes up 25% of the total waste stream. This is now being will be bio-digested using an anaerobic digester system. This will convert the food and other organic waste into slurry and generate biogas which can be used as a fuel.

Moreover, some of the non-recyclable plastic packaging waste is being used by patients in the burns unit to turn into bags, baskets, slippers and other useful items. This also acts as therapy for people with reduced mobility in their hands as a result of their injuries.

9.1.2 Genotoxic waste

The genotoxic waste are generated from the departments that treat the cancer patient during the cancer treatment. It included the waste item such as the saline bottles used, vials, IV sets etc which cause the genotoxic effect. The waste generated from the oncology ward includes special chemical waste i.e., the genotoxic waste which needs the special treatment.

Genotoxic wastes are highly hazardous. Its effect may be mutagenic, teratogenic and mutagenic. It is highly hazardous to the health of the individual and to the environment.

These drugs should not be landfilled or discharged into the waste water or sewerages. This waste should be disposed in a safe manner. The disposal options for the genotoxic waste may be i) Incineration at high temperature and ii) chemical degradation. Since HECAF is promoting for the non- incineration technology, chemical degradation is the best option for the treatment of the genotoxic waste. Methods of detoxifying the drugs used in Bir were investigated (Roy *et al.* 2005, Pruess *et al.* 1999) and sodium hypochlorite was chosen. So, the genotoxic waste is being treated with 5% sodium hypochlorite solution, which is injected into the vials and saline bottles containing cytostatic or cytotoxic drugs and left for 24 hours to neutralise genotoxic materials.

9.1.3 Waste Disposal Costs

At the start of the project, the hospital was spending 36,000 Nepalese Rupees (almost USD 500) per month to have the waste collected for disposal in the municipal system. By July 2011, the amount of waste requiring collection has reduced by approximately one third, and the disposal cost has reduced accordingly- to 24,000 NRs (USD335) per month. It is anticipated to fall further now the anaerobic digester is in operation.

The hospital is earning approximately NRs 3 per bed per day, or 13 USD per bed per year, from the sale of recyclable waste.

Before the system was in place, the approximate waste collection costs were USD 6,000 per year. It is likely that this can soon be reduced to half, or USD 3,000 per year. Assuming that the level of waste sales remains the same, and there are 460 beds in the hospital, then the waste sales will generate around USD 6,000 per year.

The combination of reduced disposal costs and income will reduce the financial burden of maintaining the waste treatment system. The income is not expected to cover all the investment and operating costs of the new system, but it is still a cost effective system that provides excellent value and is not only treating the waste safely but has a number of other benefits to the hospital.

9.1.4 Improved Hospital Environment

Before the system was put in place, mixed medical and municipal waste was piled in the rear courtyard of the hospital, where is created an odour nuisance and attracted rats, cockroaches and other vermin.

After the implementation of the HCWM system in the wards, the staff reported that the number of rats in the hospital had been reduced by a large amount. They believe this is due to the health care waste management system. They reported that after the implementation of the system, the smell of the biodegradable waste has been reduced so the rat frequency has also been reduced.

The courtyard is used as a waiting area by patient's families. That space is now cleaner, clearer and more pleasant. .

9.1.5 Infection Control

During the HCWM system implementation emphasis is placed on the importance of the cleanliness of the buckets and medication trolley. Waste buckets are washed daily and trolleys are cleaned properly. The ward staff, especially the staff of the Male Surgical Ward reported that the infection rate has been reduced and the patients' stay in the ward has been decreased. This means the waste management system in the hospital has been contributing to infection control.

9.1.6 Reduction in mercury releases and exposure

It is estimated that 2.8g of mercury per bed can be released each year from broken thermometers, which would equate to over a kilogram of mercury per year. This would enter the air of the hospital and then the wider environment. Eliminating mercury thermometers reduces the exposure of the patients and staff and global mercury contamination.

All the mercury thermometers have been substituted by the digital ones and the sphygmomanometers have also been replaced by the aneroid one except in Cardio out-patients department where a mercury sphygmomanometer is being used. The doctors in this section will receive orientation in the near future and the complete elimination of mercury will be completed.

9.1.7 Protection from needle-stick injuries and related infections

The introduction of needle cutters will prevent used syringes from causing injury during disposal. In Nepal, syringes can also be bought by unscrupulous waste traders and repackaged, without sterilisation, for sale. Many hospitals in Nepal save money by asking patients to bring their own syringes and these second hand syringes, which are sold cheaply from market stalls and small pharmacies, are often bought by the poorest members of society.

Unsterilized syringes can not only spread blood-borne diseases such as hepatitis, but also cause abscesses and infections at the site of injection, so cutting the syringes will prevent unnecessary disease and suffering.

Even with these new measures, there will inevitably be some needle-stick injuries. The post exposure advice and prophylaxis system will help prevent these injuries resulting in infection.

9.1.8 Improved patient and staff attitudes/hospital reputation

In the past the hospital had a reputation for being dirty, which has been completely transformed. In the beginning of the system implementation in the hospital it was difficult to convince the staff of the importance of the system, but now they appreciate the system. Some of the ward staff have initiated waste management in their own homes. They have started segregation in their houses and begun to compost biodegradable waste.

The success of the treatment system has attracted a lot of attention and the reputation of the hospital has improved as a result.

The staff, patients and visitors are all satisfied with the system. Most of the patient and visitors had cooperated a lot during the segregation in the wards.

Similarly, as a result of the improved reputation of the hospital, different visitors from different governmental, non governmental and private institutions, hospitals, blood banks had also visited the waste management system of Bir Hospital and appreciated the system.

Different hospital has requested HECAF for the initiation of this work of waste management system. Hospitals like Norvic International, Kathmandu Model Hospital, Civil Service Hospital of Nepal had shown keen interest for the implementation of the waste management in their hospital and some had started the work on it.

9.2 Current Challenges

No system emplacement is without challenges, hence the need for an experienced team to support the hospital through the implementation phase of the project.

9.2.1 Autoclave problems

Two autoclaves were allocated for waste treatment. Unfortunately, though one has operated efficiently, the other has shown problems since the validation, despite service visits from the manufacturer's and supplier's engineers. However, the decision to install two smaller autoclaves, rather than one larger one, was taken partly to ensure that even if there were mechanical problems, it would still be possible to disinfect the waste.

As a result, the hospital has retained the ability to disinfect all its waste, by conducting two runs per day in the operational autoclave. The faulty autoclave will be replaced in the coming months, enabling the hospital the capacity to treat all its waste, with capacity to spare even after its planned expansion.

9.2.2 Food and Pathological waste

Food waste and the pathological waste from the Operation Theatres has become the challenge for HECAF for their management. So there is the need of the technology for the management of both the pathological as well as the food waste. Generally, food waste goes into the municipal waste. Too often in Nepal, the pathological waste does too; otherwise it may be burned or buried. Incineration is discounted on pollution grounds and burial is inappropriate for a large, city centre hospital. So, the bio-digestion of the biodegradable waste is proposed for the food and pathological waste.

Anaerobic digestion is a well-established technology for the disposal of food and other organic wastes such as sewage and animal manure.

Rastriya Gobar Gas Company is constructing a 25cubic metre bio-digestion plant underneath the rear courtyard of the hospital. It will convert the waste into solid compost, liquid fertiliser and a biogas which will be used as a fuel within the hospital.

The construction of Bio digestion plant has been completed and the food waste has been fed in the plant. The total project cost is around NRs. 5,19,000 (USD6300). Till now Ministry of Local Development, Solid Waste Management and Resource Mobilization Center has agreed

to contribute 3,00,000 and Biogas Support Program through the Biogas consultants has agreed to contribute 1,00,000. The remaining cost is to be collected.

9.2.3 Gauze and Cotton waste

All the waste that are generated from the wards and other units are recyclables and they can be converted into the cost. But the recycling options for the gauze and cotton waste could not be found and it can be degraded along with other biodegradable. So HECAF team has found the possible option for the gauze and cotton waste. The possible option is the vermicomposting. In this process, the earthworm of species *Eisnia foetida* is used for the composting process. The vermi-composting of the gauze and cotton waste is in testing phase, using autoclaved waste for safety.

It has been found that vermicomposting can be used for the treatment of infectious biodegradable waste and may be the source of different commensals like *Citrobacter freundii* and aerobic spore bearing microorganism usually found in the soil all over (Mathur *et al* 2006). So HECAF will also test the vermi-composting option for treatment of infectious gauze and cotton which may be one of the success of HECAF in HealthCare Waste Management if it succeeded.

10 Project completion

In the first year, the project has trained 350 staff and processed 20 tonnes of waste. Four tonnes of infectious waste has been rendered harmless and 8 tonnes of waste have been recycled.

In the next phase of the replication all the units in Emergency and Out Patient Department (OPD), administration offices, maintenance, and stores will be covered. In this phase the system will be completed and each and every waste generating section will have the waste management system.

A bio-digestion plant has been constructed. It is being fed with food waste and biogas generation is beginning. Tests with pathological wastes are planned.

Once all parts of the hospital are covered, the system will be handed over to the hospital, with HECAF continuing to monitor regularly. Each year, the system should handle over 79 tonnes of waste, 15 tonnes of it infectious. 43 tonnes of recyclables should be sold and another 21 tonnes will be bio digested.

A full report will be published including full data analysis and the results of a cost benefit analysis.

11 Future concepts for Kathmandu/Nepal

Safe health care waste management in Bir Hospital has become the model for the country and may be the motivator for other hospitals of the country. Many hospitals have shown keen interest in waste management systems in their hospitals. The system of Bir Hospital can be replicated in other hospital.

Moreover the hospital has the potential to treat waste from other places- ambulances and local clinics, which do not have the space or resources to have a complete waste treatment centre like Bir.

11.1 Initiation of Academic Centre

Students from different medical colleges visited the hospital for the observation of the health care waste management system as a part of their curriculum. The team of students of Public health also visited and appreciated the system. Thus, Bir hospital is planning to build as an academic centre for health care waste management.

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