An Analysis of Medical Waste Management Practices During and After Covid-19: A Case of B&C Hospital, Nepal

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Abstract

During COVID-19, Nepal witnessed an increase in the generation of highly infectious waste, including contaminated needles, syringes, soiled bandages, and disposable personal protective equipment. The study aims to assess the waste management practices at B&C Hospital and evaluate the awareness level of various hospital personnel through a questionnaire involving 105 and 200 respondents during and after COVID-19 in B&C Hospital, Jhapa, Nepal. This Study shows that hospital practiced source segregation and disinfection using chemicals and autoclaves, both during and after COVID-19. While 100% of doctors and administrative staff were aware of waste management, the awareness levels among visitors were comparatively lower, 52% during COVID-19 and 80% after the pandemic. Regarding the practice of color-coded waste segregation, 85% and 100% of respondents confirmed its implementation during and after COVID-19. The study was conducted over two periods: March 13 to July 14, 2021, and July 1 to December 31, 2024. The maximum degradable waste generation during COVID-19 was recorded in March at approximately 3.17 kg/day whereas after COVID-19 the highest degradable waste was observed in October reaching 11.6 kg/day. The hospital's total waste generation during COVID-19 was estimated at 151.9 kg/day, comprising 65% non-hazardous and 35% hazardous waste. Post-COVID-19, the total waste generation increased to 483.5 kg/day with 72% classified as non-hazardous and 28% as hazardous. Based on these findings, it is recommended that B&C Hospital strengthen its regulatory measures for waste management and explore the implementation of appropriate waste-to-bioenergy technologies to enhance sustainability and environmental safety.

Introduction

Medical waste, which is hazardous and contagious, has increased due to the expansion of several hospitals (Chaudhary *et al.*, 2014). The number of healthcare facilities in cities is rapidly expanding. Nepal has 6,934 public and private healthcare facilities (Department of Health Service Facilities Nepal, 2017). Hospitals, primary health care centers, health posts, urban health centers, community health units, and other health facilities are among the 816 public health services establishments in Koshi province. The manufacture of vaccines to stop the pandemic from spreading has negative

impacts on the environment and results in a global energy deficit (Klemevs *et al.*, 2021). Additionally, it is expensive to create equipment for distribution and storage demands, particularly in developing nations. Therefore, it is crucial to have a system in place for handling and categorizing medical supplies and waste during the pandemic (Van Fan *et al.*, 2021). As a result of COVID-19's global spread, death rates have gone up (WHO, 2020). Personal protective equipment is an effective choice for safeguarding both healthcare workers and the public from COVID-19, as the virus's characteristics remain uncertain, and developing solutions requires significant time and resources (Cook, 2020).

Nepal's 2011 Solid Waste Management Act sets up a regulatory framework. It provides guidelines for handling healthcare waste which primarily focuses on establishing an organized and effective approach to solid waste management by reducing waste production at the source and encouraging reuse, processing, and safe disposal. Moreover, it aims to protect public health and the environment by lessening the negative impacts of solid waste on the ecosystem (NLC, Solid Waste Management Act, 2011). The amount of waste generated in healthcare facilities depends on various factors, such as the waste management practices in place, the type and specialization of the facility, the use of reusable items, and the proportion of patients treated on a day-care basis (Eleyan, 2013). According to WHO (2017), approximately 15% of waste in healthcare facilities is hazardous, while 85% is general waste. Unlike all developing countries, in Nepal, hospital waste management has not been given sufficient attention. The current state of hospital waste management in Nepal is unsatisfactory, as safe practices for handling, storing, and disposing of waste are not effectively implemented (NHRC, 2002).

Global practices and medical waste management Trends on COVID-19

COVID-19 continues to impact the world, and approximately a year after the pandemic, there were 233,503,524 confirmed cases and 4,777,503 deaths, resulting in a case fatality rate of 2.0 as of October 1, 2021 (WHO, 2021). The number of infections has surged by over 1800% within a year, increasing from 5 million in March 2020 to 22 million in August 2020, 95 million in January 2021, and over 234 million by October 2021, with no indication of reaching its peak (Van Fan *et al.*, 2021). As the world's largest producer of medical waste, the United States generates over 3.5 million tonnes annually (Lee *et al.*, 2004), which increased to more than 6 million tonnes per year (Laura, 2020). Globally, nearly 3.4 billion single-use face masks and shields are discarded daily (Benson *et al.*, 2021). Additionally, COVID-19 PCR testing has generated 15,000 tonnes of plastic waste, 97% of which was incinerated (Celis *et al.*, 2021).

COVID-19 Pandemic and Waste Management

The COVID-19 pandemic has burdened the government and healthcare providers to manage this issue to ensure public health and safety and to prevent this crisis into a disaster (UNEP, 2020). During this COVID-19 pandemic, many types of infected waste are generated with large volumes of non-infected waste. To achieve this, healthcare workers and waste collection workers need to be protected because they are the most vulnerable part of

the population who are exposed to infection. Therefore, safe handling and final disposal of waste are vital elements in the COVID-19 crisis (Nzediegwn *et al.*, 2020). According to Nepal's 2014 waste management guidelines, all healthcare facilities in Nepal need to follow safe waste management practices efficiently within healthcare settings. Along with this, healthcare personnel and waste handlers need to wear personal protective equipment while handling COVID-19 Waste (Healthcare Waste Management guidelines-2014).

Materials and Methods

Study site: B&C Hospital

B&C Hospital is located in Birtamod municipality of the Jhapa district in Nepal with a latitude and longitude of 26.6454° N, 87.9976° E. The hospital used to have 206 beds during COVID-19, at present it has 300 beds capacity. The hospital provides a wide range of services, including a blood bank, cafeteria, 24-hour emergency care, diagnostic and curative treatments, laboratory testing, pharmacy, and radiology services. A huge number of people were affected by the first and second waves of the pandemic and their exposure to healthcare waste, an investigation was conducted at the hospital to assess the current levels of healthcare waste generation and the existing waste management practices during COVID-19 and after COVID-19. The study area of the B&C hospital is shown in Figure 1.

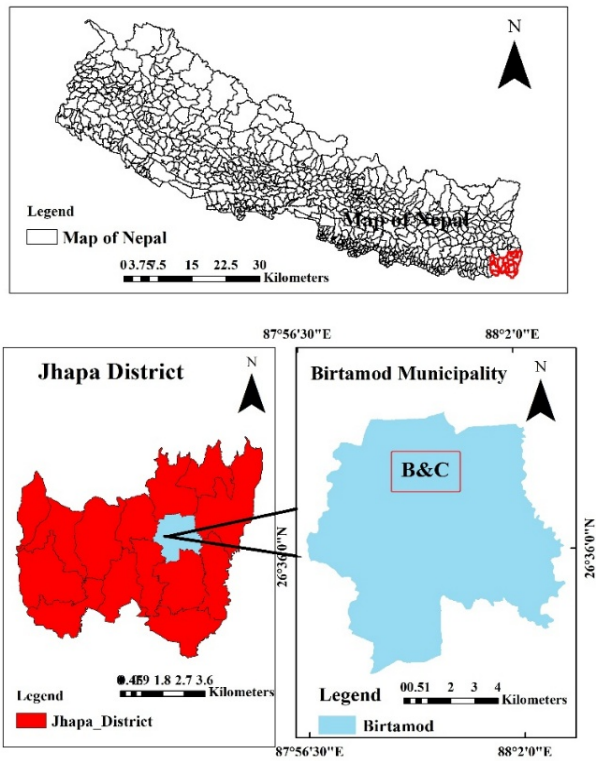

Fig. 1. Location map of the study area showing Districts and Municipality.

Data Collection

Data were collected by weighing the waste, analytical questionnaire surveys, and interviews with hospital staff, visitors, and patients to determine the average waste production and its composition, the hospital was visited regularly from March 13 to July 14, 2021, and July 01 to December 31, 2024. The waste production of each day was weighed. The questionnaire survey aimed to evaluate waste disposal techniques and assess the awareness of healthcare personnel regarding these practices.

A simple Random Sampling Method was applied in this study. A structured questionnaire was used among 105 (73 males and 32 females) during COVID-19 and 200 (140 males and 60 females) after COVID-19 among doctors, nurses, administrative staff, visitors, and patients. The questionnaire focused on participants' demographic profiles, types and sources of hospital waste, the volume of waste generated, and waste management methods. Responses were collected through interviews and questionnaires. Additionally, informal discussions were held with patients, outpatients, visitors, and hospital staff. The collected data were analyzed to address key issues related to hospital waste management, particularly waste generation from various sources. Simple descriptive statistics were used to analyze questionnaire data, while qualitative analysis of healthcare waste management practices was presented narratively. This method was considered for the qualitative abstraction of present hospital waste management practices.

Results and Discussion

Level of Awareness

Managing biomedical waste is a delicate process that demands a high level of preparedness (Gao *et al.*, 2018). However, studies reveal insufficient awareness among key individuals-such as cleaners, laborers, patients, and visitors regarding the challenges of hospital waste management during COVID-19 whereas the awareness level has increased after COVID-19. Well-structured training is essential to understanding health, safety, and environmental issues (Singh *et al.*, 2018). Workers must know and understand the risks associated with healthcare waste (Joshi *et al.*, 2013). Awareness of hospital waste management was evaluated, including hospital staff, inpatients, outpatients, and visitors. The data indicated that during COVID-19, 70% and after COVID-19, 92% of participants had a positive attitude toward waste management. Regarding color coding, 86% and 100% of respondents acknowledged the use of separate-colored bins for waste disposal during COVID-19 and after COVID-19. Additionally, 87% and 97% agreed that medical waste segregation takes place in waste storage areas disposal during COVID-19 and after COVID-19. However, very few participants were aware of government guidelines on waste management. Encouraging this positive attitude, alongside workshops and training programs, can contribute to creating a safer and healthier environment in the future (Almuneef *et al.*, 2003). The hospital waste management awareness is given in Table 1.

Table 1. Hospital Waste Management Awareness during COVID-19 and after COVID-19.

Type	No of respondent		Awareness (%)		Color coding (%)		Segregation of medical waste (%)	
	During	After	During	After	During	After	During	After
Doctor	10	10	100	100	100	100	100	100
Nurses	18	11	55	100	100	100	100	100
Administrative staffs	5	2	100	100	100	100	100	100
Cleaners/Sweepers	16	11	62	100	68	100	81	100
Security guards	3	2	66	100	100	100	100	100
Patients	11	104	54	86	66	100	72	89
Visitor	42	60	52	80	64	100	57	74

Waste Handling

Healthcare waste management poses a significant challenge for hospitals and medical institutions across Nepal. Inadequate knowledge and improper handling of biomedical waste can have severe health and environmental consequences (Sutha, 2018). Many workers lack specialized training on infectious diseases associated with biomedical waste. According to the survey, most waste collectors opted for this job due to limited employment opportunities and to meet their basic needs. The study revealed that 98% of workers reported wearing gloves and masks during 2021 and 100% in 2024 while handling biomedical waste. It was observed that there is a segregation of different types of healthcare waste, which helps minimize technical issues and reduces the risk of human error leading to the mixing of different waste types (Singh *et al.*, 2018). Color coding provides a visual indication of the waste's potential risks, while the containers are in the facility of waste origin and after they have been transported elsewhere (Maryam *et al.*, 2016). At B&C Hospital, four separate-colored bins are used to segregate biodegradable and non-biodegradable waste during COVID-19 whereas three different colored bins are used after COVID-19. The various types of waste collected in color-coding waste bins are presented in Table 2. However, waste containing high levels of heavy metals, such as batteries and pressurized containers, is not managed effectively. The (MoHP, 2014), it is highly emphasized that all generated waste should be separated into different labeling color code bins. However, there is no standardized system for applying color coding across healthcare facilities, allowing variations in implementation (MoHP, 2014). The different types of color-coding bins during and after COVID-19 are shown in Figures 2a and b.

Table 2. Color coding for collection of hospital wastes during COVID-19 and after COVID-19.

Type	Waste Material (during COVID-19)	After COVID-19
Red	Blood, and blood products	Infectious, vials and syringes
Blue	Ampoule	Non-degradable waste
Green	Infectious Needle, Degradable waste	Degradable waste
Light Green	Vials and Syringe	-

(a) 

(b) 

Fig. 2. Different types of color-coding bins during (a) and after (b) COVID-19.

Waste generation by patients

The increasing generation of healthcare waste has posed significant challenges in managing medical waste effectively (Sutha, 2018). During our field survey, it was observed that patients generate various types of waste, including paper, blood-stained textiles, cotton pads, glass and plastic bottles, cans, foods, fruits, and vegetables, as well as pathological and infectious waste. The waste generation rate is divided into seven different types of waste at B&C Hospital. During COVID-19, the highest average patient flow was recorded in March at 147 patients, whereas after COVID-19, the peak occurred in October with 79 patients, correlating with the highest waste generation that month. Degradable waste reached a maximum of around 3.17 kg/day in March and a minimum of 1.59 kg/day in May. In contrast, after COVID-19, the maximum degradable waste was observed in October at about 11.6 kg/day, with the lowest recorded in November at approximately 7.37 kg/day. The total waste generated by the hospital was estimated at 151.94 kg/day of which 65% was non-hazardous and 35% was hazardous during COVID-19, Similarly, the total waste generated by the hospital was estimated at 483.47 kg/day of which 72% was non-hazardous and 28% was hazardous. Table 3 presents the physical analysis of various types of waste (kg/day) generated in the hospital. Additionally, Figure 3 (a and b) illustrates the total hazardous and non-hazardous waste during and after the COVID-19 period, along with the total number of patients.

Table 3. Waste generation by patients during COVID-19 and after COVID-19.

	During COVID-19				After COVID-19						
Months (kg/day)	March	April	May	June	July	July	Aug	Sept	Oct	Nov	Dec
Average no. of patients	147	103	141	117	107	57	74	78	79	77	70
Degradable waste	3.17	2.63	1.59	2.38	3.07	8.07	7.68	7.67	11.6	7.37	7.89
Non-Degradable waste	1.32	0.77	0.89	1.13	1.12	2.98	3.67	3.05	4.59	3.36	3.27
Sharp	0.20	0.12	0.49	0.23	0.26	0.05	0.06	0.06	0.12	0.06	0.05
Hazardous	0.10	0.17	0.20	0.11	0.15	0.05	0.05	0.06	0.07	0.04	0.05
Vial	0.04	0.06	0.12	0.09	0.14	0.04	0.04	0.04	0.05	0.04	0.03
Pharmaceutical	0.07	0.08	0.18	0.07	0.18	0.18	0.12	0.11	0.10	0.12	0.11
Pathological	0.009	0.01	0.02	0.08	0.04	0.02	0.03	0.02	0.02	0.01	0.02

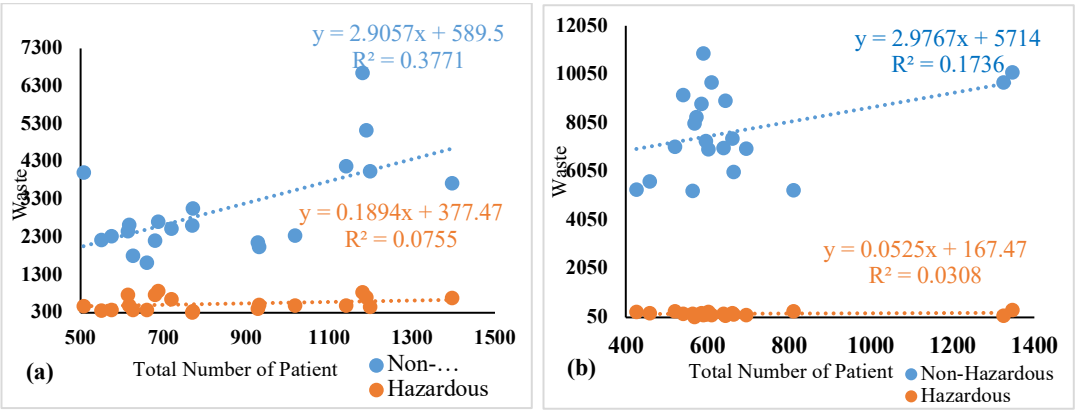

Fig. 3. Total patients with hazardous & non-hazardous waste during (a) & after (b) COVID-19.

Management of Waste Before and After COVID-19

The use of personal protective equipment, including gloves, masks, and face shields, has increased significantly to safeguard health in healthcare settings. An increase in demand for medical supplies (Kargar *et al.*, 2020) has directly contributed to the rise in medical waste. The increased usage of PPEs leads to a higher volume and density of medical waste (Singh *et al.*, 2020). PPEs, masks, gloves, and face shields are major contributors to the waste generated (Ilyas *et al.*, 2020). Medical waste such as contaminated masks and gloves, which are classified as hazardous, must be separated from regular domestic waste (Zambrano-Monserrate *et al.*, 2020). In addition to recycling, managing COVID-19 waste includes spraying waste bags with 1% sodium hypochlorite and storing the waste in a temporary storage area for over 24 hours. The checklist for managing before and after COVID-19 waste (Rhee *et al.*, 2020) and other waste management practices followed at B&C Hospital are shown in Table 4. Similarly, Figure 4 (a and b) illustrates temporary waste storage in B&C premises before disposal during and after COVID-19.

Table 4. Checklist to manage before and after COVID-19 waste in B&C Hospital.

Waste Management	Mode of Disposal	2021	2024
Personal Protection Equipment	PPEs should always be worn while handling and transporting waste from the designated area to the treatment zone.	Done	Not Done
	Safely remove PPEs and dispose if it is non-reusable and disinfect them if they are reusable.	Done	Not Done
	Staff should select appropriate PPEs to prevent the risk of infection and overuse of PPEs.	Done	Done
Waste Minimization	Waste Reduction at source	Done	Done
	Preference for recyclable and reusable items	Not Done	Not Done
Waste Segregation	Use separate color-coded bins to discard generated waste.	Done	Done
	Use double-layered waste bags.	Done	Done
	Dispose of sharps in the Puncture proof Container	Done	Done

Waste collection and labeling	Seal the bag before transporting	Done	Done
	Spray the bag with 1 % sodium hypochlorite solution before transporting it to the treatment zone or temporary storage point.	Not Done	Done
Waste Transportation	Place the waste bag in a closed trolley while transporting it to the treatment zone or temporary storage point.	Done	Done
	Disinfect the trolley and waste containers with 1% hypochlorite solution daily and after each use.	Done	Done
Waste storage	Waste should not be stored in the temporary storage area for more than 24 hours.	Not Done	Done
Waste Treatment	Treat the waste with an Autoclave, friction Heat system, or any other waste treatment technology.	Done	Done
	Treat for 60 minutes at 121 to 135 degrees Celsius	Done	Done
	If a treatment zone is unavailable within the healthcare facility coordinate with the waste treatment provider.	Done	Done
Waste disposal	Treated waste can be discarded as regular waste	Done	Done

(a)  (b) 

Fig. 4. Temporary waste storage in B&C premises during and after COVID-19 (a and b).

Waste Types and Generation Rate

The amount of waste generated in hospitals is influenced by several factors, including the number of beds, the types of healthcare services offered, the economic, social, and cultural status of the patients, and the overall condition of the surrounding area where the hospital is located (Amin *et al.*, 2013). Hospital waste can be categorized into general, infectious, and hazardous (Singh *et al.*, 2018). General waste is further divided into inorganic and organic types, neither considered infectious nor hazardous, while hazardous waste is classified into combustible, sharps, and non-combustible categories (Eleyan *et al.*, 2013). Infectious waste includes materials suspected to contain pathogens, such as used needles, gloves, drain tubes, cotton gauze, swabs, and body parts (Maryam *et al.*, 2016). During our field survey, it was observed that patients generate various types of waste, including paper, syringes, bandages, gauze, needles, and blades, in

addition to pathological and infectious waste. The data on the minimum and maximum waste amounts were analyzed to assess the quantities of degradable, non-degradable, sharp, hazardous, vial, pharmaceutical, and pathological waste, which are shown in Table 5.

Table 5. Statistical analysis of different types of waste during and after COVID-19

Month	Category	Mean	Minimum	Maximum	SD	Skewness	Kurtosis
During COVID-19 March	Degradable	656.15	3.23	1976.5	615.17	1.03	-0.04
	Non-Degradable	274.01	1.1	854.32	295.54	1.06	-0.54
	Sharp	42.4	0.1	88.12	28.35	-0.44	-1.16
	Hazardous	21.77	0.01	50.12	16.27	0.11	-1.14
	Vial	9.21	0.1	25.43	7.7	0.84	0.11
	Pharmaceuticals	9.76	0.11	31.54	7.18	0.95	2.94
	Pathological	1.92	0.01	7.43	2.54	0.92	-0.72
During COVID-19 April	Degradable	403.68	89.43	987.43	237.72	1.05	0.83
	Non-Degradable	119.14	41.45	232.13	53.96	0.56	-0.54
	Sharp	19.12	0.32	45.32	10.67	0.16	1.08
	Hazardous	16.47	1.98	32.54	8.91	-0.06	-0.44
	Vial	14.73	0.1	47.53	11.83	1.14	1.94
	Pharmaceuticals	12.49	1.24	34.32	8.25	0.69	1.23
	Pathological	2.37	0.01	11.43	3.26	1.56	2.001
During COVID-19 May	Degradable	246.93	3.21	987.65	221.52	2.02	4.29
	Non-Degradable	139.53	1.65	388.65	83.43	0.89	1.56
	Sharp	77.05	0.37	365.2	75.09	2.40	7.55
	Hazardous	31.39	0.12	111.21	26.46	1.20	1.99
	Vial	19.44	0.1	89.65	19.04	2.06	5.98
	Pharmaceuticals	28.06	0.25	176.21	38.85	2.62	7.64
	Pathological	3.55	0.01	15.32	4.88	1.42	0.75
During COVID-19 June	Degradable	308.54	0.84	986.54	259.59	0.66	0.11
	Non-Degradable	147.14	0.67	532.12	139.41	1.28	0.99
	Sharp	30.33	0.43	77.54	21.68	0.67	-0.27
	Hazardous	14.56	0.32	43.21	10.82	0.52	0.39
	Vial	12.05	0.11	33.21	9.56	0.5	-0.47
	Pharmaceuticals	10.26	0.2	28.43	7.65	0.46	-0.04
	Pathological	3.65	0.001	36.45	7.38	3.73	15.77
During COVID-19 July	Degradable	192.07	14.65	654.32	157.53	1.63	2.63
	Non-Degradable	76.21	5.23	213.54	52.65	0.97	0.59
	Sharp	16.28	0.83	65.43	16.01	1.99	3.75
	Hazardous	9.60	0.21	21.44	6.84	0.10	-1.22
	Vial	8.78	0.1	21.77	6.81	0.70	-0.44
	Pharmaceuticals	11.26	0.23	43.77	11.56	1.63	2.42
	Pathological	2.77	0.01	7.75	2.24	0.40	-0.50
After COVID-19	Degradable	632.64	435.43	785.43	86.80	0.27	-0.08
	Non-Degradable	233.85	168.55	301.5	29.80	0.24	0.39

July	Sharp	4.48	2.16	8.43	1.33	0.80	1.11
	Hazardous	3.94	2.45	5.32	0.81	0.17	-0.98
	Vial	3.46	2.43	5.98	0.87	1.63	2.81
	Pharmaceuticals	8.47	5.43	13.23	1.7	0.49	1.06
	Pathological	2.09	1.43	3.21	0.41	0.57	0.52
After	Degradable	568.32	345.54	785	124.04	0.24	-0.99
COVID-19	Non-Degradable	271.84	210	454	51.66	1.83	4.24
August	Sharp	5.01	3.54	6.55	0.83	0.18	-0.64
	Hazardous	3.88	1.54	5.78	1.17	-0.10	-1.008
	Vial	3.45	1.56	5.98	1.23	0.67	-0.68
	Pharmaceuticals	7.56	2.65	13.43	2.25	0.41	0.48
	Pathological	2.46	1.43	4.32	0.88	0.81	-0.26
After	Degradable	598.88	398.47	832.13	123.16	0.07	-1.07
COVID-19	Non-Degradable	238.54	167.56	321.43	45.80	0.04	-1.18
September	Sharp	4.86	3.21	8.53	1.17	0.95	1.82
	Hazardous	4.63	2.54	7.54	1.11	0.49	0.40
	Vial	3.38	1.32	5.98	1.20	0.55	-0.13
	Pharmaceuticals	8.66	2.65	14.32	2.75	-0.39	-0.19
	Pathological	2.04	1.22	3.55	0.55	0.72	0.55
After	Degradable	658.29	454	890	112.74	0.03	-0.28
COVID-19	Non-Degradable	259.97	155	385	52.29	0.55	0.09
October	Sharp	6.92	2.3	12.5	2.7	0.38	-0.44
	Hazardous	4.41	1.54	9.5	1.87	1.19	1.76
	Vial	2.94	1.45	6.25	1.13	0.98	1.08
	Pharmaceuticals	6.12	2.34	11.95	2.15	0.76	1.6
	Pathological	1.52	0.25	2.5	0.52	-0.04	0.45
After	Degradable	561.47	389.6	700.54	89.42	-0.17	-0.97
COVID-19	Non-Degradable	255.93	206.43	305.43	30.83	-0.12	-1.22
November	Sharp	4.56	2.33	6.45	1.13	-0.64	-0.48
	Hazardous	3.68	2.54	5.32	0.69	0.29	-0.47
	Vial	3.07	1.87	4.32	0.55	0.16	-0.34
	Pharmaceuticals	9.35	6.99	11.54	1.15	0.21	-0.41
	Pathological	1.48	1.02	2.44	0.43	0.95	-0.14
After	Degradable	587.48	389.6	735.45	79.54	-0.51	0.39
COVID-19	Non-Degradable	243.64	175.42	302.45	39.43	-0.39	-1.13
December	Sharp	3.93	2.43	5.65	0.83	0.39	-0.23
	Hazardous	4.006	2.13	7.54	1.24	0.95	1.22
	Vial	2.75	1.32	4.32	0.60	-0.07	1.41
	Pharmaceuticals	8.52	5.76	11.54	1.38	0.31	-0.07
	Pathological	1.81	1.02	2.55	0.42	0.06	-1.11

The various types of waste generated during and after the COVID-19 pandemic are illustrated in Figure 5 (a and b). During the pandemic, March experienced the highest levels of both degradable and non-degradable waste, 14,435.5 kg and 6,028.4 kg, respectively. In May, the largest amounts of sharp, hazardous, vial, pharmaceutical, and pathological waste were generated, i.e., 2,157.4 kg, 879.1 kg, 544.3 kg, 785.8 kg, and 98.76 kg, respectively. After COVID-19, October saw the highest amount of degradable waste, with a total of 20,407 kg. August produced the most non-degradable and pathological waste, at 8,427.2 kg and 76.3 kg, respectively. October also recorded the largest sharp waste, at 214.7 kg, while September generated the most hazardous waste (138.9 kg). July produced the most vial waste (107.5 kg), and November produced the highest pharmaceutical waste, with 280.7 kg.

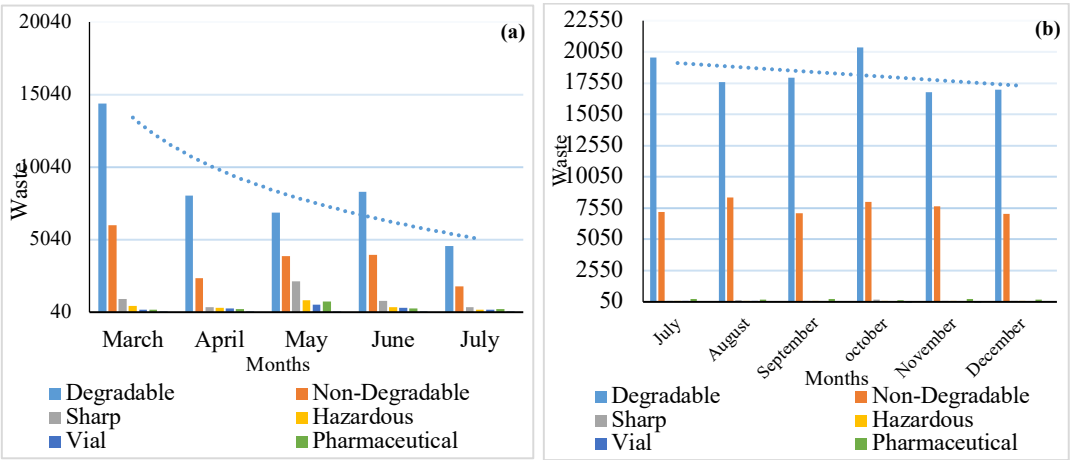

Fig. 5. Different types of waste generated in different months during (a) & after (b) COVID-19.

Waste Disposal Methods During and After COVID-19

Waste management is a challenge for healthcare institutions and policymakers (Amin *et al.*, 2013). At B&C Hospital, waste is sent to private companies called Niraakar Sarsafai Sewa Pvt. Ltd for waste disposal. The dumping site is situated along the Biring riverbank during COVID-19 whereas after COVID-19 company manages all the waste in landfill sites. As the waste is dumped so close to the riverbank, there is a risk that infectious waste could mix with the river water during high water levels, potentially spreading contagious agents throughout the river system (Joshi, 2013). It was also noted that the organic portion of the waste was mixed and buried along the riverbank during COVID-19.

Hospitals typically use burial, burning, and incineration methods for waste disposal (Almuneef *et al.*, 2003). Biomedical waste is primarily treated using autoclave technology, Hazardous waste, and biodegradable bags are directly fed into the incinerator. This method can release toxic air pollutants such as dioxins, furans, mercury, and lead, which pose risks to patients, hospital staff, and nearby communities (Maryam *et al.*, 2016). Given these

environmental concerns, an alternative to incinerators should be considered. Additionally, autoclaves are typically used for limited quantities of waste, especially highly infectious materials like microbial cultures or sharps during and after COVID-19. Autoclaving could be a better option for treating medical waste to reduce the volume that ends up in landfills (Liu *et al.*, 2013). Nepal lacks training or guidelines materials for emergency healthcare waste management, and there are no established quarantine facilities for disease control. Various government bodies, including the Ministry of Health, the Ministry of Federal Affairs, Local Development, the Ministry of Population and Environment (MoPE), and local health offices, are responsible for enforcing medical waste management regulations (WHO, 2017). It was also observed that the hospital lacks essential infrastructure such as a bio-gas plant and wastewater treatment plant, which are needed to convert waste into energy and protect the environment. The types of waste generated and their disposal methods are listed in Table 6.

Table 6. Mode of Waste disposal method during and after COVID-19.

Health-care waste	Mode of disposal		Remarks
	During COVID-19	After COVID-19	During & After COVID-19
Degradable waste	Dumped into a bank of Biring river	Dumped into landfill sites	Not according to the guideline
Non-Degradable waste	Dumped into the bank of Biring River deep below mixed with other waste.	Dumped into landfill sites and mixed with other waste.	Not according to the guideline
Sharp	Disinfected (Autoclave)	Disinfected (Autoclave)	Done as per the guideline
Hazardous waste	Incineration	Incineration	Done as per the guideline
Vial	Autoclave/Incinerate	Autoclave/Incinerate	Done as per the guideline
Pharmaceutical waste	Mixed with other waste in a sanitary landfill	Mixed with other waste in a sanitary landfill	Not according to the guideline
Pathological waste	Buried deep down	Buried deep down	Done as per the guidelines

Proposed Healthcare Waste Management Scheme

Hospitals and other sectors that generate harmful waste must ensure proper transportation and treatment to minimize its impact on human health and the environment. The Asian Development Bank emphasizes that medical staff do not know enough about the risks associated with improper hazardous waste disposal (Chaudhary *et al.*, 2015). As a result, the ADB recommends training healthcare personnel on safe waste disposal practices. Various treatment methods, including incineration, chemical, biological, and immobilization techniques, can be applied to hazardous waste. The proposed waste management framework for B&C Hospital is illustrated in Figure 6. Waste is typically categorized into degradable, non-degradable, hazardous, and non-hazardous

types. Recycling and proper disposal are critical stages in managing hazardous waste. Hazardous and infectious waste can be treated through incineration, while segregated general healthcare waste can be transported to disposal centers.

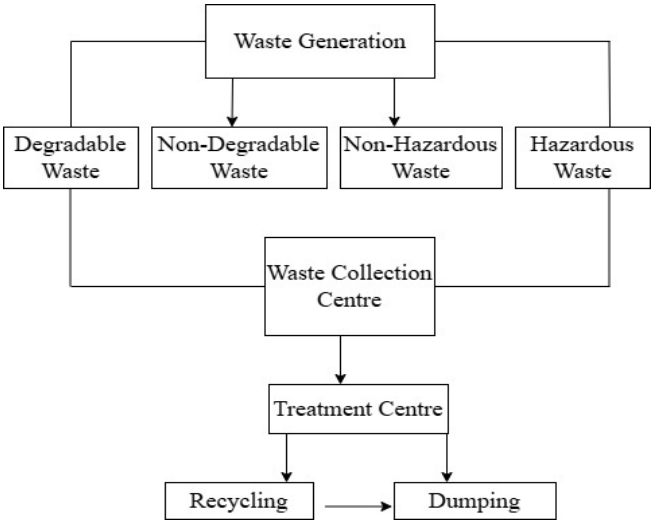

Fig. 6. Conceptual framework for waste management practices in B&C Hospital.

Conclusion

Healthcare waste management poses a significant challenge at B&C Hospital in Nepal. The findings indicate that factors such as a lack of awareness, inadequate policies and regulations, and the unwillingness of stakeholders contribute to improper waste management. Improper handling of medical waste, due to its toxic nature, can damage the environment and disrupt the balance of ecosystems. The results of this study show that the current waste management practices do not practice according to the recommended standards. There is a clear need for proper segregation of infectious and non-infectious medical waste. Furthermore, hospitals should establish clear plans and policies to ensure proper management and disposal of medical waste. It can be concluded that managing hospital waste requires an effective awareness program, along with knowledge, motivation, education, and collaboration from the community.

Based on the findings from the data surveyed, the following actions to improve hospital waste management at B&C Hospital are:

- Regular segregation of infectious and non-infectious healthcare waste.
- Implementation of awareness programs focusing on public health, safety, and environmental concerns, along with clear plans and policies for the proper management and disposal of infectious and hazardous waste.
- Installation of biogas and wastewater treatment plants at the hospital.
- The waste dumping site should be far from residential and river areas.

- Hospitals should search for efficient and environment-friendly technologies for the treatment of biomedical and hazardous waste.

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