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Medical waste management and impacts of biomedical wastes from hospitals in India– Review article

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Abstract
The article aims to review the medical waste management assessment, to analyze the sources of medical wastes, to examine the impact of medical waste, and to know about the various methods of disposal of medical waste. Safe handling, segregation, storage, subsequent destruction and disposal of hospital 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. Mismanagement of health care waste disposal cause dangerous infection and posses a potential threat to the surrounding environment, persons handling it and to the public. In the past, medical waste was often mixed with household waste and disposed of in municipal solid waste landfills. In recent years, increased public concerns over the improper disposal of health care waste have led to a movement to regulate the waste more systematically and stringently by the Indian government. Waste minimization and recycling are still not well promoted, which results in significant amounts.

Keywords: biomedical wastes (BMW), waste segregation and waste disposal

Introduction

Biomedical waste (BMW) differs from general municipal waste as it poses various health hazards. BMW management rules 2016 and the amendment rules 2018 are the latest guidelines from the ministry of environment, forest & climate change to regulate the handling of BMW activities in the country [1, 2]. Biomedical waste poses various health and environmental hazards. Hence, it should be handled with the utmost care and disposed off safely. Several lacunas exist in the management of biomedical waste in India. Untreated and improperly managed BMW is a potential source of infection [3]. The diligent handling and management of BMW can prevent the occurrence of hospital-acquired infection and lower the rates of disease transmission. In addition, the untreated or the rudimentary handling of BMW creates a nuisance and decreases patient satisfaction.7 According to the data published by the central pollution control board (CPCB) in the year 2018, the total amount of BMW generated in India is 517 tonnes/day in the year 2016 and around 501 tonnes/day in the year 2015, out of which around 4–5% remains untreated.8 The annual report 2018/2019 released by CPCB showed the generation of 557 tonnes/day BMW in 2017, out of which 517/day was treated. The country has a total of 238,170 healthcare facilities, out of which 87,267 are bedded while the remaining 151,208 are non-bedded healthcare facilities (HCFs) generating BMW. There are 198 approved common biomedical waste disposal facilities (CBMWFs) in the country and 28 are under construction.

Medical care is vital for our life and health, but the waste generated from medical activities represents a real problem of living nature and human world. Improper management of waste generated in health care facilities causes a direct health impact on the community, the health care workers and on the environment every day, relatively large amount of potentially infectious and hazardous waste are generated in the health care hospitals and facilities around the world. Indiscriminate disposal of BMW or hospital waste and exposure to such waste possess serious threat to environment and to human health that requires specific treatment and management prior to its final disposal.

Biomedical waste is generally extracted from hospitals, health care teaching institutes, research institutions, blood banks, clinics, laboratories, veterinary institutes and animal houses etc. In recent times the treatment and disposal of medical waste from hospitals has been of growing concern. The hazardous nature of these wastes spread deadly diseases to humans and living organisms. Medical wastes have been identified as the 3rd largest known source of dioxin air emission and 10% of mercury emission to the environment by the US environmental agency.

Bio-Medical Wastes

Bio-medical waste means “any solid and/or liquid waste including its container and any intermediate product, which is generated during the diagnosis, treatment or immunization of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps.

Biomedical waste poses hazard due to two principal reasons – the first is infectivity and other toxicity.

Bio Medical waste consists of

- Human anatomical waste like tissues, organs and body parts
- Animal wastes generated during research from veterinary hospitals
- Microbiology and biotechnology wastes
- Waste sharps like hypodermic needles, syringes, scalpels and broken glass
- Discarded medicines and cytotoxic drugs
- Soild waste such as dressing, bandages, plaster casts, material contaminated with blood, tubes and catheters
- Liquid waste from any of the infected areas

- Incineration ash and other chemical wastes

Sources of biomedical waste
- Hospitals
- Emergency care facilities
- Outpatient facilities, dialysis centers, transfusion centers, blood banks
- Clinical laboratories
- Research laboratories
- Mortuaries, death care facilities
- Veterinarians
- Nursing homes
- Doctor and dentist offices
- Oncology Clinics

Categories of Biomedical Waste
Hazardous health-care wastes
- **Sharps waste**: Used or unused sharps (e.g. hypodermic, intravenous or other needles; auto-disable syringes; syringes with attached needles; infusion sets; scalpels; pipettes; knives; blades; broken glass)
- **Infectious waste**: Waste suspected to contain pathogens and that poses a risk of disease transmission (see e.g. waste contaminated with blood and other body fluids; laboratory cultures and microbiological stocks; waste including excreta and other materials that have been in contact with patients infected with highly infectious diseases in isolation wards)
- **Pathological waste**: Human tissues, organs or fluids; body parts; fetuses; unused blood products
- **Pharmaceutical waste, cytotoxic waste**: Pharmaceuticals that are expired or no longer needed; items contaminated by or containing pharmaceuticals
- **Cytotoxic waste:** Containing substances with genotoxic properties (e.g. Waste containing cytostatic drugs – often used in cancer therapy; genotoxic chemicals)
- **Chemical waste**: Containing chemical substances (e.g. laboratory reagents; film developer; disinfectants that are expired or no longer needed; solvents; waste with high content of heavy metals, e.g. Batteries, broken thermometers and blood-pressure gauges)

Non-Infectious Hospital Waste
Noninfectious waste is broadly classified as kitchen waste and office wastes. It is similar to household waste. Non infectious wastes constitute nearly about85% to 80% of the total wastes generated from a health care unit. In absence of proper segregation, the noninfectious waste becomes infectious and poses environmental threat to the society.

Bio Medical Waste Management Rules, 1998 (Amended in 2000 and 2003)
Under the Environmental Protection Act, the bio medical waste management rules were introduced. These rules are directly relevant to the health sector. The salient features of these rules are as follows:
- Bio medical wastes means waste that is generated during the diagnosis, treatment or immunizations of human beings or animals or in research activities pertaining thereto or in the production or testing of biological.
- It is the duty of every occupier of an institution generating bio medical waste which includes a hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathological laboratory and blood bank by whatever name called to take all steps to ensure that such waste is handled without any adverse effect to human health and the environment, policies, legislation and regulations policy framework, March 2007.

Steps for Waste Management
- **Segregation**-Segregation refers to the basic separation of different categories of waste generated at source and thereby reducing the risks as well as cost of handling and disposal
- **Collection**-The collection of biomedical waste involves use of different types of container from various sources of biomedical wastes like Operation Theatre, laboratory, wards, kitchen, corridor etc. The containers/ bins should be placed in such a way that 100 % collection is achieved.
- **Storage**-Once collection occurs then biomedical waste is stored in a proper place. Segregated wastes of different categories need to be collected in identifiable containers. The duration of storage should not exceed for 8-10 hrs in big hospitals.
- **Transportation**-The waste should be transported for treatment either in trolleys or in covered wheelbarrow. Manual loading should be avoided as far as for as possible. The bags / Container containing BMWs should be tied/ lidded before transportation.
- **Personnel safety devices**-The use of protective gears should be made mandatory for all the personnel handling waste like gloves, aprons, masks and boots.

Treatment of Biomedical Wastes
There are mainly five technology options available for the treatment of bio-medical waste. They can be grouped as follows.
- Chemical processes
- Thermal processes
- Mechanical processes
- Irradiation processes
- Biological processes

Chemical processes
- These processes use chemicals that act as disinfectants. Sodium hypochlorite, dissolved chlorine dioxide, peracetic acid, hydrogen peroxide, dry inorganic chemical and ozone are examples of such chemicals. Most chemical processes are water-intensive and require neutralising agents.

Thermal processes
These processes utilise heat to disinfect. Depending on the temperature they operate, it is been grouped into two categories, which are Low-heat systems and High-heat systems
Low-heat systems (operates between 93 -177^{o}C) use steam, hot water, or electromagnetic radiation to heat and decontaminate the waste. Autoclave & Microwave are low heat systems.
- **Autoclaving** is a low heat thermal process and it uses steam for disinfection of waste. Autoclaves are of two types depending on the method they use for removal of air pockets. They are gravity flow autoclave and vacuum autoclave.
- **Microwaving** is a process which disinfects the waste by moist heat and steam generated by microwave energy.

High-heat systems: employ combustion and high temperature plasma to decontaminate and destroy the waste. Incinerator & Hydroclaving are high heat systems.

Mechanical processes

These processes are used to change the physical form or characteristics of the waste either to facilitate waste handling or to process the waste in conjunction with other treatment steps. The two primary mechanical processes are

a. **Compaction:** used to reduce the volume of the waste
b. **Shredding:** used to destroy plastic and paper waste to prevent their reuse. Only the disinfected waste can be used in a shredder.

Irradiation processes

In these processes, wastes are exposed to ultraviolet or ionizing radiation in an enclosed chamber. These systems require post shredding to render the waste unrecognizable.

Biological processes

Biological enzymes are used for treating medical waste. It is claimed that biological reactions will not only decontaminate the waste but also cause the destruction of all the organic constituents so that only plastics, glass, and other inert will remain in the residues.

Environment impact of biomedical wastes

The improper management in bio-medical waste causes stern environmental problems that causes to air, water and land pollution. The pollutants that cause damage can be classified into biological, chemical and radioactive. There are several legislations and guidelines in India concerning environmental problems, which can be addressed.

Improper segregation and disposal of biomedical waste has the potential to contaminate groundwater sources, which in turn may infect humans and animals alike. From a hospital's waste and storage receptacles to landfills, biomedical waste needs to be properly contained to keep it away from birds, rodents, and stray animals (as well as humans). This enhances packaging and labeling of contaminants and helps prevent the spread of illness through human and animal populations – by air, land, or water.

If not properly contained, segregated, and incinerated through on-site or off-site incineration, environmental hazards associated with improper healthcare waste management can contaminate the air we breathe through dangerous airborne particles. Radioactive particles produced with diagnostic technologies have the potential to reach a landfill or other areas of the environment, especially air. Air pollutants disseminated over huge areas of inhabited land have the potential to trigger a number of illnesses.

Health risks of bio medical wastes

Health-care waste contains potentially harmful microorganisms that can infect hospital patients, health workers and the general public. Other potential hazards may include drug-resistant microorganisms which spread from health facilities into the environment.

Adverse health outcomes associated with health care waste and by-products also include:

- Sharps-inflicted injuries;
- Toxic exposure to pharmaceutical products, in particular, antibiotics and cytotoxic drugs released into the surrounding environment, and to substances such as mercury or dioxins, during the handling or incineration of health care wastes;
- Chemical burns arising in the context of disinfection, sterilization or waste treatment activities;
- Air pollution arising as a result of the release of particulate matter during medical waste incineration;
- Thermal injuries occurring in conjunction with open burning and the operation of medical waste incinerators; and
- Radiation burns.

Sharps-related

Worldwide, an estimated 16 billion injections are administered every year. Not all needles and syringes are disposed of safely, creating a risk of injury and infection and opportunities for reuse.

Injections with contaminated needles and syringes in low- and middle-income countries have reduced substantially in recent years, partly due to efforts to reduce reuse of injection devices. Despite this progress, in 2010, unsafe injections were still responsible for as many as 33 800 new HIV infections, 1.7 million hepatitis B infections and 315 000 hepatitis C infections.

A person who experiences one needle stick injury from a needle used on an infected source patient has risks of 30%, 1.8%, and 0.3% respectively of becoming infected with HBV, HCV and HIV.

Additional hazards occur from scavenging at waste disposal sites and during the handling and manual sorting of hazardous waste from health-care facilities. These practices are common in many regions of the world, especially in low- and middle-income countries. The waste handlers are at immediate risk of needle-stick injuries and exposure to toxic or infectious materials.

In 2015, a joint WHO/UNICEF assessment found that just over half (58%) of sampled facilities from 24 countries had adequate systems in place for the safe disposal of health care waste

Review of Literature

In the literature, there are only a few analytical studies closely to health care waste management in India level.

Sharma *et al*., (2004) [4] directed an investigation on the theme 'Squander: Attitude and activities'. This review was directed to learn the mentality, practice and information on clinical staff in a medical clinic in New Delhi. Santappa (2002) [5] says that waste handlers and the community that lives in the proximity are at risk of contacting communicable disease arising due to improper handling of hospital wastes. Skin contact, injection and inhalation are possible routes of exposures which could cause chronic effects and acute problem. Containers and plastic materials, likely to be salvaged by scavengers may spread communicable disease in case they are not properly sterilized before recycling or reuse.

Gupta (2006) [6] study observed that the personnel working under the occupier were trained to take adequate precautionary measures in handling these bio hazardous waste materials, the process of segregation, collection, transport, storage and final disposal of infectious waste was done in compliance with the standard procedures, the final disposal was by incineration in accordance to Environment Product Act Rules 1998, the non-infectious waste was collected separately in different containers and treated as general waste, and on an average about 520 kg of non-

infectious and 101 kg of infectious waste is generated per day about 2.31 kg per day per bed, gross weight comprising both infectious and noninfectious waste. This hospital also extends its facility to the neighboring clinics and hospitals by treating their produced waste for incineration.

Kaiser *et al*., (2001) [7], referenced that emergency clinic squander is sub-isolated into health care general waste (HCGW). The health framework is feeling the squeeze to discard health care squander so as to stay away from pointlessly undeniable degrees of ecological corruption. The point of health care offices overall is starting to buy in to the social objectives of a cleaner and more secure climate. To oversee health care squander ideally, health care suppliers ought to consider all stages or entire life pattern of the clinical item by taking a gander at the clinical item's upstream and down-stream activities.

Mumtaaz hussain *et al***.** [8] studied that lack of knowledge and awareness regarding hospital waste among patients and more chances are there for infectious disease due to improper handling and disposal of hospital waste at DHQ hospital dera ghazi khan there was a pose risk for the patient's health. Anitha pandey [9] Study have a overview on bio medical waste management in a tertiary care hospital it was clear that bio medical waste management was lacking 30-35% health care personal and they suggested to develop the policy to meet the current requirements. The help will be educated about the change in the policy and the same will be implemented after taking permission from the hospital management committee.

Health Care Waste in India In India, there are about 6,00,000 hospital beds, over 23,000 Primary Health Centers, thousands of registered nursing homes, countless unregistered nursing homes and dispensaries, and above all a very large number of quacks practicing at every nook and corner of urban and semi-urban locality. The hospitals are tertiary care hospitals usually associated with teaching colleges, district hospitals (more than 2,000), and health care dispensaries. There are innumerable pathology laboratories, the data of which is hardly available [10]. According to health information statistics 20% of total beds are in rural hospitals while 80% are in urban hospitals. Extrapolating from past figures of number of beds and average quantity of waste generation at the rate of 1 kg per bed per day, it is estimated that about 0.33 million tonnes of hospital waste is being generated per year [11]. In India, with exception to a few large hospitals, most of the smaller hospitals and nursing homes lack any effective system to safely dispose off their waste. Even the Government and municipal hospitals are no better than the private nursing homes in this regard. Wastes generated during health services provision, the used bandages, syringes, human tissues, used culture media containing microorganisms are dumped in the open bins on the roadsides or low lying area or directed into the water bodies. Thus, an unauthorized reuse of medical wastes by rag pickers is being promoted through irresponsible dumping of these dangerous wastes into open bins [12] and in turn facilitates in spread of many diseases. World Health Organization (WHO) predicted that India is on the verge of having an HIV epidemic. Tuberculosis (TB) and HIV combined together is taking great toll on the human health and life. Hepatitis B and C infections are on the rise. Mortality due to Hepatitis C has gone up significantly [9]. A study conducted by the Central Pollution Control Board (CPCB), an apex pollution monitoring body of Government of India, on incinerators in Delhi Hospitals, concluded that the incinerators were found to spew a high level of deadly residues and toxic emissions such as cancer-causing dioxins and furans besides chemicals which cause neonatal abnormalities, reproductive and skin disorders, endocrine disruption and suppression of the immune system [13]

Present scenario of hospital wastes

In India, hospital wastes generate around 3 million tones every year and the amount is expected to grow at 8.00 per cent annually. Health care wastes if not handled and disposed indiscriminately may cause adverse effects on human health and environment. According to the available Out of 84,809 health care establishments, 43,075 authorizations have been generated by SPCBs for management of bio medical waste. Out of 420461 kg/day of waste generation, only 24 0682 kg/day of waste is treated. Out of 84,809 hospitals, 48,183 hospital are either using common bio medical waste treatment facilities (which are 170 in Numbers) or have engaged private agencies.

There are 391 incinerators (with APCB), 2562 autoclaves, 458 microwaves, 145 hydroclaves and 6047 shredders in operation. Further, 14,959 hospitals have been served as show cause notices as defaulters. Surveys carried out by various agencies show that the health care establishments in India are not giving due attention to their waste management. After the notification of the Bio medical Waste (Handling and Management) Rules, 1998, hospitals are slowly streamlining the process of waste segregation, collection, treatment, and disposal.

Challenges to Waste Management Practices In Indian Health Care Sector

Lack of Segregation Practices

Segregation practice prevents non-infectious waste to get mixed with infectious waste. Lack of segregation practices significantly increases the quantity of infectious medical waste as mixing of infectious component with the general non-infectious waste, makes the entire mass potentially infectious [14]. There is inadequate practice of segregation of the waste starting from generation to disposal as seen in Indian hospitals. Even if the segregation of waste at the point of generation is effective, waste handlers are found mixing it together during the collection and results in loss of ultimate value of segregation [15].

Lack of Proper Operational Strategy

Operational plans should include the location and capacity of the storage containers, frequency of collection for various types of wastes and schedule of activities. Infectious wastes are to be stored in the designated colour-coded leak-proof containers for safe handling and can be disinfected / sterilised by the available facility in the hospital. Transportation of waste within the hospital is to be carried out in closed handcarts to avoid spillage of waste to a disinfection or treatment facility. After disinfection/sterilisation the waste is transported to a common treatment facility, such as an incinerator or controlled landfill [16]. In Indian hospitals wastes are collected in mixed forms, transported in open carts thus allowing spillage to occur [15], and waste sharps are discarded without disinfection and mutilation, which may result in their being, re-used thus spreading an infection [16].

Poor Regulative Measures

In India, Central Pollution Control Board and the State Pollution Control Boards, the agencies responsible to enforce these rules in hospitals are on one hand lacking adequate power and on the other hand there is no commitment. As a result, most of the large hospitals have not complied with these rules even after expiry of new deadlines [12]. Even the regulatory authorities have to take the blame for not doing enough to ensure implementation. There is lack of coordination between the regulatory authorities (pollution control boards/committees) and Department of Health who exercise functional control over all healthcare facilities in one way or the other; and lack of will to enforce implementation. No agency has been assigned the task of spreading awareness [10]. Moreover the Rules have not been publicized as widely as required.

Lack of Green Procurement Policy

Personnel responsible for procuring health care products and services (materials managers or purchasing agents) come from varying backgrounds. Environmental background or training is not a prerequisite for the individuals responsible for securing health care products and services. Waste minimization can be achieved by purchasing reusable items made of glass and metals which can be disinfected and reused [11]. For example, a polyolefin intravenous (IV) bag does not contain chlorine, so it has less potential to produce dioxins through incineration than an IV bag containing polyvinyl chloride (PVC) [17]. Similarly mercury thermometers can be replaced with mercury free thermometers. Health care units should stimulate the purchase of environmentally preferable products by mandating certain practices in their purchasing policy

Waste-picking and reusing

Reuse of plastic syringes and other plastic material used in the health care is a thriving business of billions of Indian Rupees. More than one million people are engaged in rag picking (more than 100,000 in Delhi alone). The estimated figure of business on this score in Delhi alone is more than 50 million Indian Rupees per year [10]. Lucrative monetary returns and lack of awareness about the problems associated with biomedical wastes encourage waste-picking and reusing activities [13]. It would not be fair to blame the rag pickers only for this as the circle of connivance starts from the hospital staff itself. It thereafter goes to the waste handlers, then to the rag pickers, to the packaging outlets situated in a decrepit area of a 'basti (slum)', to the medical shop, and finally sold to the unsuspecting patients or their relatives [10].

Lack of Top Management Commitment

Governments and the health care providers have gone in for one type of option for treatment of the waste. No health care provider wants or has undertaken a base line survey to collect data regarding quantum of waste and its type being generated, nor about the waste generation points in its premises. Budgetary support 64 is poor in the government run hospitals, the corporate hospitals and the nursing homes. Therefore they find it convenient to ignore the rules for monetary consideration [10]. Top management in most of Indian hospitals is showing inertia in dealing with the waste problem. The wastes are therefore instead of being segregated, discharged in a mixed condition to the site of disposal, separating only the saline bottles, which are sent for auctioning [15].

Lack of Adequate Facilities

Efforts to provide facilities for storage, collection, treatment and disposal of health care wastes as well as appropriate technologies have so far been limited in India. Additionally, adequate and requisite number of sanitary landfills is lacking in India. Therefore, the biomedical waste are openly dumped into the open bins on the road sides, low lying area or they are directed into the water bodies; through which severe disease causing agents are spread into the air, soil and water [12]. Self-contained onsite treatment methods may be desirable and feasible for large healthcare facilities but are impractical or uneconomical for smaller institutes. An acceptable common system should be in place which will provide free supply of colour coded bags, daily collection of infectious waste, and safe transportation of waste to offsite treatment facility and final disposal with suitable technology [18]. Moreover available disposal techniques are neither able to meet disposal requirements nor innovations in disposal options are in pace with the evolution of complexity of health care waste streams.

Lack of Institutional Arrangements

Management of health-care waste depends on the input from the administration and active participation by trained staff in segregation, storage, collection, transportation, treatment and disposal. In India personnel responsible for these activities are mainly ward attendants and other supporting staff [10]. A committee consisting of the head of the establishment, all the departmental heads, hospital superintendents, nursing superintendents and hospital engineers should be formed with a waste management officer who would be advised by an environmental control advisor and an infection control advisor is required for proper waste management purposes [11]. Studies showed lack of such kind hospital waste management committee or a documented waste management and disposal policy in Indian hospitals [15].

Financial Constraints

With dedicated systems being installed in most of the HCUs, financial provision is necessary for capital and recurring expenditure including funds for sufficient manpower, disinfectants, devices and equipment. Normally, a separate allocation of funds for waste management is not found in Indian hospitals. It is estimated that INR 3000–4000 (US$ 70–93) per tonne of hospital waste is required [11]. Additionally funds are required for conducting training and awareness programs for health care staffs. Smaller HCUs ignore waste management practices due to financial constraints [18].

Inadequate Awareness and Training Programs

Awareness of appropriate handling and disposal of health-care wastes among health personnel is a priority; it is essential that everyone should know the potential health hazards. Regular programs will help prevent exposure of health-care wastes and related hazards. Poster exhibition, proper labeling, and explanation by staff are effective methods. Seminars and workshops, and participation in training courses are also essential [12]. Management in most of Indian hospitals is not aware of cost savings achieved due to good waste management practices. It has also been estimated that disposal savings of between 40% and 70% could be realised through the implementation of a healthcare waste reduction program [19].

Reluctance to Change and Adoption

Though now alternative technologies are permitted as per the Biomedical Rules, it takes a long time to change the mindset of the people. Even now most of the health care providers and decision making authorities talk of incinerator only although autoclaves and other advanced waste handling equipments are available. Indiscriminate throwing of the waste is still seen in most of the hospitals and the waste handlers still are without protective clothing and gears. There is hardly any change in the applied knowledge and awareness seen in Indian hospitals [10]. Inadequate Pressure from Societies

65 Previous studies show that pressure from various Environmental advocacy groups forces, organizations to seriously think about their environmental management programs [20] which is lacking in case of Indian organizations. There is no doubt in the mind of any educated or enlightened person that improper hospital waste management is the source of many communicable and infectious diseases. But when it comes to doing anything there is a complete lack of will, and there is a lackadaisical attitude towards the problem [10].

Conclusion

Hospital Management must understand the gravity of the issue and they must be able to differentiate between hospital waste and general waste. They must ensure proper identification, segregation at the source of generation, collection in prescribed colour containers, safe transportation, appropriate treatment and environmentally sound disposal of Bio-Medical Waste. They should also provide health education and training of everyone involved in the management and handling of Bio-Medical Waste. Last but not the least is effective implementation of rules by surprise visits and inspection by appropriate authorities and fixing the accountability of each and every person involved in management of Biomedical Waste. If Hospital Management wants to protect our environment and health of community Hospital Management must sense us to this important issue not only in the interest of health managers but also in the interest of community.

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