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Green Hospital Initiative by a North Delhi Tertiary Care Hospital: Current Scenario and Future Prospects

Microbiology Section

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ABSTRACT

Introduction: Climate change is likely to affect all forms of life. Healthcare professionals and planners are gearing up to shoulder responsibility to mitigate climate change. The present study was undertaken to explore the journey of our hospital towards becoming a climate friendly green hospital.

Aim: To study the progress made by our institute towards becoming a climate friendly green hospital based on seven directives of World Health Organization's (WHO) discussion draft on climate change.

Materials and Methods: A retrospective observational study was conducted from January 2013 to December 2017 by the Departments of Biomedical Waste management (BMW) and Public Works Deprtment (PWD) to analyse hospital's journey towards becoming a green hospital. The observation was made in line with the 7 WHO directives related to climate change and compared over the years.

Results: It was observed that in the past five years there have been several initiatives taken by the hospital with intent to improve energy efficiency like replacement of halogens and Compact Fluorescent Lamps (CFL) with Light Emitting Diodes (LED), diesel with Compressed Natural Gas (CNG) as fuel for boiler in laundry. For conservation and effective utilisation of resources, solar water heating system and seven rain water harvesting systems have been installed. Efforts have been made towards waste minimisation and efficient management with a sewage treatment plant for management of liquid waste and BMW management and recycling as per the guidelines.

Conclusion: Over the years we have taken several steps towards becoming a climate friendly green hospital. This study emphasises our commitment towards a healthy environment for the wellbeing of our patients.

Keywords: Biomedical waste, Carbon footprint, Climate change, Energy, Environment, Health-care

INTRODUCTION

WHO has defined green hospital as a hospital, which is responsive to local climate conditions with optimized energy use [1]. Climate change can have various adverse impacts on health [Table/Fig-1]. Healthcare facilities have a momentous task in hand to mitigate climate change, both directly, by reducing their own carbon footprint, and indirectly, by influencing others in the society.

Healthcare sector is an energy intensive organization. In the United States of America, health sector consumes an average energy worth 8.5 billion US$ annually which is about twice of the energy consumption at equivalent office space [2]. The healthcare in England is responsible for 3.2% of total CO_2 emissions in the country which is around 18 million tonnes; equivalent to 30% of total public sector greenhouse gas emissions [3]. Based on USAID ECO- III project report, energy consumption has been estimated to be between 246 to 492 Million kWh in urban Government hospitals in India while rural was assumed to be around 20% of this figure [4].

World Health Organization (WHO) has published a discussion draft based on its mandate from member states to develop programs for health care organizations to reduce their greenhouse gas emissions [5]. The present study was undertaken as healthcare's impact on carbon footprint generation that has not been explored in India.

MATERIALS AND METHODS

A retrospective observational study was conducted by the Department of BMW Management and PWD, Dr. Baba Saheb Ambedkar Medical College and Hospital, New Delhi, India for the last five years (January 2013 to December 2017) to analyse hospital's journey towards becoming a green hospital. The study is based on WHO's seven directives of a climate friendly hospital [1]. The hospital's electricity and civil departments are under PWD while BMW is managed by three dedicated nursing officers under the supervision of Department of Microbiology. Total energy consumption and waste generated over the years was compared. Steps taken towards conservation of available natural resources have also been enumerated.

RESULTS

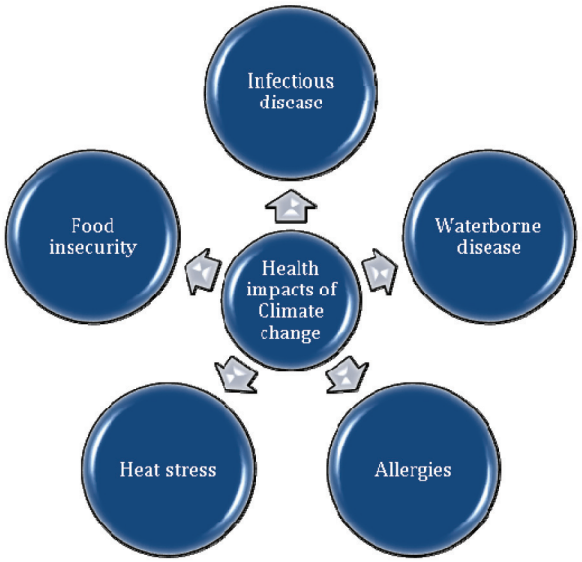
Ours is a 500-bedded tertiary care teaching hospital in North-West Delhi, which caters to a population of approximately 10 lacs. The institution has taken several steps over the years towards becoming a climate friendly hospital [Table/Fig-2].

Energy Efficiency

Since 2013, all Halogens/CFL light sources have been replaced with LED. Majority of display boards and street lights are LED based. The fuel for boiler of the laundry has been changed from diesel to more climate friendly CNG. The hospital has expanded and patient load has increased to over 130% the hospital capacity. A new Medical college has started since 2015, with a regular batch of 100 MBBS students, several teaching faculty and paramedical staff. However, our hospital's total energy consumption has not increased over the years from 5,526,450 kWh in 2014, 5,585,040 in 2015, 5,656,960 in 2016 to 5,399,380 kWh in 2017.

Green Building Design

The hospital is spread over 29.4 acres. It was built in 1999, having a sustainable architectural design which includes well lit spacious



[Table/Fig-1]: Impact of climate change on health.

	2013	2017
Energy efficiency	• Light source- Halogens/ CFL • Fuel for boiler of laundry- Diesel • Electricity unit consumption 5,556,450kWh	• Light source- LED • 5 star rated A/C • Fuel for boiler of laundry- CNG • Electricity unit consumption 5,399,380 kWh
Green building design	Mercury based equipments used	• Mercury free, 8.5 kg submitted to government authorised agency • No cytotoxic chemicals • Increase of green belt (plantation of more trees specially at the hospital boundary) • Gradual increase in momentum of swacch Bharat Abhiyan by including each and every healthcare worker • Air pollution level LED display
Alternative energy generation	-	• Solar water heater • Solar panels on rooftop • Biogas through solid waste management (proposed)
Transportation	• Metro rail • CNG based local road transport	• Metro rail • CNG Buses for trainee nurses • Electric Rickshaws • Polyclinic (OPD services) brought to the patients doorstep. So no need for unnecessary travelling
Waste	• Biomedical waste: • Average recyclable category Red waste - 38011 kg* • Metal sharps and Glass waste-4073kg	• Biomedical waste: • Average recyclable category Red - 51370* • Metal sharps- 670 kg • Recyclable glass (Category Blue)- 7485 kg* • General waste: Plastic, glass and cardboard sent for recycling • Sewage Treatment Plant- capacity 720 KL/day • Compost pit (under process)
Water	-	• Rain water harvesting system- 7 pits • Tube well- 3 in number • STP water for horticulture and flush tanks in toilet • RO and water coolers for drinking water

[Table/Fig-2]: Green hospital initiative of our hospital over the years as per the WHO directives.
*Recyclable waste

corridors and wards providing ample source of natural light and cross ventilation. There is a nursery and herbal garden, spread over an area of 3300 square metres and another green belt consisting of around 2000 trees. No cytotoxic chemicals are used in the hospital and it has been mercury free since July 2013. Daily air quality index is calculated with the help of hospital rooftop LED round the clock sensor based real-time display. Air quality of the area varies from good to moderate depending upon time of the day, climatic conditions and season.

Alternative Energy Generation

The hospital has installed Solar Hot Water System (SHWS), which provides water for washing, bathroom, emergency and operation theatres. It consists of a collector to collect solar energy and an insulated storage tank to store hot water. The solar energy incident on the absorber panel coated with selected coating transfers the heat to the riser pipes underneath the absorber panel [6]. The water passing through the pipes get heated up and delivered to the storage tank. The re-circulation of the same water through absorber panel in the collector raises the temperature to 80°C (Maximum) On a good sunny day [Table/Fig-3]. Recently fuel for boiler, of laundry, was changed from diesel to CNG, since diesel fuel is expensive and polluting. Solar panel and sustainable source of energy are new Government initiatives and hospital is working towards it. A compost pit has been proposed too and is in the pipeline.

Transportation

There is a metro station, bus depot and electronic rickshaws just outside the hospital making travel easy for both health seekers and healthcare service providers. The hospital is also connected with 4 polyclinics which are further connected with Mohalla (neighborhood) clinics, thus, reducing the need for patients to travel.

Food

Locally prepared vegetarian food and egg is served in the hospital. Meat products are not served.

Biomedical Waste

Our hospital has multispecialty wards, twelve operation theatres (OT), Outpatient Department (OPD), emergency and laboratory services. In total there are 42-waste generation sites generating 700-

[Table/Fig-3]: Sewage treatment plant, Solar water heater, air quality monitor, nursery and herbal garden (Left to right clockwise).

[Table/Fig-4]: Biomedical waste management site.

800 kg of total waste, including general and BMW, per day. A total of 200 kg of BMW is generated which includes 38.5% incinerable waste, 52.5% autoclavable waste, 6.5% glass waste and 2.5% waste sharp. All health care workers adopt standard precaution and safety measures while handling and disposing the health care waste. It is transported in separate colour-coded trolleys as per the BMW 2016 rules [7]. The waste storage site of this hospital is approximately 500 meters away from patient care areas. We are using wheeled non-motorized trolleys, which do not require any fuel. There is no incinerator in the hospital. All infected plastic waste is autoclaved, shredded and handed over to an authorized facility, which is a source of revenue generation for the hospital. Glass waste is also recycled. Only sharp waste and incinerable waste is handed over to the Delhi Pollution Control Committee (DPCC) authorised Common Biomedical Waste Treatment Facility (CBMWTF) for their respective treatment while the uninfected general waste is handed over to the municipal corporation. The waste from the generation site reaches the CBMWTF within 48 hours as per the DPCC and Central Pollution Control Board (CPCB) guidelines [8,9]. The health care workers are trained regularly on issues related to BMW management and encouraged for adopting safe practices during segregation, transportation, treatment and disposal of health care waste. Frequent intensive biomedical waste audits have been performed since 2013 to improve waste segregation and reduction [Table/Fig-4].

A total of six lac litres of waste water is generated in the hospital campus each day. Laboratory and operation theatres also generate effluent that needs treatment before disposal. Effluent is connected with Sewage Treatment Plant (STP) with a capacity of 720 KL/day present in our facility since 2013. The dry sludge 5-6 kg/month is collected from sludge drying bed and is sent for incineration as per norms of Waste Management Rules, while, treated water is reused in horticulture and flush tanks in the residential campus. Water effluent sample is analysed as per prescribed standards of pH (6.5-9), Total suspended solids (100mg/L), oil and grease (10mg/L), Bio-chemical oxygen demand (30mg/L), chemical oxygen demand (250mg/L) and bio-assay test (90-100%) through DPCC approved laboratory and a quarterly report is generated.

Water

We have seven rainwater harvesting pits, which help replenish ground water table. We have 3 tube wells with separate flow metres. This underground water is used for flushing systems in the hospital and fire fighting hydrants. For drinking, Reverse Osmosis (RO) based water purifier units are installed in all areas of the hospital for use by staff and public, thus negating the need of bottled water.

DISCUSSION

Healthcare professionals and planners can contribute to a positive climate change. It is estimated that a 30% reductions in greenhouse gas emissions by 2020 could result in savings of around €25 billion a year [10]. Climate change will have maximum adverse consequences for developing countries like ours [11] where increased expenses will bring in hunger and shortages of water and resources [3].

Through hospital wide audits, training and staff education, 21% reduction in energy use could be achieved at a Hospital in Cuba [1]. In India, National Green Tribunal (NGT) has directed hospitals to reduce energy consumption through third party audits or relevant assessment studies [12]. Our hospital has been working towards building a more climate friendly hospital since 2013. We have introduced more energy efficient means like LED, purchasing energy efficient products. The result is our hospital's total energy consumption has remained steady over the years, despite the increase in patient load.

WHO recommends incorporating green building principles in design and construction [1]. The National building code of India has stressed upon the importance of natural light and ventilation, green building design, solid waste management, availability of local public transport system and installation of energy efficient systems in healthcare establishments to reduce Health sector's carbon footprint [4]. This has been emphasised in another review by Dhillon et al., [13]. Sambhavna Trust Clinic, Bhopal is an example of green building design which includes gardens, rainwater harvesting system, SWHS, use of recycled water for irrigation, horticulture, cross-ventilation, and ample natural light [14]. Our hospital follows green architecture design with compliance of NGT norms in line with WHO's directives. Solar energy as an alternative and renewal source is being used in our hospital. It is an important energy conservation mechanism as it has been estimated that a SWH of 100 litres capacity can prevent emission of 1.5 tonnes of carbon dioxide per year though the initial investment may be higher [6].

Reference standards for National ambient air quality have been defined by the Environment Protection Act, 1986 [15]. An Air Quality Index (AQI) is defined as an overall scheme that transforms weighted values of individual air pollution related parameters (SO_2, CO, visibility, etc.,) into a single number or set of numbers [16]. The revised National Ambient Air Quality Standards are notified for 12 parameters-Particulate Matter (PM10, PM2.5), Nitrogen and sulfur dioxides (NO_2, SO_2), Carbon monoxide (CO), ozone (O_3), Ammonia (NH_3), Lead (Pb), Nickel (Ni), Arsenic (As), Benzo(a)pyrene, and Benzene. Based on these 12 parameters, the air quality has been divided into six categories [Table/Fig-5] [16].

Real time monitoring of air quality in our hospital is being done through sensor based LED display AQI of our hospital varies depending on the climatic conditions, season, time of the day. Our hospital has been given a consent order, by DPCC, to operate under section 21 of Air (Prevention and Control of Pollution) act, 1981 and under section 25/26 of the Water (Prevention and Control of Pollution) Act, 1974 under Orange Category [17,18].

There is also an emphasis on eco-driving to decrease fuel consumption. In 2001, Sweden introduced green ambulance project whereby, drivers were trained. This resulted in a decrease in fuel consumption by 10% and thus positively impacting the environment [19]. Use of public transport is known to play a pivotal role in decreasing carbon emissions. There is a metro station and bus depot in close proximity to our hospital. The staff, patients and visitors can easily access these facilities. The Delhi Government has taken an initiative aimed at bringing healthcare near patient's doorstep. Ours is a tertiary care hospital providing services at four polyclinics situated in different areas of our district. These are further connected to many Mohalla clinics situated in different neighborhoods. Thus, reducing the OPD visits in the hospital as well as carbon footprint generation due to travelling. Paperless e-office is another Government of Delhi initiative to improve efficiency and accessibility, mitigating the need to travel.

Air Quality Index values (AQI)	Levels of health concern	Colour code
Good (0-50)	Minimal Impact	Green
Satisfactory (51-100)	May cause minor breathing discomfort to sensitive people	Green
Moderate (101-200)	May cause breathing discomfort to the people with lung disease such as asthma and discomfort to people with heart disease, children and older adults	Yellow
Poor (201-300)	May cause breathing discomfort to people on prolonged exposure and discomfort to people with heart disease with short exposure	Orange
Very Poor (301-400)	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases	Red
Severe (401-500)	May cause respiratory effects even on healthy people and serious health impacts on people with lung/heart diseases. The health impacts may be experienced even during light physical activity	Maroon

[Table/Fig-5]: Air quality index categories (National Air Quality Index 2014) [16].

India: Sambhavna Trust Clinic, Bhopal [14]	Tropical gardens Rain water harvesting, recycled water for irrigation SWHS Cross ventilation, and ample use of natural light
Singapore: Changi General Hospital, Simei [14]	Koi ponds, palm trees and orchid murals. Hydroponic garden on the hospital roof, which grows produce for the hospital kitchen while cooling the building. Use of natural light, automatic doors to maximize cooling efficiency, energy-efficient ceiling fans, motion sensor lighting, and low-flow water fixtures. Reduction in energy and water costs by US$800 000/year
Italy: Meyer Children's Hospital, Florence [14]	The hospital is well ventilated with high ceilings and lots of open space. Built on a sloping hill so it causes less disruption to the surrounding environment. It features a greenhouse, landscaped roofs, open "buffer" space, and a hybrid ventilation system. The hospital consumes 35% less energy for heating and cooling than a standard newly built Italian hospital.
Sweden: AISAB, Stockholm [19]	Green ambulance initiative
United Kingdom: Addenbrooke's Hospital, Cambridge [3]	To encourage use of public transportation, the NHS has commissioned a bus to serve the hospital Incentives - discounts on bus passes and easy bicycle loans, as well as a car pooling.
Sri Lanka: Embassy Medical Center, Colombo [20]	Biogas production

[Table/Fig-6]: Green hospital initiative by various hospitals around the world [3,14,19,20].

There is a need for 'waste to energy' concept in hospital. At the Embassy Medical Center, Colombo waste has been utilized to fuel the hospital operations. They plan to collect the waste from latrines and dumps and transport via electric autorickshaw for processing in an organic waste digester. This would result in biogas production to provide energy for the hospital and local community [20]. In India, Solid Waste Management Rules 2016 (SWM 2016) direct the use of composting and bio-methanation for biodegradable waste [21]. It promotes the 3R's-Reduce, Reuse and Recycle, fostering cooperation among waste generators, collectors, processors and manufacturers. In our set up, both plastic waste and glass waste are disinfected and handed over to authorized recyclers. From an environmental perspective, reusing at source is considered better than recycling [22].

Health care management team of our hospital is committed to follow the biomedical rules, and we have a dedicated team managing the Department of BMW [23,24]. The waste from the generation site reaches the CBMWTF within 48 hours as per guidelines [8,9]. Frequent intensive biomedical waste audits have been performed since 2013 to improve on segregation and waste reduction [23]. The Ministry of Health and Family Welfare, Government of India, has launched a national initiative "Kayakalp" on 15th of May, 2015 to promote cleanliness and enhance the quality of public health facilities. To recognize efforts of ensuring Quality Assurance at Public Health Facilities, awards are given to those public health facilities that demonstrate high levels of cleanliness, hygiene and infection control [25]. Our hospital has been actively participating in the initiative. A toolkit on similar lines can be developed for health care facility officials to assess the resiliency of their facility to climate change impacts.

A series of international conventions have drawn attention of the governments throughout the world in response to global warming. The United Nations Framework Convention on Climate Change (1992), The Kyoto Protocol (1997), Bali roadmap (2007), Copenhagen Agreement (2009), were signed [26]. The international standard organization has published ISO14064 standard to measure and control the Green House Gas emissions in 2006 [27]. Several hospitals around the world have taken steps towards building a green environment [Table/Fig-6].

Future Prospects: There is ample amount of sunlight, which can be captured. Solar energy can be utilized as direct source of electricity in wards and solar geysers to heat water in wards and OT. Having a kitchen garden for in-house production of fruits and vegetables to meet patient's requirements, utilization of STP water for cleaning and washing in hospital, minimises waste-both general and biomedical through patient and staff education.

CONCLUSION

The hospital has initiated various steps towards becoming a green hospital. Despite the addition of a medical college, and increase in various clinical services with an ever-increasing patient load the energy consumption has remained steady over the past few years. This emphasises our commitment towards conserving natural resources and contributing to the environment. Further training programs, possibility of telemedicine and home working opportunities should be considered. Healthcare professionals should take a pledge to contribute towards building a carbon neutral or carbon negative healthcare facility and work towards becoming carbon literate.

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