

‘GREEN NICU’, a leap toward ‘Sustainability’
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Sustainability is the most disregarded subject while planning an intensive care and its infrastructure. World Commission on Economic Development (WCED - 1987) defines sustainability as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”, according to the Office of the Federal Environmental Executive (OFEE). The healthcare sector as it is growing immensely at a rapid pace, needs long-term sustainable goals and also a detailed plan for the meaningful and purposeful usage of the existing resources. The Indian rating system, IGBC Green Healthcare Rating System - Indian Green Building Council (IGBC) addresses the concepts of “green” in the healthcare system. Leadership in Energy and Environmental Design (LEED) rating system, LEED provides global certification for healthy, efficient, carbon and cost-saving green buildings and it is a symbol of sustainability achievement. Here we present a few simple sustainable ways for a critical care unit that can be beneficial in the long run.

Key Words: Sustainability, Environmental, Intensive care, Energy, Biophilic design.

Introduction

Intensive Care is expanding unimaginably with the over-exploitation of natural and human resources. Sustainability is an age-old idea that is the least studied and also the most disregarded subject while planning the NICU and its infrastructure. World Commission on Economic Development (WCED - 1987) defines sustainability as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. According to the Office of the Federal Environmental Executive (OFEE), “Sustainable hospitals can be defined as the practice of designing, constructing, operating, maintaining, and removing buildings in ways that conserve natural resources and reduce pollution”.¹ The healthcare sector as it is growing immensely at a rapid pace, needs long-term sustainable goals and also a detailed plan for the meaningful and purposeful usage of the existing resources. Utility and understanding ‘sustainability’ in healthcare is the need of the hour as there was a global hit of the COVID-19 pandemic and the overexploitation of healthcare resources. India has its own rating system, IGBC Green Healthcare Rating System - Indian Green Building Council (IGBC) ⁶, which addresses the concepts of “green” in the healthcare system. US Green Building Council licenses IGBC to provide LEED Certifications in India (Leadership in Energy and Environment Design). U.S. Green Building Council (USGBC), which is a non-profit organization, administers the Leadership in Energy and Environmental Design (LEED) rating system ². LEED provides global certification for healthy, efficient, carbon and cost-saving green buildings and it is a symbol of sustainability achievement. Here we present a few simple sustainable ways for a critical care unit that can be beneficial in the long run.

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Submission	13.07.2024	Revision	29.08.2024	Accepted	27.08.2024	Printing	30.09.2024
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Conserving Energy:

Energy, especially in the form of electricity is the most utilized resource in any given critical care. Maintenance of HVAC (Heating, ventilation, and air conditioning) systems, ventilation, lighting, temperature maintenance, refrigeration, and use of numerous pieces of equipment requires a substantial amount of electricity. As per the recommended NICU standards, a set air temperature of 22-26° C and relative humidity of 30-60% is acceptable. A minimum of six air changes per hour is required, with a minimum of two changes being outside air.³ A study from England calculated an average daily consumption of 15 kWh of electric energy per patient in ICU, which is similar to that of an average 4-person household.⁴ Energy consumption in community health centers and nursing homes of India in 2008 is estimated to be 769 - 1538 KWh with an estimated cost of 4324 - 8748 million rupees⁵.

Sustainable energy involves the development of renewable energy sources like wind, solar, geothermal, and hydroelectric power. Indian hospitals can benefit from uninterrupted access to the sun as a primary energy mode. Installation of solar energy panels in every healthcare gives leeway to the costs and expenditures. According to IGBC, green buildings can lead to energy savings of up to 30-40%.⁶

Sustainable energy-saving approaches:

- Installation of rooftop solar energy panels: solar energy can be used for sterilizing, sanitizing laundry, water heating, etc.
- Maximum utilization of daylight for ventilation. Use of smart lighting.
- **Zoning:** Dividing the area into zones with separate temperature controls instead of a single central control. This gives maintenance and usage of heating/cooling when necessary in the particular zone and minimizes wastage. Lighting can also be zoned in a similar manner.
- Uses 75% less energy, produces less unwanted heat, and lasts longer.
- Use of automation sensors wherever possible, Automatic lighting with sensors in conjunction with natural light. Use of sensors that detect the occupancy, detects the daylight.
- Upgrade controls - pays off and minimizes wastage of energy.
- Switch off all equipment when not in use and enable power-down modes.

Adhere to NICU design standards, ambient lighting levels in infant spaces should be adjustable through a range of at least 10 to no more than 600 lux as measured on any plane at each bedside. Ultraviolet or infrared radiation by the use of appropriate lamps, lenses, or filters should be avoided.⁷

Conserving Water

Water is the most used and most wasted resource in all healthcare facilities. Strict adherence to policies for conserving water and limiting its wastage is of utmost importance. According to IGBC green hospitals can lead to 20-30% water savings.⁶ Water can be saved in 3 ways, 3R: Reduce, Reuse, and Recycle.

Sustainable water-saving approaches:

- Rooftop Rainwater harvesting, done in St Martha's Hospital, Bangalore has saved 1957,000 Liters of water & 3100 units of electricity every year. The other example is Warragul Hospital, Western Gippsland, which collects rainwater harvested from the roof which is transferred to the boiler feed water tank. Reclaimed reverse-osmosis reject water is used for the sterilizer vacuum pump and condenser cooling before being discharged to the sewer

via the flusher system. The result has been an annual saving of 1,967 kilolitres of water and a 25 percent reduction in boiler feed water treatment chemicals.⁸

- Box Hill Hospital project: Collect water from the sterilizers: Sterilizer vacuum pump wastewater and condenser cooling water are diverted to flusher tanks. This project reclaimed 746 kilolitres per year.⁹
- STP - Sewage treatment plant installation and use of recycled water to flusher tanks and gardens
- Usage of RO (reverse osmosis) technology for drinking water.

Simple ways of water conservation:

- Tap restrictors - reduce water flow by 15%
- Push taps - turn off after a brief period of time
- Infrared controllers - provide water only when required and switch off automatically
- Installation of low-flow faucets in toilets and showerheads.
- Timely management of leaking or damaged faucets and pipelines.

Recycling and waste reduction:

Hospitals are important sites for the generation of hazardous and non-hazardous waste in abundance. As per CPCB (Central Pollution Control Board), approximately 587mt of BMW was generated daily in 2018. India alone produced over 56,898 tonnes of COVID-19 biomedical waste between June 2020 and June 2021,¹⁰ Hospital waste and its management is the growing and most disregarded problem that needs to be solved. Waste reduction warrants the 5Rs rule (reduce, reuse, recycle, rethink, and research), a commonly suggested strategy. Plastic is an abundant waste in the present healthcare sector. A study from South Korea shows that about 40% of hospital waste is plastic.¹¹ The plastics in health care are polyethylene (such as plastic saline bottles), polypropylene (such as surgical instrument wraps), their copolymers (found in syringes), and polyvinyl chloride (such as intravenous fluid bags and oxygen tubing). These plastics can be easily recycled with various methods of plastic recycling.

Simple sustainable ways for waste reduction:

- Medical plastics used should be recyclable and biodegradable, for example, a new technology using nanofibre-based medical masks is materials that can decompose in the environment over time.¹² Bio-plastics, such as starch-based or cellulose-based plastics, produce eco-friendly waste with lower carbon footprint and energy efficiency.¹³
- Aragaw et al. reported the conversion of PP face masks and PVC gloves into fuel energy by pyrolysis which converted more than 75% of waste to bio-crude oil (tar)(14).¹⁴
- Segregation of waste according to the said guidelines for waste segregation.¹⁵
- Storing consumables and supplies in a moving trolley rather than in a bedside cabinet, a study carried out in NICU at Shri Mata Vaishno Devi Super-specialty Hospital Kakryal (Jammu) showed there was a significant cost saving at the end (Average saving Rs 4383 vs. 1771, the value of p was highly significant) without significant change in patient care.¹⁶
- Use non-plastic packaging wherever possible, for example - use bio-plastic in waste collecting bins instead of conventional plastics. A hospital in the UK replaced plastic with paper-based bio-bins with less incineration toxic emissions, and a 30-tonne reduction in waste.¹⁷

- Introducing a recycling intensive care program, a study in an intensive care unit of an Australian hospital conducted a similar program for a week and found minimal infectious waste cross-contamination. Almost 60% of intensive care unit general waste could be recycled unless it is properly segregated.¹⁸

Green or sustainable cleaning

Cleanliness in an intensive care setting is of utmost importance to prevent HAIs (Hospital Acquired Infections). "Green cleaning" is a concept emerging in recent times after knowing the harmful and deleterious consequences of the currently used cleaning products in health care. Green cleaning or sustainable cleaning aims at reducing the harmful effects of cleaning on human health and the environment while maintaining the cleanliness of the healthcare environment for the purpose of infection prevention. There is a strong correlation between exposure to cleaning products and work-related asthma and respiratory irritation, musculoskeletal problems, and dermatitis, and are proven to be carcinogenic.^{19, 20, 21} Supporting and promoting "Green cleaning" in healthcare is one of the objectives of the Healthy Hospital Initiative pebble project - an evidence-based design.²² Ingredients of concern include quaternary ammonium chlorides, glycol ethers such as 2-butoxyethanol, ethanolamine, several alcohols such as benzyl alcohol, ammonia, several phenols, and most importantly VOCs.²³ Green Seal is an organization from the USA that sets standards for a cleaner to be called a "Green cleaner". It takes into account PH, ozone-depleting substances, and volatile organic compounds (VOCs), carcinogens, reproductive toxins, etc.²⁴ India updated and released the 5th draft of guidelines for chemical management and safety on 7th September 2020. The objective of the India REACH / CMSR 20XX (Chemical Management and Safety Rules) is to ensure a high level of protection for human health and the environment. The Rules provide for procedures for the Manufacturer, handling, and import of Hazardous Chemicals and preparedness.²⁵

Hospitals use a wide range of disinfectants proven to be detrimental to healthcare and janitorial staff, hence a strict layout of all the ingredients used should be laid down. Criteria for selecting the right product :

1. Minimal toxicity to humans and the environment
2. Recycling and reduction of waste
3. Minimal use of natural resources, and
4. Effectiveness of HAI prevention²⁶

Apart from selecting green cleaning products, operational optimization and building design for effective green cleaning are equally important.²⁶

Green Cleaning ideas:

- Appropriate cleanliness in different areas, eg: usage of a potent cleaner in the ICU rather than office space. As Todd Wilkening says "Never dust with dynamite" - avoid over cleaning.
- Products with minimal aerosolization and fragrances to improve indoor air quality.
- Use products that are certified as "Green"
- Designing the interior that needs minimal cleaning: Matting system - use of vacuum cleaners in place of harsh cleaners,
- Usage of micro-fiber mops as they result in less water usage and less waste. Micro-fiber mops are proven to be superior to conventional mops.²⁷
- Use of metered chemical dispensers
- Avoid spraying onto surfaces, rather spray in a cloth to reduce chemical aerosols.

- New technologies such as Eco-H2O technology: a type of machine using electrically charged water for surface cleaning - an alternative to chemical cleaning. Similarly, a sprayer device that electrically charges water (Activeion).
- Building Design:
 - Smooth surfaces are easier to clean compare to textured ones.
 - Scrubbable finishes can withstand harsh cleaning protocols.
 - Crevices should be minimized
 - Horizontal surfaces should be minimized
 - No carpeting in patient rooms or corridors

Evaluating Construction:

Space: The neonatal care unit should be designed in close proximity to the area where births occur. According to the 9th edition of Recommended Standards for Newborn ICU Design Consensus Committee, each infant space should be a minimum of 150 square feet of floor space, excluding hand washing stations, columns, and aisles. In the case of single infant rooms or fixed cubicles adjacent aisles of not less than 8 feet should be designed to permit passage of equipment and personnel. Every infant bed should be within 6 meters of a hand washing station²⁸

Ceiling, walls, and flooring: Durability and maintainability are of utmost importance while selecting architectural plans for intensive care. Ceilings being the largest area for absorbing sound, acoustic tiles as a ceiling finish material can help to improve the quality of the sound environment. Wall surfaces should be durable and easy to clean. As walls are continually subjected to scrapes by equipment and movement in a critical care unit, walls should be scrape-resistant and rigid. Rigid vinyl coverings or gypsum boards can be used for walls to prevent an impact. Vinyl wall coverings contain PVC (polyvinyl chloride) and may contribute to poor indoor air quality. Use a product that emits low or no VOCs. Floors are known to be reservoirs of microbes in any healthcare setting.²⁹ Flooring should be selected such that it can withstand harsh cleaning protocols and be less susceptible to harboring pathogenic bacteria. Materials suitable include rubber, vinyl, or linoleum and carpet tile with an impermeable backing. Avoid finely polished flooring to avoid glare, according to NICU standards, flooring material should have a light reflectance value not exceeding 30%.³⁰

Sound: NICUs are areas of constant sound and sound levels often cross the accepted standard of 45 dB recommended by the American Academy of Paediatrics. Exposure to intense and sustained sound outside the dB and frequency range as normally heard by the fetus is harmful and may be related to stress responses, alteration in physiological stability, sleep deprivation, autonomic changes, alteration in endocrine and metabolic response, and hearing deficits^{31, 32}—newer technologies like acoustical optimization (damping) of the respiratory flow device especially on high flow rates. Strategies for sound abatement may include durable high-performance acoustic wall panels. According to NICU design standards, an average noise reduction coefficient (NRC) of 0.85 and a ceiling attenuation class (CAC) minimum of 29 is recommended.³³

Tip: Lowering equipment alarm sounds decreases levels of sounds alarmingly.³⁴ Isolation room

Family-centric care:

Family-centered care is where neonates and their families stay together as a single unit and hospital staff including doctors and nurses unite to cater to them with a safe and welcoming experience. According to Griffin, family-centered care (FCC) in NICU is an approach to planning, implementing, and evaluating healthcare that is formed on the basis of the participation of different health and family professions. Its four basic principles are dignity and respect, information exchange, family participation in care, and family cooperation.³⁵ FCC has proved to be of utmost importance in neonates' clinical outcomes and parents play a vital role in the management of their infants. A study carried out in a Chinese NICU between June 2016 and June 2017 where parents were given basic care knowledge and skills followed by their active participation in care for at least 4 hours per day resulted in improved breastfeeding rates, decreased TPN days, and decreased gastric feeding days in the intervention group. Apart from the above, reduced rates of complications like BPD, ROP, NEC, and readmission rates in the intervention group were seen. Implementation of KMC as an attribute of family-centric care will be beneficial in the overall outcome of a neonate and a sense of wellness in the parents. KMC is cost-effective and advantageous to both the parents and the infant.³⁶

Gardens and landscapes:

The most upcoming topic is 'Biophilic Design' i.e. closer to nature. Biophilic design is based on the attempt to transfer the innate inclination of individuals toward natural systems and processes.³⁷ Intensive care units are the areas of extreme stress. Admission of an infant into a NICU is very stressful for parents both during the NICU stay and after discharge.³⁸ According to many studies, biophilic design is proven to improve the psychophysical well-being of an individual and reduce stress, pain, and anxiety.³⁹ According to Ulrich's research, looking at greenery and nature reduces hospitalization time by 8%.⁴⁰ By promoting staff health, the biophilic design improves satisfaction and attention levels.⁴¹ Stephen Kellert identifies six main elements of biophilia⁴².

1. Environmental features: incorporating elements such as plants, water, and green views in the built environment
2. Natural shapes and forms: simulation of natural features like spiral, oval and tubular forms, avoiding straight and right angles. "biomimicry"
3. Natural patterns and processes: designing a built environment that reflects nature through attributes such as linked series, chains, and complementary contrasts.
4. Light and space: prefer natural light and reflected light.
5. Place-based relationships: incorporating in the built environment the attributes of a geographical, historical, ecological, and cultural connection to place.
6. Evolved human-nature relationships: designing the built environment including preferential elements for human beings, which give the feeling of refuge and protection.
 - It is never too late, to implement a QI for sustainability
 - Create a green team
 - Educate staff
 - Celebrate the success
 - Display the results and benefits.

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Citation: Hafeez S., Deshabhotla Sai K. GREEN NICU', a leap toward 'Sustainability'. *Indian J Prev Soc Med*, 2024; 55 (3): **166-174**.