Original Article

A Sustainable Approach On Socio-Ecological And Socio-Economical Impact Of Hospitals

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Abstract

Objectives: The main objective of this study is to measure the ecological costs using carbon foot-printing and operational costs of a 250-bedded multi-specialty hospital with basic green hospital compliance. The study also aims to build a sustainable toolkit to manage the operational costs as well as reduce the environmental impact of the hospital.
Design: Exploratory study in which since it discusses the environmental and economic aspect of hospitals. The data was collected using observation method, focus group discussions and secondary data from the unit heads and the staff of a private setup hospital records in Chennai, Tamil Nadu
Major Outcome: The research emphasizes on the how sustainable facility management impacts the environment as well as the hospital positively.
Results: The major finding of the research was that the emissions let out by a hospital during its least occupancy are very substantial causing huge ecological impact. Also, employing green sustainable solutions decreases the operational costs of the hospital by around 30 percent which is significant. Hospital being the primary mean of promoting public health is a major contributor to carbon emissions. This is quite evident from the study, and also reflects how much more it can produce pollutants when it is providing 16.8 lakh kg of carbon just having started.
Conclusion: The model and toolkit developed by this study have been successfully validated and hence, will aid any hospital management in their journey towards green sustainability.

Strengths and limitations of this study

- This study sheds light on the often overlooked services that serves as the backbone of the hospital. It creates a pathway for the hospitals to keep a check on its CSR as well as acts as a guide to structure better practices in the each and every department of the hospitals to better aid the support services and reduce the operational costs. This will in turn enable hospitals to provide better patient care.
- This study brings in all the aspects of utility services from electricity to waste management and studies its effect on the environmental. It also explored the management aspect of these services and how with effective management, the hospital can control its operational costs.
- There have been numerous studies about the waste management practices at hospitals but very few on the entire support services and its impact on the environment due to poor management.

Keywords: Healthcare, Socio-Ecological, Socio-Economical, Sustainable Development, CSR

1. Introduction

One industry that is constantly growing in all dimensions across the globe is Healthcare sector. The healthcare sector is no different with current standing of US$ 280 billion. But this growth comes at great costs of energy and

wastes. Hospitals, alone, in our country as well all over the world consumes about one-third of the energy generated. This is the due to the 24x7 operation of the hospital throughout year which includes many types of equipment both medical and non-medical. Not only this, a hospital on an average produces 70 tons of waste per day which includes infectious as well as non-infectious wastes. Among the non-infectious wastes, less than 10 percent are being recycled while all others are being dumped as landfills. While the larger energy consumption on the grid amounts to increased economic costs, the increased waste generation pollutes the environment thereby increasing the ecological costs. Both of these again impact the public health negatively, one by increasing the service costs and others which costs their health. This again impacts the operational efficiency of the hospital especially in this post-pandemic situation where resources have become critical to procure. Thus, it becomes important to address these concerns and develop a more sustainable approach to maintain optimum costs and efficiency [9].

There have been very few studies related to the green concept and sustainability of the hospitals with focus on a particular component, but there is dearth of research in approaching the whole problem holistically and systematically. The fact that, this whole scenario is a loop with every factor dependent on each other, it becomes necessary to view this as a bigger picture of interconnected products, process and people, which is how the hospital in itself operates.

This study mainly focuses on the energy and waste aspect of the sustainable approach and deals with analyzing the factors that are correlated with them. Since these are the two main components of the green hospital, gaining a better understating about the two and focusing on them will reduce the costs drastically. The study also majorly focuses on the unit of the hospital that is responsible for major energy consumption and waste generation. The first part of the study will be completed through this research with the determination of operational efficiency and cost analysis. At the end of the analysis, the focus will be on structuring a sustainability model through a toolkit for any hospital irrespective of its size.

2. Literature Review

"Resources , Conservation & Recycling Quantifying hospital services by carbon footprint: A systematic literature review of patient care alternatives" – the authors have combined various researches done worldwide regarding sustainable hospital practices to present a study on its cumulative impact on the environmental,[1]. "Revised Guidelines Air Conditioning in OT" – These are the new standards to be followed in OT maintenance [2]. "Operating room greening initiatives – the old , the new , and the way forward : A narrative review" – The authors present this narrative literature review focuses on the trend of OR greening initiatives over the last 25 years, comparing different innovative approaches, the successes and setbacks, and the financial implications of initiatives,[3].

"Methodology Note Greenhouse Gas Emissions of India Sub national Estimates" - This report presents the estimates of emissions by various industries for the past decade,[4]. "Environmental Sustainability in Anaesthesia 6 advances in anaesthesia Environmental Sustainability in Anaesthesia" – The authors discuss various strategies to curb mismanagement of anaesthesia and improve the sustainability of OTs,[5]. UNDP "Management of Specific Infectious Wastes Module" – This report presents protocol for waste management for hospitals across the globe,[6]. "Environmental Sustainability in Hospitals: The Value of Efficiency" – This report discusses the various sustainable strategies a hospital can employ to reduce its impact on the environment,[7]. "Protocol for the quantification of greenhouse gas emissions from waste management activities" – This report provides a credible approach to quantify, report and verify greenhouse gases (GHG) direct & indirect emissions of waste management actors with the purpose of to establish best practice across the waste sector for the implementation of a coherent and homogeneous annual GHG emissions reporting,[8]. "Health Care without Harm: Healthy Hospitals, Healthy Planet, Healthy People" – This report by WHO discusses various cases studies across the world to elevate the importance of environmentally sustainable practices in hospitals and how to achieve them,[9]. "Vancity GHG inventory and carbon neutral Report", serves as a guide for carbon foot-printing for as facility. It shows how the analysis should be done and the factors to consider while calculating,[4]. "Developing a Framework for a Toolkit for Carbon Footprint that Integrates Transit Developing a Framework for a Toolkit for Carbon Footprint that Integrates Transit" – The authors present a framework for calculating GHG emissions from proposed

transportation projects and to recommend ways to incorporate this framework into five transportation planning processes,[10].

3. Methods and Material

A total of 80 articles were reviewed for the study under various categories of facility management, green hospitals, carbon foot-printing, etc. Exploratory research using qualitative and quantitative data was done for this study. Primary data was collected via observation method and secondary data from hospital database. Focus group discussion (FGD) was done with members concerned with different hospital units individually and the framed research questions were put forward to each of them in-person. Various literatures were reviewed and scope was identified. A checklist was prepared to optimize and focus the area of the study. The FGDs helped tremendously in understanding the current situation and data. The identified individuals shared their experience and knowledge regarding the industry and its real time scenario.

The study was carried out in a 250 bed multi super-specialty, quaternary care hospital in the city of Chennai. The construction was completed in the year 2013, but the operations started in full spring from April 2020. There are around 200 employees working currently spread over all clinical and non- clinical departments. The hospital is operational with a range of services from Preventive Health Checks, Out-Patient Consultancy Services, Consultation at the Hospital, Tele / Video Consultation Services, COVID Home Care Services to In-Patient Services, Surgical Services.

4. Rationale of Study

The intent of this study is to analyze the energy consumption and waste generations thereby determining its impact on operational efficiency. Carbon food-printing helps determine the emission rates and hence environmental impact. Operational efficiency will in turn say where the hospital stands in terms of profitability thus accounting for economic impact.

5. Objectives of the Study

The objectives of the study is - (i) to identify the most energy consuming and waste generating unit in the hospital, (ii) to assess the environmental costs and operation costs associated through carbon foot-printing, (iii) to develop a sustainable toolkit to reduce the environmental costs, thereby improving the expected outcomes.

6. Data Collection

Primary data was collected using observation, from hospital and focus group discussions (FGD). Secondary data was collected through various news articles, research papers, and government databases.

- ### Patient or public Involvement

No patient involved.

7. Results of Study

- ### Green Sustainability Toolkit for Hospitals

The green sustainability toolkit has been designed with the purpose of guiding hospitals towards cleaner and greener practices that will not only provide a healthy environment but also help improve the operational efficiency. The toolkit is a collection of all the step by-step procedures the hospital can follow to identify, measure, and mitigate its nonclinical and clinical practices towards green sustainability and monitor its progress towards the green compliance.

- ### Checklist for Green Compliance

The first step towards green sustainability is to list down the resources that checks off green compliance. The checklist given in the appendix enables to gain an understanding regarding the resources the hospital has and lacks. This is a basic green compliance checklist and can be altered.

• Defining the Scope

After a thorough study about the organization and green compliance assessment with the above presented checklist, identify and define the areas that have scope for sustainability. For healthcare organizations, especially hospitals, the major scope is in the engineering, maintenance, and waste management and procurement areas. The scope presents you with a clear idea of opportunities that are present and the objectives to be accomplished. Before identifying the scope, make a list of possible direct and indirect emissions (Fig. 1). Direct GHG emissions are emissions from sources that are owned or controlled by the reporting entity like wastes. Indirect GHG emissions are emissions that are a consequence of the activities of their porting entity, but occur at sources owned or controlled by entity like purchased electricity.

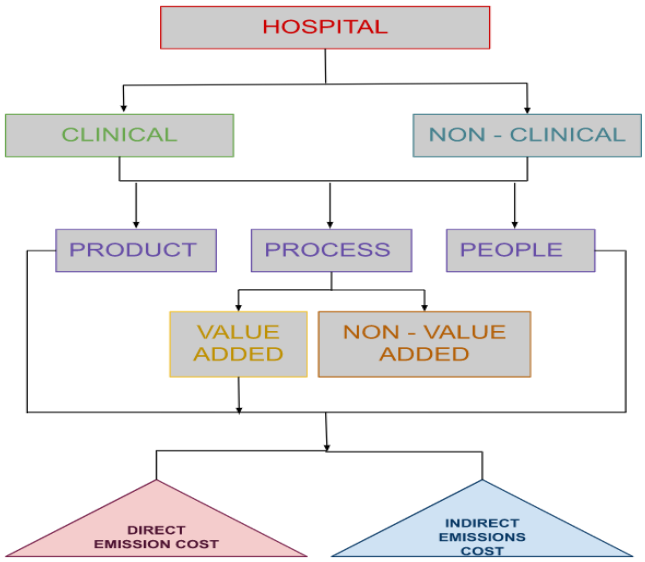

Fig 1: Green Sustainable Model

With a sustainable circle, the various scopes can be as follows:
Scope 1 – Electricity and Purchased Heat systems, where, the opportunity is to derive electricity from renewable resources such solar energy and managing heat flow through judicious alternatives that would decrease both environmental and economic costs.
Scope 2 – More eco- friendly waste management practices like recycling, compositing, etc.
Scope 3 – Reducing transport carbon footprint through pooling, bio-fuels, etc.
Scope 4 – Healthcare technology management for better and economic decision making regarding technology usage for clinical needs.
Always identify potential scopes from listed opportunities based on the importance, criticality and high bandwidth for economic and environmental impact, which will actually make a huge difference.

• Green Sustainability Model

Once, the hospital, basic green compliance is checked, we have to determine the operational efficiency of the hospital with the current system. For this, we have to do a cost analysis which also comprises environmental costs. Carbon foot-printing is employed for calculating the socio-environmental impact and cost. For socio-economical aspect the cost analysis of the currently employed resources and its viability will be estimated.
To start with, a hospital is a complex organization with numerous interconnected processes and a million resources. It therefore becomes tedious to do an impact analysis for the whole organization as a whole. To simplify it, the above sustainability model has been proposed.

For a hospital to function properly, both its clinical and non-clinical departments have to work in harmony. Every clinical department is related to all the non-clinical departments ranging from engineering to CSSD. Thus, a hospital is a result of synchronous operation between the clinical and non-clinical departments with optimum resource maintenance. These departments are again a mix of 3Ps – Product, People and Process. Among them, the process can be further segregated into value-added and non-value added components or steps. We are interested with the value-added component alone as the on-value added steps are eliminated via LEAN. Thus, breaking down each department into these units, simplifies the analysis. Now, once we have segregated the major components and units associated, we now have to identify the direct and indirect emissions or costs related with these units. This will be our first destination.

• Carbon foot-printing

A Carbon foot-print is the total sum of the greenhouse gas (GHG) emissions caused by an organization, event, product or a person. As discussed in the previous sections, hospitals consume large amounts of electricity and are one of the primary sources of waste generation (biomedical wastes). Along with causing significant damage to environment they also widely impact the profits of the organization if proper protocols are not followed. As a report by WHO, 85 percent of wastes generated by the healthcare organizations are non-infectious. Thus, carbon footprint of a hospital reflects on its impact on the environment. This study predominantly deals with creating sustainable solutions for energy and waste management in hospitals.
Therefore, the scopes include:
Scope 1 - Purchased Electricity and Purchased Heat/Steam
Scope 2 – Biomedical Wastes

• GHG Emission formula:

The carbon footprint is measured and represented in the units of carbon dioxide equivalents (kgCO2e) and it is calculated using the following formula:

GHG (kg CO2e) = aspect quantity data (Q) x emission factor (EF)

The aspect data quantity differs according to scope being pursued. The emissions factors for various data have already been given by the GHG protocol. The values of the emission factor for the scopes defined above are given in table 1.

Table 1: Emission Factors

Operational Boundary	Environmental Aspects(EA)	Aspect Data Unit	Emission Factor (EF)	EF Unit
Scope 1	Electricity	kWh	0.85	kgCO2e/kWh
	Gasoline	litres	2.42	kgCO2e/l
	Diesel oil	litres	2.66	kgCO2e/l
	LPG	litres	1.58	kgCO2e/l
Scope 2	Green or Non-Hazardous Waste	kg	0.33	kgCO2e/kg

	Hazardous plastics waste (land filled)	kg	0.88	kgCO2e/kg
	Hazardous waste (land filled)	kg	0.83	kgCO2e/kg
	Hazardous wastes (incinerated)	kg	0.54	kg CO_2e/kg
Scope 3	Paper and Board	kg	0.02	kgCO2e/kg
	Glass	kg	0.02	kgCO2e/l
	Batteries	kg	0.65	kgCO2e/kg
	Construction	kg	1.27	kgCO2e/kg

(Source: Primary data)

a. For Purchased Electricity and Purchased Heat/Steam

i. Write the facility and year for which the emissions are calculated.
ii. Collect and enter the amount of electricity/ heat consumption and units (kWh)
iii. Select the custom emission factor appropriate to the region or country in which the hospital is located.
iv. Calculate the GHG emission using the formula (1)

b. For Biomedical Wastes

i. Write the facility and year for which the emissions are calculated.
ii. Collect and segregate the data into different categories of wastes – green wastes, hazardous and non-hazardous wastes.
iii. Enter the amount of waste generated and units (kg) under each category
iv. Select the custom emission factor appropriate to the region or country in which the hospital is located.

- **Economic Impact Analysis**

Every activity, irrespective of the level of size and criticality, amounts to an organization's operational cost. Many a time, a healthcare organization suffers from clinical myopia where its major focus remains on the clinical departments. As much as it is true that, a clinical entity forms the heart of a healthcare organization, it is undeniable that the non-clinical entity is its brain. And if any part of this non-clinical entity derails due to improper design or management, then the entire organization bears the brunt, as all non-clinical departments serve each and every clinical department. This results in increased operational costs. This study aims at viewing the economic impact of two main non-clinical departments – engineering and maintenance. The scope here is the same as defined for carbon foot-printing.

Scope 1 - Purchased Electricity and Purchased Heat/Steam
Scope 2 – Biomedical Wastes and Stationary Wastes Management
Scope 3 – Healthcare Technology Assessment

- **Calculation Instructions:**

a. For Purchased Electricity and Purchased Heat/Steam

i. Write the facility and year for which the emissions are calculated.

ii. Collect and enter the amount of electricity/ heat consumption and units (kWh)

iii. Select the custom emission factor appropriate to the region or country in which the hospital is located.

iv. Calculate the GHG emission using the formula (1)

b. For Biomedical Wastes

Write the facility and year for which the emissions are calculated.

i. Collect and segregate the data into different categories of wastes – green wastes, hazardous and non-hazardous wastes.

ii. Enter the amount of waste generated and units (kg) under each category

iii. Select the custom emission factor appropriate to the region or country in which the hospital is located.

iv. Calculate the GHG emission using the formula (1) for each category and sum total them.

v. The feasibility study involves checking if that practice is suitable in the hospital location and premises, resources available within the hospital for the purpose, analyzing the procurement cost, operating cost, transport cost applicable along with vendor availability, and comparing the total costs of this alternative with the current process cost.

c. Healthcare Technology Assessment

i. Conduct an assessment of clinical needs

ii. Review the various brands and versions of the equipment available in the market.

iii. Conduct a site requirement for the equipment and staff requirement if any.

iv. Perform a cost benefit analysis taking into consideration, the long-term use, depreciation, CMC and AMC for a sustainable procurement.

v. Check for the regulatory and reimbursement policies of the manufacturer.

- ## Sustainability Circle

The important component of the socio-ecological and socio-economical aspect is the human touch, i.e, active involvement of people. For an organization to achieve its sustainable goals, it should inculcate the culture of sustainability in its stakeholders, especially the employees. Every hospital or a healthcare organization has a quality circle to ensure continuous quality improvement. Sustainability is a part of quality system which has been long neglected. It is now time to put sustainability at the centre of the continuous quality improvement by including a sustainability team that keeps check on the progress and ensures that the goals are being met.

A sustainability team should consist of – a member from top level management, technical engineers with sound knowledge and experience (Electrical, Mechanical, Civil and IT), a clinician and a nurse, a maintenance personnel, member from quality department, member from R&D, member from purchase department. The responsibilities of a sustainable team includes – Working closely with quality circle to assess and review the gaps in the various departments, Periodically performing energy and waste and technological audits, Finding and defining scopes for improvement and setting sustainable development goals, Creating awareness of the importance of sustainable practices. Educating and training the employees of various departments on sustainable culture, Conduct monthly sustainable circle team meetings and communicating the findings to the top management, Project management and continuous monitoring, Risk and Cost Analysis.

- ## Alternative Solutions

There are various judicious alternatives that can help a facility reduce its carbon emissions as well as save costs. Few of the viable alternatives available today is given in the Table 2. The organization should choose the alternative based on the criteria such as location, space adaptability, cost-benefit analysis, etc. Cost- benefit gives us the economic viability of the solutions that tell us whether it optimizes the operational costs compared to the already available product or technology.
For example take purchased electricity – The current rate of electricity per unit for commercial sector is 8 rupees/kWh. Thus, annually, with the stated consumption in Table 3, the bill amount is 1.5 Cr/ year. For a commercial purpose, the hospital makes a down-payment to the government on estimated electricity consumption. This means, irrespective of how many units the hospitals has consumed, they would have to make the same payment. This is a clear loss if the hospital does not reach the estimated consumption. This is the problem faced by the hospital and hence to reduce the bill, the hospital needs for alternative energy generation. There are only a few solutions for this.

The economic viability of promising solution for the problem are discussed below -

i. Solar Energy

To point out, the hospital has already invested in 145 solar panels with a total output capacity of 50kWh. The investment cost of which has been 55 lakhs. The maximum amount of units generated by the system has been 3000 kWh/ month, which saves a cost of 24000 rupees. This generation is not uniform throughout the year. The solar energy generation has its constraints, that is, electricity is generated only during the peak hours of the day when the sun rays are intense. This is only 4-5 hours a day and not only that, the position of the panels have to be in south or south-west directions for maximum exposure. The panels also occupy space and care should be taken that they are placed in a no-shadow zone. Also the maximum efficiency for a solar output is taken to be between 75-80 percent.
Due to the seasons, the generation is at its low during rainy season with hardly reaching 1000 kWh. Thus on an average the units generated by the solar system per year is around 20000 kWh, which gives us a cost savings of around 1.6 lakhs (8 Rs/Unit). It will take around 30 years to get the return on investment (ROI) with these solar system specs. We require a minimum of 500 kW to see profits within two to five and to rise the output to this level, we have to invest in new solar panels of 500kW output. The number of panels required for this increases thus, requiring more number of space as well as more installation costs. Unfortunately, the hospital cannot afford such a space due to location constraints. Hence, this solution is economically non-viable.

ii. Combine Heat and Power (CHP) System

Combined heat and power (CHP), also known as co-generation, produces both electricity and thermal energy on-site, replacing or supplementing electricity provided from a local utility and fuel burned in an on-site boiler or furnace. CHP systems increase energy security by producing energy at the point of use, and significantly improve energy efficiency. A properly designed CHP system based on site requirements will typically operate with an overall efficiency of 65–85% (USDE, 2017).

CHP/Cogeneration equipment usually burns fossil fuel such as natural gas or fuel oil to generate electricity on-site. At a power station, the heat generated when electricity is produced has to be dissipated via cooling towers. With CHP, the heat is recovered on-site, and used for space heating and hot water. This means that overall, the process is more efficient, so less fuel is used. To gain maximum benefit from CHP, the system needs to be in operation for as many hours of the year as possible. With year-round requirements for electricity and significant amounts of hot water, hospitals are ideally suited to using CHP System. The commercial value of the electricity and heat produced by a CHP unit is greater than the combined cost of the fuel and maintenance required for the system to operate.

Fortunately, the hospital mentioned in the study met the site requirements for installing a CHP system as per the government guidelines. And one more advantage was that there was no need to replace the electricity generator back-up set. The CHP supplements the set there reducing the costs significantly.

Outsourcing energy management to third party contractor absorbs the initial risk of investment as well as reduced

the installation and maintenance cost of first few years. CHP can be used to heat various hospital appliances and aids in other non-clinical departments like laundry, CSSD, etc.. The investment cost of a CHP is around 15lakhs with very less maintenance costs. The cost of biogas or bio- fuel required for operation is far less than normal fuel. Thus, it is environment friendly as well as economically viable solution.

Table 2: Alternate Solutions

Scope	Judicious Alternative
Energy	Hydroponic Garden Use of Natural Light Energy efficient Ceiling Fans Motion Sensor Lightening Solar Energy Combined and heat and power technology(CHP) Computerized
Waste	Recycling and Composting On-site treatment Biogas production
Technology	Local Vendors Renewing period of AMC and CMC Periodic Healthcare technology assessment
Fuel	Biogas Bio-diesel
Water	Occupancy Sensor Switches Rain Water Harvesting Onsite Water treatment Garden Irrigation Replaced bottled Waters

(Source: Primary)

- ## Green Building Certification for Healthcare Facilities

Against this background, the Indian Green Building Council (IGBC) has launched 'IGBC Green Healthcare rating system to address National priorities. This rating programme is a tool which enables the designer to apply green concepts and reduce environmental impacts that are measurable. Green Hospitals can have tremendous benefits, both tangible as well as intangible. The most tangible benefits are the reduction in water and energy consumption right from day one of occupancy. The energy savings could range from 30 - 40 % and water savings around 20 - 30%. The intangible benefits are improved health and hygiene, enhanced daylight, connectivity with the nature, improved health & hygiene for better infection control, faster recovery of patients by 15%, Reduction in patient stay by 41%(IGBC, 2021).

There are different levels of certifications based on the compliance of the green factors such as indoor environment and quality, sanitation and hygiene, water and energy conservation, etc. The details of various categories and fee structure in available on the website.

8. Discussion

The hospital where the study has been performed has 76 percent green compliance with current utilities and has large scopes for increasing the standards which have been identified. The most cost and energy consuming (80 percent) utility for any hospital is HVAC, also being a potential pollutant of environment. But it is a very important utility for the hospitals, not only in terms of ambience but in terms of HIC. The CHP has been identified as a judicious support of the HVAC to reduce the costs. And our government is looking in to projects to promote it.

The hospitals have adapted themselves to biomedical waste management but it still requires novel processing methods. The management is more concentrated towards the government protocol and has failed to understand its effects and aftermath.

Table 3: Carbon foot-print of Energy Consumption

Year	Environmental Aspects	Units Consumed per year	Emission Factor	Amount of emission
2020	Electricity	198000 kWh	0.85kgCO2e/kWh	1683306 kg

(Source: Primary data)

Table 4: Carbon foot-print of Biomedical Wastes generated

Year	Type of Waste	Amount (kg)	Method	EF(kgCO2e/kg)	Amount of Emission(kgCO2)
2020	Red	350	Autoclave plus landfill	0.88	308
	Yellow	412	Autoclave plus deep burial	0.83	314.96
	Green	120	Landfill	0.33	40
	Blue	68	Incineration	0.54	36.72
	White	45	Incineration	0.54	24.3
				TOTAL	723.98

(Source: Primary data)

The study has found that the current segregation of BMWs has to become more focused to prevent unnecessary and mounting cost. By this, it means the already colored wasted has to be further divided, example being, the blue wastes should be separated as broken and unbroken glasses, the green wastes into different articles, etc. This provides scope for recycling reducing transportation, disposal and investment costs. The hospital should also engage in CRM and cost-benefit analysis for biomedical waste management. Table 3 and 4 show the amount of emissions from energy consumption and biomedical wastes generated by the hospital where the study was conducted.

As much as the product and process are important to move towards environmental and economic sustainability, so is the stakeholder involvement, especially that of the employees. Only a culture of sensitivity, sensibility and responsibility will help achieve this goal. Hence, the study finds that it is essential that hospital invests optimally in educating and training its entire staff irrespective of the job description, on lines of green sustainability. Adding to those recruiting rightly qualified individuals are a key to adapting and maintaining sustainable culture.

9. Implications

The tool-kit has already has presented with the suggestions for energy and wastes. The study has been confined to energy and wastes due to limitations discussed. The scope lies in discovering all the aspects of the aspects of the conceptual framework. The first step for any hospital towards green sustainability is getting the green building certification as this coves most of the basic compliance of the independent variables presented in the framework. Once, a healthcare facility is green certified, the management gets sense of direction to proceed towards sustainability in the key areas. In the current scenario, the critical areas are that of healthcare technology, wastes, and clinical process. Also, the study is yet to explore the patient and employee outcome of the green sustainability. The focus should be on studying one whole cycle and iterating the process of quality until the standards are achieved. As discussed the sustainable circle should be employed at all healthcare facilities to monitor the process. The NABH accreditation mentions the greening of hospital in the chapter 8 (Facility Management and Safety).

The accrediting bodies should make sure that, the basic green compliance is achieved before going in for final certification. This will motivate hospital to cultivate and maintain green culture.

Data Availability Statement: All data relevant to the study are included in the article or uploaded as supplementary material.

Ethics Statements: Not applicable

Ethics approval:

Ethics approval was obtained from Institutional Ethics Committee though this study does not involve much of human participants and this paper is based on the discussion and interview with small group of experts (unit heads of the hospital) and is based on the literature review. Ethical approval was obtained from the Institutional Ethics Committee, SRIHER (DU). Ethics Review reference number is CSP/21/MAR/92/215

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Contributors: All authors were involved in conceptualising and designing the study. GK led the collection and analysis of the data. GK and ABD were involved in data validation and analysis. GK prepared the first draft, and all authors reviewed, revised and approved the manuscript. GK is also the guarantor and accepts full responsibility for the study.

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10. Conclusion

Hospital being the primary mean of promoting public health is a major contributor to carbon emissions. This is quite evident from the study, and also reflects how much more it can produce pollutants when it is providing 16.8 lakh kg of carbon just having started. A regular hospital with full swing operations will contribute around 0.6 percent. Thus the cumulative effect of all the healthcare organizations in the country will significantly add up to environmental costs. This in turn deteriorates the public health it intends to protect.

Non-clinical departments or utility services contribute equally to a hospital's economic growth like that of clinical department. These support services and its personnel being the backbone of hospital received less than required attention from management. In-fact the utility services provide when managed properly produce more profit with less investment. Among the utility services, energy and wastes is the core centre that requires environmental and economic sustainability.

Many governments have been looking into sustainable innovation projects for healthcare utility sector and large number of healthcare organizations has been moving towards green sustainability since the start of the decade. The WHO has been actively voicing out the about greening hospitals as a part of SDGs and have been motivating healthcare stakeholders from all over the world towards protecting the environment and people through green solutions.

The model and toolkit developed by this study have been successfully validated and hence, will aid any hospital management in their journey towards green sustainability.

References

1. Fadhel Alshqaqeeq, M. Amin Esmaeili, Michael Overcash, Janet Twomey, (2020). Quantifying hospital services by carbon footprint: A systematic literature review of patient care alternatives, Resources, Conservation and Recycling, Volume 154, 104560, ISSN

0921-3449, https://doi.org/10.1016/j.resconrec.2019.104560.

2. NABH 5th Edition (2020)

3. Wyssusek K, Keys Maggie T, Zundert André A J (2019), "Operating room greening initiatives – the old, the new, and the way forward: A narrative review", Waste Management and Research, Vol.37

4. Vancity GHG inventory and carbon neutral report, 2009

5. Sherman J (2016), "Environmental Sustainability in Anesthesia: Pollution Prevention and Patient Safety", Advances in Anesthesia, Vol.34

6. UNDP Global Healthcare Waste Project, 2013, Management of Specific Infectious Wastes.

7. ASHE Sustainability Report, 2014, Signature Leadership Series Environmental Sustainability in Hospitals: The Value of Efficiency.

8. Protocol for the quantification of greenhouse gas emissions from waste management activities Seche Environnement Suez Environnement Veolia Environnement 2, ePe, GHG Protocol, 2013

9. Healthy Hospitals Healthy Planet Healthy People from WHO: From Health Care Without Harm, WHO, 2010

10. Hendricks, S.J., Hillsman, E., Foster, A., Yassin, A., & Stuart, A. (2010). Developing a Framework for a Toolkit for Carbon Footprint that Integrates Transit (CFIT). Report No. 77909 produced by National Center for Transit Research for the Florida Department of Transportation.