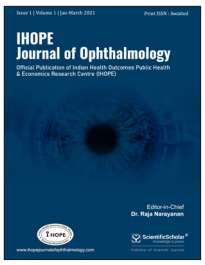
ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

www.ihopejournalofophthalmology.com

IHOPE Journal of Ophthalmology



Original Article

Eye care and the carbon foot print

Thulasiraj Ravilla[1], Venkatesh Rengaraj[2], N. Balakrishnan[3], Sriram Ravilla[4]

[1]Lions Aravind Institute of Community Ophthalmology, Aravind Eye Care System, Madurai, Tamil Nadu, [2]Aravind Eye Hospital - Pondicherry, Aravind Eye Care System, Puducherry, [3]Facility and Environment, Aravind Eye Care System, Madurai, [4]Aurolab, Madurai, Tamil Nadu, India.

***Corresponding author:**
Thulasiraj Ravilla,
Lions Aravind Institute of Community Ophthalmology,
Aravind Eye Care System,
Madurai, Tamil Nadu, India.

thulsi@aravind.org

Received : 04 March 2022
Accepted : 10 April 2022
Published : 12 May 2022

DOI
10.25259/IHOPEJO_3_2022

Quick Response Code:

ABSTRACT

Objectives: Climate change and its impact on the environment are rapidly becoming a crisis, resulting in extreme climate conditions and directly impacting health. The World Health Organization attributes 13.7 million deaths in 2016 to overall environmental factors. As health-care providers, we seem to be a significant contributor to carbon emissions. Health Care Without Harm, an organization promoting environmental health and justice, estimates that health-care accounts for an equivalent to 4.4% of global net carbon emissions. As a specialty with very high surgical volume, eye care would be contributing a significant portion of these carbon emissions. Thus, there is a need for us to explore ways of mitigating this.

Materials and Methods: A descriptive case study method has been adopted to study environmentally sustainable practices with published or real-world data. Data from power consumption and energy audits were used in the analysis. The various approaches to reducing carbon emissions in eye care were studied using a broad framework of looking at what resources are deployed and how those resources are used.

Results: Whether it is resources or how they are put to use, there is a great scope for reducing carbon emissions through reducing use, re-use, and recycling. On the energy front just through the use of energy efficient electrical devices, and 8%–10% reduction in power consumption could be achieved immediately. Since green energy is less expensive than grid power, switching to it can generate another 15% in cost savings. It was feasible to switch to green energy for 75% of the power needs in the larger hospitals. Organic water recycling technology could recycle over 90% of the water and re-used it. Lean clinical protocols showed that the carbon emissions could be reduced to 5% of what it is in the west for procedures like phacoemulsification.

Discussion: While it is inevitable that eye care delivery will generate carbon emissions, it is well within our control to minimize it, per unit of care. This could be achieved essentially by minimizing waste or underutilization, enhancing efficiency, reducing consumption, and reducing patients' efforts.

Conclusion: These are the early days of trying to figure out, how the eye care sector can change its practices to minimize carbon emissions. A lot more evidence is required, signaling the need for research and publications in this space. As with any activity, for continuous improvement, we need benchmarks and robust monitoring systems. All of these are yet to evolve in clinical care.

Keywords: Carbon footprint, Energy, Recycle, Re-use, Eye care

INTRODUCTION

Climate change and its impact on the environment have been taking the center stage in recent years. The recently concluded United Nations Climate Change Conference – COP-26 (Conference of Parties), in Glasgow had the attention of all world leaders and the participation of several Heads of State. Climate change and the threat to our planet are very real and all of us are personally experiencing it with global warming and extreme weather patterns. The World

Health Organization attributes 13.7 million deaths in 2016 to overall environmental factors.[1] As health-care providers, we need to be concerned as we are a significant contributor to carbon emissions. Health Care Without Harm and its partners, in their policy paper "Healthcare's Climate Footprint," estimate that health care accounts for 4.4% of global net carbon emissions.[2] As members of the eye care sector, we need to be concerned about our contributing role toward the current scenario. An estimated 28 million cataract surgeries are performed annually worldwide.[3] Assuming that this accounts for 60% of all procedures, the total ocular surgical and other procedures would be around 40 million. This makes eye care a very high-volume surgical specialty within healthcare. While we do not have accurate estimates, we can recognize that such high surgical volumes would make eye care a significant contributor to carbon emissions, within health care. Thus, as eye care providers, we have to hold ourselves accountable for reducing environmental harm. The aim of this article is to present and discuss some of the approaches that can mitigate to a certain extent the impact of eye care on climate change.

MATERIALS AND METHODS

A descriptive case study methodology has been adopted to describe the processes followed at a network of eye hospitals in South India, to minimize the carbon footprint in the delivery of eye care, and supported where relevant, with data. Various factors were studied using a broad framework by looking at what resources are deployed and how those resources are used, as shown in [Figure 1]. The environmentally sustainable practices are adapted across all the eye hospitals in the network. The building infrastructure, energy, equipment, water, and consumables are categorized as "resources." The service design, clinical protocols, procurement, travel of patients and staff, and maintenance protocols are all categorized under "resource utilization." The resources and their use have all been studied with an environmental sustainability perspective.

Monthly power consumption data and studies to make one of the hospitals as a Net Zero Energy Building (nZEB)[4] have been used in this article.

RESULTS

Hospital buildings

These are oriented to minimize solar heat and designed to leverage maximum natural ventilation and lighting [Figure 2], thereby minimizing the need for supplementary lighting and air-conditioning. These have a direct bearing on reducing energy needs.

Energy

With energy, the first strategy would be to minimize energy needs. This is best done by a comprehensive energy audit

Table 1: Baseline energy consumption.

Annual energy consumption	1,696,945 kWh
Energy performance index	77 KWh/Sq. Meter/year
Energy performance index goal	≤15 KWh/Sq. Meter/year
Pattern of energy consumption	
Lighting and power	44%
Heating, ventilation, and air conditioning	32%
Other equipment	24%

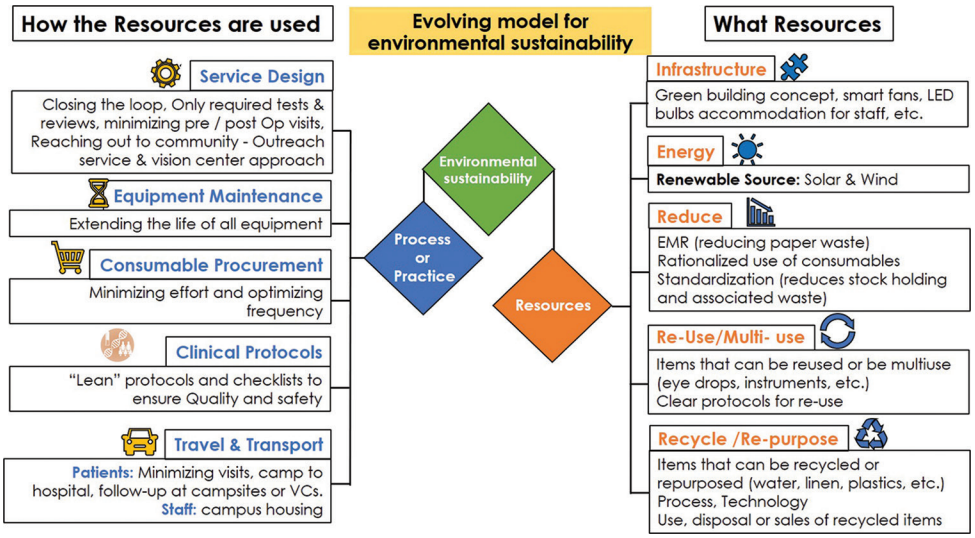


Figure 1: Resources and how they are used.

by competent agencies. This will help establish the annual energy consumption, the pattern of consumption, and the "Energy Performance Index (EPI)." The goal would be to bring the total energy consumption net of green energy (solar or wind) to be 15 KWh or less per sq. meter per year, to be declared as nZEB. In the instance of the Eye Hospital at Pondicherry, the baseline energy consumption, in the year 2020, is shown in [Table 1].

Figure 2: Patient arrival or departure waiting area.

The audit also estimated the energy savings of various interventions, the investments required, and the payback periods for each intervention, as shown in [Table 2]. This helps in making informed decisions on which interventions to prioritize and which ones to defer, based on financial and other considerations like disruption to clinical work.

Based on [Table 2], the work has started to replace all existing lights with LED lighting, switch all fans to energy efficient ones as well as replacing motors and chillers for air-conditioners. Due to the pandemic, the pace of work has been hampered and is still a work in progress.

Table 2: Investment versus returns analysis.

Measures	Energy Savings kWh	Annual Cost savings Rs.	Cost in Rs. Millions	Payback period Years
Wall insulation 50 mm	15,656	161,413	4.8	29.6
Roof insulation 150 mm	48,709	502,190	8.7	17.4
High performance glazing	37,096	382,460	4.5	11.6
Lighting power	162,705	1,677,489	3.1	1.8
Chillers with COP 6.5	73,656	759,393	7.6	10.0
AHUs with ECM Motors	22,663	233,656	3.8	16.3
5-star rated pumps	63,136	650,932	2.6	4.0

COP: Coefficient of performance, AHU: Air handling unit, ECM: Electronically commutated motor (motor that uses electronic controls to vary its speed)

Table 3: Power consumption and patient load.

Madurai Eye Hospital – Energy Consumption				
Year (Jan-Dec) →	**2018**	**2019**	**2020**	**2021**
Total energy consumption (KWH)	3,876,300	3,565,472	2,361,915	2,752,930
Change % with respect to 2018		−8.0%	−39.1%	−29.0%
Hospital outpatient visits	875,242	886,818	482,499	753,543
Change % with respect to 2018		1.3%	−44.9%	−13.9%
Hospital surgeries, lasers, and injections	168,707	165,215	83,690	143,603
Change % with respect to 2018		−2.1%	−50.4%	−14.9%

Table 4: Six months energy data (October 2020–March 2021): Source and consumption.

Location	Total Power consumption Units	Green Power Units purchased		Green Energy
		Wind	Solar	
Madurai	1,180,956		698,166	59.12%
Coimbatore	709,974		569,122	80.16%
Chennai	673,616		519,617	77.14%
Tirunelveli	504,336	475,299		94.24%
Salem	221,084	187,098		84.63%
Total	3,289,966	662,397	1,786,905	74.45%
		20.13%	54.31%	

At the eye hospital in Madurai, the energy conservation work was carried out by a company on an arrangement involving sharing of cost savings. They replaced the existing electrical items with LED bulbs for lighting, energy efficient fans, and chillers in air-conditioning plants. [Table 3] shows the power consumption over the years, starting in 2018, the base year before power conservation strategies were implemented. In 2019, when the patient volume was very similar to 2018, which saw a reduction of 8.0% in the power consumption, and this translated to an annual savings of approximately Rs. 2.5 million.

Having started work on minimizing energy consumption across all tertiary hospitals in the network, the next strategy was to switch to green energy. That is solar or wind energy. Here again, two options were available – generating own green energy or getting into purchase agreements with third-party producers of green energy. After saturating the option of roof-top solar power panels, we supplemented it by purchasing green power. [Figure 3] shows the transition from grid power to green energy (solar) at the eye hospital in Madurai.

The following [Table 4] gives the status of green energy usage in the larger hospitals in the network. With wind energy, which is available round the clock, we were able to substitute the grid power to a greater extent than solar. However, there is a seasonal factor to wind energy and similarly, solar power has the limitation of power generation happening only in the daytime. Since green energy is less expensive than grid power, this too has resulted in savings of about Rs. 6 million per year, for the hospitals in Tamil Nadu.

Water

Another important utility is water. The sustainable approach, here, is similar. The first is to minimize water use. Some of the actions toward this are to eliminate leaks and wastage of water, reduce the water flow in faucets to required levels, use of waterless urinals, and so on. Simultaneously, all the used water from all sources including toilets are treated using the organic Decentralized Waste Water Treatment System (DEWATS).[5] In hospitals, where DEWATS is installed, it treats over 90% of the water used and the treated water is reused for toilet flushing and gardens. Overall, across the hospitals, the DEWATS treats over one million liters of water a day. The goal is to have zero water discharge from the hospital and staff accommodations.

Sustainable delivery of eye care

While what is described above relates to infrastructure and utilities like power and water, a lot can be done to reduce the carbon emissions in the delivery of care as shown under "How the resources are used" of the sustainability model, as shown in [Figure 1].

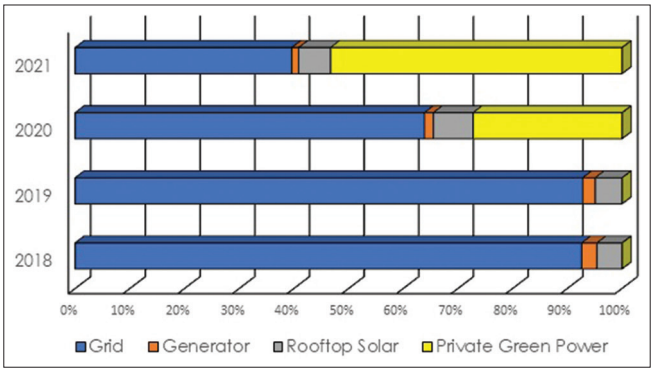


Figure 3: Trend in shift in energy sources.

Service design

When we view service design through the sustainability lens, there are several options to reduce the carbon footprint of the caregiving process. The following are some of the strategies that help are:

Closing the care loop

The reality is that the caregiving process involves the travel of patients and hospital staff, the use of equipment, and consumables. This is inevitable and it also results in carbon emissions. Hence, our approach must be to ensure such effort is not wasted on account of inadequate diagnosis, inappropriate treatment advice, or the patient not complying with the advised treatment. Through audits, establishing metrics to monitor the comprehensiveness of diagnosis, treatment advice, and compliance will lead to continuous improvement in the effectiveness of care delivery, minimize wasted effort, and thus minimize the carbon emissions per successfully treated patient.

Minimizing hospital visits

Each visit by the patient also leaves a carbon trail as well the associated effort and costs. Each visit also generates duplicated efforts such as registration, engaging the patient, and taking up a slot of the hospital's capacity for that day. Thus, completing the entire care cycle as appropriate from diagnosis to treatment, in a single visit, will significantly reduce the effort and associated carbon footprint.

Care at the appropriate level

A combination of outreach and tightly integrated primary, secondary, and tertiary levels of care, enables care to be provided at appropriate levels. At outreach, close to 75% of patients receive a complete eye examination, diagnosis, and a prescription. Those needing glasses are able to get them right at the camp site. Only those who need to go to the hospital for surgery or advanced investigations are referred to the hospital. Similarly, at Vision Centers, over 85% of the patients complete

Box 1: IAPB's call to action statement.

International agency for the prevention of blindness – Call to action for environmentally sustainable practices in the eye health sector
Reproduced from https://www.iapb.org/learn/work-groups/climate-action/, with permission from IAPB
Lead: You can acknowledge a Climate Emergency and develop an environmental sustainability strategy for your organization with targets that will help reduce your greenhouse gas emissions and support the Sustainable Development Goals
Advocate: You can develop and deliver advocacy messages and strategies and train your staff, partners and eye health workers in the knowledge of and delivery of climate action messages. Help embed these messages by seeking to create clean, green, welcoming eye health services to the benefit of staff and patients. Make every contact count by sharing your successes at conferences, networking events, and partnership meetings
Procure Sustainably: You can implement a sustainable procurement policy and/or procedure by selecting products that have a lower impact on the environment, consume less energy and water in production and use, use fewer harmful chemicals, and embed the principles of the circular economy (what happens at the end of life) into your procurement process
Reduce the use of fossil fuels: You can maximize the use of renewable energy at your office and health-care facilities and improve the energy efficiency of your buildings and equipment, including lighting, air conditioning, office, and medical equipment
Conserve Water: You can consider water saving technology, such as gray water recycling, and water efficient equipment. You can make sure your water system is monitored for leaks and any leakages repaired
Reduce and safely dispose of waste: You can consider the waste hierarchy "reduce, reuse, repair, and recycle." For hazardous medical waste, you can choose a safe disposal option which is most suitable and likely already in use for your region
Reduce and green the travel: You can reduce the amount of flying where possible considering alternatives such as video conferencing. You can reduce the amount of patient travel through alternative models of care such as telemedicine and through eye health system strengthening, for example, one stop clinics offering care at the community level. You can promote active travel and public transport for staff and patients where possible
Follow four principles of sustainable clinical practice: You can follow the four principles of prevention, patient empowerment, lean eye health service delivery, and the use of medical procedures and technologies which have a lower environmental impact. This will reduce the demand for eye health services reduce the cost of delivery and decrease their environmental impact
Embed environmental sustainability in education: For international and regional bodies, you can consider embedding environmental sustainability into your eye health education programs and the health curriculum. You can offer resources on environmentally sustainable eye health on your website
Focus your research: You can support and/or conduct research in sustainable eye health services to generate evidence for advocacy and practice for sustainable change such as the comparative environmental impact of Manual Small Incision Cataract Surgery versus Phacoemulsification, disposables versus reusables, and new service delivery models that further our understanding

the care cycle locally. Follow-up care or reviewing the outcome of surgery or interventions is all done at the outreach site or the Vision Centers. In a typical year, about 1.2 million outpatient visits are handled between outreach and vision centers and this gives the magnitude of carbon emissions averted.

Equipment maintenance

Routine and preventive maintenance as recommended by the manufacturer, training the clinical team in the proper use and care of equipment, as well as providing the right electrical power and atmospheric environment, all go toward extending the life of the equipment, while also making the equipment available in good working condition for clinical care. Through this process, the purchase of new equipment is either delayed or averted and this too results in the reduction of the carbon footprint associated with the manufacturing and shipment of equipment.

Procurement

Sharing the annual requirements with the vendors along with the delivery schedule, on the one hand, helps in getting better prices, and allows the vendor also to efficiently plan the supply-chain process. In addition to the transportation of goods, the other major area that can help reduce the carbon footprint is packaging. Bulk packaging, wherever appropriate, reduces packaging materials. When it comes to the purchase of electrical items such as lights, fans, and motors, items that consume less power are purchased – LED lights, fans with BLDC motor (Brushless Direct Current), and high-energy star rated motors. On the clinical and other consumables, there is a high degree of standardization. This goes a long way in reducing inventory and associated reduction waste and obsolescence. All of these help reduce the carbon footprint.

Clinical protocols

This probably is the area, where the most significant reductions in medical waste and associated carbon emissions can be made. In one of our publications, we have described in detail our lean surgical protocol and how the infection rates are no different.[6] In a more recent publication, the medical waste from a phacoemulsification surgery, using our lean clinical protocol, was estimated to be 5.9 kg CO2e, while it was 132.9 Kg CO2e in a UK facility, for the same

procedure.[7] During the pandemic, we experimented to see if the operating room protocols mandated in the US resulted in lower post-operative endophthalmitis rates following cataract surgery, when compared to our standard lean protocol. This clinical trial involving 85,552 sequential patients showed that the post-operative endophthalmitis rates were no different.[8]

Travel and transport

This is recognized as an important source of carbon emissions. Eye care as with many other services requires the travel of patients and staff. It also requires the transportation of supplies. While this is inevitable, it is within our scope to minimize travel and transportation. For instance, staff housing on the hospital campus, where feasible, can significantly reduce staff travel. As described earlier, completing the care cycle in a single visit, and providing care at local levels closer to the patient, can all reduce their travel. Optimizing the frequency or replenishment of supplies can potentially reduce the embedded carbon emissions in the supply-chain process.

DISCUSSION

Any activity involving the movement of people, transportation of and consumption of materials as well as waste, will generate carbon emissions. Thus, it is inevitable that eye care delivery too, will. Our goal, thus, is to see how this can be minimized, per unit of care. This is where innovative approaches and practices can be brought in. Bringing down the carbon emissions per unit of care is essentially driven by minimizing waste or underutilization, enhancing efficiency, reducing consumption, and reducing patients' effort. All of these by design will also reduce the unit cost of providing care as well the cost of accessing care by the patient. Thus, this would also be a win-win, for the provider and the patient.

Given the global urgency, a working group was formed in 2017, under the International Agency for the Prevention of Blindness (IAPB). This followed the global recognition that climate change is everyone's problem and as a significant contributor to climate change, health care is morally obliged to take lead. IAPB's climate action working group, following several rounds of deliberations, came up with a ten-point call to action statement [Box 1] for influencing eye care providers and associated stakeholders, to consciously implement initiatives to address climate change, within their organizations and programs.[9] IAPB Climate Action Working Group also brought out a more detailed companion guide, describing in detail, sustainable practices in eye care.[10]

CONCLUSION

These are very early days in the movement to address the adverse impact due to climate change. We need more evidence to catch the attention of providers and policymakers to generate the importance that this urgently requires. Recently, a survey was conducted on cataract surgeons and nurses to assess their attitudes toward operating room waste and their willingness to shift to reusable supplies.[11] Of the more than 1300 ophthalmologists and nurses interviewed, 78% believed that more supplies should be reused and 90% were concerned about global warming. More such studies are required to shift policies. We need to develop metrics and tools that will allow us to quantify and monitor the carbon emissions caused by eye care services. We also need to establish benchmarks so as to know, where we stand in this. It is important that we leave our planet as a better place for future generations. We have this responsibility and we need to act now based on what we already know and gather evidence to design newer approaches.

Declaration of the patient consent

Patient's consent not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Lenzen M, Malik A, Li M, Fry J, Weisz H, Pichler PP, *et al*. The environmental footprint of health care: A global assessment. Lancet Planet Health 2020;4:e271-9.
2. Health Care without Harm. Health care's Climate Footprint: How the Health Sector Contributes to the Global Climate Crisis and Opportunities for Action. Health Care without Harm; 2019. Available from: https://noharm-global.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint_092319.pdf [Last accessed on 2022 Mar 03].
3. Ocular Surgery News, Feb 10, 2021: Future of Cataract Surgery Seems Promising by Richard L Lindstrom, MD. Available from: https://www.healio.com/news/ophthalmology/20210126/future-of-cataract-surgery-seems-promising#:~:text=At%20present%2C%20approximately%204%20million,are%20performed%20every%20day%20globally [Last accessed on 2022 Apr 07].
4. Net Zero Energy Buildings Definitions. Available from: https://nzeb.in/definitions-policies/definitions [Last accessed on 2022 Mar 03].
5. Decentralized Wastewater Treatment System at Aravind Eye Hospital, Pondicherry. Available from: https://www.cseindia.org/decentralised-wastewater-treatment-system-at-aravind-eye-hospital-pondicherry-3769 [Last accessed on 2022 Mar 03].

6. Ravindran RD, Venkatesh R, Chang DF, Sengupta S, Gyatsho J, Talwar B. Incidence of post-cataract endophthalmitis at Aravind eye hospital: Outcomes of more than 42,000 consecutive cases using standardized sterilization and prophylaxis protocols. J Cataract Refract Surg 2009;35:629-36.
7. Thiel CL, Schehlein E, Ravilla T, Ravindran RD, Robin AL, Saeedi OJ, *et al*. Cataract surgery and environmental sustainability: Waste and lifecycle assessment of phacoemulsification at a private healthcare facility. J Cataract Refract Surg 2017;43:1391-8.
8. Haripriya A, Ravindran RD, Robin AL, Shukla AG, Chang DF. Changing operating room practices: the effect on postoperative endophthalmitis rates following cataract surgery. Br J Ophthalmol 2022;2021:320506.
9. Climate Action: Tackling Issues around Environmental Sustainability. The International Agency for the Prevention of Blindness. Available from: https://www.iapb.org/learn/work-groups/climate-action [Last accessed on 2022 Mar 03].
10. IAPB Climate Action Working Group. Guide for Environmentally Sustainable Practices in the Eye Health Sector. Available from: https://www.iapb.org/learn/resources/guide-for-environmentally-sustainable-practices-in-the-eye-health-sector [Last accessed on 2022 Mar 03].
11. Chang DF, Thiel CL. Ophthalmic instrument cleaning and sterilization task force. Survey of cataract surgeons' and nurses' attitudes toward operating room waste. J Cataract Refract Surg 2020;46:933-40.

How to cite this article: Ravilla T, Rengaraj V, Balakrishnan N, Ravilla S. Eye care and the carbon foot print. IHOPE J Ophthalmol 2022;1:25-31.