REVIEW

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CLINICAL ENDOSCOPY

Gastrointestinal endoscopy's carbon footprint

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Climate change is a global emergency. Consequently, current global targets to combat the climate crisis include reaching net-zero carbon emissions by 2050 and keeping global temperature increases below 1.5 ℃. In 2014, the healthcare carbon footprint was 5.5% of the total national footprint. Gastrointestinal endoscopy (GIE) has a large carbon footprint compared to other procedures performed in healthcare facilities. GIE was identified as the third largest generator of medical waste in healthcare facilities for the following reasons: (1) GIE is associated with high case volumes, (2) GIE patients and relatives travel frequently, (3) GIE involves the use of many nonrenewable wastes, (4) single-use devices are used during GIE, and (5) GIE is frequently reprocessed. Immediate actions to reduce the environmental impact of GIE include: (1) adhering to guidelines, (2) implementing audit strategies to determine the appropriateness of GIE, (3) avoiding unnecessary procedures, (4) using medication rationally, (4) digitalization, (5) telemedicine, (6) critical pathways, (7) outpatient procedures, (8) adequate waste management, and (9) minimizing single-use devices. In addition, sustainable infrastructure for endoscopy units, using renewable energy, and 3R (reduce, reuse, and recycle) programs are necessary to reduce the impact of GIE on the climate crisis. Consequently, healthcare providers need to work together to achieve a more sustainable future. Therefore, strategies must be implemented to achieve net-zero carbon emissions in the healthcare field, especially from GIE, by 2050.

Keywords: Carbon emission; Carbon footprint; Environment; Green endoscopy; Net-zero

INTRODUCTION

Climate change is an urgent and inevitable global emergency. According to the Global Climate Report of 2022 released by the National Centers for Environmental Information, the September 2022 global surface temperature tied for the fifth highest position for September since the record began in 1880.[1] Climate change affects the entire planet. Therefore, everyone will be affected by significant climate events, such as (1) global cyclones, (2) hurricanes such as Fiona and Ian, (3) western pacific typhoons, (4) devastating flooding in places like Nigeria, and (5) extreme increases in temperatures in Europe (Fig. 1).[1] The Global Climate Change reported by the National Aeronautics and Space Administration revealed changes in global surface temperatures, calculated by averaging sea surface temperatures and air temperatures over land.[2] Global surface temperatures in 2021 were 1.04 ℃ warmer than those measured before the industrial revolution (1880–1900). In addition, a 1 ℃ rise in global temperatures will displace or force one billion individuals to live in insufferable heat. According to the Global Risks Perception Survey for the 2021–2022 period in the World Economic Forum, environmental factors accounted for five of the ten identified risk factors for the climate crisis. In addition, "climate action failure" was identified as the most critical risk factor for climate crisis for the next ten years.[3]

The global response to this impending crisis has included a series of climate change conferences. The first conference held in 1992 was entitled the Rio Earth Summit. At the end of this

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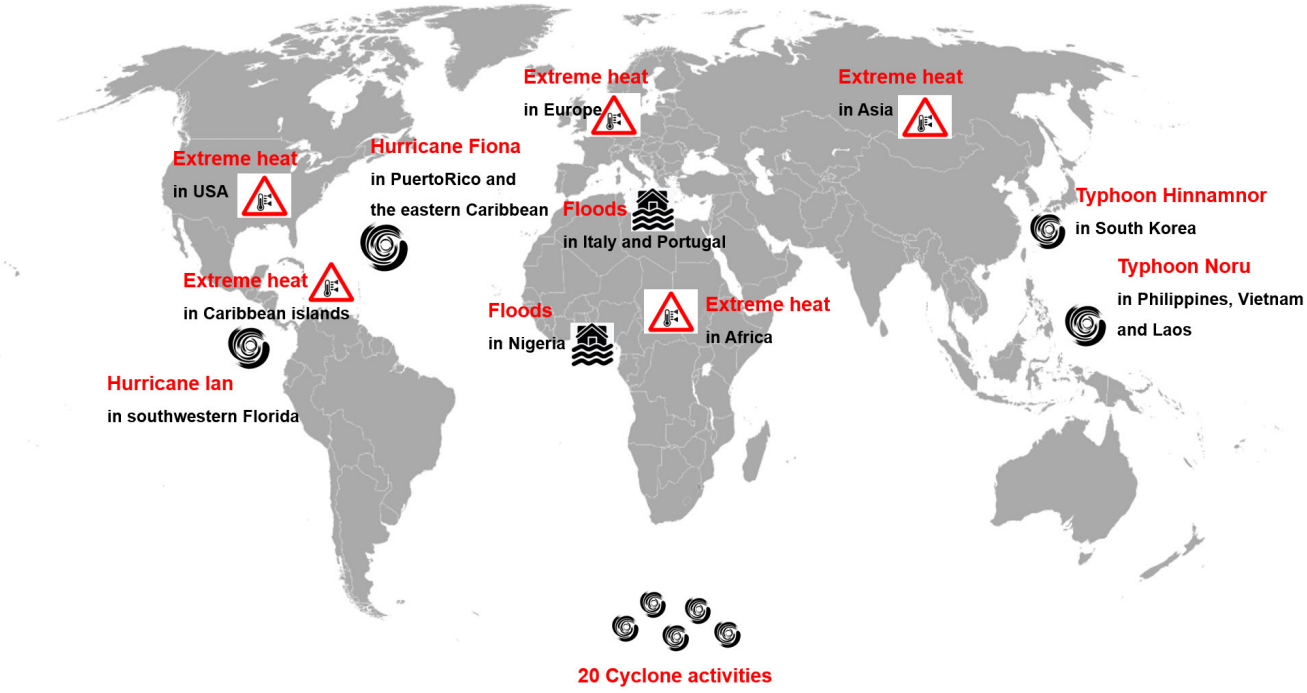

Fig. 1. Climate change affecting every corner of the planet. Modified from NOAA National Centers for Environmental Information.[1]

conference, it was concluded that sustainable economic development is an achievable goal for all individuals at the local, regional, national, and international levels. In 1997, the Kyoto Protocol stated that industrialized nations would reduce their emissions of greenhouse gases (GHG) below their 1990 levels. GHG are gases that accumulate in the atmosphere, trap heat and thereby contribute to climate change. Carbon footprint is defined as the total amount of GHG emitted directly and indirectly by the actions of humans, and it is expressed as CO_2e.[4]

The Paris Agreement was achieved in 2015. One hundred and ninety-six parties signed this agreement, also known as the Paris Accords, which covers climate change mitigation, adaptation, and financing for emission reductions. In 2021, the rulebook for the implementation of the Paris Agreement was finalized. The Conference of the Parties 26 in 2021 called for countries to establish a net-zero carbon emission target for 2050 and to maintain global temperatures below 1.5 °C by phasing out coal, reversing deforestation, and using electric vehicles and renewable energy. Net-zero carbon emissions will be achieved when CO_2 production is less than CO_2 removal. Therefore, net-zero emissions will be achieved when carbon emissions are significantly reduced and when carbon emissions removed from the atmosphere are maximized by reforestation or direct carbon removal.

HEALTHCARE CARBON FOOTPRINT

According to the 2022 Emissions Gap Report, China, the United States of America (USA), and India were the top three countries for total GHG emissions; the USA, the Russian Federation, and China were the top three countries per capita for GHG emissions. The assessment of healthcare's nitrogen footprint between 2000 and 2015 showed that the global nitrogen footprint increased from 1 megaton in 2000 to 1.4 megaton in 2015, indicating a 1.9% increase in global emissions and a 155 g increase per capita in global emissions.[5] The global nitrogen footprint significantly increased in East Asia. Analysis of international healthcare carbon footprints in the Organization of Economic Co-operation and Development (OECD) countries revealed that these countries accounted for 5.5% of the total national carbon footprint.[6] The Netherlands (8.1%), the USA (7.9%), Belgium (7.7%), and Japan (7.6%) had the highest national carbon footprints.[6] Healthcare carbon footprint in South Korea accounted for 5.3% of the total national carbon footprint. Even so, between 2007 and 2016, healthcare carbon emissions increased in most countries; a 75% increase was observed in South Korea.[7] In 2019, Asan Medical Center, Samsung Medical Center, Yonsei Severance Hospital, Seoul National University Hospital, and the Catholic University of Korea Seoul Saint Mary's Hos-

pitals were ranked 6th, 7th, 8th, 12th, and 16th, respectively, out of 20 major sources of carbon emissions in Seoul, Korea. Healthcare institutions emit a large amount of carbon. According to the Energy Statistics Handbook (2021), energy usage increased annually by 1.6% between 2000 and 2019. Therefore, carbon footprint is an important area of interest for sustainable healthcare in the future.

EMISSION SCOPES OF HEALTHCARE FOOTPRINT

Salas et al.[8] suggested three emission scopes of healthcare footprint. Scope 1 emissions comprise direct emissions from healthcare facilities. Examples of scope 1 emissions include on-site fuel combustion, fleet vehicles, and anesthetic gas leaks. Scope 2 emissions are derived from electricity produced by the healthcare facility. Scope 3 emissions include indirect emissions embedded in the supply and equipment chain, commuting of health care workers, and waste disposal. Carbon footprints from scopes 1, 2, and 3 were 17%, 12%, and 71% of the healthcare carbon footprint, respectively. However, several components of scope 3 emissions were unmeasured and were not represented in the observed 71% of total carbon emissions. Tennison et al.[9] reported divergent sectors of GHG emissions from the National Health Service (NHS) in England in 2019. Healthcare carbon footprints of the NHS were primarily derived from the supply chain (62%), followed by the direct delivery of care (24%), commuting healthcare workers and traveling patients and visitors (10%), and private healthcare services provided by the NHS (4%). In Switzerland, the life cycle of 33 acute-care hospitals evaluated 16 environmental impact categories to determine GHG emissions.[10] The environmental impact of these hospitals was analyzed at the midpoint level of the 16 environmental impact categories. Infrastructure, energy provision, and catering were key environmental hotspots for carbon footprint among the 16 environmental impact categories. In addition, variations in the environmental impacts of the hospitals revealed sizable reduction potentials.

ENDOSCOPY'S CARBON FOOTPRINT

Gastrointestinal endoscopy (GIE) is a rapidly developing field of healthcare. Even so, it is associated with a larger carbon footprint than other procedures in healthcare systems.[11] GIE is considered the third-highest waste generator in healthcare facilities. GIE is a significant contributor to the carbon footprint of healthcare facilities since it is associated with high daily caseloads, repetitive travel by patients and their relatives, the production of high-volume nonrenewable waste, the use of single-use devices, and reprocessing or decontamination processes. In addition, GIE produces a large quantity of nonrenewable plastic waste.[12] For example, the plastic covers for two major journals in the field of GIE, namely the *Gastroenterology*, and *Gut* journals, weigh 13.6 g, and contribute a total of 1.4 metric tons of waste annually. An analysis of nine colonoscopies with polypectomies and one upper endoscopy (excluding the suction and drainage tubing and canisters) by an endoscopy unit at the University of Melbourne, Australia, reported that a single endoscopic procedure generates an estimated 0.54 kg of waste.[12] Namburar et al.[13] audited all endoscopic procedures performed over five days at two USA academic medical centers with low (2,000 annual cases) and high (13,000 annual cases) endoscopy volumes. From this audit, a single endoscopic procedure generated an estimated 2.1 kg of disposable waste, with 64% of this waste en route to a landfill, 28% tagged for biohazard waste, and 9% tagged for recyclable waste. Extrapolation of this figure for 18 million annual endoscopic procedures performed in the USA revealed that the estimated weight for the total generated waste was 38,000 metric tons, which would fill 117 soccer fields with a 1 m depth of waste. Gayam[14] reported waste lists generated by an endoscopic procedure at the West Virginia University, Department of Medicine, USA. In this research, an endoscopic procedure generated an estimated 1.5 kg of plastic waste (only 0.3 kg of this waste was recyclable). Forty endoscopies are performed daily in this unit. Therefore, five workdays equate to 29,003 kWh of energy and 15.8 tons of carbon emissions per year. Extrapolation of this figure onto a national scale for the USA revealed that an estimated 13,500 tons of plastic waste were generated annually.[4] In addition, national carbon emissions were equivalent to the emissions of nearly 18,530 passenger vehicles driven for one year and 342,506,739 km driven by an average passenger vehicle.[4] In GIE, sources of carbon footprint include single-use devices, endoscopies, reprocessing, operational resource utilization (for example, for endoscopy, monitor, and computer), administration (for example, printing endoscopy reports and histology requests), travel (for patients and staff), and activities outside of the endoscopy unit (for example, catering, academic activities, and endoscopy journals).[4]

GREEN HEALTH CARE

The net-zero healthcare concept was recently introduced at Yale University Hospital. The benefits of achieving net-zero emissions in healthcare, such as mitigating climate change, saving money, reducing air pollution, and improving local communities, were also suggested. In 2022, the European Society of Gastrointestinal Endoscopy (ESGE) released the Position Statement to reduce the carbon footprint of GIE.[15] In summary, ESGE recommended implementing immediate actions to reduce the carbon footprint of GIE by adhering to guidelines, adopting audits for the appropriateness of GIE indications, avoiding unnecessary procedures, and using medication rationally. ESGE also suggested digitalization, telemedicine, critical pathways, outpatient procedures, sustainable architecture, renewable energy, 3R (reduce, reuse, and recycle) programs (Table 1),[16] revisiting waste management, and minimizing single-use devices. Regarding the 3R program, unnecessary procedures, paper reports, hot polypectomies, and single-use devices may be reduced. In addition, avoiding plastic bags and switching off lights and heating that are not in use are other strategies that can be implemented to reduce healthcare waste.

Furthermore, the adequate segregation of waste and staff training are also important strategies to maximize the success of these waste reduction measures. These interventions may be used at the individual and international levels.[4] GIE staff should review current practice protocols to identify potential sectors for interventions and identify areas in which the carbon footprint can be reduced by gradual systematic review. At the individual level, the environmental impact of GIE should include the use of reusable caps, reusable cloth and shoes, the elimination of plastic cups, adequate waste segregation, the use of telemedicine, bikes or public transport, virtual training, and switching-off computers not in use (Table 2).[15] Adequate waste segregation is important in Korea since medical waste production is increasing. For example, there was a 33% increase in medical waste production in 2018 compared to 2017. Endoscopic equipment not grossly contaminated with blood or body fluids, syringes, or diapers are classified as regular trash, but they are often categorized as regular medical waste sent to landfills. Even so, efforts to reduce the environmental impact of endoscopies may conflict with those used in infection control. Recently, single-use duodenoscopes and duodenoscopes with disposable endcaps were developed to reduce exogenous patient-to-patient infections caused by endoscopic retrograde cholangiopancreatography. However, single-use duodenoscopes contribute approximately 20 times more to carbon emissions than reusable duodenoscopes or duodenoscopes with disposable endcaps.[16] Therefore, the environmental impact of single-use duodenoscopes must not be overlooked.

CONCLUSIONS

Climate change is an urgent threat to human health. Healthcare, particularly GIE, is a major contributor to the national carbon

Table 2. Action plans for green endoscopy at the individual level

Level	Action plans
Endoscopy unit	Use reusable caps, reusable clothes, and reusable shoes
	Adherence guidelines for procedure indications
	Adequate waste segregation
Hospital	Use e-learning and telemedicine
	Rational use of optimal devices
Daily life	Think environment first
	Switch-off lights and computers
	Walking, biking, or public transport
	No use of disposable cup

Table 1. 3R (reduce, reuse, and recycle) program in gastrointestinal endoscopy

Reduce	Reuse	Recycle
Avoid unnecessary procedures with optimal indications	Reuse caps, trays, and endoscopes	Segregate waste disposal
Digitalization with paperless reports	Use rechargeable batteries	Increase the availability of recycling bins
Favor cold snare polypectomy over hot procedures	Use multi-use clips	Staff training on waste management
Reduce single-use devices		Review waste recycling streams
LED lights		Food recycling
Low carbon alternatives		
Avoid plastic bags and plastic cups		
Switch-off unused lights and equipment		
Avoid overheating		

Modified from Hernandez et al. Gastrointest Endosc 2021;93(6 Suppl):AB29.[16]
LED, light-emitting diode.

footprint. The current climate crisis demands that all healthcare providers work together to create a more sustainable planet. Therefore, it is time to act to establish a net-zero carbon emission in healthcare, especially in GIE.

Conflicts of Interest

The authors have no potential conflicts of interest.

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Author Contributions

Conceptualization: SBP, JMC; Data curation: JMC; Formal analysis: JMC; Visualization: SBP; Writing–original draft: JMC; Writing–review & editing: SBP, JMC.

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