Review

Carbon footprinting for the gastroenterologist

Sandeep Shivananda Siddhi ,[1] Mhairi Donnelly[2]

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/flgastro-2023-102612).

[1]Department of Digestive Diseases, Aberdeen Royal Infirmary, Aberdeen, UK
[2]Department of Gastroenterology, Scottish Liver transplant unit, Royal infirmary Edinburgh, Edinburgh, UK

Correspondence to
Dr Sandeep Shivananda Siddhi, Aberdeen Royal Infirmary, Aberdeen, UK; sandeepsiddhi@gmail.com

Received 5 December 2023
Accepted 6 February 2024
Published Online First
20 March 2024

Check for updates

To cite: Siddhi SS, Donnelly M. *Frontline Gastroenterology* 2024;**15**:e13–e18.

ABSTRACT
We are in a climate emergency—this is anthropogenic, and we can do something about it. An awareness of carbon footprinting is essential to allow us to understand and address this issue, both in our personal and professional lives. The aim of this article is to demystify carbon footprinting and to make the concept relevant to the gastrointestinal healthcare professional.

INTRODUCTION
We are seeing the effects of accelerated climate change all around us. It is important to understand that climate change is a direct result of human activity, such as the burning of fossil fuels. It is vital that we understand how the climate crisis has arisen and how to measure the environmental impact of human activity so that action can be taken to prevent further environmental harm. There are several ways of quantitatively expressing the environmental impact of human activity, products or processes. Carbon footprinting is one such method which has gained popularity, and it has now become an important tool to help us understand and quantify the human impact on our planet's health.

Delivering healthcare to a population contributes to climate change through greenhouse gas emissions; globally, healthcare has a carbon footprint of 2 gigatonnes CO_2e, which is the equivalent to 4.4% of global net emissions.[1] Every clinical pathway or organisation has a carbon footprint, which can be quantified. Understanding the carbon cost of providing our vital service is important for us as healthcare professionals. This understanding is known as 'carbon literacy' and is important not just for our professional but also our personal lives.

While this article aims to throw light on some of the terminology and science behind carbon footprinting and its relevance to the practice of gastroenterology, it is not exhaustive and does not cover all the nuances of this complex science. Detailed descriptions of the science and practicalities of carbon footprinting can be found elsewhere.[2 3]

THE CONCEPT
Before considering why carbon footprinting may be relevant to those working in the field of gastroenterology, it is important to have a basic understanding of the key concepts.

Important terminologies and definitions are listed in table 1.

Carbon footprint as a term and concept was adopted around the turn of the century. Put simply, it is the mark that something or someone leaves on the environment. Carbon footprinting aims to quantify the amount of greenhouse gases (GHGs) that are produced by a specific product or human activity. GHGs are gases in the earth's atmosphere that trap heat. The term carbon footprint probably originated from 'ecological footprint', which was described to define the surface area of earth needed to provide all resources for the survival of a given community or organisation.[2] The GHGs all have different global warming potentials (ie, are more or less potent than carbon dioxide) and therefore the carbon footprint is typically expressed in CO2 equivalents (CO2e). This allows the carbon footprint to be expressed as a single currency or unit, taking into account the global warming potential of different GHGs. The Kyoto protocol lays down legally binding targets for industrialised signatory nations to reduce their GHG emissions. The list of gases here is more extensive. Some definitions of carbon footprint include all these GHGs mentioned in the Kyoto protocol. Measuring the impact of all these 'extended list' of gases is sometimes referred to as climate footprint. This

Table 1 Key definitions

Greenhouse gases (GHGs)	Gases which trap heat when released into the atmosphere. These gases are: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride
Carbon footprint	Total amount of GHG that are produced by a specific product or human activity
Life cycle assessment	Provides a methodology for the measurement of the full range of environmental and social impacts associated with a process, product or activity from cradle to grave (from raw materials through processing, distribution, use and disposal)
Kyoto protocol	International agreement which legally binds signatory nations to reduce their greenhouse gas emissions. Currently, there are 192 parties signed up.
Scope 1 emissions	Emissions that result from direct activity like burning fuel. Emissions that an organisation has direct control over.
Scope 2 emissions	Indirect emissions from upstream supportive activity like generation of electricity needed for the subject of interest
Scope 3 emissions	Emissions that result from processed outside of the organisation, usually from distribution, transport and/or procurement

includes gases such as nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride and nitrogen trifluoride.[2]

The concept of carbon footprinting has been popularised by media, policy-makers, non-governmental organisations and industry but the academic and healthcare communities have not yet fully embraced it. Traditionally, in the academic world (including healthcare), the focus has been on life cycle assessment which is considered to be methodologically more robust and scientific as it evaluates the environmental impact in a broader sense over its entire lifespan.

Although carbon footprinting has its limitations, it is currently the best estimate that we can get of the environmental impact of a product, process or pathway. The carbon footprint is the sum of direct and indirect (gas) emissions attributable to a specific product, pathway or organisation. Direct emissions (also known as scope 1 emissions) are those emissions that an organisation (such as the National Health Service (NHS)) has direct control over. Indirect emissions include scope 2 emissions (associated with an organisations electricity use) and scope 3 emissions (all other indirect emissions which are the consequence of an organisations activities). Scope 3 emissions are typically associated with the highest proportion of GHG emissions. In the UK, the majority of healthcare-related emissions are scope 3 emissions.[1] Examples are given relevant to the NHS (figure 1). Notably, in healthcare, emissions associated with staff, patient and visitor travel fall out with these scopes.

So why should you calculate a carbon footprint? A key principle of delivering healthcare is 'do no harm'. The healthcare sector has a significant carbon footprint (eg, in the UK the NHS is the biggest public greenhouse gas emitter)[4] and it must now act urgently to mitigate its negative effects on our planet. Carbon footprinting helps to set meaningful targets and measure effects of climate change mitigation strategies. It is far from perfect but offers an environmental currency which allows progress to be tracked and allows comparisons of different products, services and care pathways. The main guiding principle for calculating the carbon footprint of products and processes is to identify different steps contributing to the overall footprint and devising effective strategies to tackle these steps to reduce the overall GHG emissions.

Before putting the above into practice, we should consider why we are using carbon footprinting within the healthcare setting. Carbon footprinting allows us to:

1. Evaluate and quantify a baseline, and monitor progress against that baseline.
2. Perform hotspot analysis (to allow us to consider where we can make carbon savings), for example, in the endoscopy room.
3. Compare the environmental impact of different products or pathways in healthcare (such as different abnormal Liver Function Test pathways).

Carbon emission or conversion factors tell you the amount of carbon or GHG emissions released into the atmosphere per unit of resource use. They allow the conversion of financial or activity data from their base unit to CO2e.

Activity data×carbon emission factor=carbon footprint.

There are freely available databases, which provide carbon emission factors for energy, travel, raw materials, etc.[5]

There is also the concept of a 'carbon hotspot', which is relevant to the healthcare setting. Carbon hotspots are processes or systems that are carbon intense but are also areas where there are likely to be 'quick wins' in terms of climate mitigation and carbon reductions.

In healthcare, we must now ensure that our systems are sustainable. A triple bottom line analysis takes into account the environmental, social and financial impact of an organisation, product or service and therefore is more comprehensive than carbon footprinting.

The remainder of this paper will focus on carbon footprinting only.

Calculating the carbon footprint

Calculating the carbon footprint of a product, service or pathway should involve these following key steps.

1. All known sources of emissions for the process or product must be identified and categorised. Creating a spreadsheet is often helpful for this step.

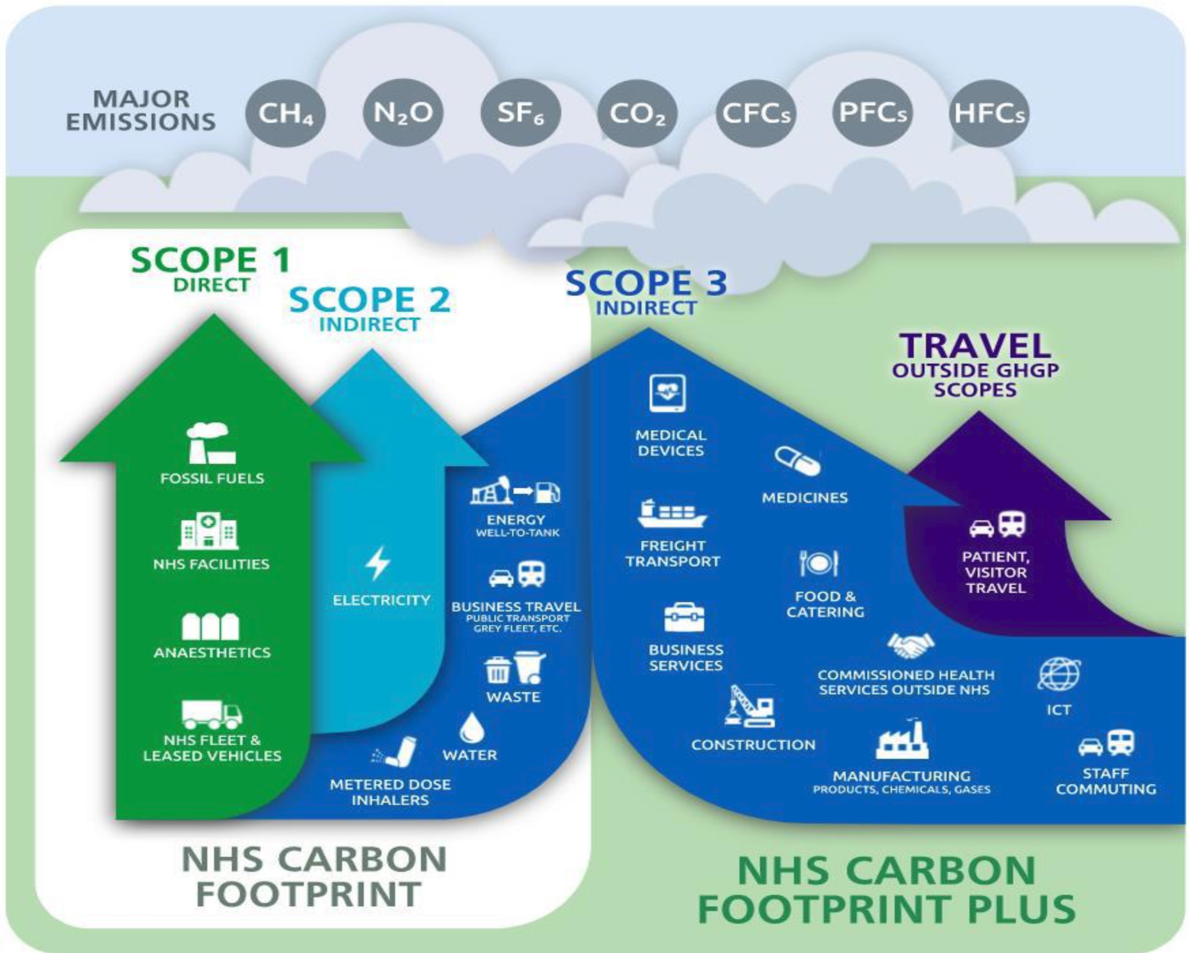

Figure 1 Image credit—delivering a Net zero National Health service, NHS England Report, Greener NHS » Delivering a 'Net Zero' National Health Service england.nhs.uk[4]. GHGP, Greenhouse Gas Protocol; ICT, information and communicatin technology; NHS, National Health Service.

2. From this list, all relevant emission sources to be included in the analysis must be agreed—this is known as boundary setting (discussed below).
3. An appropriate method of converting the emissions into CO2 equivalent in weight must be determined. There are freely available databases online (see reference above) which provide emissions factors for these calculations.
4. Data should be gathered thoroughly, and the selected methodology applied.
5. All details of the methodology should be documented so that the study can be repeated in future and results compared.

There are two broad approaches to carbon footprinting:

1) Top-down (input-output): The top-down approach uses financial data which are converted to a carbon footprint, and although this approach is simpler and quicker to perform it lacks resolution. The carbon footprint can be estimated by multiplying money spent by an appropriate emission factor. This process is best used to calculate the carbon footprint of a specific sector, for example, a gastrointestinal (GI) unit and has been used to model the carbon footprint of reflux control.[6]

2) Bottom-up (process based): The bottom-up approach is both time-consuming and complex, based on identifying and quantifying all materials, processes, energy and consumables but the results are more accurate. This approach is best used to calculate the carbon footprint of a specific process or product, such as an upper GI endoscopy, however, there is always the risk of not including all relevant items.

Hybrid methodology can also be used, when some activity data cannot be estimated or quantified (usually in bottom-up studies). This approach is typically used when calculating the carbon footprint of an intervention.

Carbon footprinting can be exhaustive, time-consuming and costly. Hence, it may not be possible to include all possible processes or sources of emissions. Therefore, study boundaries are frequently set. Boundaries provide a framework for a study and will be influenced by the availability of activity data and relevant emissions factors. These could be system boundaries, geographical boundaries or temporal boundaries. Boundaries are set to achieve a balance between the robustness of the calculations and the cost or resource implications for the organisation. This is thought to be better than omitting entire scopes which result in suboptimal studies.

Calculating the carbon footprint of a medical product or device

When calculating the carbon footprint of an individual product or device, you must consider whether to include emissions associated with the use and disposal of that item (known as the cradle-to-grave process), or whether the assessment stops at the point the item reaches the healthcare organisation (cradle to gate). An example relevant to gastroenterology would be whether to include the use and disposal of a paracentesis kit. Steps to consider and calculate include extraction of raw materials, production of plastic, paper and metal, transport to the production site, production of the final product, transport of the final product, use and disposal. When making comparisons between such medical products, it is most appropriate to use a life cycle approach or a bottom-up approach.

Calculating the carbon footprint of a care pathway or service

To calculate the carbon footprint of a specific care pathway or service, you should identify each individual step in that pathway and the consumables used at each step. It is helpful to create a spreadsheet to collate all the individual pieces of data required for the process or pathway of interest. You can then review the carbon conversion factors databases to identify available conversion factors.

We have shown an example of carbon footprinting exercise for outpatient clinics in online supplemental material.

Addressing the carbon footprint of our professional lives

We need to consider the optimal way of assessing and addressing the carbon footprint of gastroenterology service delivery. Undertaking sustainable quality improvement (QI) projects is a useful starting point to begin to understand the role and impact of carbon footprinting in GI healthcare. The Centre for Sustainable Healthcare provides information and support for those wishing to undertake a sustainable QI project.[6 7] Many NHS trusts also have sustainability teams who can provide help with projects at a local level. Projects with the greatest impact are likely to be those assessing the carbon footprint of alternative approaches or care pathways (eg, sedated oral vs unsedated transnasal upper GI endoscopy) or where the carbon footprint is compared before and after an intervention (eg, changing suction liners in endoscopy at the end of each list compared with changing between each patient). One good example of carbon footprinting in our field is a study that looked at the carbon footprint of the medical management versus surgical management of gastro-oesophageal reflux disease.[8] The authors used a top-down model (using financial costs) to examine the difference in the carbon footprint between medical and surgical management of gastro-oesophageal reflux. The boundaries set in this study are clearly described. Surgery became cost efficient in the 14th postoperative year but became carbon-efficient in the 9th postoperative year. Therefore, where two pathways demonstrate equivalent clinical benefit, we should also consider carbon emissions when choosing or recommending a preferred pathway.

We must identify 'carbon hotspots' within gastroenterology as these are the areas where carbon savings can be made—endoscopy has been identified as one such hotspot with a lot of groundwork having been undertaken to move towards 'greener' endoscopy. Over the last 3 years, a lot of work has been done to understand best practice in sustainable endoscopy and the amount of literature now published is encouraging, supported by international societies.[9 10] Data are beginning to emerge, reporting the carbon footprint of specific GI interventions. The carbon cost of ambulatory endoscopy has been estimated in a French study to be about 28 kg CO_2e per procedure.[11] This may not be applicable in other settings, however, as a large proportion of these procedures were done under anaesthesia. In a recent study, *Henniger et al* estimated the annual C02e output from a medium-sized endoscopy unit is about 62.72 tons.[12] The caveat is that all electricity consumed in this unit was from sustainable sources. Hence, it is important to understand the context of the carbon footprinting studies.

Studies have shown that simple targeted interventions such as staff education in managing and segregation of waste help reduce biomedical waste and hence result in a significant reduction in CO_2 footprint.[13] However, more impactful strategies are likely to include reducing inappropriate endoscopy.[14] In general, carbon footprinting projects likely to have the greatest impact are those comparing alternative approaches or studying the environmental impact of a specific intervention.

Medical conferences by their very nature are carbon hotspots. No doubt they are invaluable for continuing professional development, but the organisational logistics must be evaluated to reduce carbon footprint. There have been some efforts in this area recently. For example, many conferences have traditionally displayed paper posters. A recent study presented at BASL 2023 looked at the comparative carbon footprint analysis of a conference poster exhibition.[15] The authors looked at: individual delegate printing and transporting to the venue, central printing of posters in the host city and electronic displays, using a cradle-to-grave process-based carbon footprinting method. The method with the lowest carbon footprint was central printing in

Figure 2 Tips for sustainable living.

the host city. Similar work needs to be undertaken to understand the broadest environmental impact of running a medical conference, with a focus on carbon hotspots. The BSG performed a sustainability analysis of their Live conference in 2023 (internal report). During the event, the caterer calculated the carbon emissions for the food served. Due to the use of local small-sized and medium-sized enterprises, the average kg CO_2e for meals was 0.5, compared with 1.6 for the UK average. The majority of portions served were in the lowest brackets of CO_2e. Other aspects of medical conferences that would benefit from a formal assessment of the carbon footprint include the giveaway materials provided by exhibitors.

Addressing the carbon footprint of our personal lives

Personal carbon footprinting helps individuals realise the environmental impact of their own behaviour and lifestyle. It is a useful tool in education and raising awareness about how each individual and family can bring about small changes in their day-to-day life and hence empower them to contribute to mitigation measures. General tips for addressing our personal carbon footprint (many of which can also translate into our professional lives) are shown in figure 2. Calculating the carbon footprint of our personal lives allows us to identify carbon hotspots and target their reduction and compare alternative foodstuffs and other material products. For example, watching BBC iPlayer streamed on a 13-inch MacBookPro for 1 hour creates 132 g CO_2e, compared with 237 g CO_2e for terrestrial Televison (TV) viewed on a 42-inch plasma TV.[16]

CONCLUSION

We cannot underestimate the seriousness of the climate emergency. As a practical specialty, gastroenterology will be associated with a significant carbon footprint. Urgent actions are needed to bring a deep reduction in GHG emissions. We need large-scale population-based interventions at all levels in all fields driven by the carbon conscious public and healthcare professionals. It is only then that meaningful results can be achieved. Although the carbon footprinting process is fraught with limitations, it helps to start conversations due to its relative simplicity and popularity. It makes it easy for an individual and clinical department to visualise their impact on the planet and consider how each one of us can contribute positively in day-to-day life. We as healthcare professionals must make a concerted effort in understanding the environmental impact of our occupation and start to change our clinical practice in the face of the climate emergency.

Correction notice This article has been corrected since it published Online First. The article type has been changed to review.

X Sandeep Shivananda Siddhi @gastrosid and Mhairi Donnelly @mhairidonnelly

Contributors Both the authors contributed equally and wrote the manuscript collaboratively.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Provenance and peer review Commissioned; externally peer reviewed.

ORCID iD
Sandeep Shivananda Siddhi http://orcid.org/0009-0006-8224-531X

REFERENCES

1 Health Care's Climate Footprint. How the health sector contributes to the global climate crisis and opportunities for action. n.d. Available: https://noharm-global.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint_092319.pdf
2 Williams I, Kemp S, Coello J, *et al*. A beginner's guide to carbon Footprinting. *Carbon Management* 2012;3:55–67.
3 Wright LA, Kemp S, Williams I. Carbon Footprinting': towards a universally accepted definition. *Carbon Management* 2011;2:61–72.
4 Available: Greener NHS » delivering a 'net zero' national health service Englandnhsuk
5 Greenhouse gas reporting: conversion factors. 2022 Available: at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022 Greenhouse gas reporting: conversion factors 2022 - GOV.UK (www.gov.uk)
6 Sustainable services: future trends – the king's Fund. n.d. Available: https://www.kingsfund.org.uk/projects/time-think-differently/trends-sustainable-services#:~:text=The%20NHS%20is%20the%20most,to%20reduce%20its%20carbon%20footprint
7 Sustainability in quality improvement (Susqi). available at:: n.d. Available: https://sustainablehealthcare.org.uk/susqi
8 Gatenby PAC. Modelling the carbon footprint of reflux control. *Int J Surg* 2011;9:72–4.
9 Sebastian S, Dhar A, Baddeley R, *et al*. British society of Gastroenterology(BSG), joint accreditation group (JAG) and centre for sustainable health (CSH) joint consensus on practical measures for environmental Sustainability in Endoscopy. *Gut* 2023;72:12–26.
10 Santiago D, Dinis- Ribeiro M. Pohl Heiko et al reducing the environmental footprint of gastrointestinal Endoscopy. *ESGE and ESGENA Position Statement Endoscopy* 2022;54:797–826.
11 Lacroute J, Marcantoni J, Petitot S, *et al*. The carbon footprint of ambulatory gastrointestinal Endoscopy. *ENDOSCOPY* 2023;55:918–26.
12 Henniger D, Windsheimer M, Beck H, *et al*. Assessment of the yearly carbon emission of a gastrointestinal Endoscopy unit gut 2023;72:1816-1818. *Gut* 2023;72:1816–8.
13 Cunha Neves JA, Roseira J, Queirós P, *et al*. Queirós P, et al targeted intervention to achieve waste reduction in gastrointestinal Endoscopy gut 2023;72:306-313. *Gut* 2023;72:306–13.
14 Elli L, La Mura S, Rimondi A, *et al*. The carbon cost of inappropriate Endoscopy. *Gastrointest Endosc* 2024;99:137–45.
15 Elsharkawy AM, Steinbach I, Hillson R, *et al*. P136 The carbon impact of poster exhibitions at a UK medical conference; comparative analysis of different models. Abstracts of the British Association for the Study of the Liver Annual Meeting, 19–22 September 2023; September 2023
16 Berners-Lee M. *How bad are bananas? The carbon footprint of everything*. Profile Books, 2020.