Review

Challenges of developing a green gastroenterology evidence base and how trainee research networks can fill the gaps

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ABSTRACT

Trainee research networks are a collaborative effort to enable high-quality multicentre audits or research that is more widely accessible to trainees. Such networks lead, design and deliver research at a far higher scale than could be achieved locally and are carried out solely by trainees. There is an increasing focus on delivering research that is not only environmentally sustainable but also focuses on areas that can reduce the carbon footprint of service provision in gastroenterology and hepatology. In this manuscript, we performed a scoping review to understand the current evidence base of the impact of gastroenterology and hepatology services on the environment as well as exploring any association between pollution and climate change with gastrointestinal and liver disease. We further discuss the barriers that researchers face in delivering environmentally sustainable research, the limitation in clinical guidelines related to practicing environmentally sustainable gastroenterology and hepatology and how the trainee research networks are ideally placed to initiate change by developing, disseminating and implementing best practice in 'green Gastroenterology'.

WHAT ARE TRAINEE RESEARCH NETWORKS?

Trainee research networks (TRNs) are a collaborative effort to conduct high-quality multicentre audits or research that is led, designed and delivered by trainees. The first UK Gastroenterology trainee network was created in 2015 in the Midlands and there are now at least 11 established networks with many successfully delivering regional and national projects, publishing in peer-reviewed journals and presenting their data at national and international conferences.[1–8] TRNs offer the opportunity for trainees to work with and learn from peers at different stages of their training while also receiving support and guidance from senior investigators.[9] More importantly, TRNs allow trainees to develop their own ideas and prioritise projects they feel will impact their clinical practice, rather than contributing to an established programme delivered by a clinical or educational supervisor.

WHAT IS 'GREEN GASTROENTEROLOGY'?

As a specialty, gastroenterology has been at the leading edge when it comes to understanding the impact of clinical practice on climate change, with the British Society of Gastroenterology (BSG) launching its climate change and sustainability strategy in November 2021.[10] A survey led by the NHS Sustainable Development Unit reported that 98% NHS staff believe that healthcare systems should work in ways which support the environment,[11] and 86% of leading international gastroenterologists believe that climate change represents a crisis.[12] However, just over half of gastroenterologists surveyed reported having made climate-focused changes in their professional practice, suggesting that there are a number of barriers we face when it comes to putting 'green Gastroenterology' into practice.

WHAT ARE THE CHALLENGES TO DELIVERING 'GREEN GASTROENTEROLOGY'?

Barriers may be financial, systemic or behavioural in nature.[12] In the current highly pressured NHS working environment, the competing demands of clinical work can consume the time and energy

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required to introduce changes in practice. It is easy to feel that change is the responsibility of the organisation rather than the individual, and with only 9% of international gastroenterology societies having a climate working group or committee,[12] it is clear that leadership is required in setting standards to facilitate change. Unfortunately, the main limitation for publishing or setting guidelines on practising in a more sustainable manner is the lack of sufficient evidence. In 2023, the BSG, Joint Advisory Group on GI Endoscopy and Centre for Sustainable Health created working groups that assigned specific topics to address this issue. Systematic reviews were performed to assess the data available for each of the topics and a joint statement (see online supplemental table 1) published.[1] Prior to this, the European Society for Gastrointestinal Endoscopy, published 10 statements pledging recommendations for the greener practice of gastroenterology and endoscopy (See online supplemental table 2).[2]

These statements provide a scaffolding of ideas and mission statements by which the gastroenterology and hepatology community can build their practice on. When analysed alongside other publications looking at the impact of gastroenterology and hepatology on the environment, it becomes clear that a shift in routine practice including improving education, clinical pathways and rationalising of procedures can have a marked reduction in carbon emissions. Alongside these changes, an increased adoption of digital information sharing with patients and virtual consultations can have a further positive impact on the environment.[3]

Financial constraints are significant in many global healthcare settings, particularly in the wake of the COVID-19 pandemic. In fact, there are often financial incentives to undertake activity, which causes harm to the climate. For example, many national societies derive income from annual meetings, but these meetings have a significant carbon impact.[13] While the BSG has launched a 'sustainability symposium', making climate impact a key message at its meetings, we need to consider the use of technology to deliver meetings in a more climate sustainable manner. While some climate sustainable changes to clinical practice may appear costly and time-consuming in the short term, they are likely cost-effective in the long term. For example, ensuring that patients have been adequately prepared for an endoscopic procedure through rigorous preassessment and bowel preparation to reduce the chance of rebooking, and developing systems to safely recycling endoscopic equipment where possible would likely be cost-saving in the long-term.[11]

Furthermore, while there has been an understandable focus on endoscopy as a source of much visible wastage within gastroenterology practice,[14] there is a need to consider other areas that are ripe for change. For example, lessons learnt from the COVID-19 pandemic in practicing telemedicine or patient-led follow-up to cut down on travel emissions for patients and staff.[15] In fact, recent publications in gastroenterology and hepatology have shown that virtual appointments can reduce carbon emissions while providing safe patient outcomes and positive patient satisfaction scores.[16–18] Similarly, a move towards subcutaneous biologics and novel oral therapies as first line in inflammatory bowel disease (IBD) could potentially reduce traffic in our infusion units. The British Association for the Study of the Liver has formalised their commitment to delivering sustainable care in hepatology, acknowledging that the incipient changes in climate are likely to increase the global burden of liver disease.[19] Examples of sustainable practice include focusing efforts on prevention of liver disease, delivery of virtual transplant assessment pathways and identification of prognostication scores for screening of patients with stable compensated cirrhosis that could reduce hospital resource use.

Ultimately, any move towards greener practice requires collaboration between motivated individuals who have buy-in from stakeholders, and the time and agency to make changes at a local level—all of which can feel in short supply in our current clinical practice.

WHAT IS THE CURRENT RESEARCH AND UNDERSTANDING OF 'GREEN GASTROENTEROLOGY'?

Given that healthcare is responsible for 4.4% of the world's carbon footprint and that endoscopy is a high-volume generator of carbon-based waste,[20] there is a need to reduce the impact of gastrointestinal and hepatology services on the environment. We performed a scoping review (see online supplementary methods) to understand the current evidence base of what has been done to reduce waste and impact on the environment across services. A total of eight studies[16–18 21–25] were highlighted (see online supplemental figure 1), which predominately focused on endoscopy waste management (5/8) with the remaining studies exploring the impact of virtual outpatient appointments (table 1). While no randomised controlled studies were conducted, a common finding between studies was no reports of patient harm where there was a change in approach to a more environmentally sustainable way of working. This would suggest that there is likely to be further scope for innovation to reduce the impact that our services have on the environment. Importantly, one study was conducted by a trainee network[16] demonstrating that there is potential for trainees to lead development in this area.

As a gastroenterology and hepatology community, we have become increasingly aware of the impact lifestyle has on our risk of disease. However, we still have relatively limited understanding of the impact of the environment, climate change and pollution on our risk of developing gastrointestinal and liver disease.

Table 1 Scoping review of studies directly examining the impact of gastrointestinal and hepatology services on the environment (see online supplemental table 3 for inclusion/exclusion criteria and search strategy)

Study	Setting	Design	N	Outcome
Wanigasooriya *et al*[17]	Department of Colorectal Surgery, South Warwickshire NHS Foundation Trust, UK	Retrospective observational study	1531 patients referred to the lower gastrointestinal 2 week wait clinic	Virtual clinic appointments were associated with significantly lower waiting times to appointments, investigations and diagnosis. There were no differences in cancer detection rate, treatments received or time to treatment. Virtual appointments were associated with significant reductions in carbon emissions and cost and were acceptable to patients.
Mole *et al*[18]	Department of Colorectal Surgery, Royal Hampshire County Hospital, UK	Retrospective observational study with prospective patient survey	142 patients who had undergone surgery for colorectal cancer, 30 who responded to the survey	Telephone appointments led to a total saving of £67 840 over the study period and were associated with high patient satisfaction. The authors hypothesise that there was likely a reduction in carbon emission compared with conventional outpatient appointments
King *et al*[16]	Gastroenterology outpatients at 11 sites across London, UK	Retrospective observational study	2140 gastroenterology outpatient attendances	Virtual appointments had lower carbon emissions compared with face-to-face appointments through a combination of reduced travelling and reduced investigation request. There were no significant differences between cohorts for mortality of admissions
Cunha-Neves *et al*[21]	Endoscopy unit at the Algarve University Hospital Centre, Portugal	Prospective interventional study	Preintervention=185 endoscopic procedures Postintervention=350 endoscopic procedures	Following a 1 week intervention including review of data regarding waste management from preintervention audit, acquisition of recycling bins and relocation of landfill and biomedical waste bins, there was a reduction in total and regulated medical waste and an increase in recycling. This led to a reduction in the endoscopy unit's carbon footprint
Lopez-Munoz *et al*[22]	Endoscopy unit at La Fe University Hospital, Spain	Prospective interventional study	184 endoscopic procedures	There was significant variation in composition of commonly used endoscopic tools between manufacturers including forceps, snares and haemoclips which impacted their carbon footprint. A 'green mark' was developed as a distance from potential patient contamination to allow for safe recycling of tools which led to at 27.44% reduction in carbon footprint generation
Yong *et al*[23]	Endoscopy Department, Imperial College Hospital, UK	Retrospective observational study	11 781 lower gastrointestinal endoscopies	A total of 5125 polyps were removed using 4192 pots. 4563 were less than 1 cm with only 6 being cancerous and 12 demonstrating high-grade dysplasia. Combining small polyps into a single pot would reduce pot usage by one third and significant reductions in carbon emissions.
Lim *et al*[24]	Endoscopy Unit at St Thomas' Hospital, UK	Prospective observational study	225 endoscopic procedures	Trans-nasal endoscopy was associated with low complications, low discomfort scores and increased patient satisfaction and adequate procedure duration and biopsy quality. The authors hypothesise that transnasal endoscopy would reduce carbon emissions from endoscopies
Namburar *et al*[25]	Endoscopy units at two academic medical centres, USA	Prospective observational study	278 endoscopic procedures	Mean waste per endoscopy was 2.11 kg with only 9% recycled. Utilising only single use endoscopes would lead to net increase in waste by 40%.

Establishing an evidence base would allow us to inform our patients and healthcare policymakers about the range of risk associated with ongoing pollution and climate change. We, therefore, performed a scoping review to further understand the current evidence base regarding this association (see online supplementary data for methodology).

A total of 48 studies were identified (See online supplemental figure 1) which predominately explored associations between pollution/climate change and gastrointestinal/liver cancer[26–47] (22/48), followed by IBD[48–58] (11/48), liver disease[59–67] (9/48) and other gastrointestinal diseases[49 55 68–73] (8/48) (table 2). All studies were observational with the majority retrospective in design (40/48). A commonality with the studies was the challenge of eliminating or adjusting for confounding factors for disease development with socioeconomic status a clear potential confounder

Table 2 Scoping review of studies demonstrating associations of pollution and climate change with gastrointestinal and liver disease (see online supplemental methods for search strategy and online supplemental table 3 for inclusion/exclusion criteria)

Study	Setting	Condition(s) studied	Design	N	Outcome
Sun *et al*[26]	UK, Finland and Japan	Primary liver cancer	Mendelian randomisation study	1 120 000 individuals enrolled into three national biobanks	No association was demonstrated between PM2.5, PM10, NO_2 or NO with primary liver cancer. NO was associated with arginase-1 with may affect hepatocellular differentiation
Chin *et al*[27]	Taiwan	HCC	Retrospective observational study	940 patients with HCC	Increasing levels of both PM2.5 and NO_2 were associated with increasing risk of HCC mortality
VoPham *et al*[28]	Areas covered by 19 US cancer registries	HCC	Retrospective observational study	90 359 adults with hepatocellular carcinoma	There was no association between overall dioxin emissions and HCC. There may be an association between dioxin emissions from coal-fired power plants and from cement kilns with HCC prevalence
So *et al*[29]	5 European countries	Liver cancer	Retrospective observational study	330 064 adults	Liver cancer incidence was associated with NO_2, PM2.5 and black carbon exposure including at levels lower than European Union standards
Xue *et al*[30]	Texas, USA	Liver cancer	Retrospective observational study	770 participants derived from a study exploring biomarkers of aflatoxin exposure and healthy controls from two unrelated studies	Over time, there was increasing exposure to aflatoxin across all groups which was hypothesised to be due to increasing contamination among food sources due to climate change. This may lead to an increased risk in long-term liver cancer risk
Ma *et al*[31]	Taiwan	Colorectal cancer	Retrospective observational study	1,164,962 patients with newly diagnosed diabetes	A dose–response relationship was demonstrated between exposure to PM2.5 and risk of colorectal cancer
Fei *et al*[32]	Hangzhou, China	Gastric cancer	Retrospective observational study	9378 adults newly diagnosed with stomach cancer	Individual heavy metals exposure did not have an association with stomach cancer. However, a non-linear association between gastric cancer and cumulative heavy metal exposure was demonstrated
Weinmayr *et al*[33]	seven study areas across central Europe and Scandinavia	Gastric cancer	Meta-analysis of prospectively collected data from ten cohorts	227 044 adults	Long term to PM2.5 sulphur was associated with an increased incidence of gastric cancer
VoPham *et al*[34]	USA	HCC	Retrospective observational study	56 245 patients with HCC with background population data	Higher levels of ambient PM2.5 were associated with increased incidence of HCC
Deng *et al*[35]	California, USA	HCC	Retrospective observational study	20.221 patients with HCC	PM2.5 exposure was associated with increased mortality from HCC and disease progression after diagnosis
Pedersen *et al*[36]	Four study areas across central Europe and Scandinavia	Liver cancer	Meta-analysis of prospectively collected data from four cohorts	174 770 adults	No significant association between air pollution and primary liver cancer was demonstrated although only 279 liver cancers were diagnosed across these cohorts
Kachuri *et al*[37]	7 Canadian provinces	Rectal cancer	Retrospective observational case-control study	3131 adults	A significant association between diesel emission exposure and rectal cancer was demonstrated
Di Ciaula[38]	Apulia region, South Italy	Gastric cancer	Retrospective observational study	4,099,547 subjects	Deaths from gastric cancer were higher in areas within 3 km of municipal waste landfills
Pan *et al*[39]	Taiwan	HCC	Prospective observational study	23 820 adults	PM2.5 was significantly associated with ALT and likelihood of HCC
Lopez-Abente *et al*[40]	Spain	Colorectal cancer	Retrospective observational study	120 841 adults who died from colorectal cancer	Significant associations were demonstrated between the prevalence of colorectal cancer and proximity to the; mining industry, paper and wood production facilities, food and beverage sector, metal production and processing installations and ceramic industry

Continued

Table 2 Continued

Study	Setting	Condition(s) studied	Design	N	Outcome
Fang *et al*[41]	British Columbia, Canada	Colorectal cancer	Retrospective case-control study	8707 adults with cancer	Colorectal cancer was more common in individuals in occupations associated with low physical activity or significant asbestos, wood dusts, engine exhaust, diesel emissions and ammonia exposure than other cancers
Chiu *et al*[42]	Taiwan	Gastric cancer	Retrospective case-control study	7020 adults' deaths	Individuals living in municipalities with higher petrol station density were more likely to die from gastric cancer
Sjodahl *et al*[43]	Sweden	Gastric cancer	Prospective observational study	364 892 male construction workers	Male workers who developed gastric cancer were more likely to be exposed to cement dust, quartz dust and diesel exhaust with an increased incidence observed with increased exposure to each
Guo *et al*[44]	Finland	Oesophageal cancer	Retrospective observational study	1 180 231 adult census participants	Occupational diesel exhaust exposure was associated with increased prevalence of ovarian cancer. No association between occupational diesel exhaust exposure and oesophageal cancer or other cancers were observed.
Romundstad *et al*[45]	Norway	Pancreatic cancer, bladder cancer	Retrospective observational study	5627 men employed for at least 6 months at two aluminium plants	Polycyclic aromatic hydrocarbon exposure was associated with increased incidence of bladder cancer and pancreatic cancer.
Park and Mirer[46]	Detroit, USA	Gastric cancer, lung cancer, haematological cancer, bladder cancer, prostate cancer	Retrospective observational study	1870 employees of two engine plants	Deaths from stomach cancer were associated with time working in camshaft/crankshaft production as well as toolroom work. Deaths from pancreatic cancer were associated with inspection, machining with straight oil and skilled trades work. Associations were also demonstrated between specific cohorts and lung cancer, haematological cancer, bladder and prostate cancer.
Kusiak *et al*[47]	Ontario, Canada	Gastric cancer	Retrospective observational study	50 201 male miners	An association with gold mining and mortality from stomach cancer was demonstrated. This was greatest after 5 years of exposure. After 20 years of exposure, miners born outside of North America were more likely to develop gastric cancer than those born in North America.
Chen *et al*[48]	UK	IBD	Retrospective observational study	4708 adults with IBD	Increasing exposure to PM2.5 was associated with increased risk of enterotomy and increased exposure to NO, NO_2, PM10 and PM2.5 was associated with all-cause mortality
Okafor *et al*[49]	California, USA	Irritable bowel syndrome, IBD, functional dyspepsia, eosinophilic oesophagitis	Retrospective observational study	5 376 881 adults	Exposure to particulate matter<2.5 µm (PM2.5) was associated with a higher incidence of IBS but not IBD, functional dyspepsia or EoE
Adami *et al*[50]	Italy	IBD	Retrospective observational study	81 363 adults at risk of fractures	Increased exposure to PM2.5 was associated with an increased risk of several immune-mediated diseases including IBD
Li *et al*[51]	UK	IBD	Retrospective observational study	48 005 adults	Increased exposure to ambient PM2.5, PM10, NO_2 and NO were associated with increased risk of UC but not Crohn's disease
Duan *et al*[52]	Beijing, China	UC	Retrospective observational study	84 000 outpatient attendances for ulcerative colitis	There was a significant association between short-term exposure to ambient PM2.5 and increased number of outpatient attendances for UC with this greatest in younger patients
Ding *et al*[53]	Heifei, China	IBD	Prospective observational	886 patients admitted to two hospitals with IBD	PM2.5, O_3 and CO exposure were associated with increased admissions with IBD. This was accentuated in warm periods

Continued

Table 2 Continued

Study	Setting	Condition(s) studied	Design	N	Outcome
Opstelten *et al*[54]	Five centres across the UK, Central Europe and Scandinavia	IBD	Retrospective observational case-control study	710 adults	No significant association was demonstrated between exposure to air pollution and IBD
Manser *et al*[55]	Zurich, Switzerland	IBD, infectious gastroenteritis	Retrospective observational case-control study	2030 patients of all ages with either non-infection chronic intestinal inflammation, IBD or infectious gastroenteritis	Heat waves were significantly associated with increased hospital admissions for both flares of IBD and infectious gastroenteritis. Heatwaves led to an almost immediate increase in admissions with IBD. In contrast, admissions for infectious gastroenteritis peak 7 days after the onset of a heatwave
Steenland *et al*[56]	Mid-Ohio, USA	UC	Prospectively conducted interviews combined with retrospective observational data acquisition	32 254 adults	A significant association was demonstrated between exposure to perfluorooctanoic acid, an industrial surfactant used in sealants and home furnishings, and the development of UC
Ananthakrishnan *et al*[57]	Wisconsin, USA	IBD	Retrospective observational study	3890 adults admitted to hospital with diagnoses of Crohn's disease or Ulcerative Colitis	Total air emissions of pollutants were associated with increased hospitalisations with IBD. Specific air pollutants including carbon monoxide, nitrous oxide, sulphur dioxide, PM2.5 and volatile organic chemicals were all associated with increased hospitalisations with IBD
Kaplan *et al*[58]	UK	IBD	Retrospective case-control study	367 patients with Crohn's disease, 591 with UC with 1833 and 2962 matched controls respectively	Increased exposure to NO_2, SO_2 or PM_{10} was not associated with an increased incidence of IBD. However, increased SO_2 or NO_2 may be associated with earlier onset disease.
VoPham *et al*[59]	USA	NAFLD	Retrospective observational study	45 433 392 hospitalisations	Higher ambient PM2.5 exposure was associated with increased admissions for patients with NAFLD
Orioli *et al*[60]	Rome, Italy	Cirrhosis	Retrospective observational study	1 265 058 adults over the age of 30	Increased exposure to ambient air pollutants including PM10, PM2.5, NO_2 and NO was significantly associated with cirrhosis incidence
Hou *et al*[61]	Henan Province, China	Liver fibrosis	Retrospective observational study	21 010 adults	Cooking with coal or wood and higher ambient ozone level exposure was associated with increased liver fibrosis with this being greatest in females
Li *et al*[62]	New England, USA	Hepatic steatosis	Prospective observational study	2513 adults	Living closer to a major road was associated with a higher prevalence of hepatic steatosis although no association with residential-based average PM2.5 levels and steatosis were observed
Dey *et al*[63]	Assam, India	Abnormal liver function tests	Prospective observational study	46 adults living near an oil drilling site, 61 from a control site	Increased exposure to respirable suspended particulate matter and NO_2 was associated with increased ALT with NO_2 associated with increased AST as well
Kim *et al*[64]	Seoul, Korea	Abnormal liver function tests	Retrospective observational study	545 attendees over the age of 60 to a community welfare centre	Increased ambient exposure of PM2.5 was associated with increased AST, ALT and GGT whereas NO_2 was associated with increased AST and ALT and O_3 was associated with increased GGT
Hu *et al*[65]	Southeast China	Abnormal liver function tests	Prospective observational study	952 employees from two coking plants and one wire mesh plant	Liver function test abnormalities were more likely in patients with long-term high coke oven emission exposure and was greatest among employees with concomitant viral hepatitis (B or C) or body mass index≥25 kg/m^2

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Table 2 Continued

Study	Setting	Condition(s) studied	Design	N	Outcome
Kim *et al*[66]	South Korea	Abnormal liver function tests	Retrospective observational study	36 151 adults	Increases in ALT and AST were associated with increased exposure to ambient air pollutants (NO_2, SO_2, CO and PM10) in patients who drank alcohol. However, only NO_2 and SO_2 were associated with increased ALT and AST in those who did not drink alcohol
Wu *et al*[67]	Taiwan	Abnormal liver function tests	Prospective observational study	147 employees (administrative and coking workers) from two coke plants	High exposure to benzene soluble fraction was associated with elevated AST and ALT and this association remained significant when adjusted for non-occupational risk factors for abnormal liver function tests including alcohol exposure and viral hepatitis
Tsai *et al*[68]	Taipei, Taiwan	PUD	Retrospective observational study	23 205 admissions with PUD	Admissions were associated with all ambient air pollutants measured (PM10, PM2.5, SO_2, NO_2, CO and O_3) on warm days. On cool days, admissions were associated with PM10, NO_2 and O_3.
Chau and Wang[69]	Taiwan	PUD	Retrospective observational study	1 700 000 medical attendances to hospital	Increases in exposures to ambient air pollution were associated with increased attendances for a number of pathologies including PUD
Wu *et al*[70]	Yinzhou, China	PUD	Retrospective observational study	211 786 hospital attendances for peptic ulcer disease	Short-term exposure to air pollutants was associated with increased hospital visits for PUD. PM2.5 and carbon monoxide had a cumulative effect increasing hospital admissions.
Tian *et al*[71]	Hong Kong	PUD	Retrospective case-crossover study	8566 emergency admissions with bleeding PUD	Increases in ambient NO_2 exposure were associated with an increase in admissions for bleeding PUD
Wong *et al*[72]	Hong Kong	PUD	Retrospective observational study	66 820 adults over the age of 65	Increasing exposure to ambient PM2.5 was associated with increased admissions for PUD. PM2.5 was associated with gastric ulcers but not duodenal ulcers
Quan *et al*[73]	Calgary and Edmonton, Canada	PUD	Retrospective time-stratified case-crossover study	2523 admissions with upper gastrointestinal bleeding secondary to PUD	No significant associations were demonstrated between O_3, SO_2, CO, NO_2, PM10 or PM2.5 and admissions with bleeding secondary to PUD

IBD, inflammatory bowel disease; IBS, irritable bowel syndrome; EoE, eosinophilic oesophagitis; NO, nitric oxide; NO_2, nitrogen dioxide; PM, particulate matter; HCC, hepatocellular carcinoma; NAFLD, non-alcoholic fatty liver disease; UC, ulcerative colitis; PUD, peptic ulcer disease; ALT, alanine transferase; AST, aspartate aminotransferase; O_3, ozone; GGT, gamma-glutamyl transferase; SO_2, sulphur dioxide.

in the studies examining occupational risk. This is a potential challenge in understanding the impact of the environment and climate change on the risk of developing disease. It is clear that further work is required to provide better quality evidence to better appreciate the impact of the environment, climate change and pollution on gastrointestinal and liver disease.

Unfortunately, while randomised control trials would allow us to understand causation rather than correlation, this type of study analysis is methodologically unfeasible to assist our understanding of these relationships. However, there are several approaches that can be used to reduce the impact of confounding factors. Mendelian randomisation, used in the study by Sun *et al*,[26] could be employed to better understand the association of pollution and climate change with gastrointestinal and liver disease.[26] The concept of Mendelian randomisation utilises genetic variants, which are determined at birth, which are associated with an exposure of interest, for example, increased circulating levels of pollutants such as carbon monoxide (CO), to understand if they are associated with an outcome, such as a disease of interest.[74 75] Multiple gene targets are usually identified via genome-wide association studies and subsequently, analysis can be complex. While there has been increased funding and support for TRNs through charities and societies including GUTS UK and the BSG, this methodology is currently unlikely to be viable for most TRNs due to the cost and expertise required. However, using specific genetic variants can be used to increase outcome events and provide a better understanding of association between gastrointestinal and liver disease and pollution/climate change. Furthermore, this type of study analysis could allow trainees to collaborate on an international scale to compare different environmental policies used in managing the risk of climate change and pollution on the risk of developing gastrointestinal and liver disease.

WHAT ARE THE CHALLENGES TO DELIVERING RESEARCH IN AN ENVIRONMENTALLY SUSTAINABLE DOMAIN?

Ongoing research is integral to clinical practice but carries with it a significant burden to the environment. It is estimated that an average of 78.4 tonnes of CO_2 is generated per clinical trial, which is equivalent to the emissions produced by nine people in the UK for an entire year.[76] The MRC CRASH trial had estimated total emissions equivalent to 126 tonnes of CO_2, which is roughly equal to that produced by 32 individuals over a year, or 525 round trip flights to New York from London.[77] The trial centre produced the largest proportion of CO_2 (39%), followed by delivery of drugs and documents (28%) and travel (23%).[77] While it can be challenging to deliver research in an environmentally sustainable domain given that a large proportion of emissions appear to be out of the control of individual researchers, they should still aim to reduce the environmental harm caused by their activities.

Targets for sustainable practice in laboratories have been outlined[78] but a common barrier described is lack of knowledge and understanding among clinical laboratory staff.[79] Cold storage in laboratories is one of the largest energy consumers with materials often kept in refrigerators and freezers for several years, if not decades.[80] Lab research is also a high producer of plastic waste, accounting for nearly 2% of total plastic waste.[80]

The National Institute for Health and Care Research (NIHR) Carbon guidelines have key recommendations for conducting greener research.[81] These include a focus on research questions that are most important to patients and ensuring rigorous systematic review prior to embarking on research that could be answered from existing evidence. Non-English-language publications present a challenge in this respect particularly as China now has the largest global share of academic publications, with output increasing by 51% between the years 2016 and 2002[82]. It follows that a 'green researcher' should think two times before excluding them from literature searches, but translation is equally time-consuming and costly. Furthermore, regardless of the research question, there should be a focus on efficient study design and avoidance of unnecessary data collection.[81] This can be challenging while not compromising the quality of research. Efficiency can be increased by answering several research questions in a single trial, but this is logistically challenging; as demonstrated by only a small percentage of ongoing NIHR trials being factorial trials.[81] Remote data collection and utilisation of videoconferencing can help to deliver research in an environmentally sustainable way by reducing travel. However, this may not always be feasible and rather prove to be more challenging for certain demographic populations such as the elderly and/or low socioeconomic groups.

A significant barrier to conducting green research is the heavy influence of commercial activity and financial incentives, which often competes with the aim to provide significant long-term benefits to patients and the environment; a fact that is mostly unavoidable given the high cost of research. It is particularly relevant in the field of gastroenterology, with commercial research accounting for 41.8% of studies in the NIHR Clinical Research Network (CRN) portfolio.[83] Working with over 90 industry sponsors from 2019 to 2020, it gives the specialty one of the largest commercial portfolios in the NIHR CRN.[83]

The pressure on researchers to achieve publications in the so-called 'publish or perish' phenomenon[84] is in conflict with the green agenda. The focus on achieving publications rather than producing meaningful research has contributed to the rising number of publications year on year.[82] It is estimated that just 45% of articles are cited within the first 5 years of publication,[84] suggesting waste from low-quality or irrelevant research. Meanwhile high-impact journals tend to be biased towards large-scale studies with extensive data, rather than simple studies delivered in an environmentally sustainable way. The carbon cost of research remains whether it is published or not, but given duplication of work, it is increased further if it remains unreported.[81] Every effort should be made to make all data publicly available, but this is in the hands of journals' peer-review systems. It is estimated that at least 12 000 trials completed every year remain unpublished[81] and a systematic review showed that only 53% of abstracts have full data available after 9 years.[85] There are alternatives to the traditional peer review process, including postpublication peer review; however, a huge culture shift will be required for this to be recognised and respected among the academic community.

The 'IBD Bioresource' is an example of collaborative working in an environmentally sustainable domain. It is an open-access platform aimed at advancing research in Crohn's and ulcerative colitis, including data from over 25 000 patients.[86] Samples were largely collected as part of routine clinical care and so limiting its environmental impact. The use of the data is maximised as it is open to any researcher approved by an ethics committee. Hopefully, there will be an increase in such collaborative working and data sharing in the future.

Overall, the idea that it is the responsibility of the research facility rather than individuals is a key factor that needs to change in order to lead to organisation-wide improvements. Clinical researchers often have short-term contracts feeling like they have limited time to make any meaningful lasting changes; however, they should always consider the environmental impact of their research when formulating a research proposal and should aim to evaluate its carbon cost on completion.

HOW CAN TRNS HELP TO DELIVER A 'GREEN GASTROENTEROLOGY' RESEARCH APPROACH?

As part of a new generation of gastroenterologists, it is vital that we as trainees embed climate-focussed decision-making into our clinical practice. Trainees moving between trusts for their specialty training are required to demonstrate agility and flexibility in their practice, making them ideally placed to identify and adopt novel climate sustainable approaches. The interconnectedness of TRNs provides a forum in which to share examples of good practice and to audit between trusts. In aligning themselves with the BSG's 'green' agenda,[10] TRNs will be able to access the support and resources available through the society, ensuring that trainees are part of the driving force towards sustainability in our clinical practice.

Reducing waste is key to the delivery of sustainable research, whether that be carrying out systematic reviews to avoid duplicating existing research, or designing clinical trials to answer several questions through one study. Many of the NIHR's 'Carbon Guidelines' are applicable to the work of TRNs.[81] A key benefit of research delivered by TRNs is its collaborative nature. By having ready access to a group of engaged trainees from across a region, it is possible to conduct multicentre observational studies and access a large potential patient cohort, increasing the chances of generating a study, which is adequately powered to observe differences. While gastroenterology TRNs have yet to deliver a prospective clinical trial, international trainee-led surgical research networks have demonstrated that this is feasible.[81] As trainees, we are likely to have had limited involvement in trial design, so engagement with the NIHR network and local methodologists is vital to ensure that study design is efficient, making good use of patient populations and patient time.

The NIHR Carbon Guidelines recommend measuring outcomes remotely wherever possible.[7] Many TRNs are comfortable with remote monitoring, having engaged in data collection using secure online servers such as RedCAP. In connecting trainees across a geographic region or nation, TRNs are well accustomed to meeting virtually to discuss progress, reducing the impact of travelling to meetings. Although TRNs typically run on modest budgets, it is important for trainees to consider funding sources and to ensure that any industry partners are committed to green principles.

Finally, we cannot forget that environmental health is a global issue. Carbon emissions from one country affects people in another. For gastroenterology (or any medical or surgical department), to be truly 'green' international collaboration must coexist. Given the aforementioned benefits of TRNs such as remote collaboration, their regular use of remote monitoring tools and engaged trainees, TRNs are ideally placed to lead the way in international quality improvements in green gastroenterology and beyond. The Royal College of Physicians currently has 14 registered TRNs with an additional 27 TRNs registered in the UK for the surgical specialties. As such, the UK has vast experience in setting up and successfully running TRNs. Now is the right time for networks to expand not just beyond their deaneries but crossing national and international boundaries as well and green gastroenterology is the right reason to do so.

MOVING FORWARDS

Gold standards for endoscopic procedures clinical practice already exist, which are well known and well practised. Nationally there are also targets for clinical pathways and referral times. The same needs to be true for clinical practice that impacts on the environment. While societies have started to publish best practice statements on improving sustainability, more data are still required to consolidate the evidence in order to produce impactful guidance and gold standards.

To obtain more robust data and create change, a team of like-minded individuals needs to come together and supports change at both the management and grass root level, building a team of people who first acknowledge the problem; second, are interested in tackling the issue at hand; and, importantly, will be present at the time affected by the change.[87] The TRN groups are the ideal team members who can initiate change by developing, disseminating and implementing best practice in green gastroenterology—perhaps even in an internationally coordinated fashion. As Segal *et al* wrote in 2022, 'The potential of TRNs is clear. What comes next is in our hands'.[9]

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REFERENCES

1 Siau K, Hodson J, Ingram R, *et al*. Time to endoscopy for acute upper gastrointestinal bleeding: results from a prospective multicentre trainee-led audit. *United European Gastroenterol J* 2019;7:199–209.
2 Kalla R, Gashau W, Borg-Bartolo S, *et al*. Timing of endoscopy for acute upper gastrointestinal bleeding in North West England: results from a multicentre trainee-led network. *United European Gastroenterol J* 2019;7:451–2.
3 GLINT Research Network, Ahmad OF, Ayubi H, *et al*. Quality of care in adult patients with inflammatory bowel disease transferring between healthcare providers: multicentre audit. *Frontline Gastroenterol* 2021;12:5–10.
4 Kader R, Dart RJ, Sebepos-Rogers G, *et al*. Implementation of an intervention bundle leads to quality improvement in ulcerative colitis endoscopy reporting. *GastroHep* 2020;2:309–17.
5 The Trainee Collaborative for Research and Audit in Hepatology UK. Regional variations in inpatient decompensated cirrhosis mortality may be associated with access to specialist care: results from a multicentre retrospective study. *Frontline Gastroenterol* 2023;15:3–13.
6 Trainee Collaborative for Research and Audit in Hepatology UK. Electronic address: oliver.tavabie@nhs.net, Trainee Collaborative for Research and Audit in Hepatology UK. Regional variation in characteristics of patients with decompensated cirrhosis admitted to hospitals in the UK. *Lancet Gastroenterol Hepatol* 2023;8:604–6.
7 Research TTCf UAiH. Admission care bundles for decompensated cirrhosis are poorly utilised across the UK: results from a multi-centre retrospective study. *Clin Med* 2023;23:193–200.
8 Tavabie OD, Abbott J, Abeysekera KWM. Defining characteristics and outcomes for patients with non-alcoholic fatty liver disease admitted to hospital with decompensated cirrhosis. *J Hepatol* 2023;79:e165–7.
9 Segal J, Widlak M, Ingram RJM, *et al*. What next for Gastroenterology and Hepatology Trainee networks? Lessons from our surgical colleagues. *Frontline Gastroenterol* 2022;13:82–5.
10 Veitch AM. Greener Gastroenterology and Hepatology: the BritiSh society of Gastroenterology strategy for climate change and sustainability. *Frontline Gastroenterol* 2022;13:e3–6.
11 Maurice JB, Rochford A, Marshall S, *et al*. Green endoscopy: using quality improvement to develop sustainable practice. *Frontline Gastroenterol* 2022;13:342–5.
12 Leddin D, Omary MB, Metz G, *et al*. Climate change: a survey of global gastroenterology society leadership. *Gut* 2022. 10.1136/gutjnl-2022-327832 [Epub ahead of print 10 Jun 2022].
13 Leddin D, Galts C, McRobert E, *et al*. The carbon cost of travel to a medical conference: modelling the annual meeting of the Canadian Association of Gastroenterology. *J Can Assoc Gastroenterol* 2022;5:52–8.
14 Baddeley R, Aabakken L, Veitch A, *et al*. Green endoscopy: counting the carbon cost of our practice. *Gastroenterology* 2022;162:1556–60.
15 Vokes L, FitzPatrick M. Call me maybe? Telephone clinics for coeliac disease dietetic services. *Frontline Gastroenterol* 2021;12:543–4.
16 King J, Poo SX, El-Sayed A, *et al*. Towards NHS zero: greener gastroenterology and the impact of virtual clinics on carbon emissions and patient outcomes. A multisite, observational, cross-sectional study. *Frontline Gastroenterol* 2023;14:287–94.
17 Wanigasooriya K, Sarma DR, Woods P, *et al*. The benefits of index telephone consultations in patients referred on the two-week wait colorectal cancer pathway. *Ann R Coll Surg Engl* 2023;105:314–22.
18 Mole G, Murali M, Carter S, *et al*. A service evaluation of specialist nurse telephone follow-up of bowel cancer patients after surgery. *Br J Nurs* 2019;28:1234–8.
19 Donnelly MC, Stableforth W, Krag A, *et al*. The negative bidirectional interaction between climate change and the prevalence and care of liver disease: a joint BSG, BASL, EASL, and AASLD commentary. *J Hepatol* 2022;76:995–1000.
20 Health Care Without Harm A. Health care's climate footprint. 2019. Available: https://www.arup.com/perspectives/publications/research/section/healthcares-climate-footprint [Accessed 28 Aug 2023].
21 Cunha Neves JA, Roseira J, Queirós P, *et al*. Targeted intervention to achieve waste reduction in gastrointestinal endoscopy. *Gut* 2023;72:306–13.
22 López-Muñoz P, Martín-Cabezuelo R, Lorenzo-Zúñiga V, *et al*. Life cycle assessment of routinely used endoscopic instruments and simple intervention to reduce our environmental impact. *Gut* 2023;72:1692–7.
23 Yong KK, He Y, Cheung HCA, *et al*. Rationalising the use of specimen pots following colorectal polypectomy: a small step towards greener endoscopy. *Frontline Gastroenterol* 2023;14:295–9.
24 Lim S, Haboubi HN, Anderson SHC, *et al*. Transnasal endoscopy: moving from endoscopy to the clinical outpatient-blue sky thinking in oesophageal testing. *Frontline Gastroenterol* 2022;13:e65–71.
25 Namburar S, von Renteln D, Damianos J, *et al*. Estimating the environmental impact of disposable endoscopic equipment and endoscopes. *Gut* 2022;71:1326–31.
26 Sun M, Gao M, Luo M, *et al*. Association between air pollution and primary liver cancer in European and East Asian populations: a Mendelian randomization study. *Front Public Health* 2023;11:1212301.
27 Chin WS, Pan SC, Huang CC, *et al*. Exposure to air pollution and survival in follow-up after hepatocellular carcinoma. *Liver Cancer* 2022;11:474–82.
28 VoPham T, Bertrand KA, Fisher JA, *et al*. Emissions of dioxins and dioxin-like compounds and incidence of hepatocellular carcinoma in the United States. *Environ Res* 2022;204:112386.
29 So R, Chen J, Mehta AJ, *et al*. Long-term exposure to air pollution and liver cancer incidence in six European cohorts. *Int J Cancer* 2021;149:1887–97.
30 Xue KS, Tang L, Shen CL, *et al*. Increase in aflatoxin exposure in two populations residing in East and West Texas, United States. *Int J Hyg Environ Health* 2021;231:113662.
31 Ma J-W, Lai T-J, Hu S-Y, *et al*. Effect of ambient air pollution on the incidence of colorectal cancer among a diabetic population: a nationwide nested case-control study in Taiwan. *BMJ Open* 2020;10:e036955.
32 Fei X, Lou Z, Christakos G, *et al*. The association between heavy metal soil pollution and stomach cancer: a case study in Hangzhou city, China. *Environ Geochem Health* 2018;40:2481–90.
33 Weinmayr G, Pedersen M, Stafoggia M, *et al*. Particulate matter air pollution components and incidence of cancers of the stomach and the upper aerodigestive tract in the European study of cohorts of air pollution effects (ESCAPE). *Environ Int* 2018;120:163–71.
34 VoPham T, Bertrand KA, Tamimi RM, *et al*. Ambient $PM_{2.5}$ air pollution exposure and hepatocellular carcinoma incidence in the United States. *Cancer Causes Control* 2018;29:563–72.
35 Deng H, Eckel SP, Liu L, *et al*. Particulate matter air pollution and liver cancer survival. *Int J Cancer* 2017;141:744–9.
36 Pedersen M, Andersen ZJ, Stafoggia M, *et al*. Ambient air pollution and primary liver cancer incidence in four

European cohorts within the ESCAPE project. *Environ Res* 2017;154:226–33.
37 Kachuri L, Villeneuve PJ, Parent M-É, *et al*. Workplace exposure to diesel and gasoline engine exhausts and the risk of colorectal cancer in Canadian men. *Environ Health* 2016;15:4.
38 Di Ciaula A. Increased deaths from gastric cancer in communities living close to waste landfills. *Int J Environ Health Res* 2016;26:281–90.
39 Pan W-C, Wu C-D, Chen M-J, *et al*. Fine particle pollution, alanine transaminase, and liver cancer: a Taiwanese prospective cohort study (REVEAL-HBV). *J Natl Cancer Inst* 2016;108.
40 López-Abente G, García-Pérez J, Fernández-Navarro P, *et al*. Colorectal cancer mortality and industrial pollution in Spain. *BMC Public Health* 2012;12:589.
41 Fang R, Le N, Band P. Identification of occupational cancer risks in British Columbia, Canada: a population-based case-control study of 1,155 cases of colon cancer. *Int J Environ Res Public Health* 2011;8:3821–43.
42 Chiu H-F, Tsai S-S, Chen P-S, *et al*. Traffic air pollution and risk of death from gastric cancer in Taiwan: petrol station density as an indicator of air pollutant exposure. *J Toxicol Environ Health A* 2011;74:1215–24.
43 Sjödahl K, Jansson C, Bergdahl IA, *et al*. Airborne exposures and risk of gastric cancer: a prospective cohort study. *Int J Cancer* 2007;120:2013–8.
44 Guo J, Kauppinen T, Kyyrönen P, *et al*. Risk of Esophageal, ovarian, testicular, kidney and bladder cancers and leukemia among Finnish workers exposed to diesel or gasoline engine exhaust. *Int J Cancer* 2004;111:286–92.
45 Romundstad P, Haldorsen T, Andersen A. Cancer incidence and cause specific mortality among workers in two Norwegian aluminum reduction plants. *Am J Ind Med* 2000;37:175–83.
46 Park RM, Mirer FE. A survey of mortality at two automotive engine manufacturing plants. *Am J Ind Med* 1996;30:664–73.
47 Kusiak RA, Ritchie AC, Springer J, *et al*. Mortality from stomach cancer in Ontario miners. *Br J Ind Med* 1993;50:117–26.
48 Chen J, Dan L, Sun Y, *et al*. Ambient air pollution and risk of enterotomy, gastrointestinal cancer, and all-cause mortality among 4,708 individuals with inflammatory bowel disease: a prospective cohort study. *Environ Health Perspect* 2023;131:077010.
49 Okafor PN, Dahlen A, Youssef M, *et al*. Environmental pollutants are associated with irritable bowel syndrome in a commercially insured cohort of California residents. *Clin Gastroenterol Hepatol* 2023;21:1617–26.
50 Adami G, Pontalti M, Cattani G, *et al*. Association between long-term exposure to air pollution and immune-mediated diseases: a population-based cohort study. *RMD Open* 2022;8:e002055.
51 Li FR, Wu KY, Fan WD, *et al*. Long-term exposure to air pollution and risk of incident inflammatory bowel disease among middle and old aged adults. *Ecotoxicol Environ Saf* 2022;242:113835.
52 Duan R, Wu Y, Wang M, *et al*. Association between short-term exposure to fine particulate pollution and outpatient visits for ulcerative colitis in Beijing, China: a time-series study. *Ecotoxicol Environ Saf* 2021;214:112116.
53 Ding S, Sun S, Ding R, *et al*. Association between exposure to air pollutants and the risk of inflammatory bowel diseases visits. *Environ Sci Pollut Res Int* 2022;29:17645–54.
54 Opstelten JL, Beelen RMJ, Leenders M, *et al*. Exposure to ambient air pollution and the risk of inflammatory bowel disease: a European nested case-control study. *Dig Dis Sci* 2016;61:2963–71.
55 Manser CN, Paul M, Rogler G, *et al*. Heat waves, incidence of infectious gastroenteritis, and relapse rates of inflammatory bowel disease: a retrospective controlled observational study. *Am J Gastroenterol* 2013;108:1480–5.
56 Steenland K, Zhao L, Winquist A, *et al*. Ulcerative colitis and perfluorooctanoic acid (PFOA) in a highly exposed population of community residents and workers in the mid-Ohio valley. *Environ Health Perspect* 2013;121:900–5.
57 Ananthakrishnan AN, McGinley EL, Binion DG, *et al*. Ambient air pollution correlates with hospitalizations for inflammatory bowel disease: an ecologic analysis. *Inflamm Bowel Dis* 2011;17:1138–45.
58 Kaplan GG, Hubbard J, Korzenik J, *et al*. The inflammatory bowel diseases and ambient air pollution: a novel association. *Am J Gastroenterol* 2010;105:2412–9.
59 VoPham T, Kim NJ, Berry K, *et al*. $PM_{2.5}$ air pollution exposure and nonalcoholic fatty liver disease in the nationwide inpatient sample. *Environ Res* 2022;213:113611.
60 Orioli R, Solimini AG, Michelozzi P, *et al*. A cohort study on long-term exposure to air pollution and incidence of liver cirrhosis. *Environ Epidemiol* 2020;4:e109.
61 Hou X, Mao Z, Song X, *et al*. Synergistic Association of long-term ozone exposure and solid fuel use with biomarkers of advanced fibrosis. *Environ Sci Pollut Res Int* 2023;30:85318–29.
62 Li W, Dorans KS, Wilker EH, *et al*. Residential proximity to major roadways, fine particulate matter, and hepatic steatosis: the Framingham heart study. *Am J Epidemiol* 2017;186:857–65.
63 Dey T, Gogoi K, Unni B, *et al*. Role of environmental pollutants in liver physiology: special references to peoples living in the oil drilling sites of Assam. *PLoS One* 2015;10:e0123370.
64 Kim KN, Lee H, Kim JH, *et al*. Physical Activity- and alcohol-dependent association between air pollution exposure and elevated liver enzyme levels: an elderly panel study. *J Prev Med Public Health* 2015;48:151–69.
65 Hu Y, Chen B, Qian J, *et al*. Occupational Coke oven emissions exposure and risk of abnormal liver function: modifications of body mass index and hepatitis virus infection. *Occup Environ Med* 2010;67:159–65.
66 Kim H-J, Min J-Y, Seo Y-S, *et al*. Association of ambient air pollution with increased liver enzymes in Korean adults. *Int J Environ Res Public Health* 2019;16:1213.
67 Wu MT, Mao IF, Wypij D, *et al*. Serum liver function profiles in coking workers. *Am J Ind Med* 1997;32:478–86.
68 Tsai S-S, Chiu H-F, Yang C-Y. Ambient air pollution and hospital admissions for peptic ulcers in Taipei: a time-stratified case-crossover study. *Int J Environ Res Public Health* 2019;16:1916.
69 Chau TT, Wang KY. An association between air pollution and daily most frequently visits of eighteen outpatient diseases in an industrial city. *Sci Rep* 2020;10:2321.
70 Wu M, Lu J, Yang Z, *et al*. Ambient air pollution and hospital visits for peptic ulcer disease in China: a three-year analysis. *Environ Res* 2021;196:110347.
71 Tian L, Qiu H, Sun S, *et al*. Association between emergency admission for peptic ulcer bleeding and air pollution: a case-crossover analysis in Hong Kong's elderly population. *Lancet Planet Health* 2017;1:e74–81.
72 Wong C-M, Tsang H, Lai H-K, *et al*. STROBE-long-term exposure to ambient fine particulate air pollution and hospitalization due to peptic ulcers. *Medicine (Baltimore)* 2016;95:e3543.
73 Quan S, Yang H, Tanyingoh D, *et al*. Upper gastrointestinal bleeding due to peptic ulcer disease is not associated with air pollution: a case-crossover study. *BMC Gastroenterol* 2015;15:131.
74 Davies NM, Holmes MV, Davey Smith G. Reading Mendelian Randomisation studies: a guide, glossary, and checklist for clinicians. *BMJ* 2018;362:k601.
75 Freuer D, Meisinger C. Association between inflammatory bowel disease and Parkinson's disease: a Mendelian randomization study. *NPJ Parkinsons Dis* 2022;8:55.

76 Lyle K, Dent L, Bailey S, *et al*. Carbon cost of pragmatic randomised controlled trials: retrospective analysis of sample of trials. *BMJ* 2009;339:b4187.
77 Sustainable Trials Study Group. Towards sustainable clinical trials. *BMJ* 2007;334:671–3.
78 Lopez JB, Jackson D, Gammie A, *et al*. Reducing the environmental impact of clinical laboratories. *Clin Biochem Rev* 2017;38:3–11.
79 Molero A, Calabrò M, Vignes M, *et al*. Sustainability in healthcare: perspectives and reflections regarding laboratory medicine. *Ann Lab Med* 2021;41:139–44.
80 Subaiya S, Hogg E, Roberts I. Reducing the environmental impact of trials: a comparison of the carbon footprint of the CRASH-1 and CRASH-2 clinical trials. *Trials* 2011;12:31.
81 NIHR Carbon Reduction Guidelines. *Key recommendations for researchers*. 2019.
82 Liao Z, Zhang P. *Behind the rising influence of Chinese research*. 2022.
83 NIHR. Gastroenterology. Available: https://www.nihr.ac.uk/explore-nihr/specialties/gastroenterology.htm [Accessed 7 Sep 2023].
84 Rawat S, Meena S. Publish or perish: where are we heading *J Res Med Sci* 2014;19:87–9.
85 Scherer RW, Langenberg P, von Elm E. Full publication of results initially presented in abstracts. *Cochrane Database Syst Rev* 2007:MR000005.
86 Parkes M, Investigators IBDB. IBD bioresource: an open-access platform of 25 000 patients to accelerate research in Crohn's and colitis. *Gut* 2019;68:1537–40.
87 Donnelly L. Green endoscopy: practical implementation. *Frontline Gastroenterol* 2022;13:e7–12.