Original research

Towards NHS Zero: greener gastroenterology and the impact of virtual clinics on carbon emissions and patient outcomes. A multisite, observational, cross-sectional study.

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ABSTRACT

Objective The National Health Service (NHS) produces more carbon emissions than any public sector organisation in England. In 2020, it became the first health service worldwide to commit to becoming carbon net zero, the same year as the COVID-19 pandemic forced healthcare systems globally to rapidly adapt service delivery. As part of this, outpatient appointments became largely remote. Although the environmental benefit of this change may seem intuitive the impact on patient outcomes must remain a priority. Previous studies have evaluated the impact of telemedicine on emission reduction and patient outcomes but never before in the gastroenterology outpatient setting.

Method 2140 appointments from general gastroenterology clinics across 11 Trusts were retrospectively analysed prior to and during the pandemic. 100 consecutive appointments during two periods of time, from 1 June 2019 (prepandemic) to 1 June 2020 (during the pandemic), were used. Patients were telephoned to confirm the mode of transport used to attend their appointment and electronic patient records reviewed to assess did-not-attend (DNA) rates, 90-day admission rates and 90-day mortality rates.

Results Remote consultations greatly reduced the carbon emissions associated with each appointment. Although more patients DNA their remote consultations and doctors more frequently requested follow-up blood tests when reviewing patients face-to-face, there was no significant difference in patient 90-day admissions or mortality when consultations were remote.

Conclusion Teleconsultations can provide patients with a flexible and safe means of being reviewed in outpatient clinics while simultaneously having a major impact on the reduction of carbon emissions created by the NHS.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ There remains very little research available assessing the environmental impact of remote consultations despite the increasing threat of the climate emergency. Small studies have concluded that teleconsultations can reduce carbon emissions by accouting for the carbon footprint of transportation but there remains a scarcity in studies that calculate the carbon footprint created by teleconsultations themselves. In addition, there remains a lack of evidence surrounding the safety of teleconsultations. Our study not only provides data on the true difference in the carbon emissions between teleconsultations and face-to-face consultations but also looks at a number of endpoints allowing the safety of teleconsultations to be assessed.

INTRODUCTION

The National Health Service (NHS) accounts for 5.9% of UK carbon emissions,

WHAT THIS STUDY ADDS

⇒ It is now clear that although teleconsultations do have a carbon footprint, this carbon footprint is over 99% less than that of face-to-face (F2F) consultations. Although this may come as no surprise, a greener system is somewhat redundant if remote consultations do not provide patients a safe outcome. Our study illustrates by means of multiple endpoints, that teleconsultations can be just as safe as F2F consultations while also delivering greener and more convenient healthcare.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study can support the decision for the National Health Service (NHS) to transition care to a remote or hybrid system when it comes to outpatient consultations. This would not only lead to a greener NHS but also an NHS that can provide patients with a flexible and convenient means to be reviewed in the outpatient setting. Subsequently in the future this could enable flexibility for patients to be referred to specialist centres nationwide.

or carbon dioxide equivalents (CO_2e), which is the largest public sector contribution in England.[1] The Greener NHS programme has highlighted and begun to act on interventions needed to reach its target of being carbon net zero by 2040.[2] Transportation of equipment, patients and staff to hospitals to support face-to-face (F2F) consultations, investigations and procedures accounts for an estimated 10%–14% of the NHS's current total emissions.[2 3]

The introduction of virtual clinics during the COVID-19 pandemic would be expected to result in a reduction in CO_2 emissions by reducing the number of patient journeys for F2F consultations. However, these CO_2 savings could be significantly offset by patients needing subsequent journeys for blood tests. Furthermore, if the inability to perform physical examination led to a consequent emergency department attendance with disease progression, this would not only negate the initial CO_2 saving but more importantly result in a worse patient outcome. While there are numerous studies evaluating the cost-effectiveness of virtual clinics and evaluating the impact on emission reduction, very few studies have yet to compare in detail the impact on patient outcomes, particularly in the context of outpatient gastroenterology clinics.[3–7]

The primary outcome measurement in this study was the change in carbon emissions generated by patients attending gastroenterology outpatient appointments remotely during the COVID-19 pandemic compared with the emissions generated by F2F consultations prior. We also explored the feasibility and safety of virtual appointments by measuring secondary outcomes: rates of patients who did-not-attend (DNA) their appointment, rates of admissions and death at 90 days and the number of appointments within which clinicians requested blood tests.

Objectives

We aim to calculate the true reduction in carbon emission resulting from the transition to virtual consultations during the global pandemic and assess the safety of these appointments when compared with traditional F2F consultations. We predict that virtual consultations will have a major reduction on carbon emissions whilst resulting in patient outcomes that are similar or marginally inferior to those of F2F appointments.

METHODS

Study design and clinical setting

This was a retrospective, observational, multisite, cross-sectional study to calculate the change in carbon emissions generated by patients attending gastroenterology outpatient appointments prior to the COVID-19 pandemic in F2F consultations (group 1) and during the pandemic when the majority of consultations were virtual (group 2). In addition, patient outcomes were also collected using electronic patient records (EPR) to assess the safety of remote consultations.

Appointments at 11 NHS Trusts across the South East of the UK were analysed (5 tertiary centres and 6 non-tertiary centres).

Patient population

For both group 1 and group 2, data were collected from 100 consecutive patients attending general gastroenterology clinics at each site. The dates from which these data were collected were 1 June 2019 (group 1) and 1 June 2020 (group 2).

Data collection

Using the EPR at each site, we collected anonymised data on patients' demographics (age and sex), the date of the clinic appointment, the distance from the patients' home to hospital site (kilometres, km), whether blood tests were requested during the appointment, any subsequent admission within 90 days of the date of the appointment—including whether this admission was related to their gastroenterological diagnosis—and any death within 90 days of the appointment. Patients were then retrospectively called and asked about the mode of transport used to attend their appointment using a strict preset proforma (online supplemental appendix A). Interviewers were not allowed to diverge from this script. If a patient DNA the scheduled appointment they were excluded from the final data collection. If a patient failed to answer our phone calls on three separate occasions, or was known to have passed away, they were not included in the CO_2 data comparison however data from their EPR was still used to compare the feasibility and safety of remote consultations.

Carbon emission calculation

Carbon emissions (kg CO_2e) was calculated for each patient journey utilising taxi, car or motorbike. In kilometres, the distance travelled was estimated using the shortest geographical route acquired from Google Maps (https://www.google.com/maps/) from the patients' home address to the hospital site. We assumed that each patient returned home directly after their appointment thus doubling the distance of travel. These assumptions were made to ensure that we did not overestimate CO_2 emissions for group 1.

Using data published in the 2019 annual report produced by The Department for Business, Energy and Industrial Strategy,[8] we assumed the carbon emissions from the use of cars and taxis to be equal to the national average of 146.5 g/km and that of motorbikes to be 116.7 g/km. This value is based on a combination of data, utilising all new vehicles registered between 1997 and 2017 in combination with real world data on car usage behaviour using automated number plate recognition technology between 2007 and 2017 across 256 sites in the UK. Public transport modalities were not included in the calculations as emissions produced by these modalities were not impacted by patients attending their appointment.

We also estimated carbon emissions for the infrastructure used in virtual appointments for group 2. We used data available for the emissions produced by videoconferencing services for any video consultations that took place.[9] Data on the carbon emissions of landlines is sparse and so we analysed telephone-only clinics by applying the CO_2 emissions of phone calls made using mobile phones, which have higher emissions, instead.[10 11] Consultations were assumed to have taken 20 min rather than the 15 min allocated for appointments. These assumptions were made to minimise the underestimation of group 2 emissions. Total carbon emissions for group 1 and group 2 were then compared.

Statistical methods

This study was a service evaluation and therefore power calculations were not performed.

Statistical analysis was performed by using GraphPad, Prism and SPSS Statistics 20. Discrete data are presented as numbers and percentages, and continuous data as medians with corresponding 25th and 75th percentiles (IQR). Differences were compared using the Mann-Whitney U test for continuous variables and the Student's t-test and χ^2 test for nominal variables. All tests were two sided and significance was accepted as $p<0.05$.

A total of 2140 patients were included in the final data collection from a total possible of 2200. Group 1 included 1081 patients and group 2 included 1059 patients. Of these, the mode of transport used to attend hospital was retrieved in 756 patients (756/1081; 69.94%) in group 1 and 1055 patients (1055/1059; 99.62%) in group 2. One data point had to be removed from group 1 as the patient reported attending the clinic by aeroplane which was beyond the scope of our interviewer's scripted proforma to follow-up on. A detailed list of the reasons for data exclusion is presented in the flow charts in figure 1A,B.

All 2140 patients included in the data collection had their clinic outcomes analysed. There were no significant differences in the baseline demographics of each group (table 1).

Carbon emissions and modes of transport

In group 1, emissions associated with patient travel were 1165.29 kg CO_2e, an average of 1.54 kg/consultation. In group 2, seven consultations remained F2F and 1048 were virtual. All virtual appointments were performed using hospital landline telephones. No videoconferencing services were used. Carbon emissions for group 2, which included personal transport and estimated emissions produced by phone calls was 5.37 kg CO_2e, an average of 0.005 kg per consultation. This was an overall reduction of 1159.92 kg CO_2e (99.37%; $p=0.0001$, table 2).

There was no significant difference in the kg CO_2e between the non-tertiary and tertiary sites overall (group 1 $p=0.62$; group 2 $p=0.95$) or when adjusting for number of appointments (group 1 $p=0.45$; group 2 $p=0.89$) in either group.However kg CO_2e was found to be numerically greater in patients attending non-tertiary hospitals compared with tertiary centres (table 2). The distribution of the mode of transport used was significantly different. Patients attending non-tertiary hospitals were more likely to travel by car/taxi than those attending a tertiary centre (286/412, (69.4%) vs 116/344, (33.7%); $p=0.0001$) (figure 2). Conversely, patients attending tertiary centres were twice as likely to travel by public transport than patients attending non-tertiary hospitals (228/344, (66.3%) vs 126/412, (30.6%); $p=0.0001$).

DNA rates

There was a significant difference in DNA rates from group 1 to group 2. Group 1 had only two patients who DNA compared with 15 in group 2 (2/1081, 0.185% vs 15/1059, 1.416%; $p=0.0001$).

Blood test requests as an outcome of appointment

Significantly fewer blood tests were requested in group 2 appointments when compared with group 1 appointments (table 2). Blood tests were requested in 342 of 1081 (31.6%) appointments in group 1 and 225 of 1059 (21.3%) appointments in group 2 ($p=0.03$).

There was no significant difference in how non-tertiary ($p=0.13$) or tertiary centres ($p=0.08$) behaved from group 1 to group 2.

Ninety-day admission and mortality rates

There were 78 admissions within 90 days of appointment date in group 1, 28 of these were related to the underlying gastroenterological diagnosis (table 2, figure 3). In group 2, there were 62 any cause

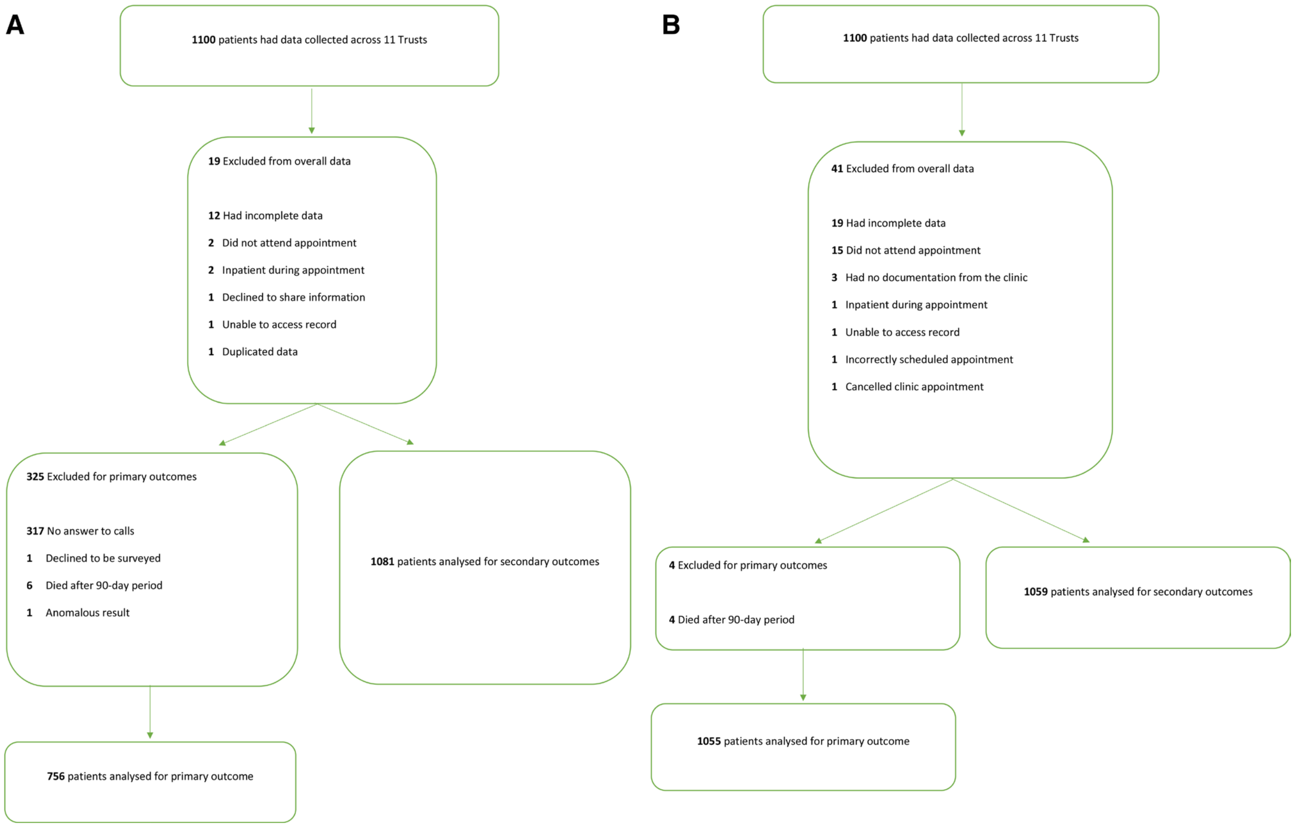

Figure 1 Flowcharts showing patient inclusion and exclusion for primary and secondary outcomes in both group 1 (A) and group 2 (B).

Table 1 Baseline demographics

	Group 1	Group 2
Total no	1081	1059
Female (%)	646 (59.8)	604 (57)
Median age (IQR), years	53 (39–67)	52 (37–67)
Region (N (%))		
Northwest London	296 (27.38)	293 (27.67)
North Central London	198 (18.32)	190 (17.94)
Northeast London	88 (8.14)	81 (7.65)
South London and Kent, Surrey, Sussex	499 (46.16)	495 (46.74)
Centre (N (%))		
Tertiary	486 (45)	474 (44.76)
Non-tertiary	595 (55)	585 (55.24)

Demographics of the patients and comparison of the distribution of patients by regionand hospital type (teriary and non-tertiary).

admissions and 21 admissions related to the underlying gastroenterology diagnosis. These differences were not significant (p value for any cause admission=0.43; p value for admission related to gastroenterological diagnosis=0.49).

The mortality rates between group 1 and group 2 were also not significant (table 2, figure 3). There were 20 deaths in group 1 and 16 deaths in group 2 within 90 days of appointment (p=0.69).

DISCUSSION

The health sector worldwide incurs a significant environmental impact, more than shipping and aviation combined.[12 13] This carbon footprint has a negative impact on public health directly by increasing air pollutants and indirectly by contributing towards global warming and climate change. The NHS committed to a 'Net Zero' Carbon footprint in 2020,[14] highlighting changes required for the delivery of healthcare. The Royal College of Physicians report, '*Outpatients: the future—adding value through sustainability*', identified current challenges and suggested changes to how outpatient care could be delivered.[15] The COVID-19 pandemic meant that significant changes, including the use of virtual consultations, were introduced in the NHS quicker than anticipated.

The data presented herein were obtained from 11 NHS Trusts and allowed us to compare trends between tertiary and non-tertiary centres. Overall, using the parameters tested, we can see that virtual clinics lead to a significant reduction in carbon emissions without any measurable adverse outcome for the patient, though DNA rates were significantly increased. Although the reasons for these were beyond the scope of this study, it is clear that there are more steps required to ensure attendance of a patient for a telephone consultation. Details on the EPR need to be up to date, the patient needs to be beside their phone with good service and the physician needs to ensure sufficient attempts are made to contact the patient before deciding that they DNA. The unfamiliarity of this system for both physicians and patients at the time of this study could have accounted for the difference in rates seen. This difference may be mitigated in time if virtual clinics become commonplace.

We showed an estimated reduction of 1159.92 kg of CO_2 emissions, at an average reduction of 5.35 kg CO_2 per appointment when the majority of appointments were virtual. This equated to a 99.37% reduction in carbon emissions. It is not easy to extrapolate what this represents as a proportion of the vast overall carbon footprint of the NHS. Data by Tennison *et al* reported patient transport accounted for 5.1% of the 2019 NHS carbon footprint or 1.23 metric tonnes CO_2e.[2] Although this figure related to all patient transport, not merely that for outpatient clinic appointments, it provides some insight into the significant benefit remote consultations could have as the NHS attempts to be net carbon zero.

The estimated reduction of 5.35 kg CO_2 per appointment in our dataset is likely to be a slight underestimate. We assumed patients to use only the shortest route, returning directly home after each appointment. We also assumed longer telephone consultations and used the CO_2e emitted by mobile phones rather than landlines. Nonetheless, this represents the equivalent of the emissions generated by a 13-hour flight, or the average use of a car in the UK for over 6 months.[16]

When comparing the emissions of tertiary and non-tertiary centres, it was noted that non-tertiary hospitals reduced their emissions by a greater amount than tertiary hospitals. This remained true when correcting for emissions per appointment. Neither value was significant but may reflect the greater transport infrastructure available in areas surrounding tertiary centres. This is further suggested by the fact that a greater proportion of patients in our study attended non-tertiary hospitals by car/taxi than public transport.

Our study did not allow for the calculation of CO_2e emissions caused by the attendance of patients for follow-up blood tests. We did not explore what proportion of patients in group 1 attended the phlebotomy department immediately or at a later date. We also did not confirm what proportions of group 2 patients attended for blood tests following the request nor calculated emissions related to these journeys. However, there were significantly fewer blood tests requested in group 2 with only 21.3% ($p=0.03$) having blood tests requested. Had all of these patients made an additional journey using personal transport, this would not have been sufficient to offset the reduction in emissions seen in group 2. Furthermore, routine blood tests have their own carbon footprint. These relate to the consumables, collection of samples and electricity and water use for laboratory analyses.[17] This represents an additional reduction in emissions in group 2 that was beyond the scope of this study to calculate.

While the reason for physicians requesting fewer blood tests from virtual clinic was not explored in this

Table 2 CO_2 emissions data and patient outcomes

	Carbon emission reduction in group 2		Admission within 90 days of clinic			Admissions related to gastro issues during clinic appt			Mortality within 90 days of appointment			No of blood tests ordered as clinic outcome		
	Reduction in CO_2 emission (kg)	Reduction in CO_2 emissions (%)	Group 1	Group 2	P value	Group 1	Group 2	P value	Group 1	Group 2	P value	Group 1	Group 2	P value
Tertiary	486.01	99.34	29	17	0.2112	6	6	1.0000	9	6	0.7525	134	78	0.0831
Non-tertiary	673.91	99.40	49	45	0.8072	22	15	0.4242	11	10	0.8430	208	147	0.1263
Overall	1159.92	99.37	78	62	0.4267	28	21	0.4890	20	16	0.6893	342	225	0.0256

The first column outlines the CO_2 emissions reduction in group 2. The subsequent columns compare the outcomes of the appointments between group 1 and group 2 when looking at admissions, including those related to underlying gastroenterolical diagnosis, at 90 days,deaths within 90 days and the number of blood tests requested.
CO2, carbon dioxide.

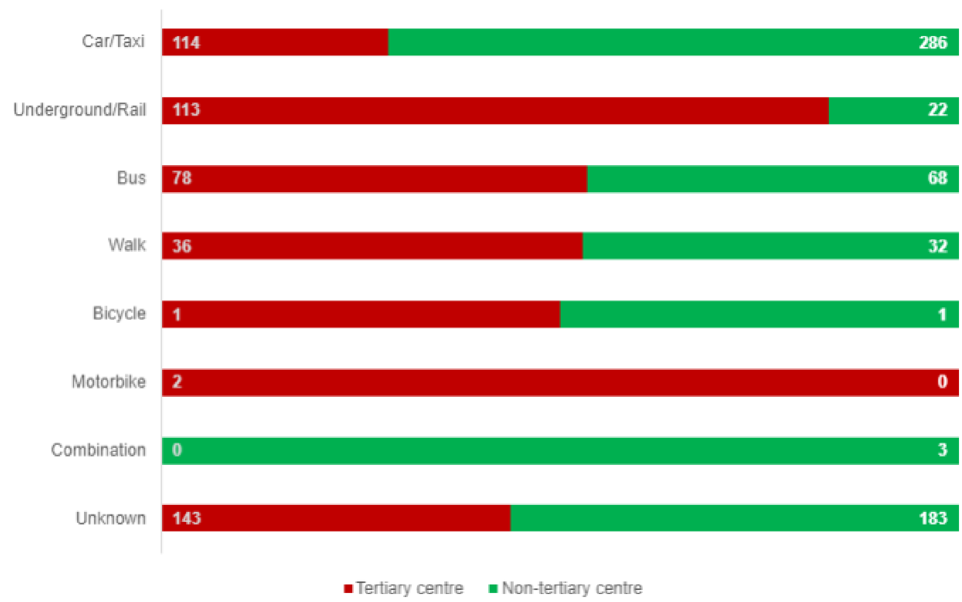

Figure 2 Comparison between teriary and non-tertiary centres of transport types used by patients attending F2F consultations in group 1.

study, this did not appear to increase adverse outcomes in terms of the parameters measured (90-day any cause admissions, p=0.43; 90-day gastroenterology-related admission, p=0.49; 90-day mortality, p=0.69). However, our methodology did not allow for the capture of any patients admitted to an alternative hospital.

Despite the clear benefit to the environment, the decision to continue virtual clinics moving out of the pandemic restrictions is nuanced and must take into account patient preference. A study of inflammatory bowel disease patients found that 94.3% expressed a preference for having the option of a telephone appointment as well as F2F consultations.[18] This suggests a desire from patients to embrace this change, but there will always remain a clinical need to review patients in person. The availability nationwide of videoconferencing is only 36%[19]; however, our study showed that telephone consultations alone are feasible and may not negatively impact patient outcomes.

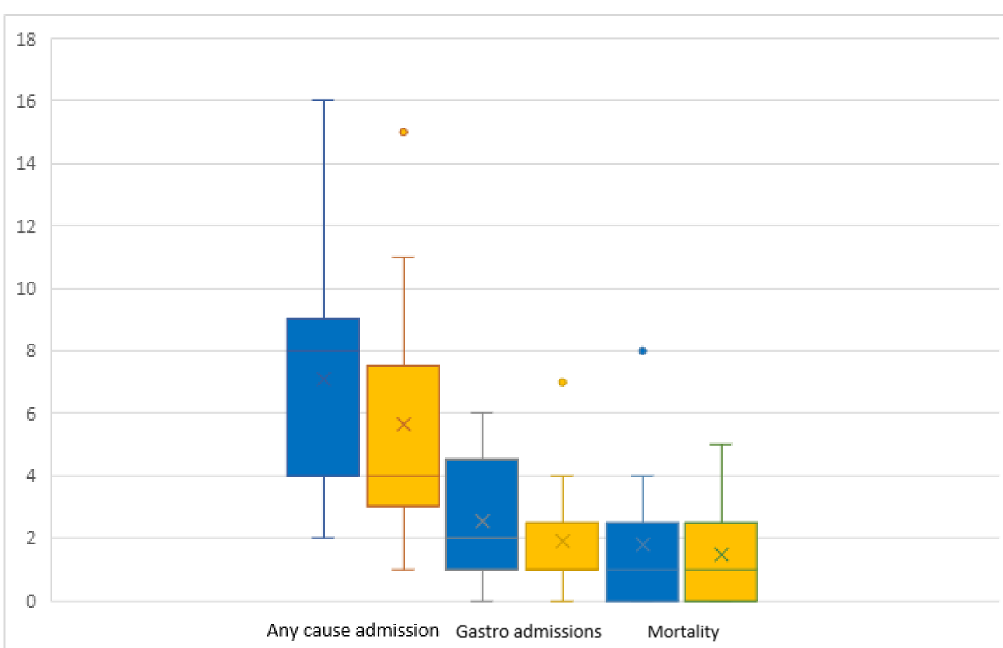

Figure 3 Whisker boxplot showing comparison between groups 1 (blue) and group 2 (yellow) of 90-day admissions and 90-mortality, including all-cause admission and admission related to underlying gastroenterological diagnosis.

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We are facing a climate crisis, with healthcare not only a significant contributor but also subsequently burdened by the negative health outcomes that result. In this study, we have shown that virtual outpatient appointments results in significant carbon savings, while offering a flexible service that does not compromise patient care. Through the use of telephone and video consultations, alongside shared care pathways with primary care providers, there is a real opportunity to assist in the goal of NHS Net Zero while developing modern, safe and effective healthcare.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study was conducted as a service evaluation and registered with each local sites Research and Development department. As no identifiable data was transferred and there was no impact on patient care, in accordance with the UK Health Research Authority guidelines, formal ethical approval was not required.

Provenance and peer review Not commissioned; externally peer reviewed.

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Telephone interview script

Instructions: When calling the patient only use verified phone numbers documented in the patient electronic records and follow the points below. Do not ask any questions beyond those listed below.

1. *Introduce yourself*
2. *Explain that you are carrying out research to assess how much more environmentally friendly remote clinics are to face to face appointments*
3. *Explain that the only information required is mode of transport used for a specific appointment, if remembered*
4. *Highlight that no personal information that may be linked back to the patient (patient identifiers) are being stored or used at all during this project*
5. *Ask permission to calculate the distance the patient would have travelled from home to hospital using Google Maps as part of the results, ensuring the patient understands that we will be accessing their post code for the calculation but NOT saving it as part of our data collection*
6. *With consent, proceed to ask what mode of transport the patient used for the set appointment*
7. *Thank the patient (whether they have consented or not)*