Towards NHS Zero: Greener Gastroenterology. The impact of virtual clinics on carbon emissions and patient outcomes - a multi-site, observational, cross-sectional study

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Abstract

Objective

The NHS produces more carbon emissions than any public sector organisation in England[1]. In 2020, it became the first health service worldwide to commit to becoming carbon net zero[2], the same year as the global 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 may seem intuitive, the reduction in emissions alongside the effect on patient outcomes has never previously been explored.

Method

2,141 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 1st June 2019 (pre-pandemic) and 1st June 2020 (during the pandemic), were used. Patients were called to confirm the mode of transport used to attend their appointment and electronic patient records reviewed to assess a number of outcomes such as did-not-attend rates, 90-admission rates and 90-day mortality rates.

Results

Remote consultations greatly reduced the carbon emissions associated with each appointment. Although more patients did not attend 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 whilst simultaneously having a major impact on the reduction of carbon emissions created by the NHS.

Introduction

The National Health Service (NHS) accounts for 5.9% of UK carbon emissions, or carbon dioxide equivalents (CO2e) 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 CO2 emissions by reducing the number of patient journeys for F2F consultations. However, these CO2 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 CO2 saving compared with a F2F consultation but more importantly mean a worse patient outcome. Whilst there are numerous studies evaluating the cost-effectiveness of virtual clinics, their comparative carbon footprint has yet to be determined, particularly in the context of outpatient gastroenterology clinics,[4] and their feasibility and safety also remains unexplored.

The primary outcome measurement in this study was the change in carbon emissions generated by patients attending gastroenterology outpatient appointments during the COVID-19 pandemic remotely compared to the emissions generated by F2F consultations. 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 90 days after the appointment 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 consolations during the global pandemic and assess the safety of these appointments when compared to traditional F2F consultations. We predict that virtual consultations will have 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, multi-site, cross-sectional study to calculate the change in carbon emissions generated by patients attending gastroenterology outpatient appointments prior to the COVID 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 eleven NHS Trusts across the South East of the UK were analysed (five tertiary centres and six 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. The dates from which appointment data was collected were 1st June 2019 (group 1) and 1st 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 pre-set proforma (appendix A). Interviewers were not allowed to diverge from this script. If a patient did not attend (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 CO2 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 CO2e) was calculated for each patient journey by taxi, car or motorbike. In km, 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 CO2 emissions for group 1.

Using data published in the 2019 annual report produced by *The Department for Business, Energy and Industrial Strategy*[5], 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 (ANPR) 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 video conferencing services for any video consultations that took place.[6] Data on the carbon emissions of landlines is sparse and so we analysed telephone-only clinics by applying the CO2 emissions of phone calls made using mobile phones instead[7,8]. Consultations were assumed to have taken 20 minutes rather than the 15 minutes 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 using *GraphPad*, *Prism* and *SPSS*. Discrete data is presented as numbers and percentages, and continuous data as medians with corresponding 25th and 75th percentiles (interquartile range). Differences were compared using the Mann-Whitney U test for continuous variables and the Student's t-test and chi-squared test for nominal variables. All tests were two-sided and significance was accepted as $p<0.05$.

Ethical Considerations

This study was conducted as a service evaluation and registered with each local sites Research and Development (R&D) department. As no identifiable data was transferred and there was no impact on patient care, in accordance with the UK Health Research Authority guidelines[9], formal ethical approval was not required.

Results

2,141 patients were included in the final data collection from a total possible of 2,200. Group 1 included 1,082 patients and group 2 included 1,059 patients. Of these, the mode of transport used to attend hospital was retrieved in 756 patients (756/1,082; 69.87%) 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 figures 1a-b.

All 2,141 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).

Table 1: Baseline demographics

Demographics of the patients and comparison of the distribution of home addresses across London.

	Group 1	**Group 2**
Total number	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 & Kent, Surrey, Sussex	499 (46.16%)	495 (46.74%)
Centre [N (%)]		
Tertiary	486 (45%)	474 (44.76%)
Non-tertiary	595 (55%)	585 (55.24%)

Carbon emissions and modes of transport

Group 1 emitted 1165.29 kg CO2e by way of personal transport to attend appointments, an average of 1.54kg per consultation. In group 2, seven consultations remained F2F and 1,048 were virtual. All virtual appointments were performed using hospital landline telephones. No video conferencing services were used. Carbon emissions for group 2, which included personal transport and estimated emissions produced by phone calls was 5.37 kgCO2e, an average of 0.005 kg per consultation. This was an overall reduction of 1159.92 kgCO2e (99.37%; $p = 0.0001$, table 2).

There was no significant difference in the kg CO2e between the non-tertiary and tertiary sites in this study although kg CO2e was found to be greater in patients attending non-tertiary hospitals compared to tertiary centres (table 2). The distribution of the mode of transport used was significantly different with patients attending non-tertiary hospitals more likely to travel by car/taxi than those attending a tertiary centre [286/412, (69.4%) vs. 116/344, (33.7%); $p = 0.0001$] (figures 2a-c). 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 to 15 in group 2 (2/1082, 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 to group 1 appointments (table 2). Blood tests were requested in 342 of 1082 (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 hospitals (p = 0.13) or tertiary centres (p = 0.08) behaved from group 1 to group 2.

90 day admission and mortality rates

There were 79 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 admissions and 21 admissions related to the underlying gastroenterology diagnosis. These differences were not significant (p-value for any cause admission = 0.39; 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).

Table 2: CO_2 emissions data and patient outcomes

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 and deaths within 90 days, the number of admissions related to underlying gastroenterological condition and the number of blood tests requested.

	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 CO2 emission (kg)	Reduction in CO2 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**	**0.3927**	**28**	**21**	**0.4890**	**20**	**16**	**0.6893**	**342**	**225**	**0.0256**

Discussion

The health sector worldwide incurs a significant environmental impact, more than shipping and aviation combined[10,11]. This carbon footprint has a negative impact on public health directly by increasing air pollutants and indirectly by negatively affecting climate change. The NHS committed to a 'Net Zero' Carbon footprint in 2020[12], highlighting changes required to 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[13]. 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 centres and non-tertiary hospitals. 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 DNA rates were beyond the scope of this study, it is clear that there are more steps required to ensure the 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 could have played a role in the difference in rates seen, a difference that may not remain if virtual clinics become commonplace.

We showed an estimated reduction of 1159.92 kg of carbon dioxide (CO_2) emissions, at an average reduction of 5.35kg CO2 per appointment when the majority of appointments were virtual. This is likely to be an under-estimate as we assumed patients only used the shortest route, returning directly home after each appointment. This total reduction in CO2is the equivalent of the emissions generated by a 13-hour flight, or the average use of a car in the UK for over six months[14]. There was a larger emission saving in non-tertiary hospitals relative to tertiary centres overall which remained true when correcting for emissions per appointment. Neither value was significant but nonetheless may be related to the greater transportation infrastructure commonly available in the areas surrounding tertiary centres. This claim is strengthened by the fact a greater proportion of patients in our study attended non-tertiary hospitals by car/taxi than by public transport.

Our study did not allow for the CO2e 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 returned at a later date. We also did not confirm what proportions of group 2 patients attended for blood tests nor calculated emissions caused by 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 for these tests, this would still not have been sufficient to offset the reduction in emissions due to the initial appointments having been remote.

While the reason for physicians requesting fewer blood tests from virtual clinic was not explored in this study, this did not appear to increase adverse outcomes in terms of the parameters measured (90-day any cause admissions, $p = 0.39$; 90-day gastroenterology-related admission, $p = 0.49$; 90-day mortality, $p = 0.69$).It should be pointed out however, that our data did not allow for the capture of patients that may have been admitted to alternative hospitals. This may have particularly been the case for patients attending appointments at tertiary centres that were not their local hospital.

The decision to continue virtual clinics moving out of the pandemic restrictions is a nuanced decision despite the clear benefit to the environment 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[15]. This suggests that there is 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 video-conferencing is only 36%[16] however our study showed that telephone consultations are feasible and may not negatively impact patient outcomes.

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, whilst 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 whilst developing modern, safe and effective healthcare.

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