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Modelling the carbon footprint of reflux control

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ABSTRACT

Background: The NHS is responsible for approximately 30% of all public sector carbon emissions. The Climate Change Act 2008 introduced legally binding targets to cut emissions of greenhouse gases (GHGs) by at least 80% of the 1990 baseline by 2050. This paper seeks to examine two different strategies for the treatment of gastro-oesophageal reflux disease and their modelled costs and carbon emissions.
Methods: This study uses data from the costs of care of patients in the REFLUX study and NHS England Carbon Emissions Carbon Footprinting Report to model the carbon emissions associated with medical and surgical treatment of gastro-oesophageal reflux disease. The main outcome measures are modelled financial costs and carbon emissions for medical and surgical treatment pathways.
Results: There is a high initial cost (financially and carbon emissions) for surgery, however subsequent year-on-year financial spend and carbon emissions are lower in patients who have had surgical treatment such that the total modelled financial cost of surgery is lower in the 14th year and carbon emissions are lower in the 9th year. The model is sensitive to changes in the efficiency of pharmaceutical procurement and surgical failure rate.
Conclusions: The model has demonstrated that in cases of equivalent clinical benefit one pathway may be preferred on the basis of other factors including carbon emissions.

1. Summary

Previous studies have demonstrated a high-rate of subsequent failure of reflux control and this combined with the cost of anti-reflux surgery have resulted in medical therapy dominating surgical reflux control on a cost-basis. Two recent multicentre studies (the UK REFLUX trial[1] and European LOTUS trial[2]) of anti-reflux surgery versus medical therapy have demonstrated similar or superior efficacy of laparoscopic fundoplication to medical treatment in the short term (up to 3 years).

The improved outcome of the surgical arms of the recent trials and UK National Health Service commitment to reduce its carbon emissions[3] bring to light the question: if clinical outcomes are comparable then will the carbon footprint of different treatment pathways influence patients', clinicians' and institutions' choices in deciding which treatment pathway to choose.

A Health Technology Assessment paper has looked at the comparative costs of the patients randomised to medical and surgical therapy[4] and this data can be extrapolated to examine the carbon footprint of the surgical and medical treatment arms.

2. Introduction

This paper examines the difference in carbon footprint between the surgical and medical treatment of gastro-oesophageal reflux. The analysis is undertaken using a top-down model of carbon emissions using data activity from the REFLUX trial HTA paper[4] and from the NHS Carbon Emissions Modelling[5] (which combines data from the Office of National Statistics (procurement data), National Travel Survey (travel data) and Multi-Regional Input-Output data (buildings use data).

3. Methods

The estimated carbon footprint is compared between two groups: 1 those who underwent antireflux surgery ($n = 154$) and 2 those who had medical control of reflux ($n = 164$). The method used for accounting for the carbon cost of each individual component of care and CO_2 emission per unit is given in Table 1.

Visits to and from the family practitioner were similar between the surgical and medical groups (46 and 45%) and data on the carbon emissions from primary care are sparse. Subsequently, these have been excluded from the model.

The model has assumed that only patients who are considered for surgery will undergo pre-operative evaluation with endoscopy, pHometry and manometry and in

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Table 1
Method for carbon accounting.

Component of Care	Financial Unit Cost (£)	Method of Carbon Accounting	Carbon Unit Emissions ($KgCO_2$ per unit)
Endoscopy	172	NHS Carbon Emissions Modelling overall carbon intensity	91.16
pH tests	84	NHS Carbon Emissions Modelling overall carbon intensity	44.52
Manometry	61	NHS Carbon Emissions Modelling overall carbon intensity	32.33
Operation time	4	NHS Carbon Emissions Modelling overall carbon intensity	2.12
Consumables	825	NHS Carbon Emissions Modelling medical instruments carbon intensity	379.5
Inpatient care/day	213	NHS Carbon Emissions Modelling overall carbon intensity	112.89
ICU	1470	NHS Carbon Emissions Modelling overall carbon intensity	779.1
HDU	628	NHS Carbon Emissions Modelling overall carbon intensity	332.84
Visit to GP	24	Excluded	
Visit from GP	69	Excluded	
Outpatient appointment	142	NHS Carbon Emissions Modelling overall carbon intensity	75.26
Day case	460	NHS Carbon Emissions Modelling overall carbon intensity	243.8
Inpatient care	1378	NHS Carbon Emissions Modelling overall carbon intensity	730.34
Non-randomised surgery	2596	NHS Carbon Emissions Modelling overall carbon intensity	1375.88
Medication costs	1	NHS Carbon Emissions Modelling pharmaceuticals carbon intensity	0.56

the model, these tests account for less than 10% of the estimated total carbon emissions in the surgical arm. The model has assumed that the medication usage will remain constant for patients in both arms following the decision to embark on medical or surgical therapy, with no changes subsequently (patients in the medical arm requiring a mean of £179 per annum to be spent on medication and in the surgical arm £55 per annum, which includes those requiring additional medication for control of reflux). The model assumes that 1 in 20 medical patients will cross-over to the surgical arm (at a higher cost than those initially treated with surgery as per the HTA paper's costings, but accounting for less than the cost of one year of medication for the whole medical cohort). There were small costs factored in to cover patients requiring further procedures or admissions within the first year, but these were not continued for subsequent years. Subsequently, after the first year, ongoing treatment costs were modelled as continued medication use in both groups only.

The outcome is the financial cost and estimated carbon emission for each group over time.

4. Results

The initial cost modelling demonstrated that the overall cost of surgery (excluding medications and GP visits) was £2039 and for medical treatment was £309 (which includes the cost of 5% of patients subsequently undergoing antireflux surgery). The breakdown of these costs is presented in Table 2. The ongoing costs modelled are those of continued medication use. This estimates that the mean cost of medication use was £179 per annum in the medical arm and £55 per annum in the surgical arm. This equates to ongoing emissions of 100 Kg CO_2 per annum in the medical arm and 30 Kg CO_2 per annum in the surgical arm. If the assumptions hold then this will result in antireflux surgery being cost-efficient in the 14th year post-operatively and carbon-efficient in the 9th post-operative year (Fig. 1).

5. Discussion

The treatment of gastro-oesophageal reflux has been revolutionized by technological advances in pharmacological and surgical technologies. The proton pump inhibitors provide excellent suppression of stomach secretions with reductions in the volume and acidity the refluxate. In England there were 36 million community prescriptions for proton pump inhibitors in 2009, at a cost of £187 million (representing 4.1% of NHS drug prescriptions and 2.2% of drug spend).[6] These figures do not cover patients who self-medicated or those taking other classes of drugs to suppress gastric acidity and reflux, however some patients (less than one third) will take these medications for indications other than reflux.[7] Ten percent of the population in western countries may experience daily reflux symptoms and larger numbers experience symptoms less frequently.[8]

Hospital Episode Statistics Data indicate that 3896 primary antireflux operations were undertaken in England in the year 2008–2009 (and 310 revision operations).[9] The average age of

Table 2
Financial and carbon costs of treatment arms.

Component of Care	Medical Use (units)	Medical financial spend (£)	Medical CO_2 emissions (kg Co_2)	Surgical Use (units)	Surgical financial spend (£)	Surgical CO_2 emissions (Kg CO_2)
Endoscopy	0	0	0	0.59	101.48	53.7844
pH tests	0	0	0	0.47	39.48	20.9244
Manometry	0	0	0	0.45	27.45	14.5485
Operation time	0	0	0	77.34	309.36	163.9608
Consumables	0	0	0	1	825	379.5
Inpatient care/day	0	0	0	1.91	406.83	215.6199
ICU	0	0	0	0	0	0
HDU	0	0	0	0.03	18.84	9.9852
Visit to GP	1.21	29.04	0	1.18	28.32	0
Visit from GP	0.01	0.69	0	0.01	0.69	0
Outpatient appointment	0.3	42.6	22.578	0.46	65.32	34.6196
Day case	0.17	78.2	41.446	0.38	174.8	92.644
Inpatient care	0.02	27.56	14.6068	0.03	41.34	21.9102
Non-randomised surgery	0.05	129.8	68.794	0	0	0
Medication costs	179	179	100.24	55	55	30.8

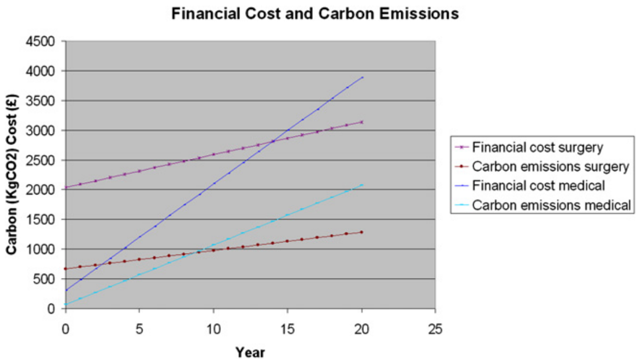

Fig. 1. Financial cost and carbon emissions over time.

patients at surgery was 46 years (when females have a life expectancy of 42.5 further years and males have 39.1 years).[10] Laparoscopic surgery provides a robust control of reflux with minimal operative morbidity, but some post-treatment symptoms are common such as bloating and diarrhoea.[8] The most recent multicentre studies of laparoscopic antireflux surgery compared to medical treatment have demonstrated similar efficacy of the different strategies.[2,4] Under these circumstances, other factors come in to decision making, which may include the carbon footprint of different strategies.

There are several flaws in the approach to this study.

The data used were taken from a large multicentre cohort from the UK. As such, the assumptions made in linking the financial cost to NHS carbon emissions are applicable, however these data from the REFLUX study[4] were not intended for this purpose and a significant assumption is that the first year data may be extrapolated into the future with regard to medication usage or failure/complications of the surgery. The pharmaceutical and instrument manufacturers may be able to improve the efficiency of their manufacturing processes and supply chain (and the overall carbon intensity ($KgCO_2$/£ spent) has been steadily falling since 1992[5]), which will have a significant impact on the carbon emissions as will small variation in the number of patients in the surgical arm who continue to take antireflux medication. The model does not take into account differences in carbon intensity for different origins of manufacture (for example procurement from European OECD countries have one sixth the carbon intensity of non-European countries).

The model has assumed that patients in the medical treatment arm did not undergo endoscopic and physiological assessment, which is likely to underestimate the use of upper alimentary endoscopy. Similarly, not all surgical patients had a full set of investigations prior to antireflux surgery, which would not be representative of all surgeons' practice.

The continued treatment modelling is also weakened by the absence of factoring in costs of further follow-up (either at the hospital or in primary care), the need to attend for ongoing prescriptions and the cost of travel to these appointments and to collect the medications.

The approach taken is top-down approach predominantly, where carbon costs are derived from financial costs and therefore the results for carbon and cost are similar. A more robust methodology would be to undertake a bottom-up approach where travel, pharmaceutical and instrument spend could be evaluated more accurately, rather than using the overall NHS figure for carbon intensity to model the majority of the costs of the surgical arm.

The ideal approach would be to know the carbon footprint of each individual medical instrument, medication, suture etc used, however these data are not yet known for the majority of items and so even this approach would need to use estimates of the carbon footprint of each item based upon DEFRA figures for carbon intensity.[5]

Despite the many methodological flaws, this paper does raise questions in the need to start to examine the carbon cost of treatment with the need for early prompt action to mitigate climate change[11] and government's Carbon Reduction Strategy commitments.

Further work should start to develop standardised methodologies, which will allow accurate comparison of care pathways to each other and over time.

For control of reflux, if the failure rate remains low and life expectancy remains around 40 years, antireflux surgery offers options for reduction in carbon footprint and costs over current best medical therapy.

Conflict of interest

None declared.

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Ethical approval

None.

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