The carbon footprint of behavioural support services for smoking cessation

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ABSTRACT
Objective To estimate the carbon footprint of behavioural support services for smoking cessation: text message support, telephone counselling, group counselling and individual counselling.
Design Carbon footprint analysis.
Data source Publicly available data on National Health Service Stop Smoking Services and per unit carbon emissions; published effectiveness data from the txt2stop trial and systematic reviews of smoking cessation services.
Main outcome measures Carbon dioxide equivalents (CO2e) per 1000 smokers, per lifetime quitter, and per quality-adjusted life year gained, and cost-effectiveness, including social cost of carbon, of smoking cessation services.

Results Emissions per 1000 participants were 8143 kg CO2e for text message support, 8819 kg CO2e for telephone counselling, 16 114 kg CO2e for group counselling and 16 372 kg CO2e for individual counselling. Emissions per intervention lifetime quitter were 636 (95% CI 560 to 2873) kg CO2e for text message support, 1051 (95% CI 560 to 2873) kg CO2e for telephone counselling, 1143 (95% CI 695 to 2270) kg CO2e for group counselling and 2823 (95% CI 1688 to 6549) kg CO2e for individual counselling. Text message, telephone and group counselling remained cost-effective when cost-effectiveness analysis was revised to include the environmental and economic cost of damage from carbon emissions.

Conclusions All smoking cessation services had low emissions compared to the health gains produced. Text message support had the lowest emissions of the services evaluated. Smoking cessation services have small carbon footprints and were cost-effective after accounting for the societal costs of greenhouse gas emissions.

INTRODUCTION
Health systems are significant sources of greenhouse gas emissions in developed countries. Patient and staff travel, building energy consumption, and other healthcare components produce emissions that contribute to climate change. The National Health Service (NHS) in England emits around 20 billion kilograms of carbon dioxide equivalents (CO2e) annually, accounting for around 25% of public sector carbon emissions and 3% of total emissions in the UK.

Reducing carbon emissions from healthcare is an important part of reducing overall emissions and mitigating climate change. In 2009, the NHS became one of the first health systems to pledge to reduce its carbon footprint, following the UK government’s introduction of legally binding emissions targets. To meet the goal of at least 10% reduction by 2015, the NHS Sustainable Development Unit has called for prioritisation of health services that are clinically effective and produce low carbon emissions.

However, identifying services that are clinically effective and produce low carbon emissions has been difficult. The NHS reports that around 50 kg carbon is emitted per appointment, but has not compared emissions of different health services. This is largely due to lack of appropriate measures: existing measures for carbon emissions do not account for clinical effectiveness and cost-effectiveness of services.

In this paper, we estimate the carbon footprint of different smoking cessation services: text message support, telephone counselling, group counselling and individual counselling. To identify effective services with low-carbon emissions, we combine existing data on clinical and cost-effectiveness with the carbon footprint estimates for each service. We develop and use new measures to compare the carbon-effectiveness—carbon emissions per health gain produced—and cost-effectiveness, including the cost of carbon, of smoking cessation services.

METHODS
We used national guidelines from the UK Department of Health and National Centre for Health and Clinical Excellence (NICE) to describe telephone, group and individual counselling. As limited data are available on text message support in practice, we used the protocol from the txt2stop trial.

Carbon emissions
Text message support, telephone, group and individual counselling involve different amounts of patient and staff travel, clinic and office space, and technology (eg, telephones, computers, text messages). For each method of cessation support, we estimated the necessary staff numbers and space of a typical service (see online supplementary appendix 1). Staff numbers and space requirements were used to calculate carbon emissions from staff commuting, computers and building emissions.

Travel, building space and technology produce typical amounts of carbon emissions per unit, such as emissions per kilometre travelled. We multiplied each component of smoking cessation services by their standard carbon emissions per unit. The UK government defines standard carbon...
emissions through estimation of greenhouse gases involved in producing, using and recycling a product: for example, carbon emissions for driving include petrol and materials used in car manufacture.\textsuperscript{14}

To obtain the total carbon footprint of a service, we summed emissions from patient and staff travel, clinic and office space, and technology usage. All carbon emissions are expressed in kilograms of CO$_2$e, which approximate the contribution of different greenhouse gases to global warming. All prices are from 2010.

**Travel**
The NHS estimates that patient and staff travel generates 0.25 kg CO$_2$e per kilometre.\textsuperscript{9} This accounts for differences in carbon emissions by mode of transport and distance.\textsuperscript{9}

**Patient travel**
A carbon emissions audit by the National Institute for Health Research (NIHR) estimated the average distance travelled to primary care settings to be 4.8 km roundtrip.\textsuperscript{15}

**Staff travel**
According to the 2010 UK National Travel Survey, the average commuting distance is 14.5 km each way.\textsuperscript{15} NHS staff commute to work around 220 days a year.\textsuperscript{15,16}

**Building emissions and energy consumption**
For different smoking cessation behavioural support services, we used the number of employees and per person clinic and office space to estimate building emissions and energy consumption.\textsuperscript{17} We assumed that smoking cessation services were delivered full-time, so space was reserved for smoking cessation within multipurpose clinics.

**Staff numbers**
Based on Department of Health recommendations, we assume two staff members share an office of 12 m$^2$.\textsuperscript{18}

**Primary care setting**
The Department of Health recommends rooms of 16 m$^2$ for group counselling and 8 m$^2$ for individual counselling.\textsuperscript{18} An audit by the NHS NIHR estimated emissions of 65.79 kg CO$_2$e per m$^2$ of primary care clinic space per year.\textsuperscript{13}

**Air-conditioned office**
Based on the NIHR audit, we estimated emissions of 154.30 kg CO$_2$e per m$^2$ for air-conditioned office space. Telephone counselling and administrative staff are predominantly based in air-conditioned offices.\textsuperscript{13}

**Telephone usage**
**Telephone call**
Data from the telephone industry estimates emissions of 0.0075 kg CO$_2$e/min of telephone calling.\textsuperscript{19,20} This includes emissions from phone manufacture, network operation and communication infrastructure.

**Text message**
Based on available industry data, we estimated emissions of 4.17×10$^{-6}$ kg CO$_2$e per text message.\textsuperscript{21}

**Information technologies**

**Manufacture and delivery**
The UK Department of Environment, Food and Rural Affairs estimates emissions of 0.58 kg CO$_2$e per pound (£) spent on computers and office machinery.\textsuperscript{22} Information technologies (IT) spending data was not available for NHS Stop Smoking Services, so we estimated one computer per counsellor or administrative staff. We assumed that computers are used exclusively for smoking cessation services, replaced every 5 years, and cost £500 on average. For text message support, we calculated carbon emissions from txt2stop trial expenditures of £700/year. For telephone counselling, we estimated £100/year spent on needed equipment.

**Usage**
Carbon emissions from IT usage are included in energy consumption at service sites.

**Carbon-effectiveness**
We compared carbon emissions in terms of two measures of smoking-related health gain: intervention lifetime quitters and quality-adjusted life years (QALY). We used pooled relative risks of biochemically verified smoking abstinence from the most recent trials of text message support and Cochrane systematic reviews of telephone, group and individual counselling to calculate lifetime quitters per 1000 participants.\textsuperscript{12,23–25} We assumed a 2% background quit rate, a 21% relapse rate between 6 months and 12 months, and a 50% lifetime relapse rate.\textsuperscript{26–28}

We calculated carbon emissions per QALY using an estimate from the cost-effectiveness analysis of txt2stop. This model estimated 2.27 QALYs gained per lifetime quitter, predominantly due to a reduction in smoking-related diseases.\textsuperscript{29} It used a lifetime horizon to calculate QALYs, a 3.5% discount rate and a comparator of current practice as per NICE guidance.\textsuperscript{30,31} Estimates of lifetime quitters and QALYs gained for each counselling method are shown in table 1. Group counselling produced the greatest gain in lifetime quitters and QALYs, followed by text-message support. As CIs for carbon emissions have not been described, we used the Box method to calculate CIs for carbon-effectiveness, focusing on the uncertainty in lifetime quitters and QALYs.\textsuperscript{32}

<table>
<thead>
<tr>
<th>Method</th>
<th>Biochemically verified abstinence at 6 months risk ratio</th>
<th>Lifetime intervention quitters per 1000 participants</th>
<th>QALYs gained per 1000 participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text message support</td>
<td>2.16 (1.77 to 2.62)</td>
<td>12.8 (8.5 to 17.9)</td>
<td>29 (19.3 to 40.6)</td>
</tr>
<tr>
<td>Telephone counselling</td>
<td>1.74 (1.27 to 2.39)</td>
<td>8.2 (3.0 to 15.4)</td>
<td>18.5 (6.8 to 34.8)</td>
</tr>
<tr>
<td>Group counselling</td>
<td>2.01 (1.51 to 2.66)*</td>
<td>14.1 (7.1 to 23.2)</td>
<td>32.0 (16.2 to 52.7)</td>
</tr>
<tr>
<td>Individual counselling</td>
<td>1.52 (1.23 to 1.88)</td>
<td>5.8 (2.5 to 9.7)</td>
<td>13.0 (5.8 to 22.1)</td>
</tr>
</tbody>
</table>

Lifetime quitter per 1000 participants=(Risk ratio of intervention×baseline quit rate)−baseline quit rate)×100% relapse rate at 12 months×100% lifetime relapse rate×1000.

*For group counselling, only a pooled 12 month quit rate was available, so lifetime quitters per 1000 does not include a relapse rate at 12 months.
Cost-effectiveness including carbon emissions

The societal impact of carbon emissions can be integrated into cost-effectiveness analysis by calculating the intervention cost, including the costs of carbon emissions, per QALY. Our comparator was no intervention with zero cost and gain in QALYS. The UK Department of Energy and Climate Change estimates the environmental, economic and social cost of damages from carbon emissions to be £0.028/kg CO2e emitted. Carbon emissions were multiplied by this figure and added to base intervention costs for each smoking cessation service.

We obtained base intervention costs per 1000 participants, excluding the cost of stop smoking medications, from recent UK studies. All prices were adjusted for inflation using the UK hospital and community services inflation index. The estimated costs of running a text message service were £16 120/1000 participants based on data from the txt2stop trial. Based on modelling by NICE, the estimated cost of telephone counselling was £59 000/1000 participants. An analysis of NHS smoking cessation clinics estimated the cost of group counselling and individual counselling to be £75 000/1000 participants.

Sensitivity analysis

As telemedicine is increasingly encouraged, staff commuting patterns may change. To account for this, we conducted a sensitivity analysis excluding staff commuting.

RESULTS

Table 2 shows carbon emissions for each component of smoking cessation services.

Carbon emissions

Overall, emissions per 1000 participants were 8143 kg CO2e for text message support, 8619 kg CO2e for telephone counselling, 16 114 kg CO2e for group counselling and 16 572 kg CO2e for individual counselling.

Patient travel was the largest source of emissions for group counselling (60%) and individual counselling (44%). Staff commuting accounted for the largest source of carbon emissions for text message support (59%) and telephone counselling (56%) and the second largest source for group (30%) and individual counselling (59%). Building emissions were the third largest source of emission for all services. Owing to different intervention activities, telephone usage and IT accounted for 7% of emissions for text message support, 12% for telephone counselling, 2% for group counselling and 2% for individual counselling.

Carbon-effectiveness

Carbon emissions per intervention lifetime quitter were 656 (95% CI 455 to 958) kg CO2e for text message support, 1051 (95% CI 560 to 2873) kg CO2e for telephone counselling, 1145 (95% CI 695 to 2270) kg CO2e for group counselling and 2823 (95% CI 1688 to 6549) kg CO2e for individual counselling.

Carbon emissions per QALY gained were 282 (95% CI 201 to 422) kg CO2e for text-message support, 466 (95% CI 248 to 1268) kg CO2e for telephone counselling, 504 (95% CI 306 to 995) kg CO2e for group counselling, and 1259 (95% CI 741 to 2823) kg CO2e for individual counselling.

Cost-effectiveness

Figure 1 shows the cost per QALY for text message, telephone and group counselling support after including the cost of damages from carbon emissions. The cost of damages from carbon emissions per QALY was £7.9 for text message support, £13.0 for telephone support, £14.1 for group counselling and £35.3 for individual counselling. The total cost per QALY was £564 (95% CI 403 to 847) for text message support, £3202 (95% CI 1702 to 8712) for telephone support, £2295 (95% CI 1394 to 4534) for group counselling and £5651 (95% CI 3324 to 12 665) for individual counselling.

Sensitivity analysis

As shown in table 2, excluding emissions generated by staff, commuting decreased the carbon footprint for all smoking cessation services. Emissions decreased to a greater extent for telephone and text message support as proportionally more of their emissions are due to staff travel.

DISCUSSION

All smoking cessation services had small carbon footprints and remained highly cost-effective after accounting for the societal impact of carbon emissions. Text message support had the smallest carbon footprint per quitter and per QALY.

Strengths and weaknesses

To our knowledge, this is the first study to estimate the carbon footprint of smoking cessation behavioural support services and develop an integrated measure of carbon emissions and clinical effectiveness. Carbon emissions are a social cost of health services provision, and our findings indicate that they can be incorporated into cost-effectiveness analysis.

In comparing smoking cessation methods, variability in population and use of medications may influence the relative risks of quitting. The systematic reviews of counselling effectiveness included trials with a range of control groups from self-help to brief interventions, while the txt2stop trial encouraged controls to use existing NHS smoking cessation support services. In all included trials, medication (bupropion or nicotine replacement therapy) was offered to the treatment and control groups or to neither; the majority reported similar usage of stop-smoking medications across groups. In practice, many people receiving inperson counselling may be prescribed concurrent stop-smoking medication, increasing the likelihood of quitting and the carbon emissions of smoking cessation interventions.

Our estimate of carbon emissions from patient travel for group counselling may underestimate travel as group counselling services are usually provided for a wider geographical area than local clinics. Administrative staff and enrolment time may be underestimated because we did not include reception staffing or call-holding. The NHS and telephone industry are working to increase energy efficiency, so we may overestimate building and telephone emissions.

We excluded recruitment costs (initial general practitioner visits), water usage and clinical waste from our analysis, although they are likely to generate a large amount of emissions. We did not calculate the carbon cost of stop smoking medications, which should be subject to a separate analysis. Pharmaceuticals account for a fifth of NHS England’s overall carbon footprint. In smoking cessation, carbon emissions from stop-smoking medications and the additional medical monitoring necessary may be partially offset by increased likelihood of quitting among those using medication. Our CIs for carbon-effectiveness may be imprecise. We could not account for uncertainty in carbon emissions because carbon emission data are available as point estimates without CIs.
<table>
<thead>
<tr>
<th>Units</th>
<th>Per unit carbon emissions (kg CO₂ equivalents)</th>
<th>Text message support</th>
<th>Telephone counselling</th>
<th>Group counselling</th>
<th>Individual counselling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Units used</td>
<td>Carbon emissions</td>
<td>Units used</td>
<td>Carbon emissions</td>
<td>Units used</td>
</tr>
<tr>
<td>Enrolment</td>
<td>Telephone enrolment</td>
<td>Minutes</td>
<td>0.0075</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Text message</td>
<td>Message</td>
<td>$4.17 \times 10^{-6}$</td>
<td>1</td>
<td>0.00417</td>
</tr>
<tr>
<td>Counselling</td>
<td>Text message</td>
<td>Messages</td>
<td>$4.17 \times 10^{-6}$</td>
<td>260</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Telephone</td>
<td>Minutes</td>
<td>0.0075</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Patient travel</td>
<td>Kilometres</td>
<td>$0.25 \text{ kg/km} \times 4.8 \text{ km/roundtrip}$</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Staff (administrative, IT and smoking cessation counsellors)</td>
<td>Daily commute</td>
<td>Kilometres</td>
<td>$0.25 \text{ kg/km} \times 14.5 \text{ km/trip} \times 2$ trips</td>
<td>3</td>
<td>4785</td>
</tr>
<tr>
<td>Office and counselling space</td>
<td>Clinic space</td>
<td>m²</td>
<td>65.79</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Office space</td>
<td>m²</td>
<td>154.30</td>
<td>18</td>
<td>2777</td>
<td>18</td>
</tr>
<tr>
<td>IT equipment</td>
<td>Text and telephone equipment</td>
<td>Pounds (£)</td>
<td>0.58</td>
<td>700</td>
<td>406</td>
</tr>
<tr>
<td>Computers</td>
<td>Pounds (£)</td>
<td>0.58</td>
<td>3 staff $\times 100$</td>
<td>174</td>
<td>3 $\times 100$</td>
</tr>
<tr>
<td>Total CO₂e</td>
<td></td>
<td></td>
<td></td>
<td>8143</td>
<td>8619</td>
</tr>
<tr>
<td>Sensitivity analysis</td>
<td></td>
<td></td>
<td></td>
<td>3358</td>
<td>3834</td>
</tr>
</tbody>
</table>

CO₂e, carbon dioxide equivalents; IT, information technologies.
Our analysis focused on the health system-dependent carbon emissions of interventions. We did not take into account potential long-term savings in emissions, due to decreased tobacco consumption and reduced need for treatment of smoking-related diseases.\(^{39, 37}\) Manufacture and distribution of tobacco products produces an estimated 0.93 kg CO\(_2\)e per pound spent.\(^{42}\) On average, British smokers spend £1500 on tobacco per year.\(^{38, 39}\) Carbon emissions from the manufacture and distribution of this tobacco are estimated to 1400 kg CO\(_2\)e per smoker per year or 1.4 million kg CO\(_2\)e per 1000 smokers. This estimate does not include carbon emissions from smoking the tobacco, which have not been published and likely increase carbon emissions from smoking. Per year, the carbon emissions of producing the tobacco used by the average smoker are greater than the carbon emissions of enrolling 1000 smokers in text message, telephone or group counselling.

We also did not take into account potential increases in carbon emissions from increased life expectancy or substituted products, although all emissions are important to climate change. The NHS aims to provide services which save lives, treat and prevent disease, while minimising the environmental impact of those services. Since average carbon emissions per capita in the UK are over 8000 kg/year, any healthcare intervention that prolongs life will increase societal carbon costs.\(^{40}\) Yet it would be counter to the goals of the NHS or other health services to contemplate reducing societal carbon emissions by reducing access to life-saving interventions.

### Comparison with other studies

There have been few studies comparing the carbon footprints of different methods of delivering healthcare. Three previous studies of NHS secondary care reported higher per patient carbon footprints as might be expected from drug-intensive and surgical procedures. These studies of renal dialysis and reflux control reported high proportions of emissions from patient and staff travel, which is consistent with our findings.\(^{41–43}\) For smoking cessation services, carbon emissions per participant, 8.1–16.3 kg CO\(_2\)e, are significantly lower than the NHS outpatient average of 50 kg CO\(_2\)e per appointment.\(^{45}\)

### Implications for research and practice

Based on our findings, the NHS and other health systems should consider including text message support in the mix of smoking cessation services. For group and individual counselling, careful consideration of the number and location of sessions could reduce carbon emissions from travel. The measures developed—carbon-effectiveness and cost-effectiveness including the societal costs of carbon emissions—could be used to prioritise health services that are clinically effective and have small carbon footprints.\(^{6}\) Text message, telephone and group counselling interventions remain highly cost-effective after accounting for the societal cost of carbon emissions (in a UK context the cut-off for cost-effectiveness of services is around £20 000/QALY).\(^{31}\)

Further research could analyse the carbon-effectiveness of stop-smoking medications and other primary care services. The long-term social cost of carbon is debated, so we urge further research on the societal impact of carbon emissions.\(^{33}\)

### Meaning of study

Smoking cessation behavioural support services have small carbon footprints, are carbon-effective and cost-effective. Text message, telephone, group and individual counselling remained highly cost-effective after accounting for the environmental cost of carbon emissions. Measures of carbon-effectiveness could help health systems meet targets for reducing carbon emissions while maximising patient benefit.
REFERENCES


Appendix 1. Assumptions about Service Delivery
The standard NHS workweek is 37.5 hours, and staff work around 45 weeks a year. (1) Services may vary by region and PCT. Around sixty percent of smoking cessation counsellors’ work time, 22 hours/week, is spent counselling clients. (2)

Since participants cycle in and out of counselling, we calculate the average number of clients per year. This assumes no re-enrolment of individuals; hence it may be an underestimate of counselling staff. Our estimates match the ratio of counsellors to participants in the one area with publicly available data. (3)

## Appendix Table 1. Components of Smoking Cessation Interventions

<table>
<thead>
<tr>
<th>Service Type</th>
<th>Enrolment and booking time:</th>
<th>Interventions:</th>
<th>Staff per 1000 participants:</th>
<th>Clients per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Text message support</strong></td>
<td>30 minute phone call.</td>
<td>Up to 260 message delivered by an automated computer system over 33 weeks. Messages were designed by smoking cessation counsellors and behavioural therapists. 30 minutes of data monitoring per participant.</td>
<td>2 smoking cessation counsellors</td>
<td>Unlimited</td>
</tr>
<tr>
<td><strong>Telephone counselling</strong></td>
<td>30 minute phone call.</td>
<td>Over-the-phone sessions delivered by a smoking cessation counsellor based in a PCT central office. A minimum of 10 counselling sessions of 10 minutes or more over a 12 week period (pre and post-quit date) is recommended.</td>
<td>2 full-time or part-time smoking cessation counsellors, 1 administrative staff for enrolment and data monitoring</td>
<td>594</td>
</tr>
<tr>
<td><strong>Group counselling</strong></td>
<td>30 minute phone call or GP referral.</td>
<td>Group therapy sessions of around 15 people (minimum of 8) are held predominantly in primary care settings (GP practices and pharmacies) and delivered by 2 smoking cessation counsellors. Sessions are 1 hour long, and clients attend an average of 8 sessions over 6 to 7 weeks.</td>
<td>2 full-time smoking cessation counsellors, 1 administrative staff for enrolment and data monitoring</td>
<td>1898</td>
</tr>
<tr>
<td><strong>Individual counselling</strong></td>
<td>30 minute phone call or GP referral.</td>
<td>Individual behavioural counselling sessions are held primarily in primary care settings and delivered by a smoking cessation counsellor. Clients attend an average of 6 sessions of 30 minutes each from pre-quit date to 4 weeks post-quit date.</td>
<td>3 smoking cessation counsellors, 1 administrative staff for enrolment and data monitoring</td>
<td>337.5</td>
</tr>
</tbody>
</table>

### Formulas

\[ \text{Clients per year} = (\text{Sessions per week} \times \text{Clients per session}) \times 45 / \text{(Weeks of treatment per participant)} \]

\[ \text{Counsellors per 1000 participants} = 1000 / \text{(Clients per year)} \]

### References

12; 15; 31; 36; McEwan A. Personal Communication. 2011.
Reference list:

