An estimated carbon footprint of NHS primary dental care within England. How can dentistry be more environmentally sustainable?

B. Duane,*[1] M. Berners Lee,[2] S. White,[3] R. Stancliffe[4] and I. Steinbach[5]

In brief

Encourages readers to consider sustainability as part of their overall dental practice.

Helps readers understand their obligations to consider sustainability along with their other societal obligations.

Provides readers with a summary and description of carbon emissions originating from dentistry, with discussion on how these could be reduced.

Introduction National Health Service (NHS) England dental teams need to consider from a professional perspective how they can, along with their NHS colleagues, play their part in reducing their carbon emissions and improve the sustainability of the care they deliver. In order to help understand carbon emissions from dental services, Public Health England (PHE) commissioned a calculation and analysis of the carbon footprint of key dental procedures. **Methods** Secondary data analysis from Business Services Authority (BSA), Health and Social Care Information Centre (HSCIC) (now called NHS Digital, Information Services Division [ISD]), National Association of Specialist Dental Accountants (NASDA) and recent Scottish papers was undertaken using a process-based and environmental input-output analysis using industry established conversion factors. **Results** The carbon footprint of the NHS dental service is 675 kilotonnes carbon dioxide equivalents (CO_2e). Examinations contributed the highest proportion to this footprint (27.1%) followed by scale and polish (13.4%) and amalgam/composite restorations (19.3%). From an emissions perspective, nearly 2/3 (64.5%) of emissions related to travel (staff and patient travel), 19% procurement (the products and services dental clinics buy) and 15.3% related to energy use. **Discussion** The results are estimates of carbon emissions based on a number of broad assumptions. More research, education and awareness is needed to help dentistry develop low carbon patient pathways.

Introduction

The English Sustainable Development Unit (SDU) imagines a sustainable health and care system as one that goes on forever within the limits of financial, social and environmental resources. The reality is, however, that the current approach to delivering healthcare cannot continue in the same way and stay within these limits.[1] Dental professionals, like their healthcare peers, need to address the sustainability of services that they provide – from the design of clinical pathways to the organisation and delivery of care. There are three reasons for this. Firstly, resources are finite. Like all health professionals, the dental teams need to understand where and how we use resources, including carbon and money, in order to be able to maintain or improve quality of care, while reducing their use. Secondly, as a result of the Climate Change Act (2008),[2] NHS England is legally required to reduce its greenhouse gas emissions by as much as 80%, from 1990 levels by 2050.[2] Thirdly, the NHS has committed to reducing its environmental impacts in the Sustainable Development Strategy for the Health and Social Care System.[3]

For the purpose of this paper, the term greenhouse gas is used to describe any gas which absorbs and re-emits heat, and thereby keeps the planet's atmosphere warmer than it would otherwise be.[4] Although the main greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide and ozone, carbon footprints generally convert all greenhouse gases into a common unit called carbon dioxide equivalents.[4]

To achieve the scale of carbon reductions required, the UK government and NHS have expanded their efforts from a focus on direct use of natural resources such as water, energy, fuel and waste, to looking at the opportunities to reduce the social and environmental impacts by designing and delivering more efficient, effective patient pathways.

From a dental perspective, there is a paucity of information available on the carbon consequences of treating oral disease. In February 2014, in order to overcome this, Public Health England (Kent Surrey and Sussex) commissioned the Centre for Sustainable Healthcare to calculate and analyse the carbon footprint of key dental procedures carried out by NHS England commissioned dental teams, in order to help identify carbon hotspots within the service. These procedures include both high volume items of care and resource intensive treatments which were considered, at the project onset, to have a particularly high carbon footprint.

[1]Associate Professor, Dublin Dental University Hospital; [2]SW Consulting Ltd; [3]National Lead for Dental Public health, Public Health England; [4]Director, Centre for Sustainable Healthcare; [5]Carbon modelling lead, Centre for Sustainable Healthcare
*Correspondence to: Brett Duane
Email: Brett.Duane@dental.tcd.ie

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It is anticipated that understanding the carbon emissions associated with commonly performed dental procedures will contribute to the development of more sustainable patterns of care.

Methods

The complexity of supply chains ensures that carbon footprints can never be measured with 100% certainty. Foot-printing is an emerging field, and while there are accepted international and national standards for organisational foot printing, there are still gaps in the guidance on more detailed lifecycle assessment and sector specific methodologies.[5] At present, there are no detailed carbon dioxide equivalent emission data for individual dental restorative procedures.

In order to calculate the carbon emissions of primary care dental practices across NHS England, the carbon emissions from staff travel (both commuting and travel for work), patient travel, energy, water, and procurement (materials and services procured to run a dental practice) were aggregated for the period April 2013 to March 2014. Secondary care dental services were not included within this footprint. Within this paper a process-based life cycle analysis was used.[6]

Ideally, practice level information for a representative sample of NHS dental practices in England would have been available on travel, procurement, energy and water use, waste, nitrous oxide use and volume of activity for each dental procedure. However, as this was not the case, estimates were necessary; data was used from the NHS Business Service Authority (BSA),[7] Information Services Division (ISD) Scotland,[8] accounting data originating from NASDA[9] and recent published Scottish papers.[10,11] The data source for each aspect of the carbon footprint can be seen in Table 1.

As is the convention, carbon emissions were excluded from carbon embedded in capital items within a dental practice. Conversion factors used originated from the Department for Agriculture and Rural Affairs (DEFRA)[12,13] and the Small World Consulting Ltd's carbon calculator.[14]

The project followed the reporting principles of the Greenhouse Gas Protocol (GGP) developed by the World Resources Institute (WRI) and the World Business Council on Sustainable Development (WBCSD).[15]

Results

The total greenhouse gas emissions of NHS dental services in England for the period, April 2013 to March 2014, in tonnes of carbon dioxide equivalents (tCO2e) is estimated at 675 kilotonnes. This carbon footprint represents 79.6 procedures (or 39.6 million CoTs). The carbon footprint makes up 3% of the overall carbon footprint of the NHS in England.[16] To put this in perspective this is the equivalent total carbon footprint of around 675,000 people.[17]

The results can be categorised into carbon footprint by individual procedure (for example, the carbon footprint of one examination), or carbon footprint of all specific procedures (for example, the carbon footprint by proportion of all examinations). In addition, the contributing factors to all NHS dentistry should be considered (for example, proportion of the carbon footprint broken down by travel, energy, procurement etc).

The carbon footprint per procedure can be seen in Table 2.

When looking at items of care on an item by item basis, examinations have a small carbon footprint of 5.50kgCO2e, with scale and polishes, radiographs, fluoride varnish and fissure sealants also having low individual carbon footprints. Placement of amalgam and composite restorations are moderate at around 14.75 kgCO2e per procedure. The higher carbon footprints come from more intensive procedures, or procedures that require more than one visit such as crowns, or dentures. Although a patient would never simply receive nitrous oxide and no other procedure, the fictitious example of a patient receiving nitrous oxide by itself would amount to the highest per item carbon footprint of 119kgCO2e.

As well as describing the carbon footprint of each procedure as above, it is important to consider the overall contribution of each procedure to the total dental carbon footprint of each item, proportional to the volume of items delivered within England NHS dentistry (see Table 2). Examinations, for example, have a low carbon footprint when assessed individually, but there is a large number of examinations carried out within the country, therefore examinations simply due to their volume, contributed

Table 1 Data source per carbon footprint

Carbon footprint element	Source	Note
Staff travel (commuting and work travel)	NHS Fife	Staff travel was assumed to be the same as travel for dentistry within NHS Fife (a small urban/rural healthboard in Scotland), so the staff travel data from the NHS Fife study were extrapolated to England.
Patient travel	BSA data (on every individual FP17)[38]	It was assumed that patients travel to the dental surgery from home.
Procurement (administrative, material and laboratory service costs)	NASDA	
Energy	NHS Fife data	
Water	NHS Fife data	
Generic disposable materials which are used for all procedures	Estimate	We estimated resource use for each procedure based on the author's (BD) clinical experience
Electrical equipment, time and energy per procedure		
Bespoke materials specific to a particular procedures, eg, amalgam, nitrous oxide.		We estimated resource use for each procedure based on the author's (BD) clinical experience. For nitrous oxide use, we measured use within Sussex Community NHS Foundation Trust, Community Dental Service for five patient treatments; and use within the Community Dental Service, NHS Fife.

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Table 2 Volume of dental activity, total and individual carbon footprints per procedure

Procedure	No of courses of treatment (Thousands CoTs)	Volume of activity (%)	Total carbon footprint (TCO2e)	Proportion of total carbon footprint of dental services (%)	Carbon footprint per individual procedure (kgCO2e)
Examination	32,985	41.46%	181,433	27.08%	5.50
Scale and polish	13,799	17.34%	90,087	13.5%	6.53
Radiograph(s) taken	7,805	9.81%	42,930	6.41%	5.50
Amalgam fillings	4,443	5.58%	65,560	9.79%	14.76
Composite fillings	4,325	5.44%	63,799	9.52%	14.75
Fluoride varnish	3,482	4.38%	19,151	2.86%	5.50
Extractions	2,765	3.48%	23,744	3.54%	8.58
Glass ionomer fillings	1,170	1.47%	10,041	1.50%	8.58
Dentures – acrylic	988	1.24%	57,489	8.58%	58.16
Study models	871	1.09%	10,545	1.57%	12.11
Crown non-precious metal	625	0.79%	21,995	3.28%	35.17
Endodontic treatment	617	0.78%	14,400	2.15%	23.34
Crown precious metal	150	0.19%	6,581	0.98%	43.81
Fissure sealants	142	0.18%	1,220	0.18%	8.58
Dentures – metal	81	0.10%	5,722	0.85%	70.52
Crown porcelain	6	0.01%	217	0.03%	36.64
Nitrous oxide	64		5,829		119.00
Unselected procedures	5,309	6.67%	54,964	8.21%	

the highest proportion to the overall carbon footprint of dental services in England at 27.1%. Similarly, simply due to the volume of procedures, scale and polish procedures made up 13.5% of the overall footprint, placement of amalgam and composite fillings 9.8% and 9.5% respectively. Extractions, due to the relatively low volume within the NHS contribute 3.5%. Precious metal crowns, metal dentures, fissure sealants and porcelain crowns contribute less than 1% to the carbon dioxide equivalents of dental procedures.

The highest proportion of emissions from dental care is caused by travel (64.5%), followed by procurement (19%), energy (15.3%) and nitrous oxide (see Fig. 1). Waste and water contribute significantly very little with only 1.5 ktCO2e and 0.5 ktCO2e respectively.

Discussion

According to *The Lancet*, climate change is the biggest global health threat of the 21st century.[18] The General Dental Council's *Standards for the Dental Team* recommends that all members of the dental team should act with integrity, take a holistic approach to patient care and work with colleagues in a way that is in a patient's best interests.[19] A dental team's core business is oral health but it could also be argued that like medical colleagues 'the dental profession has a moral duty to act on health threats, to manage long term strategic risk and to mitigate future demand on the health services.'[20]

Carbon foot printing is not an exact science. There are a number of assumptions that need to be made in order to estimate resource usage and the associated carbon dioxide equivalents. Nevertheless, in order for health care providers to understand the sustainability of our services, carbon calculations, even as estimates, are essential. The analysis of the carbon footprint of dental services as a whole, and of individual dental procedures, has helped to identify carbon hotspots within dental services. The linking of carbon data to treatment types could help identify effective, patient-centred treatment with reduced environmental impact. Dental leaders could feed into the data collection and make dental services more sustainable on the ground, by targeting travel, procurement and the management of their dental practices in combination with reviewing service configuration.

With approximately 210 ktCO2e, patient travel makes up the highest proportion (31.1%) of the total carbon emissions of NHS dental services in England. The calculation of patient travel is considerably accurate, as the analysis included BSA data of approximately 26 million people who visited the dentist over a 12-month period, based on their NHS activity (FP17) data.[7] Looking at the nature of NHS primary care dentistry, it is unsurprising that patient travel is responsible for a high proportion of the overall carbon footprint. According to HSCIC,[21] and as dentists would acknowledge, the majority of dental treatments consist of procedures such as examinations, which although high in carbon emissions due to patient and staff travel, actually take little time and have very few material costs.

The estimated carbon footprint to place a composite restoration is similar to the amalgam

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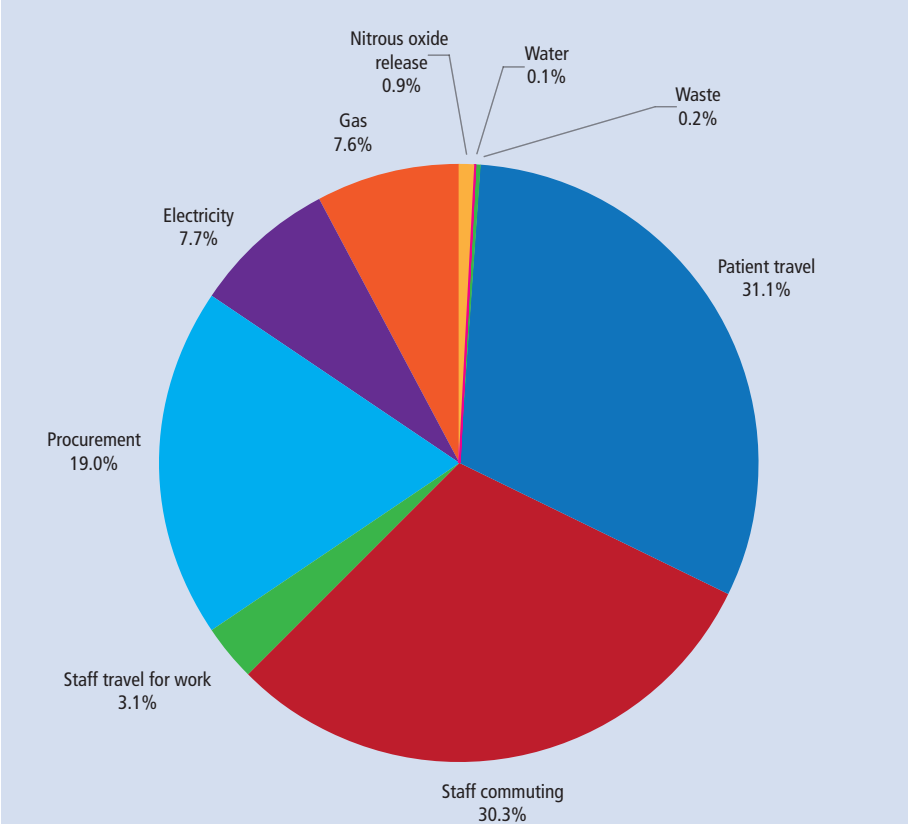
Fig. 1 Total annual carbon footprint of dental services in England – 2013/14



footprint only because most of the calculation is based on time and energy use; there is no information on the difference between the carbon emissions associated with the specific materials of composite versus amalgam fillings. This lack of specific material data means that dental professionals cannot determine with confidence the sustainability of different individual treatments. A long term strand of work is required to encourage each industry to measure the footprint of their products using the Sustainable Development Unit (SDU) published guidance on foot printing pharmaceuticals and medical devices.[22]

The total carbon footprint of dental staff commuting to and from work is 204 ktCO2e. This constitutes a similar (30.3%) percentage of the overall carbon footprint as the patient carbon footprint. The average distance and mode of transport used to commute back and from work by NHS dental staff in England, was based on the travel survey data of the carbon footprinting study of dental services in Fife (2012).[6]The average one-way distance commuted by dentists in Fife is 27 miles. There was no accurate way of determining this in England, without running a separate questionnaire, and the study's resources did not allow for this. However, as the distance travelled by dental patients in Fife is similar to the one travelled by patients in England (7.26 vs 7.57 miles per return journey), it was assumed that the English staff travel would also be similar.

In England there are 8,422 dental practices, and although for pragmatic reasons it was assumed that the mode of transport for dental staff in England would also be the car, in many urban centres commuting behaviour might differ with a proportion of professionals opting to commute on foot or by cycling, taking public transport or car sharing.

There are a number of ways to consider reducing travel. Patients and staff could be encouraged to switch to active travel, public transport or car sharing. While ensuring patient quality and safety, practitioners could consider how they provide care, combining procedures together to reduce the number of patient visits and therefore patient travel. Due to the volume of examinations carried out, policy makers could consider the NICE guidance on examination frequency when considering how to improve sustainability.[23] NHS England needs also to ensure when it commissions services that it considers travel optimisation, to place services in locations that minimise both patient and staff travel. It is argued that some consultations with dentists could perhaps take place without the patient visiting a dental surgery.[24]

Procurement (after patient and staff travel) is the second highest contributor to the total greenhouse gas emissions of NHS dentistry, though, at 19%, the carbon footprint attributed to procurement is low compared to the carbon footprint of procurement for the whole of the NHS in England, which is 58%.[16] To reduce the greenhouse gases associated with procurement, the most obvious choice would be to review expenditure; however there are perhaps less obvious options. As NHS England is responsible for commissioning dental services, it is in a position to request statements from providers on their carbon reduction and sustainability in routine contracts.[25,26] Larger group practices and corporates could consider supporting sustainability by acting in a similar fashion. Sustainability would improve further if dentistry could support the development of clinical software to embed sustainability measurements. Once carbon is included in the reporting alongside money, carbon will become much more familiar and valued as a resource, and specific carbon modelling would be an automatic part of the patient pathway.

In a small internal survey of consultants in dental public health, and clinical dental directors in Scotland several years ago, most dental leaders considered that energy would be the highest contributor to carbon emissions within a dental practice. As shown by the results, this is not the case, with the energy contribution being much smaller than that of travel. To reduce the greenhouse gas emissions produced by energy, water use and waste disposal, dental practices can follow similar processes to those used at home, for example, use efficient energy, insulate, install solar panels, or choose electricity providers who offer electricity produced by renewable sources.

Nitrous oxide released during the sedation of an estimated 63,749 patients, produced 5,829 tCO2e or almost 1% of the total carbon footprint of NHS dental services in England. The actual amount of nitrous oxide used in England is difficult to quantify. For this purpose, therefore, Scottish data was used.

The concern with nitrous oxide is that it is a toxic greenhouse gas with a high global warming potential. One kg of N2O is equivalent to 298 kg CO2. Obviously, reducing the use of nitrous oxide would be beneficial for the environment, but managing patients with nitrous oxide, is often the only alternative to intravenous sedation or general anaesthetic,

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both of which have a higher carbon footprint than nitrous oxide.[27,28] One way of reducing the carbon footprint is to capture and neutralise the gas instead of releasing it into the air. There are several technologies which can be used to extract gases from released air, such as 'scrubbing' which is widely used at an industrial scale, but is implemented also in hospitals.[29]

The waste calculation showed a low proportion from dental waste. The carbon emissions produced by the incineration facility to generate electricity is attributed to the incineration/electricity generation plant. The disposal and treatment of amalgam waste is likely to have more serious environmental consequences than simply its carbon calculation.[30]

Sustainability is not just about carbon reduction, but about delivering high quality care within economic, social and environmental limits. Care that is offered under the NHS, cannot be solely based on their sustainability measures. An extraction, for example, has a considerably lower carbon footprint than a restoration, or a crown, but the authors of this paper would not advocate this choice. Within the field of sustainability, it is expected that an upstream, preventative approach to promote health is a much more sustainable health model. It is suspected that preventive items such as fluoride varnish, and fissure sealants are likely to be very sustainable, as they will reduce future dental care and associated carbon consequences.[31,32]

The pressure that the NHS faces to continue to improve patient care while reducing costs is substantial.[33] Policy makers, however, must consider sustainability as part of this quality improvement process. Fortuitously improving sustainability is usually also a cost effective process. To achieve long-term improvement in the sustainability of dental services, a multi-agency response is required. Engagement with those working in policy, education and research (Health Education, Public Health England, research institutions), those working in delivering, or commissioning patient care (the dental team, NHS England dental commissioners) and the dental industry is critical. It is important to help understand how, alongside all the other challenges dental care providers face, NHS England and its supporting partners can support sustainability.

Unlike carbon emissions from the overall NHS, the proportion of carbon coming from travel, and proportionately from nitrous oxide, is high. Policy makers should consider the implications of this study for dentistry overall, including how to reduce carbon emissions from travel.

Note

There are many opportunities for dentists to become involved in sustainability initiatives, including joining a network[35] or becoming involved in the Green Impact programme.[36] A tool to help the dental team learn more about sustainability was launched earlier last year.[37] Grants are also available for European member states from local European Regional Development Fund projects.

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