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The carbon footprint of a renal service in the United Kingdom

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Summary

Background: Anthropogenic climate change presents a major global health threat. However, the very provision of healthcare itself is associated with a significant environmental impact. Carbon footprinting techniques are increasingly used outside of the healthcare sector to assess greenhouse gas emissions and inform strategies to reduce them.
Aim: This study represents the first assessment of the carbon footprint of an individual specialty service to include both direct and indirect emissions.
Methods: This was a component analysis study. Activity data were collected for building energy use, travel and procurement. Established emissions factors were applied to reconcile this data to carbon dioxide equivalents (CO_2eq) per year.
Results: The Dorset Renal Service has a carbon footprint of 3006 tonnes CO_2eq per annum, of which 381 tonnes CO_2eq (13% of overall emissions) result from building energy use, 462 tonnes CO_2eq from travel (15%) and 2163 tonnes CO_2eq (72%) from procurement. The contributions of the major subsectors within procurement are: pharmaceuticals, 1043 tonnes CO_2eq (35% of overall emissions); medical equipment, 753 tonnes CO_2eq (25%). The emissions associated with healthcare episodes were estimated at 161 kg CO_2eq per bed day for an inpatient admission and 22 kg CO_2eq for an outpatient appointment.
Conclusions: These results suggest that carbon-reduction strategies focusing upon supply chain emissions are likely to yield the greatest benefits. Sustainable waste management and strategies to reduce emissions associated with building energy use and travel will also be important. A transformation in the way that clinical care is delivered is required, such that lower carbon clinical pathways, treatments and technologies are embraced. The estimations of greenhouse gas emissions associated with outpatient appointments and inpatient stays calculated here may facilitate modelling of the emissions of alternative pathways of care.

Introduction

Anthropogenic climate change, driven by greenhouse gas (GHG) emissions resulting from human activity, presents a major global health threat.[1,2] However, the provision of healthcare itself is associated with significant GHG emissions.[3] Strategies to mitigate these emissions are therefore required, and reductions are also anticipated to deliver public health co-benefits and to allow organizations opportunities to exhibit good corporate citizenship.[2,4,5] Meanwhile, the recent introduction of carbon trading via the Carbon Reduction Commitment Energy Efficiency Scheme,[6] the inclusion of sustainability within the Audit Commission's annual performance assessments,[7] and the uptake of carbon efficiency as a local indicator by commissioners and providers,[8] mean that the quest for carbon reduction is not only an increasingly real pressure on NHS organizations but also a timely driver for financial savings.

The NHS Carbon Reduction Strategy sets targets for GHG emissions within the NHS; using 2007 levels as the baseline, the strategy requires an 80% reduction before 2050 and a 34% reduction as early as 2020.[9] These are challenging targets which will only be achieved by fully understanding the GHG emissions associated with the delivery of healthcare. While the GHG emissions associated with NHS England and individual aspects of healthcare services, procedures and trials are discussed in the literature,[3,10–12] this study represents the first assessment of the carbon footprint of an individual specialty to include both direct and indirect emissions. The primary aim of this study was to calculate the carbon footprint of the Dorset Renal Service, thereby providing an evidence base for future decision-making by highlighting the areas of a renal service with the greatest carbon footprint. The secondary aims were to calculate the carbon footprints of both an outpatient appointment and an inpatient bed day, in order to facilitate modelling of alternative pathways of care and to provide a template by which other services might ascertain their own carbon footprints.

Methods

This study calculates GHG emissions for the Dorset Renal Service for the period 1 April 2008 to 31 March 2009. The Dorset Renal Service covers a geographical area of ~1300 square miles and a population of 865 000. The six component services of the Dorset Renal Service are inpatient care, outpatient care, peritoneal dialysis, haemodialysis (in-centre and home), transplantation and administration. These are provided across five geographically separate sites (Dorset County Hospital Dorchester, DCH; Yeovil District Hospital, YDH; Poole General Hospital, PGH; Royal Bournemouth Hospital, RBH; and Southmead Hospital in Bristol, SMH). Inpatient care is provided in a 14 bed ward (DCH). Outpatient care is provided through the seven clinics held each week across four sites (DCH, RBH, PGH, YDH), with less frequent clinics held by the nurse-led pre-dialysis and anaemia teams and transplantation Specialist Nurses (who also undertake home visits). Haemodialysis was being provided to 225 patients across four sites (55 at DCH, 60 at RBH, 63 at PGH, 45 at YDH) with two patients undertaking home therapy, while peritoneal dialysis was being provided from two centres to 54 patients (15 from DCH, 39 from RBH). Patients receiving renal transplants have their investigative work-up undertaken at the hospital local to their clinic. Transplantation surgery is performed at a tertiary centre (SMH). After discharge, patients remain under outpatient follow up at the tertiary centre for an average of three weeks prior to referral back to their local clinic. Further surgery integral to the care provided by the Dorset Renal Service (dialysis access surgery, parathyroidectomy) is primarily undertaken at DCH, with those patients requiring inpatient stays being managed on the renal inpatient ward. A small amount of day-case dialysis access surgery is undertaken at RBH. Administrative work is undertaken primarily at DCH.

Emissions terminology

The Kyoto Protocol identifies multiple gases with global warming potential although only three are commonly reported [carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O)].[13] CO_2 is most commonly used as the reference gas, with the emissions of the other gases being expressed in the units of CO_2equivalents (CO_2eq). This study reports the total emissions in tonnes of CO_2eq per year.

Approach

This was a component analysis, in which activity data were collected from the component services across the different sites and summated to calculate the carbon footprint. A process analysis, or 'bottom up', approach was adopted to collate the data relating to the sectors of building energy use, travel, waste and water use. These data were physical in nature. The procurement data were collected predominantly through a 'top down' approach (e.g. pharmaceutical and medical equipment data) and complemented by data collected using a 'bottom up' approach where possible (e.g. construction). This data included both economic and physical components.

Emissions have been calculated on a consumption basis, and are the sum of three primary sectors: direct emissions from building energy use (heating, cooling, hot water and electricity consumption); direct emissions from the travel of patients, visitors and staff; and indirect procurement emissions. Procurement emissions can be defined as the embodied emissions associated with the production, consumption and disposal of all goods and services either consumed within the Dorset Renal Service or arising in the industrial supply and disposal chains.

Established emissions factors were applied to reconcile the activity data from the different sources to a single unit of measurement for GHG emissions (CO_2eq). This report adheres to the principles and definitions defined within the Publicly Available Specification for the measurement of GHG emissions from goods and services (PAS2050).[14]

Assumptions and data sources

It was necessary to make a number of informed assumptions during the undertaking of this study and the contexts of those assumptions are outlined here. The activity data (the materials and energy involved in a service or product) were almost exclusively primary data (determined by direct measurements made within the service). The two exceptions were waste, which was estimated from a combination of primary and secondary data and building energy use, for which secondary data relating to the hospitals, rather than the service components of the Dorset Renal Service within them, were collected.

Building energy use data. Building energy use at the different sites was calculated from data submitted to the national Estates Return Information Collection database and is based upon the proportion of floor space occupied by the Dorset Renal Service at its different sites.

Travel and transport data. ‘Travel’ is defined as the movement of people and ‘transport’ as the movement of goods. Data relating to patient travel (including outpatient appointments, inpatient admissions, dialysis treatments and pathology investigations) and staff travel (both business and commuting) were derived from travel surveys. The data collected included the distances and modalities of travel used (active travel, car, bus, train and air). These data were extrapolated up to represent annual data. Data regarding the distances travelled by patients attending radiological investigations and day-case treatments were sourced from computerized departmental records and assumptions were made regarding the modes of travel used (based on the distances and data from the National Transport Survey 2006).[15] Data regarding distance and mode of visitor travel were estimated from the National Transport Survey 2006.[15] It was assumed that only inpatients received visitors, and that each inpatient would receive one visitor every other day. It was assumed that each visitor undertook a 25-mile round trip reflecting the geographical region covered by the inpatient ward. Assumptions were made regarding the mode of travel (based on the distances and data from the National Transport Survey 2006).[15]

Procurement data. Expenditure data for pharmaceuticals, medical equipment, paper, food, sanitation products and information technology were collected from the relevant departments and deflated to 2004 values; this was necessary as the conversion factors for supply chain emissions were produced from economic input–output tables using 2004 prices.[3,16]

The numbers of radiological and pathological investigations were determined from computerized departmental records. The volume of water used to provide haemodialysis was determined from meter readings at DCH and estimated for other sites. The weight of linen sent to laundry was determined from measurements of the linen generated by individual patient activities. The distance that linen was transported to the private laundry companies was determined using GoogleMaps. Assumptions were made regarding the mode of this transport and regarding the energy consumption of the washing and drying machines used.

Waste was categorized as either clinical or domestic. While the vast majority of clinical waste undergoes incineration, assumptions regarding the proportions of domestic waste being incinerated, recycled or sent to landfill were made from published data.[16] Secondary data, in the form of the weights of these different types of waste produced by the different component services, were estimated from published reports.[17,18–20] It was assumed that emissions resulting from the disposal to landfill of any ash from incineration would be negligible and that no energy recovery would be feasible from incineration.

Boundary Setting

Inclusions

Emissions arising from the primary sectors of building energy use, travel and procurement were included, and the impact of every identifiable staff member was considered. Although PAS2050 demands that the boundary of the service should exclude emissions associated with the travel of employees to and from their normal place of work, and of consumers (in this case, patients) to and from their point of service use,[14] this study includes such travel activity in order to maintain consistency with the NHS England Carbon Footprinting Study.[3]

Inter-departmental overlap of resource use. The provision of healthcare involves considerable overlap between different clinical services. For example, a patient whose care is primarily delivered by the Dorset Renal Service may also undergo diagnostic investigations performed by a local Radiology Service. Those aspects of such secondary services that are directly attributable to the care provided to patients from the Dorset Renal Service have been included.

Dialysis access surgery, parathyroidectomy and renal transplantation are integral to the care provided by the Dorset Renal Service. Emissions relating directly to these surgical procedures (e.g. building energy use and procurement of equipment and pharmaceuticals), to the peri-operative care of the patients, and to associated travel, were therefore considered to lie within the carbon footprint of the Dorset Renal Service.

Universal exclusions

To maintain consistency with PAS2050,[14] the following sources of GHG emissions were considered to lie outside of the study: the capital cost of machinery; buildings; human inputs into the processes; food and beverages for staff; scientific research into renal medicine; staff training; water use other than that used in haemodialysis; business services; and immaterial emissions sources (those anticipated to be <1% of total footprint).

Emissions factors

The choice of emissions factors

Only two emissions conversion factors were identified for pharmaceuticals and medical equipment and these displayed considerable variation (Table 1).[3,16]

An analysis of the carbon footprint, calculated from the weights and primary constituent materials of the items procured, of a sub-group of the medical equipment procured by the Dorset Renal Service indicated that the emissions factors produced by DEFRA most accurately reflect the emissions attributable to the medical equipment used by the Dorset Renal Service. These emissions factors were also found to correlate very closely with the only identified example of a carbon footprint calculated for an individual product comparable in nature to those used in kidney care (the Viaflo®, produced by Baxter Healthcare, information by personal communication). As the subsector of pharmaceuticals does not lend itself to a similar assessment of the available emissions factors, we have used the DEFRA emissions factors for the purposes of consistency.

Table 1 Emissions factors for the pharmaceuticals and medical equipment subsectors

Source of emissions factors	Emissions factor for pharmaceuticals (kg CO_2eq per £)	Emissions factor for medical equipment (kg CO_2eq per £)
NHS England Carbon Footprinting Study[3]	0.27	0.23
DEFRA[16]	0.81	0.57

Emission factors used in this study

The emissions factors applied to activity data for building energy use, travel and transport, procurement are provided in Tables 2–5.

Emissions factors for building energy use.

Table 2 The emissions factors applied to building energy use activity data

Energy source	Emissions factor to convert to GHG emissions (kg CO_2eq per kWh)[a]
Electricity	0.54418
Heating/hot water from gas	0.18396
Heating/hot water from oil	0.27652
Heating/hot water from coal	0.33920

[a]Emissions factors from DEFRA (2009).[16]

Emissions factors for travel and transport.

Table 3 The emissions factors applied to staff, patient and visitor travel, and freight transport, activity data

Travel or transport modality	Emissions factor to convert to GHG emissions (kg CO_2eq per km)[a]
Active travel (walking, cycling)	0.0
Car	0.20487
Bus	0.10462
Train	0.06113
Air travel (domestic)	0.17283
Freight transport	0.80201

[a]Emissions factors from DEFRA (2009).[16]

Emissions factors for procurement. In the absence of specific data, it was assumed that the emissions attributable to a radiological investigation were 0.1 kg CO_2eq (a relatively small value intended to reflect the small amount of materials

Table 4 The emissions factors applied to procurement activity data

Procurement subsector	Source of emissions factor	Emissions factor to convert to GHG emissions
Pharmaceuticals	DEFRA[16]	0.81 kg CO_2eq per £
Medical equipment	DEFRA[16]	0.57 kg CO_2eq per £
Diagnostic Investigations (Pathology)		No emissions factor available. An individual blood test has been assigned a nominal carbon cost of 0.05 kg CO_2equivalents.
Diagnostic Investigations (Radiology)		No emissions factor available. An individual radiological investigation has been assigned a nominal carbon cost of 0.1 kg CO_2equivalents.
Paper and office supplies	DEFRA[16]	1.30 kg CO_2eq per £
Food and catering	NHS England Carbon Footprinting Study[3]	Emissions factors were used for individual foods and beverages.
Construction	DEFRA[16]	0.54 kg CO_2eq per £
Information Technology	DEFRA[16]	0.58 kg CO_2eq per £
Water	DEFRA[16]	0.276 kg CO_2eq per cubic metre of water
Sanitation products	DEFRA[16]	0.80 kg CO_2eq per £

Table 5 The emissions factors applied to waste collection, treatment and disposal activity data

Waste disposal method	Waste constituent	kg CO_2eq emitted per tonne of waste constituent[a]
Incineration	Paper	
	Plastics	
	Cardboard	
	Glass	1800[b]
	Other waste	
	Metal	
Recycling	Paper	−713
	Plastics	−1500
	Cardboard	−713
	Glass	−315
	Other waste	−259
	Metal	−9000
Landfill	Paper	550
	Plastics	40
	Cardboard	550
	Glass	10
	Other waste	81
	Metal	10
	Organic waste (food)	365
	Organic waste (non food)	230

[a]Emissions factors from DEFRA (2009).[16]

[b]DEFRA emissions factors for incineration do not specifically account for clinical waste, which is commonly undertaken at higher temperatures. To reflect the increased emissions that are likely to result from the incineration of clinical waste, the highest available emissions factor for incineration was applied to each of the constituents.

consumed in producing radiological images that are viewed electronically) and that the emissions attributable to a pathological investigation were 0.05 kg CO_2eq.

Emissions factors for waste. Our model assigns the carbon embedded in products to their manufacture and it is therefore included within the emissions attributable to their procurement. To avoid 'double counting' this carbon, the 'end of life' carbon footprint has been calculated using the DEFRA emissions factors for waste treatment processes,[16] as opposed to the sum of the 'end of life' and 'production' carbon footprints.

Since the recycling of domestic waste is not undertaken within the Dorset Renal Service, the carbon recovered is realized outside of the boundary of this study. However, we have elected to apply the DEFRA emissions factors for recycling to this waste (rather than to consider the disposal of this waste to have no impact upon the overall carbon footprint of the Dorset Renal Service) in order to maintain consistency in our approach to waste management.

Results

The carbon footprint of the dorset renal service

Primary sector results

The carbon footprint of the Dorset Renal Service was 3007 tonnes CO_2eq. The contributions of the primary sectors are displayed in Figure 1.

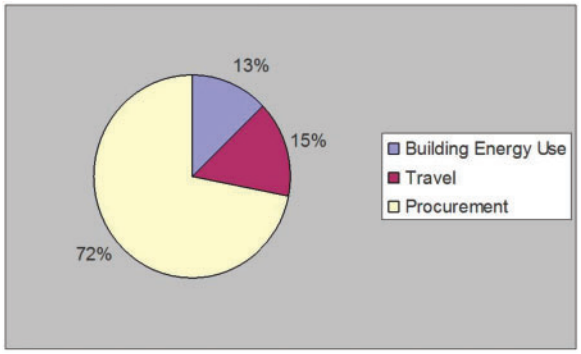

Figure 1. Primary sector breakdown of the GHG emissions of the Dorset Renal Service.

Table 6 Sub-sector breakdown of the GHG emissions of the Dorset Renal Service

Sector	Subsector	GHG emissions (kg CO_2eq)	Percentage of GHG emissions
Building Energy Use		381 331	12.68
	Total for building energy use	381 331	12.68
Travel	Staff commuting	143 774	4.78
	Staff business	17 774	0.59
	Patient travel	279 293	9.29
	Visitor travel	20 448	0.68
	Other travel	598	0.02
	Total for travel	461 886	15.36
Procurement	Pharmaceuticals	1 043 660	34.71
	Medical equipment	752 862	25.04
	Diagnostics (Radiology)	209	0.01
	Diagnostics (Pathology)	4720	0.16
	Paper	9401	0.28
	Food	6933	0.23
	Laundry services	14 070	0.47
	Construction	31 692	0.94
	IT	5908	0.18
	Water	6169	0.20
	Sanitation products	1954	0.06
	Waste	291 125	9.68
	Total for procurement	2 163 403	71.95
Overall total	Kg	3 006 620	100%
	Tonnes	3007	100%

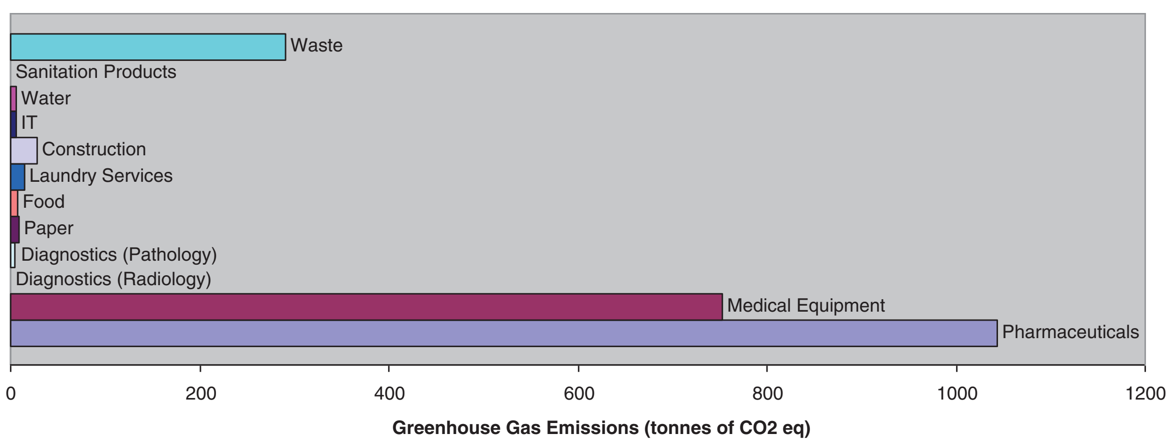

Figure 2. Procurement subsector GHG emissions within the Dorset Renal Service.

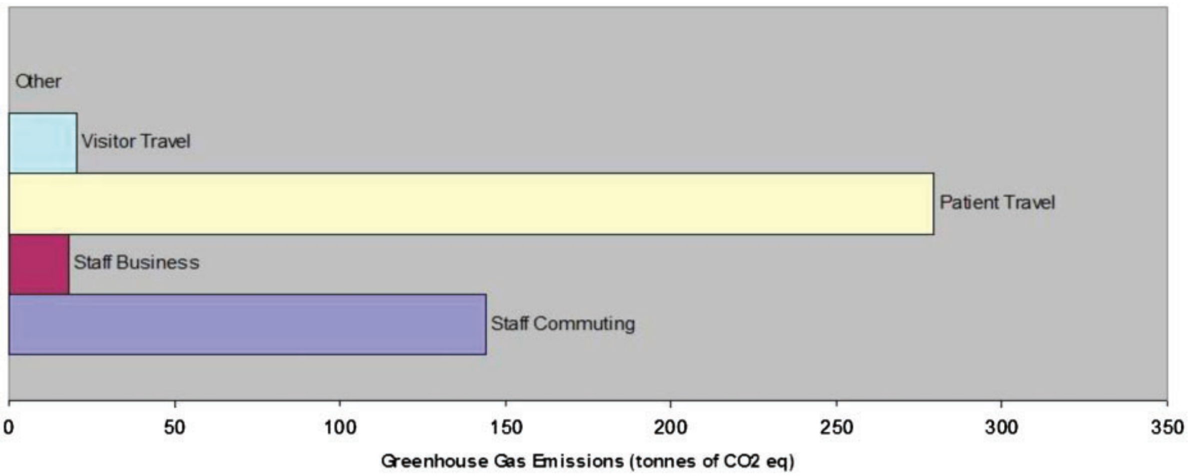

Figure 3. Travel subsector GHG emissions within the Dorset Renal Service.

Sub-sector results

The calculated emissions of the sub-sectors are given in Table 6 and displayed in Figures 2 and 3.

Carbon emissions per unit of healthcare activity

Table 7 GHG emissions directly attributable to the provision of haemodialysis and peritoneal dialysis within the Dorset Renal Service

Sector	GHG emissions attributable to the provision of haemodialysis and peritoneal dialysis (kg CO_2eq)	GHG emissions expressed as a percentage of the total emissions of the Dorset Renal Service (%)
Building energy use	278 398	9.3
Travel[a]	507 225	16.9
Procurement (excluding waste)	917 552	30.5
Waste	262 128	8.7
Total	1 965 305	65.4

[a]Return travel by patients to attend haemodialysis treatments produces 173 248 kg CO_2eq, which represents 34.2% of the overall travel emissions, and 5.76% of the overall emissions, of the Dorset Renal Service.

Table 8 GHG emissions attributable to the provision of outpatient appointments within the Dorset Renal Service

Sector	GHG emissions attributable to the provision of outpatient care within the Dorset Renal Service (kg CO_2eq)	GHG emissions expressed as a percentage of the total emissions of the Dorset Renal Service (%)
Building energy use	15 992	0.53
Total travel	104 490	3.48
Staff-commuting travel	*22 157*	*0.74*
Staff-business travel	*4144*	*0.14*
Patient travel	*78 189*	*2.6*
Procurement (excluding waste)	45 848	1.52
Waste	5641	0.18
Total	171 971[a]	5.72

[a]Within the Dorset Renal Service, a total of 171 971 kg CO_2eq result from approximately 7800 appointments per year. This equates to 22 kg CO_2eq of GHG emissions per outpatient appointment.

Table 9 GHG emissions attributable to the provision of inpatient care within the Dorset Renal Service

Sector	GHG emissions attributable to the provision of inpatient care within the Dorset Renal Service (kg CO_2eq)	GHG emissions expressed as a percentage of the total emissions of the Dorset Renal Service (%)
Building energy use	63 432	2.1
Total travel	121 306	4.0
Staff-commuting travel	*77 390*	*2.6*
Staff-business travel	*7446*	*0.2*
Patient travel	*17 620*	*0.6*
Visitor travel	*18 850*	*0.6*
Procurement (excluding waste)	587 153	19.5
Waste	52 125	1.7
Total	824 016[a]	27.4

[a]Within the Dorset Renal Service, a total of 824 016 kg CO_2eq result from an estimated 5110 bed days per year. This equates to 161 kg CO_2eq of GHG emissions per bed day.

Discussion

The carbon footprint of the Dorset Renal Service

The total GHG emissions of the Dorset Renal Service in 2008 are 3007 tonnes CO_2eq. Supply chain emissions are responsible for 72% of these. The increased contribution of the pharmaceutical subsector (35%) compared to its contribution to the carbon footprint of NHS England (21%) reflects, in part, the polypharmacy commonly experienced by patients with kidney disease, and would have been greater still had the medications originally commenced by the Dorset Renal Service but subsequently provided by Primary Care also been included.[3] The significant contribution attributable to medical equipment (25%) reflects the role that single-use, pre-packaged products have played in facilitating the increasing availability of dialysis and is further evident in the contribution of waste to the overall emissions (10% compared with 3% within NHS England).[3]

Although carbon-reduction strategies often focus on building energy use, this contributes only 13% of the overall emissions—considerably <22% contribution made by building energy use to the NHS England carbon footprint.[3] This discrepancy is probably the result of two factors. First, while the overall building energy use attributable to business services was accounted for in the NHS England study, we excluded from our study the proportion of building energy use attributable to the hospital business services that might reasonably have been allocated to the carbon footprint of the Dorset Renal Service (as it was not quantifiable). Second, the considerable amount of emissions resulting from the procurement sector will have impacted upon the balance of the contributions of the different primary sectors with the carbon footprint of the Dorset Renal Service. Overall, the results of this study support the assertion that measures to reduce building energy use, although important, should form only part of strategies intended to reduce the carbon footprint of renal services.[22]

Similarly, even with the inclusion of staff commuting travel, overall travel emissions contribute only 15% of the carbon footprint of the Dorset Renal Service. Patient travel contributes 60% of the overall travel emissions. That this is greater than the contribution made by patient travel to the overall travel emissions of NHS England (44%) is not unexpected given that the most common form of renal replacement therapy, in-centre haemodialysis,[23] requires that patients undertake return journeys to their dialysis facility three times per week. However, this discrepancy is lessened by the provision of dialysis at satellite units, which reduce patient travel within renal services. In this regard, the Dorset Renal Service is typical in that it has three such units (the mean number of satellite units per hub unit in England is 3.02, range 0–10, calculated using data from the 12th Annual Renal Registry Report[23]). The contribution of dialysis-related patient travel is of interest. While patient travel to haemodialysis is responsible for 173 tonnes of CO_2eq, representing 34% of overall travel emissions, this amounts to only 6% of the overall emissions of the Dorset Renal Service. Given that the Dorset Renal Service provides in-centre haemodialysis in a relatively rural population, and to a higher than average proportion of the patients requiring renal replacement therapy

(49.8%, compared to a mean within England of 39.6%, range = 7.2–72.2%, calculated using data from the 12th Annual Renal Registry Report[23]), these results indicate that, while necessary, initiatives to reduce the emissions associated with dialysis-related patient travel are unlikely to impact significantly upon the overall carbon footprint of renal services.

Carbon emissions per unit of healthcare activity

But is renal medicine a carbon intensive specialty? The 21.3 million tonnes of emissions attributed to NHS England result from the provision of care to 51.4 million people (0.4 tonnes per patient per year).[3] Data regarding the proportion of the population of England accessing renal services are not available, and neither are similar data for the population covered by the Dorset Renal Service. However, data from the UK Renal Registry confirms that the proportion of the population of England receiving either haemodialysis or peritoneal dialysis is extremely small (0.04%).[23] Yet, it is to be expected that the provision of these two forms of renal replacement therapy will contribute significantly to the emissions arising from a renal service, and, indeed, these two components of the Dorset Renal Service contribute 65.4% of its overall carbon footprint (Table 7). The provision of haemodialysis and peritoneal dialysis to just 277 patients, from a population of 865 000, results in 1965 tonnes of CO_2eq, equating to 7.1 tonnes of CO_2eq per dialysis patient per year. Therefore, just as kidney care is considered to be a 'high cost, low volume' specialty in financial terms, it seems likely that it is also a carbon intensive specialty when considered in terms of the numbers of patients treated with renal replacement therapy.

This line of thinking is supported by our finding that a total of 824 of the 3007 tonnes of CO_2eq attributable to the Dorset Renal Service result from the provision of an estimated 5110 inpatient bed days per year, equating to GHG emissions of 161 kg CO_2eq per bed day (Table 9). This estimate is considerably higher than the only other published figure of this nature; a recent top-down study by the NHS Sustainable Development Unit (SDU) estimated the GHG emissions associated with one bed day (within all clinical specialties) to be 80 kg CO_2eq through the application of four methodologies to data from the NHS England Carbon Footprinting report.[3,24] The discrepancy appears to be largely due to the emissions arising from the procurement of pharmaceuticals and medical equipment, and is therefore perhaps explained in part by the provision of renal replacement therapy to patients on the inpatient renal ward.

We have calculated the GHG emissions attributable to an outpatient appointment to be 22 kg CO_2eq (Table 8). Given the current lack of carbon footprinting studies within healthcare, it is noteworthy that this estimation, produced by a 'bottom-up' approach, is comparable in magnitude to that of the only other published data, again from the 'top-down' NHS SDU study,[24] which applied three methodologies to data from the NHS England Carbon Footprinting report,[3] and reported estimations of 24, 38 and 78 kg CO_2eq per outpatient appointment. The figure reported here lies at the lower end of this range, perhaps reflecting the exclusion of pharmaceuticals prescribed from primary care.

Limitations

While prospective collection of primary activity data would perhaps provide a more accurate carbon footprint, such an approach would be resource and time intensive and would not be easily transferable to other services. There are two other limitations to the technique of carbon footprinting relevant to this study. First, it should be appreciated that a carbon footprint does not provide a complete assessment of the environmental impact of a service or product. For example, although water is a finite natural resource, the 22 million litres of water used annually by the Dorset Renal Service for haemodialysis alone result in <1% of its GHG emissions.

The second limitation relates to the evaluation of uncertainty within the results. The two main approaches to carbon footprinting, process analysis and input–output assessments, have differing uncertainty profiles, and their use in isolation can present difficulties in interpreting these profiles.[25] Within this study, the extent of any truncation error, occurring as a result of the exclusion of components of the service or product within the process analysis approach (as was used in this study), cannot easily be estimated without applying a concurrent input–output approach (termed a 'hybrid life cycle analysis', which was not feasible in this study). Furthermore, although we undertook measures to identify the most appropriate emissions factors for this study, the considerable variation between emissions factors quoted by different sources for the medical equipment and pharmaceutical supply chains, and the extent to which these subsectors contribute to the carbon footprint, means that uncertainty is conveyed to our final results.

Recommendations

The implementation of carbon-reduction strategies should be informed by economic analyses, enabling the prioritization of those initiatives proven to be either cost-effective or, indeed, cost-saving. Within renal medicine, cost-effective carbon-reduction strategies already exist, for example, within the practice of waste management and the use of building energy and water.[26–28]

However, where possible, carbon-reduction strategies should also target those areas of the provision of healthcare that are associated with the greatest burden of emissions. Within a renal service, this study indicates that measures to reduce the emissions arising from the procurement of pharmaceuticals and medical equipment are of particular importance. Such measures might take a number of forms, including: strategies to improve patient compliance with, and reduce wastage of, pharmaceuticals; exploration of opportunities to re-use medical equipment through re-evaluation of the extent to which risk management defines infection control policies; and the adoption of sustainable procurement policies. The elimination of ineffective, or 'low value', treatments and models of care from clinical practice will lower healthcare-related emissions while also improving clinical care, and should therefore be prioritized. Healthcare research has an important role to play in ensuring that only safe and effective healthcare is provided; the carbon footprint of the clinical trials required to determine reliable information is significant,[10] but is likely to be far less than that of the ineffective treatments, technologies and models of care that may persist in the absence of such trials.

We, therefore, propose that a transformation to lower carbon clinical care is required. The NHS Next Stage review identified that improvements in the quality of care will require service change and innovation,[29] presenting an opportunity to introduce lower carbon clinical care pathways. The estimated GHG emissions identified for outpatient appointments and inpatient admissions calculated here and in previous studies[23] may be of value in modelling lower carbon pathways of care, but further research, including carbon footprinting studies, is required to better understand the environmental impacts of healthcare technologies, treatments and models of care. This will necessitate the generation of more specific healthcare-related emissions factors, particularly with respect to the medical equipment and pharmaceutical sub-sectors.

A second requirement is improved accessibility to high quality primary activity data in order to increase the accuracy and ease of completion of further carbon footprinting studies. This might be achieved through simple measures such as sub-metering of electricity consumption in renal units, improved waste auditing and the use of more refined procurement data recording systems.

Conclusions

This study has calculated the carbon footprint of the Dorset Renal Service. The contributions of the three primary sectors (travel, building energy use and procurement) and their subsectors have been identified, and the emissions associated with different healthcare activities have been estimated. The methodology employed in this study can be translated to other renal services and might be used to inform similar studies in other specialties. The results support the proposal that a clinical transformation is required if the carbon-reduction targets identified for the NHS are to be met within renal services, and might be used to inform the necessary carbon-reduction strategies. The variation in the contributions of the different sectors to the carbon footprints of a renal service and the NHS indicate that carbon-reduction strategies should be tailored to individual specialties.

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