Determining an Approach to Estimating the Carbon Footprint of Mental Health Care that is Fit for Purpose

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Declarations

I confirm that this thesis has not been submitted for any degree at another university.

The work presented (including data generated and data analysis) was carried out by the author except in the cases outlined below:

- In Chapter 4, Dr Frances Mortimer in collaboration with the author designed the surveys used to collect data on the sustainability of mental health services across England. The author undertook the subsequent data collection, analysis and interpretation.
- In Chapter 6, health care administrative staff performed the data collection for the patient travel survey based on data collection sheets prepared by the author.
- In Chapter 9, the survey regarding non-attendance at clinic appointments was jointly constructed with Dr Michael Pearce. The author undertook the subsequent data collection, analysis and interpretation of the results.

Parts of this thesis have been published by the author

Maughan, D. L., Lillywhite, R., & Cooke, M. (2015). Cost and carbon burden of long-acting injections: a sustainable evaluation. BJPsych Bull, pb.bp.114.049080. http://doi.org /10.1192/pb.bp.114.049080

Maughan, D., Patel, A., Parveen, T., Braithwaite, I., Cook, J., Lillywhite, R., Cooke, M., (2015) Primary-care-based social prescribing for mental health: an analysis of financial and environmental sustainability. Primary Health Care Research & Development 05/2015; DOI:10.1017/S1463423615000328

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Maughan, D., Wallace, S., & Lillywhite, R. (2014). Clinical practice: key to meeting the NHS's energy targets. Health Services Journal, July (2)

Abstract

The NHS has to meet the Climate Change Act targets of an 80% reduction to their carbon emissions by 2050. Investigation into the components of the carbon footprint of mental health care is needed to understand how services can meet these targets.

This thesis first seeks to understand what is known about the carbon footprint of mental health care through two systematic reviews and two national surveys. Second, existing methodologies for estimating carbon footprints are examined to assess whether an approach is available that is 'fit for purpose' in mental health care. The approach needs to be applied feasibly within a clinical context and the results need to be sufficiently robust to reliably inform decisions about service design. The aim of this research is to provide an approach that service providers can use to estimate the carbon footprint of services and then use the information obtained to inform service design.

This thesis defines the boundaries of assessment to ensure a consistent approach. It suggests an approach to data collection that includes financial and activity data. It presents a review of the available methods for converting this data to carbon equivalents and finds a potential five-fold range associated with carbon footprint estimates of medication. The approach developed within this study is termed the combined approach.

The combined approach is then evaluated using a scenario analysis, a four-year retrospective cohort analysis and a prospective care modelling analysis to assess whether it is fit for purpose according to specified criteria. It is concluded that the combined approach is fit for the purpose of assessing how the carbon footprint of a service changes over time. However, due to the use of financial data and the problems with estimating the carbon footprint of medication, this approach has significant weaknesses, which limits its wider use.

Word count of abstract: 300

Presentation of research from this thesis

Regional Conferences

September 2014	Northern Ireland Divisional Conference; What does Sustainability look like?
November 2014	Eastern RCPsych Divisional Conference; Sustainable Psychiatry
November 2014	West Midlands RCPsych Divisional Conference; Sustainable Psychiatry
December 2014	Welsh RCPsych Divisional Conference; Sustainable Psychiatry

National Conferences

October 2014	RCPsych National Sustainability Summit; Why Sustainability?
October 2014	British and Irish Group for the Study of Personality Disorder National Conference; Are PD Services Sustainable?
October 2014	Academy of Medical Royal Colleges Sustainability in Medical Royal Colleges Launch; The state of Sustainability.
March 2013	Prestigious Lecture Series, RCPsych; Sustaining Psychiatric Services

International Conferences

July 2014	RCPsych International Congress; Sustainability and Parity of Esteem
June 2014	Choosing Wisely Roundtable, Amsterdam; Reducing Clinical Waste in the NHS
July 2013	RCPsych International Congress; Key Note: Sustainability; the New Frontier

Preface

This MD thesis has been performed as part of the Royal College of Psychiatrists Sustainability Fellowship. This was a two-year full time fellowship (2013-2015) taken during a break to my advanced training in general adult psychiatry. During this fellowship I have worked with the Centre for Sustainable Healthcare, the Royal College of Psychiatrists and the University of Warwick to stimulate the adoption of sustainable practices in mental health organisations around the UK. I have run an online sustainability network for mental health professionals, published national reports for the Academy of Medical Royal Colleges and the Royal College of Psychiatrists. I have published a commissioning guide for sustainable mental health care for the Joint Commissioning Panel for Mental Health. I have organised two mental health sustainability summits and have published several articles in scientific journals about why sustainability needs to be considered and how the sustainability of mental health care could be improved. A list of articles and reports published by the author during this two-year research fellowship is provided.

Related publications by author

Peer Reviewed Journals

- Maughan, D. L., & Davison, P. (2015). The need for sustainable psychiatry. The Lancet Psychiatry, 2(8), 675–677.
- Maughan, D. L., & Berry, H. L. (2015). Mind games: standing by while the world ignores climate change. BJPsych International, 12(2), 29–30.
- Yarlagadda, S., Maughan, D., Lingwood, S., & Davison, P. (2014). Sustainable psychiatry in the UK. Psychiatric Bulletin, 38(6), 285–290.
- Malhotra, A., Maughan, D., Ansell, J., Lehman, R., Henderson, A., Gray, M., et al. (2015). Choosing Wisely in the UK: the Academy of Medical Royal Colleges' initiative to reduce the harms of too much medicine. BMJ (Clinical Research Ed.), 350(may,12;7). doi:10.1136/bmj.h2308
- Maughan, D., Berry, H., & Davison, P. (2014). What psychiatrists should know about environmental sustainability and what they should be doing about it. International Psychiatry, 1–4.
- Maughan, D. (2013). A sustainable future. Mental Health Practice, 17(4), 13–13. doi:10.7748/mhp2013.12.17.4.13.s16

National Reports / Publications

- Maughan, D. (March 2015). *Sustainable Psychiatry*. Occasional Paper. Royal College of Psychiatrists Press.

- Maughan, D., & Ansell, J. (November 2014). Report: *Protecting resources, promoting value: a doctor's guide to cutting waste in clinical care.* Academy of Medical Royal Colleges
- Maughan, D. (September 2014). *Facing the future; Sustainability for Medical Royal Colleges.* Academy of Medical Royal Colleges
- Maughan, D. (October 2015) *Guidance for commissioners of financially, environmentally, and socially sustainable mental health services*. Joint Commissioning Panel for Mental Health.

List of abbreviations

CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent Unit
CSH	Centre for Sustainable Healthcare
DNA	Did Not Attend (appointment)
GHG	Greenhouse Gas(es)
HR	Human resources
kg	Kilogram(s)
km	Kilometre(s)
kWh	Kilowatt Hours
LCA	Life Cycle Assessment
NHS	National Health Service
PAS 2050	UK standard method for assessing the life cycle greenhouse gas emissions of goods and services
PD	Personality Disorder
RCPsych	Royal College of Psychiatrists
SDMP	Sustainable Development Management Plans
SDU	Sustainable Development Unit
TC	Therapeutic Community (ies)
UK	United Kingdom

Aim

- To obtain an approach to estimating the carbon footprint of mental health care that is fit for purpose in mental health care

Research questions

1. What methods exist for estimating the carbon footprint of health care?
2. What attempts are being made to reduce the carbon footprint of mental health care?
3. Can existing methodologies for estimating carbon footprints be applied to provide an approach that is fit for purpose in mental health care?

Chapter 1

Sustainable health care and carbon footprint assessment: an introduction

Introduction

The understanding that the health care sector should reduce its carbon footprint is relatively new (SDU 2009). This issue has become more pertinent since the NHS signed up to the 2008 Climate Change Act targets of an 80% reduction to its greenhouse gas (GHG) emissions by 2050 (SDU 2009). Importantly, there is uncertainty about how the carbon footprint of health care should be estimated (SDU, 2013a; Connor et al. 2010; Pollard et al. 2013). The research presented in this thesis has examined the options available for estimating the carbon footprint of mental health care. The intention is to use and develop this evidence to provide a feasible and robust methodology that can be used by NHS service providers (those who design and manage NHS clinical services) to inform some understanding of the scale of the emissions associated with NHS services. This will consequently allow changes to service design that could reduce GHG emissions.

The research reported here has been undertaken as part of a two-year sustainability fellowship with the Royal College of Psychiatrists. The aim of the fellowship was to increase awareness about and attempt to improve the environmental sustainability of mental health services in the UK. This research therefore necessarily focuses on mental health services, however, it remains important to establish a methodology for estimating the carbon footprint of all health care specialties. It may be that the carbon footprint estimation methodologies suggested in this research could be applied to other specialties. However, the bounds of this research does not include the testing of these methodologies in other specialties.

This chapter introduces the concept of environmentally sustainable health care. It discusses the drivers for reducing the GHG emissions associated with mental health care and the various opportunities for reducing these emissions. It provides an account of environmental legislation and an outline of current reporting requirements for GHG emissions in the NHS. Following this, a description of the existing carbon footprinting methodologies is presented and finally an overview of the research is provided.

Sustainability

The term sustainability is ubiquitous when discussions of environmental impact are concerned. This concept arose out of the UN Conference on Environment and Development in Rio de Janeiro in 1992 (Meakin 1992). It was further developed in 1994, in the corporate context by John Elkington, who developed the sustainability 'triple bottom line' framework (Elkington

1994), which has subsequently been widely adopted across for-profit, non-profit and governmental sectors (Slaper & Hall 2011). It is now the term used by most organisations for environmental reporting, including the NHS (SDU 2014a). Sustainability, as defined by the triple bottom line framework, refers to a broader understanding of the impacts of an organisation and the need to account, not only for economic impacts, but also for environmental and social impacts (Elkington 1994).

Sustainable health care

Sustainable healthcare involves balancing the economic, environmental, and social constraints, demands and outcomes within health care settings. Importantly, while the sustainability triple bottom line framework focuses on reducing the economic, environmental and social impacts of health care, it should never be to the detriment of high quality patient care.

There is an abundance of research and knowledge about health economics (Mogyorosy & Smith 2012) and how financial sustainability might be achieved (McCrone et al. 2008). While social sustainability relates closely to the concept of personal recovery in mental health (Knapp et al. 2013; Anthony 1993) and this area has also been extensively investigated (Anthony 1993; G. Roberts & Boardman 2014; Knapp et al. 2013). However, there is less known about the environmental impacts of mental health care (Yarlagadda et al. 2014) and it is this element of the sustainability triple bottom line framework that is the focus of this research.

Measuring greenhouse gas emissions

This research uses carbon footprint as a proxy measure for environmental impact. It does not review ecological impacts, such as the potential effects that pharmaceuticals in rivers has on biodiversity, nor does it review how the associated GHG emissions might affect the climate or weather systems. Investigating all the potential environmental impacts of mental health care is too broad a subject and could not be dealt with adequately.

The Kyoto Protocol identified seven gases with global warming potential (known as greenhouse gases) (Nations 1998). Out of these gases, CO_2 is most commonly used as the reference gas (IPCC 2013), with emissions of other gases expressed in CO_2 equivalent units (CO_2e). This is because it is often the largest component of the environmental impact and other gases can be easily converted into CO_2e (Nations 1998), see Table 1 below. CO_2 emissions in 2004 accounted for over 85% of NHS England GHG emissions (Scott et al. 2008).

Table 1. The comparative global warming potentials of gases identified by the IPCC presented in carbon dioxide equivalent units (IPCC 2013)

Greenhouse gas	**Global warming potential (Unit CO_2e)**
Carbon Dioxide	1
Methane	25
Nitrous Oxide	298
Hydrofluorocarbons	124-14,800
Perfluorocarbons	7,390-12,200
Sulfur hexafluoride	22,800
Nitrogen trifluoride	17,200

Emissions are generally categorised as follows (WBCSD & WRI 2011):.

- Scope 1 includes the direct GHG emissions from the organisation (e.g. fuel for travel)
- Scope 2 includes indirect GHG emissions associated with the generation of electricity purchased by the organisation
- Scope 3 includes all other indirect GHG emissions associated with the operations of the organisation, such as those embedded in procured goods (e.g. medications and equipment).

The scale of the problem

The NHS is the single largest emitter of GHG in the UK public sector and emits 25 million tonnes of CO_2e each year (SDU 2013a). This is equivalent to the total GHG emissions of a medium-sized eastern European country such as Slovenia (Rogers 2012). The provision of mental health services accounts for 1.47 million tonnes of this (6% of NHS carbon emissions) (SDU 2013b). The carbon footprint of mental health care is made up of fuel from travel (scope 1) and energy use (scope 2) but also the embodied emissions in the products it uses to deliver care (scope 3), such as medication and equipment (SDU 2013a). Environmental reporting in the NHS, has tended to focus on the energy consumed by buildings (ERIC 2014). However, a study performed by the NHS Sustainable Development Unit (SDU) in 2009 found that the majority of the environmental impacts of mental health care (and health care more generally) stem from clinical aspects of care, such as those embedded in pharmaceuticals and medical equipment (SDU 2009a). Environmental reporting in health care needs to include these aspects of clinical practice to provide a more complete understanding of GHG emissions.

Drivers for reducing the carbon footprint of health care

The Carbon Reduction Commitment Scheme (DEFRA 2015) is an emissions trading scheme for UK public sector organisations, which stipulates a legal requirement for health care organisations to pay for the carbon emissions associated with their energy use. The NHS has also developed the ‘Good Corporate Citizenship’ model (SDU, 2012b) and the ‘Sustainable Development Strategy’ (SDU 2014a), both of which are strategic drivers for reducing the carbon footprint of health care.

The NHS is in financial crisis and budgets for health providers are frequently being cut (A. Roberts et al. 2012). In this context, the incentive for services to reduce their environmental impact can seem insignificant, particularly as these environmental impacts, unlike financial overspend, are mostly borne, not by the NHS, rather they add to the global impact of GHG emissions. However, the carbon footprint of health care tends to vary with financial cost (SDU 2010). Reducing the carbon footprint of health care often involves reducing resource use and therefore also financial cost, such as reducing travel or over-medication (Maughan et al. 2015; Maughan & Pearce 2015) or more simply reducing heating or temperature of hot water supplies (Somner et al. 2008). In order to incentivise mental health organisations to reduce their carbon footprint, a strategy is needed to target carbon footprint reductions that can also reduce the financial cost of care.

Figure 1. Win-win strategies for reducing the carbon footprint of mental health care

Box 1. Low financial cost High carbon footprint	Box 2. High financial cost High carbon footprint
Box 3. Low financial cost Low carbon footprint	Box 4. High financial cost Low carbon footprint

Some service changes can reduce financial costs but increase the carbon footprint, e.g. moving from box 4 to box 1 in Figure 1 above. An example of this might be closing several existing health care sites and building one central health facility. The reduced staffing costs in the new facility could lead to reduced financial costs, but the likely increase in staff and patient travel and the carbon footprint of constructing the new premises could lead to an overall increase in the carbon footprint (Pollard et al. 2013). Greater understanding about the carbon footprint of clinical care would help service providers to reduce the carbon footprint alongside the financial cost.

Opportunities to reduce the carbon footprint of mental health care

Clinical service developments that could reduce the carbon footprint

The Centre for Sustainable Healthcare have developed principles of sustainable health care (Mortimer 2010) that can act to reduce the carbon footprint:

1. Prevention
2. Patient education and empowerment
3. Lean service delivery
4. Preferential use of treatment options with lower environmental impact

First, acting *preventatively* would commonly lead to a reduction in the future need for services and therefore the carbon footprint of mental health care (Maughan 2015). However, it must be noted that acting preventatively in some cases does increase the need for services, for example the case of breast cancer screening, which increases the number of operations performed (Malhotra et al. 2015). Second, services can *empower* patients to manage their own health by providing comparatively 'carbon light' resources such as community support groups, online educational tools, peer support networks and online symptom monitoring websites (Maughan 2015). Third, if patients actually do need to be seen by mental health services, lean service design should be introduced (Young & McClean 2008). Lean service has been derived from the management approach developed by Toyota, which has been applied to many business and health settings and reviews all processes within an organisation with the aim of reducing wasted resource (Young & McClean 2008; Womack & Miller 2005). Reducing medication waste, reducing travel, implementing telephone or online patient reviews are all examples of Lean service changes that have the potential to reduce the carbon footprint of clinical care (Yarlagadda et al. 2014).

The fourth principle is that of using treatment options that have a reduced carbon footprint. Examples might include group sessions, which could reduce the energy used because less clinical space is required, while staff travel may also be reduced because less staff are generally required per patient. Options such as social prescribing have good evidence of benefit and potentially have a reduced carbon footprint compared to long-term medication (Yarlagadda et al. 2014). Encouraging active travel methods, such as cycling or walking to work and to patients' homes, or using public transport, are also likely to reduce the carbon footprint of mental health care (Zander et al. 2011).

There are many different and potentially effective ways to reduce the carbon footprint of mental health care. However, this research focuses on the last of these principles; adopting treatment options or models of care that have a reduced carbon footprint.

Non-clinical developments that could reduce the carbon footprint

Reductions to the carbon footprint of mental health care could also be achieved by changing to renewable energy sources (SDU 2010). Reductions could be achieved more simply by improving the insulation of buildings and by using efficient boilers and lighting (SDU 2010). Reducing the carbon footprint of corporate services would involve reviewing the travel, energy and equipment used in management services alongside ensuring sustainable procurement strategies are in place. Externally commissioned services that help deliver mental health care, such as catering, cleaning, construction or estates management companies also have their associated carbon footprint (SDU 2013b). These external services could be required to report on their carbon footprint and have an obligation to reduce their carbon footprint.

Environmental analysis

Global and UK environmental legislation

The first UN environmental conference was held in Rio de Janeiro in 1992 and discussed how environmental impacts needed to be "*integrated into every economic, political and social activity*" (Meakin 1992). Since the late 1990's and the Kyoto protocol, the UN Framework Convention on Climate Change (UNFCCC) have provided specific targets for reducing GHG emissions (Nations 1998).

The current environmental legislation in the UK is the 2008 Climate Change Act (National Archives, 2008). This requires UK GHG emissions to be reduced by 80% by 2050 from a 1990 baseline. The NHS has signed up to meet these targets (SDU 2009). Crucially, meeting these targets will require a transformation in the way mental health care is delivered (Maughan et al. 2014).

Reporting requirements for greenhouse gas emissions in the NHS

The governance structures for reporting the environmental impacts of NHS organisations in England are 'Sustainable Development Management Plans' (SDMPs) (SDU 2013c). These SDMPs are required to include plans for reducing the carbon footprint, their focus is almost exclusively on reducing building energy use and waste (SDU 2013c). Estates and facilities staff are currently responsible for producing SDMPs, as they manage buildings energy use and waste. Currently there is little collaboration with clinical staff in the creation of these reports (Maughan et al. 2014). The quality of SDMPs is highly variable and, while most provide information about scope 1 and 2 emissions, they do not include scope 3 emissions, despite the fact that these likely make up the majority of the carbon footprint associated with health care (SDU 2013a). Further, none of these reports include or refer to the carbon footprint of clinical activities (SDU 2013c).

Carbon footprinting methodologies

Carbon footprint assessments provide 'estimates' of environmental impact, because, even when using the most stringent methodology, inaccuracies can prevail (DEFRA et al. 2011). Fundamental principles of carbon footprint assessments are therefore transparency and clarity about the potential uncertainties that exist (WBCSD & WRI 2011). There are two methodologies available for estimating carbon footprints; process based life cycle assessment (LCA) and environmental input-output analyses (Minx et al. 2009; DEFRA et al. 2011). A brief overview of each methodology is provided below.

Process-based life cycle assessment

Process-based LCA is widely used for estimating the embodied emissions in products or services (DEFRA et al. 2011). It is a time and resource intensive method that requires the identification of all the activity data that is associated with a product or process to account for indirect emissions, such as those embedded in the production and manufacture of equipment or medication. Given their complexity, guidelines have been created that explain how to undertake these assessments. The two guidelines that are widely accepted standards for performing process-based LCA (Sinden 2009) are the Greenhouse Gas Protocol and the PAS 2050 guide (WBCSD & WRI 2011; DEFRA et al. 2011).

According to the internationally accepted guideline PAS 2050, the following components are required to produce a process-based LCA (DEFRA et al. 2011):

- Production materials (e.g. extraction of raw materials from the earth).
- Energy (e.g. electricity required to run machinery or heat building).
- Production processes and service provision (e.g. electricity required to drive a process).
- Transport
- Storage
- Use phase (e.g. energy consumed when using the product).
- End-of-life (e.g. waste disposed of in a landfill, waste recycled).

It is usually not possible to include every potential activity in a process-based LCA, since each activity has, in turn, its own set of inputs. The total number of processes in the system is therefore potentially infinite (Suh 2009). An example of this is medication, where the company manufacturing medication might require chemicals from another factory. This chemical factory might use equipment from a different factory, which uses materials from another and so on. Although guidance suggests that activities contributing less than 1% of the carbon footprint of the product can be ignored (WBCSD & WRI 2011), the sum of all these activities can often be significant. Some sources state that where there are five or more layers of activity, the resulting systematic underestimation of the carbon footprint, known as 'truncation error', can be as much as 50% (Suh 2009; Lenzen 2000).

Once all the activities have been identified, they can be converted to a carbon footprint by applying emission factors. An emission factor is defined as the average emission rate of greenhouse gas (in the case of this research; carbon dioxide) for a given source, relative to units of activity (Carbon-Trust 2013), for example grams of carbon dioxide released per litre of petrol used. The Department of Food and Rural Affairs (DEFRA) and the Intergovernmental Panel on Climate Change (IPCC) publish databases of emission factors for all types of resources; materials, travel, medication, energy etc. (DEFRA 2013; IPCC 2013). Academic papers that have performed assessments of the carbon footprint of various products or services (e.g. furniture or travel) are also sources for emission factors

(Connor 2010; FIRA 2011). Process-based LCA methods rely heavily on the accuracy of the emission factors used in the assessment, which can vary considerably. Care needs to be taken to ensure that the emission factors applied are accurate (DEFRA et al. 2011).

In summary, a process-based LCA method has the potential for specificity, but can be inaccurate due to the tendency for underestimation (WBCSD & WRI 2011). To perform these assessments well requires lots of time and financial resources (DEFRA et al. 2011).

Environmental input-output analysis

Estimating a carbon footprint using a process-based LCA approach can be difficult because including all scope 3 emissions is an administratively complex, expensive and methodologically challenging task (US Environmental Protection Agency 2012). In cases where there is neither the time nor financial resources to undertake process-based LCA studies, input–output models can provide a robust and cost-effective method of estimating an organisations scope 3 emissions (Tukker & Dietzenbacher 2013; Suh 2009; Huang et al. 2009). The difference with an input-output method is that estimations are usually based on the financial cost of the activity, whereas process-based LCAs attempt to measure the activity as directly as possible (Tukker & Dietzenbacher 2013). More recently, in input-output analyses, data about the carbon footprint of different sectors obtained from process-based LCA approaches has been included to allow the benefits of these two methods to be capitalised on.

Input-output analysis was originally developed by Leontief (Leontief 1970). It divides the economy into industrial sectors and maps their interdependence according to their financial transactions over a stated period of time (Leontief 1970). The sectors of an economy range from agricultural and manufacturing industries (e.g. chemical production) to transport, recreational, health and financial services (Scott et al. 2008). In the UK, the Office of National Statistics produces this information. Each sector is dependent on many other sectors, both as a customer of outputs from other sectors and as a supplier of inputs, for instance pharmaceutical industries require many resources to produce medications and then supply health care organisations with medication resources. The central feature of input-output analyses is an economic model that accounts for how demand for the products of each sector stimulates activity in each of the other sectors in the economy. This model then combines data about the carbon emissions produced by each sector to arrive at a model of the total emissions arising throughout the economy (Tukker & Dietzenbacher 2013). A carbon footprint can then be obtained from these calculations based on the financial cost of a particular product or activity and according to the sector it is classified as within the input-output table.

Input-output approaches aim to quantify all direct and indirect (embodied) emissions caused by a given product or service by taking its starting point as the whole economy. The boundaries set are therefore effectively infinite and no emissions are left outside the model, consequently the problem of truncation error found in process-based LCA approaches is overcome

(Lenzen 2000). The multi-region aspect of input-output analyses is necessary to avoid the assumption that emissions associated with domestic and import production are identical, which can introduce significant error, due to differences in the carbon intensity of national energy production and distribution factors (Turner et al. 2007; Wiedmann et al. 2007). Online tools exist that perform input-output analyses based on the cost of a particular item (EIOLCA 2012). These allow for simple translation from the cost of a given category (e.g. the medical equipment procured by a mental health organisation) into a carbon footprint.

Review of methodologies

The fundamental difference between these two methods is that input-output analysis tends to use financial data to obtain a carbon footprint, whereas process-based LCA use data about actual resource use, known as activity data. Both of these methods have their advantages and disadvantages, and which is most appropriate will depend on a number of factors including; the purpose of the carbon footprinting analysis, the type of clinical activity being measured, the precision required, the availability of primary data, the feasibility and the opportunity costs of measurement (WBCSD & WRI 2011). These are complex criteria and approaches need to balance the need for accuracy against the financial costs of accessing the information, which depends heavily on the availability of accurate primary data.

Input-output analysis is generally considered to be accurate but not precise (Lenzen et al. 2010) because it apportions emissions according to industry sectors. Different products from the same industry sector can therefore not be distinguished. On the other hand, process-based LCA are specific to one particular product and calculate impacts from resource use, bottom-up, using primary data. However, establishing a system boundary for assessment in process-based LCA means that, due to truncation error, the result, even if it is reliable, might not be accurate (Wiedmann 2010).

In a clinical context, using an input-output method, based on organisational spend for a given category, would provide an organisational level carbon footprint for that category (e.g. for medical equipment, energy or business services). To account for the carbon footprint of this category at a clinical activity level, e.g. an appointment, this would have to be scaled down to provide a carbon footprint for a particular clinical activity, according to defined allocation methods (WBCSD & WRI 2011). Process-based LCA on the other hand, could provide carbon footprints based on the resources used within clinical activities. This would involve measuring all the processes and products required to perform a clinical activity and then applying relevant emission factors.

Overview of thesis

This chapter has provided the context and rationale for the questions that will be addressed in this research, which are as follows:

1. What methods exist for estimating the carbon footprint of health care?
2. What attempts are being made to reduce the carbon footprint of mental health care?
3. Can existing methodologies for estimating carbon footprints be applied to provide an approach that is fit for purpose in mental health care?

The remainder of this chapter provides an introduction to the research undertaken. It should be noted that the first two questions provide a basis for the third question, which is the major question of this research.

The context for this research

The research reported here has been undertaken as part of a two-year sustainability fellowship with the Royal College of Psychiatrists. One objective of the fellowship was to develop a method for estimating the carbon footprint of mental health services that could be feasibly applied by service providers. This research was undertaken in order to address this aim. The methods used in this research are therefore, necessarily, applied and practical. An approach has been taken that is akin to 'action research', in that it has been initiated to solve a problem and has, through progressive problem solving, addressed this problem (Hart & M. Bond 1995). The aim of this clinician led research is to identify and develop a method for estimating the carbon footprint of mental health care that is 'fit for purpose' such that service providers can begin the process of estimating the carbon footprint of their services and then use this information in their decisions about service design. This context explains why feasibility plays such a prominent role and why the discussions about robustness have to be balanced against feasibility.

1. What methods exist for estimating the carbon footprint of health care?

In Chapter 2, the results of two systematic reviews are presented. In the first review, a broad search was performed that covered all aspects relating to the environmental sustainability of mental health care, including the mental health effects of climate change and the wider environmental impacts of mental health care. This review was designed to provide information about all that is known about the environmental sustainability of mental health care. This is a very new academic field and as such it was considered important to understand all the academic work that pertains to mental health and the environment before focusing on reviewing the available methodologies for carbon footprint assessments of health care. In the second review, a more specific search was performed to identify and appraise existing methods for estimating the carbon footprint of all types of health care. All forms of health care were included because of the novel nature of this research area. This review was designed to provide information about what methods have been employed to estimate the carbon footprint of health care and whether these methods can be applied to mental health care and could be used by service providers to assess the carbon footprint of their services.

2. What attempts are currently being made to reduce the carbon footprint of mental health care?

In Chapter 3, the results of two national surveys are presented that examine the environmental sustainability of current clinical and managerial practices across England. Given that service improvement projects performed with the aim of reducing the carbon footprint may not always be published, these surveys were undertaken to ensure that no environmentally sustainable practices occurring in mental health services across England were missed from the systematic reviews. The objectives of the surveys were to identify examples of environmentally sustainable clinical and organisational practice and determine whether environmental issues affect service design or decision-making. The first survey examined sustainable practices at a clinical team level and was completed by clinicians (the clinical survey); the second was aimed at organisational level sustainable practices and was completed by trust sustainability leads (the corporate survey).

3. Can existing methodologies for estimating carbon footprints be applied to provide an approach that is fit for purpose in mental health care?

To address this main question of the research, certain aspects of mental health have been chosen and investigated. There is a wide variety of sub-specialties within mental health care, e.g. general adult, forensic, liaison, child and adolescent, older adult, working age, learning disability and neuropsychiatry. This research has focused on aspects of general adult psychiatry, as this is the sub-specialty that provides the majority of psychiatric care delivered in the UK (NHS Careers 2013). This research examines both primary and secondary care settings, i.e. general and specialist service provision, covering mild to severe mental illness.

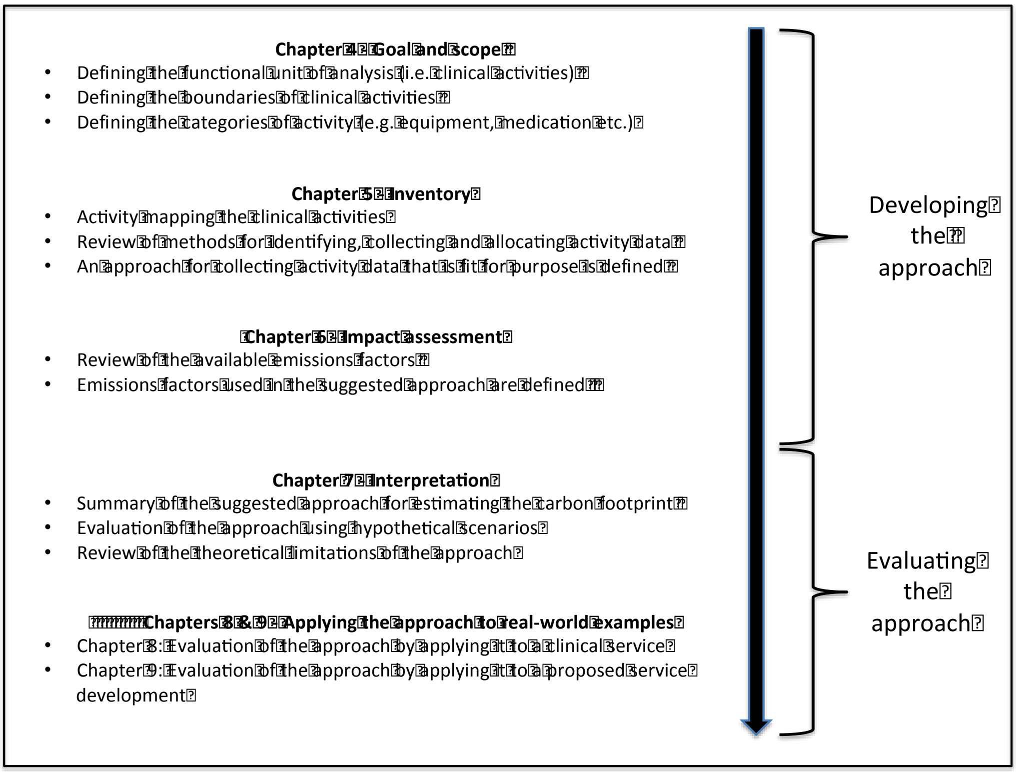
Developing an approach to estimating the carbon footprint of mental health care

The research adopts a stepwise approach to developing an approach, established by life cycle assessment (US Environmental Protection Agency 2012). These steps are:

1. Aim and scope – defining the aims and the boundaries of the assessment
2. Inventory – identifying and collecting data
3. Impact assessment – estimating the carbon footprint
4. Interpretation – review of the approach, the results and any limitations

This research considers each step (defined below) and provides an approach that can be applied to mental health care. Following this, the approach is reviewed to assess whether it is fit for purpose i.e. can it be feasibly applied to different mental health contexts and provide useful and relevant results for service providers.

Figure 2. Framework of the research in Chapters 4 – 9



Chapter 4. Aim and scope

The aim is to provide an approach to estimating the carbon footprint of mental health care that is fit for purpose. Fitness of purpose is defined in Chapter 4 and is based on whether the approach can be applied in a clinical context by service providers to allow informed choices to be made about which models of care provide the lowest carbon footprint. When estimating carbon footprints, multiple trade-offs are often required in order to achieve the objectives within the constraints of the context (WBCSD & WRI 2011). The trade-offs in this research are between robustness and feasibility and these trade-offs are based on the type of information or outcomes required by service providers to make decisions about service design and the resources available to perform the assessment. In Chapter 4, the parameters of feasibility are defined and the definition of robustness is provided.

The functional unit of analysis is defined in Chapter 4, which could be, for example, a clinical activity or a care pathway. A clinical activity is defined here as a discrete clinical encounter such as an assessment in a clinic, a home visit or one bed day. A care pathway is a set of clinical activities that make up a patient's treatment journey e.g. a course of psychotherapy or an admission.

The boundaries of assessment are also defined in Chapter 4. A boundary is a theoretical barrier that is used to contain discrete data. Defining the boundary involves making decisions about what to include in the assessment and what to leave out. Transparency and clarity are important as they allow a clear understanding about the limitations of the assessment. A review of the clinical context is presented, which provides the basis for defining the boundaries. The different categories of activity are also defined in Chapter 4, for example medication, equipment, procurement and travel.

Chapter 5. Inventory

All carbon footprint assessments require an inventory to identify and hold the data. Activity mapping is a process that identifies all the processes associated with each activity, it details each step (e.g. from arranging an appointment to writing up the notes afterwards) and identifies and measures what resources are required to perform the activity (e.g.

medication, equipment, travel etc.). Activity maps of the major types of clinical activity in mental health care are presented in Chapter 5.

The available methods of data collection are also reviewed in Chapter 5. Data can be collected from primary or secondary sources (DEFRA et al. 2011). Primary sources are specific to the activity in question and are collected 'first-hand', for example measuring travel use from surveys. Secondary sources use average or typical information about a general activity from a published source or from financial data.

The Greenhouse Gas Protocol states that using data from primary sources (collected within the activity being measured) is the method that tends to be more accurate (WBCSD & WRI 2011). Therefore, in Chapter 5, an attempt was made to collect primary data for a range of mental health clinical activities. The feasibility of collecting primary data was discussed for each category of data. If primary data could not be feasibly obtained then a review of the quality of the results obtained from secondary data was performed, based on the Greenhouse Gas Protocols data quality standards (WBCSD & WRI 2011). Chapter 5 concludes by providing a summary of the data collection methods that should be used for each category of activity.

Chapter 6. Impact assessment

The third step in estimating the carbon footprint of clinical care is that of conversion of data into a carbon footprint (DEFRA et al. 2011). This is achieved by applying an emission factor to the data. An emission factor, is defined above in more detail, but in short is a conversion factor that converts resource use into greenhouse gas emissions, for example, weight of medical equipment into $kgCO_2e$.

Emission factors can either be obtained using an input-output method (SDU 2013b) or a process-based LCA method. If an emission factor is based on an input-output method then the cost of the activity data is required for conversion to a carbon footprint, for example the emission factor for medication is 0.43 $kgCO_2e$/£. If the emission factor is based on a process-based LCA method then the amount of activity data is required, for instance the emission factor for driving a medium sized car is 0.155 $kgCO_2e$/km. The carbon footprints for each of the individual resources used can then be combined to estimate the carbon footprint of the clinical activity, see below:

Figure 3. Calculating the carbon footprint of clinical activities

$$\text{Carbon footprint of clinical activity} = \left(\text{Amount of activity data 1} \times \text{Emission factor 1}\right) + \left(\text{Cost of activity data 2} \times \text{Emission factor 2}\right)$$

Chapter 6 reviews this step of attributing emission factors to the collected data to obtain a carbon footprint. There are particular difficulties in estimating the carbon footprint of medication. Therefore, Chapter 6 provides a detailed account of the different available options for estimating the carbon footprint of medication. Due to the concerns noted in Chapter 6 about the reliability of carbon footprint estimates of medication, a sensitivity analysis is also presented. This assesses how the carbon footprint varies according to the country of manufacture and the different methods for measuring medication (according to either cost, weight of active ingredient or number of medications). A discussion is then presented that outlines the difficulties inherent in estimating the carbon footprint of medication and considers whether any approach is fit for purpose.

Chapter 7. Interpretation

The final step is interpretation, which involves defining and appraising the suggested approach, it considers the limitations and provides recommendations based on the findings of the preceding steps. The suggested approach is defined in Chapter 7 and given the term the 'combined' approach, as both primary and secondary data sources are used and both input-output and process-based LCA methods are used.

Chapter 7 also reports the results of a scenario analysis. The aim of which was to assess whether the combined approach could account for various changes to clinical practice. The scenarios were based on a single patient's outpatient treatment over the course of one year. The different scenarios were chosen to reflect clinical changes that have the potential to affect the carbon footprint. This analysis provided a foundation for discussing the limitations of the combined approach.

Chapters 8 and 9. Applying the approach

Chapters 8 and 9 consider whether the combined approach can be applied to different settings within mental health. In Chapter 8, a study is presented in which the combined approach was applied to an existing mental health service. The aim was to assess whether the approach can account for the effect that a relatively new and innovative mental health service has on the carbon footprint of the wider health care system. The service is a group-based psychotherapy service called a Therapeutic Community (TC), which is designed for the treatment of personality disorder (PD). A retrospective, cohort study is presented, which measured changes in health care service use over a four-year period for those using the TC service compared to a control group. The combined approach is used to estimate the carbon footprint difference between health care use before and after entry to the TC service.

While it is important to know how existing services affect the carbon footprint of the wider health care system, it is also important to be able to predict the carbon footprint of new services so that, if necessary, their design can be modified to contribute a reduced carbon footprint. Therefore, in Chapter 9, the combined approach was applied to a care-modelling analysis to assess whether it can predict the carbon footprint changes following the proposed service change. The approach is used to assess how a new service innovation that improves communications to patients about their appointments might affect the carbon footprint of future health care use. Here, a technological service improvement has been chosen as these types of service development are likely to become more common in the future (Maughan & Davison 2015).

Summary

The NHS has signed up to meet the 2008 Climate Change Act carbon reduction targets. To achieve this more evidence is required about the carbon footprint of clinical activities. Clarity is needed about the data requirements to support the estimation of carbon footprints so that service providers can develop systems to aid the collection of relevant data. Subsequent footprinting could then provide evidence on the major areas of carbon use and allow new services to be developed that have a reduced carbon footprint.

In mental health services in the UK, financial resources are constrained (McCrone et al. 2008). Estimating the carbon footprint is therefore likely to be driven by the financial agenda. An approach is therefore needed that is fit for purpose, which can be feasibly applied by NHS service providers to provide the most robust result within the constraints of the clinical context. By providing such an approach, this research hopes to support the reduction of the carbon footprint of mental health care.

Chapter 2

Systematic reviews

Introduction

In this chapter, two reviews are presented. First, a review that covers all aspects relating to environmental sustainability and mental health is presented. Due to the novel nature of this research topic, it was considered important to identify all relevant research. The aim of this review was therefore to provide context about the available evidence and the state of the literature about mental health care and the environment. A second, more specific review of the literature was undertaken, relevant to the estimation of the carbon footprint of health care. All areas within the health care sector were included to ensure capture of all relevant evidence. The aim of this review was to review the available methodologies for estimating the carbon footprint of health care.

Systematic review of the evidence relating to interactions between mental health care and impacts to the environment

Aim

- To collate the available evidence about the interactions between mental health care and the environment

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses was followed (Liberati et al. 2009).

Eligibility criteria

This literature search focused on sustainability and mental health care. The following eligibility criteria were used: publication from January 2000 to November 2014 inclusive; English language and those articles related to the environmental sustainability of mental health services. Given the novel nature of this research field, it was considered unlikely that any relevant publications were published prior to 2000.

Search methods

Articles were identified from a systematic search of electronic databases. These comprised PsycINFO, Medline and EMBASE. Search terms relating to both sustainability and mental health were combined in the search strategy to ensure the focus was maintained on environmental sustainability and mental health care rather than either of these areas individually. The list of search terms are listed below:

- "sustainability" OR "sustainable" OR "environment" OR "environmental"

  AND
- "mental health" OR "psychiatric" OR "psychiatry" OR "mental illness"

Abstracts of generated articles were reviewed to determine which studies related to environmental sustainability in mental health. The references of included articles were reviewed to find studies potentially missed by the search of the database. To maximise inclusion of all available evidence, no articles were excluded on the basis of quality.

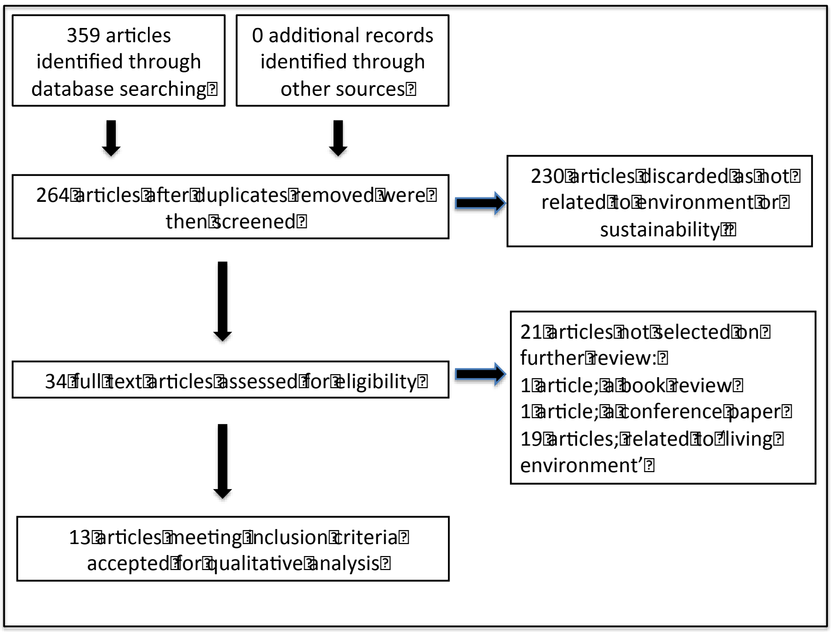
Data synthesis

No re-analysis or meta-analysis was performed. This was not appropriate given the focus of the review and the data available in the eligible articles, rather a narrative review was performed.

Results

The search identified 359 articles, which reduced to 264 following removal of duplicates. The review of abstracts revealed 34 articles related to environmental sustainability and mental health. Full texts of these articles were then assessed for eligibility. Subsequently, 21 articles were excluded on further review. One article was a book review, one article was a conference paper and 19 articles related to the 'living environment' of mental health patients rather than the global environment. The remaining 13 articles were included.

Figure 4. Search flow diagram 1



The 13 articles included eight editorial or comment articles and five review articles. There was no quantitative or qualitative study analysing original research. Seven of the articles were published and based in Australia. There were two articles from the UK, one article from Portugal and one article from the USA. Two papers incorporated evidence from multiple countries.

Analysis of articles

For the results and conclusions of the articles please see Table 2. Articles are presented in the table according to the type of article, e.g. editorial or review article, then discussed in the order they appear in the table. One review article reviewed the effect of psychiatric pharmaceuticals on the environment (Calisto & Esteves 2009). The authors reviewed the evidence for the occurrence, persistence, environmental fate and toxicity of psychiatric pharmaceuticals on non-target organisms. They found a range of concentrations of pharmaceuticals across samples but no data about the persistence or toxicity of these in organisms. One review article, performed in Australia (Berry et al. 2011), reviewed the evidence for the mental health effects from climate change in farmers. The authors did not find any evidence for this link and concluded that further knowledge is needed about the mental health of farmers facing climate change.

Three review articles related to post-environmental disaster psychiatry (Milligan & McGuinness 2009; Patel et al. 2012; L Katz 2011), e.g. following a tsunami or cyclone. One of these articles attempted to identify factors that affected the long-term sustainability of emergency psychosocial interventions in crisis situations (Patel et al. 2012). Another outlined the evidence for risk factors for mental health conditions after environmental disasters (L Katz 2011). The other review article on this subject found that mental health impacts are directly related to the level of exposure to an environmental disaster (Milligan & McGuinness 2009).

Table 2. Articles selected from systematic review of the literature regarding environmental sustainability in mental health care

Title	Author, Year, Country	Study design / article type	Objective	Summary of Findings
Psychiatric pharmaceuticals in the environment. (Calisto & Esteves 2009)	Calisto et al 2009 Portugal	Review	To review the literature data related to the occurrence, persistence, environmental fate and toxicity for non-target organisms of psychiatric pharmaceuticals.	There are large discrepancies in the amount of psychiatric pharmaceuticals removed by wastewater treatment plants. Some methods used in wastewater treatment have removal efficiencies below 10%. Consequently, large amounts of active substance pass through the wastewater treatment plants completely unaffected. Pharmaceuticals such as diazepam and fluoxetine are being accumulated in water/sediment environments due to their high persistence and resistance to biotic and abiotic degradation processes. Few data is available about chronic toxicity to better assess the exposure risks for aquatic organisms.
Climate change and farmers' mental health: risks and responses. (Berry et al. 2011)	Berry et al 2011 Australia	Review	To review evidence for the mental health effects from climate change in farmers	No association found between climate change and mental health. Australian studies have shown men in farming occupations have higher rates of suicide compared with the wider rural population or men nationally.
Transitioning mental health & psychosocial support: from short-term emergency to sustainable post-disaster development (Patel et al. 2012)	Patel 2012 Multinational	Review	To identify factors that affect the long-term sustainability of emergency mental health and psychosocial interventions in crisis and conflict.	Five thematic areas were identified that should be addressed that enable successful transition from emergency settings to development phase. Themes include: Government and Policy, Human Resources and Training, Programming and Services, Research and Monitoring, and Financing.
Disaster psychiatry: Good intentions seeking science and sustainability. (L Katz 2011)	Katz, 2011 Multinational	Review	To review the evidence regarding post-disaster psychiatry	The review outlined the evidence for both pharmacological and psychological interventions. They also outlined the evidence for risk factors of developing mental health conditions post-disaster. Author's recommendations: There should be more emphasis on acute interventions, for which there is scant evidence. There should be more emphasis working to strengthen communities.
Mental health needs in a post-disaster environment (Milligan & McGuinness 2009)	Milligan et al 2009 USA	Review	To review evidence of mental health effects post-natural disasters	The impact on survivors' mental well being is directly related to the level of exposure to a disaster. Mental health professionals must include crisis management, planning, and communication in pre- and post-disaster interventions with people who have mental illness.
An ecological approach to	Nurse et al	Editorial	Proposal of an ecological	Authors propose that the ecological public health perspective involves

promoting population mental health and well-being - A response to the challenge of climate change. (Nurse et al. 2010)	2010 UK		framework to improve mental health	addressing underlying factors and wider determinants that result in poor mental and environmental health. This involves promoting community engagement, increasing group activities and access to green space, all of which can work to improve mental health and the environment.
Mind, body, spirit: co-benefits for mental health from climate change adaptation and caring for country in remote Aboriginal Australian communities. (Berry, Butler, et al. 2010)	Berry et al 2010 Australia	Editorial	To discuss how to manage the mental health effects from climate change in rural populations	Authors suggest that Caring-for-country projects on traditional lands in remote locations may provide a novel way to achieve the linked goals of climate change adaptation with co-benefits for social and emotional wellbeing.
Pearl in the oyster: Climate change as a mental health opportunity. (Berry 2009)	Berry 2009 Australia	Editorial	A proposal for mental health promotion to reduce effects of climate change.	Author suggests that building social capital is an appropriate response to climate change as it is associated with a wide range of socioeconomic and health advantages, particularly decreased psychiatric morbidity.
The impact of climate change on mental health (but will mental health be discussed at Copenhagen?).(Page & Howard 2009)	Page et al 2009 UK	Editorial	To discuss how climate change could have consequences for global mental health	Authors suggest that climate change has the potential to have significant negative effects on global mental health and that these effects will be felt most by those with pre-existing serious mental illness
Hope, despair and transformation: Climate change and the promotion of mental health and wellbeing. (Fritze et al. 2008)	Fritze et al 2008 Australia	Editorial	To discuss the relationship between climate change and mental health.	The authors suggest four conclusions: 1. the direct impacts of climate change will have significant mental health implications; 2. climate change is already impacting on the determinants of mental health; 3. understanding the challenges posed by climate change creates emotional distress and anxiety; 4. understanding the psycho-social implications of climate change inform action
'Radical hope' and rain: Climate change and the mental health of Indigenous residents of northern Australia. (Hunter 2009)	Hunter 2009 Australia	Editorial	To discuss the effects of climate change and mental health of Indigenous residents of northern Australia	The authors suggest it is important to enhance adaptive capacity of Indigenous Australians and that the potential effects from climate change should be categorised as follows: Short term effects: distress and anxiety. Intermediate effects: distress and anxiety, substance abuse
Climate change and mental health: a causal pathways framework. (Berry, Bowen, et al. 2010)	Berry et al 2010 Australia	Editorial	Proposal of an explanatory framework for how climate change can impact on mental health	Authors suggest that climate change may affect mental health directly by exposing people to trauma. It may also affect mental health indirectly, by affecting physical health and community wellbeing. Vulnerable people and places, especially in low- income countries, will be particularly affected.
Natural disasters, climate change and mental health considerations for rural Australia. (Morrissey & Reser 2007)	Morrissey et al 2007 Australia	Editorial	To discuss the psychological approaches following climate change and natural disasters	Authors conclude that natural disasters and climate change require a sustained and interdisciplinary community preparedness and response program, alongside promotion of community health and wellbeing and preventive mental health initiatives.

The remaining eight articles were editorials. Nurse and colleagues reviewed the evidence for the co-benefits between environmentally sustainable living practices and good mental health (Nurse et al. 2010). They suggested that increasing access to green space, taking more exercise and improving community participation could improve mental health and potentially reduce the environmental impacts of health care. However, there were no discussions about how to measure the carbon footprint or define environmental sustainability in mental health care in this article. Two other editorials continued this theme of co-benefits and suggested that projects that improved community participation (Berry, Butler, et al. 2010) and increased social capital (Berry 2009) could mitigate the effects of climate change on mental health. A major theme covered in three other editorials was how mental health is affected by climate change (Hunter 2009; Page & Howard 2009; Fritze et al. 2008). Hunter (2009), Page et al. (2009) and Fritze et al. (2008) all suggested that mental health rates will be affected by climate change and agreed that the more disadvantaged communities will be the most affected by any changes. These conclusions were not based on data but on predictions about how climate change might affect communities and food and water availability. Berry and co-workers explained how climate change might impact on mental health by suggesting a causal pathway framework (Berry, Bowen, et al. 2010). This article linked how traumas, caused by climate change, might lead indirectly to mental health effects. Morrissey and Reser discussed how the mental health effects of climate change require an appropriate response from health care structures to ensure "*sustained and interdisciplinary community preparedness*"

(Morrissey & Reser 2007). For more details of all these articles, please refer to Table 2.

Limitations of search design

Environmental sustainability is a complex subject area and there are many terms that can be used to define the subject, therefore it is possible that the search terms, despite being as inclusive as possible, missed some relevant articles. There is also the possibility that environmental sustainability projects are being performed but not being published, these projects would be difficult to discover and may have been missed from this search strategy. Also, the search was only in English, so there may be published literature in other languages pertaining to this area that has been missed.

Discussion

Environmental sustainability in mental healthcare is a new discipline and there is clearly a lack of original research in this area. Most articles found were editorials and represent expert opinion. Five of the eight editorials were published in Australia. This could be due to the fact that Australia has a highly variable climate and is therefore more vulnerable to the effects of climate change (Berry et al. 2011). A range of articles was found relating to the broad topic of environmental sustainability, from mitigation to adaptation and also advocacy against climate change. One article was found that mentioned the carbon footprint of mental health care, it focused on how improving mental health and reducing environmental impacts are linked (Nurse et al. 2010). While this editorial suggested specific models of care that might have less environmental impacts, no suggestion was made about how the carbon footprint should be estimated. One article included data about environmental impacts, however this was not about the carbon footprint of care but about the levels of psychiatric pharmaceuticals located in water systems (Calisto & Esteves 2009). Two editorials suggested that increasing social capital and community participation can help reduce the mental health effects of climate change (Berry, Butler, et al. 2010; Berry 2009). Several studies discussed the potential interactions between mental health and climate change, but no evidence was found of an association between climate change effects and mental health. The remaining articles reviewed the provision of mental health care following environmental disasters, relating to the adaptation of mental health services following climate change effects.

Conclusions

These results show there is evidence about how mental health services should adapt to environmental disasters that could be caused by climate change. But there is a lack of evidence about what changes need to be made to the provision of mental health care to improve its environmental sustainability, only suggestions have been made, but these are not based on evidence (Nurse et al. 2010). Research is needed to investigate the specific mental health effects of climate change, reviews found here suggest there is a link (Berry, Bowen, et al. 2010), but currently there has been no evidence presented linking these two phenomena.

Systematic review of the evidence for estimating the carbon footprint of health care

Aim

- To review carbon footprint assessments performed in health care settings

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses was followed (Liberati et al. 2009).

Eligibility criteria

The following eligibility criteria were used: English language and those articles related to carbon footprint assessments of health care. No time limits were imposed on this search. This strategy was adopted to ensure that all available articles were included in the analysis.

Search Strategy

Articles were identified from a systematic search of an electronic database. This comprised the 'PubMed' database; a database of medical and health care related journals (PubMed n.d.). This database was chosen as it included health care related research, which was the focus of this review. The search term "carbon footprint" was used and restricted to "included in title". This search term was used, as it is the proxy measure of environmental impact used in this research and it is the most common type of environmental impact measured in health care (SDU 2014a). The term “environmental” was not used, as when restricted to “included in title”, this still yielded over 50,000 results. The term “environmental impacts analysis” was not used as, with no restrictions, this yielded over 440,000 results, but when restricted to “included in abstract and title” yielded no results.

I performed an additional search using ‘Google Scholar’ to ensure that articles lying outside of medical databases would not be missed. The search terms used were restricted to “included in title” and comprised:

‘carbon footprint’ AND (health OR healthcare OR care OR medicine OR medical OR hospital OR clinic OR clinical OR service OR theatre OR operating OR operation OR medication OR pharmaceutical OR pharmacy)

This was to ensure that any carbon footprint study relating to any aspect of health care would be included. Using these search terms without restricting to the title produced over 9,000 results, while just using carbon footprint and restricting it to the title produced over 3,000 results.

Abstracts of generated articles were reviewed to determine which studies related to carbon footprint assessments of health care services. The references of included articles were reviewed to find references to studies potentially missed by the search of the library database. To maximise inclusion of all available evidence, no articles were excluded on the basis of quality.

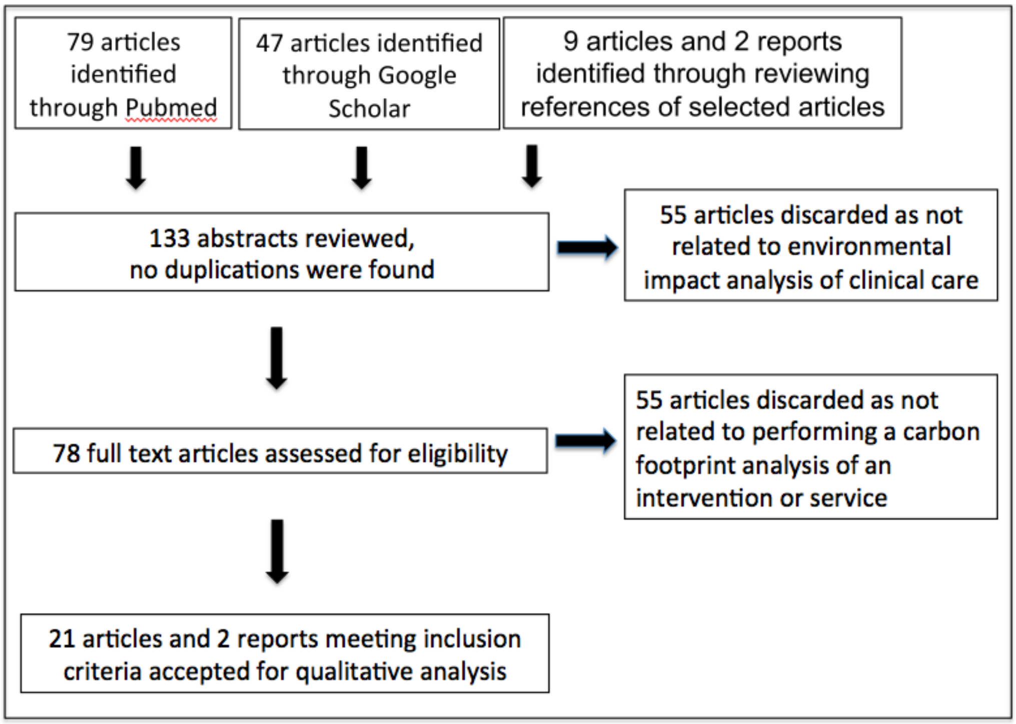
Data synthesis

No re-analysis or meta-analysis was performed; this was not appropriate given the data available in the eligible articles, rather a narrative review was performed.

Results

The PubMed search generated 79 articles, 5 further articles (Zander et al. 2011; Bond et al. 2009; Pollard et al. 2013; Lewis et al. 2009; Sherman et al. 2012) and 2 non-academic reports (Scott et al. 2008; SDU 2013b) were identified through other sources. Review of abstracts revealed 31 relevant articles. Full texts of these articles were then assessed for eligibility. 14 articles were excluded on further review. The remaining 15 articles and 3 non-academic reports were included. The Google Scholar search generated 47 articles, 4 further articles (Sorenson et al. 2014; Lui et el. 2014; Lim et al. 2013; Duane et al. 2012) were identified through other sources.

Figure 5. Search flow diagram 2



Analysis of articles

For the results of the articles please see Table 3. Articles are presented in the table according to author. Three main types of analysis were found; those looking at whole clinical systems (Chung & Meltzer 2009; Pollard et al. 2013; Scott et al. 2008; SDU 2013b; Duane et al. 2012), those looking at specific services or interventions (Sherman et al. 2012; Pollard et al. 2014; Morris et al. 2013; Somner et al. 2009; Connor et al. 2010; Connor et al. 2011; Gilliam et al. 2008; Gatenby 2011; Lim et al. 2014), those looking at specific products in health care (Sorenson et al. 2014; Lui et el. 2014, Grimmond et al. 2012; Southorn et al. 2013) and those reviewing the carbon footprint associated with health related travel (A. Bond et al. 2009; Lewis et al. 2009; Zander et al. 2011; Andrews et al. 2013; Holmner et al. 2014).

Table 3. Articles selected from systematic review of the literature regarding carbon footprint analyses in health care

Title	Author Year Country	Objective	Methods	Summary of Findings
Carbon footprint of patient journeys through primary care: a mixed methods approach (Andrews et al. 2013)	Andrews et al 2013 UK	To investigate the carbon footprint of patients travelling to general practice surgery	Mixed methods; patient travel survey, retrospective health record analysis and patient interviews.	The majority (61%) of patient journeys to and from the surgery were made by car or taxi; main reasons cited were 'convenience', 'time saving', and 'no alternative' for accessing the surgery. The annual estimated CO_2e emissions for the practice was 63 tonnes. Predominant themes from interviews about not using active travel methods was related to issues with systems for booking appointments and repeat prescriptions; alternative travel modes; delivering health care; and solutions to reducing travel.
Tackling climate change close to home: mobile breast screening as a model (A. Bond et al. 2009)	Bond et al 2009 UK	To compare the travel by patients attending mobile breast screening clinics compared to central screening services	Retrospective analysis of patient travel based on patient postcodes obtained from patient records	The availability of mobile breast screening clinics for the 60,675 women who underwent screening over a three-year cycle led to a return journey distance savings of 1,429,908 km. Taking into account the CO_2e emissions of the tractor unit used for moving the mobile clinics around, this equates to approximately 75 tonnes of CO_2 saved per year.
Estimate of the Carbon Footprint of the US Health Care Sector (Chung & Meltzer 2009)	Chung et al. 2009 US	To estimate the carbon footprint of the US health care sector	Input Output assessment from national expenditure data	The health care sector, including upstream supply-chain activities, contributed an estimated total of 546 $MMTCO_2e$, of which 254 $MMTCO_2e$ (46%) was attributable to direct activities. The largest contributors were the hospital and prescription drug sectors (39% and 14%, respectively). Approximately 80% of total global warming potential was due to carbon dioxide emissions.
The carbon footprint of a renal service in the United Kingdom (Connor 2010)	Connor et al 2010 UK	To measure the carbon footprint of an individual specialty service including both direct and indirect emissions.	Process-based LCA method. Activity data were collected for building energy use, travel and procurement.	The Dorset Renal Service has a carbon footprint of 3,006 tonnes CO_2e per annum, of which 381 tonnes CO_2e (13% of overall emissions) result from building energy use, 462 tonnes CO_2e from travel (15%) and 2163 tonnes CO_2e (72%) from procurement. The contributions of the major subsectors within procurement are: pharmaceuticals, 1043 tonnes CO_2e (35% of overall emissions); medical equipment, 753 tonnes CO_2e (25%). The emissions associated with healthcare episodes were estimated at 161kg CO_2e per bed day for an inpatient admission and 22 kg CO_2e for an outpatient appointment.

The carbon footprints of home and in-center maintenance hemodialysis in the United Kingdom (Connor et al. 2011)	Connor et al. 2011 UK	To determine the carbon footprints of the differing modalities and treatment regimes used to deliver maintenance hemodialysis	Process-based LCA method. Emission factors were applied to data that were collected for building energy use, travel and procurement.	Thrice weekly in-center HD has a carbon footprint of 3.8 ton CO_2e per patient per year. The carbon footprint of providing home HD varies with the regime. For standard machines: 4 times weekly (4 days, 4.5 hours), 4.3 ton CO_2e; 5 times weekly (5 days, 4 hours), 5.1 ton CO_2e; short daily (6 days, 2 hours), 5.2 ton CO_2e; nocturnal (3 nightly, 7 hours), 3.9 ton CO_2e; and nocturnal (6 nightly, 7 hours), 7.2 ton CO2 Eq. For NxStage equipment: short daily (5.5 days, 3 hours), 1.8 t CO_2e; 6 nightly nocturnal (2.1 ton CO_2e). The carbon footprint of HD is influenced more by the frequency of treatments than by their duration.
Taking a bite out of Scotland's dental carbon emissions in the transition to a low carbon future (Duane et al. 2012)	Duane et al. 2012	To quantify the carbon emissions of a national dental service.	Combined an input–output analysis for indirect emissions and a process analysis approach for direct emissions. Energy and water consumption were based on meter readings, waste-related emissions from collection contracts and travel from staff and patient questionnaires.	The carbon footprint for the service was 1798.9 tonnes CO2eq per annum. Travel was the greatest source (45.1%) followed by procurement (35.9%) and building energy (18.3%). Perhaps counter-intuitively older clinics had lower footprints than newer clinics as they are less energy intensive. Extrapolating the data suggests that Scotland's NHS dental service annually generates 0.16 mega tonne (Mt) CO2eq (4%) of the total Scottish NHS carbon footprint.
Modelling the carbon footprint of reflux control (Gatenby 2011)	Gatenby 2011 UK	To examine two different strategies for the treatment of gastro-oesophageal reflux disease and their modelled costs and carbon emissions	Study uses data about the costs and carbon footprint of care from an input-output analysis (SDU 2009) to model the carbon emissions associated with treatment	There is a high initial cost (financially and carbon emissions) for surgery, however subsequent 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. There are ongoing emissions of 100 $kgCO_2e$ per annum in the medical arm and 30 $kgCO_2e$ per annum in the surgical arm.
The carbon footprint of laparoscopic surgery: should we offset? (Gilliam et al. 2008)	Gilliam et al 2008 UK	To estimate the effect that the expansion of laparoscopic surgery has had on global warming.	Process-based LCA method using a retrospective analysis of patient record, assessing use of CO_2 cylinders only	There was a fourfold increase of in the number of laparoscopic procedures performed over the past 10 years. Each CO_2 cylinder produces only 0.0009 of tonnes of CO_2e. Despite increasing frequency of the laparoscopic approach in general surgery, its impact on global warming is negligible.
Impact on carbon footprint: a life cycle	Grimmond et al.	To estimate the carbon footprint of	Process-based LCA method using the manufacture,	Using recyclable sharps containers led to an annual reduction of 127 MTCO2eq (-83.5%) and saved 30.9 tons of plastic and 5.0 tons of cardboard from landfill.

assessment of disposable versus reusable sharps containers in a large US hospital (Grimmond et al. 2012)	2012 US	recyclable vs disposable sharps containers	transport, washing, and treatment and disposal of sharps and the containers.	
Carbon Footprint of Telemedicine Solutions - Unexplored Opportunity for Reducing Carbon Emissions in the Health Sector (Holmner et al. 2014)	Holmner et al 2014 Sweden	To evaluate whether telemedicine services reduces travel and thus carbon emissions.	Process-based LCA method analysing equipment used in telemedicine	Replacing physical visits with telemedicine appointments resulted in a significant 40–70 times decrease in carbon emissions. Based on the upper and lower bound scenarios defined in this paper, a one hour telemedicine appointment was estimated to generate 1.86 and 8.43 $kgCO_2e$, respectively. Consequently, tele-care is carbon cost-effective once there is a need for the patient to travel at least 3.6 km by car for a one-hour appointment using the Lenzen estimate and 7.2 km based on the Leduc estimate
Use of videoconferencing in Wales to reduce carbon dioxide emissions, travel costs and time (Lewis et al. 2009)	Lewis et al. 2009 UK	An evaluation of the environmental impact of using video conferencing	Travel survey of staff using video conferencing	In October 2006 and October 2007 users of videoconferencing equipment at one site avoided 18,000 km of car travel, equivalent to 1696 $kgCO_2e$. During October 2007, 20,800 km of car travel were avoided, equivalent to 2590 kg CO_2e.
The carbon footprint of an Australian satellite haemodialysis unit (Lim et al. 2013)	Lim et al. 2013 Australia	To estimate the carbon emission impact of haemodialysis throughout Australia	Used activity data and pre-existing emission factors from haemodialysis to estimate the relative contributions from electricity and water.	In Victoria, the annual per-patient carbon footprint of satellite HD was calculated to be 10.2 t CO2-eq. The largest contributors were pharmaceuticals (35.7%) and medical equipment (23.4%). Throughout Australia, the emissions percentage attributable to electricity consumption ranged from 5.2% to 18.6%, while the emissions percentage attributable to water use ranged from 4.0% to 11.6%.
The carbon footprint of cataract surgery (Morris et al. 2013)	Morris et al. 2013 UK	To assess the carbon footprint of a cataract pathway in a British teaching hospital.	Process-based LCA method	The carbon footprint for one cataract operation was 181.8 $kgCO_2e$. On the basis that 2230 patients were treated for cataracts during 2011 in Cardiff, this has an associated carbon footprint of 405.4 tonnes CO_2e. Building and energy use was estimated to account for 36.1% of overall emissions, travel 10.1% and procurement 53.8%, with medical equipment accounting for the most emissions at 32.6%.
Mainstreaming Carbon Management in Healthcare Systems: A	Pollard et al 2012	To explore a bottom-up modeling	A process-based LCA model was developed to analyse the carbon footprint of a	The estimated emissions from secondary healthcare in Cornwall was 5787 T CO_2e with patient travel adding 2215 T CO_2e. Closing selected sites could reduce emissions by 4% (261 T CO2eq), a reduction that is less than the resulting increases in patient transport

Bottom-Up Modeling Approach (Pollard et al. 2013)	UK	framework to aid in the decision-making for both carbon and cost in healthcare	health service based on travel, energy use and number of interventions provided	emissions. Reducing hot water temperatures by 5 °C and improving theatre usage would lower the carbon footprint by 0.7% (44 T CO_2e) and 0.08% (5 T CO_2e), respectively.
The carbon footprint of acute care: how energy intensive is critical care? (Pollard et al. 2014)	Pollard 2014 UK	To measure the carbon footprint of a critical care unit	Process-based LCA method reviewing only energy usage.	Less than 50% of the electricity within a critical care unit was used for delivering care to patients and monitoring their condition. In this paper, the carbon footprint for each type of treatment was determined based on the use of electricity provided in critical care.
NHS England Carbon Emissions: Carbon Footprint modeling to 2020 (Scott et al. 2008)	Scott 2008 UK (for the SDU)	To assess the carbon footprint of the NHS	Environmental input-output assessment from national expenditure data, travel emissions from national travel survey and energy use from national energy use data	Results were based on input-output tables from 2004, energy use data from 2004 and the national travel survey from 2004. Results revealed that the total carbon footprint of the NHS was 18 Mtonnes CO_2e. Procurement constitutes 59%, energy use 22% and travel 18%. Pharmaceutical emissions (22%) provided a similar contribution to building energy or travel sectors.
Goods and services carbon hotspots (SDU 2013b)	SDU 2013	To provide carbon footprint data for clinical activities across different health care sectors	Environmental input-output assessment from organisational expenditure data (228 organisations were reviewed for their non-pay spend data)	Results revealed that the total carbon footprint of the NHS was 25 Mtonnes CO_2e. Pharmaceuticals contribute 22% of the NHS England carbon footprint, most of this (79%) in GP prescribing, primary care and community services. Acute and mental health services contribute 13% and 5% of the pharmaceuticals footprint respectively. Medical instruments contribute 13% to the NHS England carbon footprint with most of this (75%) from acute services and a further 13% in primary care and community services. Building energy use contributes 18% of the NHS England carbon footprint with the largest contribution from acute services (73%). Travel contributes less than 5%, this was less than the analysis of the NHS in 2004 as patient related travel from the national travel survey was not included. Carbon footprint for clinical activities were extrapolated from these results.
Life Cycle Greenhouse Gas Emissions of Anesthetic Drugs (Sherman et al. 2012)	Sherman 2012 US	To examine the climate change impacts of 5 anesthetic drugs	Process-based LCA method. At each stage of the life cycle, energy, material inputs, and emissions were considered, as well as use-specific impacts of each drug.	Desflurane accounts for the largest life cycle GHG impact among the anaesthetic drugs considered here: 15 times that of isoflurane and 20 times that of sevoflurane when administered in an O_2/air admixture. GHG emissions increase significantly for all drugs when administered in an N_2O/O_2 admixture. For all of the inhalation anesthetics, GHG impacts are dominated by uncontrolled emissions of waste anesthetic gases. GHG impacts of propofol are comparatively quite small, nearly 4 orders of magnitude lower than those of desflurane or nitrous oxide.
Ophthalmology carbon	Somner	To assess the	Process-based LCA method	10.2 million cataract operations are performed each year, but it is estimated that this

footprint: Something to be considered? (Somner et al. 2009)	et al. 2012 UK	carbon footprint of cataract operations		will increase to more than 30 million cataracts per annum by 2020. If this volume of cataract surgery were to be carried out with phacoemulsification instead of MSICS, it would result in 8400 extra tons of plastic waste, 240 extra tons of paper waste, and 2361 tons of CO2 emissions. The difference between 2 types of cataract surgery strategies is 894 408 tonnes of CO_2 emissions
Life cycle assessment of alternative bedpans–a case of comparing disposable and reusable devices (Sørensen et al. 2014)	Sørensen et al. 2014 Denmark	To determine the environmental sustainability of disposable vs reusable bedpans	Used a process-based LCA method to assess the wider environmental sustainability of bedpans	Data indicates that disposable bedpans are environmentally preferable to the reusable ones. First, because of the energy use for recovery in the range, second because when using disposable bedpans the energy is recovered through waste incineration instead of wastewater treatment.
Reducing the carbon footprint of the operating theatre: a multicentre quality improvement report (Southorn et al. 2013)	Southern et al. 2013 UK	To measure the weight of clinical waste from an operating theatre	Measured the weight of clinical waste used in orthopaedic operations	Staff education strategies managed to reduce the carbon footprint of clinical waste by 50%
Comparison of the carbon footprint of different patient diets in a Spanish hospital (Vidal 2014)	Vidal et al. 2014 Spain	Aimed to quantify the carbon footprint of different diets	Average carbon footprint for a normal diet was based on detailed composition data using a process-based LCA method.	The average carbon footprint of one day of hospital food is 5.083 $kgCO_2e$.
Changes in travel-related carbon emissions associated with modernization of services for patients with acute myocardial infarction: a case study (Zander et al. 2011)	Zander et al. 2010 UK	To compare the carbon footprint of different models of cardiac care	The study estimated carbon emissions associated with ambulance transport based on postcodes from patient records	The average ambulance journey required for transporting a myocardial infarction patient to its closest care point was 13.0 km under the thrombolysis model and 42.2 km under the a percutaneous coronary intervention model, producing 3.46 and 11.2 kg of CO2 emissions, respectively. Thus, introducing percutaneous coronary intervention will more than triple ambulance journey associated carbon emissions

Regarding those articles that related to whole health systems, Chung and colleagues used an input-output method to obtain an estimate of the carbon footprint for all health care in the United States (US) (Chung & Meltzer 2009). Studies relating to the carbon footprint of the NHS are discussed below in more detail, but used input-output and process-based LCA methods (Scott et al. 2008; SDU 2013b). The assessment of dental care in Scotland also used a similar combined approach; an input–output analysis for indirect emissions and a process analysis approach for direct emissions (Duane et al. 2012). Health care in the US provides a larger proportion of the national carbon footprint (8%), compared to the UK (3%) (Chung & Meltzer 2009; SDU 2013b). Pollard et al. (2013) presented a process-based LCA that could be applied to assess the carbon footprint of discrete health care systems based on the travel, energy use and number of interventions provided (Pollard et al. 2013).

Seven articles assessed the carbon footprint of specific interventions or services; three related to dialysis (Connor 2010; Connor et al. 2011, Lim et al. 2013), two related to cataract surgery (Morris et al. 2013; Somner et al. 2009), two related to general surgery (Gilliam et al. 2008; Gatenby 2011), and one related to acute care (Pollard et al. 2014). These assessments all used a process-based LCA method to estimate the carbon footprint, except for one study which used an input-output method (Gatenby 2011). Two of these studies only studied one variable as an indicator for the carbon footprint of the service, such as electricity (Pollard et al. 2014), or gas cylinders (Gilliam et al. 2008). One article estimated the carbon footprint associated with the different types of anaesthetic gases (Sherman et al. 2012) and found gross differences between their global warming potential.

Two articles compared disposable versus reusable items; bedpans (Sorenson et al. 2014) and sharps containers (Grimmond et al. 2012). Sorenson and colleagues found that it was more environmental sustainable to use disposable as this allowed for the waste to be re-used to produce heat energy (Sorenson et al. 2014). This study did not just measure the carbon footprint of the waste but also the wider ecological impacts. In contrast, Grimmond and colleagues used a process-based LCA method and found reusable sharps containers to significantly reduce the carbon footprint of the hospital (Grimmond et al. 2012). One study measured the waste from an operating theatre and found that the carbon footprint could be reduced by 50% (Southorn et al. 2013). Another study used a process-based LCA to estimate the carbon footprint associated with hospital meals (Vidal et al. 2014)

Three articles reviewed the carbon footprint associated with health care related travel (Bond et al. 2009; Lewis et al. 2009; Zander et al. 2011). One article used surveys and patient interviews to assess methods of travel to primary care appointments and determine why patients used different travel methods (Andrews et al. 2013). Holmner and colleagues used a process-based LCA approach, to estimate the change to the carbon footprint following the initiation of a tele-medicine service and the associated reduction in patient travel (Holmner et al. 2014). Lewis et al. (2009)

estimated the change to the carbon footprint following the addition of a video-conferencing service and the associated reduction in staff travel (Lewis et al. 2009). For results please see table 3 above.

The two reports estimating the carbon footprint of the NHS, by the SDU, used a combination of input-output and process-based LCA methods to provide estimates for the carbon footprint of the NHS, across mental health care, primary care, acute care and ambulance care (SDU 2013b; Scott et al. 2008). Given that these reports provide the only evidence about the carbon footprint of mental health care and because their results are used in this research, a more detailed explanation of these studies are provided here.

A summary of the SDU reports on the carbon footprint of the NHS

Scott et al. produced the first report of the total NHS carbon footprint for the SDU based on 2004 data (Scott et al. 2008). They used an input-output approach, based on national expenditure data, to estimate the carbon footprint of embedded emissions, the national travel survey to estimate emissions associated with travel and an NHS database which provides direct energy use data to obtain emissions associated with energy use, called ERIC (Estates Return Information Collection) (ERIC 2014). The study found that procurement contributes 59% of all NHS emissions, of which medication contributes 22% and medical equipment 9%. Travel contributes 18% and energy use 22% (Scott et al. 2008).

In 2012, the SDU obtained non-pay spend data from 228 NHS organisations, including five mental health organisations, to provide carbon footprint estimates for the different specialties (SDU 2013b). An input-output method was then used to obtain the carbon footprint. Results for mental health were obtained by averaging the results from the five mental health organisations included; the results are displayed below.

Table 4. The components of the carbon footprint of mental health services, obtained from an input-output method, taken from (SDU 2013b)

Mental health services sector	NHS England tCO2e	Organisation average tCO2e	Percentage burden
Pharmaceuticals	0.23m	4,292	19.3
Business services	0.17m	3,128	14.0
Electricity	0.16m	3,009	13.5
Medical instruments and equipment	0.16m	2,969	13.3
Gas (for heating)	0.15m	2,773	12.5
Other manufactured products	0.06m	1,147	5.1
Paper products	0.04m	650	2.9
Other procurement	0.03m	591	2.7
Food and catering	0.03m	608	2.7
Construction	0.03m	524	2.4
Freight transport	0.02m	296	1.3
Waste products and recycling	0.02m	282	1.3
Information/communication technology	0.01m	241	1.1
All travel	0.04m	447	2.0
Water and sanitation	0.01m	181	0.8
Coal	0.01m	149	0.7
Manufactured fuels chemicals and gases	0.06m	1,151	5.2
Oil (for heating)	0.00m	34	0.2
Total	1.20m	22,272	100

The largest proportion of the carbon footprint is due to energy use in heating and lighting buildings, using electricity, gas, coal and oil (27%). Pharmaceuticals contribute 19% and business services contribute 14%; this latter category refers to the corporate management of an organisation and includes financial and legal activities, research and development (SDU

2013b). The only other component that contributes over 10% of the total burden of mental health services is medical equipment (13%). Travel contributes 3% of the total burden but this only includes freight deliveries and staff travel during work hours, not patent related travel (SDU 2013b). Non-medical procurement contributes 22% of the total burden including food, paper products, chemicals and information technology.

The SDU created categories for the carbon footprint that comprise: 'goods and services', 'building energy use', 'business travel' and 'commissioned activity'. 'Goods and services' includes the medication prescribed, the medical equipment, furniture, computers, equipment and other procured items used. 'Commissioned activity' refers to governance and strategic activities, for instance a financial review by a consultancy firm or a company paid to organise the car parking facilities (SDU 2013b).

Table 5. The average carbon footprint of an NHS mental health organisation in England

Mental health sector	Goods and services	Building energy use	Business travel	Commissioned activity	**Total**
Average carbon footprint per mental health trust (tonnes CO_2e)	16,059	5,965	247	4,873	**27,144**

From this organisational level data, the SDU proceeded to estimate the carbon footprint of clinical activities (SDU 2013b). They used a number of different allocation methods, that used financial cost data, number of clinical activities occurring and energy use (Tennison 2010). The carbon footprints of the different categories within each clinical activity were calculated by using the ratio between these categories in the organisational carbon footprint see Table 5 above.

Table 6. The carbon footprint of clinical activities in mental health estimated using an input-output method

Category	Carbon footprint per bed day		Carbon footprint per community assessment	
	Carbon footprint ($kgCO_2e$)	Percentage burden	Carbon footprint ($kgCO_2e$)	Percentage burden
Goods and services	58	71	35	71
Building energy use	21	27	13	27
Travel	1	2	1	2
Total	80	100	49	100

Limitations of search design

This search only used PubMed database, which may have limited the number of studies yielded through the search. Only one search term was used (carbon footprint) and this was limited to being included in the title of the article, which also likely reduced the studies yielded by the search, however this was necessary given the large number of results obtained without these limits imposed. Estimating the carbon footprint of health care is a relatively new field of academic research and it may be that different terms are used for these types of articles, therefore it is possible that the search terms missed some relevant articles. However, searching though the references of articles found from this search attempted to reduce the likelihood of any missed articles. Also, the search was only in English, so there may be published literature in other languages pertaining to this area that has been missed.

Discussion

Given the cross-discipline nature and the diversity of terms used in this field of study it is very difficult to ensure that all studies have been identified. This systematic review is therefore not considered exhaustive. Measures have been taken to attempt to ensure that all studies have been included such as searching on multiple databases and searching through the references of all articles for any that might be missed.

The assessments that have been identified that review whole health care systems employed input-output methods, although the NHS carbon footprint supplemented this with activity data regarding energy and travel (Scott et al. 2008; Chung & Meltzer 2009). Carbon footprint assessments of individual services or interventions have mostly used a process-based LCA methodology (Connor 2010; Connor et al. 2011; Morris et al. 2013; Holmner et al. 2014; Pollard et al. 2014; Somner et al. 2009; Gilliam et al. 2008). All these studies assessed highly technical areas of health care, such as anaesthetics, dialysis or surgery. The only article that related to a less technical area of health care assessed the emissions associated with travel in primary care (Andrews et al. 2013).

The two reports on the carbon footprint of the NHS found that the majority of the carbon footprint is contributed by procurement, pharmaceuticals being the single largest contributor within procurement. This was also the case for mental health (Scott et al. 2008; SDU 2013b). In support of this finding, process-based LCA studies have also found that emissions associated with procurement are highly significant (Holmner et al. 2014; Connor 2010; Connor et al. 2011; Morris et al. 2013). In one study, tele-medicine only became less carbon intensive than standard care if the patient travelled over 3.6 km by car for a one-hour appointment, because of the emissions embedded in the tele-medicine equipment (Holmner et al. 2014).

The aim of this research is to assess whether existing methodologies can be applied to provide an approach that is fit for purpose in mental health care. This review has shown that both input-output and process-based LCA methods have been applied to health care successfully. It is evident from these articles that these process-based LCAs are highly time intensive and require a considerable degree of expertise. Therefore, while carbon footprint experts with sufficient time can feasibly apply this method to health care, no studies have been found that evaluate whether non-expert service providers can feasibly use these methods in a time-poor clinical context.

This review has shown that input-output methods can be feasibly applied to a health care setting by experts (Chung & Meltzer 2009; Scott et al. 2008). Service providers in a clinical context could also potentially feasibly apply this method, as it requires using financial data from administrative records to obtain the carbon footprint, which they have access to. However, no evidence has been found as to whether this method is actually feasible, or whether this method is able to provide useful results for service providers in their review of existing services or their design of new services. The input-output method provides average carbon footprints for each clinical activity and therefore cannot account for the potential variation that occurs between clinical activities or services. Given that the use of certain resources between services is highly variable, such as medication (NHS 2009), more accurate results could likely be achieved if a process-based LCA method were used to estimate the carbon footprint of these categories. No articles have been found that investigate what combination of process-based LCA and input-output methods provide the approach that is most fit for purpose for health care.

Conclusions

An input-output method has been used to provide information about the carbon footprint of the NHS and more specifically mental health services (SDU 2013b). Process-based LCA methods have also been applied to some areas in health care, but I have not found any of these types of study pertaining to mental health. More research is needed to identify whether a process-based LCA, an input-output method or a combination of these two methods is fit for purpose in mental health care. The research provided in this thesis attempts to meet this gap in the literature.

Chapter 3

Survey of environmental practices in mental health services in England

Introduction

In order to further investigate environmental practices that are occurring in mental health care, two surveys were undertaken; this chapter presents the results. The surveys investigated whether environmentally sustainable practices are occurring in mental health care across both clinical and non-clinical domains, as it may be the case that environmental practices are occurring but not being published and therefore were not found in the systematic reviews presented in the previous chapter. Further, it is likely that, given the novel nature of this subject, these projects might not have been identified from the search strategies used.

The first survey examined sustainable practices at a clinical team level and was completed by clinicians (the clinical survey); the second was aimed at organisational level sustainable practices and was completed by sustainability leads in the organisation (the corporate survey).

Methods

The surveys were developed using the web based survey program, 'Survey Monkey' (https://www.surveymonkey.com). The clinical survey had three sections covering travel, resource use and clinical care, see Appendix 1. The corporate survey had seven sections: governance, procurement, resource and energy use, waste, estates and buildings, travel, staff engagement and training, see Appendix 2. The clinical survey was publicised in a Royal College of Psychiatrists newsletter (RCPsych 2013) and in two newsletters from the Centre for Sustainable Healthcare (CSH) (CSH 2014). However due to a poor initial response rate, a further attempt was made to obtain responses by individually requesting a response from every member of Psych SusNet by email. Psych SusNet is an online network of mental health professionals interested in sustainability (n=121) (http://sustainablehealthcare.org.uk/psych-susnet). The corporate survey was publicised on Psych SusNet, the Sustainable Development Unit (SDU) website (www.sdu.nhs.uk) and the CSH newsletter (CSH 2014). In order to maximise responses for the corporate survey, where an organisation had an allocated sustainability lead at board level, these were contacted directly (11 organisations).

The survey was conducted between January and April 2014. A sustainability score was calculated for each survey response to assess the variation in sustainable practices between mental health organisations. It was calculated by dividing the number of Yes answers by the total number of responses, excluding N/A responses. This indicated the proportion of potential sustainability practices and policies present in the organisation, as questions were structured to answer 'Yes' if sustainability practices/policies were present. The results of the survey were returned to the original respondents, with information about their own responses to the survey, allowing them to compare their practice to that of other organisations. This was done in the format of a 'PowerPoint' presentation sent to them by email, with encouragement to present the results to their team or organisation. These presentations highlighted specific areas for local improvement based on their survey responses.

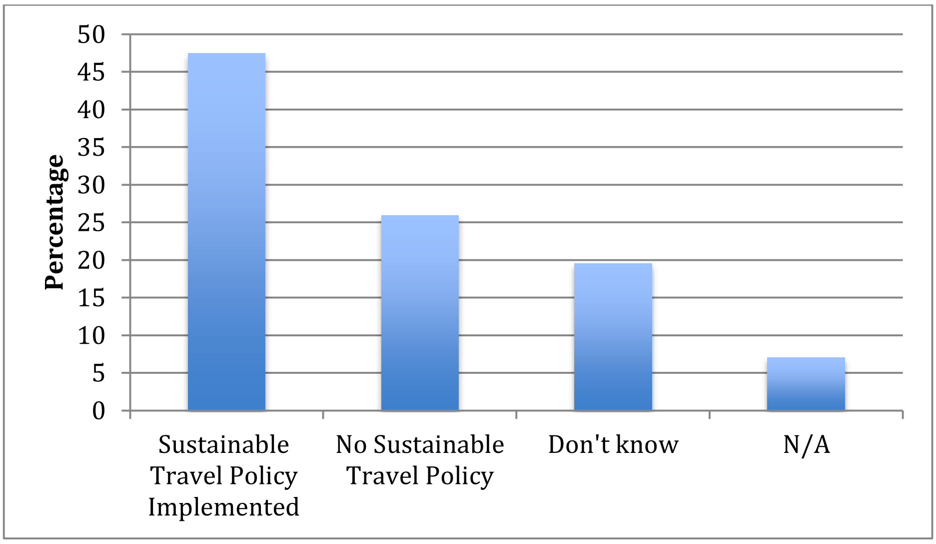
Results from the clinical survey

The clinical survey had 26 responses from 19 mental health organisations with good representation from both rural and urban settings. This survey was advertised on different websites, the response rate could therefore not be determined, however, as the request was sent to every member of Psych Susnet, that had 121 members at the time, the response rate is at most 22%. Most clinicians were based in community settings (80%), compared with inpatient settings (20%). The average sustainability score for teams was 0.47 (SD=0.15; range=0.18-0.91) indicating considerable variation of sustainable practices between teams. A high score indicates more sustainability practices or policies were present.

Travel

Figure 6 shows the accumulated responses to the 13 questions on staff and patient travel, please see Appendix 1 for the questions. Questions covered areas such as public transport links and encouraging active travel. Questions were structured such that a 'Yes' answer indicates that the organisation has implemented a particular sustainable travel initiative. The results demonstrate that only 47% of the sustainable travel policies enquired about in the survey are being implemented by mental health organisations.

Figure 6. Accumulated responses to questions relating to sustainable travel initiatives



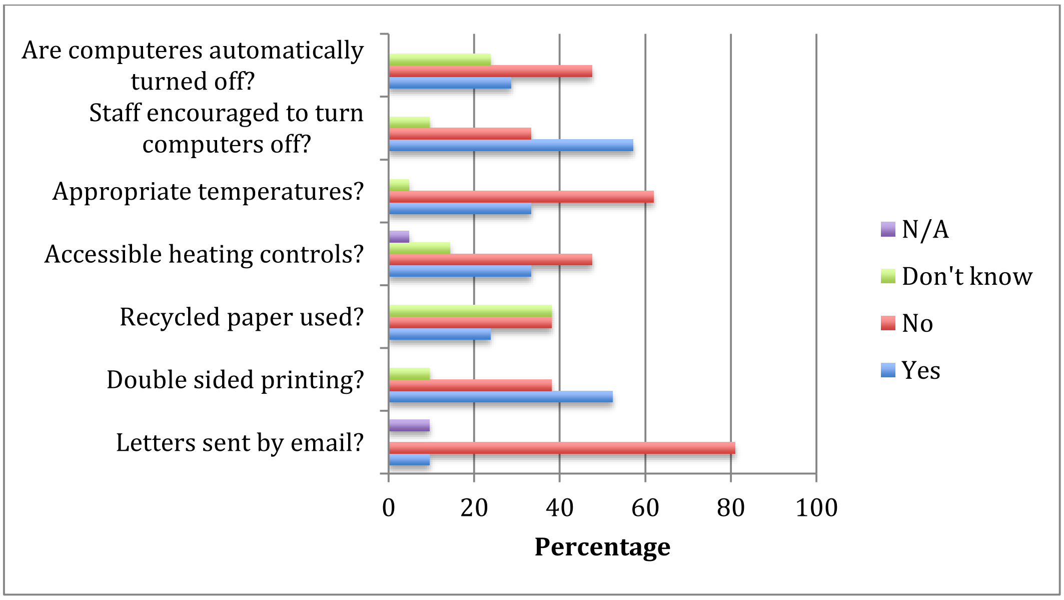
Lighting

Most respondents (57%) reported that low energy light bulbs were present in over 80% of light fittings, while 10% of responders reported that these were used less than 20% of the time. 62% of respondents reported that lights were switched off when not required, 28% reported that lights were only occasionally turned off. 19% reported that motion sensors were used where appropriate, while 62% reported that no motion sensors for lighting were in place. 86% of respondents reported that lighting intensity was about right.

Use of office equipment and resources

Figure 7 shows the use of resources in the office and whether electronic communications are used. There are mixed results; most staff are encouraged to turn off their computer, but less than 50% of responses indicated there is an automatic mechanism for switching off computers. Temperatures appear reasonable with accessible controls. Responses about communications and letters show that about 40% of teams are not using double-sided printing or recycled paper. Furthermore, only 10% of teams are using emails for correspondence for clinical letters.

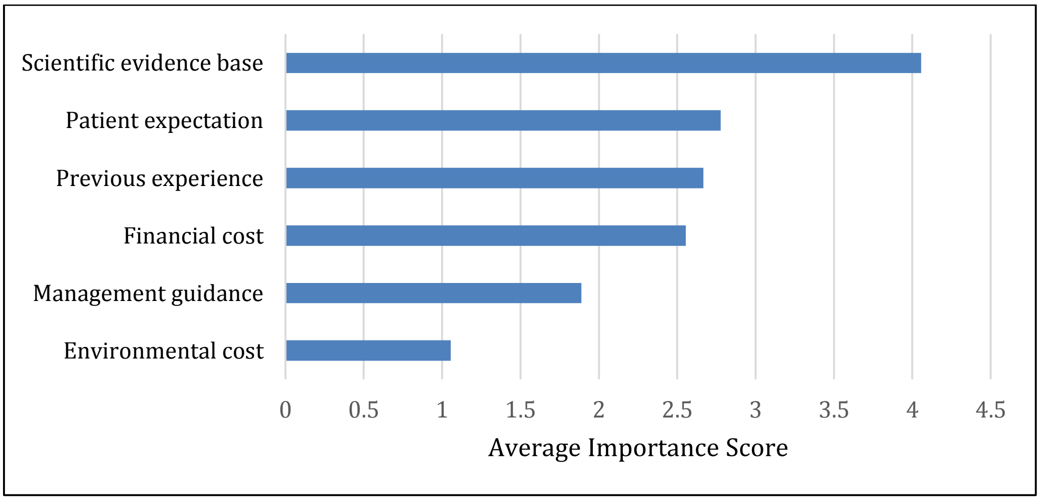
Figure 7. Office resource use and heating



Importance of sustainability in decision-making

Figure 8 shows the ranked importance of various factors for clinicians when making a clinical decision, (5=vitally important, 0=not important). It shows that a scientific evidence base was the most important factor while environmental cost was the least important.

Figure 8. Importance of factors in making clinical decisions



Sustainable practices

An attempt was made to find out if teams had developed any services that aligned with the principles of sustainable health care, defined in Chapter 1. Table 7 below displays the range of answers. Responses showed that no services had been started with an aim to reduce the carbon footprint. However, services had been initiated that aligned with the other principles of sustainable health care. While these services were not initiated with the aim to reduce the carbon footprint, they are likely to reduce its carbon footprint through reducing overall use of services (Mortimer 2010).

Preventative strategies ranged from clinical models such as early intervention teams, to providing more focus on reducing relapse such as using relapse prevention plans. Patient empowerment examples included a wide range of initiatives such as horticultural therapy, improving patient education, providing age-appropriate information and ensuring co-ownership of care plans. Strategies employed to improve 'Lean' service design, included improving referral systems, coordinating clinics to reduce multiple patient attendances and using a structured care pathway proforma to reduce admission length, see Chapter 1 for more details on Lean service design. Initiatives that used technology included improving phone and internet-based resources for patients. As mentioned above, there was no evidence of interventions aimed at reducing the carbon footprint. If responses were the same or similar then they were grouped into one answer.

Table 7. Sustainable models of care adopted by clinical teams

Preventative strategies	Patient empowerment	Lean service design	Use of technologies	Reducing the carbon footprint
1. Use of relapse prevention plans 2. Use of early intervention teams 3. Use of Wellness Recovery Action Planning 4. Started groups on debt and coping skills	1. Leaflets to help patients self-manage 2. Shared ownership and creation of care plan 3. Psycho-education groups 4. Therapeutic horticulture sessions 5. Use of child-appropriate tools/rating scales	1. Improved referral systems 2. Good links with 3rd sector organisations 3. Use of '*My shared pathway*' to improve discharge 4. Maximising prompts to reduce non-attendance 5. 'Link' clinics to reduce patient attendances	1. User-led phone and text support service 2. Patients contributing to health records 3. Use of social media for patient support via Facebook 4. Tele-health clinics 5. Online CBT 6. County-wide telephone triage service	Nil

Results from the corporate survey

Ten responses were received for the corporate survey, from Board level sustainability leads, who were contacted directly. Publicising on the various websites did not lead to any survey responses. There are a total of 53 mental health organisations across England, giving a response rate of 19%. Although, ten of the eleven organisations that had sustainability leads provided responses to the survey. There was considerable variation between sustainable practices within organisations, the mean sustainability score was 0.39 (SD=0.26; range=0-0.68). There were four organisations where responses were obtained from both the clinical and corporate survey.

Board level sustainability policies

The responses showed that 70% of organisations have a 'Sustainable Development Management Plan' and that 40% of organisations regularly consider sustainability issues at board meetings. Carbon reduction policies have been implemented by 30%, while 10% of organisations have an environmental management plan.

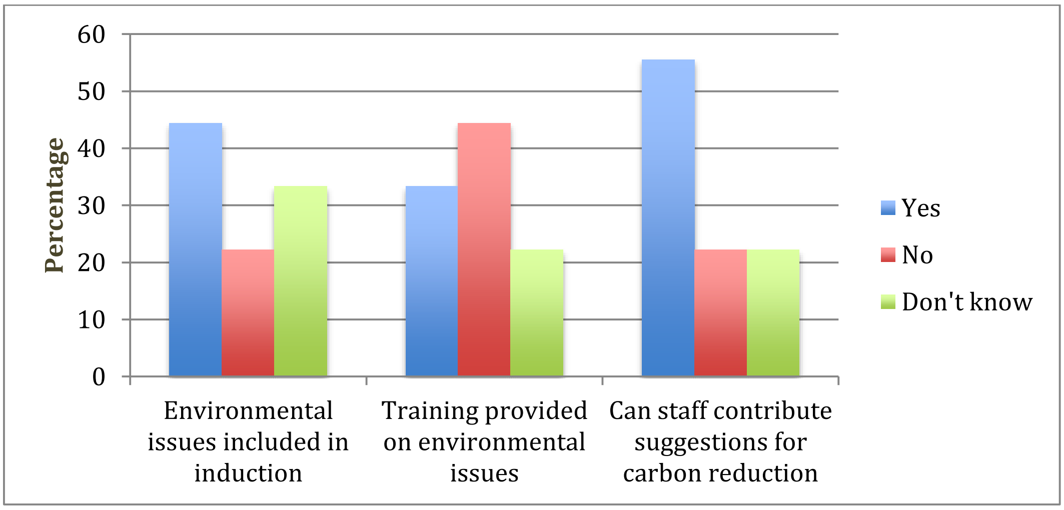
Travel

When asked about travel, 60% of responding organisations have a cycle to work scheme and 60% reimburse for business miles cycled, 30% use low emission vehicles but only 20% have a flat rate per mile for staff travel expenses, which pays more for cars with larger engines. Active travel plans are used by 30% of responding organisations to encourage staff to use healthier methods of travel.

Staff training on sustainability

Figure 9 shows that 45% of responding organisations include environmental issues at staff induction programmes or have other sustainable training opportunities for staff. While 55% of responding organisations provide an opportunity for staff to contribute ideas about carbon reductions to services. Although there were 10 respondents to the survey, not all questions were completed; this led to the results not being in multiples of 10.

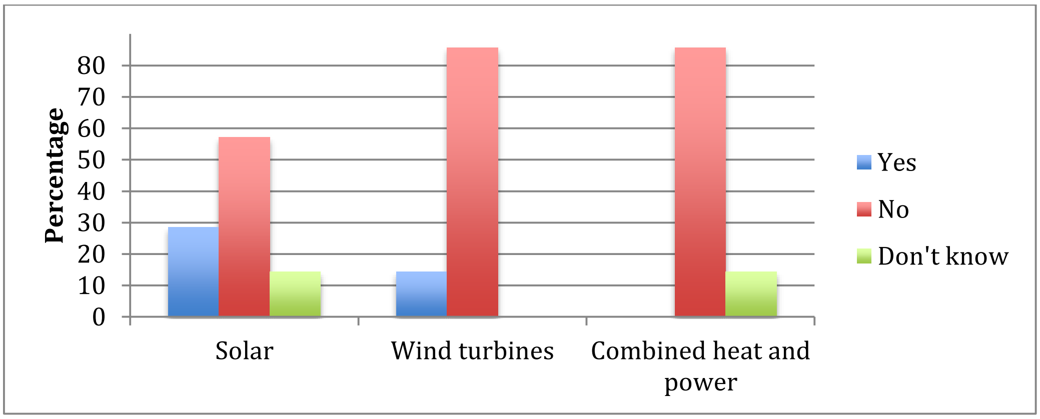
Figure 9. Staff Awareness and Training



Renewable energy

Figure 10 shows that renewable energy use varied greatly between organisations. One organisation uses both solar panels and wind turbines, but 80% do not use any form of renewable energy.

Figure 10. Renewable Energy Generation



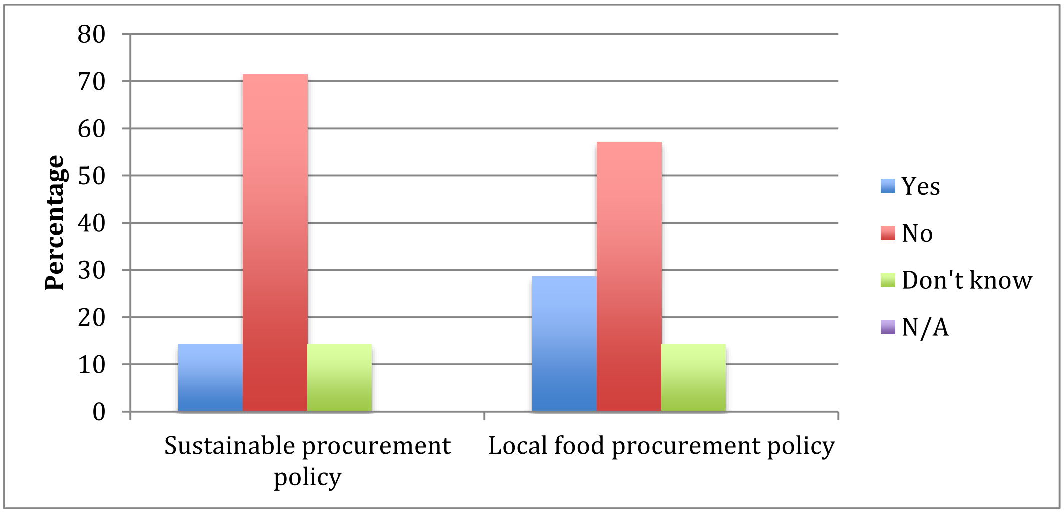
Sustainable building policies

Regarding estates and buildings; in 20% of organisations it is mandatory to have a BREEAM 'Outstanding' rating (BREEAM sets standards for sustainable building design), (BREEAM 2012). In 80% of organisations, green spaces and views are provided for patients, while 60% of organisations provide green spaces specifically for staff. In 30% of organisations, the impact of travel upon staff and patients has influenced where to build newer facilities. 60% of organisations have natural (passive) heating, cooling, lighting and ventilation incorporated into the newer buildings. 60% of organisations maintain clinical areas beneath 26^0C in hot weather.

Sustainable procurement

Figure 11 shows that 70% of organisations do not have sustainable procurement policies and over 50% of organisations do not have a local food procurement policy (Figure 11). Both of these initiatives could potentially lead to a reduction of the carbon footprint of the organisation (Vidal et al. 2015; Jowit 2009)

Figure 11. Questions on Procurement



Importance of sustainability

Figure 12 below shows the responses to the question 'How important is clinician engagement in promoting environmental sustainability within the organisation?' Most respondents considered this to be very important.

Figure 12. Importance of clinician engagement in promoting sustainability

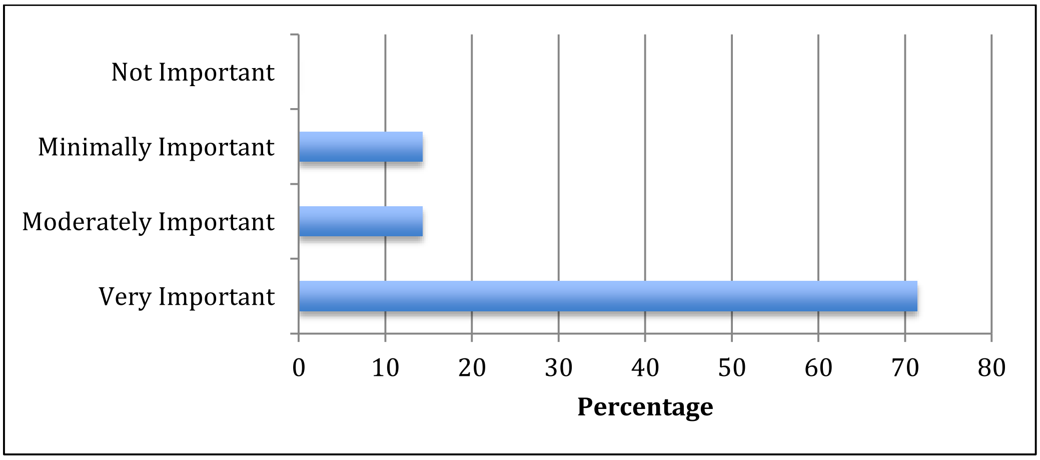
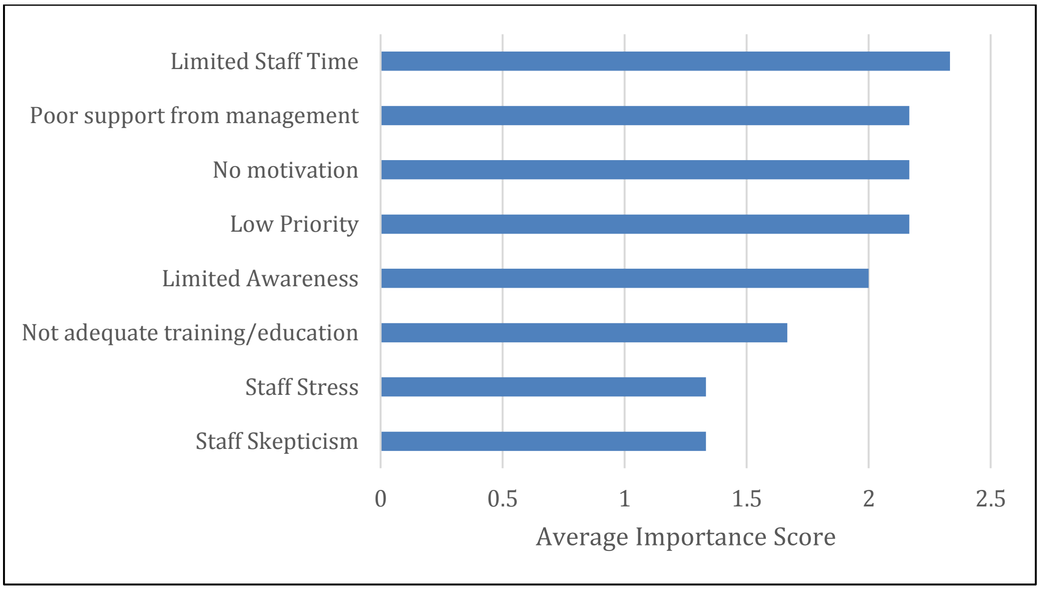


Figure 13 below, shows the average importance of factors that act as potential barriers to clinician engagement with sustainability. It shows that limited staff time and poor management from staff are considered the most important barriers to clinician engagement, whilst staff scepticism is the least important.

Figure 13. Importance of Barriers to Clinician engagement with sustainability



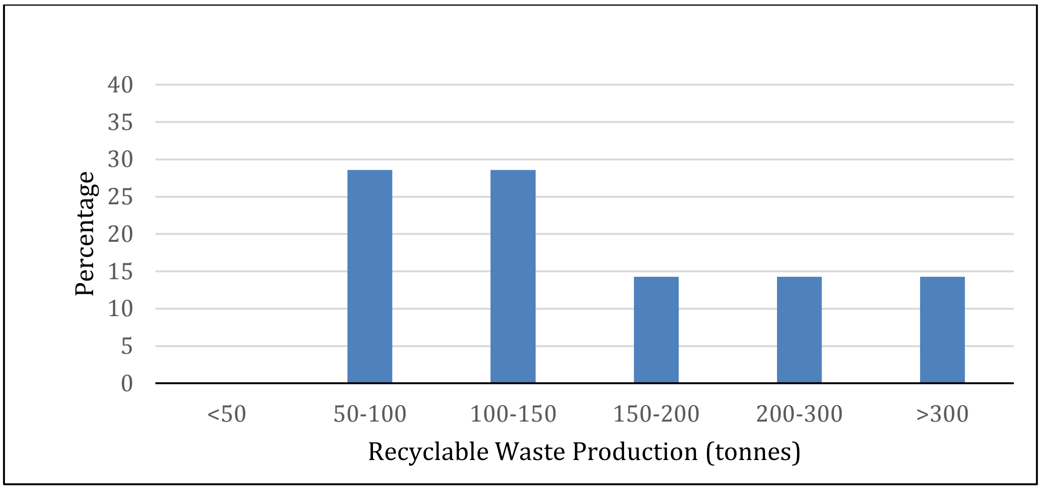
Key: 3 = most important; 2= moderately important; 1= little importance and 0= no importance.

Waste

Organisations were asked about their generation and treatment of waste. Responses showed that 70% of organisations produced less than 50 tonnes per annum of clinical waste, the remaining 30% produced between 50 and

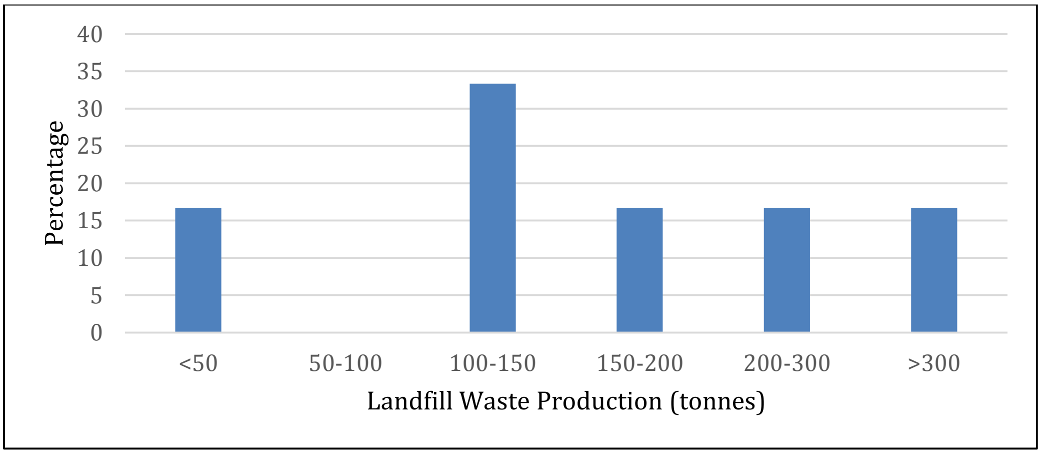
100 tonnes. There was a wide range of recyclable waste production, from 50 tonnes to over 300 tonnes per year, see Figure 14.

Figure 14. Recyclable waste production



Similar variation was found for landfill waste production; two organisations produced over 300 tonnes per year, while two produced less than 50 tonnes, see Figure 15 below.

Figure 15. Landfill waste production



Discussion

Limitations to the surveys

The major limitation to these surveys was the small response rate. The corporate survey elicited responses from ten of the 53 mental health organisations across England, reflecting 19% of total possible responses. However, the clinical survey only received 26 responses from the many mental health teams that exist across England. The actual response rate cannot be determined, as the survey was advertised on relevant websites and newsletters, however, based on the individual requests made to complete the survey, the maximal response rate was 22%. It is likely to be less than this, as people would have read the survey request in the newsletters but not responded. The results from the clinical survey are therefore less representative than those from the corporate survey, despite efforts made to contact relevant individuals to complete the survey. There are also a wide variety of teams delivering mental health care and not all of these were represented in the survey (including child and adolescent teams and neuropsychiatric teams). Given the low response rate, the results of the clinical survey were not analysed according to team type.

The surveys likely suffered from positive respondent bias i.e. those interested in sustainability were more likely to complete the survey than others. There is the potential that these more interested respondents could have made more improvements to the environmental practices of their team or organisation compared with those who did not respond, due to their interest in the area. Positive respondent bias might be more of an issue in the corporate survey where all of the 10 respondents came from the 11, out of the total 53 organisations, that had board level sustainability leads.

The design of these surveys was limited by the desire to ensure that respondents could complete the survey without undue difficulty. As such, the surveys do not include questions pertaining to all the practices within organisations that might have an environmental impact.

The clinical survey

The results of the clinical survey cannot be considered representative of clinical practices in England due to the small number of respondents. However, results suggest that sustainable practices need to improve in all areas including travel, procurement, energy use and administrative practice. The findings also suggest that clinical staff consider environmental cost as being the least important, in terms of factors that affect clinical decisions. Further, there was no evidence that awareness of environmental sustainability is impacting on service design, as the results show that no services have been designed specifically to reduce the carbon footprint of care. These results suggest that clinicians are not engaging with environmental practices to any great extent.

The survey also suggests that clinicians are not well informed about sustainable practices within their organisations. For example, clinical staff were asked 'Does your organisation reimburse for travel made by bicycle?' to which 33% answered 'Yes' but when the same questions was asked to sustainability leads, 55% stated that their organisation did in fact reimburse for bicycle travel, suggesting that many clinical staff were not aware that this reimbursement option was available. In addition, the most common response to the questions that had 'Don't know' as an option on the clinical survey was 'Don't know', which suggests that clinical staff are not aware of organisation environmental practices. Therefore, it appears from the results of the clinical survey that a lack of clinician engagement exists alongside a lack of awareness of environmentally sustainable practices. These are both likely to be major barriers to improving the environmental sustainability of mental health care.

The corporate survey

The response rate from the survey was 19%. The results of the corporate survey show that sustainability leads believe the two most important barriers to clinician engagement with sustainability include limited time and poor support from management. Despite the fact that most sustainability leads think clinician engagement is very important to promote sustainability, organisations are not acting on opportunities to educate and engage clinical staff about existing environmental policies; 60% of organisations do not have environmental issues included in their staff induction programme, while 70% provide no training on environmental issues related to clinical practice. Greater dissemination of information and improved training opportunities in environmental sustainability are therefore needed.

Results indicate that environmental thinking does impact on practice in a few organisations, for example, when new buildings are being designed, 14% of sustainability leads responded that new buildings had to conform to BREEAM standards. Clearly, more organisations need to meet BREEAM standards, but this is a start towards environmental awareness. Results also suggest that many organisations do not have sustainability policies in important areas, such as travel or procurement. Sharing and benchmarking of sustainable practices and policies could facilitate this development, although ample information and resources are already available from the SDU website (www.sdu.nhs.uk). The SDU has published a number of guidelines in the 'NHS Carbon Reduction Strategy' with which NHS organisations should comply (DEFRA 2010). The results of the corporate survey give an indication of the level of compliance with these targets, which aim for 100% compliance from NHS organisations (SDU 2012b). Some targets are being met by most organisations; 67% of organisations have a Sustainable Development Management Plan and 56% reimburse for bicycle travel. In some areas however, organisations are performing poorly against targets; only 33% have an active travel plan and only 14% require all new buildings to have a BREEAM 'outstanding' rating. There is therefore evidence from this survey of a lack of compliance with SDU targets for sustainable policy development at an organisation level.

Conclusions

The results from the clinical survey suggest that the carbon footprint of a service is currently not considered during the process of service development or design. The results from both surveys suggest there is a lack of awareness about and engagement with environmental sustainability at both a clinical and corporate level. Clinicians need to be given more information about opportunities for reducing environmental impacts within their practice and more dialogue needs to occur between corporate and clinical structures about opportunities to improve environmental sustainability. Greater responsibility needs to be taken at an organisational level to ensure sustainability policies are developed and publicised widely amongst staff in the organisation.

Chapter 4

Aim and Scope

Introduction

This chapter reviews the first step in estimating the carbon footprint of mental health care; defining the aims and scope of the intended analysis. This involves defining the functional unit of analysis, the boundaries of the analysis and the categories of data that will be used in the analysis.

The aim of the research

The aim of this research is to determine whether existing methodologies for estimating carbon footprints can be applied to provide an approach that is *fit for purpose* in mental health care. The purpose is to provide an approach that can be feasibly applied by service providers to any mental health service, the results of which can then be used to make informed choices about what changes are needed to reduce the carbon footprint. In order to assess fitness of purpose three factors need to be taken into account. First, whether the approach can be feasibly applied by NHS service providers in their time and resource poor context. Second, whether the approach can provide robust results. Third, whether it can provide results that are useful to service providers in their design and review of services.

Feasibility is defined according to the following criteria; (Bowen et al. 2009).

- 'Practicality' asks if service providers have the capacity, in terms of both finance and staff, to use the approach.
- 'Implementation' asks if mental health organisations can generate and/or collect the data to use the approach.
- 'Adaptation' considers whether the approach can be applied to different contexts within mental health care.

These criteria have been chosen because these are the factors that are likely to limit the feasibility of a carbon footprint assessment. First, the clinical context is often financially stressed and time-poor, such that service providers are unlikely to have the capacity or technical ability to perform the most accurate analyses using process-based LCA methods (WBCSD & WRI 2011). Second, collecting primary data might not be feasible given the constraints of the context, while secondary data might not be available or meet the quality standards. Lastly, an approach needs to be able to adapt to the wide range of clinical contexts in mental health care including individual appointments, admissions, group-based care or online psychotherapy. It could be that the suggested approach cannot be feasibly applied to certain clinical contexts due to issues with data collection.

A robust approach is defined as:

- An approach that is not unduly affected by outlying results and can provide accurate and reliable results from data drawn from a wide range of sources (Ripley 2004; RSC 2001).

The term ‘robust’ is being used in this research as it incorporates the concepts of validity and reliability but places an emphasis on the approach being applicable to a wide range of contexts and not being biased by outlying data. These are important factors as there is a wide range of contexts where the approach could be used in e.g. inpatient and community. Moreover, resource use between services is likely to have significant variation e.g. amount of travel or number of prescriptions, such that outlying data may be a significant issue when assessing the average carbon footprint of a service.

Determining the accuracy of carbon footprint estimates of mental health care is difficult as there have been no process-based LCA performed in this specialty that would be considered able to provide ‘gold standard’ estimates, which could then be used for comparison. Further, often there is only a single data point available and thus determining reliability is also difficult. In light of these issues, every effort is made in this research to be transparent and to document all assumptions made, such that potential systematic errors or bias that could occur are documented and discussed.

This carbon footprint assessment is aimed at informing decisions about service design. The aim of this research is not to find the most accurate carbon footprint for one particular service or clinical activity. Rather, the carbon footprint estimates need to be accurate enough to base decisions about how to change a service based on the results obtained, in order to achieve the largest reduction in carbon footprint.

A review of the context is provided here to establish what type of information would be useful to service providers. There are many factors that service providers can change in a service, for example, they could target travel, medication, procurement or energy use. Therefore it would be important to know which factors are providing the largest component of the carbon footprint, but the results would not need to inform decisions about service design, as each service will have its particular constraints and demands. Instead, decisions about how to reduce these resources could be made independently of the results once it is known which factors are contributing most to the carbon footprint, for example the carbon footprint associated with travel could either be reduced by encouraging use of public transport or by improving online assessment options, depending on the type of service. Repeated assessments could then estimate the change to the carbon footprint achieved by the service change.

Feasibility versus robustness

There is the potential that the only feasible method for estimating the carbon footprint of a particular resource category does not provide robust results. In these circumstances, assessments will have to be made about whether the results, despite their reduced robustness, are still able to provide useful information to service providers about the carbon footprint of a service. If the results can provide useful information then the method could still be viewed as fit for purpose. In this sense, fitness for purpose can be seen as a continuum, where in some cases the approach might be a perfect fit, whereas in others it has to be accepted that the fit is not ideal, but that it is the best available approach given the constraints of the context. It is important to note however that, while differing degrees of accuracy might be needed, according to what decisions the data are informing, the data might have such poor accuracy that it could lead to incorrect decisions about service design being made, potentially leading to a smaller reduction in the carbon footprint than projected, or worse, an increase in the carbon footprint. Care must be taken to ensure that accuracy of all indicators used are made transparent so this potential is kept to a minimum. Therefore, determining fitness for purpose is essentially a utilitarian assessment, as it is the aim to provide a useful tool for service providers that can be used to determine what factors should be addressed to reduce the carbon footprint. As such, feasibility plays a prominent role in determining fitness for purpose and discussions about robustness have to be balanced against feasibility.

There are numerous different ways in which carbon footprint estimates can be used in mental health care. It may be that the developed approach is fit for purpose in some instances but not in others. Estimates could be used to analyse where the carbon hotspots lie in a service in order to know where to begin to make changes, for example, is medication or travel the largest contributor. In this context, estimates would not need to be very accurate for them to be fit for purpose. However, if two services are being competitively compared to determine which should get funded, then estimates would need to be far more accurate to be fit for purpose.

There is a tension between feasibility and robustness. Given enough resource, all carbon footprint studies would use a process-based LCA method as these generally provide the most robust results (WBCSD & WRI 2011). However, undertaking a process-based LCA is time intensive (Berners-Lee 2010). Paying carbon footprint specialists to perform these studies is unlikely to be feasible in a financially constrained clinical context. Input-output approaches are more feasible since they rely on the transformation of financial data to provide organisational averages for the carbon footprints of clinical activities (Scott et al. 2008). In fact, the carbon footprint of mental health care has already been estimated based on an input-output method (SDU 2013b), however, this method does not account well for variation that exists between different services. Given the competing and often opposing demands of feasibility and robustness, the aim is to find an approach that is 'fit for purpose'.

Defining the functional unit of analysis

The majority of reports produced by mental health organisations about their carbon footprint are based on energy use in buildings (SDU 2013c).

However, as noted in Chapter 1, this method is insufficient to capture a considerable proportion of the emissions that are associated with health care (SDU 2013a). A recent report by the Royal College of Psychiatrists (RCPsych 2013) suggested that current environmental reporting standards of health care services should not be according to buildings energy use, as is the current norm, but be matched to care pathways. A care pathway is a set of clinical activities that make up a 'patient's treatment journey' e.g. a clinic assessment, a course of psychotherapy, an admission. It stated that calculating the carbon footprint according to care pathways can "*understand the full costs of services, engage clinical and other staff in sustainable approaches to care and bring carbon accounting in line with financial accounting*". Using care pathways to measure the carbon footprint of the NHS would allow all parts of the carbon footprint of health care to be included (RCPsychCSH 2013).

Issues can arise when attempts are made to estimate the carbon footprint of a whole care pathway. For example, in a course of cognitive behavioural therapy, decisions need to be made about whether the initial assessment, team meetings that discuss the patient, or interim reviews by the psychiatrist should be included. Further, each clinical activity is likely to affect future health and will likely have downstream effects on health care use. For example, when measuring the carbon footprint of a care pathway through a general hospital, following the addition of a psychiatric liaison service, patients may have a reduced use of resources in the hospital due to shortened admissions, which would result in a reduced carbon footprint of the inpatient care pathway. However, they may go on to require more follow-up care in the community as a direct result of the shortened admission. In this case, measuring the carbon footprint of the inpatient care pathway would not capture the full carbon footprint. In addition, although certain patient's admission lengths might reduce, the likelihood is that other patients will use these vacated beds. This results in a situation of discussing *theoretical* reductions to the carbon footprint rather than actual reductions. It would not be until perhaps a whole ward or unit is shut down, due to large reductions in bed use, that *actual* reductions to the carbon footprint would be realised.

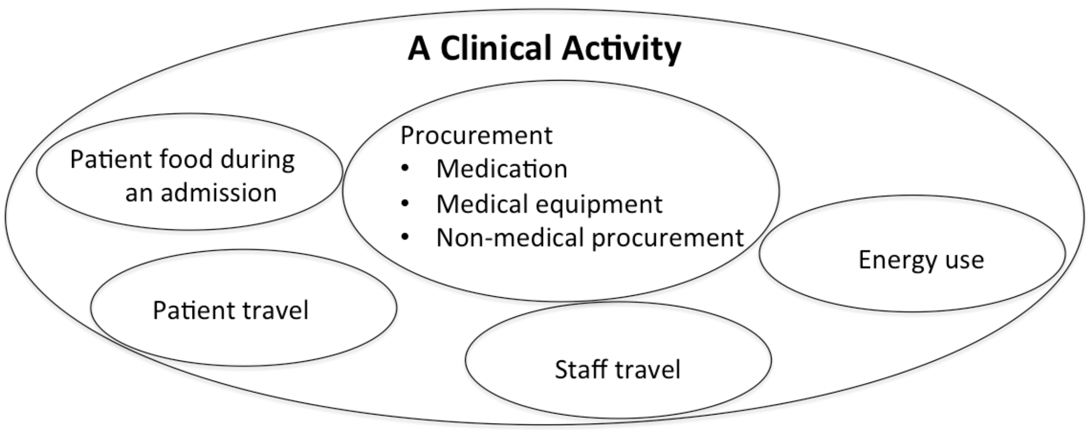
Analysing the carbon footprint at the level of individual clinical activities (such as a clinic appointment, a home visit, a psychotherapy assessment or a bed day) avoids these problems. A clinical activity is defined here as a discrete clinical encounter such as an assessment in a clinic, a home visit or one bed day. Taking individual clinical activities as *building blocks* that can ensure every component of a care pathway is included. Individual clinical activities can be used to construct care pathways, such that individual differences and variations can be accounted for. This method of using individual clinical activities as a building block of care pathways has been used in previous carbon footprint assessments in health care (SDU 2013b; Connor et al. 2011; Morris et al. 2013).

Defining the boundary of the clinical activities

A boundary is a theoretical line that is used to contain discrete data. In this case it defines what should be included and excluded from a clinical activity. It is important to be clear about what is included in the clinical activity and what is not, so that the analysis remains transparent (DEFRA et al. 2011) and a clear understanding can be gained about the limitations of the analysis (WBCSD & WRI 2011). This is particularly important as experts suggest that carbon footprint assessments inevitably leave some data out (WBCSD & WRI 2011), as ensuring every activity is included is difficult (Wiedmann 2010). This section discusses what boundaries are necessary to ensure that a consistent approach can be achieved when the carbon footprint of mental health care is estimated.

The major driver for establishing the boundary is the clinical activity itself. This is based on clinical expertise and incorporates all the activities required for a clinical activity to occur, see diagram below.

Figure 16. The boundaries of a clinical activity



Factors that are excluded are as follows:

- Infrastructure (e.g. buildings)
- Activities provided by organisations outside of the NHS
- Research and development of clinical activities or care pathways
- Staff training
- Staff canteen food
- Resources used in the patient's home (e.g. energy use)
- Those exclusions suggested by the PAS 2050 guide, (unless otherwise indicated) (DEFRA et al. 2011)

The carbon footprint derived for a product or service can be divided into sections; manufacture, distribution, retail, use and end-of-life (DEFRA et al. 2011). In the interests of providing a comprehensive assessment it has been decided that data from all these sections should be included.

In order to provide clinical activities such as an appointment or bed day, other processes need to occur, including team meetings, management and administration, waiting room facilities, correspondence etc. As such, simply measuring the resources that are used within the clinical activity would potentially exclude a considerable proportion of the carbon footprint. In life cycle assessment terms activities are referred to as attributable or non-attributable factors. An attributable factor is "*anything that is used in the activity* [e.g. medication] *or used to enable the activity to occur* [e.g. travel]" (WBCSD & WRI 2011). Any other activity would be counted as a non-attributable factor.

In the case of mental health care, there are many factors in mental health that could be included under the 'used to enable the [clinical] activity to occur' criterion. Resources used in the patient's home could theoretically be included under this criterion (for example energy or furniture) when performing home visits, as could the food consumed by staff in the staff canteen. Whether these factors should be classified as attributable needs to be decided.

A detailed analysis might include all these potential activities in order to be as inclusive as possible. However, this would be either very difficult to quantify (e.g. patient's furniture) or capture (e.g. staff eating habits or training and development). To ensure a consistent approach, I imposed two further boundaries around clinical activities. First, only factors that are wholly attributable to the delivery of clinical care are included. This therefore excludes factors such as food provided for the staff canteen and the embedded emissions in staff cars used for work, as these cannot be wholly attributed to the delivery of clinical activities. However it would include administrative and management activities, as these are wholly attributable. Second, only clinical activities provided by NHS organisations are included. This excludes factors such as energy used in the patient's home or activities provided by third sector organisations. The only exception to this is patient travel, which is included, as this is wholly attributable to clinical activities.

The PAS 2050 Guide states that "*capital goods i.e. machinery or buildings that have a lifespan >1 year* [should be excluded from carbon footprint assessments]*, except where supplementary requirements dictate otherwise.* However, these conditions can be changed when the boundaries of the activity are defined i.e. in this current process. I have chosen to include all medical equipment, irrespective of lifespan. This is because there are many items of equipment, such as blood pressure monitoring, ECG machines, resuscitation machines etc. that are likely to provide a significant contribution to the carbon footprint of mental health care (SDU 2013b). There are also national requirements for these types of equipment to be available in mental health settings for patient safety, whether they are used or not, such as resuscitation machines (RCPsych 2014). Therefore, excluding these items would compromise the robustness of the results and would not be representative of the activities required in the delivery of mental health care. It would also likely serve to diminish the face validity of the assessment from a service providers perspective, as equipment is likely to be a major component of the carbon footprint of procurement in mental health care (SDU 2013b). The same principle has been adopted for non-medical procurement items, such as computers, furniture and office equipment. This is because these items are also likely to contribute significantly to the carbon footprint of mental health care (SDU 2013b). Furthermore, given that many types of clinical activity within mental health use only a few resources, (for example psychotherapy only uses energy use and travel alongside non-medical procurement items), excluding these items would likely not be seen as representative by service providers and would therefore serve to undermine the face validity of the assessment.

As health and social care sectors continue to integrate (Naylor 2012), whether social care should be included in carbon footprint assessments of health care will remain an issue of debate. Further, the latest health reforms (DoH 2010) have created more opportunity for social enterprises and the third sector to deliver health interventions (e.g. mental health charities such as Mind or Rethink). Third sector organisations are currently providing therapeutic interventions and recovery oriented work in mental health care across the country (Bragg et al. 2013). Therefore, in a given care pathway, some interventions or treatments might be provided by the third sector or by social care, however, given that a boundary has been drawn around only including those activities provided by NHS organisations, these activities will be excluded from the analysis. This exclusion is necessary to ensure a feasible approach in terms of the ‘practicality’ criterion of feasibility. NHS service providers are unlikely to have the time and resource to engage with social care agencies or third and voluntary sector organisations to obtain the necessary data to perform carbon footprint assessments of these activities.

The boundaries - defined

In order to ensure a consistent approach to estimating the carbon footprint of clinical activities, boundaries have been drawn around the functional unit of analysis (clinical activities). It has been decided that the following boundaries will be used:

1. The following components of clinical activities are included: energy, patient and staff travel, and procurement (irrespective of lifespan)
2. The guidance set by PAS 2050 regarding boundaries has been followed (DEFRA et al. 2011), except where specifically indicated
3. Data associated with manufacture, distribution, retail, use and end-of-life will be included
4. Only activities wholly attributable to the clinical activity will be included
5. Only activities performed by NHS organisations will be included

Defining the categories of activities

The only assessment that has been performed on the carbon footprint of mental health care used an input-output approach, based on financial data (SDU 2013b). It defined the categories of activities as ‘goods and services’, ‘travel’, ‘building energy use’ and ‘commissioned activities’. The categories of activities in this research are based on these, however they have been altered to improve their relevance for service providers and potential service design options. ‘Commissioned activities’ refers to regional or national level governance and strategic activities, for example a national level financial review by a consultancy firm. Given that the aim here is to provide service providers with an approach to carbon footprint their services, this category is not relevant and not used here. The category of ‘goods and services’ includes all procurement, such as medication, medical equipment and office supplies. This is considered too broad a category to be useful, given the aims of this research and therefore has been subdivided into medication, medical equipment and non-medical procurement. This is so that service providers can assess where the hotspots of carbon are in their services with greater accuracy. Also, as some clinical activities do not use medication or medical equipment (e.g. psychotherapy services) this allows these categories to be excluded where they are not relevant to the clinical activity being assessed. Energy is included as a category as is travel, which includes both patient and staff travel. The categories of activity assessed are therefore as follows:

- Medication
- Medical equipment
- Non-medical procurement (such as office supplies, administrative activities and food)
- Energy
- Travel (staff and patient)

Conclusions

In this chapter, the aims have been defined; to provide an approach that can be feasibly applied by service providers to any mental health service, the results of which can then be used in the review and design of services. The functional unit of analysis has been defined as a clinical activity. The boundaries around clinical activities have also been defined. Issues of scope in terms of carbon footprinting can be problematic and decisions have been made to ensure a consistent approach to identifying and measuring data. The categories of activities are based on a previous assessment but have been further refined to improve their relevance for the aims of this research.

Subsequent chapters will focus on the next steps of creating an inventory of activities and impact assessment (attributing emission factors to these categories of resource use).

Chapter 5

Inventory

Introduction

Creating an inventory involves identifying relevant activities, collecting the data and then ensuring appropriate allocation of resource use to each clinical activity. Activity mapping is the process used to create an inventory; it identifies and measures all the activities that occur within each clinical activity. This chapter identifies the activities through activity mapping, reviews the options for data collection and suggests a data collection method for each category of activity; medication, travel, energy, medical equipment and non-medical procurement. An attempt is made in this chapter to collect activity data for the major types of clinical activities in mental health (NHS Confederation 2014). The aim of this chapter is to define a data collection method that provides the best data quality, but that is also feasible in a clinical context.

No consensus can be drawn from the literature about how the NHS should collect data for carbon footprint assessments of clinical care (SDU 2013b; Connor 2010; Pollard et al. 2013). This chapter examines the options for collecting data, which include primary or secondary data sources. Primary data sources are direct measures of resource use that have been created for the purpose of the assessment. Secondary data sources can be in the form of activity data or financial data. Secondary activity data can include existing records about activity use, for example existing prescription records, or data taken from a previously performed study. Secondary financial data includes data from organisational or national financial records. The process of *collecting* the data is discussed in this chapter; the difficulties encountered, the assumptions required and therefore the quality of the inventories produced by the different data collection methods.

The question of feasibility is important and will have a great bearing on whether a given data source is suitable for use in a clinical context. The data collection method needs to meet the feasibility criteria. Certain data collection methods, while they might provide better quality data, might not be feasible given the clinical context. The relevant criteria assessed here are ‘practicality’ and ‘implementation’, defined below in the methods section.

Methods

Design

The major clinical activities provided by mental health care (NHS Confederation 2014) are assessed in this chapter and include; a clinic appointment, a home appointment, a telephone appointment, an individual psychotherapy appointment, a group psychotherapy session and an inpatient bed day.

A step-wise approach was taken in this chapter to analyse the different data collection methods:

1. First, an attempt was made to obtain primary data.
2. Second, if primary data could not be feasibly obtained then an attempt was made to collect secondary activity data, (see introduction section for definitions of data types).
3. Third, if secondary activity data did not meet the data quality standards, was unavailable or could not be feasibly obtained then secondary financial data was used
4. Data collection methods were evaluated using the data quality criteria provided by the Greenhouse Gas Protocol to assess which data source should be used.

The reasons for this stepwise approach are that first, the Greenhouse Gas Protocol suggests primary data sources should ideally be used, as generally they can provide greater accuracy compared to secondary data sources (WBCSD & WRI 2011). Second, the PAS 2050 guidance states that "*secondary data shall be used where primary data has not been obtained*" (DEFRA et al. 2011). Third, where good quality activity data from secondary sources exists, this data source has the potential to provide better quality data than secondary financial data as measures are based on actual resource use rather than cost (WBCSD & WRI 2011).

The systematic reviews in Chapter 2 found no evidence of any process-based LCA of mental health care. It is only this type of assessment that is sufficiently robust to allow an empirical assessment of the accuracy of the data obtained from the different data collection methods. Therefore an empirical assessment of the accuracy obtained from these data collection methods was not possible. As such, data was assessed against the 'data quality criteria', defined by the Greenhouse Gas Protocol, see below (WBCSD & WRI 2011).

1. Technological representativeness: the degree to which the data reflect the actual activity data used in the clinical activity
2. Geographical representativeness: the degree to which the data reflects actual geographic location of the clinical activity
3. Temporal representativeness: the degree to which the data reflect the actual time the clinical activity took place
4. Completeness: the degree to which the data are representative of the clinical activity
5. Reliability: the degree to which the data source and collection methods used to obtain the data are dependable

Feasibility was defined in the previous chapter, however the criteria relevant to this chapter are presented again here (Bowen et al. 2009).

- 'Practicality' asks if service providers have the capacity, in terms of both finance and staff, to use this approach. '
- 'Implementation' asks if mental health organisations can generate and/or collect the data to use this approach and therefore, can the approach be fully implemented as proposed.

Ethics

Ethical approval for this study was obtained from the University of Warwick Biomedical and Scientific Research Ethics Committee, (REGO-2014-882).

Activity data collection methods

Activity data obtained for this analysis were taken from Oxford Health NHS Foundation Trust. The exception to this is medication prescribed in appointments, where prescription records were accessed from a primary care practice; Upper Eden Medical Practice. Activities were identified and relevant data collected, based on the boundaries defined in the previous chapter. Each activity map was checked against expert opinion (ten mental health professionals). The reasons why particular data collection methods were used are presented in the discussion.

Medication

Medication used in appointments was obtained retrospectively using primary care prescription records of 59 patients over a period of two years from one primary care practice; Upper Eden Medical Practice. These patients had been diagnosed with a mental health condition and were receiving psychotropic medications. Medication used during admissions was obtained from reviewing 20 medication charts of psychiatric inpatients and by taking an average cost of medications per day. These patients were selected using convenience sampling from two wards within Oxford Health NHS Foundation Trust during April 2014. The only available emission factor for medication is based on cost (DEFRA 2013), therefore to obtain a carbon footprint, the financial cost of medications was obtained from the British National Formulary (www.bnf.org). The cheapest cost for each medication was taken as this study has adopted a conservative approach, but it is likely that typical costs are higher.

Travel

Travel data was obtained from two surveys, one patient survey, performed on 100 rural outpatients and 100 urban outpatients in Oxfordshire, and one staff survey, performed on 20 mental health staff in Oxfordshire, which covered both rural and urban areas. Travel associated with admissions was based on the outpatient travel survey due to time constraints, where travel for one bed day was assumed to be equivalent to travel for 50% of an appointment. The surveys were carried out in January 2014 in Oxford Health NHS Foundation Trust. They obtained data for method of travel and the postcodes of the origin and destination for each journey. A Microsoft Excel programme was then used to determine distance travelled by road for each different method of travel. Staff commuting was excluded according to the PAS 2050 guidance (DEFRA et al. 2011).

Energy

Each clinical or office space required to deliver a clinical activity was measured; 15 clinical appointment rooms, three wards, eight administrative offices, three clinical examination rooms and one group psychotherapy service (only one was available to assess in Oxford Health NHS Foundation Trust). To obtain an energy use estimate from room size, a conversion factor was taken from a previous study, which provided the energy used per square meter of clinical space per year in kWh units (Connor 2010). This study directly measured the energy used in a standard clinical appointment room in a general hospital by using a plug-in electricity meter; there was no equivalent energy data from a mental health setting. The energy used per clinical activity was then calculated by measuring the area and the time that the spaces were used in each clinical activity.

Equipment and procurement

In order to measure procurement items, including medical equipment, furniture, office equipment and supplies, inventories were developed based on the activity maps. These were compiled by visiting each relevant clinical and administrative area used in the clinical activity and identifying relevant procurement items (15 clinical appointment rooms, three wards, eight administrative offices, three clinical examination rooms and one group psychotherapy service). Inventories were checked against expert opinion (ten mental health professionals) to ensure they provided a reasonable representation. Where discrepancy occurred between the inventories and views of the mental health professionals, an average was taken from the expert opinions and the initial inventory to obtain the final inventory list.

Corporate services and administration

The activities performed by human resources, business services and administration were accounted for using a standard conversion factor based upon a UK-based health economics method (Curtis 2013). In this method, direct overheads were 29% of direct care salary costs, which include costs to the provider for administration and management. Indirect overheads were 16% of direct care salary costs. They include general management and support services such as finance and human resource departments (Curtis 2013). Non-clinical activity data for the appointment were therefore increased by 45% (i.e. the categories of energy, non-medical equipment and travel) to account for indirect and direct overheads. This method is far from ideal, as it does not relate specifically to these categories of activity data, however it was an available, pragmatic method for accounting for overheads. Searches of the literature to find other methods for apportioning management activities to clinical activities proved unsuccessful.

Assumptions required for allocating activity data

Allocating activity data to individual clinical activities required multiple assumptions to be used, which were based on expert opinion (an average of the responses from ten mental health professionals who were asked to estimate from their opinion about each assumption). Table 8 below shows the assumptions required.

Table 8. Assumptions made in order to determine resource use from primary data

Clinical activities	Assumptions made
All clinical activities	Average day is 8 hours long
	4 contacts with patients per day
	Medications prescribed in an appointment are for the duration of one month
	The average length of assessment is 45 minutes
	Average length of use of office furniture and all types of equipment is 5 years
	1 hour is spent by clinical staff organising assessment/writing letters /notes and having relevant clinical meetings per hour of face to face patient time
	No staff sickness absence
	100% attendance at clinical activities by staff and patients
	All furniture and equipment lasts exactly 5 years
	Combined heat and power boilers are not used
	Energy used per square metre is equivalent to that in an outpatient appointment room in a general hospital
	Overheads account for 45% of the carbon footprint of clinical activity (for staff time, energy use, furniture and non-medical equipment)
Face to face clinic appointment	There is 7.4 times the amount of non-clinical to clinical space in the organisation
	One clinical examination room per 10 outpatient rooms
	All appointment rooms have the same standard furniture
	Appointment room has 45% occupancy
	Appointment and clinical examination rooms are used 5 days a week and 52 weeks a year
Home appointment	Travel for staff to get to patient's home is equivalent to travel by patient to get to clinic
	No medical equipment is used on a home visit.
Telephone appointment	Phone appointment takes the same length of time as a face to face appointment
	No additional equipment is needed for the telephone appointment than that which is already in a clinic room
	No medical equipment is used
	Staff phone the patient from a standard clinical appointment room
Individual psychotherapy appointment	No medications prescribed (as it is a psychotherapy session)
	Appointment length remains 45 minutes
	Room is twice the size of a standard appointment room
Bed day in psychiatric unit	All bed days last exactly 24 hours
	The ward is 100% occupied (NHS data found Oxford Health NHS Foundation Trust bed occupancy as >90% in 2015)
	Three meals are eaten per day
	1 clinical room per ward
	Staff to patient ratio = 0.4
	Patients travel home every other day
	All beds are in single rooms
Group psychotherapy appointment	Patients attended 100% of psychotherapy sessions
	No sessions were cancelled
	Proportion of time dedicated by staff to service is constant each week
	No patient was taking medication prescribed directly by the service
	Six patients per group appointment
	Admin time for group appointments is based on the number of (i.e. administration takes six times longer if six patients in the appointment)

Data collection method for financial data

Financial data were obtained from a previous input-output analysis based on an average of five mental health organisations financial expenditure, located in England (SDU 2013b). Their process of allocating financial data to clinical activities is described in Chapter 2 (Tennison 2010).

Results

Activity maps

The following activity maps show that each clinical activity is made up of several component activities, which include travel, arranging the appointment, waiting for the appointment, the actual appointment and human resources, administration and management activities.

Table 9. Identified activities for a face-to-face appointment at a health care facility

Component activity	Data required	
Travel	Fuel patient	
	Fuel for staff to get to workplace	
	Fuel HR and admin	
Non-clinical space used (including waiting room) and receptionist office and equipment	Furniture	Desk
		Easy chair
		Office chair
	Energy	
	Computer	
Appointment	Medication	
	Energy	
	Furniture	Desk
		Easy chair
		Office chair
	Computer	
	Medical equipment (in clinical examination room)	Blood pressure monitor
		Stethoscope:
		Patella hammer
		Weighing scales
		Phlebotomy kits
		Thermometer
		Pulse oximeter
		Glucose testing
		Urine testing
		Sharps bin
		Waste bin
		Ophthalmoscope
		ECG machine
		Defibrillator
		Height measure
		Medical bed and stool
		Drug trolley
		Pharmacy cupboards
		Medical refrigerator
		Chair
Arranging appointment and writing notes following appointment	Energy	
	Furniture	Desk
		Office chair
	Computer	
Admin and HR support	Energy	
	Furniture	Desk
		Office chair
	Computer	

Table 10. Identified activities for a home visit

Component activity	Data required	
Travel to/from appointment and to workplace (for staff)	Fuel for staff to pt's home	
	Fuel for staff to get to workplace	
	Fuel HR and admin	
Appointment	Medication	
Arranging appointment and writing notes following appointment	Energy	
	Furniture	Desk
		Office chair
	Computer	
Admin and HR support Direct overheads=29% Indirect overheads =16 %	Energy	
	Furniture	Desk
		Office chair
	Computer	

Table 11. Identified activities for a telephone appointment

Component activity	Data required	
Travel	Fuel for staff to get to workplace	
	Fuel HR and admin	
Appointment	Medication	
	Energy	
	Furniture	Desk
		Office chair
	Computer	
Arranging appointment and writing notes following appointment	Energy	
	Furniture	Desk
		Office chair
	Computer	
Admin and HR support Direct overheads=29% Indirect overheads =16 %	Energy	
	Furniture	Desk
		Office chair
	Computer	

Table 12. Identified activities for an individual psychotherapy appointment

Component activity	Data required	
Travel	Fuel patient	
	Fuel for staff to get to workplace	
	Fuel HR and admin	
Non-clinical space used (including waiting room) and receptionist office and equipment	Furniture	Desk
		Easy chair
		Office chair
	Energy	
	Computer	
Appointment	Energy	
	Furniture	Desk
		Easy chair
		Office chair
Arranging appointment and writing notes following appointment	Energy	
	Furniture	Desk
		Office chair
	Computer	
Admin and HR support	Energy	
	Furniture	Desk
		Office chair
	Computer	

Table 13. Identified activities for a group psychotherapy session

Component activity	Data required	
Travel	Fuel patient	
	Fuel for staff to get to workplace	
	Fuel HR and admin	
Therapy rooms	Furniture	Easy chairs
		Guitar
		Tables
		Board games
		Piano
		Flip charts
		Rubber mats
		Bean bags (large)
		Office chairs
		Desks
		Computers
		Phones
		Filing cabinets
	Energy	
	Computer	
Arranging appointment and writing notes following appointment	Energy	
	Furniture	
	Computer	
Admin and HR support	Energy	
	Furniture	
	Computer	

Table 14. Identified activities for a bed day in a psychiatric unit

Component activity	Data required	
Travel	Fuel patient	
	Fuel for staff to get to workplace	
	Fuel HR and admin	
Ward activity data	Medication	
	Energy	
	Furniture	Office chairs
		Easy chairs
		Dining tables
		Small/dining chairs
		Beds
		Desks
		Bed side tables
		Book cases
		Cupboards
		Wide screen tvs
		Filing cabinets
		Microwave oven
		Toaster
	Computer	
	Food	
	Medical equipment (in clinical room)	Blood pressure monitor
		Stethoscope:
		Patella hammer
		Weighing scales
		Thermometer
		Pulse oximeter
		Glucose testing
		Urine testing
		Sharps bin
		Waste bin
		Phlebotomy kits
		Ophthalmoscope
		ECG machine
		Defibrillator
		Height measure
		Medical bed and stool
		Drug trolley
		Pharmacy cupboards
		Medical refrigerator
		Chair
Admin and HR support	Energy	
	Furniture	
	Computer	

These tables show that only a small range of resources are required to deliver most types of clinical activity; office equipment, medical equipment, computers, medication, travel and energy. The only exception to this is the clinical examination room, which contains a wide range of equipment.

Activity data from primary and secondary sources

Medication

The average cost of medication in an outpatient appointment was found to be £23.26 (SD=10.2), which was calculated by taking an average of 59 outpatient appointments. The time frame assumed for prescriptions was one-month duration. The average cost of medication per bed day was £13.49 (SD=5.8), which was calculated by taking an average of 20 prescription charts from mental health inpatient units.

Travel

The average travel for community and inpatient clinical activities are shown below. The total distance for each method of travel was calculated for all staff and patients. An average distance per patient or staff member was then taken per clinical activity for the different methods of travel.

Table 15. Average patient travel per clinical activity

Clinical activity	Method of travel	Average distance per patient per clinical activity (km)
Outpatient appointment (urban)	Walk	1.05
	Bus	2.23
	Cycle	0.73
	Car	7.81
Outpatient appointment (rural)	Walk	1.24
	Bus	1.92
	Cycle	0.63
	Car	10.58
One bed day (extrapolated from appointment)	Walk	0.62
	Bus	1.04
	Cycle	0.34
	Car	4.61

Table 16. Average staff travel per clinical activity

Clinical activity	Method of travel	Average distance travelled per staff member per clinical activity (km)
Outpatient appointment	Walk	0.06
	Bus	0.40
	Cycle	0.17
	Car	1.81
One bed day	Walk	0.03
	Bus	0.20
	Cycle	0.09
	Car	0.91

Procurement and equipment

Tables 17 below show the procurement required for the different rooms used in clinical activities. These were obtained by developing inventory lists based on the activity maps.

Table 17. Inventory of rooms used in clinical activities

Room / clinical service	**Resource**	**Average number of items**
Outpatient appointment room	Desk	1
	Easy chairs	3
	Office chair	1
	Computer	1
	Room size	$18m^2$
Office space used by administrative, clinical and management staff	Desk	1
	Office chair	1
	Computer	1
	Room size	$16m^2$
Clinical examination room	Blood pressure monitor	1
	Stethoscope:	1
	Patella hammer	1
	Weighing scales	1
	Thermometer	1
	Pulse oximeter	1
	Glucose testing	1
	Urine testing	1
	Sharps bin	1
	Phlebotomy kits	50
	Waste bin x 2	2
	Ophthalmoscope	1
	ECG machine	1
	Defibrillator	1
	Height measure	1
	Medical bed and stool	1
	Drug trolley	1
	Pharmacy cupboards x 3	3
	Medical refrigerator	1
	Chair	1

Ward (excluding clinical examination room)	Office chairs	16
	Computers	12
	Easy chairs	52
	Dining tables	10
	Small/dining chairs	38
	Beds	20
	Desks	10
	Bed side tables	20
	Book cases	12
	Cupboards	34
	Wide screen TVs	2
	Filing cabinets	6
	Clinical examination room	1
	Microwave oven	1
	Toaster	1
	Average area of ward	640m^2
Group psychotherapy service	Easy chairs (Therapy rooms)	48
	Guitar (Therapy rooms)	1
	Tables 2m x 1m (Therapy rooms)	5
	Board games (Therapy rooms)	12
	Piano (Therapy rooms)	1
	Flip charts (Therapy rooms)	4
	Rubber mats (Therapy rooms)	3
	Bean bags (large) (Therapy rooms)	8
	Office chairs (Office rooms)	14
	Desks (Office rooms)	14
	Computers (Office rooms)	12
	Phones (Office rooms)	9
	Filing cabinets (Office rooms)	4
	Total area of all treatment rooms and office space used by service	185m^2

Financial data

Data were taken from a previously performed study and is based on 2009-2010 financial data based on an average of five mental health organisations (SDU 2013b), see Table 18 below.

Table 18. Financial expenditure per mental health organisation in England for each category of activity

Category	Expenditure per organisation per year (£ millions)
Medication	11.0
Medical equipment	7.3
Non-medical procurement	24.1
Building energy use	1.4
Travel	0.3
Total	44.0

Review of data collection methods

The data collection methods were reviewed according to the data quality criteria (WBCSD & WRI 2011) and the feasibility criteria (Bowen et al. 2009), to assess which method is fit for purpose. The below table 19, assesses each data collection method according to the steps defined in the methods.

Table 19. Determining data collection methods

Category of activity	Primary activity data	Secondary activity data	Secondary financial data	Data collection method chosen
Medica-tion	Obtaining primary data for medication involves measuring the medications dispensed from a pharmacist. Once medications are dispensed they cannot be re-dispensed to another patient. However, these data would require considerable time to acquire and collecting this data is therefore considered unfeasible in this context, under the criterion of 'practicality'.	NHS prescription records have been found to have 97.5% accuracy (HSCIC 2010). These data can provide good technological, geographical and temporal representativeness as data can be obtained for each clinical activity. These records also provide good completeness and reliability, as prescription records are accurate. GP prescribing data can be feasibly obtained through the database: Clinical Practice Research Datalink (CPRD n.d.).	n/a	Secondary activity data
Travel	Surveys are a widely used method for obtaining travel data for carbon footprint assessments (WBCSD & WRI 2011). Survey data can meet the data quality standards depending on the size of the sample and the relevance that the data has to the clinical activity in question. The survey methods used in this analysis, recorded method of travel for staff and patients, while a computer programme calculated distance by road from the postcodes obtained. Obtaining survey data is considered feasible in this context.	n/a	not available	Primary activity data

Energy	Obtaining primary data about energy use involves using electricity and gas meters to measure the energy used in each room that is attributable to the clinical activity being measured. This method could not be applied, as the meters did not pertain to discrete rooms, but covered whole buildings. Further, several rooms were attributable to each clinical activity (for clinical, administrative and management activities) and most of the rooms assessed had multiple uses, which resulted in significant difficulties when attempting to apportion energy use to specific clinical activities. Primary data collection was therefore considered unfeasible according to the 'implementation' criterion.	Energy use could be measured according to the size of the rooms (primary data) and applying a previously established conversion factor for energy use, per square metre (secondary data) (Connor 2010). However, while this method is feasible, it does not meet the data quality criteria. Energy required to heat and light one room will be different to another, dependent on insulation, number of windows etc. These are likely to vary between organisations, this method therefore does not meet the geographical representativeness criterion. Data completeness is also a problem when using this method because accounting for the energy used in all the rooms attributable to the clinical activity is very difficult. To account for these overheads, energy use was increased by 45%, see methods for rationale. Consequently, the technological representativeness of data obtained using this method is also poor.	Organisational financial data for energy can be feasibly obtained and provides good geographical representativeness, as the data is specific to the organisation. Good temporal representativeness can also be achieved, as it is easy to measure energy costs, so it could be measured at whatever frequency is required e.g. quarterly. Energy use is unlikely to change according to clinical practice, as in psychiatric practice few energy intensive pieces of equipment are used. Energy is therefore more likely to be associated with time spent in the room. Further, as costs of energy use do not fluctuate greatly between energy providers (Government 2012), cost of energy is likely representative of the energy used, therefore technical representativeness is not adversely affected. Using financial data removes the issue of estimating overheads, encountered with the method of basing energy use on room size, therefore, completeness of the data is improved compared with this method.	Secondary financial data
Medical equip-ment	Primary data could not be measured at a clinical activity level, due to the necessary inclusion of equipment in wards and clinics, such as a defibrillator machine or an ECG machine that are rarely used but are required due to national standards (RCPsych 2014). Simply measuring the equipment used in the room therefore	Not available	Organisational financial data is able to meet the data quality standards, except for the technical representativeness criterion. However, because there is only one emission factor available for the broad category of 'medical equipment' (DEFRA 2013), which is based on the cost of the equipment rather than type of equipment, using aggregated primary	Secondary financial

	greatly reduces data completeness. Primary data could also be measured by creating inventories of clinical examination rooms and then allocated to clinical activities. A limitation with this approach is that actual equipment use in a given clinical activity is not measured, rather an average is provided, thus technical representativeness is reduced with this method. However, this method of aggregating primary data is considered to provide better quality data, due to the issue associated with including necessary but rarely used equipment items when only the equipment used in the clinical activity is measured.		data based on the equipment present in a clinical examination room is therefore unlikely to provide more robust results compared to using secondary financial data. Financial data therefore is comparable to aggregated primary data, according to the data quality standards. As secondary financial data is more feasible to obtain, it is considered fit for purpose. Activity data in this category is difficult to measure and the PAS 2050 guidance suggests it should be excluded, but as the carbon footprint contribution made by this category is likely to be significant (SDU 2013b), it will be included using financial data.	data
Non-medical procure-ment	Using primary data to measure non-medical procurement per clinical activity results in poor data completeness. This is because there are many miscellaneous activities included in this category that are difficult to identify and measure, such as textiles, cleaning products, office equipment etc. As this category bears little relation to clinical practice, inventories have to be created for the whole organisation and then allocated to clinical activities, which is highly time-intensive. This method is therefore considered unfeasible under the criterion of 'practicality'.	Not available	Organisational financial data can meet the data quality standards, except for the technical representativeness criterion, because the type of procurement used cannot be determined from financial data. However, it does provide good data completeness and reliability and is representative of geographical region. It also can be obtained annually, so meets the temporal representativeness criterion. This data can be feasibly obtained from financial accounts. Activity data in this category is difficult to measure and the PAS 2050 guidance suggests it should be excluded, but as the carbon footprint contribution made by this category is likely to be significant (SDU 2013b), it will be included using financial data.	Secondary financial data

Discussion

Different methods of data collection have been suggested for each category of activity. It has been suggested that primary data about travel should be collected using surveys. Data for medication should be collected from primary care prescription records, which is classified as secondary activity data. Lastly it has been suggested that financial data should be collected for the categories of energy, medical equipment and non-medical procurement.

Using primary or secondary data sources

Primary data is that which is collected for the study in question, while secondary data is obtained from an existing data source. The reasons for using secondary data sources are as follows; for medication, a good quality secondary data source was available, which met the data quality standards and, obtaining primary data was considered unfeasible. Primary data about energy use in clinical activity rooms could not be obtained, as the energy meters did not allow for such measurement. Attempting to base energy use on room size did not meet the data quality standards. Therefore the best available method was to measure energy use using organisational level financial data.

Regarding medical equipment, simply measuring the medical equipment used in the clinical activity led to greatly reduced data completeness. This is because of the requirements to provide some types of equipment that are infrequently used (RCPsych 2014). Aggregating primary data for medical equipment according to clinical examination room provided no benefit to using organisational financial data, therefore financial data was chosen. For non-medical procurement, financial data was also chosen as obtaining primary data was considered unfeasible because it required creating inventories across the whole organisation for all non-medical procurement, which is highly time consuming.

Review of data sources

In this analysis, financial data were obtained from a previous input-output analysis based on an average of five mental health organisations financial expenditure, located in England (SDU 2013b). Therefore, the financial data did not pertain to the same organisation as the activity data, rather it provided an average financial data for mental health organisations in England. Given that this study is reviewing the process of collecting data, rather than the quantification of activities used in mental health, this issue was not considered relevant to the aim of this study. All activity data was obtained from Oxford Health NHS Foundation Trust and it is unknown whether this data is representative of other mental health organisations in the UK.

Collecting the data

It is likely that collecting activity data for medication and travel will be the major time-intensive components, as it will involve obtaining prescription records from primary care and performing both staff and patient travel surveys. However, the results from the activity mapping exercise suggest that these categories have significant variation between clinical activities.

Travel methods vary depending on whether the appointment is in a rural or urban setting, see Table 15. Medication use varies considerably between a bed day and an appointment (one bed day: £13.49, an appointment: £23.26). Therefore using an average carbon footprint obtained from financial data would likely not provide accurate results. Further, no data exists at an organisational level for patient travel, so this method would not be feasible either.

Using financial data

Using organisational level financial data to obtain a carbon footprint from an input-output method, requires a further step of allocating a carbon footprint to individual clinical activities. The two main clinical activities are outpatient appointments and bed days. The method of allocation is based on the proportion of inpatient or outpatient spend out of total spend. An average carbon footprint is then allocated for either a bed day or appointment on the basis of numbers of these activities occurring in the organisation. For example, an organisation might spend £1 million a year on patient care, of which £600,000 is spent specifically on outpatient care and £400,000 on inpatient care, while there are 30,000 appointments a year and 10,000 bed days a year. If the carbon footprint for energy obtained from an input-output method for this trust is 100,000 $kgCO_2e$ (based on overall financial expenditure on energy), then the carbon footprint for energy used in a bed day and appointment is as follows:

$$\text{Carbon footprint of energy use in one bed day} = \frac{\underline{100{,}000 \times (400{,}000/1{,}000{,}000)}}{10{,}000} = 4\ \text{kgCO}_2\text{e}$$

$$\text{Carbon footprint of energy use in one appointment} = \frac{\underline{100{,}000 \times (600{,}000/1{,}000{,}000)}}{30{,}000} = 2\ \text{kgCO}_2\text{e}$$

This method of allocation is based on one of the methods used by the SDU (Tennison 2010). This particular method has been chosen as it most accurately reflects the financial cost of resources used in the different types of clinical activity in relation to the overall spend by the organisation.

Using NHS financial data has limitations, it can have inaccuracies and inconsistencies (Peabody et al. 2004), although these are unlikely to be large (Chan 1993). Using secondary financial data, as shown above, provides average carbon footprints for each clinical activity and therefore cannot account for the variation in clinical practices that might occur between services or clinical activities. For example, the carbon footprint of a child psychiatry appointment may be very different from an older adult appointment. Using an organisational average in this case might not be accurate. The assumption that each admission or appointment has a uniform carbon footprint can also lead to false reasoning that if there are fewer appointments then fewer resources are used.

Conclusions

This chapter has noted that there are only a few different types of resources used in the delivery of mental health care. Despite this, due to the team based approach in psychiatry and the milieu of team working, identifying all the attributable activities and then allocating them to a particular clinical activity can be difficult, such as team meetings or informal 'catch-ups' about patients and management and administrative activities. Ensuring all these activities are taken into account when producing inventories requires assumptions to be made. Other than prescriptions data, the data required for carbon footprint assessments are not collected routinely, so if activity data is to be used it has to be collected specifically for the assessment, which although considered feasible for travel, was not feasible for energy, medical equipment and non-medical procurement. Therefore, for these categories, it has been suggested that relying on organisational financial data can provide similar or improved data quality against the data quality standards (WBCSD & WRI 2011).

This chapter has suggested an approach to collecting data that provides the best quality of data, while also being feasible in a clinical context. I consider the approach suggested here therefore to be 'fit for purpose'.

Chapter 6

Impact Assessment

Introduction

This chapter reviews the third step in the process of estimating the carbon footprint of clinical services, that of impact assessment. Once activities have been identified through activity mapping and their use allocated to a particular clinical activity, a carbon footprint can then be obtained by applying an emission factor. Emission factors are used to convert activity or financial data into a carbon footprint, see Chapter 1 for more details on this process. It is the application of these emission factors that is discussed in this chapter.

Emission factors can be determined through process-based LCA or input-output methods and have varying degrees of relevance to the activity being measured. The accuracy of emission factors can vary and every factor has some level of inaccuracy due to estimations about the combinations of energy obtained from different sources such as renewable, coal, gas or nuclear (Lenzen et al. 2004).

Both methods have their weaknesses, process-based LCA methods struggle to incorporate all the processes involved with manufacturing the item, known as truncation error (Suh 2004). Input-output methods use an indirect approach to estimating the carbon footprint based on financial data. Economic analyses are performed based on national emission datasets (Wiedmann 2010). The results obtained are therefore subject to the inaccuracies that stem from using these national generic datasets (Wiedmann 2010).

Data for travel can be reliably obtained from primary survey data. Its carbon footprint can then be accurately determined using emission factors obtained from process-based LCA methods, which are widely accepted within the discipline (DEFRA 2013). Chapter 5 showed that energy, medical equipment and non-medical procurement can only be reliably and feasibly measured using organisational financial data, therefore an input-output method has to be used to obtain the carbon footprint of these categories. For a summary of this method and its associated limitations please see Chapter 1. An analysis has shown that carbon footprint estimates using this input-output method can provide reliable results (Wiedmann et al. 2008).

Determining which method should be used to estimate the carbon footprint of medication is more complex. Chapter 5 showed that medication can be accurately measured using secondary activity data. Therefore either a process-based LCA method could be applied to obtain a carbon footprint or an input-output method could be used, if the medication use is converted to financial cost. This chapter reviews the available methods for estimating the carbon footprint of medication. The aim is to assess which methods are feasible and subsequently whether these methods are fit for purpose in mental health care.

Estimating the carbon footprint of medication

Obtaining an accurate carbon footprint for medication is important, as medication is likely to contribute a major part of the carbon footprint of clinical care, as suggested by a previously performed input-output analysis (SDU 2013b). Further, medication is the major medical intervention used in mental health care. It provides the foundation to most of the care plans for those under secondary mental health services, alongside psychological therapies.

There is no accepted approach in the literature for how NHS service providers should estimate the carbon footprint of medication; see Chapter 2. There are three possible options; two use a process-based LCA method and one uses an input-output method:

1. Guidance suggested by Environmental Resources Management (ERM) (SDU 2012a) – a process-based LCA method
2. A tool designed by the Association of the British Pharmaceutical Industry (ABPI) (ABPI 2013) – a process-based LCA method
3. An emission factor, obtained from an input-output method and supplied by DEFRA (DEFRA 2013).

Process-based LCA methods

The method provided by ERM (SDU 2012a) is based on the greenhouse gas protocol (WBCSD & WRI 2011). It is a detailed assessment designed to estimate the carbon footprint of individual medications. It is the method, which, according to the Greenhouse Gas Protocol, is likely to produce the most accurate results (WBCSD & WRI 2011). It was designed as a tool for pharmaceutical companies to estimate the carbon footprint of their products. It was not intended to be used to provide information to compare medications or suppliers (Hawkes 2012), although if the relevant information is available, it obviously can be used as such. There are, however, substantial market sensitivities of such data.

Given the stringent information required for this process, for example the complex procurement and distribution lines involved, only the companies producing the medication have the information required to use this guide. Pharmaceutical companies have used this guide internally to see whether the carbon footprint calculated can provide options for marketing (Hawkes 2012), but none have published the carbon footprint of their products. However, as the information required to complete this tool produced by ERM does not lie in the public domain, those outside the pharmaceutical industry attempting to estimate the carbon footprint of medication cannot feasibly apply this method.

In 2013, the Association of the British Pharmaceutical Industry (ABPI) produced a tool that also uses a process-based LCA method (ABPI 2013).

This tool is less time intensive than the tool produced by ERM. It was developed to allow pharmaceutical companies to more easily estimate the carbon footprint of their medications (ABPI 2013). As with the ERM guidance, it was not designed to allow external comparisons to be undertaken. ABPI states it is for "*assisting internal evaluations, …. and screening product portfolios to prioritise more detailed footprinting studies and carbon reduction initiatives."* (ABPI 2013). It is therefore a screening tool for pharmaceutical companies to determine the carbon 'hotspots' present in the production and development of their medications. In this role, it does not take into account as much information about medication production, marketing and distribution as that suggested by ERM. It takes into account the following parameters:

- Weight of active ingredient
- Number and weight of excipients (bulking agents in the tablet)
- Country of production
- Country of packaging
- Packaging details e.g. number of tablets in blister pack etc.
- Distribution and retail details

These data can be entered into a pre-prepared Excel spreadsheet, which calculates an estimate of the carbon footprint of the medication and its major constituents.

Using the Association of the British Pharmaceutical Industry tool

Given that there is currently no other process-based LCA method available, an attempt was made to use this tool to estimate the carbon footprint of two psychotropic medications, (Lithium Carbonate and Sodium Valproate). The aim was to determine whether their carbon footprints could be calculated using publicly available information. These medications were chosen because they are commonly prescribed medications, they are also off patent and therefore more information about their production is likely to be available.

Considerable difficulties were encountered when acquiring the information needed to complete this tool for both medications. The tool provides a 'default' setting in cases where the information is not known. When calculating the carbon footprint of Lithium Carbonate this 'default' setting had to be used in most areas. Despite attempts made to contact relevant pharmaceutical companies directly, no information could be found relating to the following areas:

- Active ingredient emission factor
- Number of formulation sites
- Process wastage rate
- Production share
- Transport methods
- Packaging methods

The information provided by the ABPI tool for calculating the carbon footprint of Lithium Carbonate is displayed below in Table 20. As can be seen in the 'high' and 'low' column in the table below, there are large uncertainties in the estimated carbon footprint. This is partly due to the fact that, as little information was known, the 'default' setting had to be used in the calculations.

Table 20. The carbon footprint of 200mg of Lithium Carbonate as determined by the ABPI tool

		Carbon footprint per tablet (gCO_2e)	Percentage	Uncertainty	
				Low (gCO_2e)	High (gCO_2e)
Material inputs	Active Pharmaceutical Ingredient	188.4	87.5%	24.3	1,461.5
Material inputs	Excipients	0.1	0.0%	0.0	0.3
Material inputs	Packaging Materials	11.2	5.2%	3.4	36.6
Material inputs	Total	199.6	92.8%	28.9	1,381.2
Formulation	Energy	2.6	1.2%	1.3	5.2
Formulation	In-bound Transport	0.0	0.0%	0.0	0.1
Formulation	Waste	0.0	0.0%	0.0	0.0
Formulation	Total	2.6	1.2%	1.3	5.2
Packaging	Energy	2.0	0.9%	1.0	4.2
Packaging	In-bound Transport	0.0	0.0%	0.0	0.0
Packaging	Waste	3.4	1.6%	1.4	8.2
Packaging	Total	5.5	2.5%	3.0	10.1
Distribution	RDC	0.359	0.2%	0.09	1.48
Distribution	Transport	0.204	0.1%	0.15	0.27
Distribution	Total	0.652	0.3%	0.30	1.44
Waste		0.089	0.0%	0.04	0.18
Retail & Use	NHS	3.5	1.6%	1.1	11.0
Retail & Use	Retail Pharmacies	0.1	0.0%	0.1	0.1
Retail & Use	Total	3.6	1.7%	1.2	11.0
End of Life		3.24	1.5%	1.91	5.48
Total		**215.2**	**100%**	**35.8**	**1295.0**

In order to compare the results obtained from the ABPI tool to the input-output method provided by DEFRA, (based on the cost of medication), the price of Lithium Carbonate was obtained from the British National Formulary (www.bnf.org); £2.30 for 100 x 200mg tablets. Given that the global average for UK consumption for medication (provided by DEFRA) is 0.43 kgCO_2e per £ (DEFRA 2013), the estimated carbon footprint per 200mg tablet of Lithium Carbonate is 9.9 gCO_2e. This is substantially different from that calculated by the ABPI tool (215.2 gCO_2e). In fact, the result obtained using the DEFRA emission factor does not even lie between the uncertainty parameters provided by the ABPI tool.

There was insufficient information available to complete the tool for Sodium Valproate, despite the use of all the default settings. The information that could not be obtained included all the same items as Lithium Carbonate as well as the list of excipients in the medication, (those components of the tablet that are not the active ingredient).

It is likely that the accuracy of the ABPI tool could be improved by access to higher quality information, however, obtaining access to this information looks to be unlikely at the current time. In this example, the attempt to estimate the carbon footprint of two medications has resulted in complete failure, since the requirement to rely on 'default' settings for most sections renders the results unreliable at best and complete fabrication at worst. The twenty-fold difference in the results between the two approaches to estimating the carbon footprint of Lithium Carbonate, using the ABPI tool and the input-output emission factor from DEFRA, is too large to even guess where the major uncertainties occur.

This ABPI tool was designed for pharmaceutical companies to perform internal investigations, as such it is perhaps unsurprising that the data required to use the tool are not publicly available. Despite this, the tool has provided some insights. It suggests that the active ingredient contributes the vast majority of the carbon footprint for Lithium Carbonate (87.5%). A recent report by the SDU (SDU 2014d) also suggests that the majority of the carbon footprint of a medication stems from the active pharmaceutical ingredient. However, the type and complexity of the active ingredient is variable and big differences in the percentage accounted for the active ingredient are likely between old generic active ingredients and newer more sophisticated ones.

The environmental input/output method

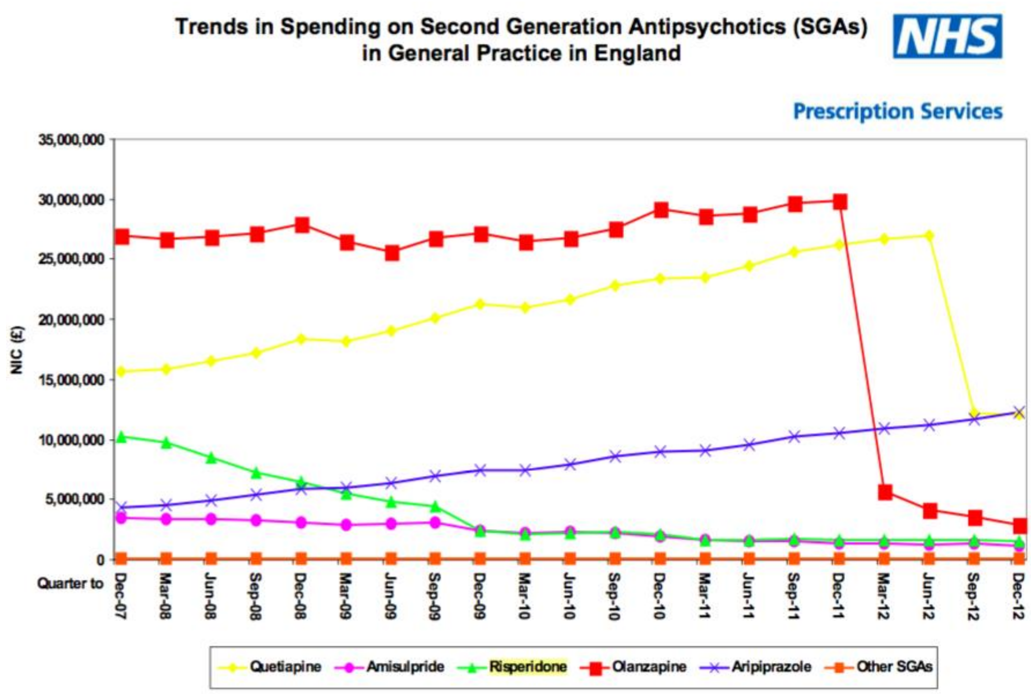
Calculating the carbon footprint of medication using an input-output method requires the financial cost of medication to be obtained. The global average emission factor for UK consumption is 0.43 $kgCO_2e$/£ (DEFRA 2013). Unlike the two previous methods that use process-based LCA methods, this method can be easily applied to clinical settings to estimate the carbon footprint of medication, because the cost of medication is freely available in the British National Formulary (www.bnf.org).

Using an input-output method for calculating the carbon footprint of medication presents two particular issues. The first relates to the issue associated with patent laws on medications. The second is that different regions have different emission factors for medications, but pharmaceutical companies do not provide information about the country of production. An environmental lead at a large pharmaceutical company who has performed detailed carbon footprint analysis on several of their medications stated that using the cost of the medication to determine the carbon footprint is not an accurate method (this person asked to remain anonymous, but agreed that his quote can be used):

"We haven't looked at CO2eq/£ for the simple reason that whether a product is in patent or not impacts on price and bears no relation to carbon, …. carbon footprints might be similar per kg of medication but the comparison of CO_2e/£ would be vastly different."

Patent law states that for the first ten years of a products life, it is protected against infringements. This is to allow the company that created the medication to cover the cost of research and development for that medication, and the many others that fail to make it to market, and to increase revenue for the company. During this period a relatively high product price is maintained (NHS 2013). After ten years the price tends to drop to a small proportion of its original cost. Applying the input-output method here, results in the apparent carbon footprint of a particular medication potentially dropping by a considerable proportion because of the drop in price. Figure 17 below shows the national expenditure for antipsychotic medications and the effects that coming off patent had on the cost of Olanzapine and Quetiapine antipsychotic medications in 2012. Quantities of prescriptions for these medications were reasonably constant during this period (NHS 2013). This illustrates how the patent issue can have a dramatic effect on the calculated carbon footprint of a medication if calculations are based solely on cost.

Figure 17. Reduction in costs of Olanzapine and Quetiapine following their end of patent in the UK, taken from (NHS 2013)



An argument for using cost as a basis for estimating the carbon footprint of medication is that the larger carbon footprints estimated from on-patent medications are likely to be, to some extent, representative of the carbon footprint of its research and development costs. However, a proportion of this increased cost is also likely to be associated with the profit made by the organisation and for recouping losses from other medications that have failed to reach the market. In Chapter 4, research and development activities for new models of care were excluded from the boundaries of a clinical activity. However, given that this is the only available method for estimating the carbon footprint of medication, there is no choice but to include these factors. In this chapter an assessment is made to assess the extent to which these additional on patent costs, affect estimations of the carbon footprint of medication.

The second issue with using cost of medications as a basis for estimating the carbon footprint is that different regions have different emission factors for medications. A report by the NHS Sustainable Development Unit has provided emission factors for medication based on the region where they were manufactured (SDU 2013a). Those produced in China have the largest carbon footprint per pound spent (1.37£/kgCO_2e), while those produced in the European Union (EU) have the smallest (0.29£/kgCO_2e) (SDU 2013a). This is due to the relative contributions of renewable energy sources in these countries (SDU 2013a). This is reflected in the fact that 2% of NHS expenditure on pharmaceuticals from China relates to 7% of the NHS carbon footprint while 40% of NHS expenditure on pharmaceuticals from the EU relates to 29% of the NHS carbon footprint (SDU 2013a). However, through investigation for this research, it has been evident that pharmaceutical companies do not provide information about where their medications are produced. The consequence is that the only available method for estimating the carbon footprint based on cost is to use a single emission factor for all medications (DEFRA 2013). In this chapter an assessment is made to assess the extent to which having to use a global standard emission factor for medication affects estimations of the carbon footprint of medication.

These two issues can combine to add further uncertainty, as often the latest medications, that are on-patent, are made in the EU (WHO 2014). Therefore, if the standard global emission factor is used for a new medication produced in the EU, this would result in a large carbon footprint due to their high on-patent cost, when in actual fact, their carbon footprint is likely to be smaller because it has been produced in the EU (SDU 2013a). Contrastingly, once medications come off their patent, they are often then made in factories in India or China to reduce costs (WHO 2014). Due to the new low price, using the global emission factor for these medications would provide a low carbon footprint estimate, however in reality the carbon footprint is likely to be higher, due to these countries' greater reliance on coal power stations (SDU 2013a).

Applying the emission factor obtained using an input-output method

Neither of the process-based LCA methods can be feasibly applied due to a lack of available data, the only available method is to use the emission factor provided by an input-output method. However, the previous section noted two concerns; first, about the potential for outlying data due to expensive on-patent medications, and second, about being unable to account for the regional differences between emission factors for medication due to a lack of data about country of production. Two sensitivity analyses are presented here with the aim of assessing the potential range of the estimated carbon footprint using an input-output method.

In the first sensitivity analysis, the use of medication will be measured using three different methods, based on; cost of medication, number of medications prescribed and weight of active pharmaceutical ingredient in the medication. As these last two methods use a standard cost for medications, (see below for methods), they are not viable alternatives to estimating the carbon footprint of medication. Rather they have been chosen because they are methods for accounting for medication that are not dependent on the individual cost of the medication, rather they allow an assessment to be made about how using the cost of medications as a basis for determining the carbon footprint might be affected by outliers, i.e. the expensive on patent medications. In the second sensitivity analysis, the cost of medication will be applied to the regional emission factors for medication, using the largest and smallest emission factors available; China and the EU respectively (SDU 2013a).

These sensitivity analyses use data from an observational analysis, which compares the prescriptions of two groups, one receiving a social prescription, the other, treatment as usual. The intention was to provide information about how using the different methods for measuring medication affected the results of the study. In other words, do the different methods provide the same result e.g. a reduction in carbon footprint of medication use after the service change, or do they provide different results.

Social prescribing services support people with mental health problems to access health resources and psychosocial support (Kimberlee 2013). These services have the potential to reduce the carbon footprint of care by using carbon light alternatives such as community support groups, rather than carbon intensive medications (Maughan, Patel, et al. 2015).

Methods

Design

This study was a retrospective, observational study that compared the psychotropic medications prescribed to two groups. One group received a social prescription for their mental health problems, the other group was the control. The study period was 24 months. Medication use was measured both before and after patients were given a social prescription for mental health in primary care. As this was a retrospective, observational study of a single service, no power calculations were performed. All patients entering the Connect service were included in order to maximize the power of the study.

The carbon footprint of medication was assessed in two ways; first, the three different methods for measuring medication use were applied to assess how using these different methods affected the estimated carbon footprint changes between groups. Second, both groups were analysed together as a whole sample and the average carbon footprint of medication per appointment calculated according to the different methods available. The results from this analysis were then reviewed to see how these different methods affected the overall carbon footprint of an appointment.

Ethics

Ethical approval for this study was obtained from the University of Warwick Biomedical and Scientific Research Ethics Committee, (REGO-2014-882).

Setting

This observational study was based in one primary care practice that had initiated a social prescribing service for mental health called *Connect*. This service was based in Kirkby Stephen in Cumbria.

Participants

All patients using Connect during December 2013 were compared to a control group. Eligible patients for the Connect group (n=30) were adults with a common mental health condition, who were not under mental health services, but had been using Connect for at least 6 months. The control group (n=29) was made up of patients from the same primary care practice who had a common mental health condition, such as anxiety or depression, but were not under secondary mental health services, did not have a substance misuse disorder (as this was an exclusion factor for the Connect service) and did not attend Connect. Patients in the control group received routine care from their general practitioner during the study period. There was limited availability for Connect so control patients were those who would have been referred had there been the capacity within the Connect service, otherwise there should be no difference between the groups. Patients spent between 6 and 18 months in the Connect project and were seen up to a maximum of 20 times.

Data collection

Data was retrospectively collected from primary care prescription records for a two-year period. The Connect group were measured from 6 months prior to referral to 18 months after entry to Connect, this spanned a period from June 2011 to January 2014. 6-month periods were used in this study to analyse health care use before and after referral to Connect. Corresponding data for the control group was collected for the same two-year period.

Methods for estimating the carbon footprint of medication use:

Assessing the impact of on-patent costs

1) The first method estimated the carbon footprint of medication based on the *cost* of the medication. Cost of medication was obtained from the British National Formulary (www.bnf.org) and the cheapest cost for each medication taken. The standard emission factor provided by DEFRA was then applied to this cost; 0.43 $kgCO_2e/£$ (DEFRA 2013).
2) The second method estimated the carbon footprint of medication based on the *number* of medications prescribed, rather than the different costs of individual medications. An average standard cost

for all medications was obtained for the whole sample; £4.87 per month. If a patient was prescribed one medication per month then this would equate to £4.87, however, if three were prescribed, this would equate to £14.61. The standard emission factor provided by DEFRA (DEFRA 2013) was then applied to this 'new' cost.

3) The third method estimated the carbon footprint of medication based on a standard cost of medication per unit weight. This was obtained by calculating an average 'cost per milligram' of active ingredient for the whole sample; 0.17mg/£. Following this, a 'new' cost was calculated for each medication, based on this average cost per weight and the weight of active ingredient of each medication. The standard emission factor provided by DEFRA (DEFRA 2013) could then be applied to this new cost. This method, while still based on cost, reflects the *weight of active pharmaceutical ingredient* of the medication prescribed.

Assessing the impact of regional emission factors

In the second sensitivity analysis, the carbon footprint of medication was estimated by applying one of three different emission factors; the standard emission factor that can be applied to all medications (0.43£/kgCO_2e), the emission factor for medications produced in China (1.37£/kgCO_2e) and the emission factor for medications produced in the EU (0.29£/kgCO_2e) (SDU 2013a). Emission factors for China and the EU have been chosen as they represent the largest possible range of the conversion factors available (SDU 2013a). Given that using these different emission factors will not affect the results of the observational analysis, as they are direct conversion factors, this sensitivity analysis was only applied to the analysis involving the whole sample.

Statistical analysis

Statistical significance was assessed at the 2-sided 5% level. Mean carbon footprints were compared between groups using a t-test; change scores (post 6 month average minus pre 6 months) were used for this analysis. Percentile bootstrapped 95% confidence interval and corresponding p-values were presented to account for non-normality of data (Briggs & Gray 1998). All analyses were carried out in Stata SE 13 (StataCorp 2013). Missing data were not imputed.

Results

Comparing groups

Table 21 displays the differences between groups for the carbon footprint of medication per 6-month period, following adjustment for baseline use. Carbon footprint changes after social prescription were calculated by subtracting the pre-treatment 6-month period from the average 6-monthly carbon footprint during the treatment period taken at intervals 6, 12 and 18 months. Positive values indicate carbon footprint reductions in favour of the Connect group. Only one result was found to be statistically significant at a 5% level, this was at 18 months following entry to Connect, using the method of measuring medication according to number of prescriptions.

Here, the control group had a significantly greater reduction in carbon footprint compared to the control group after 18 months ($p=0.05$). In all other calculations, the Connect group demonstrated no significant differences compared to the control group.

Table 21. Sensitivity analysis comparing the different methods for measuring medication use

Variable	Mean carbon footprint difference between groups adjusted for carbon footprint in baseline year ($kgCO_2e$) (95% CI); P value		
	Over 6 months	Over 12 months	Over 18 months
Carbon footprint of medication by cost	-3 (-16, 7) p=0.57	1 (-13, 15) p=0.84	14 (-2, 28) p=0.80
Carbon footprint of medication by number of prescriptions	-3 (-27, 21) p=0.36	1 (-13, 14) p=0.62	-6 (-11, 0) p=0.05
Carbon footprint of medication by weight of active ingredient	-6 (-64, 53) p=0.44	-1 (-57, 54) p=0.79	-6 (-31, 18) p=0.19

In the first two study periods there was little difference in the results obtained from using the different methods for measuring medication. After 6 months in Connect, the estimated carbon footprint difference between groups was; according to cost= -3 $kgCO_2e$, number of prescriptions= -3 $kgCO_2e$, weight of active ingredient= -6 $kgCO_2e$. After 12 months in Connect, the estimated carbon footprint difference between groups was; according to cost= 1 $kgCO_2e$, number of prescriptions= 1 $kgCO_2e$, weight of active ingredient= -1 $kgCO_2e$. However, in the last study period (over 18 months), there was a large difference between the carbon footprints obtained from these different methods. Estimating the carbon footprint according to the cost of medication provided a carbon footprint difference between groups of 14 $kgCO_2e$, as compared to differences of -6 $kgCO_2e$ according to weight of active ingredient and -6 $kgCO_2e$ according to number of medications. Not only are these differences large but also, estimating the carbon footprint according to cost finds an advantage for the Connect group, while measuring according to weight or number of medications prescribed finds an advantage for the control group, (although these findings are not significant).

These large differences between methods, noted in the 18-month study period, were mostly due to the effects of prescribing one type of antidepressant medication; Venlafaxine. Currently the on-patent modified release version of Venlafaxine costs about £100 per month at higher doses, whereas an equivalent dose of standard, or off-patent, Venlafaxine costs about £5 (obtained from www.bnf.org). Two patients in the control group were prescribed this modified release version in the last six-month period and one patient in the Connect group had their dose of this medication reduced. These small changes in only three subjects resulted in a large mean difference between groups when using a cost-based approach. The other two accounting methods were not largely affected by these changes. It is clear that a small number of outlying data has had a considerable effect on the result of this observational analysis. The very high cost of only a few on patent medications has the potential to skew the carbon footprint estimates of whole samples.

Reviewing the whole sample

The whole sample was used to perform a further sensitivity analysis addressing i) concerns about outlying data due to on-patent costs and ii) international differences in emission factors for medication. The whole sample was used in order to include the maximum number of subjects (n=59) for the analysis so that the most accurate average figure could be calculated. The different methods for estimating the carbon footprint of medication were assessed to review how they affect the estimated carbon footprint of medication used in a standard clinic appointment.

Table 22 below shows there are considerable differences between the carbon footprints calculated for medication obtained from the three methods for measuring medication; cost, weight and number of prescriptions. The method based on cost provided the highest carbon footprint for medication per appointment; 10.0 $kgCO_2e$. The method based on the number of medications provided a smaller carbon footprint of 3.3 $kgCO_2e$ per appointment. Measuring according to a standard cost per weight of active pharmaceutical ingredient provided a carbon footprint of 6.8 $kgCO_2e$ per appointment. This analysis concurs with the first analysis, that a small number of outlying data, due to on patent costs, can have a considerable impact on the estimated carbon footprint of medication used per appointment. This small sample demonstrates that on patent costs can have the effect of increasing the average carbon footprint of medication per appointment three-fold.

Table 22. Sensitivity analysis comparing how the different methods for measuring medication affect the estimated average carbon footprint of medication per appointment

Scenario	Carbon footprint of medication per primary care appointment ($kgCO_2e$)
Carbon footprint by cost	10.0
Carbon footprint by number of medications prescribed	3.3
Carbon footprint by weight of active ingredient	6.8

Table 23 below shows that the estimated carbon footprint varies considerably according to which regional emission factor is used. Using the standard global emission factor, provides a carbon footprint estimate of 10 $kgCO_2e$ per appointment. Assuming all medications were produced in the EU provides a carbon footprint estimate of 6.7 $kgCO_2e$, whereas assuming all medications were produced in China provides a carbon footprint estimate of 31.9 $kgCO_2e$. There is almost a five-fold range caused by the differences between the regional emission factors for medication.

Table 23. Sensitivity analysis comparing how regional emission factors affect the estimated average carbon footprint of medication per appointment

Scenario	Carbon footprint of medication per primary care appointment ($kgCO_2e$)
Using the standard emission factor for all medications (global) (0.43 £/$kgCO_2e$)	10
All medications used are produced in the EU (0.29 £/$kgCO_2e$)	6.7
All medications used are produced in China (1.37 £/$kgCO_2e$)	31.9

Discussion

Due to its retrospective nature, small sample size and lack of randomisation, this study is not able to robustly determine whether social prescribing services actually reduce the carbon footprint of psychotropic medications used in primary care. Further the results of the first sensitivity analysis demonstrate that the carbon footprint estimates are not sufficiently robust to determine how social prescribing affects the carbon footprint of medication use in primary care. However, the aim of this study has been to assess the potential range of the carbon footprint estimates of medication when using an input-output method.

Medication 'on patent' costs

The first sensitivity analysis based on the results of the observational analysis demonstrated that if one or two medications are expensive due to being on-patent, as was the case with modified release Venlafaxine, this has a significant effect on the estimated change in carbon footprint following social prescription. The observational study has shown that, in some instances, the method based on cost finds in favour of the Connect group, while the other two methods find in favour of the control group. This sensitivity analysis demonstrates that a small number of on-patent medications has a significant impact on the overall results due to on-patent costs.

The second sensitivity analyses based on the whole sample demonstrate that using a cost-based approach provides a much larger carbon footprint estimate for the carbon footprint of medication in an appointment than the other two methods. A three-fold increase was found in this sample when the estimate was based on cost, compared to number of prescriptions.

Basing the carbon footprint estimate on the weight of the active pharmaceutical ingredient of medication to estimate the carbon footprint of medication has been suggested by the SDU as the most likely to provide accurate results (SDU 2014d). However, using a standardised cost per weight of ingredient, or basing medication use on number of prescriptions, does not account for the fact that all active pharmaceutical ingredients are different. For instance, older medications that use basic ingredients, such as Lithium, may have a far smaller carbon footprint than modern medications, which might have much more complex manufacturing processes and more complex raw ingredients. Therefore, while measuring medication based on weight of ingredient or number of prescriptions can reduce the effect of outliers, they are not viable alternatives because they provide no basis for estimating the carbon footprint of the active pharmaceutical ingredient.

Regional emission factors for medication

The second sensitivity analysis demonstrated a potential five fold range for the estimated average carbon footprint of medication per appointment due to the differences between regional emission factors (SDU 2013a). This issue of regional differences in emission factors is not usually a problem for input-output analysis, as a multi-region model can be applied to account for where items are produced (Wiedmann et al. 2008). This is the case for other categories used in this research such as non-medical procurement. However, this chapter has demonstrated that it is difficult to obtain information about where a medication is produced, therefore a standard global emission factor for all medications has to be used, which results in a five-fold potential range of carbon footprint estimates for medication in a clinical activity.

Should medication be included in carbon footprint assessments of mental health care?

Both on-patent costs and being forced to use one global emission factor create a large potential range of the carbon footprint estimate. The research and development costs of the medication have to be taken into account because the only available method for estimating the carbon footprint of medication is based on cost, which includes these factors in the on patent costs. As shown in the sensitivity analysis, it is not ideal that the costs of a few on patent medications cause the results to be skewed to such a degree. It is also not ideal that decisions made by service providers to reduce the carbon footprint of services should be overly affected by on-patent costs, as this three fold difference in the carbon footprint is likely to have a considerable effect on the carbon footprint estimate of any clinical activity that uses medication. Further, the five-fold potential range in estimates of the carbon footprint of medication due to differences in regional emission factors makes any estimate unreliable and almost impossible to interpret. However, excluding medication from carbon footprint analyses of mental health care would also be problematic from a face validity perspective, as it is a major component of psychiatric practice. It would also affect the completeness of the results, as medication is likely to contribute a significant proportion of the overall carbon footprint of clinical activities (SDU 2013b).

If a clinical activity either does not use medication, or if medication does not contribute a large proportion of the carbon footprint, then the potential range stemming from carbon footprint estimates of medication will be smaller and the robustness of the estimate improved. However, if medication contributes a large proportion of the carbon footprint of a clinical activity then the carbon footprint estimate of the clinical activity would have such a large potential range that interpretation of the results would be difficult and the results potentially considerably inaccurate. However, the Greenhouse Gas Protocol states "*when a single facility uses the same estimation methodology each year, the systematic parameter uncertainties in a source's emission estimates for two years are, for the most part, identical. … In such a situation, quantified uncertainty estimates can be treated as being comparable over time and used to track relative changes in the quality of a facility's emission estimates for that source category*" (WBCSD & WRI 2011). This can be applied to repeated estimations of the carbon footprint of a clinical activity or service where, if one organisation is using an input-output method to estimate changes to the carbon footprint of a service over time, then the potential range associated with the carbon footprint estimates of medication can be discounted. Of course, there are issues with this assumption, as the variation in medications from the different regions might lead to spikes and troughs in the cost of medication, which would directly impact on the carbon footprint estimation. This would be particularly true if the service was small, as relatively minor changes in cost, as demonstrated in the above example, can have a large impact on the carbon footprint differences noted. The larger the service, the less this issue would have an impact as the likely variation in obtaining medications from the different regions would be averaged out across the service. Using an input-output method to estimate the carbon footprint of medication could in this particular circumstance, be considered fit for this purpose. However, the Greenhouse Gas Protocol states that this range cannot be discounted when comparing "*operationally similar facilities use identical emission estimation methodologies*" (WBCSD & WRI 2011), therefore an input-output method cannot be considered fit for the purpose of comparing between two different services or clinical activities where medication contributes a moderate or large percentage burden.

Despite the inaccuracy of the carbon footprint estimation of medication, there is utility in including the carbon footprint of medications over and above using costs as a proxy measure. The reasons for this are two-fold; first, using the emission factor for medication would enable the carbon footprint of the whole service to be presented, rather than the carbon footprint of other aspects of the service and then the cost of medications presented alongside this. Second, service providers could review the relative contribution made by medication to the carbon footprint of the service to determine which aspects of the service they should prioritise in order to most effectively reduce the carbon footprint.

Conclusions

While pharmaceutical companies remain unwilling to provide carbon footprints of their medications, or unwilling to provide public access to their records so that carbon footprint calculations can be performed by others, the preferred method, provided by ERM, cannot be used. The screening tool provided by the ABPI is also unable to provide robust carbon footprint estimates due to a lack of publicly available data. The results displaying a 21-fold difference between the carbon footprint estimated from the ABPI tool and the input-output method estimated by the emission factor from DEFRA suggest large inaccuracies in potentially both approaches. Governmental policy would have to change or market influences would have to incentivise the publication of the carbon footprint of medications in order for pharmaceutical companies to publish their data.

The only available option for estimating the carbon footprint of medication is an input-output method, based on the cost of medication. This input-output method falls short of being a robust approach because of two issues; the large costs associated with on-patent medication and the regional differences in the emission factors for medication. Basing the carbon footprint of medication on cost includes the research and development costs of medications and increases the carbon footprint estimate of medication potentially three-fold. While this issue skews the results, it is likely to be at least to some degree, representative of the emissions associated with producing a medication. Therefore using cost to estimate the carbon footprint of medication is potentially reasonable in these circumstances. However, the potential extent of impact these on-patent costs have on the carbon footprint of clinical activities should arguably not have an impact on decisions made about service design.

Being forced to use a global emission factor for medication leads to the larger five-fold potential range, as it cannot be determined from publicly available data where a medication is produced to enable application of regional emission factors. As a consequence of this range, using an input-output method to estimate the carbon footprint of medication is not fit for the purpose of providing a point estimate of a service or comparing two services, rather it is only fit for the purpose of comparing one service or clinical activity over time, as then the large range associated with the estimations can be discounted (WBCSD & WRI 2011).

The available methods for estimating the carbon footprints of other categories are considered fit for purpose both for comparing between services and for comparing one service over time. Travel can be reliably estimated because its use can be accurately measured via survey and there is good availability of reliable emission factors (IPCC 2006). Regarding energy use, non-medical procurement and medical equipment; to obtain reliable data for their use in clinical activities, secondary financial data should be used, as discussed in Chapter 5. Following this an input-output method has to be used to obtain a carbon footprint, which can provide robust carbon footprint estimates (Wiedmann et al. 2008). New types of medical equipment also have patents (Raviola et al. 2011) and therefore potentially suffer from the same issue as medication, however, unlike specialties such as intensive care or surgery, psychiatric practice does not use complex equipment to deliver care, (see Chapter 5 for an inventory of medical equipment). Therefore, outlying data are unlikely to have the same degree of effect as the patent costs of medication in mental health care. To assess the extent to which equipment is affected by on patent costs, a similar sensitivity analysis to that performed in this chapter would have to be performed.

Chapter 7

Interpretation

Introduction

The final step in the process of developing an approach to estimating the carbon footprint of mental health care is that of interpretation. This chapter therefore summarises the approach that has been developed so far and its theoretical weaknesses. It also reports and analyses the results obtained from using the approach and considers any limitations. It also provides recommendations based on the findings of the preceding steps. A scenario analysis is presented that reviews hypothetical service changes that could affect the carbon footprint. The aim is to assess whether the approach is fit for purpose by exploring whether it can robustly account for the changes to the carbon footprint following changes to service design.

The proposed approach is termed the *combined* approach as it uses primary and secondary data and employs both process-based LCA and input-output methods.

The combined approach

The previous three chapters have determined how the carbon footprint of mental health care can be feasibly estimated within the constraints of a clinical context. In Chapter 4, the boundaries and categories of assessment were defined. In Chapter 5, each category of activity was assessed according to data quality standards and feasibility criteria to determine which methods of data collection are fit for purpose. In Chapter 6, the process of estimating a carbon footprint from the data was reviewed and a method of carbon conversion suggested for each category.

This research has proposed that patient and staff travel should be measured using primary data from surveys, and emission factors, based on process-based LCA, then applied to the travel data. The carbon footprint of non-medical procurement, energy and medical equipment should be estimated using organisational level financial data and an input-output method. Medication should be measured from secondary activity data, (the GP prescriptions database (CPRD n.d.)), and an emission factor that is obtained from an input-output method (i.e. based on cost) should be applied.

These findings provide the foundations for the combined approach for estimating the carbon footprint of mental health care, shown below in Table 24.

Table 24. A summary of the combined approach

Category of activity	Step 1 Aim and scope	Step 2 Data source for inventory	Step 3 Impact assessment (method used to obtain carbon footprint)	Uncertainty of estimate or potential range (type of uncertainty)
Medication	Included within boundaries	Secondary activity data	Input-output	2.5% (parameter) five-fold range
Travel	Included within boundaries	Primary activity data	Process-based LCA	2% (parameter)
Medical equipment	Included within boundaries	Secondary financial data	Input-output	5% (model)
Non-medical procurement	Included within boundaries	Secondary financial data	Input-output	5% (model)
Energy	Included within boundaries	Secondary financial data	Input-output	5% (model)

The uncertainties noted in the above table are discussed in detail below. It is acknowledged that the uncertainties included in this table do not represent the total uncertainties for each category, as potential uncertainties have not been assessed, for example, the statistical uncertainty associated with data collection. However, they represent the uncertainties that are currently known.

As can be seen from the table above, most categories use an input-output method to estimate a carbon footprint. However, travel and medication are measured using activity data because these categories have significant variation between clinical activities and services. Chapter 5 shows that travel varies according to region and prescription data shows that medication use changes considerably based on type of clinical activity. Variation also exists between sub-specialties. In child and adolescent psychiatry, much less medication is used (Klykylo & Kay 2012), while specialist centers are more widely dispersed (JCP-MH 2013), hence travel will also likely be different. While the opposite is true for adult psychiatry

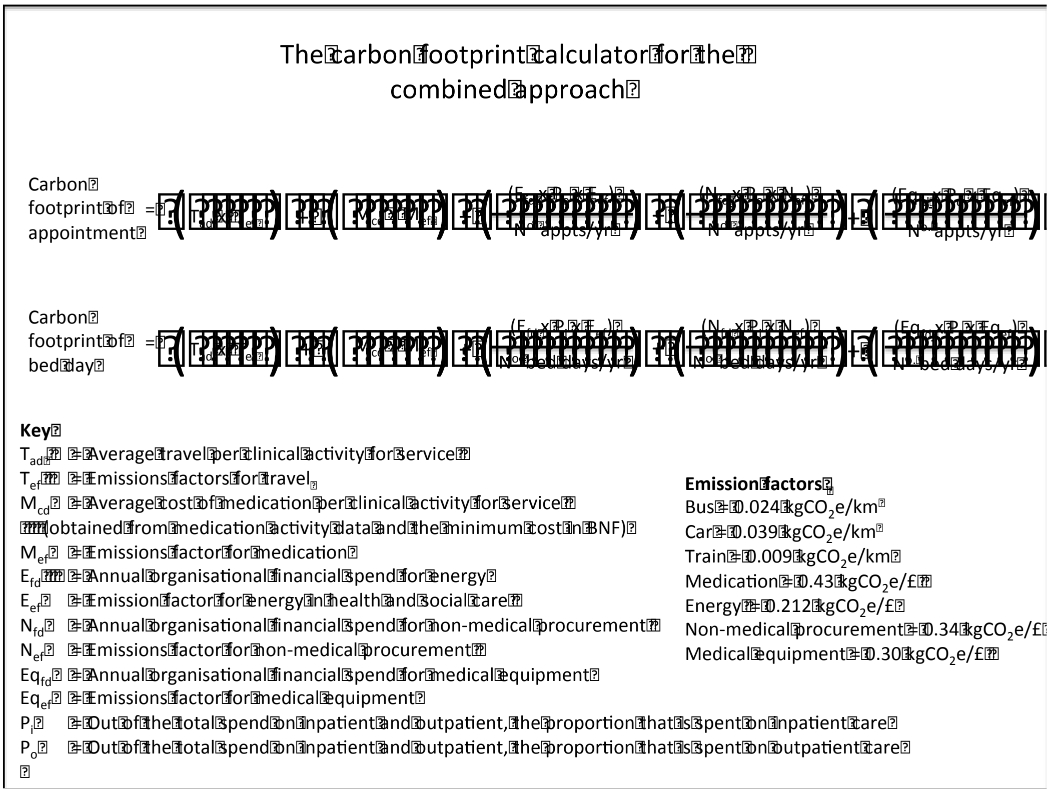
(NHS 2009). Further, complete financial data about psychotropic medications cannot be obtained from mental health organisations as the vast majority is prescribed from primary care. (GOV 2012). There is also no available financial record of patient travel and therefore activity data has to be used for this category (Scott et al. 2008). Therefore using financial data and an input-output method to estimate the carbon footprint of medication and travel, which provides an average carbon footprint across the organisation, is not considered fit for purpose.

In Figure 18 below, the combined approach has been presented as a carbon footprint calculator. This formula is not based on any previous formula, but has been created based on the findings of this research. Emission factors are taken from DEFRA, which are based on 2009 data (DECC 2012). The carbon footprint of travel is calculated by taking the average travel per clinical activity for the service in question and applying relevant emission factors. The carbon footprint of medication is calculated by taking the average cost of medication per clinical activity, which is obtained from a GP prescription database (CPRD n.d.) and by taking the minimum cost of the medication from the British National Formulary (www.bnf.org). Activity data for medication has to be converted to financial data, as the only emission factor available is taken from an input-output method, which uses financial cost to translate to a carbon footprint.

The financial spend data required for this carbon footprint calculator for energy, medical equipment and non-medical procurement can be acquired from accounts data from mental health organisations. While there are specific emission factors for energy and medical equipment, the emission factor used for non-medical procurement is that termed 'health and social work' as there was no specific category for non-medical procurement. This category includes all aspects of health and social care, which also includes medications, travel and medical equipment. This is a clear weakness in the carbon calculator as this category does not directly correspond to the products it refers to. It is difficult to predict how this factor relates to what the emission factor for non-medical procurement actually should be.

The carbon footprint of these categories is based on share of inpatient or outpatient spend out of the total spend for patient care for the organisation for that category. For example if £100,000 is spent on energy by the organisation, 60% of spend for patient care is on outpatients and there are 60,000 appointments per year. The cost of energy per outpatient appointment is £1, which can then be translated into a carbon footprint using the relevant emission factor. This method of allocation has been taken from a report produced by the SDU that used an input-output method to estimate the carbon footprint of clinical activities, described in Chapter 2 (SDU 2013b). The underlying assumptions with this allocation method are that all patient contacts are either appointments or admissions and that all of these are recorded. However, it is likely that there are phone calls to patients, or informal meetings that might not be recorded, or other services provided by the organisation such as day hospital or group therapy, that do not fit into the categories of appointments or admissions. These assumptions reduce the robustness of the results, however out of the available options, it is the method of allocation that can most accurately account for the cost of resources per clinical activity.

Figure 18. The carbon footprint calculator for the combined approach



Emission factors have been obtained from DEFRA and are based on data from 2009 (DECC 2012)

This tool attributes the carbon footprint according to clinical activities. There are, of course, other relevant drivers in mental health organisations that affect the carbon footprint, such as management activities or buildings. However, as the aim of a mental health organisation is to provide clinical care, the ‘product’ of these organisations is clinical activities. Therefore it is appropriate that the carbon footprint is stratified according to these activities. A report published by the Royal College of Psychiatrists about estimating the carbon footprint of mental health services also supports this approach (RCPsychCSH 2013). The combined approach incorporates these other significant drivers within the categories of energy and non-medical procurement. The category of non-medical procurement is broad and inclusive of a wide array of resources including buildings, office equipment, food for inpatients and ward supplies. A weakness of the combined approach is that this category is broad. As there is a single emission factor for this category, which is the generic emission factor for 'health and social care', no information can be provided by the combined approach about where the carbon hotspots might lie within the non-medical procurement category. If a decision were made to address this category then service providers would have to review what the main contributors were to this category in terms of financial cost. This clearly is not ideal as financial cost is not a reliable indicator of carbon footprint (DEFRA 2013).

Uncertainties associated with the combined approach

There are two different types of uncertainty associated with carbon footprint estimations; model uncertainty and parameter uncertainty (WBCSD & WRI 2011). Model uncertainty refers to the uncertainty associated with the model structure used to obtain the estimates and the assumptions explicitly or implicitly made (WBCSD & WRI 2011). In the case of the combined approach, this refers to the categories of energy, medical equipment and non-medical procurement as these carbon footprints are estimated using an input-output model. A Monte Carlo analysis into the uncertainties provided by UK multi region input-output models for environmental accounting found that the standard error is less than 5%, and concluded that a "*MRIO [multi-region input-output] model is robust enough to provide a reliable indication of CO_2 emissions embedded in UK economic activity, including trade from and to the UK*" (Wiedmann et al. 2008). This 5% model uncertainty cannot be applied to medication as, although an emission factor based on an input-output model is used, a multi-region analysis cannot be implemented, because data about the country of production is not publicly available. A global emission factor for medication therefore has to be used. The uncertainty associated with this economic model is unknown, however, in the context of the potential five-fold range associated with the carbon footprint estimates of medication, found in the previous chapter, it is not considered important.

Parameter uncertainty refers to the uncertainty associated with quantifying the 'parameters' used as inputs i.e. the data collected and the emission factors (WBCSD & WRI 2011). The statistical uncertainty associated with the data collection methods can be assessed by performing repeated measures or using multiple sampling sites, however, this research has not attempted to determine this type of uncertainty due to time limitations. However, the statistical uncertainty associated with travel data would be reliant on the size of the survey and the relevance of the population surveyed to the clinical activity or service in question. Regarding the statistical uncertainty associated with medication, administrative data has inaccuracies (Peabody et al. 2004), however, prescription data in the NHS has been found to be

97.5% accurate (HSCIC 2010). The statistical uncertainty associated with financial data for energy, medical equipment and non-medical procurement is unknown, however, given that this is based on accounts data, it is unlikely to be large (Chan 1993).

The parameter uncertainty associated with using emission factors (in the case of medication and travel) is also significant. Regarding travel, the IPCC suggests that an uncertainty factor for travel emission factors is about 2% (IPCC 2006). This is considered to be a 'fair' level of certainty according to the Greenhouse Gas Protocol (WBCSD & WRI 2011). However, by far the largest uncertainty is the potential range associated with using a single global emission factor for medication, which was found in Chapter 6 to be a five-fold range. This range is based on the differences between regional emission factors.

Using the carbon footprint calculator

Table 25 below shows the carbon footprint of a bed day and an appointment at a clinical facility (an outpatient appointment). This has been calculated by applying the carbon footprint calculator to resources used at Oxford Health NHS Foundation Trust. This is presented in this section to demonstrate the type of information that the carbon footprint calculator provides. Details about how the data was collected for this however, is provided in the methods section below, as the same methods are used for this calculation as are used in the scenario analysis below.

Table 25. The estimated carbon footprint of a mental health bed day and a community assessment using the combined approach

Category	Carbon footprint of one bed day		Carbon footprint of one appointment at a clinical facility	
	$kgCO_2e$ [uncertainty]	(% burden)	$kgCO_2e$ [uncertainty]	(% burden)
Medication	5.8 [5.6-6.0]	(8%)	10.0 [9.7-10.3]	(20%)
Range for medication	3.5-18.0		6.0-31.0	
Medical equipment	9.6 [9.4-9.8]	(13%)	5.9 [5.8-6.1]	(12%)
Non-medical procurement	32.8 [32.0-33.6]	(46%)	20.1 [19.6-20.6]	(39%)
Energy use	21.6 [21.1 – 22.1]	(30%)	13.2 [12.9-13.5]	(26%)
Travel	1.6 [1.6-1.6]	(2%)	2.0 [2.0-2.0]	(4%)
Total	71 .4 [69.7-73.1]	(100%)	51 .2 [50.0-52.5]	(100%)

For a bed day, non-medical procurement contributes the largest percentage burden (46%), followed by energy (30%), medical equipment (13%) and medication (8%). Travel only contributes a small proportion of the carbon footprint at 2%. For an outpatient appointment, non-medical procurement contributes the largest percentage burden (39%), followed by energy (26%), medication (20%) medical equipment (12%). Travel only contributes a minor component of the carbon footprint at 4%.

The model and parameter uncertainties associated with the carbon footprint estimate of these clinical activities are not large. The statistical uncertainty associated with data collection has not been included, as it cannot be calculated from the data available in this study. The potential range for the carbon footprint estimate of medication is large. The sensitivity analysis in Chapter 6 suggests that medication has a five-fold range of which 40% lies below the estimate provided by a single emission factor for medication and 210% lies above. This range is based on the relationship between the single emission factor used for all medications and the emission factors for medication manufactured in Europe (lowest) and China (highest) (SDU 2013a). For a bed day, the potential range of the carbon footprint of medication is 15 $kgCO_2e$, which is 20% of the total carbon footprint for the clinical activity. For an outpatient appointment, the potential range of the carbon footprint of medication is 25 $kgCO_2e$, which is 49% of the total carbon footprint for the clinical activity. The range is proportionally larger for an outpatient appointment, as medication contributes a larger percentage burden to this clinical activity.

Weaknesses of the combined approach

Two major weaknesses of the combined approach have been noted so far in this research:

- The use of a single emission factor based on an input-output method for estimating the carbon footprint of medication
- The reliance on financial data to estimate the carbon footprint of energy, medical equipment and non-medical procurement.

Estimating the carbon footprint of medication has to rely on an emission factor obtained from an input-output method, as currently no other methods are available, see Chapter 6 for details. This represents a considerable weakness in the combined approach, since the use of a single emission factor for medication creates a potential five-fold range in the estimate provided. Chapter 6 also demonstrated that expensive on-patent medications can lead to spuriously high carbon footprint estimates (in the example provided, a three-fold range was noted). This is because the cost of on-patent medications includes the considerable research and development costs of the medication (NHS 2009). The scenario analysis presented in this chapter considers whether the combined approach is fit for purpose, despite this potential range associated with estimates of the carbon footprint of medication.

The other major weakness in the combined approach is its reliance on organisational level financial data to measure energy, medical equipment and non-medical procurement. Chapter 5 concluded that organisational level financial data should be used because obtaining primary data was either unfeasible (energy) or there were problems with accounting for overheads (medical equipment and non-medical procurement). The disadvantage of using financial data is that it does not base the carbon footprint estimate on the activity occurring within a clinical activity, rather it provides an organisational average carbon footprint for each clinical activity. This is a problem, as one service might use more resources than another; using an organisational average would not account well for this variation.

Importantly, using financial data for these categories has been found to provide more complete data than that provided by activity data. To demonstrate this, the estimated carbon footprint of the energy, medical equipment and non-medical procurement used in a bed day and a community assessment, obtained from a process-based LCA method using activity data, are compared to those provided by a previously performed input-output method, using financial data in Table 26 below (SDU 2013b). The methods of activity data collection are described in Chapter 5. The emission factors used and the results of this analysis are presented in Appendix 3. Every effort was made to include all relevant activity data, including administrative and management activities, as described in Chapter 5. An average carbon footprint for a community assessment was taken from the four different types of mental health assessment; clinic appointment, home visit, telephone assessment and psychology assessment. The methods used to obtain the carbon footprints using an input-output method are described in Chapter 2 (SDU 2013b).

Table 26. A comparison of the carbon footprint of clinical activities obtained using process-based LCA and input-output methods

Category	Carbon footprint of one bed day ($kgCO_2e$)		Carbon footprint of one community assessment ($kgCO_2e$)	
	Process-based LCA (activity data)	Input-output (financial data)	Process-based LCA (average of 4 different assessment types) (activity data)	Input-output (financial data)
Medical equipment	0.0	9.6	0.0	5.9
Non-medical procurement	11.0	32.8	0.1	20.1
Energy use	8.3	21.6	5.7	13.2

The carbon footprint estimates obtained using the two methods are significantly different for these categories. The process-based LCA method provides considerably lower carbon footprint estimates compared to the input-output method. The largest difference is in the 'non-medical procurement' category, where, for a community assessment, a process-based LCA method provides an estimate of 0.1 kgCO_2e, whereas an input-output method provides a carbon footprint of 20.1 kgCO_2e; a 200 fold difference. This suggests that data completeness is a highly significant issue when attempting to use activity data for this category. Over-estimation of the carbon footprint stemming from the use of an input-output method could also have caused these differences, however, data completeness is more likely the cause, given the many miscellaneous activities included in this category that are difficult to identify and measure such as plastic products, paper supplies, office equipment, textiles, (for a full list of these, please see Scott et al (2008) where over 150 items were included (Scott et al. 2008)). Therefore, although using organisational level financial data is a weakness in the combined approach, it provides more complete data for the categories of energy, medical equipment and non-medical procurement and is therefore considered more fit for purpose than using activity data for carbon footprint assessments of mental health care .

Scenario analysis

In light of these weaknesses, in order to evaluate the fitness for purpose of the combined approach, a scenario analysis is now presented. This analysis used the combined approach to estimate the carbon footprint of different scenarios of care. Different scenarios were chosen to reflect clinical changes that could affect the carbon footprint of care. The aim was to assess the robustness of the results provided by the combined approach following changes made to clinical practice.

Hypotheses

1. As the potential range for carbon footprint estimates of medication is large, the combined approach will only be fit for purpose for assessing point estimates of the carbon footprint of care where medication is either not included in the clinical service or contributes a minimal percentage burden.
2. As organisational averages are used for the carbon footprint of energy, medical equipment and non-medical procurement in clinical activities, the combined approach will be more sensitive to changes in the number of appointments than to changes that occur in these categories within individual clinical activities

Examining the results provided by the combined approach in the scenario analysis will test these hypotheses.

Methods

Design

The scenarios are based on a single patient's outpatient treatment over the course of one year. Scenarios have been created by taking hypothetical service changes that could affect the carbon footprint of clinical practice. The range of scenarios represent changes to each of the categories defined in the combined approach. These changes include changing the type of appointment e.g. telephone appointment or home visit, changing travel methods, changing length or frequency of appointments, changing medication use, changing energy use or changing the duration or cost of procured goods. Every clinical activity occurring within mental health care during the one-year period is included. In the scenarios provided, unless otherwise stated, all appointments are assumed to be occurring at a clinical facility i.e. an outpatient department.

Estimating the carbon footprint of activities

Activity data for travel and medication was taken from the inventory chapter (Chapter 5). Data on travel was collected using surveys. The emission factor for travel was obtained from DEFRA (based on a process-based LCA approach) (DEFRA 2013), see Table 27. Data on medication was collected from primary care prescription records. The emission factor for medication was obtained from DEFRA (based on an input-output approach) (DEFRA 2013), see Table 27. Carbon footprints for energy, medical equipment and non-medical procurement for a mental health appointment were taken from a previously performed input-output analysis by the SDU (SDU 2013b), see Table 26. This input-output analysis was based on organisational financial accounts data from five mental health organisations in England (SDU 2013b).

Table 27. Emission factors used

Emission factor	Unit and source
Medication emission factor	0.43 $kgCO_2e$/£ (DEFRA 2013)
Bus conversion factor	0.1 $kgCO_2e$ / mile (DEFRA 2013)
Small-medium sized car emission factor	0.2 $kgCO_2e$ / mile (DEFRA 2013)

Results

Table 28 shows the results of the scenario analysis, based on outpatient treatment for one patient over the course of one year. Non-medical procurement is a major component of the carbon footprint of care, contributing between 26% and 57% to the carbon footprint of scenarios. Energy in most scenarios is the next largest component, contributing between 21% and 37% to the carbon footprint of scenarios. Medication contributes between 0% (if only psychological treatment is provided) and 33% to the carbon footprint. Medical equipment contributes between 0% and 13%, while travel is the smallest component, maximally contributing 9% to the carbon footprint of one scenario.

Table 28. Scenario analysis using the combined approach to estimate the annual carbon footprint of patient care

Clinical change	Scenario (Nº of appts)	Carbon footprint of different categories $kgCO_2e$ (uncertainty) % burden						
		Medication	Medication range	Non-medical procurement	Medical equipment	Travel	Energy use	Total
Format of appoint-ment changes	1. All appointments were at a clinical facility (12)	120 (116-125) 19%	72-372	240 (234-246) 39%	72 (70-74) 12%	28 (28-28) 5%	156 (152-160) 25%	616 (600-633) 100%
	2. All appointments were at patient's home (12)	120 (116-125) 22%	72-372	240 (234-246) 43%	0 0%	28 (28-28) 7%	156 (152-160) 28%	544 (530-559) 100%
	3. All appointments were via telephone (12)	120 (116-125) 23%	72-372	240 (234-246) 46%	0 0%	6 (6-6) 1%	156 (152-160) 30%	522 (508-537) 100%
	4. All appointments were for psychological treatment (52)	0 0%	n/a	1040 (1014- 1066) 57%	0 0%	121 (120-122) 7%	676 (659-693) 37%	1837 (1793-1881) 100%
Medication changes	5. If medication reduced by 50% (12)	60 (58-62) 11%	36-186	240 (234-246) 43%	72 (70-74) 13%	28 (28-28) 5%	156 (152-160) 28%	556 (542-570) 100%
Travel changes	6. If patient and staff cycled or walked (12)	120 (116-125) 20%	72-372	240 (234-246) 41%	72 (70-74) 12%	0 0%	156 (152-160) 27%	588 (572-605) 100%
	7. If patient and staff used cars for all travel (12)	120 (116-125) 19%	72-372	240 (234-246) 39%	72 (70-74) 12%	32 (32-32) 5%	156 (152-160) 25%	620 (604-637) 100%
	8. If patient and staff used public transport (12)	120 (116-125) 20%	72-372	240 (234-246) 39%	72 (70-74) 12%	20 (20-20) 3%	156(152-160) 26%	608 (592-625) 100%
	9. If distance by patient and staff doubled (12)	120 (116-125) 19%	72-372	240 (234-246) 37%	72 (70-74) 11%	56 (55-57) 9%	156 (152-160) 24%	644 (627-662) 100%
Energy changes	10. If no lighting or heating was used (12)	120 (116-125) 19%	72-372	240 (234-246) 39%	72 (70-74) 12%	28 (28-28) 5%	156 (152-160) 25%	616 (600-633) 100%
Appoint-ment time changes	11. If all appointments reduced length by 50% (12)	120 (116-125) 19%	72-372	240 (234-246) 39%	72 (70-74) 12%	28 (28-28) 5%	156 (152-160) 25%	616 (600-633) 100%
	12. If number of appointments doubled (24)	120 (116-125) 11%	72-372	480 (472-488) 43%	144 (140-148) 13%	55 (54-56) 5%	312 (304-320) 28%	1111 (1086-1137) 100%
	13. If number of appointments halved (6)	120 (116-125) 33%	72-372	120 (117-123) 33%	36 (35-37) 10%	14 (14-14) 4%	78 (76-80) 21%	368 (358-379) 100%
Procure-ment changes	14. If all procured goods used lasted twice as long (12)	120 (116-125) 26%	72-372	120 (117-123) 26%	36 (35-37) 8%	28 (28-28) 6%	156 (152-160) 34%	460 (448-473) 100%
	15. If cost of all procured goods reduced by 20% (12)	120 (116-125) 23%	72-372	192 (187-197) 37%	58 (57-60) 11%	22 (22-22) 4%	125 (122-128) 24%	517 (504-532) 100%

Discussion

Medication

In most of the scenarios, medication provides around 20% of the percentage burden of the scenario. In these scenarios, the range of the carbon footprint of medication is between 72 and 372 $kgCO_2e$. This potential range is equivalent to around 50% of the carbon footprint for those scenarios. It is clear that where medication contributes a large percentage burden to a clinical activity or service, the potential range is so large that the results become very difficult to interpret. Therefore the first hypothesis is proven; that the combined approach is only fit for the purpose of providing point estimates of the carbon footprint of care where medication is either not included in the clinical service provided or contributes a minimal percentage burden. However, as discussed in the previous chapter, the Greenhouse Gas Protocol states that this range can be discounted if repeated measures are taken of one service (WBCSD & WRI 2011). This is because these quantified uncertainty estimates can be treated as being comparable over time (WBCSD & WRI 2011). The combined approach is therefore considered fit for the purpose of assessing how the carbon footprint of the service has changed over time, irrespective of the percentage burden contributed by medication.

Travel

In scenarios 6, 7, 8 and 9 changes are made to travel. The scenario analysis demonstrates that the combined approach can robustly estimate the carbon footprint differences following changes made to travel and is therefore considered fit for the purpose of assessing the carbon footprint of travel. However, as the changes made to travel result in only small changes to the carbon footprint (a maximum change of 28 $kgCO_2e$ or 5% of the percentage burden), changes to travel would not likely be a driver for change. Given the large potential range of carbon footprint estimates of medication, it is unlikely that the combined approach has the sensitivity to account for the potentially small changes to the carbon footprint following changes made to travel.

Energy, medical equipment and non-medical procurement

These categories are reviewed together because their carbon footprints are estimated using the same method and therefore the same limitations apply. The scenario analysis demonstrates that changing the number of appointments is the factor that has the largest impact on the carbon footprint. Results suggest a five-fold difference in the carbon footprint of care in one year (from 368 $kgCO_2e$ to 1837 $kgCO_2e$) according to whether the patient has six appointments per year or weekly psychotherapy appointments. The categories that contribute the majority of the carbon footprint for each scenario are energy and non-medical procurement, while medical equipment contributes a smaller percentage burden. These carbon footprint estimates are organisational averages for each clinical activity, therefore increasing the frequency of clinical activities, irrespective of changes made within a clinical activity, directly increases the carbon footprint of these categories.

The carbon footprint estimated by the combined approach is more sensitive to changes in the number of appointments than it is to any changes that occur within a clinical activity for the categories of energy, medical equipment and non-medical procurement. This is demonstrated in scenario 11, where halving the length of appointments for one patient over one year had no effect on the estimated carbon footprint. Changing the length of the appointments for one patient will have very little effect on the organisational cost of energy, medical equipment or non-medical procurement. The average carbon footprint for these categories is therefore not affected by these changes. In contrast, in scenario 12, doubling the number of appointments has a considerable effect on the estimated carbon footprint (the carbon footprint of care increases from 616 $kgCO_2e$ to 1111 $kgCO_2e$). Therefore, the second hypothesis is proven, that the combined approach is more sensitive to changes in the number of appointments than for changes that occur to these categories within individual clinical activities. However, the combined approach is sensitive to changes in these categories that are large enough to affect the whole organisation, such as in scenario 15, where the cost of all procured items is reduced by 20% across the organisation. Other system wide changes might include for example increasing the duration of all procured goods (scenario 14), or improving insulation or using more efficient boilers (these changes are not represented in the scenario analysis). These larger changes affect the total cost to the organisation for these categories and consequently affect the scaled down average carbon footprint per clinical activity.

Given the nature of the mental health care context, changes in the categories of energy, medical equipment and non-medical procurement are more likely to be system wide, such as improving insulation in all buildings or changing procurement strategies. Small changes 'within' clinical activities, such as using more natural lighting and less heating, while these do affect the carbon footprint of the clinical activity, enabling these changes to occur is far more dependent on system wide changes such as improving building infrastructure to improve natural lighting or improving insulation such that lighting or heating is less necessary. Further, regarding medical equipment, given there are standard requirements for 'stock' equipment (RCPsych 2014), unless system wide changes occur to improve the environmental sustainability of procurement strategies, changes made within clinical activities by mental health professionals are unlikely to have a significant effect on the carbon footprint.

Despite this lack of sensitivity for these 'within clinical activity' changes, there are few examples of these types of changes in mental health. Further, they are unlikely to have a large effect on the carbon footprint. Therefore, while the combined approach lacks sensitivity to these smaller changes, it is considered fit for the purpose of estimating the carbon footprint associated with changes made to energy, medical equipment and non-medical procurement.

A further problem of using financial data is that the average carbon footprint has to be applied in full, even in circumstances where the carbon footprint of resources used within the combined approach is likely to be less than the average carbon footprint provided. This is because the combined approach has defined the categories of activity according to the type of activity provided (e.g. energy, medical equipment etc.). Therefore, if a certain category is not included in a clinical activity, it can be omitted from the carbon footprint. Examples of this include psychological treatment, which can exclude medication and medical equipment, or home visits and telephone appointments, which can exclude medical equipment. However, some clinical activities include a proportion of a given category, which in some instances can be calculated, however, in other instances, assumptions have to be made about whether or not it should be included. For example, telephone appointments exclude patient travel, but staff travel would not change. As travel is measured using activity data, patient travel can simply be excluded and staff travel included, see Appendix 3 for this example.

Consideration of whether to include categories that have been estimated using organisational level financial data is more difficult. For example, as the carbon footprint of energy is estimated using financial data, an organisational average is provided per clinical activity. In a home visit, energy use in the patient's home should be excluded (based on the boundaries defined in Chapter 4), but energy used by staff to administer the appointment (e.g. to arrange the appointment and write notes etc.) should be included. However, as only an average carbon footprint per clinical activity is provided, a decision needs to be taken about whether to include this carbon footprint in the clinical activity. To account for this issue, a principal of inclusion is applied, whereby, if a component of any category measured using financial data should be included in the carbon footprint, then the organisational average carbon footprint will be applied to the clinical activity in these circumstances. This is to ensure that all activities within the boundaries of the clinical activity are accounted for. Another situation where this issue presents is in scenario 10, where appointments use natural lighting and do not use heating. Because energy is still required by staff for administration activities, the average carbon footprint for energy per clinical activity is included.

Conclusions

This chapter has assessed whether the combined approach is fit for purpose by assessing the robustness of the results following changes made to clinical practice. The combined approach can robustly estimate the carbon footprint associated with changes made to travel. The combined approach can also robustly estimate the carbon footprint associated with changes in the numbers of clinical activities. The scenario analysis has shown that it does not provide robust results for smaller changes in energy, medical equipment and non-medical procurement that occur within a clinical activity, it is therefore not considered fit for purpose in this circumstance. Lastly, this analysis has shown that because the potential range of the carbon footprint of medication is large, where medication contributes a moderate or large percentage burden, point estimates of the carbon footprint of a service are not robust. However, as discussed in Chapter 6, if repeated carbon footprint estimates are made of the same service to assess how it has changed over time, the Greenhouse Gas Protocol states that this range can be discounted (WBCSD & WRI 2011). Therefore the combined approach is considered fit for the purpose of assessing how the carbon footprint of a service has changed over time, irrespective of the percentage burden contributed by medication. Although, if the changes to the carbon footprint are small, such as changes made to improve use of public transport, shown in scenario 8, there remains the potential that the large range associated with carbon footprint estimates of medication will make these small changes difficult to interpret, due to the large 'noise to signal' ratio caused by medication.

The following conclusions have been made about the fitness for purpose of the combined approach:

1. The combined approach is only fit for the purpose of comparing two services or clinical activities if they do not involve the administration of medication (e.g. psychological treatment) or where medication contributes minimally to the carbon footprint of the service
2. The combined approach is only fit for the purpose of providing a point estimate of the carbon footprint of a service or clinical activity if they do not involve the administration of medication or where medication contributes minimally to the carbon footprint of the service

3. The combined approach is fit for the purpose of estimating the changes to the carbon footprint of a service or clinical activity over time

This chapter has used a scenario analysis to evaluate the potential issues with applying the combined approach and has proposed three functions where the combined approach is considered fit for purpose. The next two chapters provide real-world examples of applying the approach to different clinical contexts. The aim is to further assess whether the combined approach is indeed fit for purpose in the three functions this chapter has proposed.

Chapter 8

Estimating the carbon footprint of an existing mental health service

Introduction

In this chapter, the aim is to test two functions of the combined approach proposed in the previous chapter as fit for purpose; providing a point estimate of the carbon footprint of a service that does not involve the administration of medication and comparing two services where medication contributes minimally to the carbon footprint. These functions are tested by assessing whether the combined approach can robustly estimate the effect one mental health service has on the carbon footprint of the wider health care system. The analysis of the wider health care context is necessary because, while every service will have its own carbon footprint, it is important to assess how the treatment received in one service affects the use of, and therefore the carbon footprint associated with, other types of health care use. This study assesses whether further limitations are found when the approach is applied to a real-world clinical context. In addition, through this analysis of a particular clinical context, an assessment can be made about whether the combined approach meets the 'adaptation' criteria of feasibility (Bowen et al. 2009). The chosen service is a group-based psychotherapy service called a Therapeutic Community (TC), which is designed for the treatment of personality disorder (PD).

Therapeutic community services for personality disorder

This service has been chosen because it has been suggested that, from a financial perspective, these services can reduce the costs of the wider health care system through reduced subsequent health care use (NICE 2010) there is, therefore, the potential that they could also reduce the overall carbon footprint of the health care system.

TCs have been shown to be cost effective. Chiesa (1996) measured all aspects of subsequent health care use following an inpatient TC service and found a significant reduction in the use of medical, surgical and psychiatric services in the year following treatment (Chiesa et al. 1996). Dolan (1996) found that costs were recovered within two years of entry to an inpatient psychotherapy service for PD due to reduced subsequent psychiatric care and prison use (Dolan et al. 1996). Davies (1999) found that costs of an inpatient TC were recovered after four years due to reduced frequency and duration of psychiatric admissions alone (Davies et al. 1999). Bateman (2003) examined day hospital treatment for borderline personality disorder and found it was no more expensive than treatment as usual and that there were additional reductions in subsequent health care use (Bateman & Fonagy 2003). More recently, a study looking at a one-day a week psychotherapy service found that costs could be recovered after three years (Barr et al. 2010).

Hypothesis

- If the combined approach is fit for the purpose of i) providing a point estimate of the carbon footprint of a service that does not involve the administration of medication and ii) comparing two services where medication contributes minimally to the carbon footprint, it can robustly estimate the effect of the TC service on the carbon footprint of the wider health care system

This hypothesis needs to be tested as in the previous chapter the combined approach was considered fit for these two functions. As the TC service is a psychotherapy service, it does not use medications and because of the likely demographic of patients in this service, medication use is likely to be minimal. Further evaluation is needed in this real-world example to test whether this is indeed the case.

Methods

Design

A retrospective, cohort study is presented that used the combined approach to estimate the carbon footprint of the TC service and the carbon footprint of all health care service use before and after entry to the TC service. Two groups were compared over four years; those who had attended the Oxfordshire TC service and those who were referred but declined further care. As this was a retrospective, observational study of a single service, no power calculations were performed. All patients entering the Connect service were included in order to maximize the power of the study.

Setting

The Oxford TC service is provided at four units that offer care of varying intensity. Patients were offered care over 18 months at one of the following centres: Oxford (three days per week) or Wallingford or Witney (two days per week) or Banbury (one day per week). All centres offered the same types of group interventions (maximum number in group = 12), including behavioural, cognitive, and emotional therapies, transactional analysis, and psychodrama. The different therapy centres were established in part to provide care closer to home where possible.

Ethics

Ethical approval for this study was obtained from the University of Warwick Biomedical and Scientific Research Ethics Committee, (REGO-2014-881).

Data collection

Data on the TC group were obtained for the period covering one year prior to referral to three years after entry to TC. Twelve-month time periods were used in this study to analyse health care use before and after entry to TC. Corresponding data for the control group were collected over the same four-year period (April 2010 – April 2014).

Health care use was ascertained separately for primary care, secondary mental health care and secondary physical health care. For secondary mental and physical health care, data were obtained from electronic data records held by Information Services departments in the main local provider organisations (Oxford Health NHS Foundation Trust and Oxford University Hospitals Trust respectively). Data was collected on outpatient consultations, inpatient admissions, mental health crisis appointments and A&E attendances. There was no access to health use data from other providers and it is possible that some people received care elsewhere.

For primary care outcomes (medication and GP appointments), records were sourced using health care record numbers and all patient identification was removed prior to analysis. Data were only available on a smaller number of patients (TC n=10; control n=10) due to difficulties accessing data from primary care practices. These results however, have been included as it is the application of the combined approach that is being studied here rather than assessing the effects of the TC service on subsequent health care use.

Travel was measured directly from primary data sources, using surveys. Average patient travel to each appointment or inpatient unit was based on the same local travel survey presented in Chapter 5. Staff travel for the TC service was based on a survey of 15 staff employed by the TC service. Staff travel for other types of health care was based on a survey of 20 mental health staff presented in Chapter 5. Staff and patient travel for primary care and secondary physical health care was based on the staff and patient surveys in Chapter 5; one appointment / bed day was assumed equivalent to those same activities in mental health care.

Participants

Two groups were compared: the TC group and a control group. Patients in the TC group were all those adults with a diagnosis of PD who had been referred to the service and had started treatment between April 1st 2011 and 1st April 2012. Patients in the control group were those who were referred during the same year (due to a diagnosis of PD) but then did not attend their initial appointment and were subsequently discharged. There were 228 patients who did not attend their first appointment during this year and were subsequently discharged, 45 were randomly chosen from this group as this represented a similar number to the TC group. No matching was performed to ensure this sample was representative of all non-attenders, although the random sampling serves to achieve representation. Reasons for not attending appointments were not established. The control group received treatment as usual, which might have included either primary care input or secondary mental health care or both.

Estimating the carbon footprint

The combined approach was applied to obtain the carbon footprint of health care use and is described here. The carbon footprint of travel was calculated using previously established emission factors for different methods of travel, see below Table 29 (DEFRA 2013). The carbon footprint of medication was calculated using an emission factor obtained from input-output analysis, provided by DEFRA (DEFRA 2013). The cost of medications was obtained from the British National Formulary (www.bnf.org) and the cheapest cost of medication used to ensure a conservative estimate was obtained. Data regarding the carbon footprint of energy, medical equipment and non-medical procurement for all types of health care activity were obtained from secondary data from a previous analysis by the SDU that used an input-output method based on an average of the expenditure data from 228 different NHS organisations (discussed in Chapter 2) (SDU 2013b). Carbon footprints for these categories did not therefore pertain to the health care organisations assessed here.

Table 29. Emission factors for health care use and assumptions made

Category	Emission factors / assumptions
Bus conversion factor	0.1 $kgCO_2e$ / mile [a]
Medium sized car conversion factor	0.2 $kgCO_2e$ / mile [a]
Staff and patient travel to TC (see survey in Chapter 5)	8 $kgCO_2e$/pt/wk
Staff and patient travel to a mental health care appointment (see survey in Chapter 5)	2.34 $kgCO_2e$
Staff and patient travel for one mental health bed day (see survey in Chapter 5)	1.68 $kgCO_2e$
Medication	0.43 $kgCO_2e$ / £ [a]
Medical equipment, procurement and energy used in ED attendance / one physical health bedday	82 $kgCO_2e$ [b]
Medical equipment, procurement and energy used in primary care appointment	24 $kgCO_2e$ [b]
Medical equipment, procurement and energy used in physical health outpatient appointment	50 $kgCO_2e$ [b]
Medical equipment, procurement and energy used in mental health outpatient appointment	39 $kgCO_2e$ [b]
Medical equipment, procurement and energy used in mental health bed day	64 $kgCO_2e$ [b]
ASSUMPTIONS	
Type of car used	Small average car size
Number of patients in service at any given time	Estimated by director of service
Staff and patient travel for primary and secondary physical health	Equivalent to travel in mental health
Medication	Cheapest cost available was used

a: DEFRA (DEFRA 2013) b: SDU (SDU 2013b)

As the TC intervention provided group-based care that had prolonged therapy sessions, the combined approach was not able to provide a carbon footprint for this type of clinical activity. As a result, those categories of activity used by the TC service that were based on financial data (energy and non-medical procurement) had to be based on the carbon footprint of outpatient appointments. Appointments were chosen as a basis for the carbon footprint of group therapy, as this activity has more similarities in terms of resource use compared to a bed day. As it was unclear how the carbon footprint of group therapy might relate to an outpatient appointment, three different assumptions were made about this relationship. This was to assess the extent to which this assumption affected the overall result of the study. The available options for making assumptions were based on a standard appointment, the time of an appointment or the number of people in the appointment. The three assumptions were; i) the carbon footprint for one hour of group therapy is equivalent to the carbon footprint used in a one hour appointment ii) the carbon footprint for one hour of group therapy is equivalent to the carbon footprint used in a standard (30 minute) appointment iii) the carbon footprint for one hour of group therapy is equivalent to the carbon footprint used in 1/12 (5 minutes) of an appointment (as a maximum number of patients in one group is 12). The carbon footprint of medical equipment used in an appointment was not included, as the TC service did not use any medical equipment. The carbon footprint of medication was included under primary care, so was not included in the TC service. The carbon footprint of one course of treatment in the TC service was based on the average duration of therapy (12.9

months or 56 weeks) and the average number of therapy days per week (2 days).

Analysis

All analyses were carried out in Stata SE 13 (StataCorp 2013). Summary statistics were used to understand the main effects. Differences were assumed to be significant at a 2-tailed 5% level. Mean carbon footprints were compared between groups using a t-test; change scores (post annual average minus baseline year) were used for this analysis. Percentile bootstrapped 95% confidence interval and corresponding p-values were presented to account for non-normality of data (Briggs & Gray 1998).

Results

The treatment group contained 40 patients (females=29, males=11). Numbers from each therapy base were as follows Oxford (n=12), Banbury (n=11), Wallingford (n=10), and Witney (n=7). The control group contained 45 patients (females=33, males=12). The mean age was 34 years for the treatment group and 39 years for the control group. In the treatment group 20 patients stayed the full 18-month course, while the minimum duration of treatment was 2 months (n=4). Mean duration in treatment was 12.9 months (SD=6.4), or 56 weeks, median duration was 18 months. For secondary care, all patients were included in the analysis, however for primary care outcomes (medication and GP appointments), data were only available on a smaller number of patients (TC n=10; control n=10) due to difficulties accessing data from primary care practices.

Table 30 shows the carbon footprint of the TC intervention estimated according to the three assumptions used. This table shows that these different assumptions, required because of an uncertainty about how the carbon footprint of a standard appointment relates to the carbon footprint of a group therapy session, provide a ten-fold difference in carbon footprint estimates for the TC service. It is unclear which assumption should be used and therefore the combined approach has not been able to provide a robust estimate for the carbon footprint of the TC service. Despite this issue, the relationship between the different components of the carbon footprint can be noted, as these are not affected by the assumptions. The majority of the carbon footprint is contributed by non-medical procurement, followed by energy. Travel contributes a minimal proportion to the carbon footprint, this does not change according to the different assumptions used as the combined approach estimates the carbon footprint of travel from primary survey data.

Table 30. The carbon footprint of the TC intervention

Category of resource	One therapy day ($kgCO_2e$)		
	Assumption 1. If one hour of group therapy = one hour of appointment	Assumption 2. If one hour of group therapy = 30 mins of appointment	Assumption 3. If one hour of group therapy = 5 mins (i.e. 1/12) of appointment
Energy	52.8	26.4	4.4
Non-medical procurement	80.4	40.2	6.7
Travel	2	2	2
Total	135.2	68.4	13.1

The combined approach was able to provide robust estimates of the carbon footprint of the wider health care system. This was because no additional assumptions were required to apply the approach and medication contributed minimally to the carbon footprint; the range of reductions to the carbon footprint of psychotropic medication was 1% and 4% of the overall reduction in carbon footprint noted between groups. Table 31 shows the mean carbon footprint differences between groups for wider health care use, adjusted for baseline year and controls. Changes to the carbon footprint of health care use were calculated for each group by taking the carbon footprint of the pre-treatment 12-month period away from the average 12-monthly carbon footprint of the treatment period taken at 1, 2 and 3 year intervals. Positive values in the table below indicate greater reductions in the carbon footprint for the TC group from baseline compared to controls. It can be seen that for most categories, the TC group demonstrates greater reductions in the carbon footprint compared with controls, although few of these findings were significant.

Table 31. Mean carbon footprint difference between groups, adjusted for baseline year and controls

Type of secondary care	Health care activity	Mean carbon footprint difference between groups (MD) adjusted for carbon footprint in baseline year (kgCO2e) (95% CI); p value		
		Over 1 year	Over 2 years	Over 3 years
Mental health care	Secondary care appt med equipment, energy and procurement	MD = 197 95% CI (-4, 398) p=0.05	MD = 155 95% CI =(13, 324) p=0.07	MD = 154 95% CI (-16, 323) p=0.08
	Crisis appointments med equipment, energy and procurement	MD = 55 95% CI (2, 108) p=0.04*	MD = 40 95% CI (4, 77) p=0.03*	MD = 40 95% CI (-4, 85) p=0.08
	Inpatient days med equipment, energy and procurement	MD = 251 95% CI (-132, 634) p=0.20	MD = 208 95% CI (-185, 600) p=0.30	MD = 259 95% CI (-138, 656) p=0.20
Physical health care	Secondary care appt med equipment, energy and procurement	MD = 3 95% CI (-73, 79) p=0.94	MD = 2 95% CI (-61, 64) p=0.96	MD = -9 95% CI (-73, 55) p=0.77
	Physical inpatient days med equipment, energy and procurement	MD = 84 95% CI (-1, 170) p=0.05	MD = 58 95% CI (5, 112) p=0.03*	MD = 122 95% CI (-36, 280) p=0.13
	A&E attendances med equipment, energy and procurement	MD = 47 95% CI (3, 90) p=0.04*	MD = 32 95% CI (-10, 74) p=0.14	MD = 32 95% CI (-9, 72) p=0.12
	GP appointments med equipment, energy and procurement	MD = 488 95% CI (-127, 1104) p= 0.11	MD = 528 95% CI (4, 1060) p=0.05	MD = 491 95% CI (-16, 997) p=0.06
Total travel (staff and patient)		MD = 44 95% CI (2, 89) p=0.03*	MD = 52 95% CI (0, 104) p=0.05*	MD = 40 95% CI (0, 80) p=0.05*
Psychotropic Medications		MD = 12 95% CI (3, 21) p=0.01*	MD = 21 95% CI (5, 36) p=0.01*	MD = 22 95% CI (4, 40) p=0.02*
Physical Medications		MD = -9 95% CI (-16, -1) p=0.03*	MD = -6 95% CI (-12, 0) p=0.06	MD = -4 95% CI (-11, 4) p=0.30
Total carbon footprint of all health care use (other than the TC sevice)		MD = 1,172 95% CI (-84, 1658) p=0.06	MD = 1090 95% CI (-266, 2305) p=0.14	MD = 1,147 95% CI (-124, 2052) p=0.11

* = significant at 5% level, (Positive values indicate greater reductions in the TC group from baseline compared to controls)

Mean carbon footprint differences between TC and control groups were significant for the resources used in crisis appointments after one and two years, with greater reductions to the carbon footprint found in the TC group, following adjustment for baseline year, see Table 31. For physical health care, at one year following entry to TC, mean differences between groups were significant for A&E attendances, with greater reductions found in the TC group, compared to controls. At two years following entry to TC, significantly greater reductions were noted in the carbon footprint for the resources used for physical health inpatient days in the TC group, compared to controls. At one, two and three years following initiation of TC, significantly greater reductions were seen to the carbon footprint of travel in the TC group, compared with controls. Lastly, at one, two and three years following initiation of TC, significantly greater reductions were seen to the carbon footprint of psychotropic medications in the TC group, compared with controls.

Table 32 below, shows the carbon footprint difference between groups with the carbon footprint of the TC service taken into account. The results are presented according to the assumption used to estimate the carbon footprint of energy and non-medical procurement. These three assumptions provide grossly different carbon footprints for the TC intervention and this had a significant impact on the results. Table 32 below shows that if assumption one or two is used then the carbon footprint of all health care use in the TC group was found to be larger than that of the controls at one, two and three years. This is because the larger reductions in the carbon footprint of subsequent health care use in the TC group were not large enough to outweigh the carbon footprint of the TC intervention. However, if assumption three is used then the carbon footprint of all health care use in the TC group was found to be reduced compared to controls at two and three years, this is because the assumption resulted in the TC service having a much smaller carbon footprint, compared to the other assumptions. The carbon footprint of the TC intervention reduces over the three years as the intervention last 18 months and the average carbon footprint over the time period is presented.

Table 32. The total difference in carbon footprint between groups according to the different assumptions for how the carbon footprint of therapy sessions equates to appointments

Assumption		Over 1 year	Over 2 years	Over 3 years
Assumption 1. If one hour of group therapy = one hour of appointment	Carbon footprint of Therapeutic Community service	15142	7571	5047
	Total difference in carbon footprint between groups	MD = -13,970 p=0.06	MD = -6481 p=0.14	MD = -3900 p=0.11
Assumption 2. If one hour of group therapy = 30 mins of appointment	Carbon footprint of Therapeutic Community service	7661	3830	2554
	Total difference in carbon footprint between groups	MD = -6,489 p=0.06	MD = -2740 p=0.14	MD = -1407 p=0.11
Assumption 3. If one hour of group therapy = 5 mins (i.e. 1/12) of appointment	Carbon footprint of Therapeutic Community service	1243	622	414
	Total difference in carbon footprint between groups	MD = -71 p=0.06	MD = 468 p=0.14	MD = 733 p=0.11

(Positive values indicate greater reductions in the TC group from baseline compared to controls)

Discussion

Strengths and limitations of applying the combined approach

The combined approach cannot robustly estimate the effect of the TC service on the wider health care system because, while the combined approach could robustly estimate the carbon footprint of the wider health care system, it could not robustly estimate the carbon footprint of the TC service. This issue could not have been predicted prior to performing this study as an investigation into the payment structures was required. To ascertain whether separate payment mechanisms were available for this service, which they were not. Following this, the extent of the effect of the assumptions had to be tested on the model in order to determine whether these assumptions might be considered reasonable, however, these assumptions were found to exert a large influence on the results of the study.

The two functions, proposed as fit for purpose in the previous chapter, that were tested in this study were i) providing a point estimate of the carbon footprint of a service that does not involve the administration of medication and ii) comparing two services where medication contributes minimally to the carbon footprint. The concern about medication is that the sensitivity analysis in Chapter 6 showed that the carbon footprint estimates of medication have a potential five-fold range. However, the TC service does not use medication and medication contributed little to the carbon footprint of the wider health care system (on average less than 2% of the total carbon footprint difference). Therefore the five-fold range associated with carbon footprint estimates of medication is unlikely to have a major effect on the results of this study.

The combined approach could not provide a robust point estimate of the carbon footprint of the TC service because of the use of organisational level financial data for estimating the carbon footprint of energy and non-medical procurement. This provides an overall carbon footprint for the organisation, which can then be scaled down according to how many clinical activities are provided by the organisation (see Chapter 2 for details of this method (SDU 2013b)). However, the combined approach only provides carbon footprint estimates for the major types of clinical activity in mental health; appointments and bed days because it is difficult to allocate an average carbon footprint for unusual paradigms of care, as the numbers occurring in the organisation are not sufficiently large to obtain an accurate average figure. Consequently, the carbon footprint of these categories in the TC service had to be based on the carbon footprint of one of the two major clinical activities in mental health. Appointments were chosen as a basis for the carbon footprint of group therapy, as this activity has more similarities in terms of resource use compared to a bed day.

Three different assumptions were used to assess how the carbon footprint of a group therapy session was equivalent to the carbon footprint of an outpatient appointment because it was not clear how the carbon footprint of these two clinical activities might relate. It was found that these assumptions have a considerable effect on the results. Two of the assumptions find that the patients in the TC service have a larger health care carbon footprint, while the other finds the opposite. Therefore basing the carbon footprint of energy and non-medical procurement for a group therapy session on the carbon footprint of an appointment is problematic. The carbon footprint estimates obtained are not robust because there is no obvious assumption that can be made about how the two activities relate. The activity maps for these clinical activities presented in Chapter 5 illustrate this issue. Consequently the hypothesis was rejected because the combined approach cannot robustly account for the non-standard delivery of care provided by the TC service.

The combined approach was able to robustly account for the carbon footprint of the wider health care system. Applying the combined approach found that the TC group was associated with greater reductions to the carbon footprint in some aspects of the wider health care system. It also showed that the major factors that contribute to the reductions in the carbon footprint of the wider health care system are associated with the energy, medical equipment and non-medical procurement used within all types of clinical activity. While travel and medication contribute a smaller proportion of these carbon footprint reductions.

A limitation that was noted in the previous chapter also affects the robustness of this study, that of the combined approach being unable to robustly account for changes that are made to these categories within a clinical activity. This is because the combined approach uses organisational level financial data to measure energy, non-medical procurement and medical equipment. The following example illustrates this point; prior to starting the TC service, an A&E attendance might have been as a result of alcohol intoxication, physical self-harm and an overdose (a typical presentation for a patient with personality disorder (NICE 2009)). This A&E attendance potentially may have a large carbon footprint, given the resources required for managing this presentation (NICE 2009). However, following entry to TC and subsequent patient improvement, an A&E attendance might be more likely to be due to a minor physical illness that would require less resources and therefore would likely have a reduced carbon footprint. Using an organisational average carbon footprint, does not account well for these changes, as the reductions in the carbon footprint are spread across the organisation. Further sensitivity analysis would be required to determine the potential impact of this limitation on the carbon footprint of the different clinical activities.

It should also be noted that the combined approach has been developed on the basis of the availability of data and the types of resources used within secondary mental health care settings, (i.e. the specialist provision of mental health care by mental health services). Whether this is the most robust method for estimating the carbon footprint of other types of health care, such as physical health care, has not been assessed. In this analysis however, the combined approach was applied to all health care settings. It is possible that there is a greater availability of primary data in these other types of health care, for instance the equipment used in operating theatres is well documented (Thiel et al. 2015). This presents the possibility that other approaches are available for estimating the carbon footprint for other forms of health care that are less reliant on the use of financial data. These alternative approaches could provide a more robust approach to the combined approach used here.

Despite the concerns that have been noted about applying the combined approach to estimating the carbon footprint of the wider health care system, the approach was applied without the need for any additional assumptions and the carbon footprint reductions noted were in line with the reductions in health care service use. Therefore, the combined approach is considered fit for the purpose of estimating the carbon footprint of the wider health care system. Although, this is with the noted qualification that if medication had contributed a larger percentage burden of the carbon footprint of the wider health care system then the combined approach would likely not have been fit for purpose, as the potential range of carbon footprint estimates would have been too large to provide useful results.

Strengths and limitations of the observational analysis

This exploratory study proposes a methodology for estimating the carbon footprint of a health service. It is the first of its kind to estimate the carbon footprint of a psychotherapy service. These results, based on the application of the combined approach, show carbon footprint reductions due to reduced subsequent health care use following entry to TC. However, whether these reductions cause an overall reduction to the carbon footprint of all health care use is based on which assumption is used to estimate the carbon footprint of the TC service. Due to this issue, this study is not able to determine whether entry to the TC service is associated with a reduced overall carbon footprint of health care use. What this study is able to show is that, in order to minimise the impact of the new service on the carbon footprint of the wider health care system, it is important to address the non-medical procurement of the TC service, as this is likely to be the major factor that affects the carbon footprint of the wider health care system.

As the study is observational and retrospective, there was no randomisation between groups. In fact, the controls were those who did not attend appointments. The groups are therefore likely to be different and the results potentially confounded, this is illustrated by the higher health care use in the TC group in the baseline year. As a result, the carbon footprint of the TC group may be over-estimated, as these patients were easier to detect, conversely, there may be missed information about the control group since (as non-attenders) they may not have been as visible. Also, while people were attending the TC they may have had less opportunity to use other services, which would have biased the results in the opposite direction; because they were in TC groups for several hours each week, they would not have had less time to use other services. This issue with the controls is a limitation of the observational study, however, an attempt was made to control for differences in prior health care service use by adjusting for the baseline year when comparing groups.

Regarding the quality of the data used in this study, a further limitation was that assumptions were made about how travel to physical health clinical activities related to travel for mental health clinical activities. It could be that staff or patients travel further to general hospitals compared to clinical activities in mental health. Another limitation was that carbon footprints for energy, medical equipment and non-medical procurement were obtained from another analysis (SDU 2013b), the data did not therefore pertain to the health care organisations assessed in this study. The other limitation was that less than 25% of patient data was obtained from primary care practices, due to time restrictions on this analysis. It may be that the control patients were using a lot of primary care resource relative to the TC group, but this could not be fully evaluated by this study. The small numbers available from primary care (TC=10, control=10) restrict the conclusions that can be drawn from this data about whether the TC service affects the carbon footprint of subsequent use of primary care. However, given that it is the application of the method that is being studied here rather than the outcome it was thought reasonable to include this data in the analysis in order to allow for testing of the methodology.

Conclusions

The hypothesis that the combined approach could robustly account for the effect the TC service has on the wider health care system could not be proven due to the fact that the combined approach cannot robustly estimate the carbon footprint of the TC service as it does not use the standard paradigm of care delivery i.e. bed days or appointments. This conclusion imposes a further limitation on the functions of the combined approach proposed in the previous chapter. When using an input-output method, the organisational carbon footprint obtained for a given category has to be allocated to individual clinical activities. This can be calculated with relative ease for admissions or appointments, where the numbers of these clinical activities occurring within the organisation are large. However, if a service model does not use these standard methods of care delivery (such as group therapy in this chapter) then allocating an average carbon footprint for these clinical activities can be very difficult. In this circumstance, assumptions have to be made based on their equivalence to a more standard paradigm of care delivery e.g. an appointment or a bed day and these assumptions can be difficult to justify and have a large impact. For this reason the combined approach does not account well for these unusual forms of care delivery and therefore is not fit for the purpose of estimating the carbon footprint of the TC service.

The combined approach is fit for the purpose of estimating the carbon footprint of the wider health care system. However, there were limitations in applying the approach to the wider health care system that affect the robustness of the results obtained. These include the potential range associated with the carbon footprint estimates of medication and the lack of sensitivity for changes to the carbon footprint of energy, medical equipment and non-medical procurement due to using an input-output method. If the combined approach were applied to other types of health care services that use greater amounts of medication, for example inpatient care, the range associated with estimations of the carbon footprint of medication would reduce the robustness of the results obtained and make the overall carbon footprint estimates of the service more difficult to interpret.

Regarding the 'adaptation' criteria of feasibility (Bowen et al. 2009), the combined approach cannot robustly estimate the carbon footprint of clinical activities or services that do not use the standard paradigm of appointments or bed days, such as group-based interventions, online therapy or ecotherapy programmes. It is therefore only fit for purpose in the cases of estimating the carbon footprint of bed days and appointments, which reduces the adaptability of the approach considerably. In these cases, sensitivity analyses could be performed to improve awareness about the extent these assumptions have on the estimated carbon footprint of the service, however, the results would not be robust and are therefore not considered fit for purpose.

Chapter 9

Estimating the carbon footprint of a proposed technological service change

Introduction

In this chapter, the aim is to test the third function of the combined approach proposed in Chapter 7 as fit for purpose; estimating the changes to the carbon footprint of a service over time. Assessing whether the combined approach can robustly estimate the change in the carbon footprint of a proposed new service model tests this hypothesis. The ability to model and/or predict changes in carbon footprint values is key to promoting the use of carbon tools within organisations. This builds on the previous two chapters, by assessing whether the third function of the combined approach is considered fit for purpose. Through this assessment it can also be determined whether the combined approach meets the 'adaptation' criteria of feasibility (Bowen et al. 2009).

A study is provided in this chapter investigating whether the provision of extra communications to patients about their appointment, can reduce non-attendance at clinic appointments (known as DNAs; 'Did Not Attend'), and therefore reduce the carbon footprint of the service. This service change has been chosen because there is good evidence to suggest that improving communications to patients can reduce DNAs (Reda & Makhoul 2001) and that reducing DNAs can reduce subsequent health care use (Nelson 2000). There is therefore the potential that this service change could also reduce the carbon footprint of the service. In the previous chapter the combined approach was applied to a new type of clinical service, whereas in this chapter the approach is applied to a technological service development. Advancements in technology are likely to have greater impact on mental health care in the future and have significant potential to improve the sustainability of clinical care (Maughan 2015). It is therefore important to review whether the combined approach is fit for the purpose of estimating the carbon footprint changes following these types of service development.

Non-attendance at clinic appointments

The average DNA rate in mental health services in the UK is between 15% and 20% (NHS-England 2013). Mental health services would benefit from a reduction in DNAs for many reasons. From a patient benefit perspective, there are three main reasons why mental health services should reduce DNA rates. First, patients who DNA are likely to be more unwell and more functionally impaired than those who attend (Killaspy et al. 2000). Second, non-attendance following hospital admission predicts subsequent readmission (Mitchell & Selmes 2007). Patients who DNA their follow-up appointments have a 25% chance of being readmitted, compared with 10% of those who do attend (Nelson 2000). Third, higher DNA rates are closely linked with medication non-adherence, further increasing the chances of relapse (Mitchell & Selmes 2007). Non-attendance, therefore, likely indicates a patient group that is at an increased risk of poorer health outcomes and higher future service use.

From a sustainability perspective there are three further reasons to reduce DNA rates. First, they are financially costly. In the UK, the cost has been estimated at £600 million per year (Sims et al. 2012). Second, they have an opportunity cost of wasting staff time. Third, there are environmental costs. These include, for example, the use of fuel from failed home visits. However, these environmental costs increase dramatically when potential future health costs following DNAs are included, such as the carbon footprint of an admission. Mitchell et al (2007) demonstrated that DNAs can affect the development and worsening of a mental health condition due to failure to administer appropriate management (Mitchell & Selmes 2007). It is the carbon footprint associated with these future health costs following DNA that are considered in this chapter.

Reducing DNAs; what works?

The two most common reasons for DNAs include patients forgetting about the appointment and administrative errors (NHS Institute for Innovation and ImprovementImpr 2013). There is a nine-fold variation in DNA rates for initial assessments between mental health services in the UK (Quest 2013), which suggests that it should be possible to reduce non-attendance in many instances, although reasons for this variation were not discussed. A Cochrane review on the effectiveness of communications to improve appointment attendance for people with serious mental illness found that telephone calls and texts (otherwise known as 'short message service' or SMS) improve attendance (Reda & Makhoul 2001). Evidence also suggests that patients are more likely to attend following telephone reminders even if they have failed to attend their initial clinic appointment (Mitchell & Selmes 2007) and that the higher the DNA rate, the greater the impact of reminders (NHS Institute for Innovation and Improvement 2013). A recent study found that using a text reminder service led to a 25% reduction in DNA rate (Sims et al. 2012). There is no evidence to suggest that simply sending further repeat appointment letters will increase attendance (Mitchell & Selmes 2007). Using a range of communication methods is therefore an important component of reducing DNA rates.

In order to assess whether the combined approach can robustly estimate the change in the carbon footprint, following an increase in communications to patients, first, a survey is presented that investigates the association between DNA rates and the use of different communication methods. This survey then provides a basis for the exploratory care modelling analysis, which uses the combined approach to investigate the potential impacts of DNAs on subsequent healthcare use and the associated carbon footprint.

Hypothesis

- If the combined approach is fit for the purpose of estimating the changes to the carbon footprint of a service over time, then it can be applied to robustly estimate the carbon footprint difference, following an increase in communications to patients

This hypothesis needs to be tested as, in Chapter 7, the combined approach was considered fit for the purpose of this function i.e. to estimate the changes to the carbon footprint of a service over time. Further evaluation is needed to test whether this is indeed the case.

Survey of communications used to remind patients about appointments

A survey was conducted at Oxford Health NHS Foundation Trust, investigating how DNA rates vary against communication methods used by staff to inform patients about appointments. This survey was carried out to provide an estimate of the reduction in DNA rate that could be achieved by improving communication methods.

Survey methods

An electronic survey using the web-based survey platform Survey Monkey was devised (www.surveymonkey.com), see Appendix 4. The survey investigated the following communication methods: telephone call, email, letter, arranging the appointment in the room, offering an appointment card, and text messaging. The survey request was sent out by email in January 2014 to all staff working in adult community settings at Oxford Health NHS Foundation Trust. Staff were asked about the communication methods they used to remind patients about their appointment. DNA rates were obtained from administrative data for each community mental health team from April 2013 to January 2014. DNA rates were only available at a team level, not at an individual staff level, therefore the analysis had to be performed at a team level. Teams with a respondent rate of less than 50% were not included in the analysis to ensure a good representation of team practice. For each team, the average number of communication methods used was calculated. For example, 100% of members of one team may send an initial appointment letter, 57% call the patient and 71% routinely send text messages. Individual communication options were then added together into an average percentage of the total possible communication methods, so (100+57+71)/3 = 76% of possible communication methods were used by the team.

Survey results

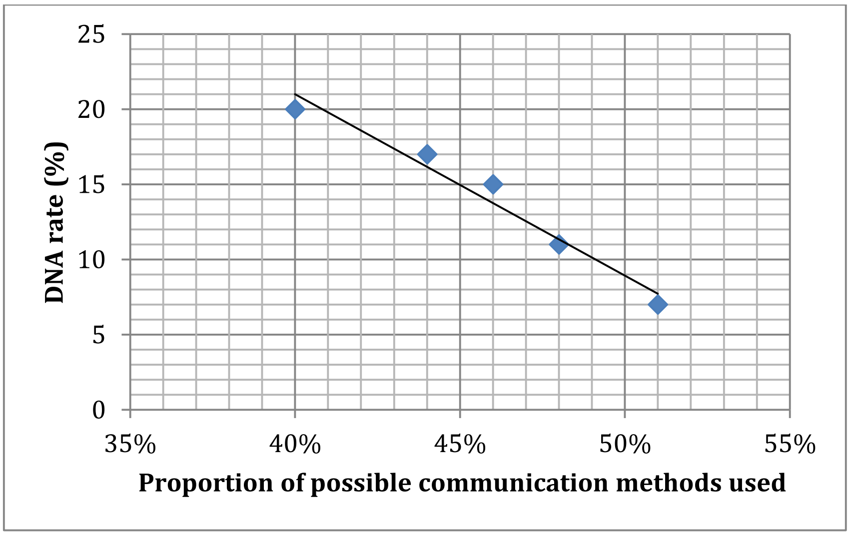
The survey was sent out to 450 staff, and 153 responses were received, representing a 34% response rate. Table 33 shows the DNA rates for 5 of the 11 adult community mental health teams over the period April 2013 to January 2014 (the other six teams did not meet the 50% respondent rate required for inclusion in the analysis). The final column provides the summation of the positive responses for each question option given as a total percentage for all the types of communication used by the team.

Table 33. DNA rates of adult community mental health teams and number of communication methods used by the team

Community team	No. of patients attended	No. of DNAs	DNA rate (%)	Proportion of total possible communications (%)
1	11827	860	7	61
2	4895	984	20	47
3	7497	1302	17	52
4	7551	928	12	53
5	7418	1186	16	55

There was a weak association between any individual type of communication method and team DNA rate (R^2<0.4). There was however, a strong association between the total number of communication methods used and team DNA rate for adult community teams (R^2=0.90). Figure 19 below shows that a 10% increase in the proportion of total possible communication methods sent to patients had the effect of reducing the DNA rate by over 50%.

Figure 19. Effect of communications on team DNA rate



Applying the combined approach to a predictive care modelling analysis

The survey has provided an estimate for how improving communications to patients might reduce DNA rate. Given the evidence that DNA rates are associated with increased subsequent health care use (Mitchell & Selmes 2007; Nelson 2000), increasing communications could reduce health care use and potentially also the carbon footprint of the service. In order to explore these potential reductions in future care, scenarios have been created about patients who are likely to DNA their appointments. There is significant variation in the type of patient who DNAs and the care they subsequently receive (Mitchell & Selmes 2007), as such, scenarios have been created that attempt to represent the range of problems that can present following DNA.

Methods of care modeling analysis

Design

Scenarios were created of hypothetical patients who have an increased risk of not attending their appointment and their future health care service use predicted over the two-month period following initial DNA. The combined approach was used to estimate the carbon footprint of health care use following DNA and the carbon footprint of the proposed service change.

Ethics

No ethical approval was required for this analysis as no patient data was used.

Creating the scenarios

Patient types were created using key predictors of non-attendance at mental health clinics from the UK (Mitchell & Selmes 2007). These predictors were grouped into three hypothetical patients see Table 34 below. The combination of these predictors into the three patient types was not random or based on evidence but on clinical experience of the author. Further, the hypothetical scenarios for these patients were not based on evidence, but attempted to summarise the different types of patient presentation, based on clinical experience of the author. These patient types and the scenarios were checked against expert opinion (ten mental health staff) to ensure they provided a reasonable reflection of real world situations. Medication was not included in these scenarios as there was no evidence found to suggest how prescriptions might vary following DNA.

Table 34. Predictors of non-attendance, grouped according to hypothetical patient types, adapted from Mitchell (2007)

	Patient A	**Patient B**	**Patient C**
Demographic factors	Young age Lives far from clinic	Homeless Patient disagrees with the referral	Lower socio-economic status
Patient factors	Forgetting date Overslept Early stages of treatment	Being too psychiatrically unwell Poor adherence to psychotropic medications	High trait anxiety Dismissing attachment styles Quality of therapeutic alliance
Illness factors	Not that unwell Depressed	Substance misuse Psychosis with poor insight	Personality disorder
Clinician factors	Referrer's scepticism about the value of psychiatry	Non-collaborative decision-making	Long delay between the referral and the appointment Poor quality referral letter

Obtaining the carbon footprint of health care use

The combined approach was used to estimate the carbon footprint of health care use in the scenarios. Travel data was obtained from the travel survey presented in Chapter 5 and the carbon footprint was calculated using previously established emission factors for the different methods of travel, see Table 35 (DEFRA 2013). Data regarding the carbon footprint of energy, medical equipment and non-medical procurement for the clinical activities were obtained from a previous analysis by the SDU that used an input-output method (discussed in Chapter 2) (SDU 2013b).

Table 35. Emission factors and assumptions

Category	Emission factors / assumptions
Medical equipment, procurement and energy used in one physical health bed day	82 $kgCO_2e$ [a]
Medical equipment, procurement and energy used in mental health outpatient appointment	39 $kgCO_2e$ [b]
Medical equipment, procurement and energy used in mental health bed day	64 $kgCO_2e$ [b]
Bus conversion factor	0.1 $kgCO_2e$ / mile [a]
Medium sized car conversion factor	0.2 $kgCO_2e$ / mile [a]
Staff and patient travel to a mental health care appointment (from surveys)	2.34 $kgCO_2e$
Staff and patient travel for one mental health bed day (from surveys)	1.68 $kgCO_2e$
ASSUMPTIONS	
Type of car used	Small average car size
Patient travel for primary and secondary physical health	Equivalent to travel in mental health
DNA rates	Can reduce by 50% if all communications methods are used
Health care use after attending appointment	Are two mental health appointments

a: DEFRA (DEFRA 2013) b: SDU (SDU 2013b)

Calculating the carbon footprint of the service change

Table 36 below shows the alternative model of care, which involved sending more communications to the patient.

Table 36. Communications in the current and proposed service model

Current service model – communication methods	New service model – communication methods
One letter	One letter
	One phone call
	One text
	One email

Resources used for communicating to patients lie within the category of non-medical procurement. The combined approach suggests that this category should be measured using an input-output approach based on organisational level financial data. However, given that these communications can be provided to patients at no cost to the organisation (Sims et al. 2012), the combined approach therefore cannot account for these costs as they lie outside the organisation. However, the cost of these communications are likely to be minimal (Fazlollahi 2001) and carbon footprint estimations for these communications are also likely insignificant (Berners-Lee 2010), therefore an assumption has been made that these communications would not affect the overall spend for this category and therefore, the same average carbon footprint for non-medical procurement per clinical activity can be used as that for standard care.

Calculating the potential reductions to the carbon footprint following increasing communications

An assumption was made, based on the survey results, that if all the different types of communication are used then the DNA rate will reduce by 50%. A further assumption is made that if a patient does attend their appointment, their care consists of two further appointments during the two-month period of the scenarios. Based on these assumptions, and given that the new service change has also been assumed not to change the carbon footprint of each clinical activity, the potential reduction in carbon footprint can be calculated per patient following the proposed service change.

Results of care modeling analysis

Scenarios

Patient A - Low risk

Ms A, is 22 years old and has depression. She is referred to mental health services following a poor response to antidepressant treatment. She receives a letter asking her to attend an appointment but she forgets the appointment. She is sent another letter but, as her GP told her that he was sceptical about the value of psychiatric support and because she lives far from the clinic, again she does not attend. Following this, a third letter is sent and the secretary phones her to encourage her to attend, however the patient's depression has now worsened and she does not want to leave the house so a home visit is arranged.

Table 37. Carbon footprint of predicted healthcare use for patient A

Stage of presentation	Carbon footprint ($kgCO_2e$)	Carbon footprint (% burden)
First appointment (med equipment, energy and procurement)	13[2]	24
Total carbon footprint prior to DNA	13	24
Second appointment (med equipment, energy and procurement)	13[2]	24
Third appointment (med equipment, energy and procurement)	13[2]	24
Travel to home visit	2[1]	4
Fourth appointment (med equipment, energy and procurement)	13[2]	24
Total carbon footprint following DNA	41	76
Total carbon footprint	54	100

Key: Carbon footprint data were obtained from the following sources: 1= local travel survey; 2= SDU (SDU 2013b);

Patient B – Moderate risk

Mr B has bipolar disorder. He is referred due to concerns about his behaviour following recent discharge from hospital. He is homeless and has been displaying signs of mania and smoking cannabis. An appointment letter is sent to his sister's house (where he often stays), but it is not read. A letter is sent for another appointment and three phone calls made to his mobile, but he does not agree with the referral so does not initially respond. He answers the last phone call and agrees to come in for the appointment. The patient forgets to attend this appointment so the team cold-call at the patient's sister's home; he is not there. Reports are made about increasingly erratic behaviour and a Mental Health Act Assessment arranged, following which he is admitted for four days.

Table 38. Carbon footprint of predicted healthcare use for patient B

Stage of presentation		Carbon footprint ($kgCO_2e$)	Carbon footprint (% burden)
Second appointment (med equipment, energy and procurement)		13[2]	4
Total carbon footprint prior to DNA		13	4
Second appointment (med equipment, energy and procurement)		13[2]	4
Travel to first home visit		2[1]	1
Third appointment (med equipment, energy and procurement)		13[2]	4
Travel to second home visit		2[1]	1
Fourth appointment (med equipment, energy and procurement)		13[2]	4
Mental Health Act Assessment (requires 2 doctors + 1 social worker)	Travel	(3 x 2) = 6[1]	2
	Appt	13[2]	4
Travel to hospital		2[1]	1
Mental health admission – 4 days	Med equipment, energy and procurement	(4 x 64) = 254[2]	76
	Travel	(2 x 2) = 4[1]	1
Total carbon footprint following DNA		322	96
Total carbon footprint		335	100

Key: 1= local travel survey; 2= SDU (SDU 2013b);

Patient C - High risk

Ms C has low mood and personality disorder. As the referral letter is poor and the referrer is not aware that her suicide risk is high, the psychiatrist sends a letter for an appointment in the following week. She DNAs and is upset as she expected a review the following day. The secretary calls the patient to make another appointment. After some persuading, she agrees to be assessed, but DNAs again due to anxiety. A further phone call is made and she again agrees to be seen, however, she becomes overwhelmed with anxiety again so DNAs the appointment. Her suicidal thoughts worsen and she takes an overdose of tablets. She is found collapsed at home by her mother, who takes her to hospital where she is admitted to hospital for three days for resuscitation.

Table 39. Carbon footprint of predicted healthcare use for patient C

Stage of presentation	Carbon footprint ($kgCO_2e$)	Carbon footprint (% total burden)
First appointment (med equipment, energy and procurement)	13[2]	5
Total carbon footprint prior to DNA	13	5
Second appointment (med equipment, energy and procurement)	13[2]	5
Third appointment (med equipment, energy and procurement)	13[2]	5
Travel to hospital	2[1]	1
General hospital admission (med equipment, energy and procurement)	(82 x 3) = 246[2]	86
Total carbon footprint following DNA	273	95
Total carbon footprint	287	100

Key: 1= local travel survey; 2= SDU (SDU 2013b);

Applying the combined approach to this care modelling analysis has found that the majority of the carbon footprint following DNA stems from the resources used in admissions, with the next largest component being the energy and procurement used in clinical assessments. Travel contributed little to the overall carbon footprint, it contributed most in scenario B, but this was still only 6% of the total carbon footprint of care. The carbon footprint of health care use following DNA was at least 76% of all estimated health care use.

The proposed model of increasing communication methods

In this analysis, two assumptions have been made first, that if the extra communication methods were used, the DNA rate would reduce by 50%. Second, if a patient does attend their appointment, they attend two further appointments during the two-month period. Based on these assumptions, the potential reduction in carbon footprint per patient is 80 $kgCO_2e$, as shown in Table 40 below.

Table 40. Potential carbon footprint reductions per patient following increasing communications

Scenario	Carbon footprint ($kgCO_2e$)
Average carbon footprint of health care use following DNA per patient	212
Average carbon footprint of health care use that could be avoided with additional communications (50% less DNAs)	106
Average carbon footprint of health care use following an attended appointment per patient ($kgCO_2e$)	26
Carbon footprint of additional communications	0
Potential carbon footprint reductions attained per patient by using additional communications	80

Discussion

Strengths and limitations of applying the combined approach

The objective of this analysis was to assess whether the combined approach is fit for the purpose of being applied to estimate the carbon footprint changes following a proposed technological service change. This discussion explores the benefits and limitations of this approach and reviews whether the hypothesis has been proven.

The hypothesis tested whether the combined approach can be applied to robustly estimate the carbon footprint difference, following an increase in communications to patients. First, with regards estimating the carbon footprint of health care use, the combined approach was applied without any issues arising or further assumptions required. Using the combined approach provided information about where the carbon footprint hotspots of health care lie, following DNA. This study has shown that the major factors that contribute to the carbon footprint following DNA are associated with the energy, medical equipment and non-medical procurement used within admissions and appointments. However, medication was left out of this study, as there was no evidence to suggest how prescriptions might be associated with DNA rate. It may be that medication contributes significantly to the carbon footprint of care.

Second, regarding whether the combined approach is fit for the purpose of estimating the carbon footprint of the proposed service change. Communications to patients lie within the category of ‘non-medical procurement’. In the combined approach, an input-output method is used to estimate the carbon footprint of this category. As a result, the carbon footprints of these communications are not individually added to each scenario. Instead, the additional financial costs of sending these communications are added on to the organisational spend for this category and a new average carbon footprint per clinical activity calculated for non-medical procurement for the organisation. However, these extra communications did not incur any additional financial costs for the organisation due to the fact that service providers usually already gather this data and computer programs exist that can send out these communications free of charge (Sims et al. 2012). Therefore, as the combined approach uses organisational financial data, it cannot robustly account for the carbon footprint associated with the use of internet servers and equipment required to send the extra communications (Le et al. 2010), as costs are paid for by the company running the computer program (INPS

2015). Additional data about the costs incurred by other companies providing the service to the mental health organisation is therefore required in these circumstances. In this study, these costs could not be obtained, as a company had not been chosen and the service had not yet been implemented. These costs are likely to be minimal and the carbon footprint of these extra communications is very small (email: 0.004kgCO_2e; SMS text: 3^{-9} kgCO_2e; letter: 0.14 kgCO_2e; phone call: 0.003 kgCO_2e (Berners-Lee 2010)). However, as the costs could not be determined, the carbon footprint of these extra communications could not be estimated, therefore the hypothesis could not be accepted; the combined approach cannot be applied to robustly estimate the carbon footprint difference, following an increase in communications to patients.

Limitations of the care modelling analysis

This care modelling analysis is a predictive study using hypothetical patients, hypothetical scenarios and assumptions about how health care use reduces following a reduction to DNAs. The results can therefore not be relied upon to provide details about the actual carbon footprint following this proposed service change, rather they should be viewed as indications of potential changes to the carbon footprint. Although the hypothetical patients have been constructed from evidence based characteristics of patients that DNA their appointments (Mitchell & Selmes 2007), the combination of these characteristics into the three patient types was not random or based on evidence. Furthermore, the scenarios were not based on evidence but attempted to summarise different types of patient presentation, based on the clinical experience of the author. Lastly, medication use was not included in the scenarios as there was no evidence available for how prescriptions might change following DNAs. It is likely that the inclusion of medication would have had a significant effect on the carbon footprint impact, as the analysis presented in Chapter 7 suggests medication contributes around 20% of a standard outpatient appointment.

Conclusions

The hypothesis that the combined approach can robustly estimate the carbon footprint change following an increase to communications has been rejected. This is because, while the combined approach can robustly estimate the carbon footprint of subsequent health care use, it cannot robustly estimate the carbon footprint of a technological service development. It therefore does not meet the 'adaptation' criteria of feasibility for this context (Bowen et al. 2009).

While input-output methods can usually reliably estimate the carbon footprint of resources based on financial cost (Wiedmann et al. 2008), there are certain changes (such as technological developments) that may not have an associated cost to the organisation. Other examples of technological developments that might not incur financial cost to the health care organisation include electronic cognitive behavioural therapy, online self-help groups, online educational resources, video conferencing or online face-to-face appointments (Maughan 2015). However, other types of service developments may also incur no cost to the organisation, such as electric bikes provided by the local council (Bristol City Council 2013). In these circumstances, wherever this cost is incurred, it should be added to the financial data for the organisation, in order to account for the associated carbon footprint. These costs can be difficult to obtain, but unless these costs are insignificant, to robustly account for the new service design, these costs need to be included.

Chapter 10

Conclusions

Introduction

This concluding chapter reviews the rationale for this research and the key findings. The influence of these findings upon the ongoing efforts to reduce the environmental impact of mental health care in the UK is discussed. Recommendations for the translation of these findings into policy decisions are made, and suggestions for the direction of future research are outlined.

Review of the context

The research reported here has been undertaken as part of a sustainability fellowship with the Royal College of Psychiatrists. The aim of the fellowship was to increase awareness about and attempt to improve the environmental sustainability of mental health services in the UK. The drivers for this work were both legal and ethical. The legal driver was the Climate Change Act target of an 80% reduction in its carbon footprint by 2050 (National Archives, 2008). Given that evidence has suggested that a considerable proportion of this carbon footprint stems from those emissions related to clinical care such as medications and equipment (Connor 2010; SDU 2013a), it is unlikely that simply changing to renewable energy sources or improving the efficiency of heating and lighting will meet these targets. Clinical practice needs to change. The ethical driver was climate change (Maughan & Berry 2015). The Lancet Commission and the World Health Organisation have both stated that climate change is likely to be the largest threat to human health in the 21st century (MA et al. 2015; M. Chan 2008; Costello et al. 2009). The ethical dilemma is that health care organisations, in their attempts to improve health, are actually contributing significantly to this health threat (Maughan & Davison 2015).

In spite of this strong rationale for reducing the carbon footprint of mental health care, this research has found that mental health organisations are not making sufficient attempts to reduce their carbon footprint. In fact, no evidence has been found of any service improvement project initiated with the aim of reducing the carbon footprint of mental health care. Although it must be acknowledged that these types of projects are hard to find in the literature and may exist but have not been discovered through the search strategies or the surveys. Two potential reasons for this were found in the systematic reviews presented in Chapter 2. First, there is little evidence available in the literature about how service providers could redesign services to improve the environmental sustainability of mental health care. Second, no method has been found that suggests what method service providers could use to estimate the carbon footprint of their services.

Other reasons for this lack of response were found by the two national surveys, presented in Chapter 3. These surveys were the first investigation to take place into sustainable practices within mental health care. They found that clinicians are not engaged with the process of improving environmental sustainability. Further, most mental health organisations do not provide adequate information to staff about their environmental policies nor do they have the required sustainable policies in place. However, current NHS environmental reporting requirements do not require organisations to demonstrate how they aim to meet the carbon footprint reduction targets of the Climate Change Act, nor do they require them to include clinical factors (National Archives, 2008). Therefore even if all organisations were fulfilling current reporting requirements of their carbon emissions, of which, as shown by the survey in Chapter 3, only 70% of mental health organisations currently do, the likelihood is that even this would not be a sufficient response to meet the Climate Change Act targets.

Given that current reporting requirements for environmental sustainability in the NHS are essentially nominal, that there is no suggested method in the literature for how mental health service providers can estimate the carbon footprint of their services and that there appears to be little clinician or corporate interest in reducing the carbon footprint of care, it is perhaps unsurprising that there has been little change to the carbon footprint of mental health care over the past five years (SDU 2013a). Realistically, for mental health services to engage in reducing the carbon footprint of clinical services, an approach to estimating the carbon footprint of care that is fit for purpose in the time and resource constrained context of the NHS is needed. This research has attempted to assess whether such an approach is available.

Is there an approach to estimating the carbon footprint of mental health care that is fit for purpose?

The main aim of this research was to determine whether existing methodologies for estimating carbon footprints could be applied to mental health care to provide an approach that is fit for purpose. The methods used in this research have been akin to 'action research' in that, through progressive analysis, available methods for estimating the carbon footprint of mental health care have been assessed to find an approach that is 'good enough' or 'fit for purpose' (Hart & Bond 1995).

The question of feasibility has been central throughout, as the carbon footprint of mental health care can be accurately estimated, given enough time and financial resource (WBCSD & WRI 2011; DEFRA et al. 2011). An investigation was therefore required into what approach could provide the most robust results and could also be feasibly applied by service providers. This assessment has been based on i) the clinical context that is time and resource poor, ii) the variation that occurs between different clinical practices, iii) the feasibility of collecting primary data, iv) the availability and quality of secondary data and v) the availability of relevant emission factors.

A summary of the development of the combined approach

First, the boundaries of clinical activities were defined in Chapter 4. This was in order to ensure a consistent approach was taken that also had good face validity for service providers. Following this, in Chapter 5, an investigation was made into whether primary or secondary data should be collected. The problems encountered with collecting primary data and the suggested method of collection for each category of activity is summarised below:

- Good quality primary activity data about staff and patient travel can be feasibly obtained using surveys and given that this is likely to vary considerably between services, it was considered the suggested source for data collection.
- Primary activity data could be obtained for medication from pharmacy records, however, a good quality source of secondary activity data (GP prescriptions database) was considered more feasible and could provide accurate results (HSCIC 2010). Further, as medication use is likely to vary considerably between services, secondary activity data was the suggested source for data collection
- Primary activity data for energy could not be feasibly obtained at a clinical activity level as the electricity and gas meters covered large areas. Consequently, to ensure data completeness, using primary activity data required aggregation of data to an organisational level and then subsequent scaling down to clinical activity level. It was decided that using financial data provided a similar level of robustness to this aggregated primary data, it could also be more

feasibly obtained. Therefore financial data was the suggested source for data collection

- Primary activity data for medical equipment could not be measured at a clinical activity level, due to the inclusion of equipment that may not be used in the clinical activity but national standards require them to be present in the facility (RCPsych 2014). Thus, primary data had to be measured by creating inventories of clinical examination rooms and then scaled down to individual clinical activities. Given that the only emission factor available for medical equipment is based on cost (DEFRA 2013), aggregated primary data (from clinical examination rooms) did not provide any benefit over financial data. As organisational level financial data is more feasible to obtain, it was the suggested source for data collection.
- Primary activity data for non-medical procurement could not be collected at a clinical activity level as other activities such as management and administration activities had to be included. It was considered unfeasible to collect primary data for all non-medical procurement across the organisation. As financial data was the only other available option, it was the suggested source for data collection.

The process of attributing an emission factor to collected data was discussed in Chapter 6. The two different methods available for obtaining emission factors were presented; process-based LCA and input-output methods. The emission factors for all categories of activity were considered fit for purpose except for the emission factor for medication. Consequently, the available methodologies for obtaining emission factors for medication were evaluated. It was concluded that, currently, there is no robust method for estimating the carbon footprint of medication. This is because pharmaceutical companies have provided no emission factors for their products and the data required to perform process-based LCAs to obtain emission factors for individual medications is not publicly available. A sensitivity analysis was presented which evaluated the other available method for estimating the carbon footprint of medication, an input-output method. This demonstrated that the emission factor provided by an input-output approach provides a five-fold range for the carbon footprint estimates of medication. This range is due to regional differences in the emission factors for medication (SDU 2013a). As a consequence of this large range, it was concluded that where medication is used in a service or clinical activity, then the combined approach cannot be used to compare between services or provide robust point estimates of the carbon footprint. Instead, if medication is used in a clinical activity or service, then the combined approach is only fit for the purpose of comparing how the carbon footprint of one service or clinical activity changes over time, as in this circumstance, the potential range associated with the carbon footprint estimates of medication can be discounted (WBCSD & WRI 2011). It has been noted that the smaller the service the more difficult it would be to discount this range as the proportion of medications obtained from different regions might vary dramatically. If a service was larger the relative contributions of medication fro different regions would be more likely to average out and therefore create less of an issue. The range in these circumstances would therefore likely be less of an issue in these larger comparisons.

As a result of these investigations, an approach to estimating the carbon footprint of mental health care was suggested that met the practicality and implementation criteria of feasibility; the data required for the combined approach can be feasibly obtained and the approach feasibly applied by service providers within the constraints of the clinical context. This was termed the combined approach as it used both primary and secondary data and process-based LCA and input-output methods, see Table 41 below.

Table 41. A summary of the combined approach

Category of activity	Step 1 Aim and scope	Step 2 Data source for inventory	Step 3 Impact assessment (method used to obtain carbon footprint)
Medication	Included within boundaries	Secondary activity data	Input-output
Travel	Included within boundaries	Primary activity data	Process-based LCA
Medical equipment	Included within boundaries	Secondary financial data	Input-output
Non-medical procurement	Included within boundaries	Secondary financial data	Input-output
Energy	Included within boundaries	Secondary financial data	Input-output

A summary of the evaluation of the combined approach

In order to evaluate whether the combined approach is fit for the purpose of estimating the carbon footprint of mental health care, chapters 7, 8 and 9 assessed the application of the approach. The scenario analysis presented in Chapter 7 assessed whether the combined approach could estimate the carbon footprint differences following changes made to the care of a patient receiving community mental health care. The combined approach was considered fit for purpose for three specific functions defined below.

1. For comparing two services or clinical activities where medication contributes minimally to the carbon footprint of the service
2. For providing a point estimate of the carbon footprint where medication contributes minimally to the carbon footprint of the service
3. For estimating the changes to the carbon footprint of one service or clinical activity over time

The reason the combined approach cannot be used in other contexts is because of the weaknesses inherent in the approach. The main weakness that gives rise to this reduced functionality is the large range associated with carbon footprint estimates of medication.

Chapters 8 and 9 then applied the combined approach to different clinical contexts to test these three proposed functions of the approach. Different contexts were chosen in these chapters to review whether the approach could meet the 'adaptation' criterion of feasibility. Reviewing the combined approach in real-world examples found that there are further limitations to the proposed functions of the approach that were not identified through the scenario analysis in Chapter 7. Both chapters found that the combined approach is fit for the purpose of estimating the carbon footprint of standard clinical activities such as appointments or bed days for mental health and other medical specialties. In Chapter 8 however, the combined approach was found to be unfit for the purpose of estimating the carbon footprint of services or clinical activities that do not use the standard paradigm of care delivery i.e. appointments or admissions. This is because the assumptions required to allocate a carbon footprint to non-standard clinical activities are hard to justify and these assumptions were shown to have large effects on the estimated carbon footprint of the service. Therefore the combined approach cannot robustly account for non-standard clinical activities. Chapter 9 found that if a service development affects energy, medical equipment and non-medical procurement use and is not paid for by the organisation, (as is frequently the case with technological developments such as electronic cognitive behavioural therapy, online health records or internet-based software for online consultations), then the costs need to be added to the relevant category of organisational spend. These costs can be very difficult to obtain as patients can often use these technologies without identifying themselves (Poole et al. 2012). Attempting to allocate to the relevant organisations is therefore sometimes impossible. Chapter 9 therefore concluded that the combined approach cannot robustly account for services where the costs are not incurred directly by the organisation. This issue, while it may seem minor, will become more prevalent as mental health organisations are increasingly using online technologies to augment or even replace care (Maughan 2015; Burns et al. 2010; Poole et al. 2012).

Through these progressive studies presented in Chapters 8 and 9, the functions of the combined approach proposed in Chapter 7 were further refined to provide a more detailed understanding about where the combined approach is fit for purpose and where the approach is unlikely to provide robust results, and therefore not considered fit for purpose.

It is proposed that the combined approach is fit for the purpose of:

- Estimating how the carbon footprint of a clinical activity or service changes over time (only when standard paradigms or care are used)
- Providing a point estimate of the carbon footprint of standard mental health care clinical activities (i.e. appointments and bed days) that either do not involve the administration of medication or where medication contributes minimally to the carbon footprint
- Estimating the carbon footprint difference between two clinical activities or services that either do not use medication or where medication contributes minimally to the carbon footprint (only when standard paradigms or care are used)

It is also proposed that the combined approach is not fit for the purpose of:

- Estimating the carbon footprint of clinical activities or services that do not use the standard paradigm of care delivery i.e. appointments or bed days
- Estimating the carbon footprint difference between two services or clinical activities where medication contributes a moderate or large proportion of the carbon footprint

- Estimating changes made to energy, medical equipment and non-medical procurement that occur 'within' clinical activities, unless these changes are widespread across the organisation
- Estimating the carbon footprint of service developments where the costs are not paid for entirely by the organisation

The framework applied in this research of fitness for purpose has been justified by the complexities encountered. The combined approach does not provide the most robust carbon footprint estimations of mental health care, however it does have specific utility and in these circumstances can provide an approach can be feasibly implemented and provide sufficiently robust results for service providers to use to implement changes to reduce the carbon footprint of their services.

These limitations, however, demonstrate that the combined approach does not meet the adaptation criteria of feasibility (Bowen et al. 2009). Its use is limited to very specific functions and cannot provide robust results in other circumstances. Ideally, the approach would be fit for purpose in all circumstances, however, the two main methodological factors that give rise to the reduced functionality of the combined approach is the use of financial data, second, is the five-fold range of carbon footprint estimates of medication provided by an input-output method. These methodological issues are discussed below.

Methodological issues

Methodological issues have been encountered throughout the development and testing of the combined approach. These are presented here and strategies for overcoming these issues are discussed. Using a single emission factor based on an input-output method for estimating the carbon footprint of medication is arguably the most significant methodological issue in the combined approach. The first option of managing this issue would be to accept that the uncertainties inherent in this method are so large, that quantification of medication should be kept as financial data, and attempts at translating to a carbon footprint, abandoned. Service providers could then simply attempt to reduce the cost of medication, in the hope that this would lead to a reduction in the carbon footprint. However, Chapter 6 demonstrated that the cost of medication is a very poor indicator of the carbon footprint of medication due to patent issues and different emissions associated with energy production from different countries. Further, providing a carbon footprint for medication would enable the carbon footprint of the whole service to be presented. Service providers would then be able to assess the relative contributions made by each different category to the carbon footprint of the service to determine which aspects of the service they should prioritise in order to most effectively reduce the carbon footprint. From this perspective the inclusion of medication in the combined approach is helpful.

The second option to overcome this methodological issue of estimating the carbon footprint of medication would be to exclude medication from the combined approach altogether. This would serve to substantially reduce the uncertainties associated with the approach, however, it would also reduce the completeness of the assessment and impact the face validity of the assessment. The benefit of taking a categorical approach in the development of the combined approach is that medication can be excluded at any stage of the assessment. This then allows medication, and the uncertainties associated with its estimated carbon footprint, to be excluded if the service providers choose to disregard this aspect of service provision. Thus, inclusion of medication, does not necessarily undermine the other results included in the combined approach.

An input-output method is currently the only feasible method for estimating the carbon footprint of medication because pharmaceutical companies withhold the data necessary to perform either multi-region input-output analyses or process-based LCA. Given this issue, more efforts could have been made to encourage pharmaceutical companies to make their data available. This data certainly needs to be made available if the accuracy of carbon footprint estimates of mental health care are to improve, however, in order for this to be achieved, given market sensitivities, it is likely to require government standards to change. Instead, to address this methodological issue, guidance could be provided alongside the combined approach, to help limit the uncertainties associated with the carbon footprint of medication. This is because the potential range of carbon footprint estimates for the clinical activity increases and the robustness of the result decreases as the relative carbon footprint contributions of medication increases. Deciding on the accepted limits of uncertainty will of course be dependent on the particular use of the combined approach. If changes to the carbon footprint of a service were being measured over time then an example of such guidance might be that an uncertainty of no more than 25% should be allowed, which is generally considered an unacceptable level of uncertainty in the result obtained (WBCSD & WRI 2011). Therefore, the guidance should be that if medication contributes more than 10% of the percentage burden of the carbon footprint a clinical activity, medication should then be excluded from the assessment (as this would give rise to 25-30% uncertainty for the clinical activity).

Another methodological issue was present because of the lack of available activity data for energy, medical equipment and non-medical procurement. As a consequence of this, the combined approach used financial data to estimate the carbon footprint of these categories, which imposed limitations on the utility of the approach. The benefits of an intensive process-based LCA based on activity data would be that more accurate results could likely be achieved and that there would be less problems when trying to account for services that did not use a standard service design. However this research found inherent complexities in measuring activity data for these categories. First, these resources are often shared between services; therefore allocating activity data to specific clinical activities is problematic. Second, it is difficult to account for overheads for these categories given the milieu of team working and the myriad activities that are relevant to providing a clinical activity, such as team meetings or informal discussions about patients. As such, to ensure adequate data completeness when using primary data for these categories, data needs to be aggregated across whole departments (for non-medical procurement and medical equipment) or buildings (for energy use) and then allocated to individual clinical activities. Consequently, attempting to directly measure resource use from activity data for these categories provides no clear benefit over using financial data, is far more time consuming to collect and therefore was not considered fit for purpose. This use of secondary financial data is a major limitation to the combined approach, but is necessary to ensure feasibility and, given the complexities of obtaining and allocating primary data, likely improves the completeness of the data and therefore the robustness of results.

Lastly, performing the assessment at a clinical activity level has created methodological difficulties as allocating activity data between these clinical activities is very difficult, leading to a reliance on financial data to improve robustness. Performing the assessment at the level of buildings would allow far easier allocation of activity data and would allow for direct measurement of energy activity data. This would lead to improved accuracy of estimations, particularly of energy, medical equipment and non-medical procurement, however, allocation of travel data would become more difficult as staff move between buildings in their work. More fundamentally, however, is that there would be less culpability for addressing the carbon footprint of mental health care. Currently, the few assessments that are made about the carbon footprint of mental health care are based on energy use according to buildings and are run by the estates and facilities managers (SDUa, 2012).

Clearly more interest needs to be garnered for addressing the carbon footprint of mental health care and there are many who agree that in order for carbon footprint assessments to be taken up, more focus needs to be given to clinical domains and assessments should be performed along service lines in order to align with other cost measures (Curtis 2013, RCPsych, 2013, SDUa 2013). Therefore the potential benefits of improved accuracy from performing the assessments would not progress the current status quo of little interest from clinicians and little changes made to models of care to reduce the carbon footprint, there is therefore an argument, despite the uncertainties inherent in the combined approach, to perform carbon footprint estimates at the clinical activity level.

Will the combined approach generate change?

Given the concerns about the accuracy and reliability of the results provided by the combined approach, it is uncertain whether this information will lead to changes to models of care. The degree of uncertainty associated with the carbon footprint of medication may lead service providers lose trust in the tool and therefore not implement changes based on the results.

Certain categories provide more reliable data than other categories in the combined approach. Medication is the least accurate and reliable category. However, reducing the use of medication is the responsibility of individual psychiatrists and cannot be decided upon at a service design level. Ascertaining what percentage contribution is made by medication would be helpful, to establish whether there is necessity in either consulting with psychiatrists about reducing prescribing levels or providing alternative models of care that do not rely on medication, for example psychotherapy services. The other categories have a more acceptable level of reliability and accuracy and are more applicable to service providers in their designing of services. This would include for example deciding between using several different clinics (with perhaps less associated travel but more energy and equipment), or using one central hub (with perhaps more travel but less energy and equipment).

Decisions about service design in health care in the past have tended not to be based on evidence (Timmermans and Berg 2010). This is despite the fact that all new interventions used in health care are now subjected to rigorous testing (Timmermans and Berg 2010). In fact, the understanding that health care managers should be responding to evidence is a relatively new concept compared to evidence-based medicine (Humphries et al. 2014). Certainly, health care managers have a different relationship towards evidence with a tendency to see the results as more subjective, contingent and less generalisable (Walshe et al. 2001). From this perspective, service design that is informed by any level of evidence would be beneficial, the results of the combined approach could be seen as a move in a positive direction.

A systematic review of evidence-use in health care management suggests that tailored information improves the implementation of evidence (Humphries et al. 2014). The combined approach would fit well here as it provides organisation-specific information to aid decision-making.

Interestingly, the accuracy of results did not feature as an important barrier or facilitator of evidence use, instead, personal communication and mutual respect featured strongly as factors that lead to the use of evidence in service design (Humphries et al. 2014).

Reflecting on this information, in light of the uncertainties associated with the combined approach, it is arguable that the results provided could be sufficiently informative to create change, if appropriate dialogue occurred with service providers. This would involve meeting with them face to face and explaining how to apply the results in their decision-making. This targeted dissemination of data has good evidence for improving the uptake of evidence in health care design (Humphries et al. 2014).

Other strategies for reducing the carbon footprint of mental health care

This research has proposed an approach to estimating the carbon footprint of mental health care, in the hope that, by understanding more about the emissions associated mental health care, steps will be taken to reduce the carbon footprint. Importantly, other strategies could have been adopted in the attempt to achieve the same aim. First, an in depth qualitative investigation into the barriers and facilitators of action on carbon footprint, over and above that provided by the survey in Chapter 3, might well have been more helpful. This is because awareness about this topic is minimal and there are myriad reasons why service providers might not wish to address the carbon footprint of care including; scepticism about climate change, being too busy to consider additional factors, or being so overwhelmed by financial pressures that other factors become insignificant. Investigation into potential barriers and facilitators may have provided some understanding about how best to engage service providers with this issue. Second, research could have investigated the barriers and facilitators for policy recommendations to ensure adequate data amongst both health care providers and those supplying health care with goods and services. It has become clear, through this research, that a lack of relevant data is the major obstacle in accurately estimating the carbon footprint of health care. Further information in this area would be able to highlight the factors that are hindering the ability to obtain accurate carbon footprint estimates of health care.

This research chose to propose an approach for estimating the carbon footprint of mental health care, rather than these other two avenues of investigation, because understanding what underpins the carbon footprint of mental health care is a fundamental step in understanding where the challenges exist in estimating the carbon footprint and what sorts of changes are required to reduce the carbon footprint. It remains unclear what the major components of the carbon footprint of mental health care are. It may well be that reducing the expensive components of care exactly align with the carbon footprint, in which case, a qualitative investigation into the barriers and facilitators of change, whether clinical or policy, would not be necessary. Further, the process of developing an approach to estimating the carbon footprint of mental health care has clarified the areas where policy needs to change and / or develop in order to support carbon footprint assessments. While the combined approach contains uncertainties that significantly limit its utility, it is the knowledge gained through these limitations that provide the basis for further research into what policy changes are needed. Lastly, it is reasonable to suggest that having data about the carbon footprint of mental health services, despite them perhaps being rudimentary or uncertain, is the first step towards increasing acting to reduce the carbon footprint. This is a long process, but begins with increasing awareness, improving understanding and beginning to understand the major components of the carbon footprint of mental health care.

Options for reducing the carbon footprint of mental health care

This aim of this research has been to establish an approach to estimate the carbon footprint of mental health care that is fit for purpose. It has not attempted to discover details about the different components of the carbon footprint or robust data about an average carbon footprint for different clinical activities. As such, most of the data for the research has either been collected from one organisation or taken from a previous input-output study (SDU 2013b) for expediency. The results about the relative contributions of the different components of the carbon footprint presented here are not considered generalisable. However, given these limitations, some basic conclusions can be drawn about what changes are likely to provide reductions to the carbon footprint of mental health care.

Non-medical procurement and energy use likely contribute a large proportion of the carbon footprint of clinical activities. Medical equipment and travel likely contribute comparatively less to the carbon footprint. However, travel will likely contribute a larger component of the carbon footprint of services that cover large rural areas. The contribution made by medication to the carbon footprint of clinical activities remains largely unknown, as the potential range of carbon footprint estimates of medication is so large.

Based on the findings of this research, reducing the carbon footprint of a mental health appointment should start with improving sustainable procurement strategies. These are vital as non-medical procurement contributes around 40% of the carbon footprint and equipment contributes around 10%. Reductions to energy use such as using renewable energy sources or improving insulation will also likely have a considerable effect as this research suggests that energy contributes around 25% of the carbon footprint. Telephone appointments, increasing active travel or use of public transport would all lead to reductions in the carbon footprint but these would be smaller reductions, as travel has been found in this research to contribute around 5% of the carbon footprint. It is difficult to assess the extent of the contribution by medication, however, reducing unnecessary medication or over-prescribing should always be a priority for mental health services for clinical reasons alone (Maughan, Lillywhite, et al. 2015).

In order to reduce the carbon footprint associated with admissions, improving procurement strategies for furniture, office equipment and food is essential, given their large contribution to the carbon footprint of a bed day; around 45% found by this research. Such examples could be reducing the proportion of meat in the foods or by sourcing equipment more locally. In addition, energy usage should be minimised as this research suggests that it contributes around 30% of the carbon footprint. Using renewable energy or more efficient heating and lighting such as using combined heat and power boilers can lead to significant reductions to the carbon footprint (SDU 2010). Use of medical equipment might be more difficult to reduce, given that there are requirements for equipment in clinical examination rooms (RCPsych 2014), while this research suggests that travel contributes little to the carbon footprint of a bed day; around 2%.

Table 42 below outlines the influences that each different staff group can have on the carbon footprint of services. This demonstrates that it is the responsibility of many different staff groups within provider organisations to reduce the carbon footprint of mental health care. These different staff groups would respond to the results of the combined approach in their own ways to reduce the carbon footprint of services.

Table 42. Influencing factors and interventions each staff group can perform to reduce the carbon footprint

Category of activity	Clinicians	Patients	Clinical service managers	Estates managers	Procurement managers
Medication	Reduce over-prescribing. Stop prescribing to those who are non-compliant with medication Use medications developed and manufactured in EU	Take prescribed medication.	Provide alternative care models that do not use medication	n/a	Where possible, ensure that medications are purchased from EU countries
Travel	Use active transport where possible Provide alternatives such as telephone clinics or Skype for patients Prioritise telephone-conference for meetings	Use active transport where possible, or public transport otherwise.	Ensure options for telephone assessments are available in every care pathway. Provide local services where possible. Design care pathways that reduce number of face to face contacts.	Ensure clinic and hospital sites are on major public transport links Provide bicycle shelters Provide cycle routes where possible	Provide fleet of electric bikes and cars for staff use. Procure goods locally to reduce transport emissions
Energy	Take active steps to turn off electrical equipment / lights when not used. Ensure doors are kept shut where appropriate.	n/a	Design care models that use group based interventions as this generally reduces clinical space used. Reduce non-attendance at clinics where possible. Provide alternatives to carbon intensive admissions	Ensure insulation and air flow are optimised Provide automatic sensor lighting. Provide auto-turn off for hot water taps. Ensure thermostats can be operated in each room.	Ensure that energy suppliers provide a high proportion of renewable energy Invest in combined heat and power boilers
Non-medical procurement	Look after goods such that lifespan increases	n/a	Design care models that use outdoor space to reduce need for procurement.	Ensure that estates/buildings are not negatively impacting on the lifespan of equipment	Procure food locally and reduce use of meat in food Procure items locally and those made from recycled materials where possible
Medical equipment	Look after goods such that lifespan increases	n/a	Work with national representative bodies to review required equipment in clinical spaces	n/a	Procure items locally or from the EU and those made from recycled materials where possible

Influence of research

This research has provided the basis for four peer-reviewed research publications (Maughan, et al. 2014; Maughan, Lillywhite, et al. 2015; Maughan, Patel, et al. 2015; Maughan & Pearce 2015) and four peer-reviewed editorials (Maughan & Berry 2015; Maughan, Berry, et al. 2014; Yarlagadda, Maughan et al. 2014). This research has also been presented at four regional conferences, four national conferences and three international conferences. Given the original nature of this work and the current lack of an evidence base, it is likely that these publications will provide a substantial basis for future research into the carbon footprint of both mental health care and other health care disciplines.

The combined approach is being used as a basis for a national recommendation from the Royal College of Psychiatrists to "*seek to establish the carbon impacts of interventions and models of care within mental health*". This recommendation is currently in development and falls under objective 7 in the strategic plan for 2016-2019 for the Royal College of Psychiatrists, currently unpublished; "*to achieve carbon efficient services we will work to make sure the sustainability of mental healthcare is improved*". This objective is a new addition to the plan and is a direct result of the research presented in this thesis.

This research has provided the basis for two national reports, written by the author, for the Academy of Medical Royal Colleges (Maughan & Ansell 2014; Maughan 2014). The first report was entitled '*Protecting Resources,* *Promoting Value*' (Maughan & Ansell 2014). This report argued that doctors in the UK need to look more critically at the resources they use and become stewards of NHS resources. Case studies were presented throughout this report about how doctors could reduce the financial cost and carbon footprint of care by making changes to their clinical practice. This received national interest and was reported on the front page of The Guardian, the BBC Radio 4 Today programme, the BBC 24 news channel and 14 local BBC radio stations. This report was also presented to the Parliamentary Health Select Committee in November 2014. The other Academy report was entitled '*Facing the Future, Sustainability for Medical Royal Colleges*' which was the first audit of its kind that reviewed how Medical Royal Colleges are promoting environmentally sustainable practices within their profession (Maughan 2014). This had a national launch where several prominent members of Royal Colleges attended and spoke. The Academy of Medical Royal Colleges now intends to perform this review annually.

The author has worked with the Royal College of Psychiatrists as their Sustainability Fellow to produce key documents to underpin future mental health policy and commissioning. One is a college paper entitled '*Sustainability in Psychiatry* (Maughan 2015)'. This report defined how psychiatrists can improve their sustainable practice. The second report was a commissioning guide entitled: '*Future-proofing mental health care; Ensuring sustainable, high-value care'* This is the first commissioning guide of its kind in mental health to provide commissioners with the tools to ensure that future mental health services are environmentally sustainable.

This guide has been endorsed by Simon Stevens; Chief Executive of the NHS, Geraldine Strathdee; National Clinical Director for Mental health at NHS England, and Sue Bailey; President of the Academy of Medical Royal Colleges. Five Clinical Commissioning Groups have already publicly committed to using this guide in their upcoming commissioning decisions (West Hampshire CCG, Brighton and Hove CCG, Salford CCG, Oxfordshire CCG and Cambridge and Peterborough CCG). This guide was launched on October 27th 2015 at the Royal College of Nursing.

As part of the Royal College of Psychiatrists Sustainability Fellowship, the author has developed a network of mental health professionals interested in sustainability called *Psych Susnet* (http://sustainablehealthcare.org.uk/psych-susnet), which has grown to over 200 mental health professionals in the last two years. The research presented in this thesis has provided a basis for new projects undertaken by network members across the UK to improve the sustainability of mental health services. One example was measuring the economic and environmental impacts of a social prescribing service in a primary care practice in Cumbria (Maughan, Patel, et al. 2015). This led to a request from local commissioners to produce a report of the findings, as they were keen to commission this type of service across the region. Another example has helped provide evidence to support the ongoing funding for the Oxfordshire Complex Needs service by demonstrating cost and carbon savings from future health care use following entry to the service. This came at a time where the funding for this service had almost halved. Another example was a study exploring the carbon footprint of depot prescribing (Maughan, Lillywhite, et al. 2015).

The national surveys of sustainable practices presented in Chapter 3 provided support for those working in mental health to improve the environmental sustainability of their clinical practice and operational processes (Maughan, S, et al. 2014). Each respondent to the survey was emailed a Microsoft Powerpoint slide set detailing their sustainable practice and where they needed to make improvements, based on their survey responses. Each respondent was followed up and encouraged to present the findings in their local Trust.

Recommendations for policy changes

The aim of this research was to provide an approach to estimating the carbon footprint of mental health care that is fit for purpose. An approach has been found that is fit for purpose in some circumstances, but not others. This research has found that the major limiting factor to estimating the carbon footprint of mental health care is the poor quality or scarcity of available data. This results in having to rely on a method for estimating the carbon footprint of medications that is not robust and having to use financial data to measure energy, medical equipment and non-medical procurement. While more research can be done to fully explore how to improve the robustness of carbon footprint estimates, given this poor data availability, it is fundamentally important to improve national reporting requirements to ensure the provision of relevant information for carbon footprint assessments. In this section, policy changes are therefore considered first, further research required is discussed latterly.

The major factor that limited the functionality of the combined approach was the large range associated with using an input-output method to estimate the carbon footprint of medication. This is the primary issue that serves to undermine the robustness of carbon footprint estimates of mental health care. The methodology for performing process-based LCA assessments on medications is available (SDU 2012a), but using this method requires pharmaceutical companies to provide the relevant information. However market sensitivity means that there is little incentive for pharmaceutical companies to disseminate this information (Hawkes 2012). More stringent Government standards are required for transparent reporting of the environmental impacts of medications. Unless pharmaceutical companies are required to provide carbon footprints of their medications or provide the information so that others can perform these assessments, any estimation of the carbon footprint of mental health care will be grossly limited. An ideal scenario would be for the British National Formulary of medications (www.bnf.org.uk) to provide estimates of the carbon footprint of medications alongside the cost of medications. The importance of the carbon footprint of medications could then be appropriately recognised and acted upon.

The poor quality of available data in mental health care settings provides the other major limitation to estimating the carbon footprint of mental health care. New methods of accounting for resource use within mental health care settings could lead to improved data availability. This would improve the feasibility and the robustness of carbon footprint estimations. National reporting requirements in mental health care have been developed to account for financial expenditure and patient outcomes (HSCIC 2012), but not for estimating the carbon footprint. Different data are required to estimate the carbon footprint of services. An example of this is the adequate information available about the cost of procurement categories such as equipment or furniture, but no available information about the type of resource procured, such as a computer or an ECG machine. Consequently, primary data often has to be collected specifically for the task of estimating the carbon footprint and this is unfeasible in some cases and impossible in others because of the lack of available records, as was shown to be the case for measuring energy use in Chapter 5.

One way to overcome this issue of poor quality data would be to place a requirement for service providers to collect records that are more relevant to carbon footprint assessments. Requirements should include recording staff and patient travel and more detailed recording of energy consumption, ideally an energy meter per room. The lifespan, frequency and duration of use for all types of procured items should also be recorded, however this would be a very time consuming task. A feasible approach to collecting the necessary data about procurement would be to place a requirement on companies supplying the NHS to provide carbon footprint data for all their products and initiate a barcode system that records the use of procured items in each clinical administrative or management activity (Mahoney et al. 2007). This system, used for financial accounting in the United States, involves scanning the barcode of a product every time it is used e.g. a medication or a blood pressure machine. All activities used could then easily be traced to a particular clinical activity. If these requirements were placed on service providers and those providing products for the NHS, accurate carbon footprint assessments could then be performed based on activity data, rather than having to rely on financial data, which has significant limitations.

Implications for future research

First, with regards the application of the combined approach, further research is required to assess whether service providers can feasibly apply this approach in different organisations across the UK. Although the combined approach has been designed to allow service providers to apply this approach, this has not yet been examined. This would involve asking service providers to use the combined approach to estimate the carbon footprint of their services and performing both qualitative and quantitative analysis to determine whether i) the combined approach could be applied without further assumptions and ii) the ease of application of the combined approach from a service providers perspective. Following this, research is needed to understand whether the information provided by the combined approach is used to inform service design. This would involve a survey of service providers asking about whether the results obtained from the combined approach impacted on service design. If service design was not changed, an investigation into the reasons for this lack of change would be needed, again through either a survey or instead perhaps through a qualitative analysis using focus groups. These groups could assess whether the combined approach is providing the right sort of information for service providers to act on, whether service providers found the level of information provided by the combined approach useful, or whether more detailed information is needed. For example, whether the category of non-medical procurement requires a more detailed categorisation.

Second, further research could use the combined approach to assess how changing different elements within a particular mental health service could reduce the carbon footprint, for example increasing active travel, reducing medication, improving insulation, restoring furniture and equipment to improve lifespan. This would require assessment over time, using surveys of service providers to assess what changes they have made to service design and what impact this has had on the carbon footprint. This knowledge could then be shared, to allow service providers in other organisations some indication of what changes might bring about the largest carbon footprint reductions. This research could provide useful evidence that could help service providers begin to meet the stringent targets of the 2008 Climate Change Act (National Archives, 2008).

Third, further research is required to understand where the carbon hotspots lie in the production and manufacture of each product used in mental health care. Intensive process-based LCA would be required to provide this level of knowledge (DEFRA et al. 2011). This evidence could help form policies about sustainable procurement, such that companies providing products to the NHS could be required to avoid particularly carbon intensive processes in product development and manufacture.

Fourth, if the previously suggested policy recommendations were applied, further research would be required to assess whether using a barcode system could be implemented effectively to improve the accuracy of carbon footprint estimates (Mahoney et al. 2007). This research would involve using this system in a mental health organisation and assessing whether it enabled activity data to be collected about procurement that could be used in carbon footprint assessments. If pharmaceutical companies were required to report on the carbon footprint of their medications, then the combined approach could be improved to include the use of emission factors based on activity data rather than financial data, which would likely serve to improve the robustness sufficiently to allow comparisons between services across the UK to assess what models can provide good patient care for the least carbon footprint. This is currently not possible because of the five-fold range associated with the current method of estimating the carbon footprint of medication (WBCSD & WRI 2011).

Summary

This research has provided an approach to estimating the carbon footprint of mental health care. There remain significant issues with this approach, due to a lack of available data, which give rise to large uncertainties in the results provided. However, this is the first model of its kind that estimate the carbon footprint of clinical activities within mental health care and provides a level of information that in certain circumstances may help service providers understand how to reduce the carbon footprint of their services when making changes to service design. This approach requires service providers to perform regular travel surveys of staff and patients, as well as recording the medication prescribed in each clinical activity. These data can be used with relevant financial data for energy, medical equipment and non-medical procurement and the relevant emission factors to complete the carbon footprint calculator, provided in Chapter 7. If carbon footprint assessments using the combined approach were performed regularly then service providers could begin to use this information in the review of existing services and the design of new services, alongside other factors such as clinical effectiveness, cost effectiveness and user and carer views. While there are many factors that could reduce the carbon footprint of mental health care, such as ensuring preventative practice, reducing waste and empowering patients to self-manage, beginning to understand the major components of the carbon footprint of care delivery is essential to improving the environmental sustainability of mental health care. The research provided in this thesis provides a method that can feasibly be used by all mental health organisations to monitor changes to the carbon footprint of their standard services.

Appendices

Appendix 1

The Mental Health Sustainability Survey 2013 - Clinical

1. Please enter your name:
____
_

2. Please enter your job title:
____
_

3. Please enter your email address:
____
_

Most mental health teams are based either in inpatient, day hospital or community settings although some are based over different settings. Please decide which setting the answers you give throughout this survey will relate to. It is important that you remain consistent. However, wherever possible, please use the 'free text' boxes to highlight points of interest in other clinical areas you are work in.

4. Please decide whether your answers will refer to an inpatient or community setting.

Inpatient □
Community □
Day hospital □
Other □

5.
a) What is the name of your team?

-
____
____

b) What is the name of your Trust?

____

6. If you are working in a community setting, which of the following services are provided at the team base?

Outpatient clinics □
Psychotherapy □
Day hospital or day center services □
Employment support □

7. Which of the following best describes your team?

It covers an exclusively urban area □
It covers a predominantly urban area □
It covers an equal mix of urban and rural areas □
It covers a predominantly rural area □
It covers an exclusively rural area □

SECTION 1: TRAVEL

With regard to STAFF travel...

Is secure parking for bicycles provided?
Yes No Don't know NA

Are showers and changing facilities provided?
Yes No Don't know NA

Are walking & cycling to the team base or ward generally considered to be safe?
Yes No Don't know NA

Do you know whether your Trust has signed up to the 'Cycle to Work' scheme?
Yes No Don't know NA

Has anyone in your team bought a bike through this scheme?

Does your Trust reimburse for travel mileage on bicycles?
(The NHS standard is 10p/mile)

Does your Trust have a flat rate per mile for staff travel expenses? (You may need to speak to your Trust finance department for this information)

Is the team base or ward reasonably accessible by public transport?
Yes No Don't know NA

Does your team or ward run a 'car share' or 'car pool' system?
Yes No Don't know NA

If you work in a community setting, are patient home visits coordinated or grouped to reduce travel miles?

Do any staff in your team use bicycles when conducting home visits?

Are walking & cycling encouraged among patients where appropriate?
Yes No Don't know NA

In your team is information about public transport actively provided to patients?
Yes No Don't know NA

Please add any further comments here.

SECTION 2: RESOURCE USE

Please consider all areas, both clinical and non-clinical that your team use. Your local estates team may help you to answer many of these questions.

In your team, low energy light bulbs are used...
a) in all, or almost all, of the lights (81-100%)
b) in most of the lights (51-80%)
c) in some of the lights (21-50%)
d) in none, or only a few, of the lights (0-20%)
e) Don't know

Lights are switched off when not required...
a) Always
b) Most of the time
c) Occasionally
d) Rarely or never

The intensity of the lighting in your team is generally...
a) too high
b) too low
c) about right
d) very varied

Does your team use movement-sensitive light switches?
a) Yes, wherever it is appropriate
b) Yes, but only in a few places
c) No, not at all
d) Don't know

Are staff actively encouraged to shut computers down overnight?
Yes No Don't know NA

Is there a mechanism in place for auto-shutdown of computers overnight?
Yes No Don't know NA

Please enter any further evidence of environmental good practice in relation to the provision of IT services.

Are letters to GP's sent out by email (in place of paper copies)?
Yes No Don't know NA

Are the printers mostly set to draft-quality?
Yes No Don't know NA

Are the printers mostly set to double-sided?
Yes No Don't know NA

Is recycled paper purchased for the printers?
Yes No Don't know NA

Are there accessible thermostat and heating controls in each area?
Yes No Don't know

In your opinion are appropriate temperatures generally maintained?
Yes No Don't know

Is shading provided for south facing windows?
Yes No Don't know NA

Is any air chilling facility (ie 'air conditioning') automatically switched off when the heating is on? (You may need to liaise with your Trust's estates department for this)
Yes No Don't know NA

Are there any electrical appliances that you think would be worth upgrading or fixing to improve energy efficiency? (e.g. fridges / computer monitors)
Yes No Don't know NA

Please comment:

Please enter any further comments regarding heating & cooling or the equipment in your team here.

SECTION 3: SUSTAINABLE CLINICAL PRACTICE IN YOUR TEAM

The Centre for Sustainable Healthcare has identified four principles of sustainable clinical practice. These are: prevention, patient empowerment/self-care, lean care systems and low carbon alternatives.

Are there any examples of (or opportunities for) improving sustainable practice in your team in these areas:

a) Improving preventative strategies (e.g. improving identification or reducing relapse rates)

b) Increasing patient involvement in / ownership of their care (e.g. through patient education, patient booking, self monitoring)

c) Streamlining use of services (e.g. reducing inpatient stays or follow-up appointments)

d) Use of technology that also improves sustainability (e.g. telephone clinics, patient self-monitoring app or website, online self-referral system to day centers or self-help groups, or providing online peer support networks)

e) Have interventions or services been implemented by your team with the aim of reducing carbon?

Please list in order of priority the factors that determine the implementation of interventions by clinicians:

a) Environmental cost
b) Financial cost
c) Patient expectation
d) Management guidance
e) Scientific evidence base
f) Previous experience

Priority: first second third fourth fifth sixth

Do you have anything further that you wish to mention on any aspect of sustainability in mental health care?

Appendix 2

The Mental Health Sustainability Survey 2013 - Corporate

1. Please enter your name:

____

2. Please enter your job title:

____

3. Please enter your email address:

____

5. What is the name of the Trust you work in?

____
____

7. Which of the following best describes your Trust?

Mental Health Trust ☐
Mental Health and Community Care Trust ☐
Learning Disability Trust ☐
Other ☐
Please specify:

____

8. In order to help us stratify the survey results, please provide the following two pieces of information:

The total number of patients on the Trust's caseload

The size of the population that the Trust serves for general adult and older adult psychiatric services

SECTION 1: GOVERNANCE
Does your Trust have a Board level representative for sustainability?

Name: ___________________ Job title: _________________

Is there a clinical lead for sustainability at Trust level?

Name of clinical lead: _____________ Job title: _________________

Does your Trust's annual report include sustainability measures?

If yes, what are they?

Does your Trust have any of the following?

- Sustainable Development Management Plan, Y / N
- a published policy on carbon reduction Y / N
- an environmental management system eg ISO14001 Y / N
- Is sustainability a regular item in your Trust's management or Board meetings?

If yes, what are your carbon reduction targets and what carbon reductions have been achieved to date?

Please state whether these reductions refer to Scope 1 and 2 only or whether they also refer to Scope 3 emissions?
(Scope 1: All direct GHG emissions. Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam. Scope 3: Other indirect emissions, such as the production of pharmaceuticals, transport-related activities in vehicles not owned or controlled by the Trust, outsourced activities, waste disposal etc)

SECTION 2: TRAVEL
Does your Trust have an active travel plan to encourage staff/patients/visitors/users/clients to take regular exercise?

Has your Trust signed up to the NHS 'Cycle to Work' scheme?
Yes No Don't know NA

Does your Trust use low-emission vehicles

- for patient transport?
- (other categories of vehicles? maintenance, home visits, deliveries?)

Does your Trust reimburse for travel mileage on bicycles?
(The NHS standard is 10p/mile)

Does your Trust have a flat rate per mile for staff travel expenses?
Has your Trust got a sustainable travel policy, or one that has sustainability mentioned?

If your Trust has got a sustainable travel policy has this led to any changes? (please give examples)

What steps does your Trust take to promote the use of public transport by staff, visitors and patients? [list of options?]

SECTION 3: WORKFORCE

Are environmental issues included in your staff induction programmes?

Is any training or education provided to staff on environmental issues related to their daily work?

Is there a system in place to allow staff to contribute suggestions for carbon reduction within the Trust?

Yes No Don't know NA

SECTION 4: FACILITIES MANAGEMENT

How much energy is used in your trust in kWh per year?

Which energy supplier (suppliers) does your Trust use?

Does your Trust use solar panels, wind turbines or combined heat and power to generate any energy?

Solar panels
Wind turbines
Combined heat and power
Yes No Don't know NA

What weight of waste does your Trust produce in tonnes per year?

Clinical waste:

Recycled waste:

Landfill waste:

What volume of mains water does your Trust consume in m^3 per year?

SECTION 5: PROCUREMENT AND FOOD

Does your Trust have a sustainable procurement policy?

Could you provide details of examples where sustainability considerations have influenced procurement of goods or services in your Trust?

Does your Trust have any policy for procuring food from local suppliers?

SECTION 6: ESTATES AND BUILDINGS
Has the impact of travel upon staff and patients influenced where to build newer facilities?
Yes No Don't know NA

Have opportunities for natural (passive) heating, cooling, lighting and ventilation been incorporated into the newer buildings?
Yes No Don't know NA

Is it mandatory that new buildings achieve the BREEAM "Outstanding" rating?
Yes No Don't know NA

Are 'green spaces' and 'green views' provided for staff?
Yes No Don't know NA

Are 'green spaces' and 'green views' provided for patients?
Is your Trust signed up to the NHS Forest (www.nhsforest.org)?

SECTION 8: YOUR VIEWS
How important do you think engage clinician engagement is when promoting sustainability within the Trust?

a) Not important
b) Minimally important
c) Moderately important
d) Very important

Please indicate how important the following factors are as barriers to clinician engagement in sustainability
Low priority
Limited awareness
Staff stress
Staff skepticism
Limited staff time
Poor support from management
No motivation
Not adequate training/education

1. It is not important at all.
2. It is quite important, but other issues should take priority.
3. It is very important and must be a high priority.

Appendix 3

The carbon footprint of mental health clinical activities determined using a process-based LCA method

The process-based LCA approach to estimating the carbon footprint involved the following steps: defining the boundary of the activity and identification of resources used through activity mapping, measurement of resources, and attribution of a carbon footprint to the resources used. In Chapter 5, the resources used in the various mental health clinical activities were identified and measured (including a standard face-to-face mental health assessment, an assessment at a patient's home, an individual psychotherapy assessment, a telephone assessment, an inpatient bed day, and a group psychotherapy service). In the below tables resources have been attributed a carbon footprint by using the most relevant available emission factor, and the estimated carbon footprints of clinical activities and their subsidiary component activities presented.

Most emission factors were obtained from DEFRA (DEFRA 2013). Activity data categories were grouped according to the emission factors available, such as 'small/medium car' as opposed to an individual car type, or an overall emission factor for medication based on cost, rather than an individual emission factor for each type of medication. Where DEFRA was not able to provide specific emission factors, others were sought from relevant academic papers to improve quality. For example, the standard carbon footprint for an average hospital meal was obtained from a study

(Vidal et al. 2015). For furniture, a carbon footprint study was used that provided benchmarking carbon footprints for furniture (FIRA 2011).

Table 43. Emission factors used for converting activity data

Emission factor	Unit and source
Medication emission factor	0.43 $kgCO_2e$/£ (DEFRA 2013)
Medical equipment emission factor	0.30 $kgCO_2e$/£ (DEFRA 2013)
Energy emission factor	0.5 $kgCO_2e$ / kWh (DEFRA 2013)
Bus conversion factor	0.1 $kgCO_2e$ / mile (DEFRA 2013)
Small-medium sized car emission factor	0.2 $kgCO_2e$ / mile (DEFRA 2013)
Office chair emission factor	72 $kgCO_2e$ (FIRA 2011)
Easy chair emission factor	36 $kgCO_2e$ (FIRA 2011)
Office desk emission factor	36 $kgCO_2e$ (FIRA 2011)
Filing cabinet emission factor	48 $kgCO_2e$ (FIRA 2011)
Bedside table emission factor	55 $kgCO_2e$ (FIRA 2011)
Cupboard emission factor	31 $kgCO_2e$ (FIRA 2011)
Dining table emission factor	25 $kgCO_2e$ (FIRA 2011)
Dining chair emission factor	36 $kgCO_2e$ (FIRA 2011)
Miscellaneous kitchen items emission factor	0.87 $kgCO_2e$ / £ (DEFRA 2013)
Flat screen TV emission factor	268 $kgCO_2e$ (WILLIS 2010)
Average meal on ward emission factor	2.9 $kgCO_2e$ (Vidal et al. 2015)
OTHER CONVERSION FACTORS OR ASSUMPTIONS MADE	
Type of car used by patients and staff	Small average car size
Carbon footprint per square metre of outpatient room	147kWh/m^2 annually (Connor 2010)
Staff time dedicated to group psychotherapy service and number of patients in service at any given time	Estimated by director of service
Travel survey at Oxford Health NHS Foundation Trust –Dec 2013	1.87 $kgCO_2e$ / appt

Table 44. Cost of medical equipment in a clinical examination room

Equipment in clinic room	Cost
Cost of blood pressure monitor:	£75
Cost of stethoscope:	£35
Patella hammer:	£6
Weighing scales:	£260
Thermometer:	£40
Pulse oximeter:	£45
Glucose testing machine:	£20
Urine testing;	£5
Sharps bin:	£3
Waste bin x 2	£120 x 2
Opthalmoscope:	£45
ECG machine	£650
Defibrillator:	£1200
Height measure	£120
Medical bed and stool	£450
Drug trolley	£15
Pharmacy cupbaords x 3	£90 x 3
Medical refrigerator	£390
Chair	£105
Total	£3974

Data obtained from medisupplies.co.uk

Table 45. Carbon footprint of a face-to-face assessment at a health care facility using a process-based LCA method

Activity	Resource	Carbon footprint per 45 minute assessment ($kgCO_2e$)	Percentage burden (%)
Travel to/from assessment and to workplace (for staff)	Fuel patient	1.87	10.0
	Fuel for staff to get to workplace	0.35	1.9
	Fuel HR and admin	0.12	0.6
	TOTAL	**2.34**	**12.5**
Non-clinical space used (including waiting room) and receptionist office and equipment	Furniture	0.005	0.0
	Energy	1.307	7.0
	Computer	0.003	0.0
	TOTAL	**1.312**	**7.0**
Assessment	Medication	10.000	53.6
	Energy	1.590	8.5
	Furniture	0.035	0.2
	Computer	0.052	0.3
	Medical equipment (in clinical room)	0.035	0.2
	TOTAL	**11.71**	**62.8**
Arranging assessment and writing notes following assessment	Energy	1.590	8.5
	Furniture	0.018	0.1
	Computer	0.052	0.3
	TOTAL	**1.660**	**8.9**
Admin and HR support Direct overheads=29% Indirect overheads =16 %	Energy	1.570	8.4
	Furniture	0.020	0.1
	Computer	0.038	0.2
	TOTAL	**1.628**	**8.7**
GRAND TOTAL		**18.655**	**100**

Table 46. Carbon footprint of a home visit using a process-based LCA method

Activity	Resource	Carbon footprint per 45 minute assessment ($kgCO_2e$)	Percentage burden (%)
Travel to/from assessment and to workplace (for staff)	Fuel for staff to pt's home	1.87	12.0
	Fuel for staff to get to workplace	0.35	2.2
	Fuel HR and admin	0.12	0.8
	TOTAL	**2.34**	**15.0**
Assessment	Medication	10	64.0
	TOTAL	**10**	**64.0**
Arranging assessment and writing notes following assessment	Energy	1.59	10.2
	Furniture	0.018	0.1
	Computer	0.052	0.3
	TOTAL	**1.66**	**10.6**
Admin and HR support Direct overheads=29% Indirect overheads =16 %	Energy	1.57	10.0
	Furniture	0.02	0.1
	Computer	0.038	0.2
	TOTAL	**1.628**	**10.4**
GRAND TOTAL		**15.628**	**100**

Table 47. Carbon footprint of a telephone assessment using a process-based LCA method

Activity	Resource	Carbon footprint per 45 minute assessment ($kgCO_2e$)	Percentage burden (%)
Travel	Fuel for staff to get to workplace	0.35	2.3
	Fuel HR and admin	0.12	0.8
	TOTAL	**0.47**	**3.1**
Assessment	Medication	10	64.8
	Energy	1.59	10.3
	Furniture	0.035	0.2
	Computer	0.052	0.3
	TOTAL	**11.71**	**75.6**
Arranging assessment and writing notes following assessment	Energy	1.590	10.3
	Furniture	0.018	0.1
	Computer	0.052	0.3
	TOTAL	**1.660**	**10.7**
Admin and HR support Direct overheads=29% Indirect overheads =16 %	Energy	1.57	10.2
	Furniture	0.02	0.1
	Computer	0.038	0.2
	TOTAL	**1.628**	**10.5**
GRAND TOTAL		**15.435**	**100**

Table 48. Carbon footprint of an individual psychotherapy assessment using a process-based LCA method

Activity	Resource	Carbon footprint per 45 minute assessment (kgCO_2e)	Percentage burden (%)
Travel to/from assessment and to workplace (for staff)	Fuel patient	1.87	21.9
	Fuel for staff to get to workplace	0.35	4.1
	Fuel HR and admin	0.12	1.4
	TOTAL	**2.34**	27.4
Non-clinical space used (including waiting room) and receptionist office and equipment	Furniture	0.005	0.1
	Energy	1.307	15.3
	Computer	0.003	0.0
	TOTAL	**1.315**	15.4
Assessment	Energy	1.59	18.6
	Furniture	0.008	0.1
	TOTAL	**1.598**	18.7
Arranging assessment and writing notes following assessment	Energy	1.59	18.6
	Furniture	0.018	0.2
	Computer	0.052	0.6
	TOTAL	**1.66**	19.4
Admin and HR support Direct overheads=29% Indirect overheads =16 %	Energy	1.57	18.4
	Furniture	0.02	0.2
	Computer	0.038	0.4
	TOTAL	**1.628**	19.1
GRAND TOTAL		**8.541**	**100**

Table 49. Carbon footprint of a bed day in a psychiatric unit using a process-based LCA method

Activity	Resource	Carbon footprint per bed day (kgCO_2e)	Percentage burden (%)
Travel to/from ward and to workplace (for staff)	Fuel patient	0.940	3.5
	Fuel for staff to get to workplace	0.550	2.1
	Fuel HR and admin	0.190	0.7
	TOTAL	**1.680**	**6.3**
Ward resources	Medication	5.800	21.7
	Energy	6.220	23.2
	Furniture	1.212	4.5
	Computer	0.534	2.0
	Medical equipment (in clinical room)	0.052	0.2
	Food	8.700	32.5
	TOTAL	**21.943**	**84.1**
Admin and HR support Direct overheads=29% Indirect overheads =16 %	Energy	2.177	8.1
	Furniture	0.223	0.8
	Computer	0.187	0.7
	TOTAL	**2.587**	**9.7**
GRAND TOTAL		**26.79**	**100**

Table 50. Carbon footprint of a therapeutic community service per patient per year using a process-based LCA method

Costs for one year of TC	Environmental cost ($kgCO_2e$)	Percentage burden (%)
Travel	386	60
Energy use	239	37
Procurement	14	2
Total	**639**	**100**

Appendix 4

Survey of communication methods made by mental health staff to patients for arranging appointments

1. Which team do you work in?
2. What method(s) do you use to offer an initial assessment appointment with a patient?
    a. Appointment letter
    b. Telephone call
    c. Text message reminder
    d. Email
3. If the patient misses their initial assessment appointment, what are your usual methods for offering them a second (or subsequent) assessment appointment?
    a. Appointment letter
    b. Telephone call
    c. Go to clients house (cold call)
    d. Text message
    e. Email
4. When you see a patient, what are your usual methods of arranging a follow up appointment?
    a. Arrange appointment whilst in the room
    b. Offer appointment card
    c. Telephone call

d. Appointment letter

e. Text message

f. Email

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