What's in a bin: A case study of dental clinical waste composition and potential greenhouse gas emission savings

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VERIFIABLE CPD PAPER

IN BRIEF

- Discusses climate change and its impact on health services resources.
- Suggests dental care is a heavy user of potentially vulnerable resources.
- Advises that identifying where and how to reduce resource use is essential.
- Highlights potential for cost saving in dental practice.

RESEARCH

Background Dental practices have a unique position as dental staff use a high number of dental materials and instruments on a daily basis. It is unclear how dentists' and dental care professionals' choices and behaviours around selecting and using materials impact on the amount of unnecessary waste production. Although there are a number of articles exploring the quality and quantity of waste in dental practices, there are no studies on organisational strategies to decrease unnecessary waste. There is no clear economic analysis of the impact on associated cost to dental practices which consequently can affect the access of dental care for disadvantaged groups. **Methods** This study used an audit approach to explore the potential for sustainability in dental practice by measuring the nature and quantity of dental clinical waste, and assessing the feasibility of measuring the financial costs and potential carbon savings in the management of dental clinical waste. **Conclusions** The data from our study would appear to support the view that it is possible to reduce carbon emissions and increase profitability. Successful implementation of an environmentally sustainable approach to waste management will be dependent on the practicalities involved and the financial incentives for adopting such practices.

INTRODUCTION

The impact of high levels of carbon on the environment has been well documented.[1,2] Healthcare services are responsible for a significant percentage of these emissions[3] and need to review where services and activities can make reductions. Due to relatively large carbon dioxide (CO_2) emissions, the use of toxic materials and the production of vast amounts of waste, healthcare is compromising public health and damaging the ability of future generations to meet their needs.[4] In the EU, the health sector creates at least 5% of total CO_2 emissions.[5] Furthermore, improving energy and resource efficiency, and the development of sustainable procurement policies and waste management are vital for the health sector.[3] Although a small number of studies of waste management have been conducted in health and social care waste management,[6-10] studies on waste management in dentistry are limited.

Of equal concern is the variety of materials used in healthcare and dentistry, (for example, plastics, cotton and rare metals) that are subject to the influences of climate change and geopolitical unrest.[11-13] Since 2009 a number of guidance documents have been developed which enable health service providers to begin to embed sustainability principles into policy and practice.[2,14] The NHS has begun to reduce carbon output while at the same time managing to increase productivity.[15] There is still a long way to go to embed sustainability across all departments and to ensure that items used in healthcare come from sustainable sources. Items should be purchased with reuse in mind, and, methods of disposal chosen with environmental protection as a core purpose. As the climate changes and affects accessibility to some raw materials, prices of these raw materials will rise and choices will need to be made about what is essential and whether or not alternatives can be found. Furthermore, to reduce the impact of carbon produced from long supply chains, the manufacture and disposal of items used in healthcare will need to be closer to the end user.

RATIONALE

Although there are a number of articles exploring the quality and quantity of waste in dental practices, there are no studies on organisational, educational or behavioural strategies to decrease unnecessary waste.[16] Dental practices have a unique position as staff use a high number of dental materials and instruments on a daily basis (unlike medical practices). It is unclear how dentists' and dental care professionals' choices and behaviours around selecting and using materials impact on the amount of unnecessary waste production. Much of the current environmental discussion in dentistry is focused around the use and disposal of dental amalgam, and several European countries have banned its use due to the negative environmental impact. This may be a highly relevant issue, but it would appear to have deflected the focus from other environmental considerations including the impact of clinical waste management in dental practices.

Farmer *et al.*[17] undertook a waste audit of dental practices in Australia and reported that

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materials used to support infection control constituted up to 91% of total waste produced. Although individual dentists generate a relatively small amount of environmentally unfriendly wastes, the accumulated waste produced by the profession may have a significant environmental impact. Dental waste not only has negative effects on the environment, but the cost of its removal falls heavily on dental practice budgets. In 2009 new infection control guidance was introduced within England and Wales (Scottish guidance contains variations) under the Health Technical Memorandum HTM01-05.[18] This was subsequently revised in 2013. This has impacted significantly on dental practices and is considered to have had a deleterious effect on environmental sustainability in dentistry.

This study seeks to investigate clinical waste production in a single dental practice as a case study, building on the evidence gap by using methods previously developed through healthcare waste and procurement studies[9,10,12,19] and the rapid evidence review undertaken by Nasser.[16]

AIM

This study aims to measure the nature and quantity of clinical dental waste, and assess the feasibility of measuring the potential financial and carbon savings of appropriate segregation and recycling.

OBJECTIVES

1. To measure the nature and quantity of clinical dental waste
2. To assess the feasibility of measuring the financial cost of dental clinical waste
3. To measure the extent to which waste is incorrectly segregated in order to estimate the potential greenhouse gas (GHG) savings that might be achieved through better waste management.

METHODS

Rationale for data collection process:

Evidence suggests that inappropriate healthcare waste segregation can lead to non-clinical waste being disposed of in the clinical waste stream.[17] The consequence of this is the unnecessary incineration of non-clinical waste at high financial cost and excessive GHG emissions. In order to examine the extent of non-clinical waste being allocated to the clinical waste stream an audit approach was designed to weigh and categorise the clinical waste of one dental practice. The audit approach used in this study has been tested in recent research by the Sustainability Society and Health Research Group (SSHRG) at Plymouth University in a study of waste management in health and social care in Cornwall.[10,19]

Sample

The site for the study was a mixed NHS/private dental practice in North Devon. The clinical waste generated during treatment sessions over a specified period in this practice was audited by the research team.

Data collection

Clinical waste at the study practice is collected weekly by a waste management company and collection is always scheduled for a Friday. A decision was made to carry out the waste audit on two separate occasions: Thursday, 28 August 2014 (session 1) and Wednesday, 10 September (session 2). This would ensure that a sufficiently large amount of waste was available from which to select a sample. In addition to examining the contents of the waste bags from the two data collection sessions, the total clinical waste for session 2 was weighed to provide an estimate of the mass of waste produced. Since the waste that was weighed on session 2 had accumulated over a four day period, its mass was inflated by a factor of 25% in the analyses in order to estimate the amount of waste produced in a working week (five days). Waste was recorded and classified according to the type of material and the frequency with which it was found. A range of the most common items used in each treatment session was photographed. Each item was identified, weighed, and the amount of waste recorded (frequency and mass).

Minimising the risk of bias

The clinical waste audit was conducted on days of the week shortly before collection was due, and on two occasions separated by a five week interval. This allowed for some variation in clinicians and in working practices and treatments. Ultimately, the focus of the study is the use and disposal of dental consumables and not an examination of treatment so the potential for bias is reduced. All data entry has been quality assured by: (i) a sample of quantitative data entry that was audited by a member of the audit team not involved in entry; (ii) an audit trail that has been kept for all aspects of the project.

Ethical approval safety and study conduct in relation to normal working of the practice

Activities took place using the code of practice for research developed through Plymouth University's Faculty of Health and Human Sciences Research Ethics Committee. All data collected were anonymised to protect the participants and maintain confidentiality. Patients were aware of a researcher in the building. The practice used an electronic notice board and information about the study was made available as part of the daily notices. A reflective log noting any issues that impact on study design or practical issues of data collection was maintained throughout the study period. This was used to make any necessary revisions to inform a possible larger study involving diverse dental practices. Relevant and appropriate protective clothing and face shields were used during the data collection process.

Table 1 The independent variables:

Clinical waste items	Variable
Sterile wrapping	Recyclable waste variable (IV1):
	Within each dental clinical waste bag
	(Percentage of [mass of recyclable clinical waste items per / total mass per bag])
Tissues, gloves, bibs, 3 in 1 tips, other clinical items	Non-recyclable waste variable (IV2):
	Within each dental clinical waste bag
	(Percentage of [mass of non-recyclable waste items per bag / total mass per bag])

Table 2 Waste composition minimum, maximum, sum, mean and standard deviation (N = 10 bags of clinical waste)

	Minimum	Maximum	Sum (10 bags)	Median	Mean	SD
Unique items	6	28	206	25	20.6	7.95
Item frequency	44	286	1,841	174.5	184.1	78.11
Materials	4	10	67	7	6.7	1.7
Mass (g)	150	1,270	6,720	6,118	672.4	322.6

Data analysis

Descriptive statistics describing the composition of the clinical waste at the participating dental practice were obtained from the raw data using the statistics package SPSS version 21. Further analyses were undertaken to explore whether simple linear relationships exist between the possible recyclable waste (sterile wrapping packaging) and the total mass of waste within each dental clinical waste bag. In order to undertake this linear regression analysis, the data for each clinical waste bag were uploaded onto Microsoft Excel. The clinical wastes of these bags were divided into two groups namely recyclable waste, (sterile wrapping packaging) and the non-recyclable waste, (all other clinical waste items). These data formed the independent variables respectively of the simple regression analysis as reflected in Table 1. The 'Y' variable of the simple linear regression analysis were the natural logarithm of the total mass of each dental clinical waste bag recorded during the dental waste audit by this research study and of each simulated clinical waste bag. The identified coefficients associated with the recyclable and non-recyclable waste within the dental clinical waste bags indicate whether there are any minimum immediate potential financial cost savings (recyclable waste) that can be made on dental clinical waste disposal.

RESULTS

The summary composition of waste bags from the clinical waste stream at the participating dental practice is described in Table 2.

Waste bags contained a median of 25 different types of item and a median of 174.50 items in total. Items were composed of seven different materials and each bag had a mean weight mass of 0.6724 g.

The most frequently disposed of items during clinic sessions can be seen in Figure 1. Tissues were the most frequently found item in the clinical waste. Gloves were the second most frequently disposed of item during dental clinic sessions; the different colours of gloves reflect size and were analysed separately due to their different weights. The sterile wrapping, in which re-usable dental instruments were brought to the treatment rooms post sterilisation and before use, were the third most frequently disposed of item type.

Figure 2 shows that paper comprised the most frequent material proportion of waste from the dental clinic sessions. The material nitrile, from which the gloves are made, was the second most frequently disposed of material. Plastic was the third most frequently disposed of material. The sterile wrapping, which was the third most commonly disposed of item, was comprised of separable paper and plastic material components. Separable paper and plastic was the fourth most frequently disposed of material type.

The total mass of items disposed of during the dental clinic sessions sampled can be seen in Figure 3. Almost 3,000 g of the total 6,720 g waste audited was tissues, and almost 1,800 g of waste was comprised of nitrile gloves (blue and pink). Overall the third heaviest material type was the sterile wrapping.

Figure 4 shows that paper constituted over 3,000 g of the total audited waste and Nitrile waste had the second highest overall mass (1,800 g). Mixed materials, plastic and separable paper and plastic material types all had similar overall masses of just over 500 g each.

The findings of the waste audit showed that the most common items in dental waste by frequency were also the most frequent items by mass. The material type frequency and mass findings were similarly consistent. The item type and material type findings were also fairly consistent with each other. Paper tissues and nitrile gloves were the two most commonly disposed of item and material types during dental clinic sessions.

Sterile wrapping was the third most frequently disposed of waste item. Although by weight sterile wrapping only contributed less than one third of the mass that nitrile gloves did, it is a highly recyclable piece of waste. More effective separation of sterile wrapping (for recycling) before it comes into contact with any form of contamination could potentially reduce waste amounts by up to 5 kg per week at this practice.

Table 3 shows that at 99% significant level, the weights of the recyclable waste (weight of sterile wrapping) have a negative linear relationship to the total mass of the clinical waste bags. The negative linear relationship is due to the fluctuations that exist in the weights of sterile wrapping within the clinical waste bags. The sterile wrapping fluctuates between 5% and 10% per waste bag, depending on the quantity of sterile wrapping disposed of by the dental practice during the given time period. The masses of the recyclable clinical waste (for example, mass of sterile wrapping), indicate where potential immediate minimum

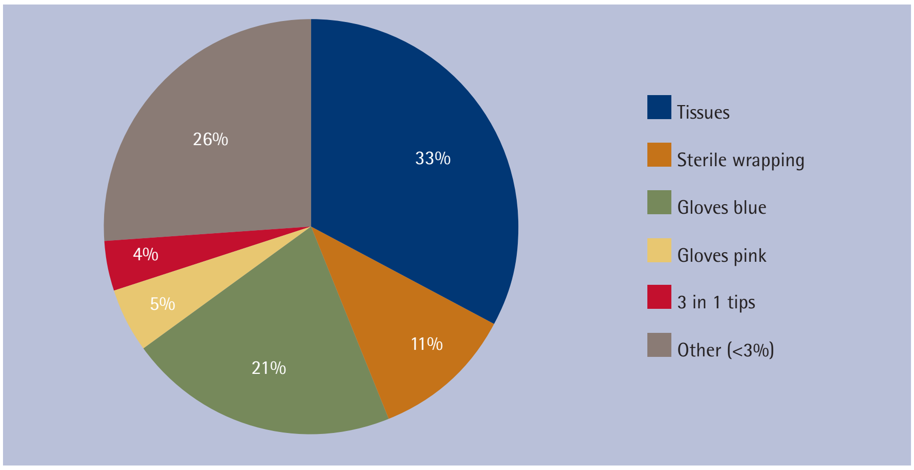

Fig. 1 Item type frequency occurrence in dental waste audit (%)

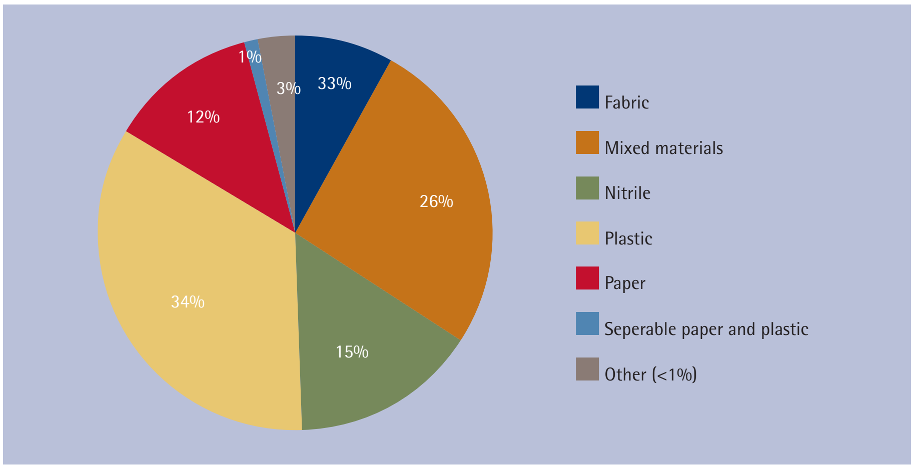

Fig. 2 Material frequency occurrence in dental waste audit (%)

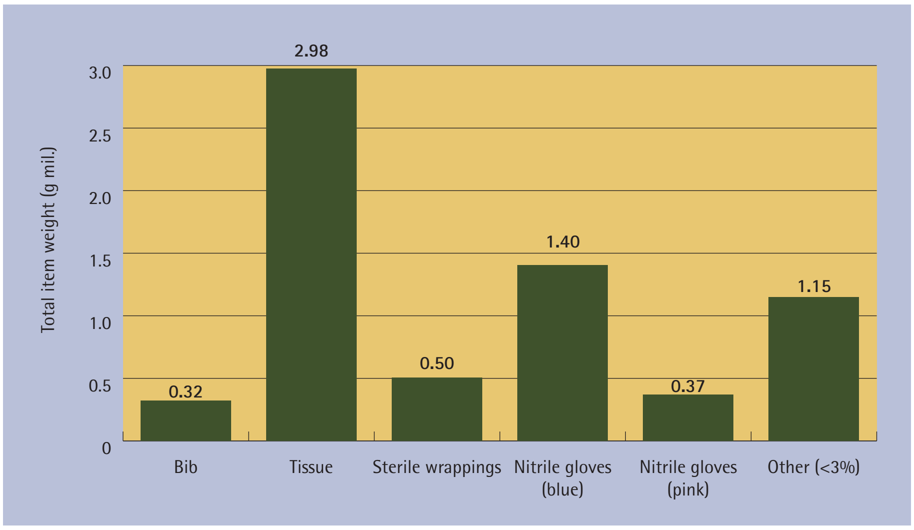

Fig. 3 Total mass for item types (grams)

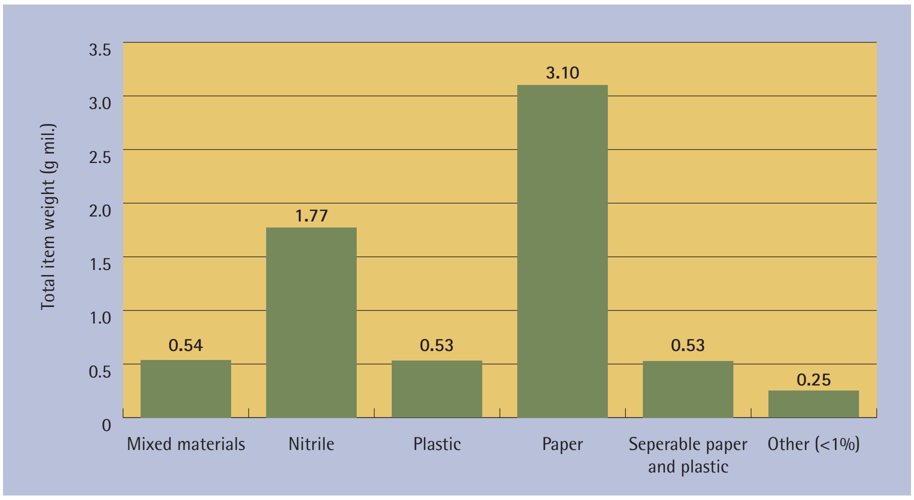

Fig. 4 Total mass for material types (grams)

Table 3 The possible coefficients associated with recyclable and non-recyclable waste within clinical waste bags

Model	Constant	Recyclable waste	Non-recyclable waste	ADJ R^2
Simple linear regression model: 1	1.209***	-0.012***	0.684	1,082.53
Simple linear regression model: 2	1.058*	0.013***	0.706	1,197.4

Note: The table reports the possible coefficients associated with recyclable and non-recyclable waste within clinical waste bags. In the simple linear regression model 1 and model 2, the natural logarithm of the total weight of each simulated clinical waste bag has been used as the dependent variable. Additionally, in model 1: for each simulated clinical waste bag, the mass of recyclable waste items over the total mass of each bag expressed as a percentage forms the independent variable, and in model 2, for each simulated clinical waste bag, the mass of non-recyclable waste items over the total mass of each bag expressed as a percentage forms the independent variable. Additionally, ADJ R^2 reports the Adjusted R^2, F-STAT is the F-statistic. ***, ** and * denotes statistical significance at the 99%, 95% and 90% levels respectively.

financial cost savings can be realised by the dental practice when, for example, sterile wrappings are not included within the dental clinical waste bags.

At 99% significance level, the mass of the non-recyclable waste (mass of all other clinical waste items excluding sterile wrapping) have a positive linear relationship to the total mass of the clinical waste bags. This shows that an increase in the total mass of dental clinical waste will result in an increase in the weight of non-recyclable waste. In order to explore the potential GHG savings we conducted further analysis of the data related to sterile wrapping. GHG conversion factors for waste disposal were obtained from the 2011 Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting (Table 9d).[14] The GHG for incineration of clinical waste was taken as 1,833 kg CO_2e emitted per tonne of waste. This is a lifecycle conversion factor accounting for the entire product cycle from material extraction to final disposal. Defra emissions factors for incineration do not specifically account for clinical waste, which is commonly undertaken at higher temperatures. To reflect the increased emissions that are likely to result from the incineration of clinical waste, the highest available emissions factor for incineration was applied. In this audit we have about 5 kg per week of sterile wrapping = 0.005 tonnes, resulting in the following calculations:

- GHG emissions from using and disposing of sterile wrapping as clinical waste per week: 0.005 tonnes × 1,833 kg CO_2e per tonne = 9.165kg CO_2e.
- GHG emissions from using and disposing of sterile wrapping as clinical waste per year: 9.165 kg CO_2e per week × 52 weeks = 476.58 kg CO_2e.
- GHG emissions for using and disposing of sterile wrapping as recycled waste per week: 0.005 × -302 kg CO_2 per tonnes = -1.51 kg CO_2e per week.
- GHG emissions from using and disposing of sterile wrapping as recycled waste per year: -1.51 kg CO_2e per week × 52 = -78.52 kg CO_2e per year.
- GHG savings per year are: 476.58 kg CO_2e – (-78.52 kg CO_2e) = 555.1 kg CO_2e.
- GHG savings per year: 0.5551 tonne CO_2e savings per year.

These calculations are based on the waste in the dental practice we audited and the fact that this waste stream is always sent for incineration.

DISCUSSION

The three R's (reduce, reuse, recycle) are commonly referred to in managing environmental sustainability. This tends to be given fairly low priority within NHS dental practices, where the focus is predominantly on patient safety, NHS targets and financial stability. Environmental sustainability in dentistry is challenging, and certainly became all the more so following the introduction of revised infection control guidelines in 2009 (HTM01-05).[18] The guidelines encourage single use instruments, materials and consumables and reuse is discouraged wherever possible. Sterile wrapping and storage of instruments is advocated, which has had an impact on the amount of plastic and paper disposed of through the increased use of sterilisation bags.

It is difficult to argue against implementation of best practice infection control guidelines if this results in improved patient care. However, the increased use of plastic and paper wrapping is considerable and this has led to increased production of waste and cost. The practice in which this study was conducted incurred a 58% increase in waste management costs over a four-year period following the introduction of HTM01-05.[18] Reuse of materials and instruments may have limited potential in view of safety concerns, and the focus must therefore be on reduce and recycle.

Holland identified waste management as an aspect of dental practice for which it would be worth developing practice-based eco guidelines in an attempt to 'save money and minimise impact on the environment.'[20] In discussions with waste management organisations she acknowledged that 'poor waste segregation was an issue'. This has also been recognised in the NHS and long-term care sites studied by Manzi *et al.*[19] However, in this feasibility study, although some items were wrongly segregated, the majority of waste contained tissues, sterile packaging and gloves used in treatment, and was appropriately disposed of. We therefore concluded that those items appropriately discarded need to be reduced to enable both financial and environmental savings.

The British Medical Association (BMA) has also begun to raise awareness about climate change and the need to manage resources more efficiently. In the report 'Doctors taking action on climate change,'[21] the BMA looked to its own premises and identified areas where it can reduce carbon emissions, serving as an example to doctors to enable changes in practice, for example, in terms of the amount of waste produced.

The collection of data from a greater range of dental practices and over a greater period of time would provide a more representative data set. Using detailed data about the waste composition it would also be possible to provide more accurate estimations of dental waste production across the country and estimate cost and carbon footprint figures for any size and type of dental practice. This information could then be used to inform strategic planning for the reduction of the cost and the carbon footprint associated with dental activities and monitor changes over time.

Healthcare is under increasing pressure in terms of demands on services and the spiralling cost of providing care to an ageing population. The need to maximise efficiency has been a key feature of recent healthcare reforms with £20 billion worth of efficiency savings targeted over the last four years in the NHS. Dentistry has not been immune to these efficiency savings and has been tasked with reducing costs by 4% year on year.

A recent report by the Academy of Royal Medical Colleges[22] recognised the need for clinicians to be 'innovative in order to tackle the huge financial challenges we are facing.' The report identified a range of behaviours to achieve this, among which were highlighted the need for a 'change in culture – where doctors resolve to eradicate waste.'

To our knowledge, GHG and efficiency savings through waste reduction has not been explored within NHS dentistry. The recycling of wrapping used on sterile equipment would probably be the easiest change to implement which could result in considerable waste savings. Based on our results, the financial efficiency savings would be relatively modest due to the significant charges for removal of domestic waste and the practical difficulties in recycling commercial paper and plastic. It is questionable whether small projected savings for a six surgery practice would be sufficient incentive to influence change. This does not take into consideration a potential reduction in glove and tissue use which would also result in considerable waste reductions and equivalent cost savings. Our GHG savings are tentative, and this approach needs further development with larger data sets in order to determine suitable strategies to achieve both reduction of the GHG contribution of dental practices and make financial savings without compromising practices and care.

CONCLUSIONS

In a recent article for the *British Dental Journal*[20] Caroline Holland asks 'can a dental practice go green and increase profits?' She concludes that it is 'possible to operate an eco-friendly practice and make a difference to the bottom line.'

Holland's opinion, and the system changes recommended by the BMA and the ARMC are recent, but mark a change in attitude towards sustainable practice in clinical care.

There are significant benefits in reducing waste production within the NHS, both in terms of cost and the impact on the environment. The data from our study would appear to support the view that it is possible to reduce carbon emissions and increase profitability, although this is likely to require a degree of reorganisation within the practice. Successful implementation of an environmentally sustainable approach to waste management will be dependent on the practicalities involved and the financial incentives for adopting such practices. It is therefore unlikely that significant change will be affected without the influence of government.

STUDY LIMITATIONS

This feasibility study was carried out in one dental practice so the data must be treated with caution and should not be generalised. However, the study achieved its aim of providing valuable data for a larger study to further explore the findings. The waste audit only included 9% of the clinical waste in a specific time-frame and didn't include domestic waste or observations of practice.

Benefits to NHS dentistry:

- Reduction of NHS carbon emissions through reduce, re-use and recycle approaches.
- Income generation from viewing waste as resource/recycling.
- Reduced waste management costs.
- More data is required, but this approach has the potential to inform strategic planning in dentistry.

Benefits to patients

- Potential efficiency savings within NHS dentistry.
- Supports greater choice for patients who are concerned about sustainability and the impact of healthcare on the environment.
- Limiting the environmental burden of dentistry will have a positive impact on patients' general health and wellbeing (for example, reduced respiratory disease, allergies etc).

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