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Abstract

Oral healthcare has an environmental impact that is specific to the profession and is currently unsustainable. This impact results in unwanted and difficult to manage waste, carbon emissions and other environmental impacts that contribute to climate change. Contributions to this pollution come from the supply chain that provides the required materials and sundries, patient and staff commuting/ travelling, direct patient care, the use and end-of-life management of restorative materials and single use plastics (SUPs) such as personal protective equipment (PPE). This paper explores these various contributors to pollution arising from oral healthcare.

Clinical Relevance

The provision of oral healthcare has an environmental impact that requires consideration and action in order to become sustainable.

Objectives

Oral healthcare providers should understand the various ways that our professional activities impact the environment. Meaningful solutions stem from appropriate behaviour and attitude changes that deliver sustainable practice at the workplace.

Introduction

Oral health professionals are increasingly recognising the need to provide care in a manner that is sustainable, by minimising the impact on natural resources and at the same time promoting and delivering optimal oral health in a safe manner.[1,2] Health is intrinsically linked to the environment and therefore to adhere to the Hippocratic oath of 'first, doing no harm', healthcare has an inherent responsibility to prevent negative environmental impacts. An environmental impact is defined as "any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's activities, products, or services".[3] Pollution is the introduction of contaminants into the environment with a resultant negative change and can broadly encompass everything from air pollution, to carbon emissions to disposal of single use plastics (SUPs). Consideration of the environmental impact of dentistry is intertwined with the concept of sustainability, which is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs".[4] Application of this concept to the dental industry, can be simply transcribed as ensuring that the dental care we provide patients today, does not negatively impact future patients. A major recent challenge to sustainability within dentistry is the current COVID-19 pandemic, which has had the unintended but hugely concerning consequence of generating enormous volumes of SUP waste.[5] We should also be mindful of our personal and team behaviours and attitudes to environmental sustainability both as private citizens and in the workplace; as there needs to be a 'will' for there to be a 'way' to deliver change.

Environmental impacts from dental healthcare provision occur in a number of ways and are highlighted in an example scenario of a routine dental restoration appointment. Consider the need for patient and staff travel to/from the dental practice and the generation of carbon emissions from these journeys.[6] This is compounded with the energy and materials used in the manufacture, distribution and supply of the materials along the supply chain (Fig. 1).[7] The resulting waste that has been generated along the supply chain and in the dental surgery needs to be considered in the context of the provision of environmentally sustainable oral healthcare. This routine dental procedure scenario has a clear environmental impact through pollution, direct and indirect carbon emissions, and other environmental impacts such as eco-toxicity, ozone depletion and acidification.

Through this two-part article series, we aim to provide a broad overview of sustainability in oral health care with a focus on the challenges, the need to develop a foundation of scientific knowledge and some mitigating approaches. This first article highlights the principal environmental challenges associated with the provision of sustainable oral healthcare.

Environmental Citizenship and the Dental Team

It is indisputable that as oral healthcare providers, our primary focus is that of meeting the oral healthcare needs of the population we serve. The catch seems to be that as individuals, we show a tendency to separate our societal responsibilities of environmental citizenship from our professional (work related) duties.[8] The latter is mostly focused on the need to deliver an outcome in a cost-effective manner, with environmental citizenship concerns becoming very secondary or redundant. The driver for extending our environmental citizenship, from an individual societal role (e.g. at home, neighbourhood), to our work environment (e.g. dental practice) appears to be associated with the need to make a conscious and deliberate transition from a *behaviour* approach that is dictated by the circumstances in which we find ourselves (e.g. work place, travel, holiday…) to a stronger *attitudinal* approach that will have a stronger, more pervasive and more persistent effect.[9] The first step to environmental sustainability in the work place is to break down mindsets that distinguish between environmentally sustainable actions in the domestic setting from the actions in the dental practice – put simply, do at work as you would at home. Having translated our environmental attitudes, we can then shift our attention to dealing with the practical implementation of our sustainable actions in the work setting. This is more poignant when we acknowledge that our actions at a local level, whether in our homes or in a dental surgery, directly impacts planetary health, which is being degraded to an extent unprecedented in human history. Four out of nine planetary boundaries (safe operating limits of planetary health) have now been crossed, including climate change, loss of biosphere integrity, land-system change and altered biogeochemical cycles (phosphorus and nitrogen).[10] The concept of planetary health is based on the tenet that human health and civilisation depend on flourishing natural systems and the wise stewardship of those natural systems.[11] Planetary health studies attempt to understand the links between global environmental changes, their effects on natural systems and how these changes impact human health on a local, regional and global level.[12] The dental team has a responsibility to ensure that the way patients are cared for and the materials used, do not contribute to the disruption of natural systems and further damaging planetary health.

The Environmental Impact of Oral Healthcare Provision

All activities have a carbon footprint and lead to other environmental impacts, including the provision of oral health. Under the terms of the 2008 Climate Change Act, the UK and by extension the NHS, is committed to reducing greenhouse gas emissions to 'net-zero' by 2040.[13,14] Carbon footprints are used to calculate the total amount of greenhouse gas emissions related to a product or service and are calculated by the summation of all of the emissions at every stage within life cycle. Greenhouse gases include CO_2, methane, nitrous oxides, each having a negative environmental impact by trapping heat into the Earth's atmosphere. The Global Warming Potential (GWP), the amount of warming a gas causes over a given period of time, of each greenhouse gas can be calculated according to the unit of carbon dioxide equivalent (CO_2-eq), thereby allowing different carbon footprints to be compared.[15,16] Similarly, Life Cycle Assessment (LCA), can be used to calculate the environmental impacts of a product or service including manufacturing, procurement, travel or commuting and disposal of waste.[17,18] These environmental impacts measured include GWP (embodied carbon), embodied energy, acidification potential, eutrophication potential, toxicity, and ozone depletion.[19,20]

In the UK, the Health and Social Care (HSC) carbon footprint in 2017 was 27.1 Mega tonnes (Mt) carbon dioxide equivalent (CO_2-eq), representing around 6.3% of the carbon footprint of England.[21] Public Health England published a report in 2018 identifying that over 60% of the carbon footprint of NHS dentistry is caused by the travelling requirements of patients and staff (Fig. 2). [22] The same report highlights that the total greenhouse gas emissions of NHS dental services in England makes up 3% of NHS emissions. This is not solely a UK issue; in 2014 the healthcare systems of the world generated 1.6 giga tonnes (Gt) of CO_2-eq or 4.4% of the global total.[15] The Public Health England report (2018) report considers the carbon footprint for a wide range of dental interventions in two ways: Per item of procedure or as a total volume of activity.[22] For example, if we consider the carbon footprint for individual procedures, it is evident that intra-coronal restorations (amalgam or resin-based composite) have a relatively high footprint (16 kg CO_2-eq) compared to either a dental examination or a scale and polish procedure (6 kg CO_2-eq). If we now consider the volume of activity carried out in England, amalgam and resin-based composites (combined volume) account for approximately 11% of the total activity compared to a combined volume of 58% for dental examination and scale and polish procedures; making these the most carbon intensive dental procedures. Directly placed dental restorations are common energy intensive procedures. However, examinations and hygiene visits are more frequently performed and therefore result in comparatively higher emissions of CO_2-eq. It should be noted that the use of dental materials has other environmental impacts that examinations and hygiene visits do not (discussed in a subsequent section). The wider environmental impacts of restorative dental materials will be provided through the delivery of a robust, industry-informed LCA to be published by the authors in the near future.

Carbon Emissions and the COVID-19 Pandemic

The national lockdown enacted by the UK Government in response to the COVID-19 pandemic, from March to late June of 2020, affected dental care provision profoundly. A consequence of this was a notable reduction of waste and greenhouse gas emissions. This was brought about by a reduction in travel, slowing down of the supply chains, reduction in directly generated waste and fewer materials used to treat patients; cumulatively making a very positive contribution to the overall reduction in greenhouse gas emissions world-wide [23]. It is noteworthy that vehicular road transport is responsible for 28% of nitrous oxide and 6% of volatile organic compounds pollution which has significant impacts on respiratory health [24]. This reduction in travel had a significant contribution to a net positive impact of UK dentistry on the environment during the four-month lockdown of the COVID-19 pandemic, this impact however was transitory.

Following the relaxation of the national lockdown, dental care services were able to recommence activities, albeit in a very constrained environment and subject to very stringent health and safety regulations. These regulations required a significantly greater use of personal protective equipment (PPE) such as plastic aprons, masks, visors and gowns. A further strategy that aimed to reduce the risks associated with in-person appointments throughout the COVID-19 pandemic focused on the use and wider adoption of teledentistry for the provision of advice and remote clinical consultations (RCCs). This is explored in greater detail in part two of this article.

The Environmental Impact of Dental Restorative Materials

In dentistry, the subspecialty of restorative dentistry is by far the greatest user of materials for the provision of dental care (Table 1). As per the dental appointment scenario, the environmental impact of the diverse supply chains that converge on the dental practice should be considered and not underestimated (Fig. 1). The head of the supply chain is the sourcing of raw materials and mineral extraction[25], and then in a sequential manner the preparation and synthesis of constituents, the manufacturing and blending of the materials, associated packaging (primary, secondary and tertiary; according to the proximity to the materials and their purpose), distribution with associated repackaging and eventually concluding with end-user procurement prior to clinical use. From here follows the unavoidable management of all the waste generated along this journey, that includes materials used, additional disposable sundry and support items, such as impression trays, composite delivery guns, aspirator tips, barrier films and sleeves and all forms of packaging (including the delivery containers; e.g. composite compules). All of this currently ends as landfill or incineration with some energy recovery as best-case scenario.[26] Waste management should also consider the direct impact of the actual restoration on the environment at one of the following points: (i) As macro- to nano-scale particulate waste, during placement, finishing and polishing or removal; (ii) immediately after the procedure (as eluted monomers or mercury excreted by the patient) and (iii) at end of life, following interment or cremation.

Thus, it is clear that in the product journey, from mineral extraction to clinical usage, all materials used in dentistry have an environmental impact and there needs to be a careful balance between the desired healthcare outcomes and the management of associated environmental impacts. This balance is illustrated through the case study of direct placement dental restorative materials, that are used routinely for the restoration of form and function of teeth. Of these, the most commonly used are dental amalgam and resin-based composite (RBC) (Fig. 3).

Previously, concerns regarding the negative environmental impacts of dental materials have focused solely on dental amalgam usage due to its high (50% by weight) mercury content. There is no evidence that serious health issues are directly caused by dental amalgam[27,28,29], however national and international concern regarding the environmental impact of this material have raised concerns regarding its use. This culminated in the Minamata Convention in 2013, its ratification in 2017 and subsequent implementation of its treaty in 2018. [30] This treaty seeks to provide controls and reductions across a range of products, processes and industries where mercury is used, released or emitted.

The release of dental amalgam into the environment occurs through established release pathways, these include via wastewater discharge from dental practices and emissions into the soil, watercourse and atmosphere, and from the interment or cremation of cadavers with amalgam fillings. [31] There is an expectation that amalgam use will be phased down until it is ultimately phased out, with an anticipated increased use of the most suitable alternative direct dental material, resin-based composite (RBC). Accordingly, this has raised the question regarding the environmental credentials of RBC. In a similar way to amalgam, RBC has components that are potential environmental pollutants in the form of eluted monomers (including bisphenol-A derived from constituent Bis-GMA in the resin matrix) and microparticulate waste that are released into the environment in similar ways to dental amalgam (Fig. 3). Alternative monomers and technologies could improve negative environmental impacts such as the use of UDMA rather than Bis-GMA for example. Potential release pathways of RBC particulates and monomers into the environment have been shown to include:

- Manufacturing waste products disposed into landfill sites
- Unused waste material disposed into landfill sites
- Human waste after treatment with RBCs into wastewater and sewage
- Particulate waste from CAD/CAM milling of polymerised composite blocks discharged into wastewater and sewage
- Breakdown products following the cremation or interment of a cadaver containing dental RBC restorations, which are released into the air and ground water respectively
- Particulate waste (akin to microplastics) into water effluent from dental surgery suction systems when RBC restorations are removed, prepared, finished or polished.[32]

Based on the worldwide number of applications of direct placement restorations, RBCs are expected to become one of the largest dental contributors to environmental pollution. The latest calculation undertaken in 2012, estimated that over 500 million resin based composite restorations were placed globally, this estimate is now likely to have increased due to an increase in overall applications in the last decade [33]. Other direct-placement materials such as glass ionomers should also be considered when trying to understand the impact of dental materials. Unmodified glass ionomer materials do not contain monomers, but like any other material, they will have an environmental impact associated with the extraction of glass, the synthesis of chemicals, manufacturing, distribution and procurement.

It is pertinent to remember that whilst the use of dental materials *per se* has obvious environmental impacts, the associated primary, secondary and tertiary packaging used to contain (e.g. composite compule, adhesive blister/bottle), deliver (e.g. box with plastic separator trays) and safely transport these materials (e.g. outer wrapping, further boxing and film wrapping) is a further contribution to the plastic pollution burden. In this respect, dentistry is a considerable net contributor to the world burden of discarded plastic packaging. The net pollution effect from different packaging systems (e.g. composite syringe vs compules) is unknown and would be the focus of further Life-Cycle Analysis studies. In this context, sustainability considerations would include the volume of material used, the range of shades required, product expiration dates and relative efficacy of product packaging/delivery to avoid unnecessary waste.

Single Use Plastics

Plastic, and in particular single use plastic (SUP), forms an essential and indispensable part of current healthcare provision at all levels and in all clinical environments. Plastic provides a very safe and cost-effective alternative and can be combined with other materials to create complex bespoke devices or medicinal delivery vehicles. In doing so, SUPs provide the required clinical and public confidence of using a new clean and/or sterile device every time with no risk of contagion. Thus, SUPs fulfil all the major requirements of a risk-averse industry that operates within very tight budgetary constraints and tight regulatory frameworks, with HTM01-05 being pertinent to dentistry.[34,35] The inherent versatility, safety and low cost of SUPs is also its Achilles' heel as it is a major contributor to a highly wasteful *linear economy* resulting from their end-of-life fate, as exemplified in the montage of clinical SUPs depicted in figure 4.

In healthcare, most SUPs are classified as clinical waste and as such are disposed through landfill and incineration, with limited energy recovery (Fig.1). It is estimated that total plastic waste generation in the UK will increase to around 6.3 million tonnes by 2030. The service sector, which includes healthcare, is the largest contributor to plastic waste producing over half (53%) of all plastic waste.[36] To put this into perspective, the healthcare sector in the UK generates over 590,000 tonnes of waste annually, more than the entire municipal waste output of Luxembourg.[37]

The media, in its various formats, highlights the potential devastating impact of SUPs on the environment, mobilising public opinion at different levels. A YouGov poll commissioned by the NGO Oceana published in 2019, highlighted that 74% of the public felt that the Government needed to do more to tackle SUPs and over half wanted to see SUPs banned, due to their negative environmental impacts.[38] When questioned who should take the lead role in reducing SUP pollution, 26% of the participants of the survey felt that it should be citizens, 30% thought it should be politicians and 37% felt businesses should shoulder the responsibility. This highlights that while the general public feel they should play a role in managing SUPs, most feel it is the responsibility of government and the industries that use them. This in turn highlights the differentiation between *behaviour* and *attitudes changes*, the latter needed to drive change, but more difficult to reconcile at a personal citizen level.

Within dentistry, dental material use generates SUPs in the form of PPE (Personal Protective Equipment, such as gloves, bibs, aprons and masks), sundry clinical items (aspirator tips, tray liners, cups for rinsing and handle covers) and also in the form of material packaging as detailed previously. Disposal of this waste plastic is expensive, costing the NHS in excess of £33 million.[39]

A recent study by the authors identified that prior to COVID-19, an average of twenty (n=20) SUP items were utilised for the provision of a routine adult primary care dental operative intervention (Restoration, prosthodontic intervention, RCT, periodontal care.[34] This calculation excluded PPE that would add a further eleven items per procedure (Table 2). In the UK, based on the number of dentists and dental therapists registered with the General Dental Council in 2019 (n≈45,000)[40]; it is possible to extrapolate the number of SUPs used as a function of the approximate number of clinical operative interventions carried out. The calculation assumes a 40-week working year, with an allowance for part-time working (mean 4 days/week); an average of 5 procedures/day and a mean 20 SUP items per dental procedure. Multiplying these variables suggests that a conservative estimate for the UK usage of SUPs is in excess of 720 million dental SUP items/year that end up as waste. This previously unconsidered high volume of SUP usage within dentistry was highlighted by the authors in the national press. [41]

The impact of the COVID-19 means that with additional PPE requirements, SUP usage per dental procedure has increased significantly. The previous estimate of SUPs with the addition of COVID-19 PPE would increase this figure by 396 million PPE items to a combined conservative estimate of over 1 billion items of SUP, excluding associated plastic packaging (Table 3).

Having established that SUPs in healthcare (and dentistry) follow a largely *linear economy*, an alternative and more desirable SUP *circular economy* would focus on a reduced consumption of finite resources (such as oil-derived plastics) and would design waste out of systems.

The established strategies for the management of plastic waste of reuse, reduce and recycle, are not readily applicable to the healthcare setting. Many of the polymers used are highly cross-linked and processed so that they may not be easily broken down into the constituent raw materials or derivatives. Polymer devices used in a clinical environment are at high risk of contamination, and the nature of the polymers and/or the complex shape of the devices makes it costly and difficult to clean, disinfect and sterilize. Devices assembled from multiple polymers in multi-layer constructs and combined (glued/welded) in complex shapes are very difficult/impossible to disassemble. Thus, reusing and recycling are not currently considered viable options for the management of this waste stream in healthcare. Recycling of pre-clinical plastic waste (products and packaging) that arise from manufacturing and distribution prior to being contaminated in a clinical setting is the more feasible option through a combination of established mechanical (shredding) and innovative chemical (polymer breakdown) recovery methods. The current linearity of the supply chain suggests that the most effective strategy to minimise the impact of healthcare plastic waste on the environment is by adopting a reductionist approach combined with innovative recycling approaches at both pre- and post-clinical contamination.[34] A reductionist approach focuses on a reduction of demand, which can be achieved through a promotion of better health focused on disease prevention coupled with the provision of high-quality interventions that do not require revising. This model is an excellent fit for dentistry, that has tried and tested prevention protocols that can be successfully delivered at public health levels, professionally within the dental practice setting or by the individual at a patient-centred level.

A major impact of the current COVID-19 pandemic is an unprecedented increase in the use of SUPs within healthcare. As of October 2020, the UK Department of Health and Social Care (DHSC) estimated that since February 2020, over 4.0 billion PPE items have been distributed for use by health and social care services in England alone. Table 4 identifies a selection of PPE items relevant to primary dental care and dental material use and serves to emphasise the great difference in the use of PPE in 2020 compared to 2019.[42]

These figures highlight the amplified reliance that healthcare has on SUPs during the COVID-19 pandemic. The further requirement for face-masks to be worn by the general public significantly increases the environmental burden associated with the disposal of these additional SUPs, that are complex-compound devices and difficult to recycle. These facemasks, also worn by patients to attend dental appointments, contribute an additional 66,000 tonnes of contaminated plastic waste in household waste [43]. It is likely that due to the regulations set out in national Governmental and corporate standard operating procedures (SOPs), that SUPs in the form of disposable aprons and other additional measures will increase dramatically and may remain in place as the 'new normal' even after the COVID-19 pandemic subsides. This would be akin to the policy change and use of barrier latex gloves in response to the HIV pandemic of the late 1980s, the introduction of universal cross-infection precautions in the early 1990s, mandatory handpiece and instrument sterilisation protocols and the use of single use endodontic instruments after the variant Creutzfeldt-Jakob disease (v-CJD) outbreak of the 1990's.

Conclusion

Pollution from oral healthcare is a problem and the profession has both a duty of care and an ethical responsibility to minimise its impact, in the same manner as is expected from any other industry or professional body or indeed as private citizens. In this paper we have explored the current status of sustainability in dentistry and highlighted some action that we can engage with as oral healthcare providers and in collaboration with the public we serve and the supply chain of which we form part.

The problem has been magnified with the COVID-19 pandemic by highlighting PPE and the impact of additional millions of items of SUPs that need to be managed effectively, beyond landfill and incineration. We have identified the need to consider the wider environmental impacts of our dental restorative materials, the associated packaging and the impacts associated with their delivery to the clinical setting and from patient and staff commuting.

The concept of environmental citizenship identifies the need to 'translate' our personal environmental behaviours to the workplace. We can do this by switching to and engaging with a more attitudinal approach for the management of waste and additional environmental impacts we generate in the course of our professional activities.

The environmental impact of our activities as healthcare professionals are varied and translate as either atmospheric pollution through increased greenhouse gas emissions or waste. Mitigation strategies to managing this impact are considered in part two of this two-part publication.

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Categories of Dental Restorative Materials	
Direct placement materials	• Amalgam • Resin-based composites • Glass ionomer (acid-base reaction) • Resin-modified glass ionomer • Temporary • Cements
Indirect placement materials (Fixed & Removable)	• Metal alloys • Ceramics • Polymers
Impression & Occlusal registration materials	• Natural and synthetic polymers: Alginates and Silicones.

Table 1: Categories of materials used in restorative dentistry

Clinical Procedure & Number (n) of SUP items per Procedure		SUP Items used	
PPE for Dentist & Nurse	Generic (n≈6)	4x gloves 2x masks	
	COVID-19 (n≈10)	2x Gowns* 2x FFP3 Masks* 2x Hair nets* 2x Visors*	2x Plastic aprons Clinical waste bag
Generic Set up (n≈6)		Barrier film and sleeves LA Barrel* LA Plunger*	Needle+sheath* Denture Pot Rinse cup
Periodontal treatment (n≈7)		Rotary brush/cup Pot for prophylactic paste Lid Prophylactic paste Dappens dish	Wrapper for disclosing tablet *Oral Hygiene aid* Floss
Intra-coronal restorations (Amalgam, RBC, GIC) (n≈10)		Micro-brushes Dappens dish *Dental dam* *Dental dam silicone wedges* *Matrix system** *Mylar strips* *Plastic wedges*	Direct plastic restorative material (RBC, Flowable, RMGIC) Restorative container +/-cap (RBC compule/Amalgam or GIC capsule) *Single use adhesive brush* *Single use adhesive pouch* Finishing discs/abrasive silicone tips Finishing strips Floss
Fixed & Removable Prosthodontics (n≈8)		Micro brushes Dappens dish Impression trays Silicone impressions *Cartridge* and mixing tip for impression material *Temporary crown material*	*Cartridge* and mixing tip for temporary crown Occlusion registration paste *Cartridge* and mixing tip for the occlusion registration Polythene bag to transport impression to the laboratory *PTFE (plumbers' tape)*
Endodontics (n≈8)		Endodontic files Sponge for files Gutta Percha points Resin-based sealer	Irrigation syringes for NaOCl and EDTA Blunt needle & sheath for NaOCl and EDTA Dental dam Dental silicone wedges
Decontamination & Surgery cleaning (n≈6)		Autoclave/sterilisation sleeves Wipes Wipe dispenser tub	Gloves Plastic apron
Total (approximate) **number of SUPs per procedure = PPE + Generic set up** (+/- COVID19 PPE) **+ Treatment specific items + Decontamination**. **E.g.** SUPs for Periodontal procedure = Generic set up (n≈6) + COVID 19 PPE (n≈11) + Periodontal treatment (n≈7) + Decontamination (n≈6) ≈ 30 SUPs			

Table 2: Typical range of SUPs for different restorative procedures (Italics denotes optional items; e.g. matrix system or mylar strips. *Denotes additional individual wrapping).

A	Approximate number of dental healthcare professionals (UK GDC Report 2019)	≈45,000	
B	Working days per year	[40 weeks * 4 days] = 160	
C	Approx. no. of operative procedures per day	≈5	
D	Approx. no. of SUPs per procedure	≈20	
E	Approx. no. of PPE items per procedure	≈11	
F	**Total no. of SUPs per year**	A*B*C*D	=**720,000,000**
G	**Total no. of PPE (COVID-19) per year**	A*B*C*E	**= 396,000,000**
	Total no. of SUPs (+PPE) per year	F + G	**= 1,116,000,000**

Table 3: Approximate number of SUPs generated in the UK in one year from routine adult primary care operative interventions, excluding associated plastic packaging.

PPE Item	Cumulative total (Feb to Oct 2020)	Previous year (Jan to Dec 2019)
Aprons	581,174,000	161,632,000
Clinical waste bags	50,058,000	49,508,000
Eye protectors	50,008,000	482,000
FFP2 face masks	7,530,000	523,000
FFP3 face masks	36,874,000	2,810,000
IIR face masks	611,115,000	18,532,000
Gloves (individual)	2,494,336,000	1,763,164,000
Gowns	7,888,000	749,000

Table 4: A selection of PPE items relevant to primary care dentistry and the total number of these items used between February and October 2020

Figure 1: Linear economy supply chain: Mineral extraction, processing and synthesizing of raw materials >> Manufacturing and packaging of the dental restoratives, sundries and equipment products >> Distribution and purchase of these products >> Clinical procedure with further energy expenditure, water use and indirect material use >> Collection and disposal of waste associated with different levels of contamination, mostly managed through landfill and incineration.

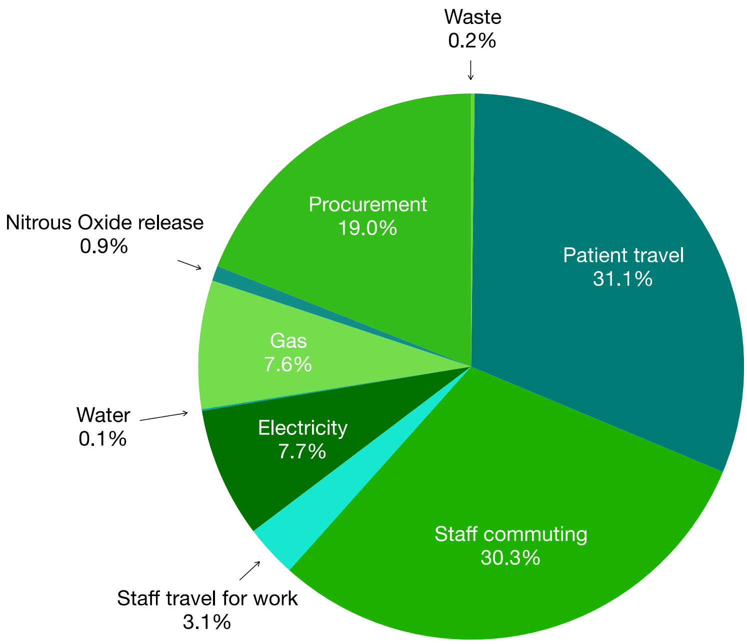

Figure 2. Breakdown of total annual carbon footprint of dental services in England for 2013–2014.[22]

Figure 3: Montage of dental restorations/materials that contribute to pollution. Top - Amalgam restoration replaced with a Resin Based Composite direct placement restoration. Bottom - Example of RBC microparticles created from machining CAD-CAM blocks or from finishing/removal of old RBCs. Centre - Scanning Electron microscope image of RBC microparticles with a scale bar of 1mm.

Figure 4. Montage illustrating the variety, volume, and complexity of plastic waste generation from clinical practice.