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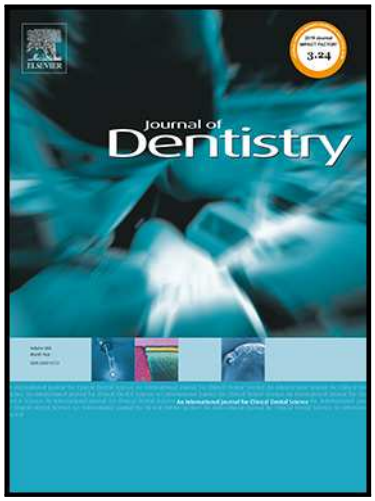

Quantification of Single Use Plastics Waste Generated in Clinical Dental Practice and Hospital Settings

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Quantification of Single Use Plastics Waste Generated in Clinical Dental Practice and Hospital Settings

Quantification of SUPs from Clinical Dental Practice

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Abstract

Objectives: To quantify (by number and mass) single use plastic waste generated from the provision of oral healthcare in primary and secondary care clinical dental settings in the UK.

Methods: An observational study of four dental practices and the clinics of a UK undergraduate dental teaching hospital was conducted. A range of routine common procedures were observed by trained and calibrated observers; these were: Examinations, endodontics, periodontics, direct placement restorations, fixed and removable prosthodontics and oral surgery. The PPE items used before and during the COVID-19 pandemic were also included.

Results: Routine 'surgery set up' generic items present a significant proportion of SUP plastic waste as these are used in every instance of patient treatment. An average of twenty-one (n=21) SUP plastic waste items are used for every procedure with a mean mass of 354g per procedure (including set up and clean up). The use of PPE increased from 14 items (pre-COVID -19) to 19 items during the pandemic. SUP items are constructed from a single plastic or from multiple plastics forming compound structures (heteropolymers); with an approximate 50:50 distribution.

Conclusions: The dental profession, at the point of care, uses a high volume of single use plastic that becomes clinical waste. The use of personal protective equipment (PPE) significantly increased during the COVID 19 pandemic and this accounts for the single greatest contribution of single use plastic, as this is used for every clinical procedure.

Clinical Significance: Manufacturers, distributors and oral healthcare providers have an opportunity to consider and implement approaches that include effective waste management with reduction, recovery and recycling at its core, towards transforming oral healthcare to a circular plastics economy.

Key words:

Single Use Plastics, SUPs, dentistry, waste management

Introduction

Globally, 8 million tonnes of plastic waste are dumped into the oceans every year [1,2]. Beyond the environmental damage, plastic pollution has wide-ranging negative effects on the natural environment [3-7]. Healthcare services, among other organisations, contribute significantly to plastic pollution [8,9]. In 2016/17, England NHS providers produced over 590,000 tonnes of waste [10]. This plastic pollution in healthcare services stands in tension with the principle of *first, do no harm* [11]. At the same time, the coronavirus (COVID-19) pandemic underscored the value of single use plastic products (SUPs), especially Personal Protective Equipment (PPE), for cross-infection control. Life-saving PPE and plastic pollution are the two sides of the same coin.

The adoption of plastic items, especially single-use products, is a relatively new development in healthcare. Plastic products were first introduced in healthcare in the 1950s as a convenient and durable alternative for traditional materials [12]. Products represented a short-term cost-saving from the beginning, when these products were designed for multiple use. This changed in the 1980s, with the increased prevalence of tuberculosis and malaria, the emergence of antibiotic resistant bacteria, and the newly emerging diseases such as AIDS, Ebola and SARS. These, all converged to drive an alternative combating tool to the use of pharmaceuticals. Thus, these different factors and especially the AIDS epidemic, led to the introduction of Universal Precautions and Single Use Plastics as both an instrument and symbol of medical hygiene [12]. In the 2000's, Variant Creutzfeldt-Jacob disease (v-CJD) gave a further impetus for using single-use instruments and single-dose packaged materials. These efforts of infection prevention and control were synthetised in the UK with the introduction of the Health Technical Memoranda in 2009 [13]. This success propelled a rapid development of cost-effective manufacturing technologies that enabled the mass production of plastic items at a comparatively low cost.

In the 1980's, when the mass use of plastic items became widely accepted in dentistry, plastic waste was not seen as necessarily problematic [14]. An audit of ten practices, in the early 1990s in Australia, found that dental surgeries are only "small waste producers". At the time, the majority of practices could utilise local government waste collection services without paying for specialised waste collection companies. The use of plastic products as cross-infection measures was not yet universally adopted, Farmer et al. found a variation of 23-91% in the composition of how much the overall waste was made up by SUP products such as gloves, cups and other items. Yet, in the same report it was noted that the introduction of Universal Precautions accounted to a nine-fold increase in waste generated.

Dental restorative materials are also experiencing a shift towards a greater use of plastic, in line with the increased prevalence of resin-based composite (RBC) restoratives, and the gradual phase-down or phase-out of dental amalgam [15]. It should be noted that RBC materials, advocated as the most commonly used substitute for dental amalgam carry their own environmental concerns [16-20].

Since 2010, plastic waste at large emerged as a worldwide public concern, especially associated with marine pollution [21-22]. These years also saw a surge in research into plastic waste in healthcare and more specifically in dentistry [23]. In the UK, it is now estimated that the total plastic waste generation will increase to around 6.3 million tonnes by 2030; with the largest contributor being the healthcare

service sector – accounting for over half (53%) of all plastic waste [24]. 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 [25].

Today, SUP devices, products and packaging are essential items for the provision of safe and economical healthcare as they fulfil the needs of every stakeholder. In this context, SUP items fulfil all the major requirements of a risk-averse industry that provides the required clinical and public confidence using new clean and/or sterile devices every time with zero risk of contagion. This is a supply chain that is tightly regulated by legislative frameworks focused on patient safety; with HTM01-05 being pertinent to oral healthcare in the UK [13,23]. This type of unilateral legislative regulation, with an exclusive focus on patient safety, is considered a further contributor to waste generation; with a 58% increase in the cost of waste services noted following the introduction of HTM 01-05 [26]. The outcome of these combined various drivers is a net increase of SUP-based biomedical waste resulting from consumer use (e.g., toothbrush, interproximal brush/floss or toothpaste tube) or from professional oral healthcare providers (e.g., clinical sundries and restorative materials); that contributes to a highly wasteful linear economy for SUPs. In order to identify the required remediation solutions, it is essential therefore to establish a baseline of data that identifies the overall use of SUPs in the provision of oral healthcare and in this way act as a driver to reverse the trend. This data will enable informed discussions with stakeholders across the supply chain to identify management strategies to reduce and recycle SUPs, as individual members and with responsibility for the chain as a whole. The aim of this study is to quantify (by number and mass) the single use plastic items used for the provision of oral healthcare in primary care clinical dental settings in the UK. Two scenarios are considered; plastic items associated with (a) the provision of routine oral healthcare and (b) the additional plastic used for PPE (personal protective equipment) as required by the UK Government for the safe delivery of oral healthcare care (COVID-19 control measures, June 2020) [27].

Methods

All items of SUP used for the provision of adult oral healthcare in UK primary care settings were identified, counted and weighed as a function of the procedure undertaken. Procedure-specific data capture tools were designed, further refined and validated through an iterative process of multiple waves during a four-week pilot study that took place in the primary care settings of general dental practice and an undergraduate clinical dental teaching hospital department of restorative dentistry (Charles Clifford

Dental Hospital, STH NHS Trust, Sheffield); that provides all items of primary care in the disciplines of endodontics, periodontics and prosthodontics (fixed and removable). The resulting data capture tool included an itemised list of the SUP items (and its associated primary packaging) used in these settings, allowing for the addition of further items not listed. The treatment procedures included in the study were: Oral examinations, endodontics, periodontics, restorative restorative (direct placement restorations), fixed and removable prosthodontics (crowns, bridges and dentures) and oral surgery (dental extractions, minor oral surgery and biopsies).

Five investigators conducted the study through a series of direct observations of patient-centred clinical care. The investigators were independent, non-participatory and non-obstructive to the actual clinical intervention. They were trained and calibrated in the data capture process and ensured full compliance with clinical governance protocols and the required health and safety requirements. Investigators recorded and itemised the following data as appropriate: Date, clinical centre and every SUP item used for every observed patient-based clinical procedure. The unit of observation was a clinical patient-intervention performed by a clinician and supported by a dental nurse. Both the patient and the clinical care team remained anonymous; no personal or identifiable data was recorded. The study setting was dental primary care clinics, constituted of three mixed care dental practices (NHS and private) and a dental teaching hospital, all located in the South Yorkshire region (England, UK). The dental practices and the teaching hospital are considered to be wholly representative of their type in the UK for the delivery of primary dental care (**Table 1**). The research was approved by the University of Sheffield, School of Clinical Dentistry Ethics Committee. The observations were risk assessed in order to ensure safety and to reduce disruption to normal working practice. All observations were anonymous and no personal or identifiable data was recorded. Observations were conducted in line with existing safety protocols. All items were weighed using a microgram scientific balance (Fisher Scientific-Analytic Series, Leicestershire, UK) and rounded to the nearest gram.

The data collected included generic information (setting, date, time, procedure) and a full itemised list of every SUP item used during the course of complete patient-centred clinical procedures. Samples of each SUP item were collected and weighed to estimate the cumulative mass of SUP used and disposed during the procedure. The investigations took place at four different locations during a four-month period between the dates of 15.10.2019 to 30.02.2020. In total, 152 observations were conducted,

distributed between the department of restorative dentistry of the dental teaching hospital and the three practices (**Tables 1 and 2**).

Subsequent to the intervention study period, the additional PPE used for the provision of aerosol generating procedures (AGPs) during the COVID-19 pandemic was also quantified and weighed.

Results

Data sets were tabulated for each site and analysed both independently and jointly as appropriate. The data revealed commonality of items and numbers for all the four sites, providing a rich data profile for analysis. The single exception to this, was for the use of nitrile gloves. There was a significant discrepancy between the number of gloves used by clinical undergraduate dental students in the department of restorative dentistry of the teaching hospital and that of qualified dentists. Dental students, in the clinical teaching environment of restorative dentistry, work with specific clinical governance cross-infection control measures for operation in open, multi-user clinical environments. In this respect they need to don and doff significantly more pairs of gloves to consult patient records, operate the chair-side computer or to retrieve equipment and materials from the dispensary. Thus, the data sets for nitrile glove usage are presented separately for treatment procedures delivered by dental students and by qualified dentists (**Table 3**). Since this increase of gloves in the teaching hospital environment reflects a local and uncommon exception, we normalised the observed data for PPE (e.g., gloves, bibs, masks) and cleaning items (e.g., tray liner, barrier film, wipes) based on the average number of procedures delivered by dentists and their nursing/assisting teams in the three general dental practices and the hospital's Oral Surgery Department; excluding the corresponding student data from the department of restorative dentistry of the teaching hospital.

The combined data for SUP items (number and mass) for each adult dental care procedure is presented in **Table 4**. This table includes the data for PPE (Generic and additional for COVID 19) and that used for cleaning and decontamination of the dental surgery after each procedure. The data identifies the different types of all the items that could potentially be used for any given procedure, and those that were actually counted for each of these procedures in the study.

Generic items (used as routine surgery set-up) present a significant proportion of SUP plastic waste as these are used for every procedure in every instance of patient treatment. We determined that a mean of twenty-one (n=21) SUP items are utilised in every routine adult primary care dental procedure (**Figure**

1); with a mean mass of 354g per procedure (including set up and clean up). Our results identify that the number of potentially used SUP items per adult care procedure is as follows, in decreasing order from most to least: The provision of direct placement restorations, root canal treatment, oral surgery for dental extractions/minor surgical procedures, provision of crowns, bridges and dentures and finally periodontal care. PPE use increased from 14 items (pre-COVID -19) to 19 items during the pandemic. The makeup of each SUP was considered and classified as either made from a single plastic or constructed using multiple plastics forming compound structures (heteropolymers); with an approximate 50:50 distribution (**Figure 2**).

Discussion

This study sought to identify, count and weigh the SUPs used during the provision of routine oral health care procedures in adults; to provide a baseline of data that highlights the magnitude of the problem and serve to identify the need for remediation strategies.

The combined data provided reflects a significant use of SUPs for the provision of common procedures in primary care dental settings. The most commonly used products are PPE worn by the dentist and nurse (at least one pair of gloves and mask) and specific items for set up and cleaning (wipes, sterilisation sleeves and tray liners) that were used with every patient, independent from the type of procedure delivered. In most cases more than one pair of gloves are used, highlighting examination gloves as the most frequently used SUP item. The data also highlights the increase in use of PPE associated with the COVID-19 pandemic.

Combining the data from this study with published workforce statistics for dentists and therapists in the UK for 2020 [28], it is possible to extrapolate with a high level of confidence, the national (UK) usage of SUPs in dental practice. The calculation is based on the following assumptions: The number of dentists and dental therapists registered with the General Dental Council in 2020 (≈ 47,000) [28]; considering a notional average of five procedures per day; a 40-week working year, with an allowance for part-time working (mean 4 days/week); and does not include student activity in teaching dental hospitals. A mean of 41 SUP items/dental procedure with a mean mass of 254g (Table 4), translates to a conservative estimate 2bn dental SUP items per year (14.4 tonnes) that end up as waste (Table 5 – Rows L and Q). The additional PPE required during the COVID-19 pandemic increased this figure to approximately 2.4bn SUP items (27 tonnes) (Table 5 – Rows M and R). The

authors have previously highlighted the significant impact associated with the use of nitrile gloves as a conservative estimate of 352 million gloves per year from routine adult primary care clinical procedures in the UK [29,30].

Observational audit approaches have been used successfully to assess the amount and composition of waste produced by dental practices [26,31]. This study draws on these approaches, with a focus on the link between dental procedures as they were delivered and the plastic products used and disposed of as a result of the delivery of this patient-centred procedure. It is relevant to note that this approach limits the scope of the investigation to the clinical environment of the dental surgery and does not take account of the additional plastic waste upstream of the supply chain.

Our assessment of the use of SUPs in the provision of routine primary oral healthcare to adults presents a mixed picture. On the one hand, a large amount of PPE items are used in every procedure (before and during the COVID-19 pandemic). In some cases, this was donned and doffed multiple times with new PPE during an individual patient-based procedure, highlighting PPE as the biggest proportion of SUP waste output. On the other hand, there is a wide variety of specialised SUP plastic items with a complex assembly nature, made from highly cross-linked plastics and processed so that they may not be easily broken down into the constituent raw materials or derivatives. Devices assembled from multiple polymers in multi-layer constructs and combined (glued/welded) in complex shapes are very difficult or impossible to disassemble. Some polymers present significant chemical challenges, such as, PVC, which releases HCl and organic Cl-containing by-products when thermal processed. Additionally, 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, hence a single-use device has been adopted [23].

This study has not considered sterilisation pouches and packaging, that would add an additional significant volume of SUPs to the data. Packaging presented a problem as items were presented already pre-open or formed part of a multi-package. Nevertheless, this form of SUP should not be disregarded as packaging is recognised as the single largest contributor to plastics in the dental industry as the product travels down the supply chain to the dental surgery and end user, with the majority (>90%) ends as waste for incineration or landfill [32]. Indeed, the management of plastic packaging is the greatest target for the UK's Plastic Pact (led by WRAP) and the European Plastics Pact by "bringing

together frontrunner companies and governments to accelerate the transition towards a European circular plastics economy" with ambitious common targets to be reached by 2025 [33,34].

It is important to put this data in the context of the frequency with which the procedure is undertaken to obtain a realistic interpretation of the actual cumulative impact of SUPs for each procedure. Consider the two procedures at each end of the spectrum for the production of SUPs as identified in this study (**Table 4**); direct placement restorations (53 items) and examinations (13 items). The picture changes significantly when we factor in the number of these procedures per annum. Published data for the volume of activity for different procedures carried out by NHS dental services in the UK enables this exercise [35]. Direct placement restorations (amalgam 5.6%, resin-based composite 5.4% and glass ionomers1.5%) accounted for 12.5% of activity in the year 2013/14. Dental examinations accounted for 41.5% of the annual volume of activity. It becomes immediately apparent that the greatest volume of SUPs generated in dentistry are those associated with dental examinations by a factor greater than x3; a point also identified by Borglin et al [36]. There is an opportunity for both manufacturers and clinical care providers to engage in a collaborative manner to identify ways of both reducing the use of these items and recycling (mechanical or chemical) these plastics for use in low-value products, such as construction bricks, fences, park benches etc or as feedstock for new plastics [37].

The impact of infectious disease pandemics, associated with a combined legislative requirement and a public desire for higher levels of patient safety makes the management of clinical waste and associated primary/secondary packaging a big challenge. In this context, the COVID-19 pandemic has raised, once more, the required safety standard for the provision of clinical care and the associated use of PPE; which history suggests is a one-way journey with ever increasing protection levels, as identified earlier in this paper. This is illustrated by the recent post-COVID 19 guidance issued by the Office of Chief Dental Officer for England (November 2021) 'Dental standard operating procedure: Transition to recovery' with regards to disposable SUP plastic aprons. This guidance requires their continued use, a measure not universally advocated by regulatory bodies prior to the pandemic [38]. Maintaining patient services and safety during the COVID-19 epidemic has moved the focus from the environment to other factors, and will require a change in mindset or re-think. Remediation strategies need to focus on establishing an appropriate and sensible standard for the use PPE in oral healthcare that is effective, practical, evidence-based and that can be implemented in

an equitable manner across all global societies, irrespective of economic and development status. Critically, PPE also needs to be environmentally sustainable so that it can be recovered and recycled effectively and, in this way, provide the required protection to both individuals and the environment.

As per the United Nations waste management inverted pyramid, source reduction and recycling are the most preferable options to minimise the environmental impact of SUPs [39]. In this context, the main drivers for the oral health supply chain are through engagement with reduction combined with recycling (pre- and post-clinical contamination). Reuse is not considered a viable option for SUPs that arise from packaging or clinical waste. The concept of 'rethink' (the fourth R of 'reduce, reuse, recycle, rethink') encourages us to consider how we can engage with reduction and recycle to overcome the inherent challenges that this presents in our industry. Reduce and recycle should be the focus of the most practical and readily implementable remediation strategy. Reduction is best achieved through the delivery and maintenance of good oral health, focused on prevention and with the provision of durable interventions, using high quality products materials, that will last longer and/or require fewer revisions. Reduction is best achieved through the delivery and maintenance of good oral health, focused on prevention [40]. This approach focuses on a reduction for the need of restorative consumables and interventive care appointments at the patient end-user level. Reduction is also achieved with a focus higher up the supply chain, at the level of manufacturing companies and distributors, through a systemic analysis of packaging needs and the elimination of unnecessary wasteful packaging that works its way downstream. The stewardship provided by the Flexible Plastics Consortium is a good example of progress in this respect [41]. Recycling opportunities arise from: (i) Engagement with stakeholders in the supply chain to add value to waste plastic packaging. (ii) the design and development of plastic items made from single plastics that can be readily recycled; (iii) engagement with end-user consumers and waste management companies to segregate, collect and recycle clinical SUPS as a valuable commodity.

In conclusion, it is important to highlight that the problem does not lie with the actual plastic used in oral healthcare itself, which is a useful item that provides effective and safe patient-centred care. There is though, a recognition of the need to transfer the plastic used from its current linear life cycle of synthesis from fossil-based constituents and waste management to a circular plastic economy [42, 43]. A circular economy uses renewable and/or biobased constituent materials for the fabrication of SUP items with the subsequent recovery and recycling as valued feedstock for the synthesis of new

plastics. Focus should consider the effect of reducing the volume at a local level and through the supply chain, including the use of packaging.

We can reduce the amount of plastic, through the promotion of high standards of oral healthcare that focuses on preventable diseases. The consequence of good oral health is a reduced need for interventive operative care that in turn leads to a reduced carbon foot print and a reduced waste pollution impact. Recycling (mechanical and chemical) should take a much greater role in the management of clinical SUPs (including PPE) and packaging. The use of best practice guidelines through the adoption of technology, effective logistical management systems and environmental regulations are also key to a more sustainable practice with less use of plastic.

Conclusions

The dental profession, at the point of care, uses a very high volume of single use plastic that becomes clinical waste. This is disposed of via either landfill or incineration, with some element of energy recovery as the best-case scenario. The material qualities of these products depend on their use, and rethinking their use is indispensable for reducing their adverse environmental effects. Established strategies for the management of plastic waste of *reduce* and *recycle*, should be adopted to the specific requirement of healthcare settings.

Focusing on dental procedures, this research established baseline data on the volume and types of SUPs that are used (and that create waste) in dental settings. The findings highlighted the recycling of PPE, such as gloves and face masks as a practice that could be organised to materialise highly positive environmental impact and economically viable business models.

The use of personal protective equipment (PPE) significantly increased during the COVID-19 pandemic compared with pre-pandemic levels and this accounts for the single greatest contribution SUP in terms of volume and weight as this is used for every clinical procedure. Legislative authorities should consider how to deliver clinical care in a manner that does not compromise patient safety whilst being mindful of limiting the environmental impact of this clinical plastic waste.

There is a need to increase our awareness of this output from the provision of oral healthcare, so that appropriate remediation strategies can be considered and implemented with urgency.

Manufacturers and distributors that provide single use plastic items to the clinical oral healthcare profession, should consider and implement approaches that include effective waste management with recovery and recycling at its core, that is part of a circular plastics economy. Oral healthcare providers have an opportunity to drive change by engaging with these stakeholders upstream of the supply chain and also with the waste recovery companies.

Author Contributions

Nicolas Martin is the principal investigator for this manuscript, has provided content expertise and contributed to the writing and editing of the manuscript. Nicolas is a co-applicant of the EPSRC award that has supported this project.

Steven Mulligan is a co-investigator for investigations reported in this manuscript. He has contributed to the writing and editing of the manuscript. Steven is a co-applicant of the EPSRC award that has supported this project.

Peter Fuzesi is a co-investigator for investigations reported in this manuscript. He has contributed to the writing and editing of the manuscript.

Paul Hatton is a co-investigator for investigations reported in this manuscript. He has contributed to the writing and editing of the manuscript. Paul is a co-applicant of the EPSRC award that has supported this project.

Declaration of Competing Interest

On behalf of the joint authorship for this manuscript, I confirm that there is no conflict of interest On behalf of the joint authorship for this manuscript, I confirm that there is no conflict of interest

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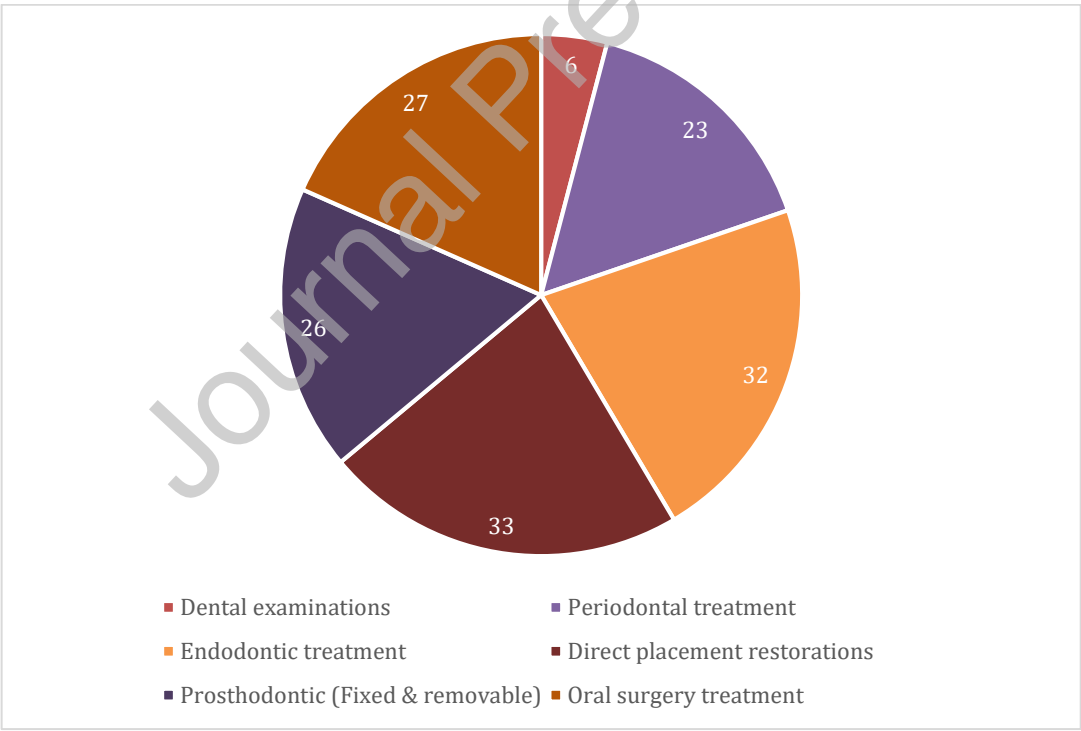

Figure 1. SUP items per routine adult dental care procedure

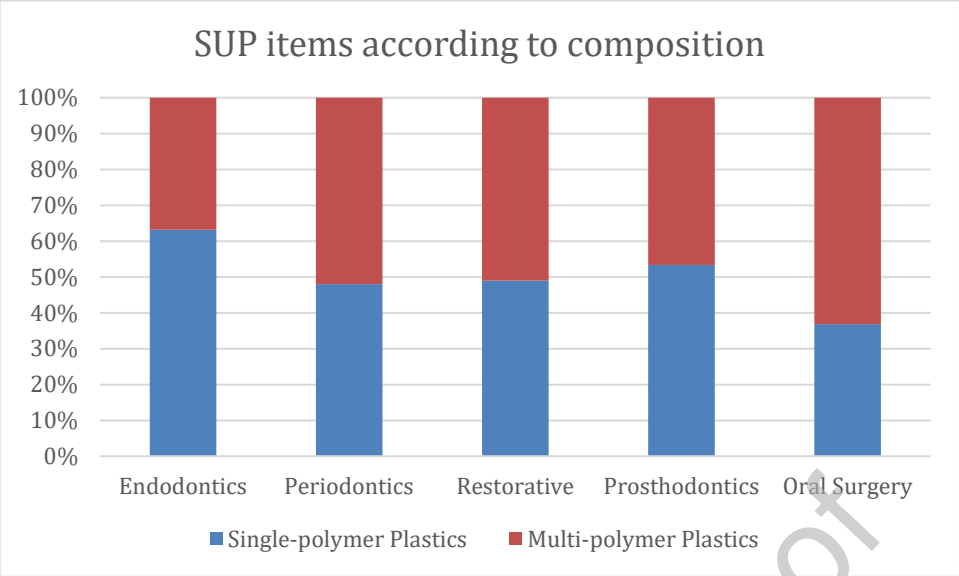

Figure 2. *SUP items according to composition. Single plastic or complex compound multi-polymer items*

Site	**Type**	**Procedures**	**Number of observations**
Teaching Dental Hospital	Primary and specialist secondary care services	Oral Surgery Restorative (Endodontic, Periodontal and Prosthodontic)	67
Dental Practice A	Primary care (NHS)	Restorative (Endodontic, Periodontal and Prosthodontic)	39
Dental Practice B	Primary care and private	Oral Surgery, Restorative (Endodontic, Periodontal and Prosthodontic)	17
Dental Practice C	Primary care and private	Restorative (Endodontic, Periodontal and Prosthodontic)	29

Table 1. Observation sites and observed procedures

Procedure	**Number of observations per procedure**
Dental examinations	78
Periodontal treatment	22
Endodontic treatment	5
Direct placement restorations	30
Prosthodontic (Fixed & removable)	9
Oral surgery treatment	8
Total	**152**

Table 2. Number of observations conducted per dental procedure

Nitrile glove use per observed procedure	**Mean number of gloves used by the team per clinical intervention**
Dental team (Clinician & assistant) (number of observations=61, two glove users)	3.64
Student team (Clinician +/- assistant) (number of observations =91)	11.19

Table 3. Use of nitrile gloves in dental practice and the dental hospital

SUP items - number and mass, for each adult dental care procedure				**SUPs per Procedure** (*Directly associated with the type of procedure*)		**SUPs per Procedure** = [(Row A) + a procedure (C to G)] (*Directly associated with the type of procedure AND Including PPE, generic set up and decontamination**)	
Clinical procedure		**SUP items *potentially* used per procedure, assuming that each one is only used once**		**Number (n) of items actually used (mean)**	**Mass (g) of items actually used per procedure**	**Number (n) of items actually used per procedure**	**Mass (g) of items actually used per procedure**
		Description of items	**Number (n) of potential items**				
A	**PPE for dentist and nurse** Standard Pre-COVID 19 and for COVID 19 non-AGP procedures	*4 x gloves; 2 x masks*	6	3	30g	26	130 g
	Generic Set-up	*Bib; Aspirator tip (disposable); 3-in-1 tip; Cup; Barrier sleeve for aspirator; Barrier film; Gloves, Dentist+Nurse (pairs); Masks, Dentist+Nurse; Tray liner; (LA barrel-needle-sheath combination; LA Plunger; Denture Pot)*	16 (13 for examinations, excluding items in *italics*)	19	70g		
	Decontamination and surgery cleaning	*Autoclave/sterilisation sleeves; wipes; clinical waste bag*	4	3	30g		

B	**PPE for dentist and nurse** Additional for **COVID-19** AGP procedures	*2 x gowns; 2 x FFP3 masks; 2 x hair nets; 2 x visors; 2 x plastic aprons*	10	9	305g	9	305g
C	Examinations	*Disposable mirror and disposable tweezers (plastic)*	2	0	45 g	**26**	**130g**
D	Periodontal treatment	*Rotary brush/cup; Prophylactic paste pot; Prophylactic paste lid; Dappens dish; LA Barrel-needle-sheath combination; LA Plunger; Denture Pot; Disclosing tablet; Oral Hygiene aid (Eg: interdental brush); Floss; Disposable scalpel handles and sheath*	13	17	106 g	**43**	**236g**
E	Intra-coronal restorations (Amalgam, Resin-based composite, Glass ionomer cement)	*Microbrush; Barrier sleeve for curing light; Dappens pot; Dental dam; Dental dam silicone wedges; Matrix system; Mylar strips; Plastic wedges (dental silicone wedges); Direct plastic restorative material (Composite, Flowable, RM- GIC); Composite container (compule); Compule silicone cap; Single use adhesive brush; Single use adhesive pouch; Amalgam container (capsule); GIC container (capsule); Finishing and polishing discs/burs; Finishing strips; Floss; Mixing pad; Silicone sectional impression/index; Disposable scalpel handles and sheath; Articulating paper*	21	27	109 g	**53**	**239g**

F	Fixed and removable prosthodontics	*Impression trays; Silicone impressions; Impression material cartridge; Impression material mixing tip; Microbrush; Silicone sectional impression/index; Disposable scalpel handles and sheath; Adhesive brush; adhesive pouch; denture pot; Dappens dish; Temporary filling material (units); Temporary filling material cartridge; Temporary filling material mixing tip; Occlusion registration paste; Occlusion registration cartridge; Occlusion registration mixing tip; PTFE (plumbers tape); Polythene laboratory bag*	21	20	175g	**46**	**305g**
G	Oral Surgery	*Sodium chloride bottle; Chlorhexidine bottle; Glucose pot; chlorhexidine tube lid; Cotton pellets packet; Straws; Swab packet; Septoject; Lignocaine tube lid; Paraffin tube lid; LA cartridge pack; Ultrasafety plus; 20ml syringe; retractable scalpel; surgical burs packet; suction connecting tube and pack; steri drape and pack; Surgical suction and pack; barrier towel and pack; gallipot and pack; surgical gown packets; xylocaine spray nozzles; ibuprofen pack; paracetamol pack; salbutamol spray; aspirin pack; scissors pack; staff aprons; lenses and frames; single scrub brush; pump bottle - surgical scrub; pump bottle - moisturising lotion; pump bottle - skin disinfection; sodium chloride pack; tubing for peristaltic pump pack; covers for thermometers; instrument bags; suction liners; medical emergencies*	36	21	230g	**27**	**360g**

H	Endodontics	*Endodontic files; Sponge for files; Gutta Percha points; Resin-based Sealer; dental dam; Dental silicone wedges; NaCl irrigation syringe; NaCL - Blunt needle & Sheath; EDTA irrigation syringe; EDTA - Blunt needle and sheath*	**10**	26	126g	52	256g

Table 4. SUP items, number and mass, for each adult dental care procedure.

- The total number of SUPs per clinical appointment = [row A + (A procedure from rows C to G)].
- The average number of SUPs per clinical appointment = mean of procedures in rows C to G) = **41**
- The burden of additional PPE for COVID-19 AGP procedures = [(rows A+B) + (one of procedures in rows C to G)]
- The average number of SUPs per clinical appointment including COVID-19 additional PPE = [(rows A +B) +(mean of procedures in rows C to G)] = **50**

A	Approximate number of dental healthcare professionals (Dentists & Therapists)	≈ 47,000	
B	Working days per year (40 weeks * 4 days)	160 days	
C	Approx. number of operative procedures per day	≈ 5 days	
D	Mean number of SUPs per procedure (including generic PPE, set up and decontamination)	≈ 55 items	
E	Additional PPE items per procedure (COVID-19)	≈ 9 items	
F	Mean mass of SUPs per procedure: Procedure specific	254g	
G	Mean mass of SUPs per procedure: Generic set up and clean up	100g	
J	Mean mass of SUPs: Generic PPE (g)	30g	
K	Mean mass of SUPs: COVID-19 PPE (g)	305g	
L	**Total annual number of SUP items** (including generic PPE, set up and decontamination)	A*B*C*D	**≈ 2 billion items**
M	**Total annual number of SUP items** (including COVID-19 PPE)	A*B*C*(D+E)	**≈ 2.4 billion items**
N	Annual mass of procedural SUPs (kg)	A*B*C*(F+G) ÷ 1000	≈ 13.3 million kg (13.3 tonnes)
O	Annual mass of PPE SUPs (kg)	(A*B*C*J) ÷ 1000	≈ 1.13 million kg (1.13 tonnes)
P	Total annual mass of PPE SUPs (including additional COVID-19 PPE (kg))	A*B*C*(J+K) ÷ 1000	≈ 12.6 million kg (12.6 tonnes)
Q	**Total annual mass of SUP waste (kg)**	N + O	**≈ 14.4 million kg (14.4 tonnes)**
R	**Total annual mass of SUP waste (kg)** (including COVID-19 PPE)	N + O + P	**≈ 27 million kg (27 tonnes)**

Table 5: Approximate number of SUPs and associated mass (kg) generated in the UK in one year (2020) from routine adult primary care operative interventions carried out by dentists and therapists, excluding associated plastic packaging.