

A review of HTM 01-05 through an environmentally sustainable lens

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Abstract:

Patients deserve to be treated in a safe and clean environment with consistent standards of care every time they receive treatment. It is essential that the risk of person-to-person transmission of infections be minimized yet it is also essential that planetary harm (and therefore public harm) is minimized with respect to resource consumption, air pollution, environmental degradation etc.

In 2013 the Department of Health introduced the Health Technical Memorandum HTM 01-05¹ providing dental practices advice on patient safety when decontaminating reusable instruments in primary care. This paper provides a commentary on HTM 01-05 and similar decontamination guidance. We believe all decontamination documents needs to reflect the so-called 'triple bottom line' - the finance, the social cost, and the impact on the planet.

The authors provide an environmental commentary on a number of items mentioned in decontamination documents including autoclaves (including the use of helix tests), disposable paper towels, undertaking hand hygiene, using a log book, plastic bag use, the use of PPE, remote decontamination units, single use instruments, single use wipes, disinfection chemicals (e.g. sodium hypochlorite) thermal disinfection and wrapping of instruments.

It is hoped that, in the spirit of the ever-increasing numbers of papers published to highlight how healthcare (and dentistry) could become more sustainable, that these critiques will be taken in the spirit of providing a beginning of further discussion from an environmental

perspective.

Introduction:

Patients deserve to be treated in a safe and clean environment with consistent standards of care every time they receive treatment. It is essential that the risk of person-to-person transmission of infections be minimized as much as possible. It is also essential that whilst ensuring patient safety that planetary harm (and therefore public harm) is minimized with respect to resource consumption, air pollution, environmental degradation etc.

In 2013 the Department of Health introduced the Health Technical Memorandum HTM 01-05.² This gave dental practices advice on patient safety when decontaminating reusable instruments in primary care. The document highlights the duty of care for dentists to ensure they provide appropriate decontamination care.

Although the document provided consistent clear advice to the dental team there has been a significant critique of the document. One of the main criticisms is concerning the cost of implementation. Anecdotally we know that adhering to HTM 01-05 is expensive.

Richardson demonstrated that waste management costs increased by 58% when HTM 01-05 was introduced.³

Another difficulty is in defining essential quality practice, best practice and comparing/contrasting this with excessive practice. HTM 01 05 expects practices to meet essential quality requirements and provides information as to how practices could strive for best practice. Excessive practice could have a significant deleterious effect on the environment which has been further highlighted by the COVID 19 pandemic.⁴

There has been a rapid increase in papers highlighting both the environmental harm associated with health systems overall^{4, 6} as well as the need for health care systems to be net zero (so their net carbon emissions are effectively zero).⁷ There is an urgent need for this

because we are not just facing a climate change crisis⁸ but also crisis across biodiversity⁹, water scarcity.¹⁰ We know from a number of studies that a number of healthcare processes and products actively cause harm; the use of some products or procedures causes a loss of Disability Adjusted Life years (DALY). Byrne's paper for example showed that using plastic disposable examination kit caused 11 seconds of DALY loss, compared with 3 seconds for a reusable kit.¹¹ Within healthcare Rizan has reported on the huge environmental cost of PPE, and this has been echoed in dentistry by Almutairi.^{4,12,13}

There needs to be consideration not only to the efficacy and safety of our decontamination processes but also to their sustainability. There have been a number of papers highlighting the need to look at the environmental consequences of decontamination guidance such as HTM 01-05^{4,12,14}. This paper will focus on the environmental sustainability of HTM 01-05, however we hope that the paper is also relevant to the majority of other decontamination documents including those in Canada¹⁵, the Republic of Ireland¹⁶, New Zealand¹⁷, Scotland¹⁸, United Kingdom², United States of America¹⁹ and Australia.²⁰

This paper provides a commentary on HTM 01-05 and similar decontamination guidance. We believe the document which is now 8 years old needs to be updated to consider the so-called 'triple bottom line' - the finance, the social cost, and the impact on the planet. It is hoped that, in the spirit of the ever-increasing numbers of papers published to highlight how healthcare (and dentistry) could become more sustainable, that the critique of HTM 01-05 will be taken in the spirit of providing a beginning of further discussion from an environmental perspective.

Methodology:

To understand how HTM 01-05 could be viewed from a sustainability perspective we followed three steps;

Firstly a consensus of people with sustainability knowledge were asked to critique the document. These included Fourth year dental students (2), paediatric specialists (2), a clinical

fellow (1), 1 DPH academic, a DPH post graduate student and a Dental Clinical NHS Trust Director (with a lead for Dental Decontamination) .

Secondly, as this was an area where we wanted specific information, we performed a simple life cycle analysis (LCA) to understand the relationship between methods of laundry. We compared chemical disinfection (25 degrees), chemo-thermal disinfection (50 degrees), and thermal disinfection (71 degrees). The reference was washing 1kilogram of laundry. The ecoinvent database v3.6.1 was used²¹, with Open LCA software 1.10.3 to calculate the environmental impact factors.²² The input out put table used to construct this analysis can be found in Appendix 1:

Thirdly we performed a quick scan of similar documents in English speaking countries to understand and compare the English document HTM 01-05 with similar documents across the decontamination arena including those in Canada¹⁵, the Republic of Ireland¹⁶, New Zealand,¹⁷ Scotland,¹⁸ United Kingdom,² United States of America¹⁹ and Australia.²⁰ We were interested in understanding the specific themes which could be similar and may have environmental consequences. Although not supposed to be exhaustive by any means we searched for the following words; disposable paper towels; chemical disinfection; plastic aprons; remote decontamination (central sterilization units);single use instruments; single use wipes; sodium hypochlorite; thermal/chemo disinfection, wrapped instruments.

Results and discussion:

1.1.1. A thematic analysis of HTM 01-05

There are several aspects of HTM 01-05 where an environmental comment would be useful, we have included our themes and comments in Table 1. Readers in sustainability would of course be aware that every thing we do in our daily/work lives causes environmental harm. We realise therefore that this list is not exhaustive.

Table 1: HTM 01-05- Environmental themes

THEME	Component of HTM 01-05	HTM 01-05 Quote
Autoclave equipment/Dishwasher equipment and manual washing	4.15	Some benchtop sterilizers require a warm-up cycle before instruments can be processed. The manufacturer's instruction manual should be consulted to find out whether this is the case.
Autoclave equipment/Dishwasher equipment and manual washing	3.3	Manual cleaning, governed by an appropriate protocol, is acceptable within the essential-quality-requirements framework
Disposable paper towels	6.6	To prevent recontamination of washed hands, disposable paper towels should be used.
Hand hygiene	6.1-6.5	The term hand hygiene covers not only hand-washing, but also alternative and additional measures such as hand disinfection using antibacterial-based hand-rubs/gels. To prevent recontamination of washed hands, disposable paper towels should be used.
Hand hygiene	6.11	Wall-mounted liquid hand-wash dispensers with disposable cartridges should be used. ...Refillable hand-wash containers should not be used as bacteria can multiply within many of these products and are therefore a potential source of contamination.
Helix Test	4.16	4.16 The daily tests should be performed by the operator or user and will normally consist of: <ul style="list-style-type: none"> • a steam penetration test – Helix or

		Bowie-Dick tests (vacuum sterilizers only);
Log book	3.19	Washer-disinfector logbooks and records should be kept by the designated “user” – an identified member of the practice staff. Cycle parameters should be recorded together with details of routine testing and maintenance of the equipment used.
Plastic bags versus plastic reusable containers: Sending products to a laboratory	7.1	If the device is to be returned to a supplier/ laboratory or in some other fashion sent out of the practice, a label to indicate that a decontamination process has been used should be affixed to the package.
PPE: All	6.14	Appropriate PPE should be worn during decontamination procedures. PPE includes disposable clinical gloves, household gloves, plastic disposable aprons, face masks, eye protection and adequate footwear. PPE should be stored in accordance with manufacturers’ instructions.
PPE: Disposable vs reusable visors	6.29	Disposable visors are available and may be used.
PPE: Gloves	6.16-6.25	Domestic household gloves, if used, should be washed with detergent and hot water

		and left to dry after each use to remove visible soil. Replace these gloves weekly or more frequently if worn or torn or if there is any difficulty in removing soil.
PPE: Plastic aprons	6.24, 6.25	6.24 These should be worn during all decontamination processes. 6.25 Aprons should be used as a single-use item and disposed of as clinical waste. Plastic aprons should be changed at the completion of each procedure.
Remote decontamination unit	2.28	Where contaminated instruments are to be transported outside of the healthcare premises on a public highway
Single use instruments	2.17	Where instruments are difficult to clean, consideration should be given to replacing them with single-use instruments where possible.such as matrix bands, saliva ejectors, aspirator tips and three-in-one tips.
Single use instruments	3.32, 4.23	Instruments should be sterilized as soon as possible after cleaning to avoid air-drying (which can result in corrosion and/or microbial growth). For instruments processed in a vacuum sterilizer, before being wrapped, instruments should be dried using a disposable non-linting cloth.

Single use instruments (including single use trays)	2.14, 2.15, 6.58, 16.3	Numerous
Single use instruments (including single use trays)	2.11	Alternatively, single-use instrument trays may be used, provided these have been stored in a clean and dry environment.
Single use wipes	4.27	It should be kept free of clutter and wiped clean by the use of detergent and and/or disinfectant wipes at sessional intervals..... the tray or shelf of instruments is to be placed must be cleaned with a pre-prepared or single-use disinfectant wipe and allowed to dry.
Sodium hypochlorite	6.74,6.84	
Thermal disinfection	3.2, 3.14	e.g. Thermal disinfection – the temperature of the load is raised and held at the pre-set disinfection temperature for the required disinfection holding time
Wrapping of instruments	2.4k	Wrapped instruments may be stored up to 1 year

1.1.2. Other similar guidance documents:

The authors looked at guidance documents from 7 countries: Canada (Canadian Dental Association, 2006), Republic of Ireland (Dental Council, 2015), New Zealand (Dental Council, 2015), Scotland (SDCEP), United Kingdom (Department of Health, 2021), United States of America (CDC, 2019), and Australia (Australian Dental Association, 2021). Six guidance documents mentioned disposable paper towels, 4 guidance documents mentioned

chemical disinfection, 5 guidance documents mentioned plastic aprons, 3 guidance documents mentioned using remote decontamination, 6 guidance documents mentioned using single use instruments, 3 guidance documents mentioned single use wipes, 5 guidance documents mentioned sodium hypochlorite, no guidance documents mentioned thermal/chemo disinfection, and 6 documents mentioned “wrapped”. See table 2

Table 2: Use of potentially environmental influential words in similar decontamination documents.

Topic of environmental concern	Canada ²³	Ireland	NZ	SDCEP	UK	C DC	AD A
Disposable paper towels	1	1	3	2	2	0	3
Chemical disinfection	4	0	6	0	1	0	4
Plastic aprons	0	0	2	4	7	2	5
Remote decontamination (CSU)	0	0	1	16	1	0	0
Single use instruments	1	1	4	10	2	0	1
Single use wipes	0	0	1	3	2	0	0
Sodium hypochlorite	2	0	2	1	1	0	7
Thermal/Chemo disinfection	0	0	2	8	1	0	24
Wrapped	5	3	5	0	16	3	31

1.1.3. Autoclave equipment/Dishwasher equipment and manual washing

The use of the washer-disinfector and the vacuum autoclave are central processes in the disinfection cycle described in HTM 01-05. There is no discussion in HTM 01-05 of the

environmental impact of either of these energy intensive processes. The bulk of the environmental impact from washer disinfectors arises from the energy consumed both in their use and to heat the water to the correct temperature. The volume of water used in a washer disinfectant cycle also depends on the chamber size. Less water is typically used in washer disinfectors than would be used in hand washing but repeated use of washer disinfectors consumes considerable volumes of water. Many washer disinfectors consume additional energy to utilize water manufactured by reverse osmosis. The chemicals used in the washer disinfectant can affect human health and can cause freshwater eutrophication.²⁴

Strategies to reduce the environmental impact of washer disinfectors include using renewable energy sources to power washer disinfectors, using full chambers to decrease the number of cycles and running cycles close together to recycle heat from previous cycles. The volume of detergent used could be reduced by utilizing selective settings based on the perceived soiling of the instruments.

The environmental impacts of vacuum autoclaves similarly originates from the water consumed and the energy required to produce reverse osmosis water and power cycles. Strategies to reduce the environmental impact of vacuum autoclaves include using renewable energy sources, using autoclaves with high energy efficiency and using full chambers to decrease the number of cycles. Autoclaves on standby mode consume significant energy and efforts should be made to confine their use to fixed times ie reduce standby mode. Where possible, thermal jackets to prevent heat loss should be fitted. Efficient procedure tray systems should be used so that only instruments required are autoclaved to reduce unnecessary cycles.

The environmental impact of the autoclave could potentially be reduced if policy makers determined that instruments were reprocessed according to use, rather than by class. In the hospitality industry, cutlery is re-used following rudimentary cleaning and is not described as a risk to public health. In healthcare, Spalding described categories of instruments that should undergo cleaning, disinfection or sterilization.²⁵ In medical practice endoscopes that traverse the oral cavity are reprocessed by disinfection alone. By contrast, all dental instruments, regardless of the level of contamination, undergo cleaning, disinfection and sterilization. Rutala estimated the risk of transmission from instruments decontaminated by disinfection but not sterilization as 8 in 100 trillion for HIV and 1 in 10 billion for Hepatitis B.²⁶

Reconsidering how we process items used in the oral cavity may be supported by reports of significant failures in the decontamination process in general practice in the UK that have not been accompanied by reports of transmission of infection between patients.^{27,28} Documented cases of transmission in the US in oral surgery practice could not be linked to the decontamination process^{29,30}. Public confidence in the decontamination process and possible demands to adhere to the current protocols may be offset by the low risk of transmission of disease by contaminated dental instruments and the need to reduce the environmental impact of autoclaves.

Both washer disinfectors and vacuum autoclaves should be properly commissioned, validated and serviced to ensure optimum efficiency in the decontamination cycle. Only devices with CE marks (in Europe) that that may be reliably initially commissioned should be purchased.

1.1.4. Disposable paper towels

HTM 01-05 recommends that hands should be dried to prevent decontamination with paper towels. From an environmental perspective, based on an LCA from the Netherlands,³¹ this practice is considerably worse from both an environmental perspective and a human health perspective than drying hands with a hot air dryer. The Dutch LCA however used an average electricity mix in the Netherlands (electricity was only 8.8% renewable in 2019).³² It would therefore be expected that drying your hands with a hot air dryer will become increasingly better from a human health perspective as the Netherlands increases its share of renewables.

The relationship between the use of hot air dryers and microbiological contamination is complex. A very recent review showed that in some studies air dryers provide better bacterial decontamination of hands than paper towels, but in other studies there was no data to support any human health claims (from a decontamination perspective) to support either model of hand drying. As an example, in a study by Pitts the use of paper towels (PTs), air dryer and jet dryer respectively decreased, increased and made no significant change to the number of microbial flora on hands. However the air and jet dryer dispersed more microorganisms than PT.³³ Similarly in another recent study there was fewer bacteria after jet drying compared with PTs,³⁴ The authors concluded that there is inconclusive and conflicting results which make recommending a specific policy difficult.³⁵

If a new edition of HTM 01-05 continues to recommend paper towels, it is our suggestion that they advocate for non bleached paper to reduce the impact of chlorinated products being manufactured and disposed of. There is however some evidence to suggest that recycled towels contain more bacterial load than virgin product.³⁶

1.1.5. Hand hygiene

Hand hygiene in the context of HTM 01-05 involves not just hand washing but also any other measures to disinfect hands such as antibacterial-based hand-rubs/gels. Use of a mild soap is the standard, antimicrobial handrubs which can be used in the absence of visible contamination. Bar soap is not permitted by the document. HTM 01-05 also mandates the use of wall mounted liquid hand wash dispensers as refillable hand wash containers are thought to carry as risk of contamination.

Clearly hand hygiene is critical, but there is some potential that the HTM 01-05 recommendations could be made more sustainable.

A recent review of hand washing vs hand sanitizer found that hand sanitizer was more environmentally sustainable than handwashing with soap. This was most likely because use of hand sanitizer reduces water use or hand drying was not required. A starting point for HTM 01-05 therefore could be to recommend hand sanitizer as the norm unless there is visible contamination.³⁷

With regards to use of soap, HTM 01-05 specifically forbids the use of it in bar form (bar soap), however there is no justification given for this. Use of bar soap cuts down on packaging waste so it is a more environmentally sustainable method of delivery than liquid soap. It is unclear why the use of bar soap is contraindicated – there is no supporting reference. Presumably there is a risk of contamination of the soap between uses, however this recommendation conflicts with a 1988 paper by Heinse who showed no risk of bacterial transfer using soap³⁸

HTM 01-05 also mandates that refillable soap dispensers are not used, again because of the risk of reinfection. Research demonstrate that washing with contaminated soap from bulk-soap-refillable dispensers can increase the number of opportunistic pathogens on the hands and may play a role in the transmission of bacteria in public settings.³⁹ Soap dispensers further add to the environmental impact of using liquid soaps and are another reason to consider recommending sanitizers over soap.

1.1.6. Helix Test

We know from the running of an autoclave generates around 20 seconds of DALYs loss.¹¹ We would hope therefore that there was good evidence as to how often we should run a Helix or Bowie-Dick tests.

A daily steam penetration test is recommended for vacuum autoclaves by both HTM 105 and ISO 17665-1:2006, alongside daily recording of maximum temperature reached and pressure achieved in a logbook. In terms of specific evidence for daily steam penetration tests, there is no reference included in HTM 105 and nor was any supporting literature identified. The tests are recommended daily to identify a malfunctioning autoclave as early as possible and therefore prevent potentially contaminated instruments being used on patients.

1.1.7. Log book

HTM 01-05 advises the use of log books to record the various aspects of decontamination. The jury is still out as to what is better, paper or electronic copies. We found one review in 2014⁴⁰, and one paper written in 2020.⁴¹ The first paper showed that electronic communication was associated with a smaller impact on the environment than printed communication when the reading time is short, which is probably the case for the reading of decontamination literature. This environmental saving will also increase as energy mix of countries increasingly becomes more renewable.

In contrast, in the second paper Sukswan showed that a paper notebook performed better from an environmental perspective compared with the tablets in the most environmental

categories.⁴¹

1.1.8. Plastic bags versus plastic reusable containers: Sending products to a laboratory

HTM 01-05 suggests that if the device is to be returned to a supplier (etc) a label should be used (etc) and affixed to the package. Although HTM 01-05 doesn't mention the type of product/packaging that should be used in transporting a product back and forth from the laboratory, The instrument to be returned should be decontaminated firstly and placed in a paper wrapping or plastic to prevent damage in transit and then in a hard plastic sealed box so it cannot puncture through. It is then labelled which may also include a sharps warning. To summarise we believe that most anecdotally would use a combination of plastic bags in plastic containers.

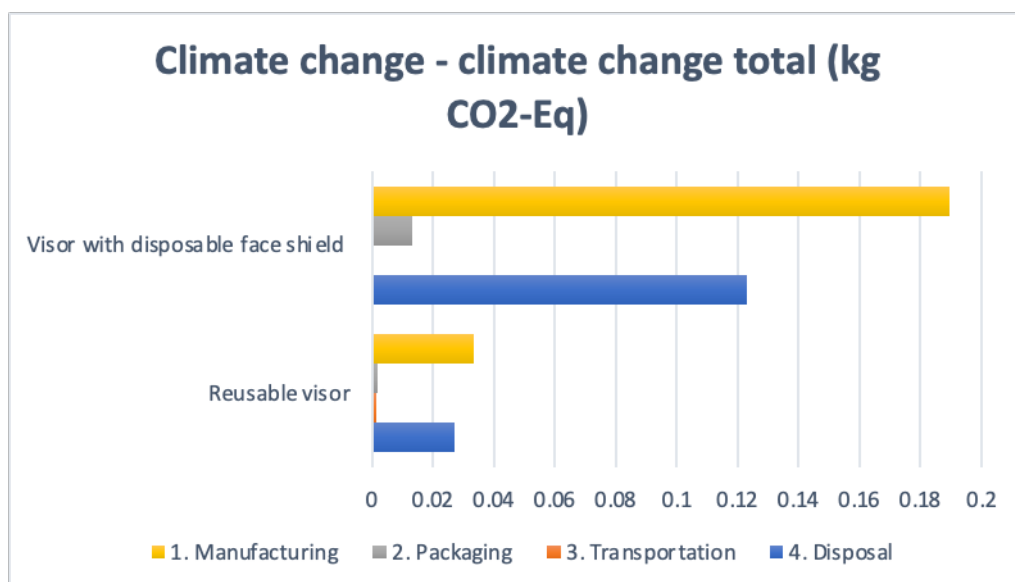
From an environmental perspective there is a significant impact of using plastic bags compared with/or alongside usable containers. According to "time for change" a plastic bag generates about 33 grams of CO₂,⁴² whereas the carbon footprint of a half litre container of has a total carbon footprint equal to 2.5 times this; 82.8 grams of carbon dioxide.⁴³ Any comparison of carbon footprints should be taken with some caution, however in keeping with the evidence presented in the rest of the paper, clinicians should be using washable reusable containers. The literature confirms that disinfection and microbiological monitoring and validation of reusable waste containers is not indicated, and that washing with hot water and detergent, using visual criteria for cleanliness and due diligence with regard to contractor selection, enable reusable containers to be safely used.⁴⁴ As well as reducing landfill waste, costs and environmental emissions the use of a reusable container also reduces sharps injury risk to healthcare workers.^{45,46}

The other environmental issue here is the production, use and disposal of labels. We advocate that reusable containers should be used with minimal packaging to transport products back and forth from the label. Healthcare providers could consider writing using wipeable pen on the container to save this environmental cost.

1.1.9. PPE: Disposable vs reusable visors

HTM 01-05 says that “disposable visors are available and may be used” with no reference to their planetary effect. In a study within dentistry comparing plastic reusable visors versus disposable visors there was clear environmental advantages using reusable visors.⁴ See figure 1. This study of the high environmental footprint associated with visors agrees with a recent paper by Rizan, where reusing visors provided definite environmental advantages.¹²

Figure 1: Climate change carbon emissions per use of disposable visor compared with reusable visor



1.1.1. PPE: Gloves

HTM-0105 states that appropriate personal protective equipment (PPE) should be worn during decontamination procedures, and specifically references both disposable clinical gloves and household gloves.² Gloves are needed to protect hands from becoming contaminated with organic matter and microorganisms; to protect hands from chemicals that adversely affect skin, such as caustic chemical agents used in disinfection; and to minimise the risks of cross-infection by preventing the transfer of organisms from staff to patients and vice-versa (also [1] from HTM itself).

However, there is growing evidence detailing the environmental impact of clinical gloves,

specifically nitrile gloves, typically manufactured from plastics or petroleum-based synthetic rubbers.¹² Rizan et al. highlighted the significant contribution that clinical gloves made to the environmental impact of healthcare during the first six months of the COVID-19 pandemic: nearly 48,000 tonnes of carbon dioxide equivalents (CO₂e). The estimated damage to human health of using gloves as part of PPE was 108 DALYs (disability-adjusted life years), equating to a loss of 0.21 species per year if describing the impact on ecosystems.

Risk assessment of glove use is necessary to mitigate the substantial environmental impacts. The WHO limits the use of medical gloves to examination (non-sterile or sterile) or surgical procedures requiring specific characteristics.⁴⁷ WHO explicitly states that inappropriate glove use represents a waste of resources if not contributing to a reduction of cross-transmission and may result in missed opportunities for hand hygiene (same ref WHO).

Crucially, HTM-0105 does offer household gloves as an option for decontamination, recommending weekly pairs of domestic household gloves if washed with detergent and hot water and left to dry after each use. These gloves, therefore, should not be sterile, and could meaningfully reduce the impact of decontamination as non-sterile gloves have the least environmental impact across gloves used in dentistry.⁴⁸

Sterile gloves can be made from natural rubber (latex) or synthetic rubber, and research by Jamal et al. describes how the climate change impact of sterile latex gloves was 11.6 times higher than non-sterile gloves.⁴⁹ Household gloves are commonly made from these two same natural and synthetic rubbers, but recently have been manufactured in durable silicone due to the prevalence of latex sensitivities. Silicone has a low chemical reactivity, has a broad range of thermal stability and is resistance to growth of microorganisms.⁵⁰

It could be suggested that swapping disposable nitrile gloves in favour of durable reusable silicone gloves for decontamination purposes could reduce the environmental impact of dental glove use. There is also considerable variation in permeability of nitrile gloves observed when testing disposable nitrile gloves potentially due to differences in movement of the operator's hands.⁵¹ These factors should be taken into consideration when favoring the convenience and disposability of say nitrile gloves over the reusability and protection of reusable silicone gloves.⁵² This same reasoning could be applied to the practice of some routine dentistry where the necessity of gloves may be called into question, but this is outside

the scope of this paper.

1.1.2. PPE: Plastic aprons/gowns: Disposable or reusable clothing

The recommendation by HTM 01-05 to use plastic disposable clothing does not come without consequences. Vozzolla showed that using reusable gowns rather than disposable gowns lowered energy(64%), carbon dioxide equivalent emissions (66%), water consumption (83%), and solid waste (84%).⁵³

According to Rizan¹² the carbon footprint of a plastic apron is 65 grams. Within her research she demonstrated that aprons accounted for 27% of the carbon footprint of NHS PPE.¹²

There are other advantages in considering reusable (washable) clothing compared with disposable clothing. Disposable gowns do not for example always meet specifications for impact penetration water resistance.⁵⁴

1.1.3. Remote decontamination unit

Although HTM 01-05 is a guide to decontamination within the dental practice, some practices may opt to outsource the reprocessing of their instruments to other organisations. The vehicle emissions that result from transporting instruments to and from dental practices are harmful to the population, contributing to air pollution (particulate matter, carbon monoxide and nitrogen dioxide) and atmospheric carbon dioxide and other greenhouse gases. In 2001 remote decontamination facilities were used by 8% of dental practices in the UK, but it is not known how this proportion has changed over the last 20 years.⁵⁵ Further research is also needed to quantify the distances that instruments travel between dental practices and reprocessing facilities, and the impact that this transportation has on the environment. As an example, a Leeds facility provides instrument reprocessing services to medical and dental services as far afield as Manchester. The 145km round trip in a light commercial vehicle would result in 8.7 seconds worth of DALYs lost from the population for every kilogram of products transported.¹ Multiple trips per week from healthcare services across the region

¹ Based on Ecoinvent data

mean the DALYs would quickly accumulate. DALYs from travel to remote decontamination facilities occur in addition to the environmental and human health impacts of the decontamination process, with no appreciable benefits to patient safety. For this reason, we cannot recommend remote instrument decontamination

1.1.4. Single use instruments (including single use trays)

HTM 01-05 suggests that difficult-to-clean reusable instruments and those for which a reliable cleaning regimen is not available should be replaced with single-use instruments. However, considerable research on the environmental impact of single-use instruments emphasizes the environmental consequences of this practice. A Life Cycle Assessment by Rizan and Bhutta (2021) evaluated the environmental impact of hybrid laparoscopic instruments (single use and reusable components) and their single use equivalents.¹³ They found that the carbon footprint of using hybrid instruments was 76% lower than using the single-use equivalent, saving 5.4kg CO₂e per operation. Similarly, Sherman et al. (2018) conducted a Life Cycle Assessment to compare reusable and single-use laryngoscopes and found that single use devices generated 16-18 times more life cycle carbon dioxide equivalents than reusable alternatives.⁵⁶ It was concluded that reusable instruments had a significantly lower environmental impact. Lastly, Byrne et al (Unpublished) compared the impact of reusable and disposable dental examination kits.¹¹ Through a Life Cycle Analysis, they concluded that the disposable dental examination kits had a three-fold increase in DALY impact compared to the reusable kits, accounting for approximately 11-seconds of lost human life, primarily attributed to global warming. As such, we conclude that single use items that pose no appreciable benefit to patient safety should not be recommended.

1.1.5. Single use wipes

Like most decontamination processes the healthcare operator needs to consider both the environmental. In a recentecoinvent LCA (undertaken for a textbook the authors are writing), it was shown that the reusable wipes contributed a high environmental footprint, with the worst single use wipe (quantity per patient 4 wipes) contributing 0.45 grams of

carbon equivalent emissions. Converting this, along with other environmental impacts shows that a wipe can cause 4.5 seconds of DALY loss⁵⁷

There is only limited evidence to suggest that single use/disposable wipes are better from a decontamination perspective than the reusable wipes.

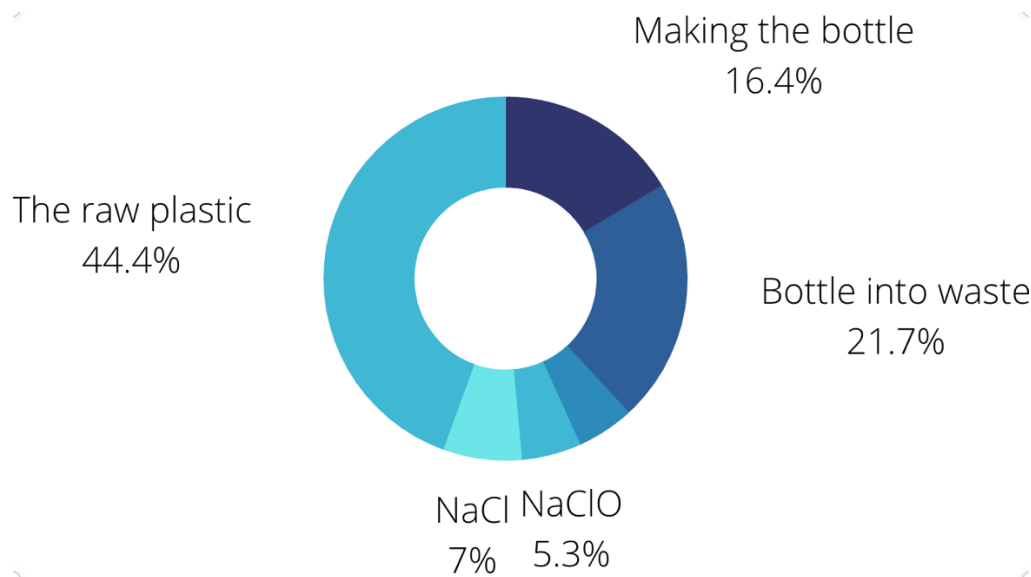
Single use wipes come already impregnated with disinfectant solution, with a constant wipe to disinfectant ratio.⁵⁸ In addition, these cloths do not require the environmental cost of regular laundry. However, despite this, there is a greater environmental impact associated with the production, procurement, storage and disposal of single use wipes.⁵⁹

Reusable wipes have the benefit of being multiple use and relatively inexpensive if made from recycled cloths⁶⁰. Laundering these wipes may potentially be ineffective in eliminating all microbes leading to a risk of contamination of surfaces.⁶¹ The evidence also suggests that reusable cloths may be incompatible with certain disinfectant solutions.⁶² Furthermore, the process of regular laundry of reusable wipes has an environmental impact, associated with transport as well as the process of the laundry itself.

1.1.6. Cleaning products e.g. Sodium hypochlorite

There are probably more sustainable products to replace the various cleaning products e.g. hypochlorite that we use but a literature review is required on this. Within the LCA ecoinvent based research we undertook for our textbook we found that the environmental consequences of the disinfection product came from the water bottle, both in its material, manufacture and disposal; (see figure 2) These impacts need to be considered; with any recommendations of products such as this also informing health professionals of the need to purchase products in higher concentrations (less packaging) or better more environmentally sensitive packaging.

Figure 2: The breakdown of the carbon footprint of a bottle of sodium hypochlorite (with sodium chloride) on the environment:



1.1.7. Thermal and or disinfection cleaning

HTM 01-05 states that uniforms and workwear should be washed at the hottest temperature suitable for the fabric to reduce any potential microbial contamination- assume this would be the same for non-disposable hand drying towels. Our life cycle analysis compared the DALYS of thermal disinfection (71 degrees), chemo-thermal disinfection (50 degrees), and chemical disinfection (25 degrees) of washing one kilogram of clothing. The biggest problem with using these chemicals is their associated carbon footprint and water consumption. The highest contributor to DALYS is chemo-thermal disinfection According to the LCA results thermal disinfection resulted in significant less DALY seconds (18 seconds) lost compared to the other methods of disinfection (chemo thermal); 18 seconds, and just chemical 27 seconds..

1.1.8. Wrapping of instruments

Sterile barrier systems are needed to prevent microbial contamination of sterile dental instruments.⁶³

Most research into sterilisation barrier systems focuses on blue single use wrapping in operating theatres but in dental practices sealable plastic and paper pouches are most commonly used.

Sterile pouches can be separated into their constituent parts and recycled⁶⁴, but reuse is not

recommended. However, there is some evidence that if packaging integrity is maintained instruments can be used clinically and sterilised up to three times and stored for 6 months without internal microbial contamination of the pouch.⁶⁵

Opportunities exist for dentists to use reusable sterilisation packaging. Rigid containers can be used for sterilisation, transportation and storage of instruments with as previously discussed a much lower environmental footprint. However these containers can be bulky, and hold large volume of instruments that may be unsuitable for dental practices and may not fit standard autoclaves.

FDA registered reusable instrument pouches have also been developed and are in use clinically in the USA, however these require ISO certification before they can be used in the UK.⁶⁶

Reusable instrument wraps are a viable alternative, however may have a larger environmental impact than disposable wraps due to the laundering process.⁶⁷ An LCA is needed to compare the environmental impact of all the available packaging options and make recommendations to clinicians.

HTM 01-05 recommend that wrapped sterilised instruments can be stored for up to 12 months before they must be reprocessed. These recommendations may be too restrictive and the evidence supporting this time-related shelf life is limited. Setting an expiry date has consequences for the availability of resources and harms to the environment and to human health. Dental instruments sterilised and cultured at intervals over a period of a year showed no increased likelihood of contamination with increasing time.⁶⁸ After 1 year only 3 out of the 300 sterilised instruments showed any microbial growth at all, and because this was not time dependent, the authors suggest that the recontamination may have occurred during the culturing process. Similar studies of medical instruments showed maintenance of sterility from 6 months up to 2 years and in one case up to 10 years.⁶⁹ However the methodologies used vary and some limitations including only small numbers of instruments being tested at longer time intervals. Recontamination of instruments may be affected by how the wrapped instruments are stored (humidity, temp, wrapping material etc) – Schwartz instruments stored in dental cupboards which are opened multiple times daily, and the choice of wrapping material.

There is evidence that a move towards event-related shelf life may be a more appropriate,

sustainable and efficient approach to maintaining instrument sterility. Instruments should be considered to be sterile unless their packaging is compromised. Event related shelf life is used in decontamination guidance from Australia**Error! Bookmark not defined.**, New Zealand**Error! Bookmark not defined.**, Scotland**Error! Bookmark not defined.** and Canada**Error! Bookmark not defined.**. These policies reduce the need for reprocessing unused instruments with the associated environmental impact, however such change would require policies and procedures that ensure sterility is maintained, for example labels which encourage staff to check packaging integrity before opening and rotation of instruments in storage.

HTM 01 05 states that unwrapped instruments require reprocessing after 1 week if stored away from clinical areas and 1 day if stored in the clinic. A literature review is needed to determine if these expiry dates are evidence based.

Conclusion:

From an environmental sustainability perspective, the world is quite a different place from when HTM 01-05 was updated 8 years ago. We are increasingly aware of the impact our resource manufacture, use and disposal have on both planetary health and in turn human health. We urge the department of health and other similar organisations internationally to consider our thoughts on environmental sustainability.

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