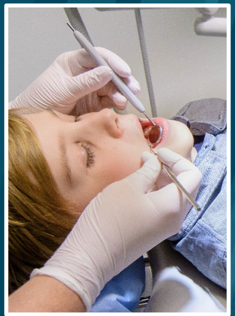
UiT The Arctic University of Norway

22 Nov. 2024:
Microplastics and Human Health: Sources, Exposure, and Impact

The environmental impact of polymer plastics used in clinical dentistry



Asbjørn Jokstad, DDS, Dr. odont.

Background

- Dentists use large quantities of synthetic polymers for multiple purposes. Estimates of waste, polymer compound elution and the ecological impact are inconsistent.

..all in a day's work →

Background

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- We systematically reviewed the literature to estimate the impact from polymer: 1. Extraoral use (personal protection, clinic items)

Compound	acronym	Items in clinic waste
Acrylonitrile Butadiene Styrene	ABS	Container, handle, suture, tray
Latex rubber		Dressing, elastics, gloves, washer
Synthetic rubber / AKA «Nitrile»		Dressing, elastics, gloves, washer
Plastics, general		Lid, packaging, tube
Polyamide 6	Nylon 6	Bag, drape, dressing, toothbrush
Polycarbonate	PC	Occludator, tray, tube
Polychloroprene / AKA "Neoprene"		Gloves
Polyester, non-woven		Disinfectant wipe
Polyethylene film		Bag, cover, drape, dressing, packaging, visor
Polyethylene resin, high/low density	LDPE / HDPE	Brush, liner, mixing tips(h), packaging(l/h), tube(h), syringe(h)
Polyethylene terephthalate	PET	Drape, glove, packaging
Polyethylene, general	PE	Glove, packaging, pouch, strips, syringe, tube
Polyisoprene		Gloves
Polypropylene injection-mould	PP	Bowl, brush, cups, , quiver, suture, syringe, tube
Polypropylene film / AKA "Prolene"	PP	Bag, drape, gown, hood, mask, packaging, wrap
Polystyrene	PS	Packaging
Polyurethane rigid/flexible foam	PU	Brush, foam cube, tube, wound dressing
Polyvinyl chloride	PVC	Bowl, drape, tube
Phthalates		Unknown quantities / qualities, < 1%

Background

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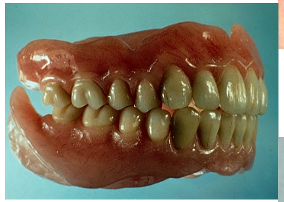
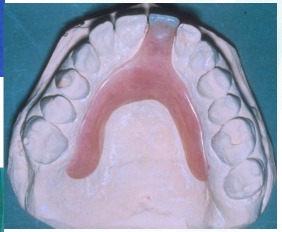
- We systematically reviewed the literature to estimate the impact from polymer: 1. Extraoral use 2. Intra-oral devices

Compound	acronym	Items
Acrylonitrile Butadiene Styrene	ABS	Orthodontics
Ethylene glycol dimethacrylate	EGDM	Prosthesis
Ethylene-vinyl acetate / AKA poly(ethylene-vinyl acetate)	EVA/PEVA	Soft splint
Polycarbonate	PC	Orthodontics, prosthesis, mouthguards/splints/ retainers
Poly(methyl methacrylate)	PMMA	Orthodontics, prosthesis, mouthguards/splints/ retainers
Polyamide 6 / AKA Nylon	Nylon 6	Orthodontics, prosthesis, suture
Polycaprolactone	PCL	Drug delivery, grafting
Polychloroprene / AKA "Neoprene"	CR	Barrier
Polyetherether ketone	PEEK	Implants, orthodontics, prosthesis
Polyethylene glycol	PEG	Gels, impressions, lubricant
Polyethylene resin, high/low density	LDPE / HDPE	Prosthesis lining
Polyethylene terephthalate	PET	Orthodontics
Polyethylene terephthalate glycol-modified	PET-G	Orthodontics, prosthesis, vacuum formed mouthguards/splints/ retainers
Polylactic Acid	PLA	Drug delivery, grafting
Polyoxymethylene / AKA Acetal resin	POM	Prosthesis (alternative re. Allergy)
Polycarbonate-modified bis-GMA	PC-bisGMA	Orthodontics, prosthesis, vacuum formed mouthguards/splints/ retainers
Polystyrene	PS	Prosthesis (alternative re. Allergy)
Polytetrafluoroethylene	PTFE	Barrier (GBR), barrier (cement, screw hole), spacer (restorations), crown fitting
Polyurethane, thermoplastic	TPU	Orthodontics, prosthesis, vacuum formed mouthguards/splints/ retainers
Polyvinyl chloride	PVC	Orthodontics, prosthesis, vacuum formed mouthguards/splints/ retainers
Polyvinylidene fluoride	PVDF	Orthodontics
Synthetic rubber / AKA «Nitrile»		Barrier membrane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- We systematically reviewed the literature to estimate the impact from polymer 1. Extraoral use 2. Intra-oral devices 3. Restorative materials

Methacrylate ester monomers	acronym
Bisphenol A glycidyl methacrylate / AKA Bowen monomer	Bis-GMA
Bisphenol A dimethacrylate	Bis-DMA
Bisphenol A polyethoxy dimethacrylate	Bis-MPEPP / BPEDMA
Dihydroxyethyl acrylate (cross-linking)	DHEA
Ethoxylated bisphenol-A glycol dimethacrylate	Bis-EMA / EBPADMA
Ethylene glycol dimethacrylate (cross-linking)	EGDMA
Glycidyl methacrylate	GMA
Hexane diol dimethacrylate	HEDMA
Hydroxyethyl methacrylate	HEMA
Isobutyl methacrylate	IBMA
Methyl methacrylate	MMA
Polycarbonate-modified bis-GMA	PC-bisGMA
Tricyclodecane - dihydroxyethyl acrylate	TCD-di-HEA
Triethylene glycol dimethacrylate	TEGDMA
Trimethylolpropane trimethacrylate	TMP-TMA
Urethane dimethacrylate	UDMA
Urethane modified bis-GMA dimethacrylate	U-bisGMA

Additives		
Accelerator	Parbenate	
Antioxydant (inhibitor)	Butylated hydroxytoluene	BHT
Photoinitiator	Camphorquinone	CQ
Chemical initiator	Benzoyl peroxide	BPO
Photoinitiator	ethyl 4-(dimethylamino) benzoate	EDMAB
Photostabilizer	Benzophenone-3	BP-3
Photostabilizer	Drometrizole trisiloxane	DTS
Filler siloxanes (Multipurpose: 60-70% 0.04, 0.2-3µm; nanocomposite: 72-79% 0.002-0.075 µm, microcomposite: 32-50% 0.04 µm, bulk fill 59-80% 0.04, 0.2-20µm; flow: 42-62% 0.04, 0.2-3µm; e.g.		
3-methacryloxypropyltrimethoxysilane		
3-glycidoxypropyl)-dimethylethoxysilane		GPMES
Degradation products		
Bishydroxypropoxyphenylpropane		Bis-HPPP
Bismethacryloxypropoxyphenylpropane		Bis-PMA
Bisphenol A diglycidyl ether		BADGE / DGEBA
Bisphenol A ethoxylate methacrylate		Bis-EMA(3) / …(6) / …(10)
Bisphenol F diglycidyl ether		BFDGE / BFDGE*2H2O
Urethane dimethacrylate derivative		UDMA-D2
Contaminants (and unreacted monomers*)		
Bisphenol A		BPA
Methacrylic acid		MAA
Triethylene glycol		TEG
*Unreacted monomer components		e.g. HEMA, MMA, TEG

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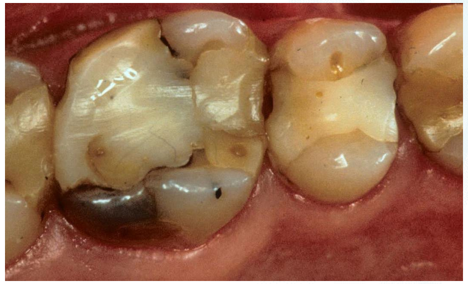
- We systematically reviewed the literature to estimate the ecologic impact from polymer use:

1. Extraoral use
2. Intra-oral devices
3. Restorative materials
    - manufacturing
    - clinical handling
    - degradation



Methods

- PROSPERO registration

NIHR | National Institute for Health and Care Research

PROSPERO

International prospective register of systematic reviews

Home | About PROSPERO | How to register | Service information | Search | Log in | Join

Click to **show your search history and hide search results**. Open the **Filters** panel to find records with specific characteristics (e.g. all reviews about cancer or all diagnostic reviews etc). See our **Guide to Searching** for more details.

Click to **hide the standard search and use the Covid-19 filters.**

CRD42023472616 | Go | MeSH | Clear filters | Show filters

First | Previous | Next | Last (page 1 of 1)

1 record found for **CRD42023472616**

Show checked records only | Export

	Registered	Title	Type	Review status
☐	27/10/2023	Polymer use in oral health care settings and impacts on human and planetary health [CRD42023472616]		Review Ongoing

Methods

- PROSPERO – (CRD42023472616 - *Polymer use in oral health care settings and impacts on human and planetary health)*
- Boolean search strategies adapted to different bibliometric databases & grey literature + www sites & resources

Pubmed search

(dentist OR "dental health services"[mesh] OR "oral health care" OR "Dentistry"[mesh]) AND ("Polymers"[mesh] OR "Organic Chemicals"[mesh] OR "plastic*"[tw] OR "polymer*"[tw] OR "Resin*"[tw] OR "acryl*"[tw]) AND (**"Environmental Pollution"[MESH] OR "waste management"[MESH] OR "ecology"[MESH] OR "environment*"[tw] OR "waste*"[tw] OR "pollut*"[tw] OR "ecolog*"[tw]) n=1911**

(dentist OR "dental health services"[mesh] OR "oral health care" OR "Dentistry"[mesh]) AND ("Protective devices"[mesh] OR "surgical equipment"[MESH]) AND (**"Environmental Pollution"[MESH] OR "waste management"[MESH] OR "ecology"[MESH] OR "environment*"[tw] OR "waste*"[tw] OR "pollut*"[tw] OR "ecolog*"[tw]) n=354**

(dentist OR "dental health services"[mesh] OR "oral health care" OR "Dentistry"[mesh]) AND **"Conservation of Natural Resources"[Mesh] n=260**

https://iebh.github.io/sra-polyglot/#

SRA Polyglot search translator

- Cochrane Library
- Embase (OVID)
- EBSCOhost: (ERIC + CINAHL + Risk Management Reference Center + GreenFILE + MEDLINE + eBook Open Access Collection + AMED (The Allied and Complementary Medicine Database)
- ScienceDirect
- Web Of Science

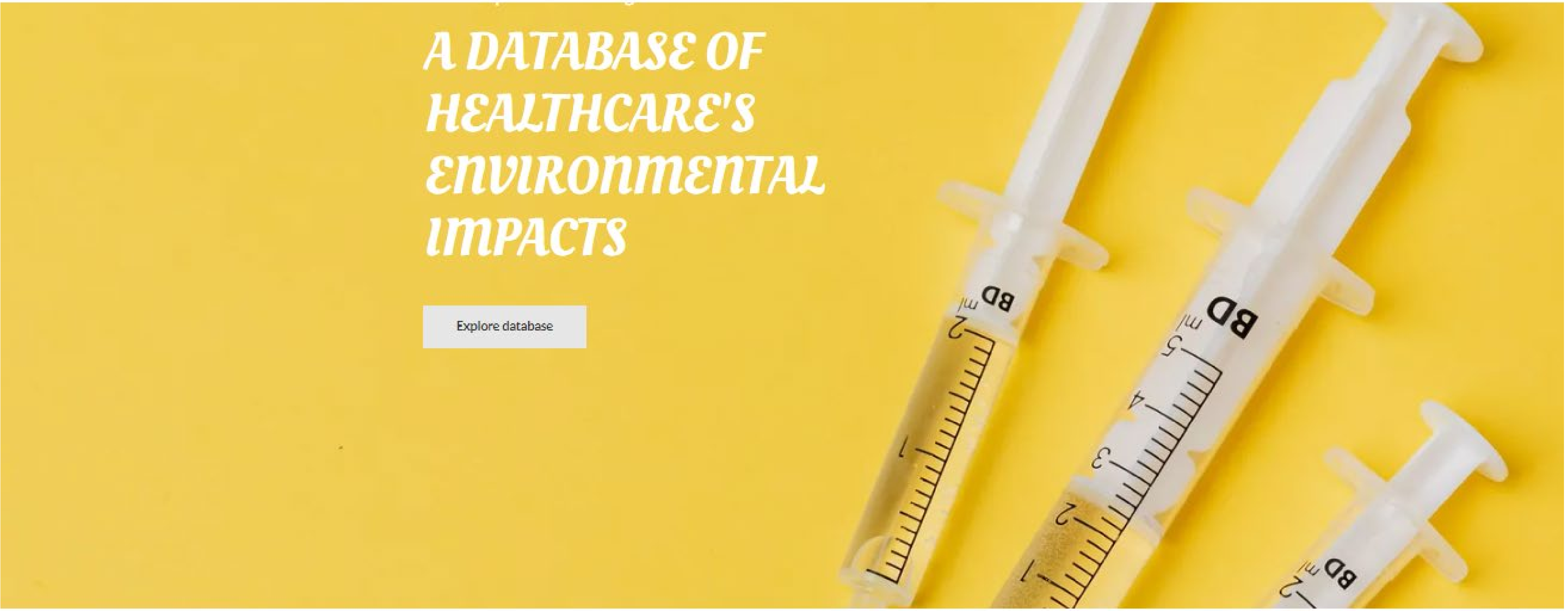
\+

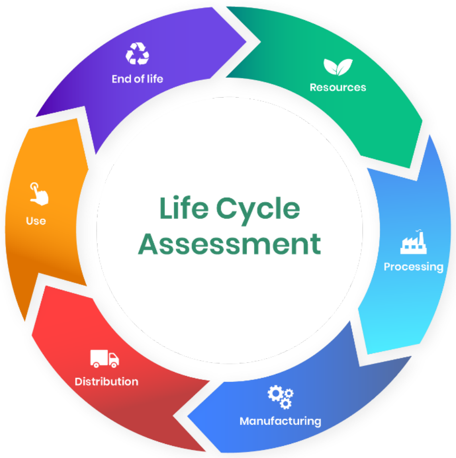
Grey: IADR abstracts + Google Scholar + ProQuest Dissertations & Theses Global
Registers: Prospero (registered SRs)
Websites: World Health Organization + NDAs: Amer. DA, Aus DA, Brit. DA, Norwegian DA
Organisations: Centre for Sustainable Healthcare U.K. + FDI World Dental Federation + Environmental defence + Arup, Health Care Without Harm
HealthLCA (Life cycle analyses)
Citation lists hand-searching

https://healthcarelca.com

HealthcareLCA

gallery database search charts tutorials about





HealthcareLCA

Database summary

7,000 impact values, 2,000 products and processes, 1,000 authors, 600 institutions, 300 data sources, 190 countries, 20 years

From individual pharmaceuticals to entire health systems, researchers around the world are working hard to assess the environmental impacts of different aspects of healthcare.

HealthcareLCA serves as an up-to-date repository for this work, bringing together

Jump to chart:

— cumulative data sources
— geographical distribution
— scale of analysis
— author institutions
— income category
— world region
— healthcare field
— disciplinary coverage
— impact categories

Methods

- PROSPERO – (CRD42023472616 - *Polymer use in oral health care settings and impacts on human and planetary health)*
- Boolean search strategies adapted to different bibliometric databases & grey literature + www sites & resources
- According to AMSTAR & PRISMA
  - One investigator identified publications
  - Two independent investigators in duplicate:
    - Examined contents for estimates of waste, pollution or material component elution -> consensus
    - Extracted data -> consensus
    - Study characteristics, study methodology & risk of bias using checklists validated for study design -> consensus
  - Extracted data subjected to meta-analyses suitable to the type of statistical data, if feasible (Revman). Alternatively, findings reported according to the Synthesis-Without-Meta-analysis (SWiM) methodology

Eligible outcomes and measures within 5 domains

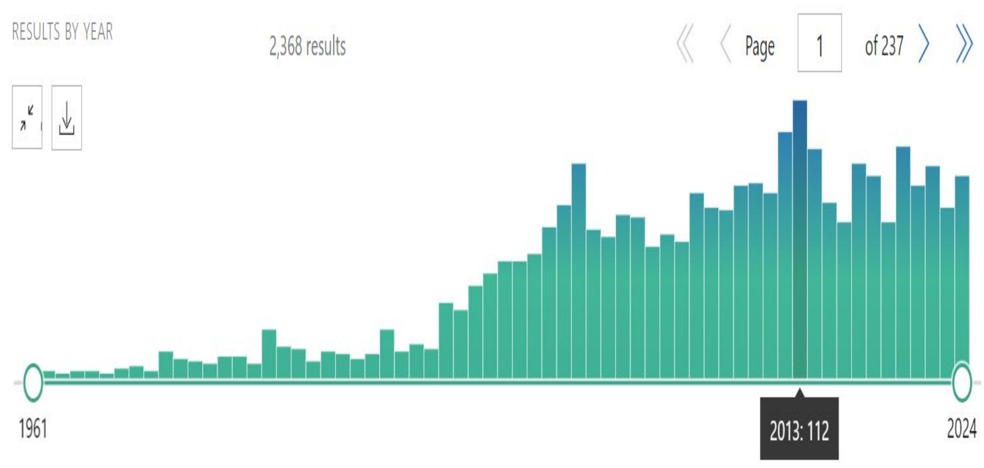
1. Environmental impact	2. NMSPs qualities or quantities	3. NMSPs qualities or quantities	4. Monomer elution or NMSPs qualities or quantities	5. Monomer elution or NMSPs qualities or quantities
SP items & devices • **manufacturing** • **procurement** • **handling** • **disposal**	**Pollution, ambient air & wastewater**	**in waste**	**in body fluids or tissues**	**in the local environment**
Validated life cycle appraisal (LCA) methodology 	mass (mg, g, kg, ton)	mass (mg, g, kg, ton) or the number of single-use items	ng/ml, ppm, ppb	ng/ml, ppm, ppb
Impact categories include potential effects on human health, ecosystem quality, climate change, and resources	per intervention or patient or clinic	per intervention, patient or clinic	after an intraoral placement of a SP device	associated with SP waste • collection, • management • deposition
	per day, week, month, or any other temporal description	per day, week, month, or any other temporal description	minutes, hours, days, weeks, months, or years	

SP: synthetic polymer

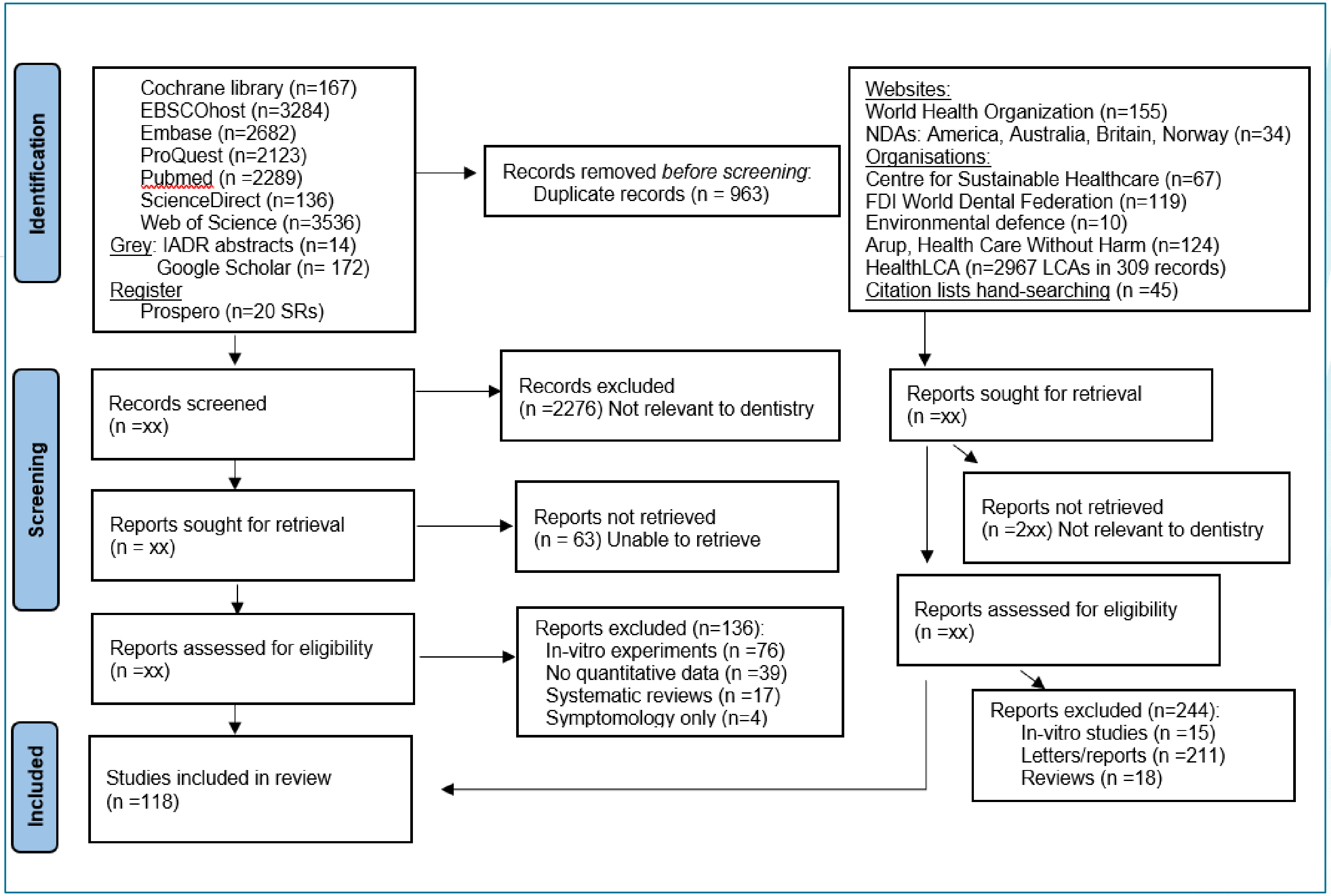
NMSPs: nano- and microparticles of synthetic polymers

Results

- >3000 records of which 118 contained data on microplastics relevant for estimating environmental impact



Pubmed Nov 12, 2024



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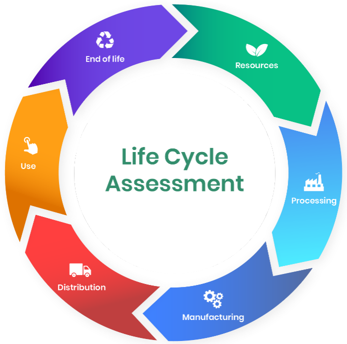
Studies (n=117):

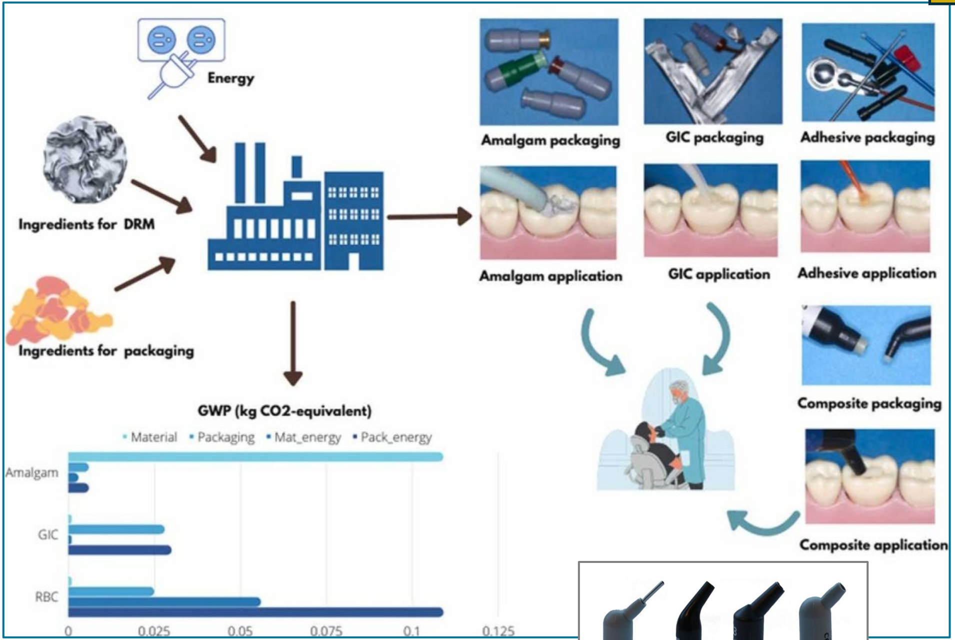
30 primary + 8 SRs	16 primary + 1 SR	14 primary	30 primary + 13 SR	5 primary studies

Domain 1: Environmental impact of restorative materials production

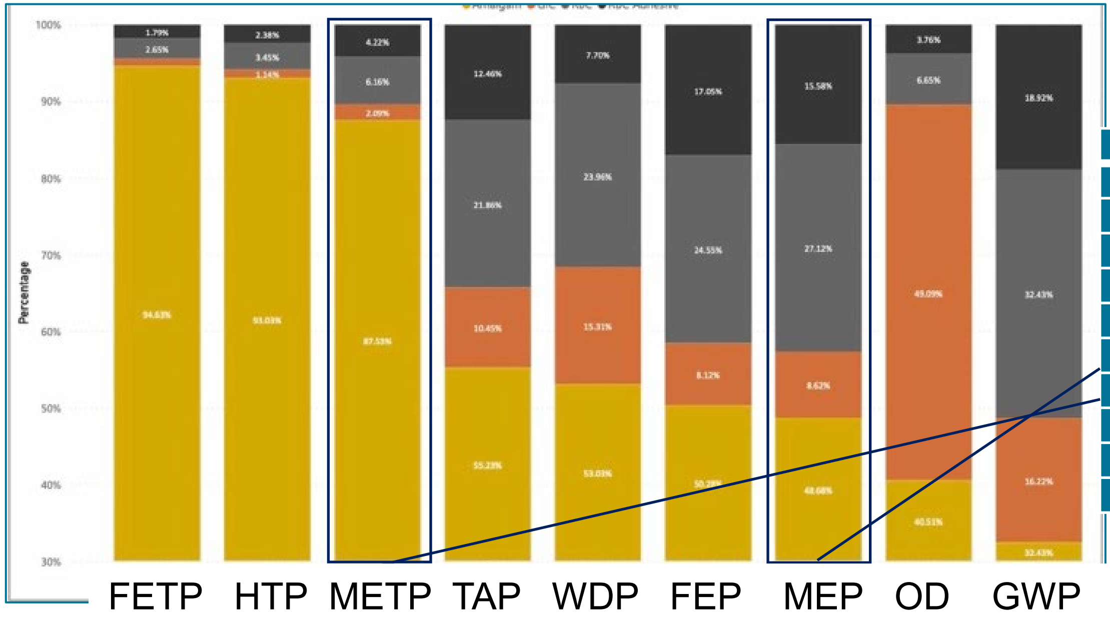


University of Sheffield
Nine impact categories
Highest impacts:

Amalgam: human- / freshwater & marine ecotoxicity,
Resin-bond composite: global warming potential, eutrophication
Glass ionomer cement: ozone depletion



Amalgam | Resin-bond composite | RBC-bonding | Glass ionomer cement



	IMPACT CATEGORY
FEP	Freshwater Eutrophication
FETP	Fresh Water Ecotoxicity
GWP	Global Warming Potential
HTP	Human Toxicity
MDP	Metal Depletion
MEP	Marine Eutrophication
METP	Marine Ecotoxicity
OD	Ozone Depletion
TAP	Terrestrial Acidification
WDP	Water Depletion

Smith et al. doi: 10.1016/j.dental.2022.11.007

Domain 2: Pollution in ambient air or clinic wastewater

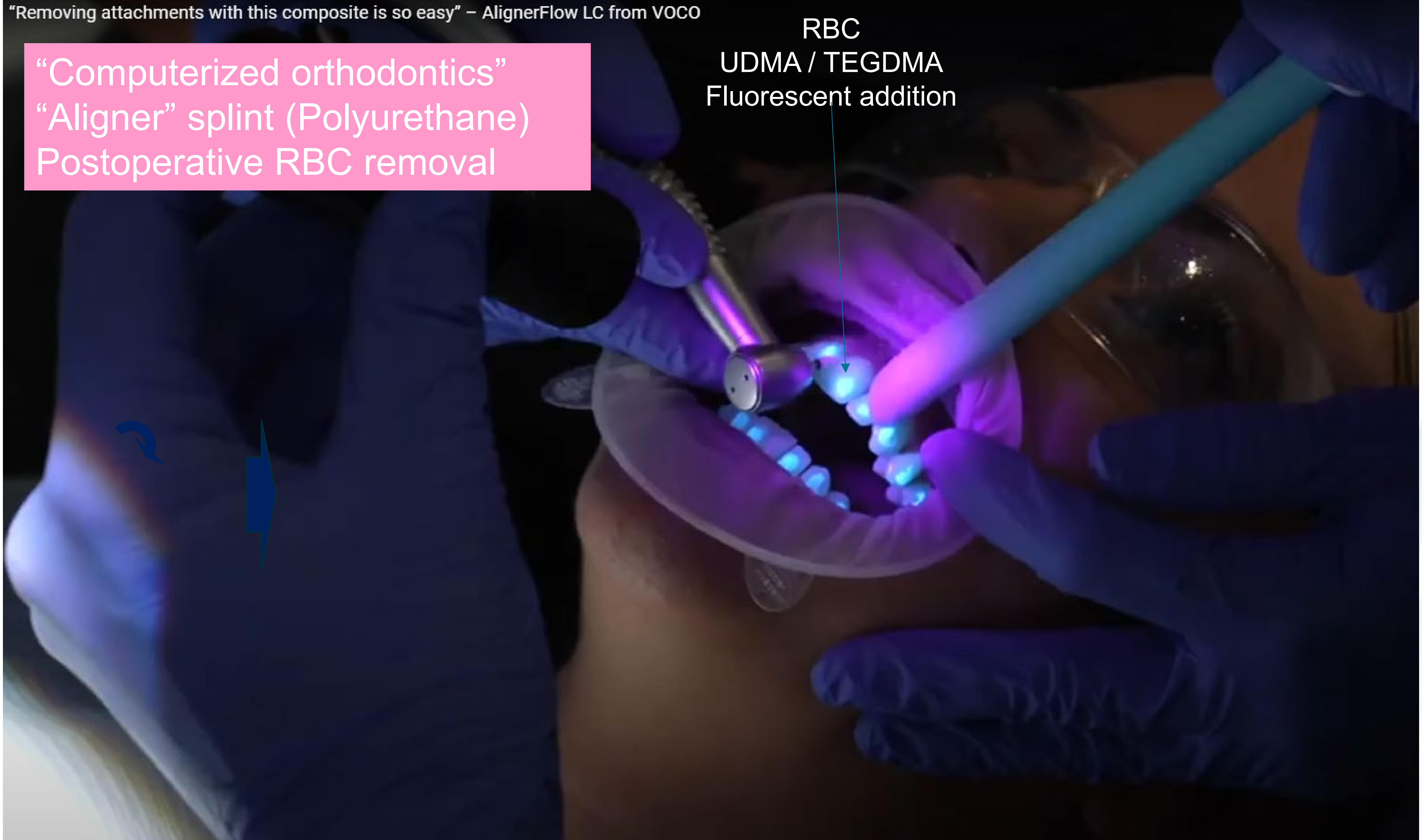
Air

Study	country	objectives	methodology
Pratt et al. (2023)	USA, Iowa	To simultaneously quantify airborne concentrations of the bacteriophage MS2 near the oral cavity of a dental mannequin and behind a face shield of the practitioner during a simulated orthodontic debanding procedure	Controlled simulation experiment
Field et al. (2022)	U.K., Kingston	to quantify and characterise the microparticles present within the surgical environment over a one-week sampling period	Sampling air next to a surgery operatory
Rafiee et al. (2022)	Canada, Edmonton	To characterise the size and concentrations of particles emitted from 7 different dental procedures	Sampling air in a dental operatory
Lahdentausta et al. (2022)	Finland, Helsinki	To measure aerosol generation in various dental procedures in clinical settings.	Sampling air in a public dental clinic
Razavi et al. (2021)	Canada, Waterloo	To assess the effectiveness of an indoor air purifier on dental aerosol dispersion in dental offices	Sampling air in a dental operatory
Iliadi et al. (2020)	Greece, Thessaloniki	To evaluate interventions and RBC properties related to the production of aerosolised dust during routine dental procedures	SR of studies sampling air in dental operatories
Vig et al. (2019)	U.K., Bristol	To investigate particulate production at debonding and enamel clean-up following the use of orthodontic brackets	Randomised controlled trial + Controlled simulation experiment
Van Landuyt 2014	Belgium, Leuven	To analyse RBC dust in actual work conditions	Sampling air in dental operatory + Controlled simulation experiment
Van Landuyt 2012	Belgium, Leuven	To characterize composite dust in vitro and to assess the clinical exposure	Sampling air in dental operatory + Controlled simulation experiment
Ireland et al. (2003)	U.K., Bath	To qualitatively determine whether airborne particles are produced during enamel cleanup at the end of orthodontic treatment	Sampling air in a dental operatory
Henriks-Eckerman et al. (2001)	Finland, Turku	To study exposure to airborne methacrylates and natural rubber latex (NRL) allergens during the placing of RBCs in six dental clinics in Finland	Sampling air in a dental operatory

Wastewater

Study	country	objectives	methodology
Binner et al. (2022) **Harding et al. (2022)** **Binner et al. (2019)**	Ireland, Cork	To measure the particle load and potential ecotoxicity of the particulate matter arising from a shift to predominately Hg-free dental filling materials in Irish dental facilities	sampling wastewater in a dental operatory
Mourouzis et al. (2022)	Greece, Thessaloniki	To detect monomers that are released during dental restorative procedures and then discharged into the environment through the drainage of the dental unit	sampling wastewater in a dental operatory
Polydorou et al. (2020)	Germany, Freiburg	To evaluate the release of bisphenol A in wastewater after grinding of RBCs and evaluated three filtration materials	Controlled simulation experiment
Polydorou et al. (2017)	Germany, Freiburg	To evaluate the release of nanoparticles in wastewater after grinding of RBCs	Controlled simulation experiment

N= 16 primary studies + 1 SR


"Removing attachments with this composite is so easy" – AlignerFlow LC from VOCO
"Computerized orthodontics"
"Aligner" splint (Polyurethane)
Postoperative RBC removal
RBC
UDMA / TEGDMA
Fluorescent addition

"Computerized orthodontics"
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R
UDMA /
Fluoresce

"Removing attachments with this composite is so easy" – AlignerFlow LC from VOCO

"Computerized orthodontics"
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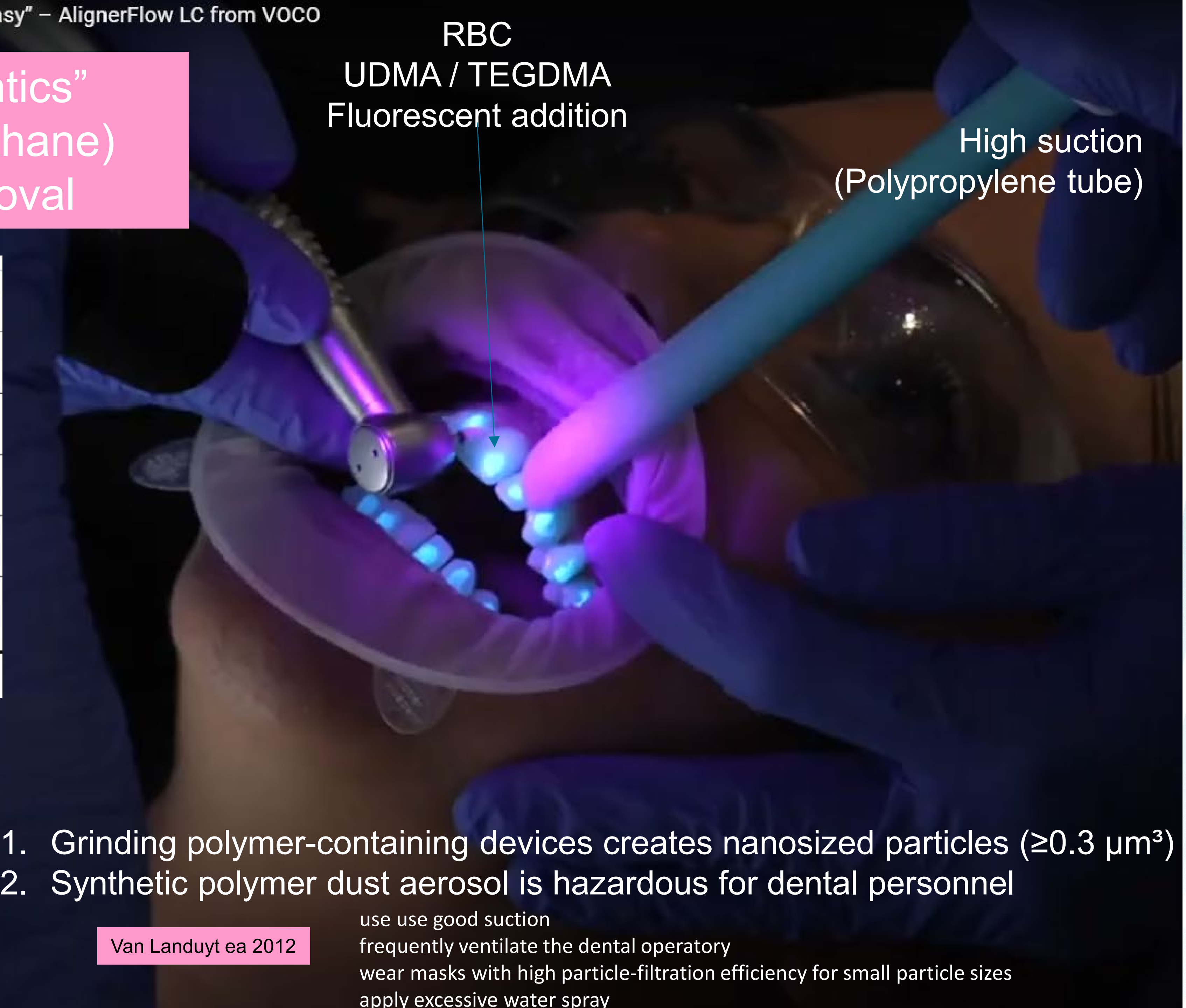


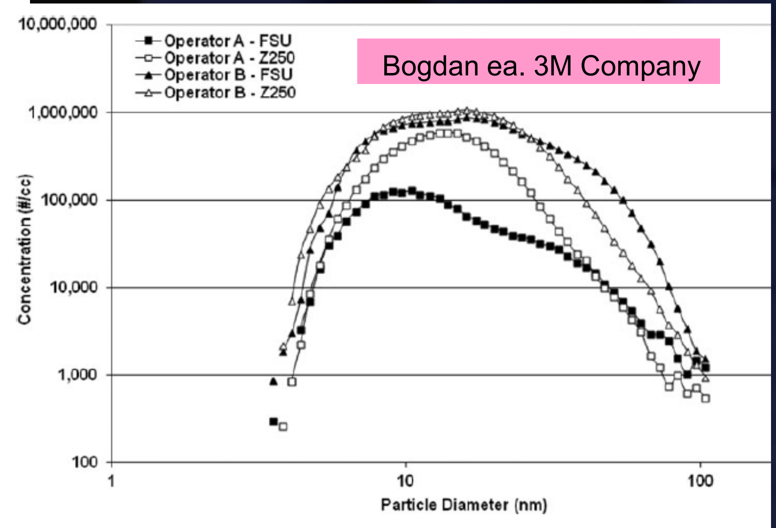
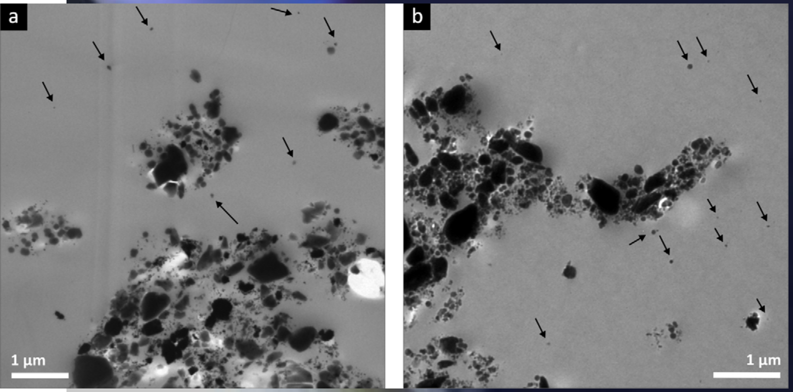


FIGURE 5. Two operators abrading the same composite materials.

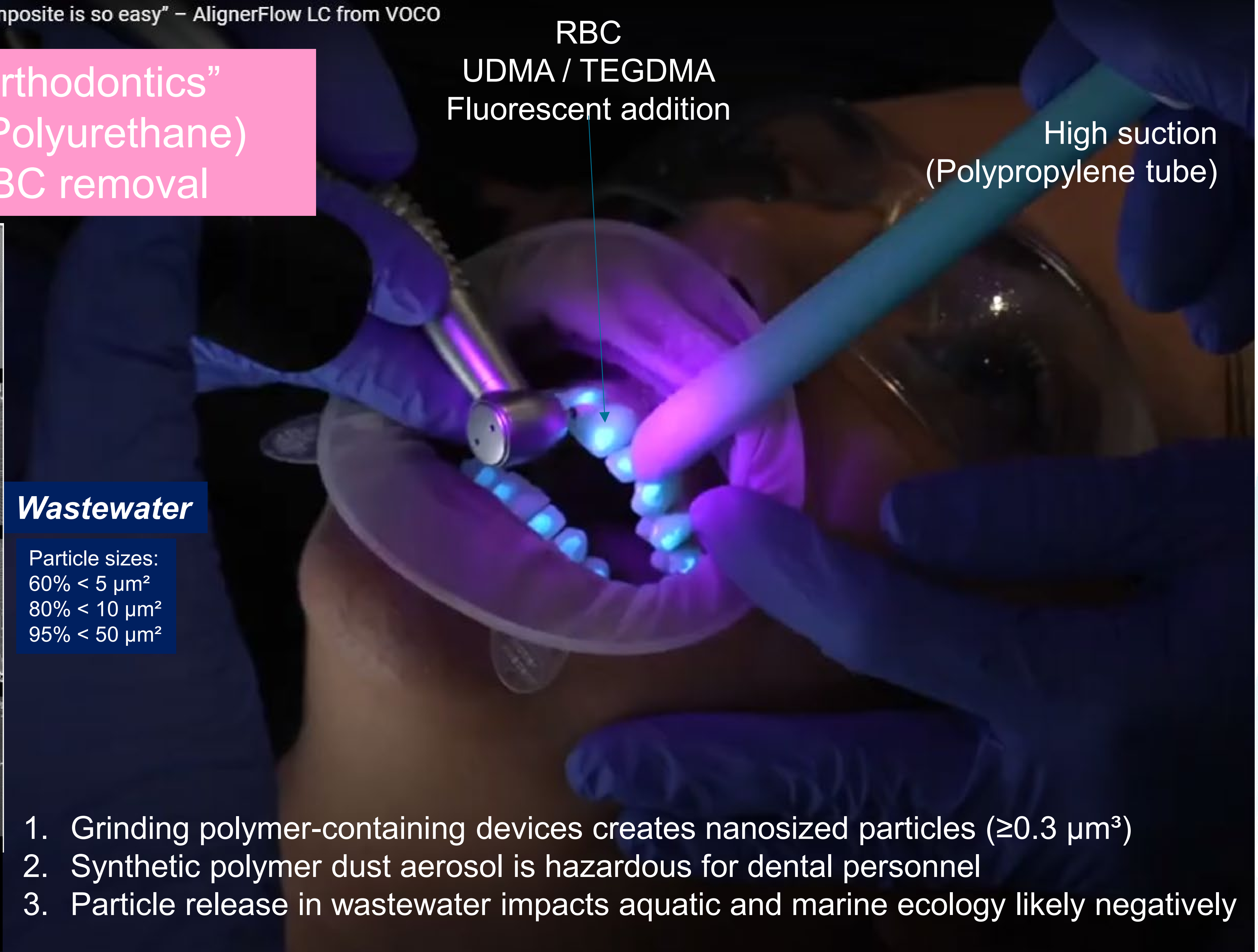
Journal of Occupational and Environmental Hygiene July 2014



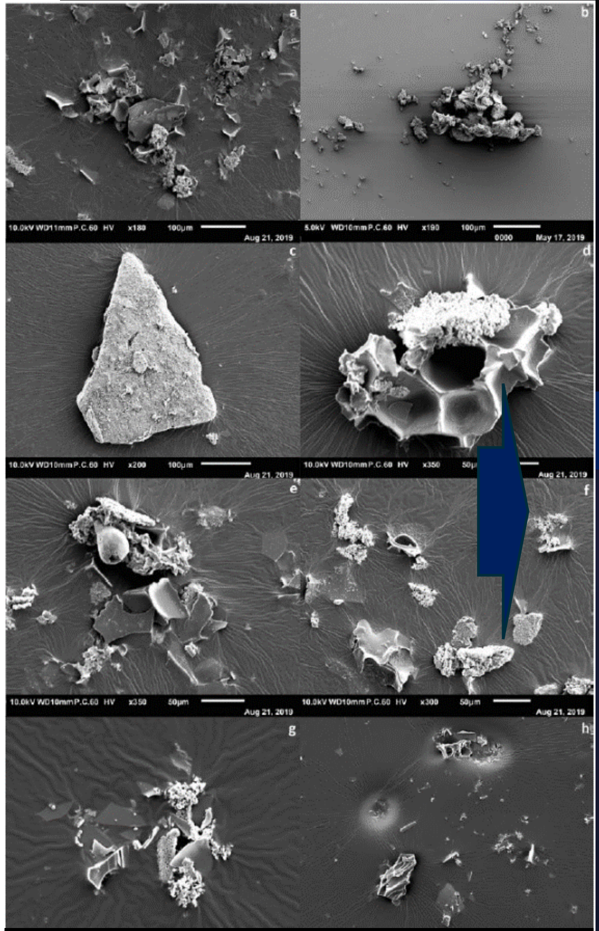
1. Grinding polymer-containing devices creates nanosized particles (≥0.3 μm^3)
2. Synthetic polymer dust aerosol is hazardous for dental personnel

Van Landuyt ea 2012

use use good suction
frequently ventilate the dental operatory
wear masks with high particle-filtration efficiency for small particle sizes
apply excessive water spray



"Computerized orthodontics"
"Aligner" splint (Polyurethane)
Postoperative RBC removal



SEM photograph:
Irish Environmental Agency
Harding ea 2022
www.epa.ie

Wastewater

Particle sizes:
60% < 5 µm²
80% < 10 µm²
95% < 50 µm²

1. Grinding polymer-containing devices creates nanosized particles (≥0.3 µm³)
2. Synthetic polymer dust aerosol is hazardous for dental personnel
3. Particle release in wastewater impacts aquatic and marine ecology likely negatively

Domain 3: Waste, containing synthetic polymers

N= 14 primary studies

Study	country	objectives	methodology
Martin et al. (2022)	U.K., Sheffield	To quantify (by number and mass) SUPwaste generated from the provision of oral healthcare in primary and secondary care clinical dental settings in the U.K.	Audited waste in the clinic
Haque et al. (2021)	Bangladesh	To provide an estimation-based approach in quantifying the amount of contaminated waste that can be expected daily from the massive usage of PPE because of the countrywide mandated regulations on PPE usage	Audited waste in the clinic
Aghalari et al. (2020)	Iran, Babol	To investigate the quantity, quality and management of wastes in general and specialised dental offices in Babol, Mazandaran Province	Audited waste in the clinic
Voudrias et al. (2018)	Greece, Xanthi	To compare the composition and production rate of Greek dental solid waste produced by three dentist groups of Xanthi, Greece	Audited waste in the clinic
Momeni et al. (2017)	Iran, Birjand	To assess dental waste production rate and composition and approaches used to manage these waste products in 2017 in Birjand, Iran	Audited waste in the clinic
Majlesi et al. (2018)	Iran, Qaem Shahr	To analyse the production of waste in dental offices of Qaem Shahr city, Iran	Audited waste in the clinic
Mandalidis et al. (2018)	Greece, Xanthi	To determine the composition, characterisation and production rate of Greek dental solid waste	Audited waste in the clinic
Amouei et al. (2016)	Iran, Babol	to evaluate the quantity and composition of dental waste produced by general and specialised dental offices in Babol City.	Audited waste in the clinic
Richardson et al. (2016)	U.K., Plymouth	To use an Audited approach to measuring the nature and quantity of dental clinical waste and assessing the feasibility of measuring the financial costs and potential carbon savings in the management of dental clinical waste	Auditeded waste in the clinic
Nabizadeh et al. (2014)	Iran, Gorgan	To investigate solid waste production and its management in dental clinics in Gorgan, northern Iran.	Audited waste in the clinic
Nabizadeh et al. (2012)	Iran, Hamadan	To identify the constituents, composition and production rate of dental solid waste and associated management practices in dental offices in Hamadan, Iran	Audited waste in the clinic
Vieira et al. (2009)	Brazil, Minas Gerais	To evaluate the composition of dental waste produced by three dental health services in Belo Horizonte, Minas Gerais State, Brazil.	Audited waste in the clinic
Kizlary et al. (2005)	Greece, Xanthi	To determine the composition and production rate of dental solid waste produced by dental practices in the Prefecture of Xanthi, Greece	Audited waste in the clinic
Ozbek et al. (2004)	Turkey, Ankara	To examine the composition of solid wastes coming from eight clinics of the dental school of a university hospital in Turkey	Audited waste in the clinic

Domain 3: Waste containing synthetic polymers

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Quantification of single use plastics waste generated in clinical dental practice and hospital settings

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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.

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	254 g	
G	Mean mass of SUPs per procedure: Generic set up and clean up	100 g	
J	Mean mass of SUPs: Generic PPE (g)	30 g	
K	Mean mass of SUPs: COVID-19 PPE (g)	305 g	
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**

A	Approximate number of dental healthcare professionals (Dentists)	1	
B	Working days per year (Grytten ea 2022)	230	days
C	Approx. number of operative procedures per day (NTF)	10	pts.
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	254	gram
G	Mean mass of SUPs per procedure:eneric set up and clean up	100	gram
J	Mean mass of SUPs generic PPE (g)	30	gram
K	*Mean mass of SUPs: COVID-19 PPE (g)*	*305*	*gram*
L	Total number of SUP items (including generic PPE, set up and decontamination) A*B*C*D	126500	items
M	*Total number of SUP items (including COVID-19 PPE) A*B*C*(D + E)*	*147200*	*items*
N	Mass of procedural SUPs (kg) A*B*C*(F+G) ÷ 1000	814	kg
O	Mass of PPE SUPs (kg) (A*B*C*J) ÷ 1000	69	kg
P	*Total mass of PPE SUPs (including additional COVID-19 PPE (kg)) A*B*C*(J + K) ÷ 1000*	*771*	*kg*
Q	Total mass of SUP waste (kg) N + O	883	kg
R	*Total mass of SUP waste (kg) (including COVID-19 PPE) N + O + P*	*1654*	*kg*

http://doi.org/10.1111/cdoe.12750

https://www.ssb.no/en/helse/helsetjenester/statistikk/tannhelsetenesta

Norge 2024: n= 4480 tannleger

3 451 840 kg
3 956 736 kg
7 408 576 kg

Domain 4: Monomer eluates / microparticles in bodily fluids from dental devices

Restorations and fissure sealants based on RBC

10 SRs:

Study	country	objectives
Lopes-Rocha et al. (2024)	Portugal, Gandra	To gather the analytical methods for the quantification of BPA release of BPA in dental materials in vitro and in vivo (biological fluids) studies
Sabour et al. (2021)	France, Clermont-F	To search for BPA release from biomaterials used in orthodontics and to highlight their possible impact on human health
Lopes-Rocha et al. (2021)	Portugal, Gandra	To perform an integrative review on the release of BPA from RBCs and potential toxic effects
Paula et al. (2019)	Portugal, Coimbra	To systematically review randomised controlled trials, cohort studies and case-control studies that evaluated BPA levels in human urine, saliva and blood
Löfroth et al. (2019)	Sweden, Malmø	To identify if direct dental filling materials are liable to leak BPA and (2) investigate if this leakage could lead to adverse health effects.
Marzouk et al. (2019)	USA, New York	To review clinical studies that have measured urinary BPA concentrations before and after dental treatment to evaluate the extent to which individuals are exposed to BPA from dental treatment.
Halimi et al. (2016)	Morocco, Rabat	To present an SR regarding the issue of BPA release by orthodontic materials and its impact on orthodontics
Kloukos et al. (2013)	Switzerland, Bern	To assess the short- and long-term release of constituents of orthodontic adhesives and polycarbonate brackets in the oral environment
Kloukos et al. (2013)	Switzerland, Bern	To assess the short- and long-term release of BPA in human tissues after treatment with dental sealants
Azarpazhooh et al. (2008)	Canada, Toronto	To investigate whether the placement of pit and fissure sealant materials causes toxicity and thus harms patients

+

N= 29 primary studies (1996 – 2023)

Other devices containing synthetic polymers

N= 1 primary study + 3 SRs

Study	country	objectives	method
Yazdi et al. (2023)	Iran, Ahvaz	To find studies relevant to the biocompatibility of clear aligners and thermoplastic retainers	SR
Peter et al. (2023)	India, Kerala	To review the available evidence on BPA release from thermoplastic clear aligners.	SR
Iliadi et al. (2020)	Greece, Thessaloniki	To appraise whether aligners are associated with estrogenic/cytotoxic effects or BPA and monomer leaching	SR
Raghavan et al. (2017)	India, Chennai	To evaluate and compare the BPA levels in saliva in patients using vacuum-formed retainers or Hawley retainer	RCT

Domain 4: Monomer eluates / microparticles in bodily fluids from dental devices

Restorations and fissure sealants based on RBC

N= 29 primary studies (1996 – 2023): several generations of innovative analytic technologies

Degradation products of resin-based materials detected in saliva in vivo

Philippe Vervliet[1] · Siemon De Nys[2] · Radu Corneliu Duca[3,4] · Imke Boonen[5] · Lode Godderis[3] · Marc Elskens[5] · Kirsten L. Van Landuyt[2] · Adrian Covaci[1]

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Abstract

Objectives Dental composites remain under scrutiny regarding their (long-term) safety. In spite of numerous studies on the release of monomers both in vitro and in vivo, only limited quantitative data exist on the in vivo leaching of degradation products from monomers and additives. The aim of this observational study was for the first time to quantitatively and qualitatively monitor the release of parent compounds and their degradation products in saliva from patients undergoing multiple restorations.

Materials and methods Five patients in need of multiple large composite restorations (minimally 5 up to 28 restorations) due to wear (attrition, abrasion, and erosion) were included in the study, and they received adhesive restorative treatment according to the standard procedures in the university clinic for Restorative Dentistry. Saliva was collected at different time points, starting before the restoration up until 24 h after the treatment with composite restorations. Saliva extracts were analyzed by liquid chromatography–mass spectrometry.

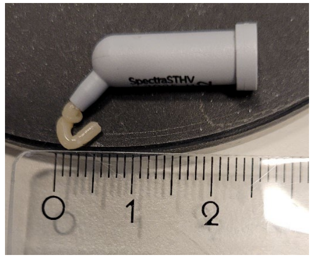
- Quantitatively monitor the short-term release of monomers and their degradation products in saliva samples collected from adults undergoing multiple composite restorations
- Liquid chromatography tandem mass spectrometry +
- High-resolution mass spectrometry to identify additional degradation products

Domain 4: Monomer eluates / microparticles in bodily fluids from dental devices

Sealed metal pouch

4 compules w/ rubber tip

0.25 g monomer per polycarbonate compule



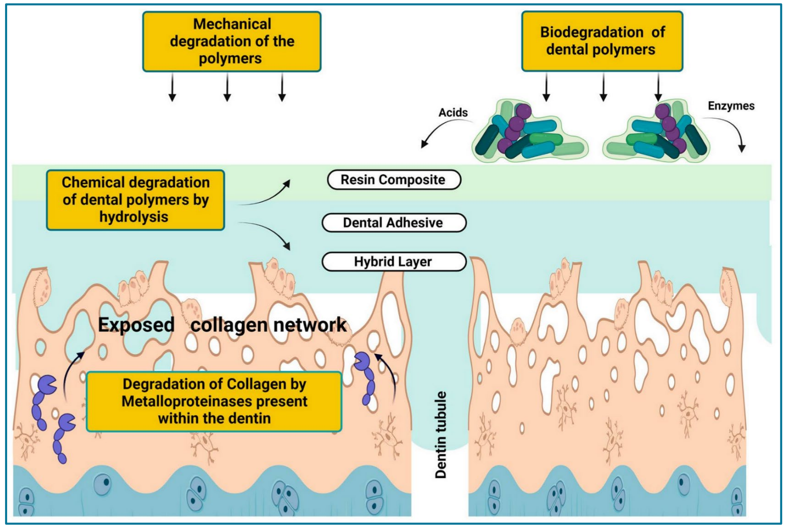
Resin-Based Composite restoration

1. Dental adhesive on tooth surface («Dentin hybrid layer»)
2. Monomer placement
3. LCU polymerisation

50-80% monomer→ polymer conversion

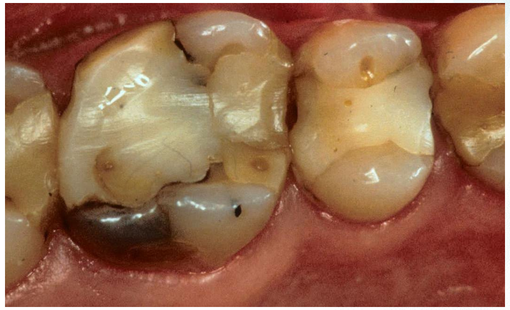
Restoration
Flash removal
Contouring
Finishing
Polishing

CAS: 41637-38-1	Esterification products of 4,4'-isopropylidenediphenol, ethoxylated and 2-methylprop-2-enoic acid Skin Irrit. 2, H315; Eye Irrit. 2, H319; Skin Sens. 1, H317; STOT SE 3, H335; Aquatic Chronic 4, H413	≥ 2,5 – < 10%
CAS: 109-16-0 EINECS: 203-652-6	2,2'-ethylenedioxydiethyl dimetharcylate Skin Sens. 1, H317	≥ 2,5 – < 10%
CAS: 13760-80-0 EINECS: 237-354-2	ytterbium trifluoride Skin Irrit. 2, H315; Eye Irrit. 2, H319; STOT SE 3, H335	≥ 2,5 – < 10%
CAS: 1565-94-2 EINECS: 216-367-7	(1-methylethylidene)bis[4,1-phenyleneoxy(2-hydroxy-3,1-propanediyl)]bismethacrylate Skin Irrit. 2, H315; Eye Irrit. 2, H319; Skin Sens. 1, H317	≥ 0,1 – < 1%
CAS: 10287-53-3	Ethyl-4-dimethylaminobenzoat Repr. 1B, H360; Aquatic Chronic 2, H411	< 0,25%
CAS: 131-57-7 EINECS: 205-031-5	oxybenzone Skin Irrit. 2, H315; Eye Irrit. 2, H319; STOT SE 3, H335	≤ 2,5%
CAS: 128-37-0 EINECS: 204-881-4 Registreringsnummer: 01-2119565113-46-XXXX	2,6-di-tert-butyl-p-cresol Aquatic Acute 1, H400; Aquatic Chronic 1, H410	≥ 0,025 – < 0,25%



From: Mokeem et al. 2023
doi: 10.3390/biomedicines11051256

Wear particle sizes
0.3-0.7 μm³



Conclusions

1. The use of different polymers in dental care clinics is frequent and in large amounts, with a largely unknown environmental impact.
2. There is a void of studies on microplastics and monomer elution secondary to resin-based composite degradation intraorally and environmentally.
3. Mitigation strategies for handling waste and reducing single-use plastics must address better practices, including reusing devices and recycling.

Thank you!

Foto: Anne M. Gussgard

Indirekte RBC etter fremstilling, mikrostruktur, polymerisering og hovedsammensetning

Manufacturing Process	Microstructure	Polymerization Mode	Material	Manufacturer	Main Composition	
					Matrix	Filler
Artisanal	Dispersed Fillers	Light	Ceramage & Ceramage up	Shofu	UDMA (+ HEMA in opaque paste)	Silica-based glass
Manuelt			Gradia	GC Corp	UDMA + other DMA	Unknown
			Signum	Heraeus Kulzer	Unknown DMA	Silica + composite (74 wt%)(64 wt% silica-based glass+ silica in Signum flow)
			Sinfony	3M-ESPE	UDMA + other DMA	Silica-based glass +silica
			Solidex	Shofu	UDMA	Unknown
			SR Nexco	Ivoclar-Vivadent	UDMA + other DMA	Silica (10-50 nm) + composite (for liner and opaque : + zirconia + silica-based glass)
			VITAVM LC	VITA Zahnfabrick	BPA + TEGDMA + other DMA	Unknown
		Light + temperature complement	Estenia C&B	Kuraray	Unknown DMA (+Bis-GMA in opaque paste)	Silica-based glass + alumina (2 μm and 2nm) (92 wt% / 82 Vf%)
			SR adoro	Ivoclar-Vivadent	UDMA + other DMA	Silica-based composite
			Twiny	Yamamoto, Precious Metal Co	UDMA + TEGDMA	Silica (20-100nm) + zirconia-, alumina-, silica-particles (200-600nm) + zirconia- aluminasilica-clusters (1-6 μm)
Industrial	Dispersed Fillers	Light	Paradigm MZ 100 block	3M ESPE	Bis-GMA + TEGDMA	Silica (0.6 μm) + zirconia (0.6 μm)(85wt%)
CAD-CAM		HT	Cerasmart	GC America	UDMA + other DMA [a]	Silica-based glass + silica (20 and 300 nm (71wt%) [a]
			Lava Ultimate	3M ESPE	UDMA	Silica (20 nm) + zirconia (4-11 nm) + zirconia-silica clusters (0.6-10 μm)(79 wt%)
			Shofu block HC	Shofu	UDMA+TEGDMA	Silica-based glass + silica (61 wt%) [a]
	PICN	HT/HP	VITA Enamic	VITA Zahnfabrik	UDMA+TEGDMA	Glass-ceramic sintered network (86 wt%/ 75 Vf%)

Fra: Oudkerk 2024