

Dental waste management and sustainability knowledge and awareness in a New Zealand oral health programme

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ABSTRACT

Background: Previous approaches for reducing dental waste have been focused on increasing the knowledge and awareness of Oral Health (OH) practitioners. For long-term changes, the emphasis should be on the education of OH students, who are the profession's future. This study aimed to investigate the knowledge and awareness levels of dental waste management and sustainability among second- and third-year OH students in New Zealand, and if their knowledge and awareness varied between year groups.

Methods: Second- and third-year students were invited to participate in a questionnaire with demographic and close-ended questions. The responses were analysed using a simple scoring system to see whether students had a 'low', 'moderate' or 'high' level of knowledge.

Results: Eighty-five per cent of participants were confident that they knew the Dental Council of New Zealand's (DCNZ) Infection Prevention and Control Standards. The majority misidentified the DCNZ's definitions of two of the three waste types produced by a dental clinic. Seventy-six per cent of participants correctly identified amalgam as the most toxic material to the environment from a list of four other options. Third-year students exhibited a lower overall knowledge than second-year students, with over 54% scoring a 'low' level.

Conclusion: The research demonstrates that students would benefit from waste management and sustainability education being added to their curriculum at university. Further research could study students from other educational institutions.

Keywords: Climate change, curriculum development and evaluation, environment, professional responsibility, sustainability, medical waste, oral health therapy

BACKGROUND

Climate change induced by humans is impacting lives and our health in a myriad of ways. For example, heatwaves and record high temperatures, extreme weather causing droughts and floods, rising sea levels, and negative impacts on health, such as exacerbations of respiratory diseases have all been linked to climate change (Bennett et al. 2014; Gershberg et al. 2021). As a result, developing solutions for the climate crisis is becoming increasingly urgent.

Across the world, nations have signed up to multiple agreements focusing on sustainability to protect our environment now and for future generations. These agreements are ratified to ensure that the human impact on the environment is regulated and managed. For example, the Paris Agreement was adopted by 196 Parties under the United Nations Framework Convention on Climate Change in 2015 and came into effect in 2020 (UNFCCC 2015). Upon signing, countries had to prepare, communicate, and maintain their contributions to the Paris Agreement.

The United Nations Sustainable Development Goals is another agreement which encompasses 17 goals to pursue the betterment of people and protect the planet (United Nations 2015). For the dental profession, this calls for implementing sustainable practices for the health

and well-being of our communities (Martin et al. 2021). As we continue to pursue sustainable dentistry, there will be a greater need for awareness and understanding of the barriers and opportunities within the profession and to align with best practices (Koyama et al. 2022).

The World Dental Federation defines sustainable oral healthcare as "the provision of equitable, ethical, high-quality, inclusive and safe care with appropriate, effective and efficient use of resources. Through this, the healthcare opportunities of current and future generations are respected and protected by actively minimising negative environmental impacts (FDI 2022).

Dentistry is a resource-intensive sector that significantly impacts the environment and humans. The vast amounts of water required daily, great electricity demands, the effects the biomaterials have on the environment, and the use of lead and mercury have all contributed to these impacts (Agarwal et al. 2012; Richardson et al. 2016; Sood & Sood, 2011). To reduce their environmental impact, oral health (OH) practitioners must consciously reduce waste, dispose of medical waste responsibly, and work sustainably. However, there are various barriers to change, such as waste management being expensive due to the complexity of managing biomedical waste, a lack of

knowledge, and supportive legislation (Martin et al. 2021). Literature has suggested ways OH practitioners (OHP) can practice sustainably, but relatively few practitioners have demonstrated changes, whilst others appear to have not taken up the research evidence (Grose et al. 2016).

The healthcare industry, including dentistry, is responsible for approximately four per cent of worldwide greenhouse gas emissions (GHGE) (Eckelman et al. 2020). Whilst this is low compared to other industrialised service sectors, the supply chain for the healthcare industry accounts for a significant share of GHGE. Emissions from materials being created, transported, used, and disposed of contribute to their share of GHGE (Pichler et al. 2019). The impact on the environment and the GHGE produced is not sustainable because we are exceeding the carrying capacity of ecosystems (Australian Dental Association 2022). To reduce emissions, it is essential to shift how healthcare is delivered, which requires educating clinicians on their potential contribution to GHGE.

Dental waste encompasses all waste generated in a dental facility (Adedigba, et al. 2013). Included under this umbrella term are hazardous and non-hazardous waste. According to New Zealand's dental regulatory authority, the Dental Council (DCNZ), hazardous waste is any waste that threatens humans and the environment, such as dental amalgam. In addition, New Zealand is a signatory to the Minamata Convention that has singled out mercury as a highly toxic substance for human health and the environment (Ministry for the Environment 2020). Non-hazardous waste includes any general and recyclable waste (Dental Council New Zealand 2016).

Waste management is a significant and expensive problem that has increased during the COVID pandemic with single-use disposable Personal Protective Equipment (PPE), and is a barrier to sustainable dentistry (Martin et al. 2021). Currently, the majority of health care waste in New Zealand is sent to landfills (Bolton 2021). The toxicity of the waste, more so than the related CO₂ emissions, is of greater concern to the environment (Martin et al. 2021). The DCNZ does not presently have sustainability guidelines; however, waste management forms part of its Infection Prevention and Control Practice Standard (DCNZ 2016).

The addition of sustainability education to undergraduate and postgraduate studies would see those clinicians entering the workforce addressing their potential environmental impact (Duane et al. 2019). Students believe that environmentally sustainable principles covered in school are important (Gershberg et al. 2022). However, the European Dental Students' Association has highlighted that environmental health and sustainability are not a part of any European dental school's education curriculum (Coughlan & Timuş 2020). Furthermore, in terms of undergraduate education, there is a lack of research assessing the knowledge of OH students on sustainability and waste management (Alqahtani et al. 2019; Bala, & Narwal 2013; Kinakh 2016; Ranjan et al. 2016).

AIMS

This study's primary aim was to investigate the knowledge and awareness levels of dental waste management and sustainability among second- and third-year undergraduate OH students at a University in New Zealand. A secondary aim was to investigate whether knowledge and awareness levels varied between the second- and third-year OH students.

METHODS

The Auckland University of Technology Ethics Committee approved the study (reference number 20/220) and was supported by the Department of Oral Health.

Participants were enrolled second- and third-year OH students during 2020. A total of 71 second- and 32 third-year students were registered at the time of this research, comprising 103 students.

Study information with a web link to a self-administered questionnaire was sent via the student virtual learning platform Blackboard. The survey was hosted on Qualtrics, a cloud-based platform for creating and distributing web-based surveys. The online survey was particularly suited during the COVID pandemic restrictions. The survey was open to participants for two weeks, and a reminder announcement was sent a week later.

This cross-sectional survey had two sections, with a total of 18 questions. The first section focused on the demographic variables of the respondents: student age and year of study. Participants could not be identified, however, as the course intake was relatively small, they were not asked about their gender, which could have created a potential way to identify the respondent.

The second section had a combination of 13 close-ended questions related to the student's knowledge and awareness of dental waste and sustainability. Participants could select 'yes', 'no' or 'not sure' on a three-point Likert type scale. These questions were developed based on the DCNZ's Infection Prevention and Control Standards. The first nine questions concentrated on waste management. Next, the questions focused on the DCNZ's waste definitions, potentially hazardous materials, and students' knowledge of dental waste disposal. The final four questions focused on sustainability and included questions regarding students' recycling habits.

Data were entered into an Excel spreadsheet and then imported into IBM SPSS, Version 27.0, for analysis.

A simple scoring system was used to examine if the second- and third-year students had a low, moderate, or high level of knowledge and awareness. Yes answers were given a score of '1', and an incorrect answer or an answer of 'unsure' were given a score of '0'. If a participant received a score below five, they were considered as having a 'low' level of knowledge

and awareness, 6 to 9 correct was considered a 'moderate' level, and ten or more a 'high' level. This scoring method was adapted from the research conducted by Memon et al. (2015).

RESULTS

Out of 103 potential student participants, the response rate was 20%, with 21 returned questionnaires (Tab 1). The results showed that 52% (n=11) of respondents were in their third year of the Bachelor of Health Science OH degree. This was slightly greater than the second-year student's 48% (n=10) participation.

Table 1: Age and year of study of participants

Variable	Subgroup	n (21)	(%)
Age	< 24	11	53%
	25 - 34	5	24%
	35 - 44	5	23%
Year of study	2	10	48%
	3	11	52%

Regarding the survey question 'have you received formal training or education for healthcare waste management?', only 28% of students indicated they had received some form of training or education (Fig 1). Over half of the participants either had not received training or were unsure if they had received such training or education. Out of the 11 responses from third-year students, 64% stated 'no' to the question, whilst 36% either had or were not sure. Comparing this to the second-year students, 40% had received, and 50% had not received education or training, while 10% were unsure.

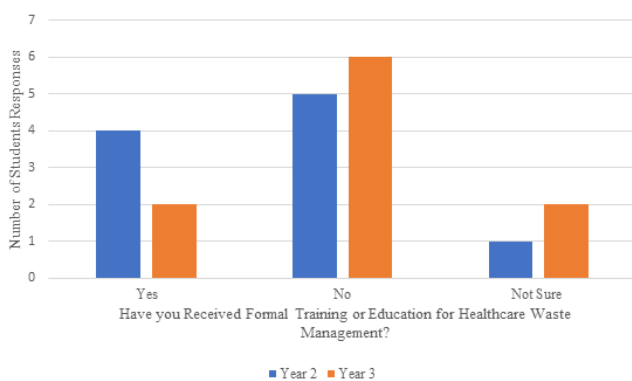


Figure 1. Response from second- and third-year students regarding education on healthcare waste management

The number of students who responded 'yes' if they understood the DCNZ's Infection Prevention Control Standard was 18 (85%) (Tab 2). The number that responded they were 'unsure' was 3 (14%).

Participants were asked the definitions of hazardous waste, controlled waste and non-hazardous waste. Out of 21 participants, 81% correctly identified the definition of hazardous waste as "waste that poses a threat to the health and safety of staff, public, or the environment".

Table 2: DCNZ definitions for waste – What is hazardous waste?

Question - What is Hazardous Waste?	n (21)	%
Waste that is either contaminated or soiled with potentially infectious fluid that is not expressible under compaction	4	19%
Waste that poses a threat to the health and safety of staff, public, or the environment *	17	81%
General and recycle waste produced in a healthcare facility	0	0%
Any category of wet and dry waste	0	0%

*Correct response

Table 3 shows that 11 participants (52%) correctly identified the correct definition. Six participants (29%) thought the term controlled waste meant 'any category of wet and dry waste'.

Table 3: DCNZ definitions of waste – What is Controlled Waste?

Question - What is Controlled Waste?	n (21)	%
Waste that is either contaminated or soiled with potentially infectious fluid that is not expressible under compaction *	11	52%
Waste that poses a threat to the health and safety of staff, public, or the environment	2	9%
General and recycle waste produced in a healthcare facility	2	9%
Any category of wet and dry waste	6	29%

*Correct response

Regarding the survey question 'what is non-hazardous waste?' all participants (n=21) correctly identified the definition, "general and recycle waste produced in a healthcare facility".

When asked, 'do you understand how hazardous waste is disposed of once it has left the dental clinic?' Fifteen of 21 participants answered they did not know what happens. Three participants were unsure. Three (14%) stated that they understand what happens to waste.

For the survey question asking students to identify what type of waste mercury is, 80% of participants correctly identified it as hazardous waste. Fourteen per cent thought it was biomedical waste and one respondent thought it was radioactive waste. No one considered mercury to be 'other waste'.

Participants were asked, 'what material is potentially the most toxic to the environment?' 17 correctly identified amalgam as the most toxic. Whilst three participants answered lead foil is, and one thought it might be an x-ray fixer. No participants selected needle sticks. Comparing the year groups, most third-year students identified the correct answer about mercury waste being the most toxic, whilst the second-year students were more split.

On the topic of amalgam separators, most participants (47%) were unsure whether a practice required an amalgam separator if the practice was amalgam free; 14% of participants answered incorrectly. Thirty-eight percent correctly identified that practices require an

amalgam separator even if it is an amalgam-free practice.

For recycling, 76% of participants recycle at home. However, twenty-nine per cent of participants did not actively try to separate waste for recycling in the dental clinic. Only two participants revealed they did not recycle at home.

In response to the question on potential sustainable solutions, more participants favoured practices of switching to biodegradable dental consumables (57%) (Fig 2.). Nineteen per cent would like to go paperless and recycle where possible, and 24% wanted to switch to digital radiographs.

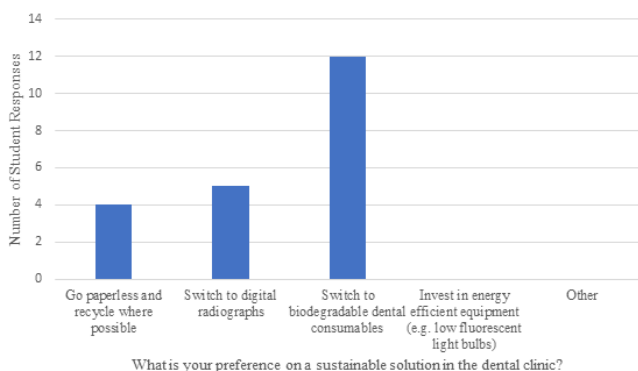


Figure 2: Sustainable solution responses from all students

The final question was ‘should sustainable dentistry methods be added to the oral health curriculum?’, eighty-six per cent of participants were in favour of this being added to the curriculum, and 14% were ‘not sure’. There weren’t any ‘no’ responses.

Comparing second and third-year students’ knowledge and awareness of dental waste and sustainability, 28% of all third-year students scored ‘low’. In addition, 57% have a moderate level of knowledge and understanding from a mix of second- and third-year students (Tab 4.). Only 14% of participants, all second-year students, scored a ‘high’ score.

Table 4: Second- and third-year students’ dental waste and sustainability knowledge and awareness scores

	Low	Moderate	High
Year 2 Students (n=10)	0	7 (70%)	3 (30%)
Year 3 Student (n=11)	6 (54%)	5 (46%)	0

DISCUSSION

This research aimed to explore the knowledge and awareness of second- and third-year OH students on dental waste management and sustainability. The results may provide valuable information for OH education providers, practising professionals, and other stakeholders.

A concerning survey result indicated that only a small percentage of students (29%) had received any form of formal

training or education for healthcare waste management or did not understand that waste management was part of infection control. This result is lower than in previous literature, where Ozder et al. (2013) found that 54% of participants had received no training in medical waste management.

Whilst research has shown that there is a severe lack of education on the topic of waste management, it also shows that professionals exhibit a willingness to participate in medical waste training programs and change their current practices (Abdulla et al. 2008; Alqahtani et al. 2019; Jamkhande et al. 2019; Ozder et al. 2013). This is also reflected in an evidence review conducted by Debrah et al. (2021) who found that despite students having a positive attitude towards the environment and displaying a high awareness of environmental issues, there is a lack of practical education to guide students into safely handling waste.

The DCNZ’s Infection Prevention and Control Standards are mandatory standards that the DCNZ is legally required to set, and all registered OHPs must observe them (DCNZ 2016). Various researchers have shown that one of the leading causes of waste management errors is confusion surrounding definitions for healthcare waste (Bala & Narwal, 2013; Ehrampoush et al. 2005; Mbongwe et al. 2008). Having a single national document for all dental professionals in the country could reduce this confusion. However, if students are not taught the standards, this leads to a lack of understanding and compliance.

Our study found that 14% of participants answered they were ‘unsure’ if they understood the DCNZ Infection Prevention and Control Practice standard. As the participants were still students, there is still time before they must register with the DCNZ to ensure they have a sound understanding of the standards.

For students to dispose of waste appropriately, they need to know what category it belongs to. This means they must understand the definitions in the DCNZ’s Infection Prevention and Control Standards. All 21 participants correctly identified ‘non-hazardous waste’, which is any general and recycled waste.

Hazardous waste is defined as waste that threatens the health and safety of staff, public or the environment according to the DCNZ’s standards framework (DCNZ 2016). Seventeen of 21 students correctly identified the definition of ‘hazardous waste’. While most participants can identify the definition, researchers have concluded that even though dental professionals may know about hazardous waste, they are not engaged in safe waste disposal (Sood & Sood 2011).

Nevertheless, the definition of controlled waste revealed that participants were less certain as answers were spread across all potential responses. Only 52% of the participants correctly identified the definition of controlled waste. Items that come under this definition are, according to DCNZ’s guidelines, used

gloves, masks, disposable gowns, and aprons. Hence, unless they are contaminated with a large amount of blood, these are considered hazardous rather than controlled waste items (DCNZ 2016). This is an important distinction for students to be aware of. Improper separation of contaminated waste can potentially cause injuries to staff and the public and are potential environmental threats (Janmaimool 2017).

Despite 85% of respondents answering that they understand the DCNZ's Infection Prevention and Control Standards, some participants misidentified two out of three correct definitions for different types of waste. If these are the standards they must adhere to, more focus should be given to them whilst at university, as this is not only a theoretical issue but also a clinical education issue. Knowing these definitions and the differences between types of waste is crucial. The review of the literature showed that this gap in knowledge regarding waste categorisation, especially hazardous waste, can lead to confusion about how to dispose of it adequately.

Another finding was that the participants demonstrated an overwhelming lack of awareness regarding what happens to hazardous waste once it has left the dental practice. Pertinently, 86% of the participating students either did not know or were unsure. Yadavannavar et al. (2010) found that employees at the Shri BM Patil Medical College and Hospital only knew what happened to medical waste because they have an on-site incineration plant. A potential gap in the literature exists where research examining OHPs' or students' knowledge regarding the journey hazardous dental waste takes when it has left the clinic is an area that has not been well investigated.

Seventy-six per cent of participants identified amalgam as potentially the most toxic material to the environment from a list of four hazardous materials in dental practices. Clinicians must know their materials and how to dispose of them safely. Dentists in North India were assessed on their awareness and performance towards dental waste. Forty per cent of dentists dispose of their amalgam by throwing it into general waste. This is a hazardous waste disposal method, and education is needed (Singh et al. 2014). Correctly distinguishing what kind of waste amalgam constitutes, is an encouraging outcome. However, students may be heading for a future where they do not place amalgam restorations, just removing and replacing them with other materials such as composite resin. The literature has shown that there has been a reduction in amalgam restorations being placed (Broadbent et al. 2020; Zabrovsky et al. 2019). Broadbent et al. (2020) found that there has been a reduction in amalgam restorations in New Zealand from 52.3% in 1998 to 7.1% in 2017. Despite this phase-out, knowing how to dispose of waste amalgam is still essential, and education should focus on its safe removal and disposal.

When in the dental clinic, sixty-seven per cent of participants actively recycle, and when they are at home, seventy-six per cent of participants also recycle. A potential barrier to recycling in dental clinics is the lack of knowledge surrounding recyclable products and materials. A possible

barrier for students is that they are unsure what type of waste can be recycled. Jang et al. (2006) have stated that there is potential for recycled waste to be contaminated, which is a major concern for recycling in a medical setting. Having clearly marked zones for 'contaminated' and 'non-contaminated' materials and waste could help ensure that recycled waste is not contaminated (Duane et al. 2019).

Researchers have determined that by providing students with the knowledge surrounding recycling, they are more motivated to recycle and practice more sustainably (Ranjan et al. 2016). Helping students to understand recycling symbols and what can be recycled could help students identify and dispose of materials they may encounter. Policies and defined processes can also reduce barriers to recycling in clinical environments.

A simple and effective solution to reducing waste in the healthcare sector is to decrease the unnecessary consumption of resources (Eckelman et al. 2020). The dental industry in New Zealand is valued at over NZD 1 billion per annum (IBIS 2020). If clinicians were to make a sustainable switch to their practice, the environmental impacts could be substantial. Professionals, given information on the seriousness of waste disposal problems and types of environmental strategies, are more likely to engage in sustainable management behaviours (Janmaimool 2017). When our participants were asked about switching to biodegradable dental consumables, 57% favoured this potential switch. While biodegradable plastics can effectively protect our environment, they should not be considered a complete solution to reducing the global plastic problem (Shen et al. 2020). Plastics still need to be disposed of according to regulations. Appropriate waste streams must be in place to prevent biodegradable waste from ending in the same location as non-biodegradable waste. Students need to ensure they are aware of how this is done.

For this gap in knowledge to be bridged, sustainability education should be integrated into schools at all levels (Debrah et al. 2021). Several studies report that dental and oral health students consider environmental sustainability in dentistry as an essential part of their education yet do not receive any related training (Gershberg et al. 2021, Martin et al. 2021; de Leon 2020).

Teaching students about climate change and sustainable healthcare have been embedded into a range of medical courses in the UK, including medicine at the University of Bristol and for students undertaking nursing and dietetics courses at Plymouth University (Duane et al. 2019; National Health Service, 2020; University of Bristol 2021). As the majority of participants (86%) stated they would like sustainable dentistry methods added to the OH curriculum, this would be a beneficial addition to their education, considering the current climate crisis.

When comparing the two year groups, the participating second-year students' levels of knowledge and awareness were substantially greater than the third-year students.

All 'low' knowledge scores were from approximately one-quarter (28%) of the third-year students. Three of the 21 (14%) students with a 'high' score were second-year students. No comparison to the existing literature regarding years at university and waste management knowledge is possible, as this is a novel finding.

Students from both years display a poor understanding of dental waste management and sustainability. Previous research corroborates this finding and has concluded that for long-term changes and the future of the profession, students need to be educated on both topics (Anozie et al. 2017; Muhamedagic et al. 2009; Ranjan et al. 2016; Sachan et al. 2012; Sudhakar & Chandrashekar 2008).

A limitation of this research was the relatively small sample size, and any generalisation needs to be undertaken with caution. Further research should be undertaken with other Oral Health programs. Furthermore, including Bachelor of Dental Surgery students would be beneficial, as the literature shows that dentists also lacked sufficient knowledge. Finally, a larger sample size could allow for more advanced statistical comparisons and make the findings more generalisable.

CONCLUSION

This study has shown that the level of knowledge amongst participating students is insufficient, along with finding differences between the second- and third-year students' knowledge of waste and sustainability. This indicates a need for education on both topics to be incorporated into the current curriculum. In addition, students have identified ways they would like dentistry to become more sustainable. A substantial majority have also indicated that they would like sustainability added to their curriculum. Arming the profession's future with awareness around dental sustainability can only improve the dental profession and hopefully reduce the GHGE produced by the healthcare industry.

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