Keywords
Sustainable dentistry; Prosthodontics; Eco-friendly materials; Practitioner attitudes; Green dentistry; Behavioral theory; Digital dentistry; Environmental sustainability

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Psychological Drivers of Sustainable Practices in Prosthodontics: The Role of Practitioner Attitudes in the Adoption of Eco-Friendly Dental Materials and Techniques

ABSTRACT

Objectives: This review will investigate the psychological elements that facilitate the adoption of sustainable practices in the dental field of prosthodontics, and focus on the attitudes of practitioners towards the use of eco-friendly dental materials and techniques.

Methods: Narrative review methodology was used to synthesize the existing literature on the environmental effects of the practice of prosthodontics, psychological models of behavior, practitioner attitudes, and sustainable innovations. Theories of Planned Behavior, Value-Belief-Norm theory, Health Belief Model and Diffusion of Innovation theory have been discussed with reference to dental practice.

Findings: The findings suggest that practitioner attitudes, awareness of the environment, and perceived behavior control play a significant role in adopting sustainable practices. The implementation is hindered by barriers like cost, limited availability of eco-friendly material, and the workflow factors which are facilitated by education, institutional support, and digital technologies. All the psychological models explain the effect of values, beliefs and social forces on sustainable decision-making.

Conclusions: A comprehensive approach to sustainable prosthodontics involves behavioral, technological, and institutional strategies. It is important that psychological determinants are addressed in order to facilitate the development of environmentally friendly practices.

Clinical Relevance: Knowledge on practitioner behavior can also help improve the uptake of sustainable materials and techniques, resulting in an environmentally responsible provision of prosthodontic care without jeopardizing clinical outcomes.

1. INTRODUCTION

Sustainability of the environment has become a burning issue in the field of healthcare systems on the global level, due to the growing level of awareness of climate change, depletion of resources, and ecological degradation. Although committed to enhancing human health, the healthcare sector, ironically enough, is a major contributor to environmental degradation through its energy use, waste products, and emission of greenhouse gases. Medical activities contribute to almost 4-5 percent of global carbon emissions, which underscores the need to radically change the nature of medical activities by adopting sustainable transformation [1]. It is in this greater framework that dentistry, and more specifically prosthodontics, is a respected but influential

area where environmentally friendly practices are becoming a growing concern.

Dentistry is a contributor to environmental burden in various ways, such as the use of single-use plastics, chemical waste, and energy-intensive processes. Dental clinics generate a considerable amount of biomedical and non-biodegradable waste, such as impression materials, gypsum products, acrylic resins, and packaging materials [2]. Furthermore, the increased use of sterilization equipment, radiographic imaging, and laboratory fabrication processes increases energy usage and carbon emissions. The overall environmental impact of dental care is hence not trivial, especially when scaled across the global practice environment [3].

As a dentistry speciality that deals with restoration and replacement of teeth, prosthodontics is a branch of dentistry that is complex in terms of material usage and workflows that require laboratories, further increasing the ecological footprint. More traditional types of prosthodontic materials, such as polymethyl methacrylate (PMMA), metal alloys, ceramics, and silicone-based impression materials, typically have high environmental costs related to their production, processing, and disposal [4]. Most of these materials are not biodegradable and lead to long-term environmental pollution. Moreover, the conventional methods of refining fabrics like casting, milling, and sintering have significant energy consumption, thus contributing to the carbon footprint of the prosthodontic procedures [5].

The other significant issue is that there is widespread application of disposable items in the practice of prosthodontics. Single-use gloves, masks, suction tips, and impression trays are required by infection control protocols, which have resulted in an explosion of clinical waste. Although these measures are crucial towards patient safety, they have serious environmental implications as recycling options are limited, and systems of managing patient-generated waste are lacking in many areas [6]. Moreover, dental laboratories, which are also a key component of the prosthodontics process, bring in more streams of waste, including metal scraps, investment materials, and chemical by-products, which further increase the ecological footprint.

In order to counter these problems, the concept of green dentistry has been brought into the limelight as a prototype of integrating the environmental sustainability concept into dental practice. Green dentistry is based on the minimization of waste, energy and water saving, use of environmentally friendly materials, and digital technologies to minimize environmental impact [7]. To include digital workflows, such as computer-aided design and computer-aided manufacturing (CAD/CAM) and 3D printing have been proposed as alternative to the traditional methods, that will help to reduce the quantity of waste and increase the efficiency of the production process. Nonetheless, the implementation of such innovations is not even across practitioners and settings.

The role of practitioner behavior and decision-making is one of the crucial but often overlooked aspects in the transition towards sustainable practices in the field of prosthodontics. Although technological innovation, and material innovation do offer the necessary tools needed to ensure sustainability, their applicability and appropriateness highly depends on the attitudes, beliefs, and motivations of dental professionals. Research has indicated that environmental attitudes of healthcare providers is a significant factor that determines whether or not healthcare providers are willing to practice in an environmentally friendly manner [8]. In dentistry, the balancing of the clinical efficacy, costs, expectations of the patients and the responsibility of the environment and, therefore, behavioral factors are the essence of the decision-making processes.

Although the literature on the psychological factors that inform uptake of environmentally friendly materials and methods by the prosthodontists is growing, there is a knowledge gap that is significant. The available literature has given more emphasis on the technological advancements and environmental effects with little emphasis on the cognitive and behavioral processes that occur when a decision is made by the practitioners. The above features of the psychology profession contribute significantly towards the development of effective interventions, education programs, and policies that are sure to bring about sustainable practices in the profession of prosthodontics.

In this regard, this review will focus on synthesising the existing body of knowledge on the environmental issues surrounding the practice of prosthodontics and to highlight the importance of practitioner attitudes and psychological motivators in bringing about possible sustainable changes. The synthesis of the knowledge of the environmental science, dental practice and study of behavior, this article attempts to provide a general outline of what we want to know and how we can enhance the adoption of environmentally friendly practices in the field of prosthodontics.

2. ENVIRONMENTAL IMPACT OF PROSTHODONTIC PRACTICES

The environmental implications of the prosthodontic practice is not simple and it entails the factors of material use, waste generation and energy consuming laboratory work. Because of the close correlation between manufacturing and processing of prostheses and the chairside care, the environmental impact of prosthodontics is not confined to the chairside care only, but extends to the manufacturing and processing of prostheses. This understanding of these effects is crucial in determining the avenues of integrating sustainability in the day to day dental practice.

2.1 Material Usage and Waste Generation

The use of materials such as the acrylic resin, metal alloys, ceramics and the elastomeric impression compounds are also heavily used in the treatment of prosthodontics. Polymethyl methacrylate (PMMA), a widely used material in the production of dentures is a product that is derived out of petrochemical sources, and is non-biodegradable and thus contributes to long term environmental pollution [9]. Similarly, dental alloys, like cobalt-chromium or nickel-based metals are made and refined using energy-intensive and

environmentally hostile mining and refining [10]. The more biocompatible ceramic materials must be processed at high temperature further increasing their environmental impact.

The increasing popularity of single-use materials is one of the major problems in the sphere of prosthodontics. Disposable impression trays, mixing tips, gloves, and barriers have become a widespread practice, as a result of infection control measures, which are a major contributor to the production of plastic waste [11]. Although there are reusable alternatives (such as metal trays, or sterilizable instruments), their use is often limited because of perceived risks, time constraints, and convenience factors.

The sources of waste streams in the field of prosthodontics are clinical and laboratory streams of waste. Clinical waste refers to impression material, temporary restorations, and packaging and laboratory waste refers to gypsum casts, investment material, wax residues and metal scraps [12]. A good number of these materials cannot be recycled and they go into landfills where they lead to environmental degradation. Table 1 uses a summary of the lifecycle characteristics and sustainability rating of commonly used prosthodontic materials to summarize the effects of these materials on the environment and their alternatives.

2.2 Energy Consumption and Carbon Footprint

Prosthodontic processes are highly energy-consuming as well, especially because of laboratory procedures that include casting, milling, and sintering. The conventional methods of casting demand the use of high-temperature furnaces where the alloys are melted, consuming a lot of energy and emitting greenhouse gases [13]. In the same vein, sintering of ceramics is associated with the prolonged heating process at high temperatures, which further raises the carbon footprint.

A more sustainable alternative has been suggested with the introduction of digital dentistry, including CAD/CAM systems and additive manufacturing (3D printing). Digital processes can help to reduce material waste, as it enables the accurate fabrication and reduction of errors that accompany the traditional methods of making impressions and casting [14]. However, the effects of these technologies on the environment are not completely negative. Milling machines use electricity and subtractive manufacturing wastes materials in the form of unused blocks. In addition, 3D printing suggests the use of resins and power-consuming curing processes and must be considered in the test of sustainability [15].

Comparative studies indicate that even though the digital workflow has the potential to assist in the reduction of some types of wastes, the overall environmental impact of the digital workflow depends on the source of energy, the effectiveness of equipment and the magnitude of its use. By doing so, the two approaches, the traditional and electronic one, will have to be looked at meticulously in order to come up with the relative sustainability of the two approaches.

2.3 Life Cycle Perspective of Dental Materials

A life cycle approach gives a general view of how the environmental impact of the prosthodontic materials including the processes of the life cycle including extraction of the raw materials, processing of the materials into final products and disposal of the final products. Lifecycle of dental materials typically includes extraction of raw material, manufacturing and processing, clinical use and waste materials [16]. The stages of the process cause environmental burden due to the depletion of resources, the use of energy, and emitting.

Extraction of metals and synthesis of polymers during the production phase cause a lot of environmental pollution in terms of greenhouse gases and toxic by-products. During the usage stage, materials can either release micro-particles or chemical residues, especially in the case of resin-based products. Disposal poses further issues since most dental materials are not biodegradable and can leak toxic materials into the soil and water systems.

Biodegradability and environmental toxicity are very crucial factors when it comes to assessing sustainable options. New environmentally friendly materials, including bio-based polymers and recyclable alloys, are emerging as a possible solution but need more validation, in terms of clinical performance and long-term durability [17]. The lifecycle assessment process of the prosthodontic materials is shown in Figure 1, which identifies the main stages of the process, as well as the environmental impact of the process at each stage.

In general, a lifecycle perspective can help practitioners and policymakers to recognize critical intervention points, including resource reduction, material efficiency, and waste management practices. It is the incorporation of such opinions into the practice of prosthodontics which can be employed to enrich the concept of sustainability and maintain the clinical success intact.

Table 1: Environmental Impact Comparison of Conventional vs Eco-Friendly Prosthodontic Materials

Material Type	Environmental Impact	Lifecycle	Alternatives	Sustainability Rating
PMMA Acrylic	High (non-biodegradable, petrochemical origin)	Linear (produce–use–dispose)	Bio-based resins	Low
Metal Alloys (Co-Cr, Ni-Cr)	High (mining + energy intensive)	Partially recyclable	Recycled alloys	Medium
Dental Ceramics	Moderate–High (high-temperature processing)	Long lifespan	Low-energy ceramics	Medium
Silicone	High (non-recyclable)	Single-use dominant	Reusable trays +	Low

Impression Materials			digital impressions	
CAD/CAM Blocks	Moderate (less waste, energy use)	Optimized use	Recyclable composite blocks	Medium–High
3D Printing Resins	Moderate (chemical waste + energy curing)	Limited recyclability	Bio-resins (emerging)	Medium

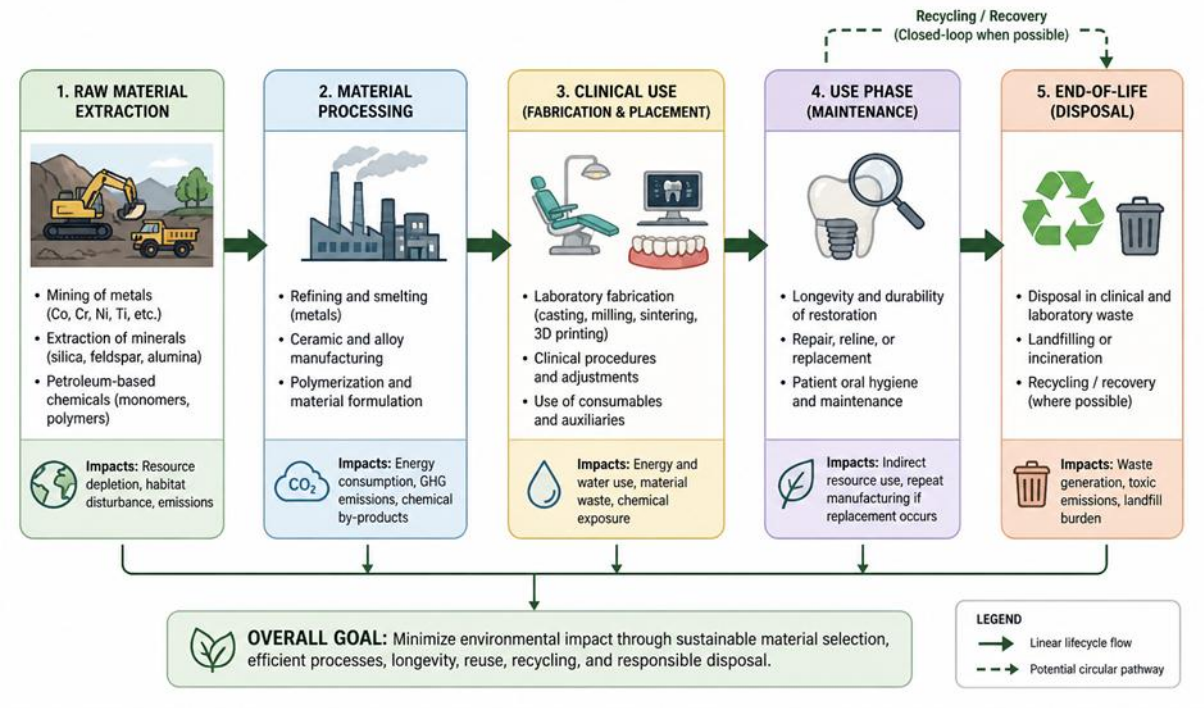

Figure 1: Lifecycle Assessment Flow of Prosthodontic Materials

3. PSYCHOLOGICAL THEORIES UNDERPINNING SUSTAINABLE BEHAVIOR

The adoption of sustainable practice in the area of prosthodontics not only lies in the availability of technology or institutional policies, but also is deeply rooted within the psychological processes of the process of decision-making of a practitioner. There are several theoretical models of behavioral science, which explain how attitudes, beliefs, values and social forces can influence the behavior of environmentally responsible individuals. To find out which are the most important drivers that can force prosthodontists to turn to environmentally-friendly materials and methods, is the reason why those theories are important.

3.1 Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TPB) which was developed by Ajzen (1991) is one of the most popular theories which are used to predict and explain human behaviour in environmental situations. TPB states that three main constructs are involved in the intentions of an individual to perform a behavior: attitudes, subjective norms, and perceived behavioral control [18]. Attitudes are the positive or negative assessment of an individual doing a certain behavior. Within the framework of eco-friendly materials in the context of prosthodontics, practitioners who view eco-friendly materials as advantageous, safe, and effective are more likely to use them. The studies show that there is a strong relationship between positive environmental attitude and sustainable healthcare practices [19].

Subjective norms are perceived social pressure of peers, professional organizations, and patients. Dental practitioners can usually work within close professional networks where it may be the colleagues who influence the adoption of sustainable practices, institutional policies, and patient expectations that are increasingly environmentally conscious [20].

Perceived behavioral control refers to the amount to which people believe that the individuals have the resources, knowledge and ability to practice a behavior. In the case of prosthodontics, perceived control may be hindered by barriers such as cost, lack of sufficient training, or even by the availability of environmental friendly substances thereby preventing its adoption. On the other hand, the confidence of the practitioners in their ability to introduce sustainable practices can be boosted by access to training and supportive infrastructure [21].

3.2 Value-Belief-Norm (VBN) Theory

The Value-Belief- Norm (VBN) theory presents an approach of environmental behavior that is moral and value based. Stern et al. (1999) developed this theory and suggested that the motivations in pro-environmental behaviors are a series of psychological processes that initiate with personal values, ecological beliefs, and moral norm [22].

Environmental values, such as altruism and the concern about future generations are of great relevance to the commitment of the practitioners towards sustainability. The closer to the ecological consideration of their clinical decision-making the more environmentally conscious may be the prosthodontist [23].

Personal responsibility and beliefs about the effect on the environment also affect behavior. The practitioners will more easily develop a feeling of responsibility to adopt sustainable alternatives when they learn that dental materials and procedures are part of the reasons why the environment is degrading. This leads to the achievement of personal norms, internalized moral commitments to do what is an environmentally responsible action.

Moral obligation is especially pertinent in the healthcare professions, where the ethical consideration is at the centre of practice. Sustainability is seen by dentists as a continuation of their responsibility to enhance the overall well-being, which also includes environmental health [24]. Thus, VBN theory discloses the importance of the intrinsic motivation and moral duty to the sustainable action.

3.3 Health Belief Model (HBM) and Risk Perception

Another framework that can be useful in understanding sustainable behavior is the Health Belief Model (HBM), which can be used in terms of the perception of risk and the perception of benefits. Initially, HBM was created to explain health-related behavior, but it has been applied to environmental conditions to understand how individuals respond to the perceived risks and benefits [25].

Perceived severity can be defined as the degree to which people feel that environmental degradation is having severe effects. In the field of prosthodontics, recognizing the environmental impact of dental waste and materials has the potential to affect the willingness of dentists to adopt sustainable practices. Research has indicated that pro-environmental behavior is linked to higher perceived environmental risk [26].

Perceived benefits: It is believed that the implementation of environmentally friendly practices will yield beneficial results, which include, but are not limited to, reduced environmental impacts, improved patient perception, and long-term cost savings. Once practitioners become aware of these advantages, they will be more inclined to implement sustainability into their clinical practices.

Also, the perceived barriers like cost and time limit, as well as the absence of evidence, can have a negative effect on behavior. Nevertheless, interventions that highlight the value and minimize the perceived barriers can positively influence the implementation of sustainable practices. In this way, HBM emphasizes the role of risk communication and benefit awareness in influencing the behavior of practitioners.

3.4 Diffusion of Innovation Theory

The theory of diffusion of innovation, introduced by Rogers (1983), describes how new ideas and technologies are spread within a social system. This model is especially applicable to interpret the application of environmentally friendly materials and methods in prosthodontics [27].

This theory states that people can be divided into various adopter groups: innovators, early adopters, early majority, late majority, and laggards. Innovators and early adopters are vital in dental practice to introduce and validate sustainable innovations, including digital workflows and materials with a low carbon footprint. Their experience and recommendations play a role in the adoption decisions of the other practitioners.

Some of the factors that affect the adoption process include, the perceived relative advantage, compatibility with existing practices, complexity, trialability and observability. Incidentally, those eco-friendly materials that are easy to work with, relatively affordable and clinically sound are likely to be accepted in the dental fraternities. [27].

Opinion leaders and professional networks are also critical factors in deciding adoption trends. The channels that may be utilized in the dissemination of information and in the promotion of sustainable practices are the continuing education programs, the professional associations and the academic institutions. A mixture of these and other psychological forces is recapped in Table 2 that provides a comparative view of significant theoretical models.

Although each theoretical framework contributes to a deeper understanding of the concept of sustainable behavior in the context of prosthodontics, a combination of these theoretical frameworks would allow addressing the issue of sustainable behavior more comprehensively. TPB concentrates on intention and perceived control, VBN focuses on the moral responsibility, HBM focuses on risk and benefit perception, and Diffusion of Innovation explains how new practices spread. All these factors are interlinked and individually contribute to shaping the behavior of practitioners, as shown in Figure 2, which gives an integrated conceptual model that links psychological drivers to adopting sustainable practices.

Table 2: Key Psychological Models Explaining Sustainable Behavior in Healthcare Professionals

Theory	Key Constructs	Relevance to Prosthodontics	Implications
Theory of Planned Behavior (TPB)	Attitudes, subjective norms, perceived behavioral control	Explains intention to adopt eco-friendly materials	Focus on training and peer influence
Value-Belief-Norm (VBN)	Values, beliefs, personal norms	Highlights ethical responsibility toward the environment	Promote sustainability ethics in education
Health Belief Model (HBM)	Perceived severity, benefits, barriers	Links environmental risk perception to behavior	Increase awareness of environmental impact
Diffusion of	Adoption stages, social	Explains the spread of	Use opinion leaders and

Innovation	influence	sustainable technologies	early adopters

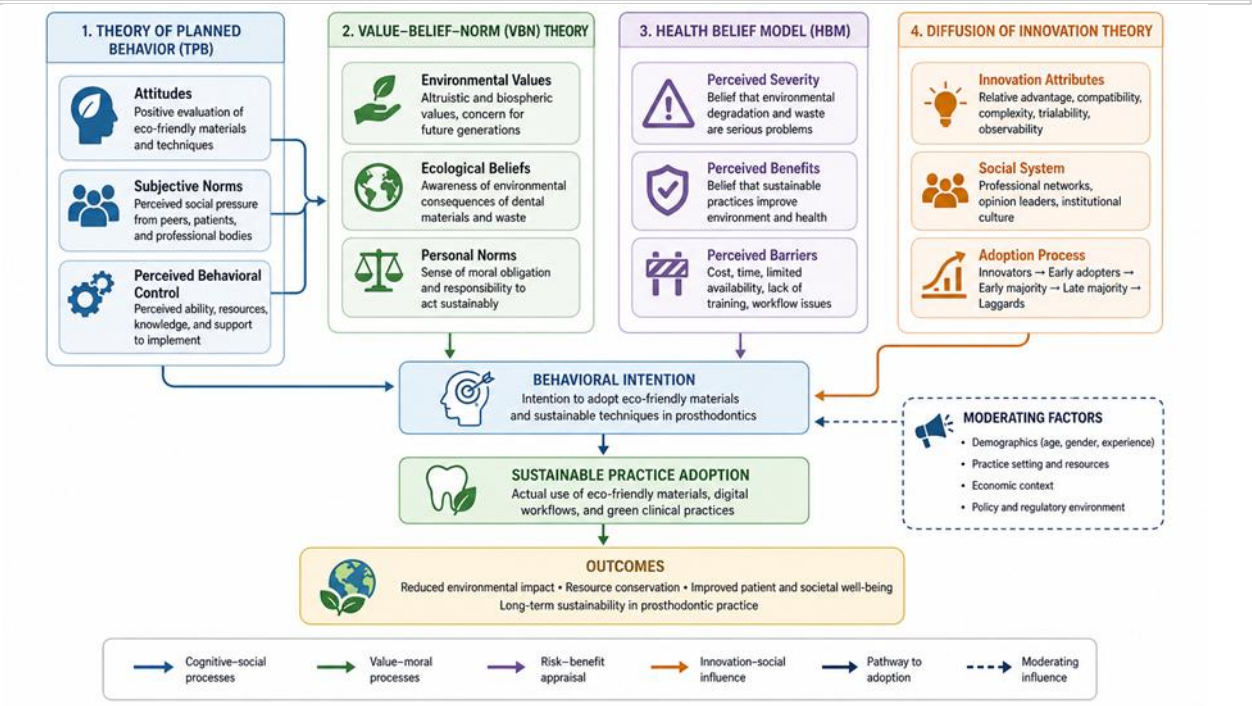

Figure 2: Integrated Theoretical Framework Linking Psychological Drivers to Sustainable Practice Adoption

4. PRACTITIONER ATTITUDES AND BEHAVIORAL DRIVERS

Attitudes and behavioral determinants of practitioners are strong determinants that can lead to the successful integration of sustainable practices in prosthodontics. Although the environmental issues and technological advances present the environment in which the change is to take place, the degree to which the given eco-friendly practices are adopted depends mostly on how the dental professionals view, assess, and react to the problems related to sustainability. This chapter examines the major psychological and situational dynamics of practitioner conduct in prosthodontics.

4.1 Attitudes Toward Sustainability in Dentistry

The attitudes of practitioners are at the heart of predicting the adoption of environmentally sustainable practices. Attitudes include the type of awareness of the existence of environmental issues and the perceived significance of tackling them in clinical practice. According to studies, despite the high awareness of many dental professionals of environmental issues, the ongoing awareness level is highly varied depending on the education, exposure, and institutional focus [28].

Perceived importance is the other significant factor. The professionals who consider sustainability as a part of the healthcare provision tend to implement eco-friendly materials and practices in their practice. Conversely, those who are not so concerned about environmental aspects, but rather focus on clinical outcomes and economic efficiency, may not be willing to change to sustainable options. This shows that there is a need to balance sustainability and core professional values to enhance its perceived relevance in the profession of prosthodontics [11].

4.2 Knowledge and Education

Knowledge and education are basic factors that influence sustainable behavior in dentistry. Traditionally, dental curricula have been founded on clinical competency and patient care, yet have received little or no consideration to environmental sustainability. Therefore, not every practitioner is trained on how to use eco-friendly practices and this could be a barrier to its adoption [29].

Undergraduate and postgraduate dental education can significantly improve the awareness and competency of the education process by incorporating sustainability in the education process. Educational interventions (workshops, seminars, curriculum reforms) have been reported to positively influence knowledge and make a positive change in attitudes towards sustainable dentistry [30]. Moreover, professional development (CPD) programs play an important role in training practitioners on new sustainable technologies and materials. The myths of eco-friendly materials, including the issues of durability, cost, and clinical effectiveness can be addressed by further education as well. Through education programs, practitioners can be empowered to make informed decisions that consider both clinical and environmental factors.

4.3 Social and Professional Norms

Social and professional norms are critical to practitioner behavior, particularly in highly regulated and interpersonal settings, like dentistry. A peer may have an influence on attitudes to sustainability because practitioners often seek advice and information on best practices with their colleagues and professional leaders [31].

The culture of an institution is also very important. The ability to contribute to the situation by creating an environment in which the behavior aimed at being environmentally friendly is encouraged is the attribute of dental practices and organizations that tend to be more sustainability-oriented. To provide an example, the normalization of sustainable practices and the impact on individual behavior can be achieved through clinics implementing waste reduction programs or using digital workflows.

Norms are further strengthened by professional associations and regulatory bodies, which provide guidelines and standards of sustainable practice. By making sustainability a professional obligation and a component of the accreditation and quality assurance processes, these institutions may promote change [32].

4.4 Perceived Barriers and Facilitators

Nevertheless, despite the increasing awareness and positive attitudes, there are a number of obstacles that prevent the implementation of sustainable practices in the sphere of prosthodontics. Cost is one of the most frequently mentioned obstacles. The cost of eco-friendly materials and technologies, including CAD/CAM technologies or biodegradable alternatives, is often higher, which may not appeal to practitioners, especially in resource-limited environments [33].

Availability of materials is another challenge. Sustainable dental materials are not easily available in many regions, thus limiting the ability of practitioners to adopt the materials even where practitioners are willing to adopt them. Supply chain limitations and a lack of standardization further complicate the issue.

The time and workflow constraints are also playing a significant role. Sustainability may imply a change in clinical practice, further training, or more processing time, which can be considered inconvenient in busy practice environments. It is therefore possible that practitioners choose to be efficient instead of sustainable when the demand and workload of patients is high.

On the other hand, there are several facilitators who can facilitate adoption. They include: financial incentives, user-friendly technologies, institutional support, and positive patient feedback. The combination of these barriers and facilitators can be summarized in Table 3, which is a structured overview of factors affecting the implementation of eco-friendly practices in prosthodontics.

4.5 Ethical and Moral Responsibility

Ethical considerations are a central issue in the healthcare practice and extend beyond patient care to encompass larger societal and environmental concerns. Within the context of the concept of sustainability, the professionals in the field of prosthodontics are gradually learning to see the notion of sustainability as an ethical demand that is aligned with the principle of doing no harm, which also implies the minimization of the environmental impact [34].

The professional ethics schemes are evolving to accommodate sustainability on the focus of dentists as agents of promoting environmental health. The shift is symbolic of the constantly growing awareness of the fact that ecological harm may have both direct and indirect effects on the human condition, thereby closing the gap between ecological responsibility and clinical practice. The other factor that affects ethical decision-making is the anticipation of the patients. As the news surrounding environmental issues continues to increase, patients are starting to consider more the environmental sustainability of healthcare services. By practicing in an environmentally friendly manner, the practitioners can build the trust and satisfaction of the patients in a positive feedback loop, which in turn reinforces the sustainable behaviour [35].

Finally, the pull towards the adoption of sustainable practices can be supplemented with the introduction of ethical and moral factors into the practice of prosthodontics and complement other psychological and contextual drivers.

Table 3: Barriers and Facilitators to Adoption of Eco-Friendly Practices in Prosthodontics

Category	Barrier/Facilitator	Description	Impact Level
Economic	Barrier	High initial cost of eco-friendly materials and digital systems	High
Resource Availability	Barrier	Limited access to sustainable dental materials	High
Time & Workflow	Barrier	Increased time and complexity in adopting new techniques	Medium
Knowledge & Training	Barrier	Lack of formal education on sustainability	High
Institutional Support	Facilitator	Policies promoting green dentistry practices	High
Technology	Facilitator	Availability of CAD/CAM and digital workflows	Medium–High
Patient Demand	Facilitator	Growing preference for eco-friendly healthcare	Medium
Professional Influence	Facilitator	Peer support and leadership endorsement	High

5. ECO-FRIENDLY MATERIALS AND SUSTAINABLE TECHNIQUES IN PROSTHODONTICS

The shift towards the sustainable prosthodontic practice is a complex phenomenon that involves the use of environmentally-friendly materials, the latest digital technologies, and an environmentally-friendly clinical workflow. Digital dentistry and advances in material science can provide the potential to minimize the ecological footprint of prosthodontics without

impairing or worsening clinical outcomes. Nevertheless, the effectiveness of these solutions relies on the technological feasibility as well as the acceptance of the solutions by the practitioners.

5.1 Sustainable Dental Materials

The creation and implementation of sustainable dental materials are key to minimizing the environmental impact of the prosthodontic process. High environmental costs are linked with traditional materials, including polymethyl methacrylate and some metal alloys, which are not biodegradable and require a lot of energy to be produced. In comparison, the more sustainable alternative is emerging biodegradable and low-toxicity materials.

Renewable-based polymers that are substitutes for conventional acrylic resins are being investigated. These materials are less environmentally toxic and more biodegradable, but long-term clinical performance will require further research. Likewise, the development of low-monomer-release composites due to progress in resin chemistry reduces environmental contamination and enhances biocompatibility [36].

Sustainability is also ensured by the recycling of alloys and ceramics. Dental alloys, especially noble metal-based alloys, can be recovered and reused, thus eliminating the need to extract raw materials. The recycling processes not only save resources but also reduce the environmental impact of the mining and refining processes [36]. The ceramic materials, though energy-consuming to manufacture, have long service life and wear, which can offset their initial environmental impact when considered over the product lifecycle.

Digital content employed in CAD/CAM systems also helps to promote sustainability by helping to optimize material use. The use of pre-fabricated blocks makes it possible to mill them accurately and minimize wastes in the form of excess materials, as is the case with conventional fabrication methods. Moreover, the development of composite and hybrid ceramic blocks has enhanced efficiency and lowered the rate of remakes and consequently reduced resource usage [37].

5.2 Digital Dentistry as a Sustainability Enabler

Digital dentistry has become one of the major facilitators of sustainable practice in the field of prosthodontics. The CAD/CAM and 3D printing technologies can streamline the workflow, achieve better accuracy, and minimize waste materials. The innovations could also lead to a reduction in treatment time and an improvement in patient experiences.

CAD/CAM systems do not use traditional impression materials and gypsum casts, which are major clinical waste contributors. Digital impressions obtained with the help of intraoral scanners are more accurate and environmentally-friendly since they reduce the use of disposable materials [38]. Moreover, digital processes allow the production of restorations precisely, with fewer errors and without remakes.

Another sustainability advantage of additive manufacturing or 3D printing is that objects are produced by adding a new layer to the existing one, thus minimizing material waste in comparison to subtractive processes of milling. The technology can be especially helpful in the creation of temporary restorations, surgical guides, and dental models [39]. However, the environmental impact of 3D printing depends on factors such as resin composition, energy consumption, and waste management practices.

The other benefit of digital dentistry is the decrease in the amount of chair time and the number of visits to the dentist. Digital workflows help decrease the energy consumed on recurring appointments and transportation to facilitate same-day restorations and effective organization of treatment. All these benefits illustrate how digital technologies can be used to maintain a sustainable practice of prosthodontics in the case of implementing digital technologies effectively [40].

5.3 Waste Reduction and Green Clinical Practices

Sustainable prosthodontics, in addition to material and technological improvements, will also require the adoption of green clinical practices that will assist in the reduction of waste and conservation of resources. A balance between sterilization and disposable material is one of the main areas. As much as the use of single-use items is essential in infection control, excessive dependence on the use of disposables has led to environmental degradation. A more sustainable solution that would not impact the safety of the patients is reusable instruments that have been properly sterilized [41].

Another significant waste minimization strategy would be efficient inventory management. The expiration of materials and their wasteful disposal may be caused by overstocking and improper storage. Inventory control systems and a just-in-time strategy can be used to minimize waste and increase the efficiency of resources [42].

Water and energy conservation, which are essential aspects of sustainable dental practice, are also part of sustainable dental practice. Large amounts of water are used in dental units, both to perform procedures and sterilization, but also the equipment found in dental units, including autoclaves, compressors, etc., require a lot of energy. Simple measures such as the use of energy saving machines, optimization of using machines, and use of water saving machines can significantly reduce the effect on the environment [43].

The resultant change in behaviors of the practitioners can be deemed as the added value to effectiveness of these strategies. Awareness, training, and dedication to sustainability can be used to fuel the gradual adoption of green practices in the day-to-day clinical activities. Figure 3 shows how the materials, technology, and practitioner behavior can be integrated to provide a conceptual representation of sustainable prosthodontic practice.

The environmentally friendly materials, digital technologies and environmentally friendly behaviors are not applied singly, but rather as a synergistic mixture to achieve the sustainable prosthodontics. Although the needed tools will be the material science and digital workflow innovations, their influence will be determined by the level of their acceptance and

implementation by practitioners. These factors interplay which as shown in Figure 3 is significant in regard to the holistic approach to sustainability in the prosthodontics field.

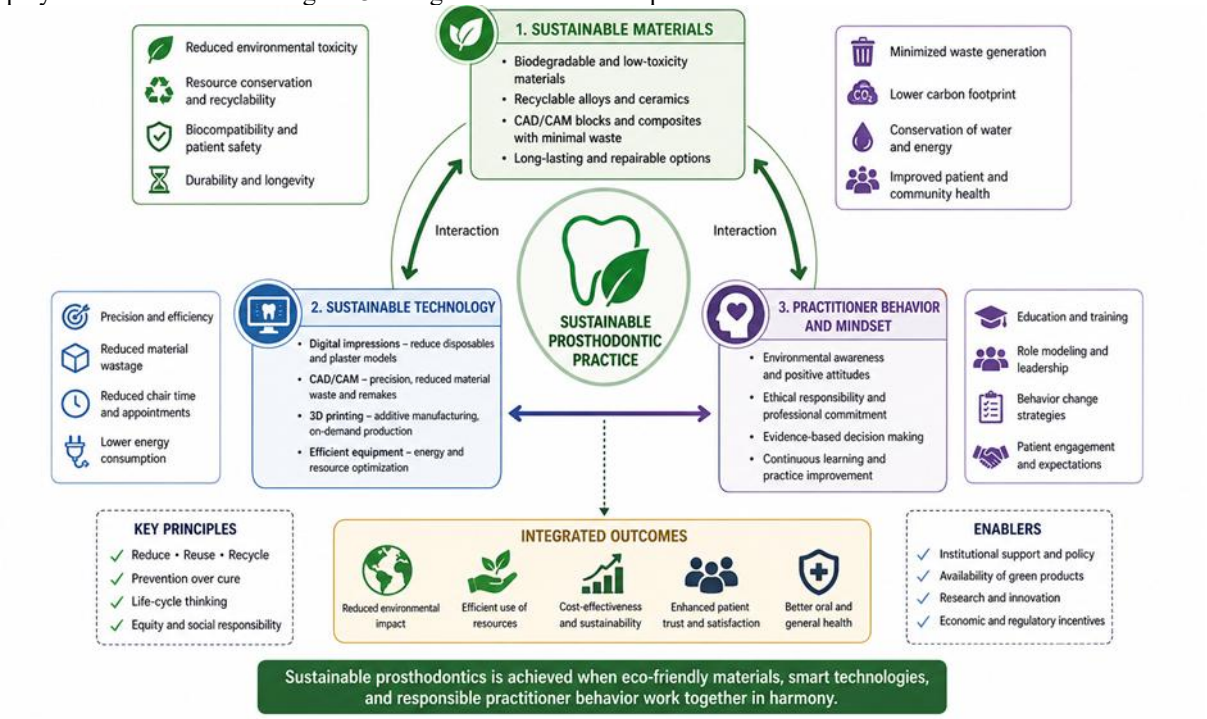

Figure 3: Sustainable Prosthodontic Practice Model (Materials + Technology + Behavior Integration)

6. STRATEGIES TO ENHANCE ADOPTION OF SUSTAINABLE PRACTICES

The application of sustainable practices in the field of prosthodontics will only be achieved after a combination of educational, institutional, behavioral, and research-oriented approaches. Although there is an increasing awareness of environmental issues, translating this awareness into a regular clinical practice is still a challenge. To fill this gap, it is essential to conduct specific interventions that could make a difference in knowledge, attitudes, and systemic structures in dental practice.

6.1 Educational Interventions

Education is one of the supporting strategies that can contribute to the promotion of the sustainability of prosthodontics. By incorporating environmental sustainability into dental curricula, future practitioners will already have an initial idea regarding environmental sustainability and its relevance to dental practice. Clinical competence and patient care have long been the focus of dental education, with little regard to environmental issues. However current initiatives aim at introducing undergraduate and postgraduate level courses that cover issues related to sustainability including waste management, lifecycle assessment, as well as the selection of green materials [44].

Integration of curriculum is not only limited to theoretical aspects but also on the practical training. The students can be assisted to learn more about how the sustainable practices can be implemented in real world scenarios through simulation based learning and case studies. Using the example of digital workflows, teaching them as a course of action can not only increase the efficiency of clinical work but also minimize the impact on the environment.

Workshops and training programs are also important to the practicing professionals. The knowledge gaps can be filled in by ensuring that the educational programs on green dentistry, digital technologies, and sustainable materials are continued to make sure that the practitioners are informed of the innovations. It is established that the immense positive effect of structured training programs, in terms of awareness and implementation of environmentally responsible practices in healthcare facilities is colossal [45]. In addition, interdisciplinary approach with the collaboration of environmental scientists and policy makers can be utilized to enrich the instructional content, and present a broader perspective with regards to sustainability.

6.2 Policy and Institutional Support

Policy frameworks and institutional support will be needed to achieve sustainable change in the area of the prosthodontics field. The regulatory bodies and professional associations play a key role in provision of the guidelines of environmental responsible dental practice. There can be standardized waste management procedures, energy conservation and specifications to make the choice of materials standardized can be given as clear guidelines to the practitioners [46].

The evidence-based recommendations on green dentistry should be generalizable across practice settings. Some of the recommendations that these guidelines can make include the abolishment of single-use plastics, the replacement of technologies with digital technologies, and recycling. The organizational goals and the environmental goals can be balanced in a

way that they entail the institutional policies that give more priority to sustainability which can provide a conducive environment to behavioral change.

Adoption is also boosted by regulatory frameworks and incentives. The initial cost (financial) of the technologies that are environmentally-friendly can be paid (with the help of financial incentives, like subsidies on digital equipment or tax breaks on sustainable practices). Alternatively, compliance can be achieved with the assistance of regulatory tools, e.g., a mandatory waste segregation and reporting [47].

It is also significant that the leadership of the dental institutions should be engaged. The administrators and senior practitioners that enable sustainability are capable of influencing organizational culture, and promoting the utilization of green practices. Organizations can remain devoted to be environmentally responsible by ensuring that sustainability is made part of the institutional policies and performance measures.

6.3 Behavioral Change Strategies

Behavior change strategies are critical to this translation of knowledge and policy into action. Nudging is a behavioral economics concept that consists of influencing people in a subtle way to adopt desirable behaviors without dictating their behavior. In prosthodontics, nudges may take the form of default choices of environmentally friendly materials, visual cues to reduce waste, and feedback devices to monitor the environmental performance [48].

Perceived barriers can also be targeted through behavioral interventions, and motivation can be increased. As an example, it may be more effective to provide real-time data on resource consumption to raise awareness and encourage practitioners to choose more sustainable practices. Equally, positive behavior can be reinforced by emphasizing the long-term cost-saving and benefit to patients of environmentally friendly practices.

The importance of the role of leadership and role models is especially prominent in behavioral shaping. Leaders in the dental community can exert influence on peers by showing the possibilities and advantages of sustainable practices. The pioneers who adopt green technologies can often be the agents of further implementation of green technologies, as their experiences will reduce the uncertainty levels and will create confidence among other players of the green technologies game [49].

Behavior can also be motivated by social recognition and professional rewards. Awards, certifications, and public recognition of sustainable practices can increase the reputation of the practitioners as well as influence others to emulate the same. Such strategies capitalize on both extrinsic and intrinsic motivation in fostering behavioral change in the long run.

6.4 Future Research Directions

Although there has been an increasing interest in sustainable dentistry, there is still a need to conduct strong empirical studies to aid in making evidence-based decisions. The existing literature is mainly descriptive, and the quantitative data on the effectiveness of sustainable interventions in prosthodontics are limited. The measurement of the environmental impact of various materials and methods based on standardized metrics should be the subject of future studies [50].

Integrating psychological and clinical research is another important direction. The information about the incorporation of behavioral factors in the development of clinical decisions can be utilized to design particular interventions. As an example, a combination of the perspectives of both behavioral science and clinical trials would allow an in-depth understanding of both efficacy and adoption.

It must also have sustainability outcomes measurement. Developing strong measures of environmental performance such as carbon footprint, minimization of waste, and efficiency of resources can help practitioners and institutions to measure their performance. They can be applied during the quality assurance and accreditation, which makes them responsible and capable of constantly improving [51].

In addition, the research should be interested in the cost-effectiveness of sustainable practices in the long-term. In spite of the fact that the initial investment may be high, the opportunities of costs reduction through less material use, energy use, and managing the waste need to be systematically taken into account. This data can be used to strengthen the thesis about sustainability and facilitate a wider adoption.

Finally, the interdisciplinary collaborations will be required in the further elaboration of the research in this sphere. The partnerships between dental professionals, environmental scientists, engineers, and policymakers could assist in the development of new solutions that can be used to address the clinical and environmental problems

7. CONCLUSION

The shift towards the eco-friendly manner of practicing the field of prosthodontics, is a significant step towards reducing the environmental footprint of the field of dental care without compromising high standards of clinical performance. This review notes that sustainability in prosthodontics cannot be simply explained by technological development and material innovations but is much influenced by the attitudes, beliefs and behavioral intentions of the practitioners. Theory of Planned Behavior, Value-Belief-Norm theory, Health Belief Model and Diffusion of Innovation are some of the psychological theories that can offer good information on how dental professionals make a decision with regard to eco-friendly practice. Even though the awareness of environmental issues is on the rise, a number of barriers to widespread adoption, including the cost factor, lack of access to sustainable materials, and workflow issues, among others, continue to be impediments to widespread adoption. This however can be made easy by taking certain measures, which are as follows: introduction of sustainability in dental education, institutional policies that are supportive, and behavioral change interventions. The plausible opportunities of waste management and

efficiency can also be offered by digital dentistry and the development of material science. Finally, there is a need to develop a culture of sustainability in the profession of prosthodontics through concerted push that will involve practitioners, educators, policymakers and researchers. The global sustainability objectives and the improvement of the quality of patient care and professional responsibility could be considerably fulfilled with the assistance of prosthodontics.

REFERENCES

1. Karliner J, Slotterback S, Boyd R, Ashby B, Steele K, Wang J. Health care's climate footprint: the health sector contribution and opportunities for action. Eur J Public Health. 2020 Sep 1;30(Supplement_5):ckaa165.843. doi:10.1093/eurpub/ckaa165.843
2. Mahesh S, Hemalata K, Shanta R, Vashistha U, Krishnakumar K, Arora S, et al. Bridging the gap: a cross-sectional study on biomedical waste management education and compliance in dental institutions of Delhi National Capital Region. GMS Hygiene and Infection Control. 2025;20:Doc24.
3. Duane B, Lee MB, White S, Stancliffe R, Steinbach I. An estimated carbon footprint of NHS primary dental care within England. How can dentistry be more environmentally sustainable? Br Dent J. 2017 Oct;223(8):589–93. doi:10.1038/sj.bdj.2017.839
4. Bardolia P. The environmental impact of dentistry. Br Dent J. 2019 May;226(9):634–634. doi:10.1038/s41415-019-0323-6
5. Khurshid Z, Alqurashi H, Ashi H. Advancing Environmental Sustainability in Dentistry and Oral Health. European Journal of General Dentistry. 2024 Sep;13(3):264–8. doi:10.1055/s-0044-1787099
6. Rautemaa R, Nordberg A, Wuolijoki-Saaristo K, Meurman JH. Bacterial aerosols in dental practice – a potential hospital infection problem? Journal of Hospital Infection. 2006 Sep 1;64(1):76–81. doi:10.1016/j.jhin.2006.04.011
7. Eliades T, Sifakakis I, Papageorgiou SN. Clinically relevant aspects of dental materials science in orthodontics. Orthodontics-E-Book: Orthodontics-E-Book. 2016;187.
8. Carnero MC. Assessment of Environmental Sustainability in Health Care Organizations. Sustainability. 2015 Jul;7(7):8270–91. doi:10.3390/su7078270
9. Anusavice KJ, Shen C, Rawls HR. Phillips' Science of Dental Materials. Elsevier Health Sciences; 2012. 588 p.
10. Noort R van. Introduction to Dental Materials [Internet]. 2013 [cited 2026 Apr 2]. Available from: https://shop.elsevier.com/books/introduction-to-dental-materials/van-noort/978-0-7234-3659-1
11. Martin N, Mulligan S. Environmental Sustainability Through Good-Quality Oral Healthcare. Int Dent J. 2021 Aug 16;72(1):26–30. doi:10.1016/j.identj.2021.06.005 PubMed PMID: 34412896; PubMed Central PMCID: PMC9275203.
12. Haralur SB, Al-Qahtani AS, Al-Qarni MM, Al-Homrany RM, Aboalkhair AE, Madalakote SS. The dental solid waste management in different categories of dental laboratories in Abha City, Saudi Arabia. The open dentistry journal. 2015;9:449.
13. Al Wadei MHD, Sayed ME, Jain S, Aggarwal A, Alqarni H, Gupta SG, et al. Marginal adaptation and internal fit of 3D-printed provisional crowns and fixed dental prosthesis resins compared to CAD/CAM-milled and conventional provisional resins: A systematic review and meta-analysis. Coatings. 2022;12(11):1777.
14. Beuer F, Schweiger J, Edelhoff D. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. British dental journal. 2008;204(9):505–11.
15. Javaid M, Haleem A. Current status and applications of additive manufacturing in dentistry: A literature-based review. Journal of oral biology and craniofacial research. 2019;9(3):179–85.
16. ISO. ISO [Internet]. 2006 [cited 2026 May 4]. Environmental management — Life cycle assessment — Principles and framework. Available from: https://www.iso.org/standard/37456.html
17. Ferracane JL. Resin composite—State of the art. Dental materials. 2011;27(1):29–38.
18. Ajzen I. The theory of planned behavior. Organizational behavior and human decision processes. 1991;50(2):179–211.
19. Armitage CJ, Conner M. Efficacy of the Theory of Planned Behaviour: A meta-analytic review. British J Social Psychol. 2001 Dec;40(4):471–99. doi:10.1348/014466601164939
20. Godin G, Kok G. The Theory of Planned Behavior: A Review of its Applications to Health-Related Behaviors. Am J Health Promot. 1996 Nov;11(2):87–98. doi:10.4278/0890-1171-11.2.87
21. Ajzen I. Perceived Behavioral Control, Self-Efficacy, Locus of Control, and the Theory of Planned Behavior[1]. J Applied Social Pyschol. 2002 Apr;32(4):665–83. doi:10.1111/j.1559-1816.2002.tb00236.x
22. Stern PC, Dietz T, Abel T, Guagnano GA, Kalof L. A value-belief-norm theory of support for social movements: The case of environmentalism. Human ecology review. 1999;81–97.
23. Stern PC. New Environmental Theories: Toward a Coherent Theory of Environmentally Significant Behavior. Journal of Social Issues. 2000 Jan;56(3):407–24. doi:10.1111/0022-4537.00175
24. De Groot JIM, Steg L. Value Orientations to Explain Beliefs Related to Environmental Significant Behavior: How to Measure Egoistic, Altruistic, and Biospheric Value Orientations. Environment and Behavior. 2008 May;40(3):330–54. doi:10.1177/0013916506297831
25. Rosenstock IM. Historical Origins of the Health Belief Model. Health Education Monographs.

1974 Dec;2(4):328–35. doi:10.1177/109019817400200403
26. Champion VL, Skinner CS. The health belief model. Health behavior and health education: Theory, research, and practice. 2008;4:45–65.
27. Rogers EM. Diffusion of innovations. 3. ed. New York, NY: Free Press [u.a.]; 1983. 453 p.
28. Duane B, Harford S, Ramasubbu D, Stancliffe R, Pasdeki-Clewer E, Lomax R, et al. Environmentally sustainable dentistry: a brief introduction to sustainable concepts within the dental practice. British dental journal. 2019;226(4):292–5.
29. Bamedhaf O, Salman H, Tegginmani SA, Guraya SS. Environmental sustainability in the dental curriculum: a scoping review. BMC Med Educ. 2025 Jun 5;25(1):844. doi:10.1186/s12909-025-07441-y
30. Field JC, Cowpe JG, Walmsley AD. The Graduating European Dentist: A New Undergraduate Curriculum Framework. Eur J Dental Education. 2017 Dec;21(S1):2–10. doi:10.1111/eje.12307
31. Yuan CT, Nembhard IM, Kane GC. The influence of peer beliefs on nurses' use of new health information technology: A social network analysis. Social Science & Medicine. 2020;255:113002.
32. Wood NH. The ethical imperative: continuing professional development in dentistry. South African Dental Journal. 2023;78(9):429–429.
33. Coronel-Zubiate FT, Farje-Gallardo CA, de la Puente EER. Environmental impact of waste in dental care: Educational strategies to promote environmental sustainability. In: ENVIRONMENT. TECHNOLOGY. RESOURCES. Proceedings of the International Scientific and Practical Conference [Internet]. 2024 [cited 2026 May 4]. p. 340–4. Available from: https://archive-journals.rtu.lv/etr/article/view/4809
34. FDI World Dental Federation. Sustainability in Dentistry Statement: FDI [Internet]. 2020 [cited 2026 May 4]. Available from: https://www.fdiworlddental.org/sustainability-dentistry-statement
35. Johnstone ML, Tan LP. Exploring the Gap Between Consumers' Green Rhetoric and Purchasing Behaviour. J Bus Ethics. 2015 Dec;132(2):311–28. doi:10.1007/s10551-014-2316-3
36. Xu X, He L, Zhu B, Li J, Li J. Advances in polymeric materials for dental applications. Polymer Chemistry. 2017;8(5):807–23.
37. Giordano R. Materials for chairside CAD/CAM–produced restorations. The Journal of the American Dental Association. 2006;137:14S-21S.
38. Mangano F, Gandolfi A, Luongo G, Logozzo S. Intraoral scanners in dentistry: a review of the current literature. BMC Oral Health. 2017 Dec;17(1):149. doi:10.1186/s12903-017-0442-x
39. Revilla-León M, Özcan M. Additive Manufacturing Technologies Used for Processing Polymers: Current Status and Potential Application in Prosthetic Dentistry. Journal of Prosthodontics. 2019 Feb;28(2):146–58. doi:10.1111/jopr.12801
40. Jodar M, Sendler E, Krawetz SA. The protein and transcript profiles of human semen. Cell Tissue Res. 2016 Jan 1;363(1):85–96. doi:10.1007/s00441-015-2237-1
41. Johnston K, Baker J. Waste reduction strategies: factors affecting talent wastage and the efficacy of talent selection in sport. Frontiers in psychology. 2020;10:2925.
42. Prado-Prado JC, García-Arca J, Fernández-González AJ, Mosteiro-Añón M. Increasing competitiveness through the implementation of lean management in healthcare. International Journal of Environmental Research and Public Health. 2020;17(14):4981.
43. Rizan C, Steinbach I, Nicholson R, Lillywhite R, Reed M, Bhutta MF. The Carbon Footprint of Surgical Operations: A Systematic Review. Annals of Surgery. 2020 Dec;272(6):986. doi:10.1097/SLA.0000000000003951
44. Sanz M, Ceriello A, Buysschaert M, Chapple I, Demmer RT, Graziani F, et al. Scientific evidence on the links between periodontal diseases and diabetes: Consensus report and guidelines of the joint workshop on periodontal diseases and diabetes by the International Diabetes Federation and the European Federation of Periodontology. Diabetes research and clinical practice. 2018;137:231–41.
45. Walsh L, Brostek A. Minimum intervention dentistry principles and objectives. Australian Dental Journal. 2013 Jun;58(s1):3–16. doi:10.1111/adj.12045
46. Dobrzański LA, Dobrzański LB, Dobrzańska-Danikiewicz AD, Dobrzańska J. The concept of sustainable development of modern dentistry. Processes. 2020;8(12):1605.
47. Eckelman MJ, Sherman J. Environmental impacts of the US health care system and effects on public health. PloS one. 2016;11(6):e0157014.
48. Adkisson RV. Nudge: Improving Decisions About Health, Wealth and Happiness. ResearchGate. 2008;45(4). doi:10.1016/j.soscij.2008.09.003
49. Bandura A. Social cognitive theory: An agentic perspective. Annual review of psychology. 2001;52(1):1–26.
50. Hickel R, Roulet JF, Bayne S, Heintze SD, Mjör IA, Peters M, et al. Recommendations for conducting controlled clinical studies of dental restorative materials. Clin Oral Invest. 2007 Feb 8;11(1):5–33. doi:10.1007/s00784-006-0095-7
51. Prüss-Üstün A, Wolf J, Corvalán C, Bos R, Neira M. Preventing disease through healthy environments: a global assessment of the burden of disease from environmental risks. Second edition. Geneva, Switzerland: World Health Organization; 2016. 147 p.