



Green Dental Practice Adoption: The Effects of Environmental Management, Organizational Support, and Staff Engagement in Saudi Dental Clinics

Randa Al-Madah^{1*}, Ghadeer Alsobahi²

¹Department of General Subjects, College of Business Administration, University of Business and Technology, Jeddah, Saudi Arabia.

²Department of General courses, University of Business and Technology, Jeddah, Saudi Arabia.

ABSTRACT

Dental clinics contribute to environmental pressures through clinical and non-clinical waste, disposable materials, chemical use, water consumption, energy-intensive equipment, sterilization processes, procurement decisions, and routine administrative activities. These impacts arise within care environments where infection control, patient safety, treatment quality, and operational continuity cannot be compromised. Environmentally responsible dental practice therefore requires the careful redesign of clinic systems rather than the isolated introduction of individual green activities. Green dental practice adoption requires more than environmental awareness or favorable professional attitudes. Sustainable changes depend on clinic policies, environmental management procedures, leadership commitment, infrastructure, financial and material resources, staff capabilities, behavioral participation, and compatibility with clinical workflows. Adoption may remain fragmented when sustainability expectations are not supported by training, monitoring, accountability, and practical implementation capacity. This article develops a conceptual model explaining how environmental management, organizational support, and staff engagement influence green dental practice adoption in Saudi dental clinics. Environmental management establishes formal operational expectations, organizational support provides the resources and authority needed for implementation, and staff engagement converts clinic-level intentions into repeated workplace behavior. The model also identifies implementation mechanisms, mediating conditions, contextual moderators, and operational boundary conditions that affect sustainability outcomes. The model proposes that meaningful adoption emerges when environmental policies, managerial support, staff participation, training, resource availability, workflow alignment, and performance feedback operate as an integrated clinic-level system. Saudi regulatory expectations, healthcare transformation priorities, patient-safety requirements, organizational capacity, and resource conditions moderate the strength of these relationships. The resulting model provides a structured basis for clinic management, sustainability planning, policy development, and future empirical examination.

Keywords: Green dental practice, Sustainable dentistry, Environmental management, Organizational support, Staff engagement, Saudi dental clinics

Corresponding author: Randa Al-Madah

e-mail ✉ r.almadah@ubt.edu.sa

Received: 02 July 2026

Accepted: 04 August 2026

INTRODUCTION

Dental care delivers essential health benefits but also involves substantial material and operational demands, including disposable clinical products, hazardous and non-hazardous waste, water-intensive procedures, electricity use, chemical handling, sterilization, procurement, and facility management (Duane *et al.*, 2019). Although environmental awareness among dental professionals is increasing, awareness alone does not consistently lead to implementation because cost, knowledge, infrastructure, product availability, workflow, and professional barriers may interrupt adoption (Martin *et al.*, 2021a). These challenges distinguish sustainability adoption from simple environmental preference. They also demonstrate why green dental practice must be examined as an organizational and operational change process.

Sustainable oral healthcare is increasingly understood as a shared responsibility involving clinicians, managers, educators,

suppliers, patients, professional organizations, and policymakers (Martin *et al.*, 2022). Education and competency development are particularly important because dental personnel require the knowledge and skills to integrate environmental considerations into clinically appropriate decisions (Field *et al.*, 2023). This broader perspective places dental sustainability within healthcare quality, resource stewardship, climate responsibility, and responsible service delivery. It also shifts attention from isolated individual actions toward coordinated clinic and system-level implementation.

For Saudi dental clinics, sustainable practice has relevance to healthcare modernization, service-quality improvement, operational efficiency, responsible resource use, and the development of more resilient care organizations (Obaid *et al.*, 2026). Practice-level sustainability principles must nevertheless be adapted to the characteristics of dental facilities, treatment volumes, ownership structures, procurement arrangements, staffing patterns, and available environmental services (Duane *et al.*, 2019). Coordination among clinic managers, dental professionals, suppliers, regulators, and healthcare administrators is therefore

necessary to translate general sustainability objectives into feasible operating practices (Martin *et al.*, 2022). The Saudi setting should consequently be treated as an active contextual condition rather than a passive geographical backdrop.

The existing dental sustainability literature identifies barriers affecting awareness, professional behavior, and practical implementation (Martin *et al.*, 2021a). Related work also emphasizes that sustainability depends on coordinated stakeholder participation rather than action by clinicians alone (Martin *et al.*, 2022). However, environmental management, organizational support, and staff engagement are frequently considered as separate concerns, which makes it difficult to explain how they interact at the clinic level (Asif & Shahbaz, 2025). An integrated model is needed to connect formal environmental systems, managerial enablement, employee behavior, and contextual implementation conditions.

This article develops a conceptual model of green dental practice adoption in Saudi dental clinics. The model treats environmental management, organizational support, and staff engagement as distinct but interdependent driver constructs that influence adoption through policies, resource allocation, training, communication, workflow redesign, behavioral routines, monitoring, and feedback (Ayitey *et al.*, 2025). Its practice-level orientation reflects the principle that dental sustainability is produced through recurring clinical and operational decisions rather than through symbolic commitments alone (Duane *et al.*, 2019; Le *et al.*, 2025). The model further incorporates sustainability culture and implementation capacity as mediating conditions, while regulation, patient-safety expectations, resources, infrastructure, and organizational capability function as moderators and boundary conditions (Le *et al.*, 2026).

Green dental practice adoption in Saudi dental clinics

Green dental practice adoption refers to the systematic integration of environmentally responsible activities into clinic operations, professional routines, resource decisions, and service-delivery processes while maintaining clinical quality and safety. Evidence from private dental practices indicates that clinics may perform selected sustainability activities without developing an integrated environmental approach across the organization (Tâncu *et al.*, 2023). Favorable knowledge and attitudes may similarly coexist with inconsistent green-dentistry practices, indicating a gap between environmental intention and routine implementation (Zia *et al.*, 2024).

Adoption should therefore be evaluated through observable organizational and operational changes rather than awareness alone.

The construct includes waste segregation, recycling, reduced material consumption, responsible handling of chemicals, energy conservation, water efficiency, paper reduction, digital workflows, preventive care, sustainable procurement, and environmentally informed product selection (Ganesh *et al.*, 2026). These activities must remain compatible with good-quality oral healthcare, because environmental objectives cannot justify diminished infection control, patient safety, treatment effectiveness, or equitable access (Martin & Mulligan, 2022). Green dental practice is consequently a multidimensional construct integrating materials, resource efficiency, waste, procurement, prevention, professional responsibility, and organizational coordination (Guerra *et al.*, 2025). No single environmental activity can adequately represent the overall level of adoption.

A context-sensitive approach is particularly important because the feasibility of green practices differs across dental clinics. Private practices may vary in their ability to invest in efficient equipment, negotiate procurement requirements, arrange recycling services, and allocate staff time to environmental work (Tâncu *et al.*, 2023). The broad range of sustainability domains identified in dentistry also means that clinics may progress unevenly across waste management, energy, water, materials, digitalization, and preventive care (Guerra *et al.*, 2025). Green adoption should therefore be viewed as a staged clinic-level capability that can mature as resources, knowledge, systems, and staff participation improve.

In Saudi dental clinics, adoption occurs within the combined influence of healthcare transformation, environmental responsibility, regulatory expectations, patient-safety obligations, clinic infrastructure, organizational support, and staff behavior. Environmentally responsible changes must be clinically defensible and integrated into service pathways rather than treated as activities separate from quality improvement (Martin & Mulligan, 2022). The interaction of these forces explains why equivalent sustainability policies may produce different outcomes across clinics with different resources, leadership arrangements, workforce capabilities, and operating conditions (Guerra *et al.*, 2025). **Figure 1** illustrates the clinic-level context for green dental practice adoption in Saudi dental clinics.

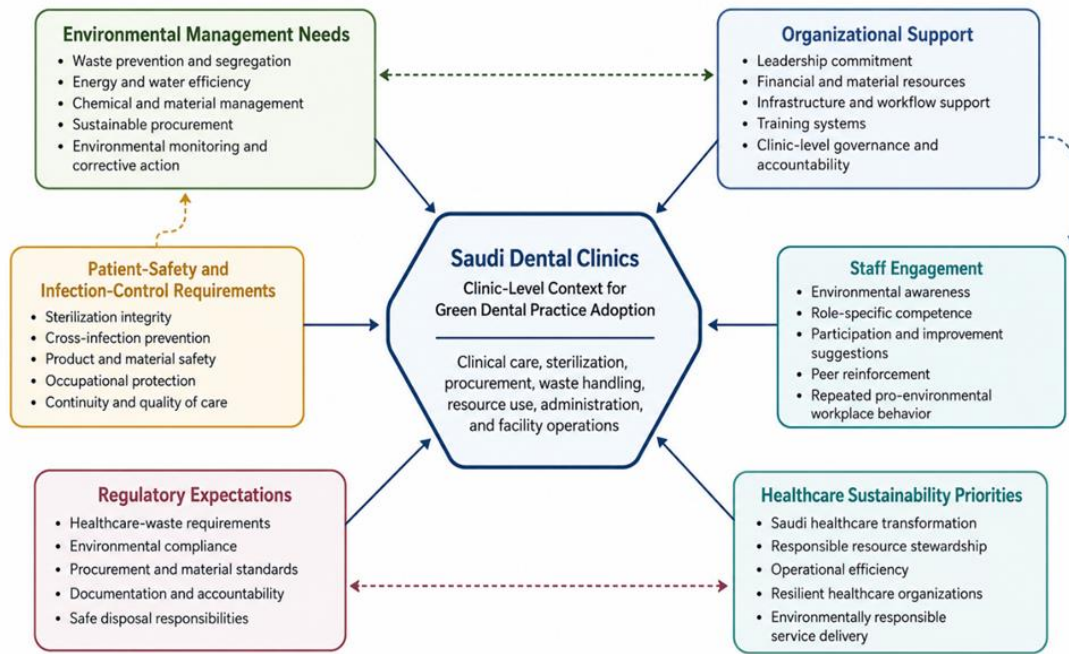


Figure 1. Clinic-Level Context for Green Dental Practice Adoption in Saudi Dental Clinics

Alt-text: A conceptual systems map showing Saudi dental clinics at the center, surrounded by environmental management needs, organizational support, staff engagement, patient safety, regulatory expectations, and healthcare sustainability priorities.

Environmental management in dental clinic sustainability

Environmental management is the formal clinic-level system through which sustainability expectations are converted into policies, responsibilities, procedures, targets, and measurable practices. Evidence from dental clinics in Jeddah indicates that weaknesses in waste segregation, disposal knowledge, and environmental training can create implementation gaps even when waste-management requirements are recognized (Sabbahi *et al.*, 2020). Dental environmental management must also account for the material composition of solid waste and the different environmental consequences associated with clinical products, packaging, restorative materials, plastics, metals, and contaminated items (Khanna *et al.*, 2023). A formal management approach therefore provides the structure needed to move from general concern to controlled environmental performance.

Operational environmental management requires clinics to characterize waste streams, define segregation procedures, assign responsibilities, and assess opportunities for reduction, recovery, and recycling. Dental-clinic waste assessments can expose errors in handling and reveal where materials are being directed into inappropriate or unnecessarily costly disposal streams (de Sousa *et al.*, 2024). Detailed audits of contaminated waste can also identify non-contaminated items that have been placed in higher-impact clinical waste categories (Yeoh *et al.*, 2024). These findings support the use of routine auditing and feedback as practical mechanisms for improving environmental performance.

Beyond waste, environmental management includes energy and water monitoring, equipment-maintenance standards, procurement criteria, digital documentation, inventory control, chemical management, and environmental performance targets. Waste data can help clinic managers redesign storage, collection, labeling, and staff responsibilities rather than relying on informal disposal habits (de Sousa *et al.*, 2024). Similarly, audit findings should be communicated to employees so that mistakes can be corrected and improvements incorporated into routine clinical and administrative workflows (Yeoh *et al.*, 2024). Environmental management becomes effective when information is linked to corrective action, managerial accountability, and repeated performance review.

Dental clinics must ensure that sustainability measures remain compatible with sterilization, infection prevention, occupational safety, and patient protection. Material reduction or reuse should occur only when clinically appropriate, legally permissible, and supported by validated infection-control procedures, while procurement decisions should consider safety, durability, packaging, lifecycle impacts, and waste consequences (Khanna *et al.*, 2023). Saudi clinic managers can use defined indicators to monitor waste segregation, resource consumption, procurement compliance, staff training, and corrective actions without weakening clinical standards (Sabbahi *et al.*, 2020). **Table 1** summarises environmental management practices relevant to green dental practice adoption.

Table 1. Environmental Management Practices for Green Dental Practice Adoption in Saudi Dental Clinics: Waste Reduction, Resource Efficiency, Sustainable Procurement, Infection-Control Compatibility, Monitoring, and Implementation Risks

Environmental management	Clinic-level practices	Adoption mechanism	Infection-control and patient-safety	Illustrative monitoring	Principal implementation
--------------------------	------------------------	--------------------	--------------------------------------	-------------------------	--------------------------

domain			considerations	indicators	risks
Waste prevention and reduction	Review product use, avoid unnecessary opening of sterile items, improve inventory rotation, reduce excess packaging, and replace avoidable disposable administrative materials	Reduces waste at source and makes environmental responsibility part of treatment preparation and inventory control	Reduction must not limit clinically necessary barriers, sterile products, emergency supplies, or legally required disposables	Waste generated per treatment visit; expired inventory; unopened items discarded; packaging volume	Staff may interpret reduction targets as pressure to compromise clinical readiness or safety
Waste segregation and disposal	Use clearly labelled containers, separate infectious, sharps, chemical, amalgam, recyclable, and general waste, and define collection responsibilities	Improves disposal accuracy, lowers contamination of recoverable materials, and supports regulatory compliance	Segregation procedures must prevent exposure, sharps injury, cross-contamination, leakage, and unauthorized handling	Segregation error rate; clinical waste volume; sharps incidents; proportion of correctly classified waste	Inadequate training, confusing labels, limited space, inconsistent collection services, and staff workload
Resource efficiency	Monitor electricity and water use, maintain equipment, use efficient lighting and devices, control leaks, and optimize sterilizer and compressor use	Converts conservation goals into measurable operational routines and cost-awareness practices	Equipment optimization must preserve validated sterilization cycles, ventilation, suction performance, and treatment reliability	Electricity and water use per patient visit; equipment downtime; leak frequency; sterilizer load efficiency	Upfront investment costs, unsuitable infrastructure, inaccurate baselines, and resistance to revised routines
Sustainable procurement	Establish environmental purchasing criteria, evaluate product durability and packaging, consolidate orders, and engage suppliers regarding lower-impact alternatives	Extends environmental management into supply-chain decisions and reduces lifecycle impacts	Purchased products must meet clinical, regulatory, infection-control, material-safety, and quality requirements	Percentage of purchases meeting sustainability criteria; packaging reduction; supplier compliance; product failure rates	Limited supplier options, higher initial prices, uncertain environmental claims, and procurement restrictions
Chemical and material management	Control inventories, store materials safely, minimize expired chemicals, maintain amalgam controls where relevant, and evaluate less harmful alternatives	Reduces hazardous waste and promotes responsible material selection	Substitution decisions require evidence of clinical performance, biocompatibility, safe storage, and regulatory acceptance	Chemical expiration rates; hazardous-waste volume; spill events; material traceability	Inadequate technical information, unsafe substitution, poor storage, and incomplete documentation
Digital and paper-efficient workflows	Use electronic records, digital imaging, online communication, digital consent where permitted, and controlled printing	Reduces paper, physical storage, processing materials, and administrative duplication	Digital systems must protect confidentiality, cybersecurity, informed consent, record integrity, and service continuity	Paper consumption; digital-document completion; duplicate printing; system downtime	Technology costs, cybersecurity risks, interoperability problems, and unequal staff digital capability
Environmental auditing and feedback	Conduct scheduled audits, assign responsible personnel, review performance indicators, communicate results, and implement corrective action	Creates organizational learning, accountability, and continuous environmental improvement	Audit procedures should complement clinical governance and avoid disrupting patient care	Audit completion rate; corrective actions closed; repeat non-conformities; staff feedback participation	Weak data quality, unclear responsibility, limited managerial follow-through, and monitoring fatigue
Staff environmental training	Provide role-specific instruction on waste, resources, procurement, chemicals, incident reporting, and	Builds practical capability and aligns staff routines with clinic environmental policies	Training must clarify that environmental actions remain subordinate to validated safety and infection-control	Training completion; competency assessment; observed compliance;	One-off training, high staff turnover, insufficient protected time, and lack of reinforcement

	improvement procedures	requirements	environmental incident reports		
<i>Organizational support for green dental practice adoption</i> Organizational support refers to the policies, resources, authority, infrastructure, and managerial attention that enable dental personnel to implement environmentally responsible practices. Healthcare sustainability implementation is strengthened when governance arrangements define responsibilities, provide organizational knowledge, allocate resources, and establish managerial accountability (van Schie, 2024). In dental clinics, these conditions signal that sustainability is an institutional priority rather than an optional activity dependent on individual enthusiasm. Organizational support therefore converts environmental intentions into legitimate, resourced, and coordinated clinic programs. Leadership commitment becomes operational when managers communicate clear environmental objectives, connect them with clinical priorities, and involve employees in implementation. Experience from healthcare climate action shows that change management, staff communication, participation, and visible leadership are necessary to translate sustainability goals into organizational practice (Webster, 2023). Dental clinic leaders can reinforce this process by allocating protected training time, approving workflow changes, resolving resource barriers, and recognizing staff contributions. Leadership support is consequently expressed through repeated managerial decisions rather than general			statements of environmental concern. Organizational structures can also distribute responsibility and prevent sustainability initiatives from depending on a single motivated employee. Green teams and designated sustainability functions provide coordination, continuity, ownership, and channels for staff participation within healthcare organizations (Kalogirou & Baumbusch, 2025). In dental clinics, a green team may include dentists, dental assistants, hygienists, sterilization personnel, administrators, procurement staff, and clinic managers. Such multidisciplinary participation allows environmental decisions to be assessed against clinical feasibility, infection-control requirements, costs, workforce capacity, and patient-service implications. Sustainability becomes a clinic-level capability when environmental objectives are incorporated into management controls, performance indicators, review processes, and corrective action. Healthcare sustainability management requires links among targets, measurement, feedback, accountability, and managerial decision-making (Bauer <i>et al.</i>, 2026). Dental clinics can operationalize this approach through waste indicators, resource-use audits, procurement criteria, staff competency checks, and scheduled management reviews. Table 2 outlines organizational support mechanisms that enable green dental practice adoption.		
Table 2. Organizational Support Mechanisms for Green Dental Practice Adoption: Leadership Commitment, Resource Allocation, Training Systems, Policy Support, Sustainability Culture, and Clinic-Level Governance					
Organizational support mechanism	Clinic-level managerial actions	Enabling effect on adoption	Expected staff response	Illustrative indicators	Implementation risks
Leadership commitment	Establish environmental priorities, communicate expectations, participate in reviews, and model responsible resource use	Legitimizes green practice and aligns it with clinical and organizational objectives	Greater confidence that sustainability activities are valued and supported	Leadership review frequency; communicated objectives; completion of agreed actions	Symbolic commitment without resource allocation or follow-through
Financial and material resources	Fund efficient equipment, suitable waste containers, monitoring tools, staff education, and safer product alternatives	Removes practical barriers and enables implementation of environmental procedures	Increased ability to comply with clinic sustainability requirements	Environmental budget; equipment upgrades; availability of required materials	Competing financial priorities, uncertain returns, and short-term cost emphasis
Training systems	Provide induction, role-specific training, refresher sessions, competency assessment, and practical demonstrations	Builds knowledge, confidence, and procedural consistency	Improved environmental awareness and correct execution of green routines	Training completion; competency scores; observed compliance; retraining rates	One-time training, insufficient role relevance, staff turnover, and limited protected time
Policy and procedural support	Develop written waste, procurement, energy, water, chemical, and reporting procedures	Standardizes expectations and reduces reliance on informal individual judgment	More consistent behavior across roles, shifts, and clinic locations	Policy coverage; procedure accessibility; audit compliance; policy-review dates	Overly complex policies, poor communication, and weak enforcement
Procurement authority	Allow purchasing teams to apply	Integrates sustainability into product and	Greater use of durable, lower-	Sustainable-product share; supplier	Limited alternatives, higher prices,

	environmental criteria while preserving clinical requirements	supplier selection	waste, and appropriately packaged products	assessments; packaging indicators	unsupported environmental claims, and contractual restrictions
Time allocation and workflow support	Provide time for audits, team meetings, training, improvement projects, and environmental documentation	Makes sustainability work feasible within routine clinic operations	Higher participation and lower perception that green tasks are additional unpaid work	Protected hours; meeting attendance; completed improvement projects	Workload pressure, patient-volume demands, and cancellation of environmental activities
Communication and participation	Share performance data, invite staff suggestions, discuss barriers, and report progress	Creates transparency, shared ownership, and organizational learning	Increased voice, engagement, and willingness to identify improvement opportunities	Suggestion rates; feedback participation; communication frequency; issues resolved	One-way communication, lack of response to suggestions, and participation fatigue
Recognition and incentive systems	Acknowledge contributions, include sustainability in performance discussions, and reward practical improvements	Reinforces desired behavior and demonstrates organizational appreciation	Stronger motivation and continuation of environmental routines	Recognition events; staff participation; sustainability objectives in appraisal	Incentives that encourage superficial compliance or competition
Clinic-level governance	Assign responsibility, establish green teams, define escalation routes, and integrate sustainability into management meetings	Creates accountability, continuity, and coordinated decision-making	Clearer understanding of roles and stronger cross-functional cooperation	Named accountable leads; governance meetings; action closure; escalation response	Unclear authority, role conflict, dependence on one champion, and weak executive support
Monitoring and management control	Set targets, track indicators, review performance, and implement corrective action	Connects environmental policy with measurable outcomes and continuous improvement	Greater awareness of results and reinforcement of effective behavior	Target achievement; trend reports; corrective-action closure; repeat deficiencies	Inaccurate data, excessive reporting burden, weak feedback, and indicator gaming

Staff engagement and pro-environmental behavior

Staff engagement is the behavioral engine through which environmental policies and organizational resources become recurring dental-clinic practices. Perceived organizational support can strengthen employees' willingness to undertake pro-environmental workplace behavior because it signals that such efforts are valued and practically enabled (Zhang *et al.*, 2024). In dental settings, engaged staff influence waste segregation, material preparation, energy-saving routines, documentation, inventory use, patient communication, and reporting of environmental problems. Adoption therefore depends on employees choosing to apply sustainability expectations consistently during everyday work.

Environmentally focused leadership can shape healthcare employees' behavior through role modelling, perceived support, and the development of environmental self-efficacy (Peng *et al.*, 2022). Dental personnel are more likely to adopt unfamiliar routines when leaders explain their clinical relevance, demonstrate feasible procedures, and respond constructively to implementation difficulties. Training should therefore combine environmental knowledge with role-specific demonstrations and opportunities for supervised practice. Staff engagement is strengthened when employees believe they can perform the required behavior without compromising safety,

productivity, or professional standards.

Support must also operate across organizational levels rather than flow only from senior management. Pro-environmental engagement is reinforced when senior leaders, supervisors, coworkers, and organizational systems provide consistent environmental expectations and support (Albrecht *et al.*, 2024). Peer norms are especially relevant in dental clinics because waste handling, room preparation, sterilization, inventory control, and shutdown procedures are frequently interdependent. When colleagues reinforce the same routines, green behavior is more likely to become a shared clinic norm rather than an isolated personal preference.

Sustainability culture influences whether environmental behaviors are repeated, discussed, and socially reinforced. Healthcare evidence indicates that organizational culture and leadership can encourage green behavior, whereas workplace isolation may weaken employees' ability or motivation to convert supportive values into action (Mohamed *et al.*, 2025). Dental clinics should therefore create participatory channels through which staff can discuss workflow problems, propose improvements, receive feedback, and observe the results of their efforts. **Table 3** compares staff engagement pathways and behavioral mechanisms for green dental practice adoption.

Table 3. Staff Engagement Pathways for Green Dental Practice Adoption in Dental Clinics: Environmental Awareness, Motivation, Participation, Training, Behavioral Routines, Feedback, and Adoption Outcomes

Staff engagement pathway	Behavioral mechanism	Dental-clinic application	Organizational conditions required	Expected adoption outcome	Risk if poorly implemented
Environmental awareness	Increases understanding of environmental consequences and the purpose of green procedures	Education on waste streams, material impacts, water use, energy use, chemicals, and procurement	Accurate information, role relevance, and regular reinforcement	Greater recognition of environmental responsibilities	Awareness without practical capability or organizational support
Role-specific training	Builds competence and environmental self-efficacy	Demonstration of segregation, shutdown, inventory, chemical-handling, and reporting procedures	Protected time, qualified trainers, competency checks, and refresher sessions	More accurate and consistent execution of green practices	Generic instruction, low retention, and failure to address clinical realities
Leadership modelling	Establishes behavioral expectations through visible managerial and professional example	Clinic leaders follow waste, resource, procurement, and reporting procedures	Credible leaders, consistency, and alignment between words and decisions	Increased legitimacy and imitation of desired routines	Perceived hypocrisy when leaders do not follow clinic policies
Staff participation	Creates ownership and draws on operational knowledge	Employees contribute to audits, green teams, procurement reviews, and workflow redesign	Psychological safety, response to suggestions, and decision transparency	More feasible interventions and stronger commitment	Token consultation or repeated rejection of staff input
Motivation and perceived usefulness	Connects behavior with meaningful clinical, organizational, and environmental outcomes	Explain cost savings, safety benefits, reduced waste, and professional responsibility	Clear benefits, feasible expectations, and credible performance information	Greater willingness to sustain behavior over time	Staff may view environmental tasks as burdensome or irrelevant
Peer reinforcement	Converts individual behavior into a shared social norm	Coworkers remind one another about segregation, equipment shutdown, and material use	Team cohesion, consistent procedures, and respectful communication	Stable routines across teams and shifts	Blame, interpersonal conflict, or inconsistent norms
Workflow integration	Reduces the effort required to perform green behavior	Place labelled containers appropriately, simplify documentation, and align procedures with treatment flow	Usable infrastructure, staff testing, and process redesign	Higher compliance and lower disruption to care	Procedures added without adjusting workload or physical layout
Feedback and monitoring	Reinforces behavior by showing outcomes and areas for improvement	Share waste trends, energy indicators, audit findings, and corrective actions	Reliable data, timely communication, and supportive coaching	Continuous learning and improved environmental performance	Punitive monitoring, poor-quality data, or feedback without action
Recognition and incentives	Signals organizational appreciation for environmental contributions	Acknowledge improvement ideas, team achievements, and sustained compliance	Fair criteria, team orientation, and alignment with clinical quality	Stronger engagement and continued participation	Superficial compliance, competition, or focus on rewards alone
Sustainability culture	Embeds environmental responsibility in clinic identity and routine decision-making	Include sustainability in meetings, induction, policies, and improvement discussions	Leadership consistency, shared values, and cross-role participation	Durable pro-environmental norms and collective accountability	Cultural statements that are not reflected in resources or decisions

Saudi dental clinic context and implementation barriers

The Saudi dental clinic context includes workforce development, healthcare transformation, institutional variation, regulatory expectations, and evolving environmental

awareness. Research among Saudi healthcare students indicates that education and professional preparation influence attitudes toward environmental sustainability in healthcare (Cruz *et al.*, 2018). This finding suggests that the future dental

workforce may enter clinics with differing levels of environmental knowledge, confidence, and perceived responsibility. Clinic-level training and professional socialization are therefore necessary to create consistent sustainability expectations.

Environmental implementation is also shaped by the wider healthcare-waste system. Saudi healthcare-waste sustainability has been associated with policy, organizational, and individual challenges involving coordination, segregation, staff knowledge, monitoring, and shared responsibility (Alharbi *et al.*, 2021). Dental clinics may consequently face constraints that cannot be solved solely through staff motivation, particularly when external collection services, recycling infrastructure, procurement arrangements, or regulatory guidance are insufficient. The model therefore treats environmental infrastructure and system support as important contextual moderators.

Within Saudi dental education, environmental sustainability is generally recognized as relevant, but institutional integration and practical application remain uneven. Evidence from dental schools across Saudi Arabia indicates variation in perceptions, teaching practices, barriers, and opportunities related to environmental sustainability (Jamal *et al.*, 2023). These differences may carry forward into clinical employment by influencing staff awareness, expectations, and readiness to participate in green initiatives. Dental clinics cannot assume that all employees possess equivalent sustainability knowledge merely because they have professional dental qualifications.

Institutional support remains essential even when individual attitudes are favorable. Saudi dental educators have identified structural and educational barriers that require organizational resources, preparation, and formal integration rather than reliance on personal interest (Binduhayyim, 2026). Comparable constraints may affect clinical adoption through limited training time, unclear indicators, cost concerns, workload pressure, inadequate infrastructure, weak leadership support, and uncertainty about infection-control compatibility. Implementation barriers should therefore be understood as interacting organizational and system-level conditions rather than evidence of individual resistance alone.

Proposed green dental practice adoption model

The proposed model conceptualizes green dental practice adoption as the outcome of interactions among environmental management, organizational support, and staff engagement. Dental sustainability is inherently multifaceted because it

involves clinical care, materials, waste, procurement, resource consumption, professional behavior, organizational systems, and wider policy conditions (Duane *et al.*, 2020). The three driver domains are therefore treated as complementary constructs rather than interchangeable variables. Adoption is expected to be strongest when each domain reaches a sufficient level of clinic capability.

Environmental management provides formal policies, targets, operational procedures, and performance information; organizational support supplies authority, resources, infrastructure, training, and managerial reinforcement; and staff engagement converts these conditions into repeated behavior. Dental sustainability drivers and good practices indicate that education, leadership, resource efficiency, professional participation, prevention, and stakeholder coordination work together rather than through a single intervention (Martin *et al.*, 2021b). The model therefore proposes that environmental management influences adoption both directly and indirectly through staff understanding, workflow design, and performance feedback. Organizational support similarly strengthens adoption by enabling environmental systems and increasing the feasibility and perceived legitimacy of staff participation.

The model identifies sustainability culture and clinic-level implementation capability as mediating conditions. Sustainability culture reflects shared expectations that environmental responsibility is part of quality dental care, while implementation capability reflects the clinic's ability to coordinate people, resources, procedures, data, and corrective action. Oral-healthcare implementation is affected by facilitators and barriers at practitioner, clinic, product, supply, and system levels (Volgenant *et al.*, 2022). These multilevel conditions explain why similar environmental policies may generate different outcomes across clinics.

Saudi dental clinic context operates as a moderating and boundary condition within the model. Regulation, patient-safety expectations, infection-control requirements, infrastructure, resource availability, procurement systems, organizational capacity, clinic ownership, and external environmental services can strengthen or weaken the effects of the three driver domains. Evidence from safety-critical clinical settings shows that time, sterility requirements, product availability, infrastructure, leadership, and practical workflow constraints affect the feasibility of environmental improvement (Petit *et al.*, 2023). **Table 4** presents the proposed green dental practice adoption model for Saudi dental clinics.

Table 4. Proposed Green Dental Practice Adoption Model for Saudi Dental Clinics: Environmental Management, Organizational Support, Staff Engagement, Adoption Mechanisms, Implementation Conditions, and Sustainability Outcomes

Model component	Construct definition	Principal dimensions	Adoption mechanisms	Mediating or moderating role	Expected influence on green dental practice adoption
Environmental management	Formal clinic system for controlling environmental impacts and improving sustainability performance	Policies, waste protocols, resource targets, procurement standards, audits, indicators, and feedback	Waste segregation, resource monitoring, environmental procedures, corrective action, and responsible purchasing	Direct driver; also strengthens staff capability through clarity and feedback	Creates structured and measurable environmental practices
Organizational support	Degree to which clinic leadership and	Leadership commitment,	Resource allocation, policy enforcement,	Direct driver; enables	Makes green practice feasible, legitimate,

	systems provide authority, resources, and recognition for sustainability	budget, infrastructure, training, time, communication, procurement authority, and governance	workflow redesign, staff development, green teams, and incentives	environmental management and increases perceived support	and organizationally sustained
Staff engagement	Cognitive, emotional, and behavioral participation of dental personnel in sustainability activities	Awareness, motivation, self-efficacy, participation, peer support, perceived usefulness, and proactive behavior	Daily routines, improvement suggestions, correct waste handling, resource conservation, and patient communication	Direct driver; behavioral mediator between organizational conditions and outcomes	Converts policies and resources into consistent clinic behavior
Sustainability culture	Shared belief that environmental responsibility is part of professional and organizational quality	Collective values, leadership example, peer norms, communication, learning, and recognition	Social reinforcement, shared responsibility, discussion of environmental performance, and normalization of green routines	Mediates the effect of organizational support on staff engagement	Increases durability and consistency of environmental behavior
Clinic implementation capability	Ability to coordinate environmental goals with people, workflows, infrastructure, data, and clinical requirements	Management competence, staffing, workflow fit, data systems, technical resources, and improvement capacity	Planning, testing, adaptation, monitoring, and corrective action	Mediates the conversion of drivers into implemented practice	Determines whether sustainability initiatives progress beyond intention
Adoption mechanisms	Processes through which the three drivers produce operational change	Waste reduction, resource efficiency, sustainable procurement, training, communication, monitoring, and feedback	Repeated integration of environmental actions into clinical and administrative routines	Proximal mechanisms linking driver constructs with adoption outcomes	Produces observable environmental changes in clinic operations
Saudi dental clinic context	Regulatory, organizational, cultural, financial, and healthcare-system conditions surrounding adoption	Healthcare transformation, regulation, ownership, patient expectations, infrastructure, procurement, and environmental services	Contextual enablement or constraint of clinic sustainability initiatives	Moderator of the strength and feasibility of model relationships	Explains differences in adoption across clinic settings
Patient-safety and infection-control alignment	Requirement that environmental practices preserve clinical effectiveness and risk control	Sterilization, cross-infection prevention, product safety, occupational protection, and continuity of care	Safety review, clinical validation, risk assessment, and protocol integration	Boundary condition for acceptable environmental change	Prevents unsound sustainability practices and supports professional legitimacy
Green dental practice adoption	Extent to which environmentally responsible practices are embedded in routine clinic operations	Waste, energy, water, materials, procurement, digital workflows, staff behavior, and accountability	Institutionalization, routine compliance, continuous improvement, and cross-role coordination	Central outcome construct	Reflects substantive rather than symbolic sustainability implementation
Sustainability outcomes	Environmental, organizational, behavioral, and operational results of adoption	Reduced waste, resource efficiency, staff participation, accountability, cost awareness, and service alignment	Monitoring, learning, reinforcement, and adaptation	Feedbacks into management priorities and staff motivation	Supports continuous improvement and long-term clinic sustainability

The model also provides an operational pathway through which broad sustainability intentions can be translated into clinic routines. The environmental-management construct may be implemented through reduce, reuse where safe and permitted, rethink, recycle, and rationalized waste-management practices

(Di Spirito *et al.*, 2025). These routines must be supported by procurement review, infection-control assessment, staff participation, environmental monitoring, and corrective feedback. **Figure 2** visualises the proposed green dental practice adoption model for Saudi dental clinics.

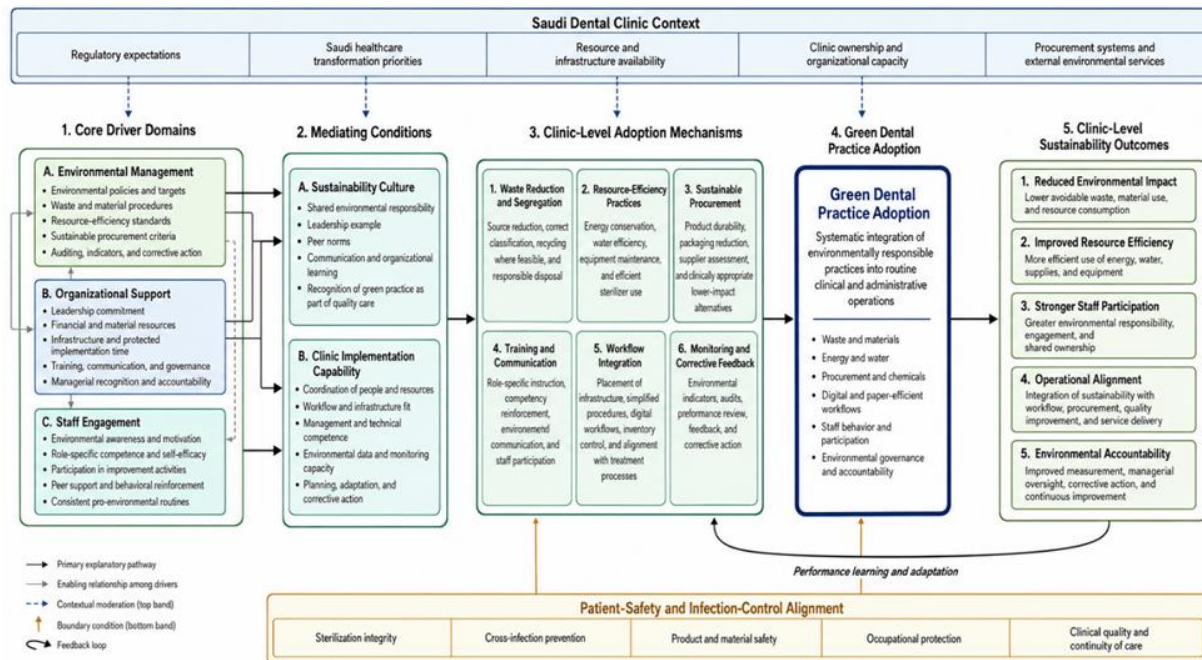


Figure 2. Proposed Green Dental Practice Adoption Model for Saudi Dental Clinics

Alt-text: A left-to-right conceptual model showing environmental management, organizational support, and staff engagement feeding into adoption mechanisms and green dental practice adoption outcomes, with Saudi dental clinic context as a moderating condition.

Practical implications and future research

Dental clinic managers should begin implementation with baseline assessments of waste, energy, water, procurement, staff competency, and workflow conditions. Structured environmental education can improve dental professionals' green knowledge and reported practices, supporting training as an actionable implementation mechanism (Hassan *et al.*, 2025). Training should be role-specific, repeated, assessed, and connected to practical clinic procedures rather than delivered as a single awareness activity. Managers should combine training with clear policies, suitable infrastructure, leadership communication, staff participation, and non-punitive performance feedback.

Healthcare administrators, procurement teams, regulators, and sustainability officers can support clinics by developing practical environmental standards that remain aligned with infection control and service quality. Dental sustainability education should be longitudinal and competency-based because curriculum evidence indicates the need for structured integration, assessment, and reinforcement rather than isolated teaching sessions (Bamedhaf *et al.*, 2025). Procurement criteria should address product safety, durability, packaging, lifecycle considerations, and supplier transparency, while waste systems should support correct segregation and environmentally appropriate disposal. Public and private clinics may require different implementation pathways because their authority,

budgets, procurement flexibility, patient volumes, and access to environmental services may differ.

Future research should empirically test the proposed relationships among environmental management, organizational support, staff engagement, adoption mechanisms, contextual moderators, and sustainability outcomes. The green-dentistry evidence base supports the need for stronger evaluation, standardized measures, and clearer assessment of implementation outcomes (Wolf *et al.*, 2026). Relevant studies could include surveys of Saudi clinics, comparative public-private analyses, staff-engagement research, intervention trials, waste and resource audits, and longitudinal evaluations of environmental performance. Research should also examine whether green adoption influences operational efficiency, staff participation, environmental accountability, cost patterns, patient perceptions, and clinical-quality indicators.

CONCLUSION

This article presents a conceptual model explaining how environmental management, organizational support, and staff engagement jointly shape green dental practice adoption in Saudi dental clinics. The model moves beyond awareness-based explanations by treating adoption as an organizational, behavioral, and operational process. It also clarifies how

sustainability culture, implementation capability, contextual moderators, and patient-safety requirements influence the transition from environmental intention to routine clinic practice.

Green dental practice adoption requires formal policies, adequate resources, committed leadership, trained and engaged staff, feasible workflows, suitable infrastructure, and reliable monitoring. Environmental practices must be integrated with procurement, waste management, resource use, infection control, quality improvement, and managerial accountability. Clinics are unlikely to achieve durable sustainability outcomes when any of the three central driver domains is absent or poorly developed.

Saudi dental clinics have an opportunity to incorporate environmental responsibility into ongoing healthcare modernization and service improvement. Progress should remain clinically safe, operationally realistic, measurable, and responsive to differences among clinic settings. Through coordinated management, organizational support, and staff participation, dental clinics can reduce environmental impacts while preserving patient safety, clinical quality, and practical feasibility.

ACKNOWLEDGMENTS: None

CONFLICT OF INTEREST: None

FINANCIAL SUPPORT: None

ETHICS STATEMENT: None

REFERENCES

- Albrecht, S. L., Dalton, J. R., & Kavadas, V. (2024). Employee pro-environmental proactive behavior: The influence of pro-environmental senior leader and organizational support, supervisor and co-worker support, and employee pro-environmental engagement. *Frontiers in Sustainability*, 5, 1455556. doi:10.3389/frsus.2024.1455556
- Alharbi, N. S., Alhaji, J. H., & Qattan, M. Y. (2021). Toward sustainable environmental management of healthcare waste: A holistic perspective. *Sustainability*, 13(9), 5280. doi:10.3390/su13095280
- Asif, S., & Shahbaz, M. S. (2025). Project success through organizational climate and work behavior: Systematic literature review. *Journal of Organizational Behavior Research*, 10(1), 1–14. doi:10.51847/cUhp6D
- Ayitey, V., Bokor, M. J., & Mensah, B. A. (2025). Role of employee commitment in the nexus between green human resource management practices and environmental performance. *Journal of Organizational Behavior Research*, 10(1), 112–127. doi:10.51847/kjINDwcRo4
- Bamedhaf, O., Salman, H., Teggimani, S. A., & Guraya, S. S. (2025). Environmental sustainability in the dental curriculum: A scoping review. *BMC Medical Education*, 25(1), 844. doi:10.1186/s12909-025-07441-y
- Bauer, P., Greiling, D., Grüb-Martin, B., & Kienast, L. (2026). Sustainability management control in healthcare organizations—Current state and future directions. *BMC Health Services Research*, 26(1), 125. doi:10.1186/s12913-025-13845-9
- Binduhayyim, R. I. H. (2026). Attitudes and barriers of dental educators toward integrated environmentally sustainable oral health education in Saudi Arabia. *BMC Medical Education*, 26(1), 863. doi:10.1186/s12909-026-09265-w
- Cruz, J. P., Alshammari, F., & Felicilda-Reynaldo, R. F. D. (2018). Predictors of Saudi nursing students' attitudes towards environment and sustainability in health care. *International Nursing Review*, 65(3), 408–416. doi:10.1111/inr.12432
- de Sousa, A. T. R., Pataca, L. C. M., Maia, C. C., Vimieiro, G. V., Gonçalves, M. F., & Mol, M. P. G. (2024). Waste management from dental clinics: A case study in Belo Horizonte, Brazil. *Waste Management*, 189, 177–184. doi:10.1016/j.wasman.2024.08.027
- Debnath, B., Shakur, M. S., Bari, A. B. M. M., Saha, J., Porna, W. A., Mishu, M. J., Islam, A. R. M. T., & Rahman, M. A. (2023). Assessing the critical success factors for implementing Industry 4.0 in the pharmaceutical industry: Implications for supply chain sustainability in emerging economies. *PLoS one*, 18(6), e0287149. doi:10.1371/journal.pone.0287149
- Di Spirito, F., Giordano, F., Di Palo, M. P., De Benedetto, G., Aulisio, L., & Boccia, G. (2025). Sustainable dental and periodontal practice: A narrative review on the 4R framework—reduce, reuse, rethink, recycle—and waste management rationalization. *Dentistry Journal*, 13(9), 392. doi:10.3390/dj13090392
- Duane, B., Harford, S., Ramasubbu, D., Stancliffe, R., Pasdeki-Clewer, E., Lomax, R., & Steinbach, I. (2019). Environmentally sustainable dentistry: A brief introduction to sustainable concepts within the dental practice. *British Dental Journal*, 226(4), 292–295. doi:10.1038/s41415-019-0010-7
- Duane, B., Stancliffe, R., Miller, F. A., Sherman, J., & Pasdeki-Clewer, E. (2020). Sustainability in dentistry: A multifaceted approach needed. *Journal of Dental Research*, 99(9), 998–1003. doi:10.1177/0022034520919391
- Field, J., Martin, N., Duane, B., Vital, S., Mulligan, S., Livny, A., Lindberg, P., Lundegren, N., Gummeson, C., Long, R., et al. (2023). Embedding environmental sustainability within oral health professional curricula—Recommendations for teaching and assessment of learning outcomes. *European Journal of Dental Education*, 27(3), 650–661. doi:10.1111/eje.12852
- Ganesh, S., Paulraj, J., & Maiti, S. (2026). Bioengineered green-synthesized titanium dioxide and chitosan nanoparticle-modified glass ionomer cement: Antimicrobial, mechanical, and surface properties evaluation. *Annals of Dental Specialty*, 14(2), 1–15. doi:10.51847/MRLjvvlef7
- Guerra, M., Morgado, M., Leira, Y., Leitão, T., Botelho, J., & Mendes, J. J. (2025). Integrating sustainability in dentistry: A pathway towards achieving the UN 2030 Agenda. *Frontiers in Oral Health*, 6, 1549020. doi:10.3389/froh.2025.1549020
- Hassan, E. H., Lotfy, N., Abdou, M. H., Fetohy, E. M., & Hussein, M. F. (2025). Effectiveness of an environmental educational program on intern dentists' knowledge and practices regarding eco-friendly green dentistry: A quasi-experimental study. *BMC Medical Education*, 25(1), 32. doi:10.1186/s12909-024-06523-7

- Jamal, H., Marghalani, A. A., Al-Sharif, A., Shinawi, A., Gaffar, B., Al-Edaili, E. A., Al-Baqami, G., & AlQarni, M. (2023). Exploring the perception of dental undergraduate students and faculty on environmental sustainability in dentistry: A cross-sectional survey in 26 dental schools in Saudi Arabia. *Dentistry Journal*, 11(4), 103. doi:10.3390/dj11040103
- Kalogirou, M. R., & Baumbusch, J. (2025). Examining Canadian hospitals' support for planetary health through the implementation of green teams and sustainability offices. *Journal of Healthcare Leadership*, 17, 269–284. doi:10.2147/JHL.S517669
- Khanna, R., Konyukhov, Y., Maslennikov, N., Kolesnikov, E., & Burmistrov, I. (2023). An overview of dental solid waste management and associated environmental impacts: A materials perspective. *Sustainability*, 15(22), 15953. doi:10.3390/su152215953
- Le, H. T., Nguyen, A. T., Vu, D. B., Nguyen, V. B., & Nguyen, T. T. T. (2026). Green human resource management and in-role green behavior: University students' perceptions. *Journal of Organizational Behavior Research*, 11(1), 85–98. doi:10.51847/Jb01a29ARS
- Le, O. T. T., Tien, D. N., Hoang, H. T., Tran, P. T. T., & Nguyen, T. T. P. (2025). Does management accounting positively influence the performance of businesses operating within the circular economy? *Journal of Organizational Behavior Research*, 10(3), 46–61. doi:10.51847/Zmb1oS9n6N
- Martin, N., England, R., & Mulligan, S. (2022). Sustainable oral healthcare: A joint stakeholder approach. *International Dental Journal*, 72(3), 261–265. doi:10.1016/j.identj.2022.02.008
- Martin, N., & Mulligan, S. (2022). Environmental sustainability through good-quality oral healthcare. *International Dental Journal*, 72(1), 26–30. doi:10.1016/j.identj.2021.06.005
- Martin, N., Sheppard, M., Gorasia, G. P., Arora, P., Cooper, M., & Mulligan, S. (2021a). Awareness and barriers to sustainability in dentistry: A scoping review. *Journal of Dentistry*, 112, 103735. doi:10.1016/j.jdent.2021.103735
- Martin, N., Sheppard, M., Gorasia, G. P., Arora, P., Cooper, M., & Mulligan, S. (2021b). Drivers, opportunities and best practice for sustainability in dentistry: A scoping review. *Journal of Dentistry*, 112, 103737. doi:10.1016/j.jdent.2021.103737
- Mohamed, H. M., Saleh, M. S. M., Attia, N. M., Abdelaziz, M. M. A., & Ata, A. A. (2025). Exploring the role of clan culture in promoting nurses' green behaviors: Paternalistic leadership as a mediator and workplace loneliness as a moderator. *BMC Nursing*, 24(1), 436. doi:10.1186/s12912-025-03027-7
- Obaid, A. M., Saeed, H. S., Nayef, T. N., & Al-Fandawi, H. H. F. (2026). Green activity-based costing to enhance production flow and its impact on sustainable development. *Journal of Organizational Behavior Research*, 11(2), 237–249. doi:10.51847/yVH56hBLUX
- Peng, J., Samad, S., Comite, U., Ahmad, N., Han, H., Ariza-Montes, A., & Vega-Muñoz, A. (2022). Environmentally specific servant leadership and employees' energy-specific pro-environmental behavior: Evidence from the healthcare sector of a developing economy. *International Journal of Environmental Research and Public Health*, 19(13), 7641. doi:10.3390/ijerph19137641
- Petit, H. J., Sullivan, G. A., Hughes, I. M., Pittman, K. L., Myers, J. A., Cocoma, S. M., Gulack, B. C., & Shah, A. N. (2023). Exploring barriers and facilitators to reducing the environmental impact of the operating room. *Journal of Surgical Research*, 292, 197–205. doi:10.1016/j.jss.2023.07.045
- Sabbahi, D. A., El-Naggar, H. M., & Zahran, M. H. (2020). Management of dental waste in dental offices and clinics in Jeddah, Saudi Arabia. *Journal of the Air & Waste Management Association*, 70(10), 1022–1029. doi:10.1080/10962247.2020.1802366
- Țâncu, A. M. C., Didilescu, A. C., Pantea, M., Sfeatu, R., & Imre, M. (2023). Aspects regarding sustainability among private dental practitioners from Bucharest, Romania: A pilot study. *Healthcare*, 11(9), 1326. doi:10.3390/healthcare11091326
- Tawfik, E. A., Tawfik, A. F., Alajmi, A. M., Badr, M. Y., Al-Jedai, A., Almozain, N. H., Bukhary, H. A., Halwani, A. A., Al Awadh, S. A., Alshamsan, A., et al. (2022). Localizing pharmaceuticals manufacturing and its impact on drug security in Saudi Arabia. *Saudi Pharmaceutical Journal*, 30(1), 28–38. doi:10.1016/j.jsps.2021.12.002
- van Schie, V. (2024). Governance-related factors influencing the implementation of sustainability in hospitals: A systematic literature review. *Health Policy*, 146, 105115. doi:10.1016/j.healthpol.2024.105115
- Volgenant, C. M. C., Bras, S., & Persoon, I. F. (2022). Facilitators and barriers to implementing sustainability in oral health care. *International Dental Journal*, 72(6), 847–852. doi:10.1016/j.identj.2022.08.002
- Webster, R. J. (2023). Climate action, staff engagement, and change management: A paediatric hospital case study. *Healthcare Management Forum*, 36(4), 195–198. doi:10.1177/08404704231165482
- Wolf, T. G., Müßig, L., Paulmann, K., Lamloum, D., & Campus, G. (2026). Green dentistry and sustainability in oral healthcare: A systematic review. *Dentistry Journal*, 14(6), 377. doi:10.3390/dj14060377
- Yeoh, S., Bourdamis, Y., Saker, A., Marano, N., Maundrell, L., Ramamurthy, P., & Sharma, D. (2024). An investigation into contaminated waste composition in a university dental clinic: Opportunities for sustainability in dentistry. *Clinical and Experimental Dental Research*, 10(6), e70015. doi:10.1002/cre2.70015
- Zhang, Y., Dong, Y., Zhang, Y., Wang, R., & Jiang, J. (2024). Can organizations shape eco-friendly employees? Organizational support improves pro-environmental behaviors at work. *Journal of Environmental Psychology*, 93, 102200. doi:10.1016/j.jenvp.2023.102200
- Zia, N., Doss, J. G., John, J., & Panezai, J. (2024). Sustainability in dentistry: Assessing knowledge, attitude, and practices of dental practitioners about green dentistry. *Pakistan Journal of Medical Sciences*, 40(1), 233–241. doi:10.12669/pjms.40.1.7606