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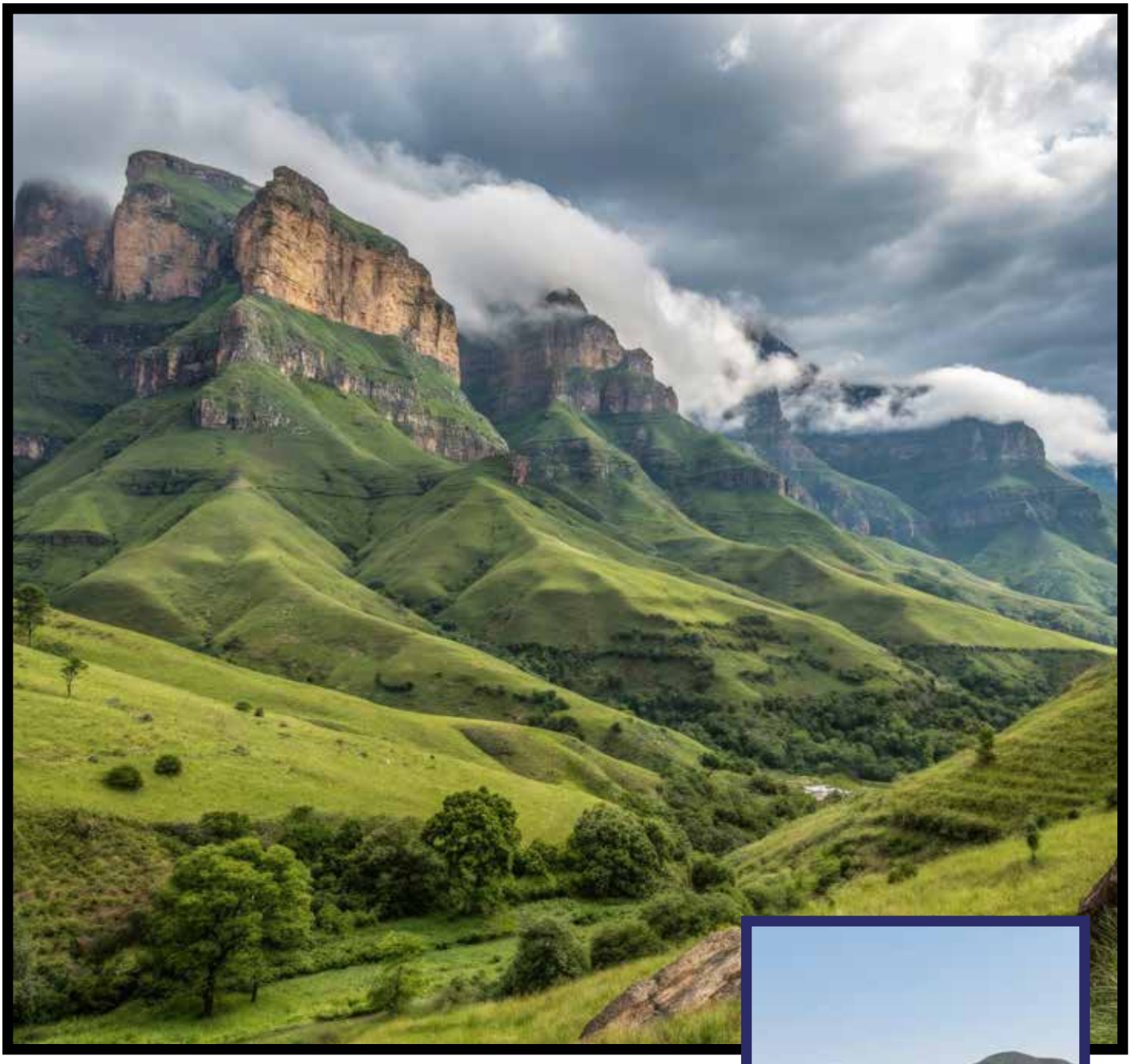

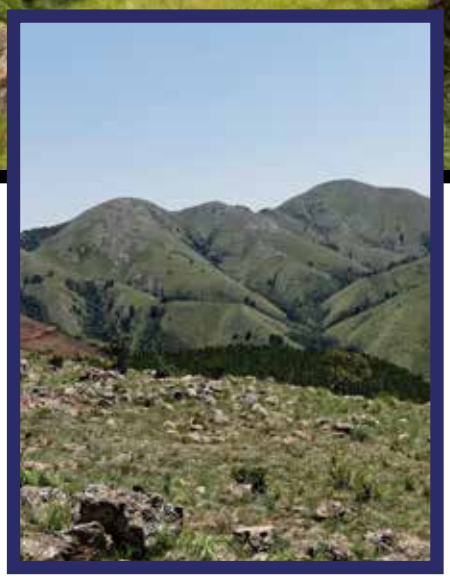

Barberton Makhonjwa Mountains

The Barberton Makhonjwa Mountains lie in Mpumalanga near the border of Eswatini. They are among the oldest exposed rock formations on Earth, dating back more than 3.5 billion years. This UNESCO World Heritage Site provides rare evidence of early life and planetary development. The range features rolling green hills, deep valleys and clear rivers. It attracts geologists, hikers, photographers, and visitors interested in natural history and scenic landscapes.

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References: 1. Li M, Sun Z, Zhang H, *et al.* Recent advances on polaprezinc for medical use (Review). *Experimental & Therapeutic Medicine* 2021;22:1445. **2.** Hepilor® Capsules for oral use. Product Information. Sept 2019. **3.** Hepilor® Liquid Suspension for oral use. Product Information. May 2019. **4.** Hepilor® Liquid Suspension for oral use in single-dose stick packs. Product Information. May 2019. **5.** Hepilor® Mouthwash. Product Information. April 2021.

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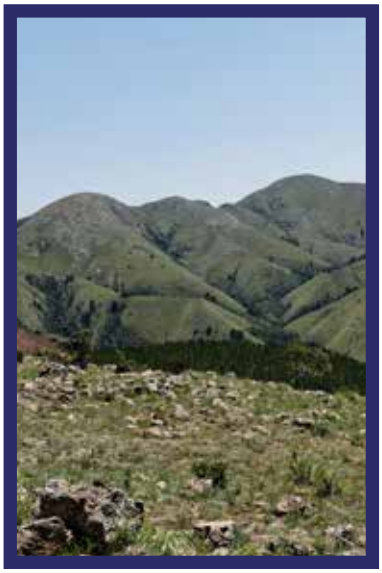

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marketing@sada.co.za

CPD Enquiries:
sadj@sada.co.za

Member contact detail update:
South African Dental Association
Tel: +27 (0)11 484 5288
sadamembership@sada.co.za

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Project management:
Leani Thomson – Leani@creativespacemedia.co.za
Sizwe Zim – sizwe@creativespacemedia.co.za

General and advertising enquiries:
James Chademana
james@creativespacemedia.co.za

Design and layout:
Leani Thomson
leani@creativespacemedia.co.za

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When Certification Outpaces Competence: Microcredentialling in Dentistry

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Prof NH Wood, Managing Editor, SADJ – BChD, DipOdont(MFP), MDent(OMP), FCD(SA), PhD

1. A quiet shift in what it means to be "Qualified"

There is a subtle but profound shift occurring in global education, one that is beginning to reshape how competence is defined, acquired, and recognized. Increasingly, the traditional architecture of professional formation structured degrees, supervised training, and longitudinal assessment, is being complemented, and in some instances challenged, by a new form of certification: the microcredential.

Microcredentials, broadly defined as short, targeted learning experiences that certify discrete competencies, have rapidly gained traction across higher education and workforce development systems. Their rise is not accidental. It reflects a world in which knowledge evolves quickly, skills must be updated continuously, and learners seek flexible, accessible pathways to remain relevant. Policymakers, institutions, and industry stakeholders increasingly view microcredentials as tools to address skills gaps, enhance employability, and support lifelong learning.

Yet beneath this promise lies a more complex and less explored question, particularly for regulated professions such as dentistry:

What happens when competence is no longer built as a whole, but assembled in parts?

This question is not merely academic. It speaks directly to the integrity of professional identity, the safety of patients, and the credibility of educational systems. Dentistry, perhaps more than many other fields, has historically depended on integrated, longitudinal training, where knowledge, technical skill, clinical reasoning, and professional judgement develop in concert. The emergence of microcredentialling invites us to reconsider whether such integration can or should be modularized.

2. The promise of microcredentials: flexibility, access, and lifelong learning

The appeal of microcredentials is both intuitive and evidence-supported. At their core, they offer flexible, focused, and often digitally enabled learning opportunities that allow professionals to acquire specific skills without committing to extended periods of formal study. In a rapidly changing global landscape, characterized by technological advancement, shifting disease burdens, and evolving patient expectations, this adaptability is undeniably valuable.

Within health professions education, microcredentials have been positioned as a mechanism to support continuous professional development and workforce responsiveness. The COVID-19 pandemic, alongside accelerated digitalization, further catalyzed their adoption, demonstrating the feasibility of short, targeted learning interventions delivered at scale. For many practitioners, particularly those balancing clinical practice with ongoing education, microcredentials provide a pragmatic pathway to remain current and competitive.

From a systems perspective, they are also aligned with broader global trends. Organizations such as the OECD have highlighted their potential to enhance employability, widen access to education, and support more inclusive learning pathways, particularly for non-traditional learners. Similarly, higher education institutions are increasingly exploring microcredentials as a means to bridge the gap between academic training and industry needs, offering targeted competencies that are immediately applicable in practice.

In dentistry, this promise is already visible. Short courses, certification programmes, and digitally credentialled training modules are proliferating, particularly in areas such as implantology, aesthetic dentistry, and aligner therapy. These offerings respond to genuine demand: clinicians seeking to expand their scope of practice, adapt to new technologies, and meet patient expectations in a competitive environment.

And yet, as this landscape expands, an important tension emerges. While microcredentials excel at delivering discrete skills, dentistry does not operate in discrete fragments. Clinical competence is inherently integrative, requiring not only technical proficiency, but also diagnostic reasoning, ethical judgement, and an understanding of when not to intervene.

It is at this intersection, between modular learning and integrated competence, that the true debate around microcredentialling in dentistry begins.

3. Microcredentialling in dentistry: promise, positioning, and tensions

Before turning to these deeper concerns, it is worth examining how microcredentialling is currently understood and applied within dentistry and the broader health professions.

Microcredentialling in dentistry is most often encountered within the domain of continuing professional development (CPD), where it takes the form of short, focused learning interventions designed to certify discrete competencies. These may include digital badges, modular courses, or micro-learning units targeting specific areas such as periodontal instrumentation, pharmacological updates, or emerging digital workflows. While dentistry-specific implementations remain relatively limited and heterogeneous, the broader literature in health professions education provides a relevant and transferable evidence base, given the shared

need for flexible, responsive upskilling in complex clinical environments.

Contemporary perspectives position microcredentialling as part of a wider post-pandemic recalibration of education and workforce development. The rapid expansion of asynchronous, digitally delivered learning during and after COVID-19 demonstrated the feasibility and, in many cases, the necessity of more agile educational models. In this context, microcredentials have been advanced as tools to support lifelong learning, rapid reskilling, and personalised professional development, particularly for clinicians balancing service delivery with ongoing education.

Proponents argue that microcredentials align well with the realities of modern dental practice. They offer time-efficient, targeted learning opportunities, allow for the accumulation of stackable credentials, and provide visible markers of engagement with contemporary techniques and knowledge domains. For practitioners operating in increasingly competitive and technologically evolving environments, such features are attractive and, in many cases, pragmatically necessary.

However, these advantages are accompanied by important and unresolved concerns. Critics caution that microcredentialling may contribute to the progressive dilution of traditional qualifications, particularly if short-form certifications begin to be interpreted as equivalent to comprehensive training. Questions also arise regarding the alignment of microcredentials with established licensure and regulatory standards, especially in a profession where competence must be demonstrated holistically and under conditions of accountability.

These tensions may be usefully summarised as follows:

Aspect	Potential Advantages	Key Concerns
Flexibility	Asynchronous delivery accommodates clinical schedules; supports just-in-time learning	Limited capacity for hands-on training in procedural disciplines requiring supervised practice
Employability	Digital credentials signal engagement with new skills and technologies	Variable recognition; lack of standardisation affects credibility and interpretability
Accessibility	Lower cost and modular entry points enable participation in niche or emerging topics	Quality assurance is inconsistent; absence of universal accreditation frameworks
Innovation	Potential for personalised, technology-enhanced learning pathways	Terminological inconsistency and conceptual ambiguity create confusion among stakeholders

Importantly, these are not binary positions. Rather, they reflect a field in transition, one in which the educational, professional, and regulatory implications of microcredentialling are still being actively negotiated. For dentistry, the central challenge lies not in whether microcredentials should exist, but in how they are interpreted, governed, and integrated within a system that must ultimately prioritise patient safety and professional accountability.

4. The problem: fragmentation of competence

While the appeal of microcredentials is clear, their rapid expansion raises an important and often under-examined concern: the fragmentation of competence. At its core, professional competence in dentistry is not simply the accumulation of discrete technical skills, but the integration of knowledge, clinical reasoning, psychomotor ability, ethical judgement, and contextual decision-making. These elements develop over time, through supervised practice, feedback, and reflection within authentic clinical environments.

Microcredentials, by design, tend to isolate and certify specific components of performance. They are highly effective at signaling that a learner has engaged with a defined body of content or acquired a particular skill. However, the critical question is whether such certification reliably reflects transferable, context-sensitive competence. Educational literature has long cautioned against equating short-term performance or task-specific proficiency with true professional capability, particularly in complex, high-stakes environments such as healthcare. Competence is not only about what can be done, but when, why, and under what circumstances it should be done.

This distinction becomes particularly important when microcredentials are interpreted by practitioners, employers, or patients, as indicators of readiness to perform clinical procedures independently. Without robust frameworks for assessment, supervision, and integration into broader competency models, there is a risk that microcredentials may inadvertently contribute to a form of credential inflation, where the appearance of qualification outpaces the depth of competence. This concern is not theoretical. Studies in higher education and workforce development have highlighted variability in the quality, assessment standards, and recognition of microcredentials, raising questions about their reliability as indicators of professional capability.

In dentistry, where clinical interventions carry direct implications for patient safety, the stakes are considerably higher. A certificate in a discrete procedure, whether implant placement, aesthetic restoration, or orthodontic alignment, does not in itself guarantee the ability to diagnose appropriately, manage complications, or integrate that procedure within a comprehensive treatment plan. The danger lies not in the existence of microcredentials, but in the misalignment between what is certified and what is assumed.

This raises a fundamental question for the profession:
Can competence in dentistry be meaningfully modularized, or does its nature demand integration that cannot be captured in isolated units of certification?

Until this question is addressed with clarity and rigour, the growth of microcredentialling will continue to outpace our ability to ensure that what is being certified truly reflects what is required for safe, ethical, and effective clinical practice.

5. Dentistry as a special case: why this matters more here

The implications of microcredentialling are not uniform across professions. In some fields, discrete skill acquisition may be

sufficient to perform bounded tasks with limited risk. Dentistry is not such a field. It is a high-stakes, intervention-based profession in which clinical actions are often irreversible, biologically consequential, and deeply dependent on diagnostic accuracy and longitudinal judgement.

At its core, dentistry requires the integration of multiple domains of competence: biomedical knowledge, procedural skill, patient communication, ethical reasoning, and critically, clinical judgement under conditions of uncertainty. These are not independent attributes. They are developed together, over time, through supervised clinical exposure, structured feedback, and reflective practice. It is precisely this integration that allows a clinician not only to perform a procedure, but to determine whether it should be performed at all, and if so, how it should be adapted to the specific patient context.

Microcredentials, by contrast, are inherently reductive. They isolate a component of practice, often a procedure or technique, and certify exposure to it. While this may be appropriate for continuing professional development, it becomes problematic when interpreted as evidence of clinical readiness or expanded scope of practice. A certificate in implant placement, for example, does not necessarily imply competence in case selection, risk stratification, management of complications, or long-term maintenance, each of which is essential to safe and effective care. The same holds true across aesthetic dentistry, orthodontics, and emerging digital workflows.

The concern, therefore, is not that microcredentials exist, but that they may obscure the difference between procedural familiarity and professional competence. In doing so, they risk creating a parallel system of recognition: one that is faster, more accessible, and often commercially driven, but not always aligned with the standards required for safe clinical practice. This is particularly relevant in environments where regulatory oversight may be uneven, and where market demand for new techniques can outpace the systems designed to evaluate them.

There is also a deeper educational implication. Dentistry has, over time, moved toward integrated, outcomes-based curricula, supported by concepts such as programmatic assessment and competency-based education. These approaches recognize that competence cannot be inferred from isolated performances, but must be demonstrated across multiple contexts, over time, and through diverse forms of evidence. Microcredentialling, if not carefully aligned with these principles, risks reintroducing a fragmented view of learning as one that education has spent decades attempting to move beyond.

Importantly, this is not an argument against innovation in education. Nor is it a dismissal of the value that short, focused learning can bring to practicing clinicians. Rather, it is a call to recognize that dentistry occupies a position where the margin for error is small, and where the consequences of overestimating competence are borne directly by patients. In this context, the profession must ask itself a difficult but necessary question:

Are we allowing new forms of credentialling to reshape our standards of competence, or are we ensuring that these innovations are held to the standards that define our profession?

6. Regulation, responsibility, and the emergence of a parallel credential economy

As microcredentialling expands, it does not do so in isolation. It is increasingly embedded within a broader ecosystem of universities, private education providers, industry partners,

and digital platforms, each offering forms of certification that vary in scope, depth, and rigour. This diversification has introduced a new dynamic into professional education: the gradual emergence of what may be described as a parallel credential economy.

In this evolving landscape, the authority to certify learning is no longer held exclusively by traditional academic institutions or statutory professional bodies. Short courses, branded training programmes, and digitally issued certificates are becoming more visible and, in some cases, more influential in shaping clinical practice. While many of these offerings are of high quality and respond to genuine educational needs, the absence of consistent standards, transparent assessment practices, and clear regulatory alignment raises important questions about how such credentials should be interpreted.

For regulated professions such as dentistry, this is not a peripheral issue. The legitimacy of any credential ultimately rests on whether it is recognized, trusted, and aligned with established frameworks of competence and scope of practice. Where this alignment is unclear, there is a risk that credentials begin to function more as signals of participation than indicators of capability. Over time, this may blur the distinction between formal qualification, structured continuing professional development, and commercially driven certification.

The role of regulatory bodies is therefore central, but also increasingly complex. On the one hand, there is a clear responsibility to protect the public by ensuring that practitioners operate within defined competencies and scopes of practice. On the other, there is a need to remain responsive to educational innovation and evolving models of professional development. Striking this balance requires more than passive oversight; it demands active engagement with emerging credentialling systems, including the development of frameworks that can evaluate their quality, relevance, and clinical implications.

Universities and academic institutions also carry a unique responsibility. As custodians of professional standards and training, they must consider how microcredentials fit within existing curricula and postgraduate pathways. This may include integrating high-quality microcredentials into formal programmes, or alternatively, clearly delineating the boundaries between supplementary learning and recognized professional competence. Failure to do so risks ceding educational authority to external actors whose primary drivers may not always align with the long-term interests of the profession or the public.

There is, moreover, an economic dimension that cannot be ignored. Microcredentials are often marketed as efficient, accessible routes to skill acquisition and practice expansion. In competitive clinical environments, this creates incentives for practitioners to pursue such credentials as a means of differentiation or income generation. While understandable, this dynamic can inadvertently reinforce a system in which credential accumulation becomes decoupled from demonstrable competence, particularly if the underlying assessments are not sufficiently rigorous.
None of these developments are inherently problematic. Indeed, they reflect a broader shift toward lifelong learning, professional adaptability, and educational diversification, all of which are desirable. The concern arises when the structures that traditionally ensured coherence, quality, and accountability in professional education do not evolve at the same pace as the innovations they are meant to oversee.

The question, then, is not whether microcredentials should exist, but whether the profession is prepared to govern their meaning, limit their misuse, and integrate them responsibly. Without such stewardship, there is a real risk that dentistry may drift toward a fragmented credential landscape in which the appearance of qualification becomes easier to obtain than the substance it is meant to represent.

7. Reframing the future: integration, standards, and professional responsibility

If microcredentialling is to find a legitimate and sustainable place within dentistry, it must be understood not as an alternative to formal professional formation, but as a complement within a coherent, standards-driven system of lifelong learning. The task before the profession is therefore not to resist change, but to shape it deliberately, ensuring that new forms of credentialling strengthen, rather than dilute, the integrity of clinical competence.

At its best, microcredentialling offers a powerful mechanism to support targeted upskilling, rapid dissemination of emerging knowledge, and ongoing professional development. In an era of accelerating technological innovation, dentists must continually update their skills to remain current. Well-designed microcredentials can contribute meaningfully to this process, particularly when they are anchored in clear learning outcomes, robust assessment, and appropriate levels of supervision.
However, their value is contingent on how they are positioned within the broader competency framework of the profession. Microcredentials should not function as stand-alone indicators of readiness for independent clinical practice. Rather, they should be nested within structured pathways that link learning to demonstrable competence over time. This implies alignment with established principles in health professions education, including longitudinal assessment, workplace-based evaluation, and the triangulation of evidence from multiple sources.

- A useful distinction may therefore be drawn between participation, proficiency, and competence:
- Participation reflects engagement with a learning activity;
- Proficiency reflects the ability to perform a task under defined conditions;
- Competence reflects the ability to integrate knowledge, skill, and judgement across contexts, consistently and safely, over time.

Microcredentials can reliably signal the first, and in some cases aspects of the second bullet point, but they cannot, in isolation, attest to the third. Recognizing this distinction is critical if the profession is to avoid conflating exposure with expertise.

The responsibility for maintaining this clarity is shared. Regulatory bodies must articulate explicit guidance on how microcredentials relate to scope of practice, ensuring that public protection remains paramount. Academic institutions should lead in developing quality-assured microcredential offerings that are educationally sound and aligned with recognized competency frameworks. Professional associations, meanwhile, have an important role in setting expectations for ethical practice, discouraging the misrepresentation of training as qualification.

There is also an obligation at the level of the individual practitioner. In a landscape where learning opportunities are increasingly abundant and accessible, professional integrity requires discernment. The pursuit of additional skills must be guided not only by opportunity, but by a clear understanding of one's own competence, limitations, and responsibilities to patients. The ethical clinician recognizes that acquiring a certificate does not absolve one from the duty to ensure that care is delivered within the bounds of safe, evidence-based practice.

Ultimately, the question is not whether microcredentials will shape the future of dental education, especially post-qualification and registration, because they already are. The more important question is whether the profession will retain stewardship over the meaning of competence, or allow it to be redefined by convenience, market forces, and fragmented certification.

If approached with rigour, transparency, and collective responsibility, microcredentialling can enrich the professional landscape. If not, it risks becoming another layer of complexity in an already demanding field. This will only obscure, rather than clarify, what it means to be truly competent.

Conclusion: what are we certifying?

Every profession is, at some point, required to pause and ask a deceptively simple question: what, precisely, are we recognizing when we certify someone as competent? In dentistry, this question has historically been answered with clarity. Competence has meant more than the ability to perform a procedure; it has implied judgement, restraint, integration, and accountability, qualities developed over time and tested across contexts.

Microcredentialling invites us to revisit this understanding. It offers speed, accessibility, and responsiveness in a world that increasingly values all three. But it also challenges us to confront an uncomfortable possibility: that the symbols of competence may begin to outpace its substance. When certification becomes more granular, more frequent, and more visible, the risk is not simply proliferation but includes misinterpretation.

This editorial does not argue against microcredentials. On the contrary, it recognizes their potential to enrich professional learning and to support a culture of continuous development. What it calls for, however, is discipline in how they are understood, governed, and applied. Dentistry cannot afford ambiguity in this regard. Our work is not theoretical; it is biological, irreversible, and entrusted to us by patients who assume that certification reflects true capability.

There is, perhaps, a deeper issue at play. Professions are sustained not only by their knowledge base, but by their collective agreement on standards: on what counts, what qualifies, and what does not. These agreements are not static, but neither should they be easily diluted. If new forms of credentialling are to be incorporated into the professional landscape, they must do so on terms defined by the profession itself, grounded in evidence, ethics, and patient safety.

The emergence of microcredentialling is therefore not merely an educational development; it is a test of professional maturity. It asks whether dentistry is prepared to engage critically with innovation, to welcome what is valuable, and to resist what is expedient but insufficient. It challenges institutions, regulators, educators, and practitioners alike to ensure that convenience does not redefine competence.

In the end, the question is not whether we will adopt new forms of learning, we will. The question is whether we will remain clear, as a profession, about what it means to be competent, and vigilant in ensuring that our systems of recognition continue to reflect that meaning.

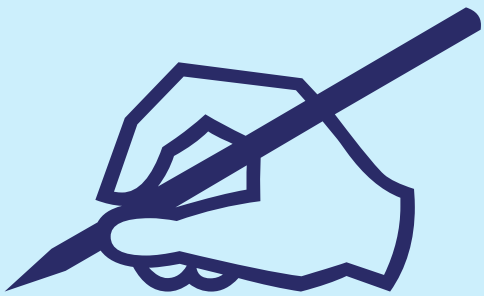
Because if we are not, we may find ourselves certifying more and understanding less.

Recommended reading:

1. Council of the European Union. Council Recommendation of 16 June 2022 on a European approach to micro-credentials for lifelong learning and employability. *Official Journal of the European Union*. 2022;C243:10-25. Available from: *Council of the European union*
2. Kato S, Galán-Muros V, Weko T. *Micro-credentials for lifelong learning and employability: uses and possibilities*. Paris: OECD Publishing; 2023. OECD Education Policy Perspectives No. 66. doi:10.1787/9c4b7b68-en
3. Oliver B. *Making micro-credentials work for learners, employers and providers*. Melbourne: Deakin University; 2019. Available from: *Making-micro-credentials-work-Oliver-Deakin-2019-full-report.pdf*
4. Harden RM. Outcome-based education: the future is today. *Med Teach*. 2007;29(7):625-9. doi:10.1080/01421590701729930
5 ten Cate O. Nuts and bolts of entrustable professional activities. *J Grad Med Educ*. 2013;5(1):157-8. doi:10.4300/JGME-D-12-00380.1

CPD questionnaire on page 122

The Continuing Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.



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The retention revolution: Why your existing patients are your most valuable (and neglected) asset

SADJ MARCH 2026, Vol. 81 No.2 P66-67

Mr KC Makhubele – CEO, South African Dental Association

A Strategic Imperative for the Modern Dental Practice

We operate in an age of relentless competition. Digital ads clamour for attention, new "smile studios" promise instant transformations and patient loyalty often feels like a relic of a bygone era. In response, many practices pour resources into the front door of new patient acquisition – often at great cost – while a quiet, costly leak drains from the back: the steady attrition of existing patients.

This article posits a fundamental shift in mindset. The single most powerful, cost-effective and sustainable growth strategy for your practice is not in the next Facebook ad campaign, but in your existing patient database. Welcome to the **Retention Revolution.** It's time to stop marketing at your patients and start building a practice with them, focusing on the profound metric of **Lifetime Patient Value (LPV).**

The Cold Economics of Attrition vs. Retention

Let's ground this in data. The Bain & Company axiom that a **5% increase in customer retention can increase profits by 25% to 95%** holds profound truth in dentistry. Consider:

- **Acquisition Cost:** The cost to attract a new patient – through advertising, special offers and practice time –can be 5 to 7 times higher than retaining an existing one.
- **Lifetime Value:** A retained patient is not a single procedure. They represent years, often decades, of recall visits, preventative care, family referrals and planned treatments (crowns, implants, orthodontics). Their LPV can easily run into tens or hundreds of thousands of Rands.
- **The Trust Dividend:** Existing patients have already overcome the barrier of trust. They know you, your team and your environment. They are pre-sold on your quality of care. Marketing to them is not about persuasion; it's about activation and deepening relationships.

When a patient lapses, you don't just lose their next hygiene appointment. You forfeit their entire future health journey and the potential referrals they would have generated. The leak is a haemorrhage of future revenue and practice stability.

The Four Pillars of a Revolutionary Retention Strategy

Moving from theory to practice requires a systematic, data-informed approach built on genuine care. Here are the four pillars:

1. The Intelligent Recall System: From Generic Reminder to Personalised Health Invitation

The recall system is the beating heart of retention, yet most have barely evolved from postcards and robocalls. Revolutionise it.

- **Segment Your Database:** Not all patients are the same. Use your practice management software to segment by:
  - **Clinical Need:** High-periodontal-risk patients, orthodontic retainers, complex restorative plans.
  - **Behaviour:** Always on-time, frequently reschedules, historically lapsed.
  - Demographics/Psychographics: Young families, time-poor professionals, retiree patients.

- **Personalise the Communication:** A segmented list allows for tailored messaging.
  - To the perio patient: *"Ms. Khumalo, as part of our ongoing management of your gum health, Dr. van Niekerk has scheduled your 4-month supportive periodontal therapy appointment for June. Let's secure your preferred time."*
  - To the parent: *"The Patel Family, it's that time of year! We have set aside back-to-school check-up slots for Anesh and Priya. Book together and save time."*

- **Multi-Channel Engagement:** Meet patients where they are. Automate SMS reminders (highest open rate), but follow up with a personalised email containing a short educational video from their hygienist. Use WhatsApp Business for confirmed appointments and pre-visit forms. The goal is a *communication continuum*, not a single, forgettable ping.

2. Beyond the Chair: Establishing Practice as a Centre for Education & Community

Transform your practice from a transactional "fix-it" shop to an indispensable source of knowledge and support.

- **Host "Lunch & Learn" Workshops:** Monthly or quarterly events on topics like:
  - "Nutrition for Healthy Gums & Teeth"
  - "Sleep Apnea & Oral Health: The Silent Connection"
  - "Invisalign & Adult Orthodontics: What You Really Want to Know" These position you as an authority, foster community and naturally lead to treatment discussions in a low-pressure environment.

- **Create "Patient Journey" Content:** For patients undergoing medium-to-long-term treatment (e.g., implants, full-mouth rehab, Invisalign), provide a personalised digital "journey pack." This could be a simple PDF or a series of emails with anticipated milestones, care tips and reassurance. It reduces anxiety and builds engagement throughout the process.

3. The Ethical Referral Engine: Harnessing the Power of Advocacy

Your happiest patients are your most powerful marketers. Activate them ethically and effectively.

- **Formalise a "Member-Get-Member" Programme:** Within strict HPCSA ethical guidelines (no direct payment for

referrals), create a valued-based reward system.
- "Thank you for referring your colleague. We've added R500 to your personal 'Smile Savings' account to use towards any future aesthetic or elective treatment."
- Or offer a premium at-home care kit or a professional teeth whitening session after a certain number of successful referrals. The key is to **thank, not pay.**

- **Make Referrals Effortless:** Provide existing patients with beautiful, simple "referral cards" or a dedicated page on your website they can easily share. Have a system to track who referred whom so you can always express gratitude.

4. Data-Driven Re-engagement: The "Lost Patient" Rescue Mission

A lapsed patient is not lost forever. They are a recovery opportunity. Implement a **Lapsed Patient Reactivation Protocol.**

- **Define "Lapsed":** Is it 18 months? 2 years? Set a rule in your software.

- **The "We Miss You" Campaign:** A warm, concerned, multi-stage outreach.
  1. **Personalised Letter or Email from the Dentist/ Hygienist:** "Dear John, while reviewing our records, I noticed it's been some time since we've seen you. Your oral health is important to us and we want to ensure everything is on track. Please reach out for a convenient check-up."
  2. **Follow-up Phone Call from a Familiar Team Member:** "Hi John, it's Sarah from Dr. Smith's office. We just wanted to follow up on our note, see how you've been and if there's anything we can help you schedule."
  3. **A "Welcome Back" Offer (if appropriate):** A complimentary hygiene check or a discounted assessment to lower the barrier to re-entry.

- **Analyse the "Why":** When patients re-engage, ask gently why they stayed away. Was it cost, fear, time, or a perceived lack of need? This feedback is gold for refining your entire patient experience.

The Mindset Shift: From Clinician to Chief Relationship Officer

Implementing these strategies requires more than software; it requires a cultural shift. Every team member, from reception to dentist, must understand that **the patient's experience begins long before and ends long after the clinical procedure.**

- **Measure What Matters:** Track **Retention Rate** (% of active patients seen in last 18 months) and **Lapsed Patient Recovery Rate** as diligently as you track new patient numbers.

- **Empower Your Team:** Front-desk staff and hygienists are your retention champions. Train them in relationship-building communication and give them the autonomy to solve problems and personalise care.

- **Lead with Value, Not Volume:** Focus conversations on the value of ongoing health, prevention and the relationship you have—not just on the next appointment slot to fill.

Conclusion: Building a Practice That Endures

In a competitive market, the practice that wins is not necessarily the one with the flashiest website or the deepest advertising budget. It is the practice that understands a profound truth: **the deepest well of growth, stabilit and professional satisfaction lies in stewarding the health of those who have already chosen to trust you.**

The Retention Revolution is a return to the core of our profession – ongoing, relationship-based care – supercharged by modern tools, data and strategic thinking. It is the path to a practice that is not just busy, but truly resilient; not just profitable, but profoundly valuable to the community it serves.

Start your revolution today. Look at your recall system. Talk to one lapsed patient. Plan one educational event. Your most valuable patients are already in your chair. It's time to make sure they stay for a lifetime.

Invest in the relationships you already have. The return will define your future.

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Oral health care and edentulism: perspectives of patients attending public health clinics in Harry Gwala and eThekwini districts, KwaZulu-Natal

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Y Bandezi[1], S Singh[2]

ABSTRACT

Introduction

Maintaining oral health is vital for overall well-being, and offering dental care services is a crucial part of public healthcare systems globally. A significant portion of South African population faces socioeconomic barriers to accessing private oral health services resulting in dependency on public oral health services. However, not much is known of patients' experiences in accessing such care in these facilities.

Aims and objectives

To determine perspectives of public health recipients on oral health care, the nature of edentulism and impact of edentulism in Harry Gwala and eThekwini districts, KwaZulu-Natal.

Design

A cross-sectional descriptive research design

Methods

A systematic sampling technique was employed to select participants that attended the public health facilities (n=810). The total sample was stratified according to urban, peri-urban and rural public health facilities deriving five sub-populations of (n=162). Data was collected using a questionnaire that was derived from the WHO Oral Health Surveys guidelines. Data was analysed using R Statistical computing software of the R Core Team, 2020, version 3.6.3. Descriptive statistics were applied for numerical measurements and categorical variables were described as counts and percentage frequencies.

Results

A total of 770 out of 810 patients consented to participate in the study with a 95% response rate, of which 73.9% were female (p=0.016). The majority of participants were between the ages of 30 to 50 (n=396; 47.9%). Pain from teeth and gums were reported by the majority of patients (n=509; 70.2%) as the reasons for visiting a dentist. The majority of the patients (n=449; 76.4%), indicated that they accessed public oral facilities and 80.9% of responses came from rural participants (n=267). All age groups reported having missing teeth (between 1-9 teeth lost) with participants aged 30 to 50 representing the majority (n=280; 75.9%). Participants identified the following reasons to replace missing teeth: difficulty to chew food (n=456 majority being 50 years and above (43%), difficulty smiling (n=95) majority being 30 years and below (62%), feelings of embarrassment (n=97) majority being 30 years and below (62%), limited consumption of food (n=460) majority being 50 years and above (44%), and being made fun of by people (n=74) majority being 30 to 50 years (52%).

Conclusion

This study found that both psychological and functional impacts of edentulism were reported as the reasons why most patients indicated their need to replace their missing teeth. The study findings suggested that participants in rural settings reported poor access to facility-based oral health care and that pain was the major reason for seeking care.

Keywords

Public oral health, edentulism, tooth loss, oral health-related quality of life, dental care, oral health access, social justice, oral health services.

Authors' Information

1. Yonela Bandezi, ND: Dental Technology (DUT), B. Tech: Dental Technology (DUT), MHSc: Dental Technology (DUT). Discipline of Dentistry, School of Health Sciences. University of KwaZulu-Natal, Private Bag X54001, Durban, 4000, South Africa, Cell: +27642048122. Email: 218088142@stu.ukzn.ac.za ORCID iD: https://orcid.org/my-orcid?orcid=0009-0004-3525-9618
2. Prof Shenuka Singh, B.OH (UDW), M.Sc [DENT], PhD (UWC), PG Dip Health Research Ethics (Stell) PhD [Clinical and Res Ethics] (Stell). Discipline of Dentistry. School of Health Sciences. University of KwaZulu-Natal. Private Bag X54001, Durban, 4000, South Africa. Telephone: +2731 260 8591. Telefax: +2731 260 8069. Email: singhshen@ukzn.ac.za ORCID iD: https://orcid.org/0000-0003-4842-602X

Corresponding author:
Name: Yonela Bandezi,
Cell: +27642048122
Email: 218088142@stu.ukzn.ac.za

Authors' contribution

1. Y Bandezi: Study conceptualisation, data analysis, manuscript preparation, writing and final editing (70%).
2. S Singh: Data analysis, manuscript preparation and editing (30%).

INTRODUCTION

Oral health is an essential component of overall health, and the provision of oral health services is a critical aspect of public healthcare systems worldwide (WHO Global Oral Health Action Plan 2023-2030). In South Africa, a significant portion of the population, particularly in rural areas faces socioeconomic barriers to accessing private dental care resulting in their only option being the reportedly under-funded public health services. Studies show that approximately 0.8% funding was allocated for oral health in some health districts of KwaZulu-Natal, which has only increased to 0.86% 22 years later.[1, 2] This under-funding negatively impacts resources for dental care resulting in lack of certain vital services such as replacement of lost teeth.

Non-replacement of lost teeth contributes to a compromised Oral Health-Related Quality of Life (OHRQoL) which affects physical, emotional, social, and functional aspects of life.

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Individuals who have lost their teeth are likely to experience feelings of sadness, highlighting the emotional strain of edentulism and being unprepared for the consequences of losing their teeth.[3] Edentulism is highlighted as one of the most critical public health burdens and should be seen as a major public health concern given its impact on the quality of life and being a devastatingly irreversible condition.[4-6] It is often associated with a significant decline in oral health and can severely impact an individual's ability to speak, eat, and maintain good nutrition.[7] The prevalence of edentulism is said to be particularly high in older populations, as tooth loss tends to be exacerbated by natural progression of aging (8, 9). Studies further show that people are now living longer in all parts of the world and the impact of poor oral health on the quality of life of older adults must be highlighted as an important public health issue.[8, 10] Considering the impacts of edentulism, restoring lost teeth becomes a salient area that requires attention for the public oral health sector, since its recipients cannot afford to obtain dental prostheses from private health providers.[11] The skewed distribution of oral health services between the private and public sector reiterates the communities' dependency on public dental clinics to provide these services.[12] However, it is unclear of the extent to which denture delivery services are offered in public dental clinics. At the same time, there is a paucity of published evidence that explores patients' perspectives on the availability and accessibility of denture services in these public sector dental clinics. This study is part of a bigger study which aims to develop a framework for the provision of denture services, as part of the minimum package of oral health care, in health districts of KwaZulu-Natal, to contribute to improved quality of oral health care.

The objective of this paper is therefore to determine perspectives of public health recipients on oral health care, the nature of edentulism and impacts of edentulism by means of a survey, with theoretical underpinnings of social justice and principles of oral health-related quality of life model. In the context of health care systems, social justice can be considered to mean that individuals with the same medical conditions have availability of the same treatment options, regardless of their socioeconomic status.[13] Engaging with patients in public health clinics is important in revealing their perspectives on their own oral health conditions based on their lived experiences.[14]

MATERIALS AND METHODS

Study design

A cross-sectional descriptive research design was used to collect the quantitative data.

Study setting

Data for this study was collected from selected public health facilities of eThekwini District which represented the urban and peri-urban areas with two of the three health facilities located in the same community or catchment, while the rural areas were represented by three distinct communities of the Harry Gwala district. This research was approved by the HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE (HSSREC) of the University of KwaZulu-Natal, with reference number: HSSREC/00000444/2019. Gatekeeper permission was obtained from the KZN Department of Health.

Study sampling

At the time of data collection, the total population of the Harry Gwala Health district was 502 265 (harrygwaladm.gov.za, 2019). The eThekwini district had a total population of 3,442,361 (Durban.gov.za, 2019). A statistically sound sample was drawn using Raosoft ® online sample calculator where the total population size was entered, with the confidence level of 95%, marginal error of 5%. This resulted in a population sample n=810 being 162 per selected public health facility, enabling a reasonable completion of 54 questionnaires per research site per day over a period of 3 days, during a fixed time period from 7:00am to 11:00am. A systematic sampling technique was employed to select participants from the walk-in patients who attended the public health facilities. The sampling interval of 3 was derived by dividing the total population per site (n=162) by the desired daily sample (n=54) and a starting point between 1 and 3 was identified, followed by selecting every third person thereafter to participate in the survey until the desired sample was reached.

Study population

The study population consisted of adult individuals who were 18 years and older, attending the public health facility. Persons who are intellectually or mentally impaired and those who do not understand English, isiZulu or isiXhosa were excluded from participating. Exclusion was also applied to individuals who presented to the facilities in critical health conditions. People of all races, gender, and education status participated in the survey.

Research Instrument

Data was collected using a digital Google Forms questionnaire which was adapted from Annexure 7 of the 5th Edition of the WHO Oral Health Surveys guidelines. The first section of the questionnaire consisted of the title of the study, researcher's information, a description of the study and reiteration of voluntary participation, confidentiality, anonymity and risks associated with participation. The next set of text contained ethical approval details, including the supervisor's contact details. The second part of the questionnaire was a mandatory field of informed consent. The subsequent sections of the questionnaire would only unlock when the respondent has indicated consent which toggled the "I Agree' to participate function.

The second section recorded biographical information such as age, gender, race, geographical location, level of education and whether the responded is a denture-wearer or not. The third section recorded data about the number of teeth lost and the perceived reasons that caused the reported loss of teeth. The fourth section recorded information about dental visits, allowing the respondents to indicate whether the last dental treatment received was from a public or a private facility. The fifth and larger section of the questionnaire solicited responses by means of a 5-point Likert scale ranging from Strongly-Agree to Strongly disagree. The statements under this section ranged from reasons for visiting a dentist to reasons for desiring to replace teeth or for having replaced lost teeth, as well as the impact of living with missing teeth. The last three sections were applicable to respondents who have replaced their missing teeth and it solicited information about the type of prostheses received, the benefits of replacing the missing teeth and the maintenance of the prostheses.

Data collection procedure

On the day of data collection, an appointed supervisor of the facility introduced the researcher to the patients. It

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was practical to interact with the patients during general administration before they were redirected to specific consultation areas. Thereafter, the researcher verbally informed the prospective participants that their participation is voluntary and that there are no incentives applicable and guaranteed them anonymity and confidentiality.

The researcher first explained the purpose of this study as well as the scope of involvement of the patients. This was done in the prospective participants' preferred language of communication between English, and IsiZulu and IsiXhosa. Subsequently, each member who agreed to participate verbally indicated informed consent which was captured on the digital questionnaire. Then the researcher proceeded to administer the digital questionnaires using a tablet as an electronic device to capture the responses. The use of an electronic device, optimised and streamlined data management because this decreased the need to carry hard copies of the collected data. It also decreased the risk of possible cross-contamination of the paper-based hard copies by contact- transmissible viruses such as Covid-19. This process was carried out until there were no more individuals presenting to the facility.

Ethical Considerations

This study was conducted following the ethical guidelines of the University of KwaZulu-Natal and ethical clearance was obtained from the Humanities and Social Sciences Ethics Committee (HSSREC/00000/444/2019). Subsequently, gatekeeper permissions were obtained from various authorities before commencing the research study. Firstly, permission was obtained from the Department of Health, KwaZulu-Natal, to conduct research in the provincial health facilities that have dental services. This was followed by gatekeeper permissions from the Harry Gwala and eThekwini health district offices. After the districts had granted their permission, the managers of the dental facilities were contacted to offer their support which was useful in obtaining the final gatekeeper permission from the managers of respective public health facilities.

Data analysis

The data collected via Google Forms was exported to a MS Excel spreadsheet for data verification and organisation in preparation to be statistically analysis. The statistical data analysis was conducted using R Statistical computing software of the R Core Team, 2020, version 3.6.3. Where applicable, the descriptive statistics of numerical measurements were summarised as the minimum, maximum, quartiles, interquartile range, means, standard deviation and the coefficient of variation. On the other hand, the categorical variables were described as counts and percentage frequencies where Likert plots were used to visually display the categorical variables. Kruskal Wallis was used for assessing the median difference of the non-normally distributed measurements for at least three categories and post-hoc tests were conducted using Dunn test for significant difference in the medians. To determine the association between categorical variables, a Chi-Square Test was used and when the distribution of the cross tabulations contained an expected value of less than five, a Fisher's exact test was applied. In the case of significant difference between the Chi-Square or Fisher exact test, a row wise paired z-test was used as a post hoc analysis following the omnibus tests (Chi-Square or Fisher exact test). All the inferential statistical analysis tests were conducted at 5% levels of significance. The results are presented in the form of descriptive and inferential statistics.

RESULTS

A total of 770 out of 810 patients consented to participate in the study with a 95% response rate, of which 73.9% were female (p=0.016). The majority of participants were between the ages of 30 to 50 (n=396; 47.9%), followed by those aged 50 and above (n=218;28.3%). The least represented age group is the 18 to 30 (n=183; 23.8%). The data on age groups shows a statistical significance (p= 0.054) with non-normal distribution across urban, peri-urban and rural participants, hence the Kruskal Wallis pairwise test was applied to determine the median differences within independent

Table 1: Distribution of participants according to age, gender and level of education by location.

Location	Urban (N=136)	Rural (N=450)	Peri-urban area (N=184)	p-value	Overall (N=770)
Age in years				**Kruskal**	
Median(Q1-Q3)	35.0(29.0-48.5)	40.0(31.0-53.0)	36.0(29.0-46.5)	0.002	38.0(30.0-51.0)
n(Min-Max)	136(18.0-86.0)	450(18.0-85.0)	184(18.0-78.0)		770(18.0-86.0)
Age				**0.054**	
<30yrs	36 (26.5%)	97 (21.6%)	50 (27.2%)	Chisq.	183 (23.8%)
30-<50yrs	66 (48.5%)	208 (46.2%)	95 (51.6%)		369 (47.9%)
50+yrs	34 (25.0%)	145 (32.2%)	39 (21.2%)		218 (28.3%)
Sex				**0.016**	
Female	89 (65.4%)	348 (77.3%)	132 (71.7%)	Chisq.	569 (73.9%)
Male	47 (34.6%)	102 (22.7%)	52 (28.3%)		201 (26.1%)
Level of education				**<0.001**	
No education	3 (2.2%)	24 (5.3%)	5 (2.7%)	Chisq.	32 (4.2%)
Primary	6 (4.4%)	62 (13.8%)	32 (17.5%)		100 (13.0%)
High School	101 (74.3%)	337 (74.9%)	131 (71.6%)		569 (74.0%)
Vocational	1 (0.7%)	5 (1.1%)	3 (1.6%)		9 (1.2%)
Tertiary	25 (18.4%)	22 (4.9%)	12 (6.6%)		59 (7.7%)

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locations. About 74.0% of participants indicated high school education as their highest education obtained. Data showed high statistical significance for responses about the level of education (p=<0.001). The majority of participants indicated that they reside in rural areas with (n=450; 58.4%). The distribution of the participants according to age, gender and level of education by location is presented in Table 1.

As shown in Table 2, the overall responses indicate that pain from teeth and gums were reported by majority of patients as the reasons for visiting a dentist (n=509; 70.2%). For this variable, participants from the peri-urban area account for 78.7%, urban area accounting for 76.7, whilst rural participants accounted for the lowest percentage of 64.8% with a high statistical significance (p=<0.001). Visiting a dentist for oral screening and dental advice has the lowest percentage of 10.5%. For this variable, participants from rural areas accounted for the least responses of 7.4% with urban and peri-urban closely related at 14.9% and 15% respectively with a moderate statistical significance (p=0.026).

Table 2: Reasons for visiting a dentist by location.

Location	Urban (N=136)	Rural (N=450)	Peri-urban area (N=184)	p-value	Overall (N=770)
Advice and oral screening				**0.026**	
Strongly Disagree	106 (79.1%)	394 (88.7%)	141 (81.5%)	Chisq.	641 (85.4%)
Disagree	3 (2.2%)	4 (0.9%)	1 (0.6%)		8 (1.1%)
Neutral	0 (0.0%)	0 (0.0%)	1 (0.6%)		1 (0.1%)
Agree	5 (3.7%)	13 (2.9%)	4 (2.3%)		22 (2.9%)
Strongly Agree	20 (14.9%)	33 (7.4%)	26 (15.0%)		79 (10.5%)
Pain from teeth or gums				**<0.001**	
Strongly Disagree	4 (3.0%)	68 (16.1%)	18 (10.7%)	Chisq.	90 (12.4%)
Disagree	9 (6.8%)	25 (5.9%)	7 (4.1%)		41 (5.7%)
Neutral	5 (3.8%)	30 (7.1%)	5 (3.0%)		40 (5.5%)
Agree	13 (9.8%)	26 (6.1%)	6 (3.6%)		45 (6.2%)
Strongly Agree	102 (76.7%)	274 (64.8%)	133 (78.7%)		509 (70.2%)

The results on access to private and public dental facilities by location are presented in Table 3. Overall, the majority of the participants from all represented locations indicated that they last presented to a public oral health facility for their dental needs at 76.4 % of which 80.9% of participants came from rural areas, followed by peri-urban at 77.4% and the least percentage representation came from the urban areas at 36.4%. The data shows a strong statistical significance of (p=<0.001).

The distribution of number of missing teeth and the last visit to the dentist by age are presented in Table 4. Overall, the highest number of teeth missing across all age groups is in the range of 1-9 (n=540; 70%) with participants aged 30 to <50 representing the majority (n=280; 75.9%), followed by age 50 and above (n=153; 70.2%) and the lowest being participants aged 18 to 30 (107;58.5%). The data for this variable shows a strong statistical significance (p=<0.001). The majority of participants indicated that they last visited a dentist over 5 years ago (n=272; 35.5%) with participants aged 50 and above having a high representation (n=100; 46.3%) in this variable. The second largest category is that of participants who have never visited a dentist at 23.8% (n=182) with the 18 to 30 years old age group accounting for the majority at 31.7%. These results have a statistical significance of p=0.001.

The indicated reasons for the participants who desire to replace the missing teeth by age groups are illustrated in a Likert plot in Figure 1. This applied to those participants who in the questionnaire indicated having missing teeth but are not wearing any prosthesis. Statistically significant variables were difficulty to chew food (p=0.007), difficulty smiling (p=0.042), feelings of embarrassment (p=0.044), limited consumption of food (p=0.003) and being made fun of by people (p=0.020). The variables that showed no statistically significant differences among different age groups were the avoidance of social activities (p=0.331), difficulty to pronounce words (p=0.79), discomfort and avoidance of speaking in public (p=0132) and inability to bite food (p=0.902).

Table 3: Access to private and public dental practices by location by location.

Location	Urban (N=136)	Rural (N=450)	Peri-urban area (N=184)	p-value	Overall (N=770)
Type of dental practice				**<0.001**	
Private dental practice	44 (36.4%)	63 (19.1%)	26 (19.0%)	Chisq.	133 (22.6%)
Public health facility	76 (62.8%)	267 (80.9%)	106 (77.4%)		449 (76.4%)
Not sure	1 (0.8%)	0 (0.0%)	4 (2.9%)		5 (0.9%)
Not applicable	0 (0.0%)	0 (0.0%)	1 (0.7%)		1 (0.2%)

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Table 4: Number of missing teeth and last visit to a dentist stratified by age.

Age	<30yrs (N=183)	30-<50yrs (N=369)	50+yrs (N=218)	p-value	Overall (N=770)
Number of missing teeth				**<0.001**	
None	76 (41.5%)	80 (21.7%)	23 (10.6%)	Chisq.	179 (23.2%)
9-Jan	107 (58.5%)	280 (75.9%)	153 (70.2%)		540 (70.1%)
19-Oct	0 (0.0%)	5 (1.4%)	23 (10.6%)		28 (3.6%)
>20	0 (0.0%)	0 (0.0%)	11 (5.0%)		11 (1.4%)
Some	0 (0.0%)	2 (0.5%)	4 (1.8%)		6 (0.8%)
All	0 (0.0%)	2 (0.5%)	4 (1.8%)		6 (0.8%)
Last visit to a dentist				**0.001**	
Never	58 (31.7%)	82 (22.3%)	42 (19.4%)	Chisq.	182 (23.8%)
<1yr	27 (14.8%)	57 (15.5%)	24 (11.1%)		108 (14.1%)
1-<2yrs	21 (11.5%)	34 (9.3%)	22 (10.2%)		77 (10.1%)
2-4yrs	33 (18.0%)	66 (18.0%)	28 (13.0%)		127 (16.6%)
5+yrs	44 (24.0%)	128 (34.9%)	100 (46.3%)		272 (35.5%)

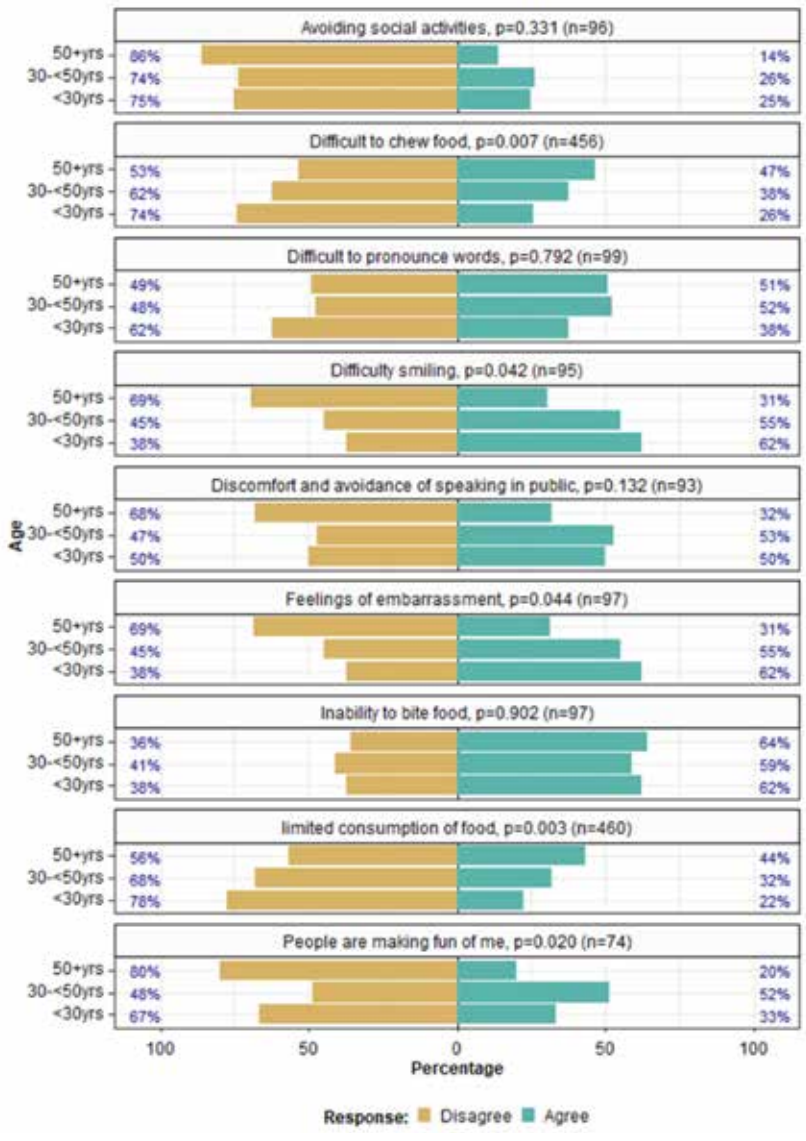

Figure 1: A Likert plot of reasons for the participants to replace the missing teeth by age groups.

DISCUSSION

The results highlight significant perceived disparities in dental health access based on location, age, and education level, underscoring the need for targeted interventions to improve oral health care, particularly in rural areas.

In this study, 74% of participants indicated high school education as their highest education obtained. This is consistent with studies that reported a demonstrable positive correlation between education, oral health awareness and practices, and lower OHRQoL.[15, 16] The overall results of this study showed a concerning lack of commitment to oral health care with majority of participants reporting to have last visited a dentist over 5 years ago, and predominantly being patients who are 50 and above. This supports the sentiment by multiple authors that highlight the need to address the impact of poor oral health on the quality of life of older adults due to people living longer in all parts of the world. [8, 9, 17] Equally concerning is that younger participants of the 18 to 30 age group reported to have never visited a dentist. This is an edentulism risk factor since these young patients may end up seeking oral health interventions when only dental extractions can be the solution, which perpetuates the prevalence of tooth loss as reported by Mthethwa, Mahomed.[18] Considering that the majority of participants indicated that they reside in rural areas, it is important to explore the determinants of access to primary oral health, particularly in the rural areas. Such information could inform and strengthen oral health planning in the province.

Reasons for seeking oral health services

This study's findings indicate that most individuals who sought access to oral services

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do so only when they start experiencing pain from teeth and gums. This is consistent with findings from another study which purported that while dental treatment in most public primary health care facilities is free or highly subsidised, patients continue to access dental treatment only in the symptomatic phases of the disease, making pain the driving force for seeking relief.[18] In support of these findings, Thema and Singh,[4] reported that there is a possibility of teeth being extracted as a quick solution to pain and discomfort without exploring the benefits of saving and restoring the dentition in public primary health care facilities.

This delay in seeking oral health highlights a gap in patient education on the importance of regular dental check-ups even when they are not experiencing pain. This correlates with this study's low results on the participants who indicated that they visit a dentist for oral screening and dental advice, particularly from those representing the rural areas.

Dependence on public oral health facilities

From the results of this study, there is an indication of significant predominance of access to public oral health facilities in comparison to private dental practices, with majority of participants representing rural areas. A study that investigated oral health community engagement for rural communities reported that while oral health strategies were effective in improving the oral health and quality of life of children and edentulous older adults in rural communities, these communities are still heavily burdened by oral diseases, due to unequal access to dental care and a shortage of oral health professionals.[19] This suggests that there are disparities between urban, peri-urban, and rural areas in terms of equity of access to oral health services that are not part of public health care. The implications of this is individuals who are predisposed to living with edentulism since the essential oral health services do not include basic dentures. Subsequently, this necessitates the review of the current essential oral health package and consider the incorporation of basic dentures. This study further found that participants across all age groups reported having lost between 1-9 natural teeth, especially in the ages 30 to 50 and above.

Reasons for needing to replace missing teeth

The results of this study indicated that all participants reported that they need to replace their missing teeth not only because of the obvious functional effects of tooth loss, but due to psychological effects as well. These results are consistent with the findings of one study which reported that there is significant evidence of causality between tooth loss and depression symptoms.[20] While these participants may be experiencing these negative psychological effects, such as difficulty smiling and feelings of embarrassment, they also indicated that they are not affected to the extent of avoiding social activities. This may be due to the iteration by Kimmie-Dhansay, Pontes,[7] that, cultural beliefs and personal values about appearance have an influence on how tooth loss affects individuals.

RECOMMENDATIONS

The results of this study indicate that there is a need to strengthen oral health education and improve community outreach programmes to resolve the issue of individuals seeking oral health care too late, which often leads to tooth extractions being the only treatment to relieve symptoms. With the occurrence of tooth loss being associated with advancing in age and considering that people are living longer, there needs to be an all-inclusive strategy that does not leave out oral rehabilitation through basic prostheses, for those patients who are already living with some form of edentulism. As mentioned earlier in this paper, the Global Oral Health Action Plan (2023-2030) is determined to address oral health inequities through a comprehensive framework that emphasises prevention, promotion, and integration into universal health coverage in rural areas. However, there needs to be an all-inclusive strategy that does not leave out oral rehabilitation through basic prostheses, for those patients who are already living with edentulism. Thus, the current district level oral health care plans should consider incorporation of basic partial dentures in primary oral health care.

There is a need for a province-wide research to determine whether there is gender-based, age-based location and cultural related barriers to accessing oral health care, particularly prosthodontic restorations. Due to the limitations of this scope of this study, more research in the form of cohort studies is necessary, to uncover and report on the extent of the need for dentures for all districts in the KZN province. Another area of future research is a prospective study that will track younger patients over a period of time from their initial tooth extraction treatment to determine the frequency of their return for further extractions with the intention to highlight the potential contribution of exodontia to edentulism.

STENGTHS AND LIMITATIONS OF THE STUDY

The study findings provided an important snapshot of the current state of edentulism for individuals who access the public oral health facilities. While, other studies have reported on patients accessing oral health services in the public sector, this is the first study, to our knowledge, that specifically focused on edentulism in the identified research sites.

Despite the value of such information, some limitations were noted. The main limitation of this study was the cross-sectional design. Thus, this study could not establish cause-and-effect relationships in respect of edentulism, because data was collected at a single point in time. The study results are also susceptible to self-reported bias whereby the data collected may be inaccurate due to being influenced by the participants' social desirability bias or recall bias which may lead to under- or over-reporting of the impacts of edentulism. It may be worthwhile for this type of research to include a clinical examination component so as to corroborate the reported findings with clinical data from the same participant. Sample bias could also have been possible as most participants of this study came from rural areas. However, this study provided much needed baseline information on patient's perspectives of accessing facility-based oral health care and such information could be of value to oral health planners in the region.

CONCLUSION

This study found that both psychological and functional impacts of edentulism were reported as the reasons why most patients indicated their need to replace their missing teeth. These results present an opportunity for an exploration of the potential to incorporate basic removable partial dentures in the essential oral health package at district level in KZN. The study findings further suggest that participants in rural settings reported poor access to facility-based oral health care and that pain was the major reason for seeking care. This highlights the need to strengthen oral health

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education and community outreach programmes in the identified research sites.

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Conflict of interest

The authors declare that there is no conflict of interest.

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Relationship between Wits appraisal and ANB angle in a South African orthodontic patient sample

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R Kobedi,[1] S Rajbaran-Singh,[2] HF Swanepoel,[3] AC Oettlé[4]

ABSTRACT

Introduction

Both earlier and recent studies have relied exclusively on the ANB angle to quantify malocclusion. Since the ANB angle is measured at the nasion, variations of the relative position of the nasion between populations may influence the reliability of ANB angle for malocclusion classifications. The Wits appraisal offers an alternative that excludes variability from skeletal differences beyond the jaws. However, few studies have examined the Wits appraisal relationship with ANB angle, and none in South Africa, leaving the interpretation of ANB measurements in local populations uncertain.

Aims And Objectives

This study aimed to assess the efficacy of the ANB angle for skeletal malocclusion by correlating it with the Wits appraisal.

Design

A cross-sectional quantitative approach.

Methods

A total of 114 lateral cephalograms were sampled and measured using ImageJ software. Spearman's correlations were performed between ANB angles and Wits appraisal using PAST statistical software.

Results

All correlations were statistically significant. The ANB angle and Wits appraisal showed a moderate correlation in the entire sample, but stronger in the negative category and weak in the positive category.

Conclusion

The ANB angle was not considered consistently reliable to distinguish between malocclusion classes because of the considerable lack of agreement with the Wits appraisal measures.

Keywords

ANB angle, cephalometrics, malocclusion, Wits appraisal.

Authors' Information:

1. Ms Ruth Kobedi. BSc MedSci, BSc (MedSci) (Hons), MSc (Med), Department of Anatomy and Histology, School of Medicine, Sefako Makgatho Health Sciences University, Ga-Rankuwa, Pretoria, South Africa.
   Telephone: (012) 521 4430 Email: deekobedi@gmail.com
   ORCID: 0000-0002-0891-0899
2. Dr Sandeepa Rajbaran Singh. MSc.Odont, Dip.Odont, BChD, Department of Maxillofacial and Oral Radiology, School of Oral Health Sciences, Sefako Makgatho Health Sciences University, Ga-Rankuwa, Pretoria, South Africa. Telephone: (012) 521 4902 Email: sandeepa.singh@smu.ac.za
   ORCID: 0000-0002-7313-1365
3. Dr Helene Franci Swanepoel. BSc MedSci, BSc (MedSci) (Hons), MSc (Anat), PhD (Anat), Department of Sport, Rehabilitation and Dental Sciences, Tshwane University of Technology. Email: swanepoelHF@tut.ac.za,
   ORCID: 0000-0001-6297-1775
4. Prof Anna Catherina Oettlé. MBBCh, MSc (Anat) (cum laude), PhD (Anat), DTE. Department of Anatomy and Histology, School of Medicine, Sefako Makgatho Health Sciences University, Ga-Rankuwa, Pretoria, South Africa. Telephone: (012) 521 3337 Email: profoettle@gmail.com
   ORCID: https://orcid.org/0000-0002-5665-6581

Corresponding author
Name: Ms Ruth Kobedi
Telephone: (012) 521 4430
Email: deekobedi@gmail.com

Authors contributions

1. Ms Ruth Kobedi. Role: principal researcher, manuscript development and write-up 60%
2. Dr Sandeepa Rajbaran Singh. Role: conception and manuscript editing: 15%
3. Dr Helene Franci Swanepoel.Role: manuscript editing: 5%
4. Prof Anna Catherina Oettlé. Role: conception, data analysis, manuscript development and editing 20%

INTRODUCTION

Malocclusion is one of the most prevalent oral health issues and is a primary reason why patients seek orthodontic treatment often driven by their own perceptions of what constitutes aesthetic dentition. Normative and objective evaluation by orthodontists entail cephalometric analyses that determine skeletal class and informs treatment objectives.[1,2]

The anteroposterior skeletal relationship between the maxilla and mandible, which is a key determinant of malocclusion type, is often quantified by ANB angles, incorporating the subspinale (A-point), nasion (N) and supramentale (B-point). Skeletal class I (associated with normal occlusion or mild malocclusion) is represented by an ANB angle of between 2° to 4°, class II (associated with maxilla positioned anterior to the mandible) by an angle greater than 4° and class III by an angle less than 2° (associated with mandible positioned anterior to the maxilla).[3,4] This classification of malocclusion using ANB angles has, however, been criticised in earlier studies[5,6] and more recently[7]. The ANB angle alone may not provide a true reflection of occlusal relationships, as it is affected by changes in anterior cranial lengths that may influence the nasion position. More specifically, features of a relatively more posteriorly positioned nasion in people of African ancestry, when compared to people of European ancestry, have been noted.[8]

The Wits appraisal, on the other hand, measures the anteroposterior jaw relationships[9] without incorporating the nasion. This Wits appraisal is the distance on the occlusal plane between AO and BO, where AO is marked at 90° from the subspinale and BO at 90° from the supramentale.[6,9,10] When BO is anterior to AO, Wits appraisal indicates negative readings and is associated with class III. Positive Wits appraisal readings are indicated by an AO that is anterior to BO and is associated with class II malocclusion.[9]

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The Wits appraisal has been used as a reference for evaluating the reliability of the ANB angle in the classification of malocclusion. Despite the correlation between the two parameters (Wits and ANB) being absent, weak, or moderate but seldom strong,[11,12,13] recent studies continue to categorise malocclusion based solely on the ANB angles.[3,14,15] This study aimed to explore the relationship between the ANB angle and Wits appraisal in a South African Black sample, thereby assessing the efficacy of the ANB angle for skeletal malocclusion in this specific population.

MATERIALS AND METHODS

This study was conducted on lateral cephalograms of 114 Black South African patients from an academic oral health centre, before any orthodontic treatment. Population group was assigned based on patients' records. The sample was selected by means of a convenience sampling strategy due to the accessibility and availability of data at the oral health centre. Sample distribution comprised 51 males and 63 females aged between 18 and 58 years who were generally referred for the assessment of malocclusion or for skeletal examination. Cephalograms that indicated bone trauma or any modifications to the areas investigated were excluded from the study.

Measurements were obtained using ImageJ software[16] with scales calibrated prior to data collection. The Wits appraisal and ANB angle measurements are illustrated in Figures 1 and 2 respectively. Statistical analyses were performed using Paleontological Statistics (PAST).[17] Firstly, normality tests were applied (based on the results of the Shapiro-Wilk's tests)[18]. Thereafter, correlations between ANB and Wits appraisal were performed for the entire sample, negative categories and positive categories. For non-parametric distributions, Spearman's correlation coefficient (r_s) tests were applied.[19] A Pearson's correlation coefficient (r) test would apply in a case where data was normally distributed. Perfect positive and negative associations are indicated by +1 and –1 respectively,[20] while the absence of any linear association is indicated by a value of 0.

Intraobserver reliability was performed using the intraclass correlation coefficients (ICC)[21]. The ICC below 0.5 indicate poor reliability while it is moderate when values range between 0.5 and 0.75. Reliability is good with ICC values that range between 0.75 and 0.90 and considered excellent when above 0.90.

RESULTS

The intra-observer error indicated excellent measurement agreement, where ICC values were 0.93 and 0.96 for the ANB angle and Wits appraisal respectively. The 95% confidence intervals for both parameters were good to excellent, where lower and upper bounds were 0.76 and 0.98 for ANB respectively, and those of Wits appraisal were 0.85 and 0.97 respectively.

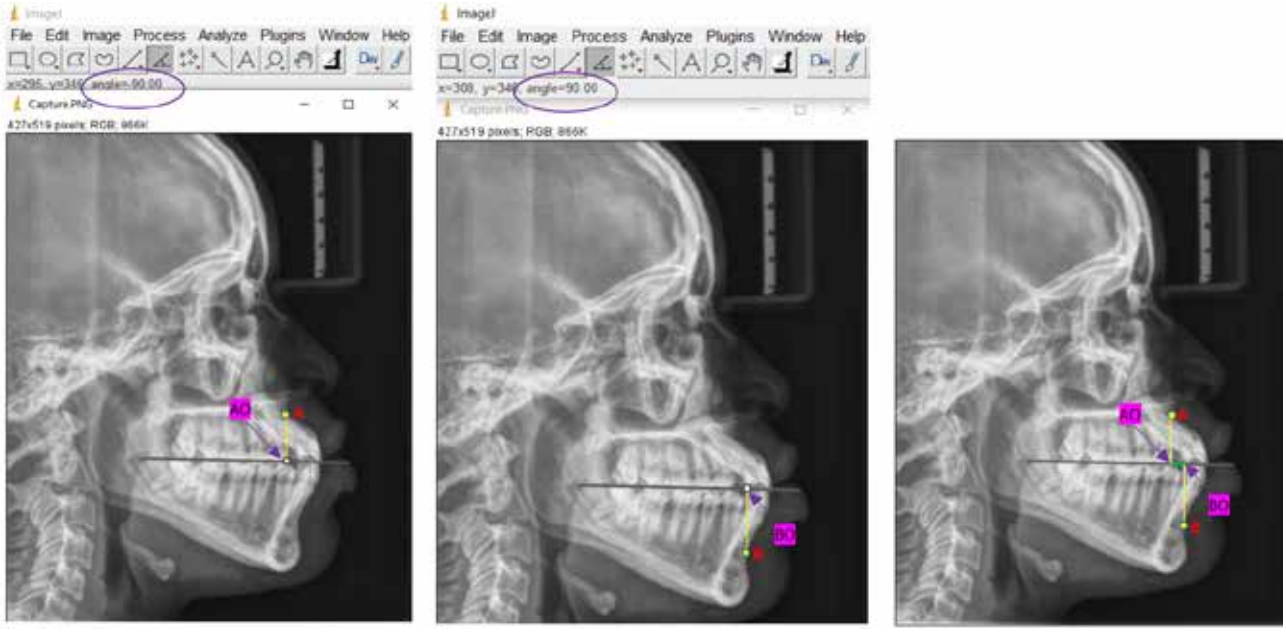
Only 19 out of 114 cephalograms had a negative ANB. Of these 19 individuals with a negative ANB reading, 16 had negative Wits appraisal readings, while 3 had a positive Wits appraisal. Correlations for negative groups were thus performed on 16 individuals (Table I).

Table I: ANB angle and Wits appraisal sample distribution per reading

	Wits (+)	Wits (-)	Wits (0)
ANB (+)	51	37	7
ANB (-)	3	16	0

The symbols + and – refer to positive and negative readings respectively. Shaded cells indicate groups that were correlated.

The remaining 95 cephalograms had positive ANB readings, where 51 of these individuals with a positive ANB exhibited a positive Wits appraisal, 37 had a negative Wits appraisal and 7 presented with zero Wits appraisal (Table I). Correlations for positive groups were therefore performed on 51 individuals.



A B C

Figure 1: Grey horizontal lines = occlusal plane. 2A: Yellow line from A point to occlusal plane at 90 degrees; 2B: Yellow line from B point to occlusal plane at 90 degrees; 2C: Wits appraisal: (distance between AO and BO)

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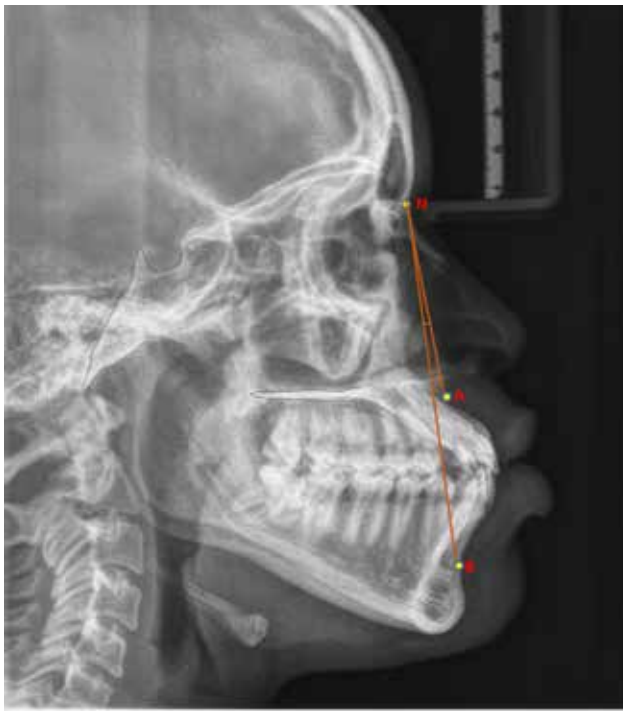

Figure 2: The ANB angle measured from the subspinale (A), nasion (N) and supramentale (B)

Variables in all three groups (entire sample, negative and positive categories) were not normally distributed. Spearman's coefficient of correlation (r_s) tests were thus applied. All correlations were highly statistically significant ($p \leq 0.01$). The ANB and Wits appraisal correlations for the entire sample (N = 114) were moderate ($r_s = 0.51$), while strong in the negative category ($r_s = 0.77$) and weak in the positive category ($r_s = 0.37$).

DISCUSSION

While discrepancies associated with the use of the ANB angle as a measure of malocclusion have been reported in historical literature,[5,6] recent studies continue to use ANB angles to classify malocclusion.[3,14,15,22] To assess the value of using the ANB angle for skeletal malocclusion classifications in the Black South African population, the relationships between the ANB angle and the Wits appraisal were explored in this study. Although all correlations were statistically significant, positive categories (N = 51) resulted in weak correlations, suggesting that Wits appraisal findings associated with class II malocclusion could not solely be explained by the ANB angle in this category despite the larger samples size than those of the negative categories. The strong correlations in the negative groups indicate that ANB angle could to a certain extent be reliable when grouping skeletal class III only.

The ANB angle and Wits appraisal correlation for the overall sample was moderate, which was similarly moderate in a Chinese sample,[23] where a correlation coefficient of 0.65 between the two parameters was reported. Varying reports were found by Al-Jabaa and Aldrees (2014),[13] who found a strong correlation coefficient of 0.73 between ANB angle and Wits appraisal in their overall sample. In Zhou et al., (2008)'s study, correlations remained moderate for the three malocclusion classes, which varied from our findings where correlations were strong for class III (negative group) and weak for the positive category.[23] Correlations remained strong across the three malocclusion classes in the study by Al-Jabaa and Aldrees (2014),[13] which also varied from our findings except for class III, where the correlation was strong in both our study ($r_s = 0.77$) and in their study ($r = 0.75$).

Other factors, such the vertical development of the face or the position of the nasion,[11,12] could have influenced the readings of the ANB angle. A relatively shortened anterior cranial base resulting in a varying angle position at the nasion to the subspinale and supramentale have been implicated in another Black population.[8] These findings further verify what has been reported in the historical literature, that the ANB angle does not provide a complete reflection of jaw relationships and it is not synonymous with Wits appraisal.

Although the ANB angle showed statistically significant differences between Wits appraisal categories and correlated to some extend with the Wits appraisal especially in the negative categories, it did not prove consistently reliable for distinguishing between categories because of the substantial overlap in angle values in especially the positive categories. There were 37 of the 95 individuals with a positive ANB angle that presented with a negative Wits appraisal and 3 of the 19 individuals presenting with a negative ANB angle that had a positive Wits appraisal.

CONCLUSION

Skeletal malocclusion classes categorised solely by ANB angles should be interpreted with caution in South African Black populations. Clinicians should consider using the Wits appraisal to quantify malocclusion as it is a linear measure expected to present with less variability than angular methods and minimises the interpopulational differences that are introduced when using ANB angles.

ETHICAL CONSIDERATIONS

Approval to conduct the study was granted by Sefako Makgatho Health Sciences University (SMUREC/M/274/2023:PG). Details of patients were only obtained for sample categorisation purposes. Information of patients will not be publicised in relations to this study.

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Conflicts of interest

None.

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Knowledge, attitudes, and self-reported practices related to oral squamous cell carcinoma among oral health practitioners in South Africa

SADJ MARCH 2026, Vol. 81 No.2 P79-P83

LN Masuka,[1] AI Masilana[2], A Bhayat,[3] RAG Khammissa,[4] MM Beetge[5]

ABSTRACT

Introduction

Oral cancer remains a major global health concern, with oral squamous cell carcinoma (oral SCC) accounting for most cases. Early detection is critical for improving prognosis, and oral health practitioners (OHPs) play an important role in screening and referral.

Aim

To describe the self-reported knowledge, attitudes, and practices of oral health practitioners in South Africa regarding oral squamous cell carcinoma.

Methods

A descriptive, cross-sectional survey was conducted among oral health practitioners in South Africa between October 2023 and January 2024. Participants were recruited through professional associations using a non-probability sampling approach. Data were collected using an adapted, self-administered online questionnaire. Descriptive statistics were used to summarise responses, and exploratory comparisons of mean knowledge and practice scores were performed using analysis of variance (ANOVA), with cautious interpretation.

Results

Of the 342 oral health practitioners invited, 164 completed the questionnaire (response rate: 48%). The mean self-reported knowledge and practice scores were 75% and 67%, respectively. Exploratory analyses suggested differences in practice scores across levels of knowledge ($p = 0.017$). Most respondents reported routinely examining the oral mucosa and referring patients with suspicious lesions, while fewer reported participation in continuing professional development activities related to oral SCC.

Conclusion

Within the limitations of this exploratory, self-reported survey, participating oral health practitioners demonstrated generally acceptable awareness and practices related to oral squamous cell carcinoma, alongside identifiable gaps in specific knowledge areas and post-qualification training. These findings highlight the need for further research using validated instruments and representative sampling, as well as targeted educational initiatives to support early detection and referral.

Keywords

Oral squamous cell carcinoma, oral health practitioners, knowledge, practice, attitudes, malignant transformation.

Authors' information

1. Lucy Nurse Masuka, BDS. Registrar, Department of Periodontics and Oral Medicine, University of Pretoria, Pretoria, South Africa.
2. Aubrey Issac Masilana, BDS, MDent (OMP). Department of Periodontics and Oral Medicine, School of Dentistry, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.
3. Ahmed Bhayat, BDS, MSc (Dent), MPH, MDent (Com Dent). Department of Community Dentistry, School of Dentistry, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.
4. Razia Abdool Gafaar Khammissa, BChD, MSc, PDD, MDent, HDip Educ. Department Periodontics and Oral Medicine, School of Dentistry, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.
5. Mia-Michaela Beetge, BChD, PG Dip/Aesthetic Dentistry, MChD (OMP), PGDip(HPEL,). Department of Periodontics and Oral Medicine, School of Dentistry, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.

Corresponding author:
Name: Lucy Nurse Masuka
PO Box 1266, Pretoria 0001, South Africa
E-mail: lucy.masuka@up.ac.za
ORCID number: 0000-0002-9757-2317

Authors Contribution

1. Dr LN Masuka: Principal researcher – 40%
2. Dr. AI Masilana: Protocol development and writing article (introduction and conclusion) – 15%
3. Prof. A Bhayat: Statistical analysis – 5%
4. Prof. RAG Khammissa: formulating a questionnaire and writing an article (results) – 20%
5. Dr. MM Beetge: Protocol development and writing article (discussion) – 20%

INTRODUCTION

Oral cancer (OC) represents a substantial global health burden and remains among the most common malignancies of the head and neck region.[1] Population-based analyses from the Global Burden of Disease Study demonstrate considerable geographic variation in incidence and mortality. Oral squamous cell carcinoma (oral SCC) accounts for more than 90% of malignancies arising within the oral cavity and is associated with high mortality, particularly when diagnosed at advanced stages. [2-4]

The principal risk factors for oral SCC include tobacco use and alcohol consumption, which have been shown in multiple case–control and retrospective studies to act synergistically in oral carcinogenesis.[5] Dietary deficiencies, particularly low intake of fresh fruits and vegetables, have also been associated with increased risk.[4-6] While infection with high-risk human papillomavirus (HPV) genotypes is a well-established etiological factor for oropharyngeal squamous cell carcinoma, primary molecular studies indicate a relatively low prevalence of transcriptionally active HPV in oral cavity SCC[7-9] (Machado et al., 2010, Shomorony et al., 2019, Fonseca 2023). This distinction has important implications for risk assessment, prevention strategies, and clinical suspicion during oral examination.

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Oral SCC most commonly affects the ventral and lateral surfaces of the tongue and the floor of the mouth.[10] Clinicopathological and population-based studies consistently identify these sites as high risk, likely due to thinner non-keratinized epithelium and prolonged exposure to pooled carcinogens.[10] Despite advances in diagnostic and therapeutic modalities, survival outcomes for oral SCC have improved only modestly over recent decades.[11] Primary registry data indicate that five-year survival exceeds 85–90% for early-stage disease but declines to below 30% in advanced stages, highlighting the importance of early detection.[12]

Oral health practitioners (OHPs) are well positioned to contribute to early identification of oral SCC through routine oral mucosal examinations and timely referral of suspicious lesions. However, empirical evidence suggests variability in practitioners' knowledge, confidence, and clinical practices related to oral cancer screening[13-15] (Novak et al., 2025; Marino 2017; Algudaibi et al., 2021). This study aimed to describe the self-reported knowledge, attitudes, and practices of oral health practitioners in South Africa regarding oral squamous cell carcinoma, providing baseline descriptive data to inform future educational and implementation-focused research.

MATERIALS AND METHODS

The study included dentists, dental therapists, and oral hygienists registered with the South African Dental Association (SADA) or the Dental Professionals Association (DPA) and licensed by the Health Professionals Council of South Africa (HPCSA) practicing in the field of general dentistry. Dental specialists and those who did not consent to participate in the study were excluded. All the OHPs resided and practiced in South Africa. A sample size of 342 was calculated using the Raosoft® sample size calculator.

A modified version of published questionnaires was converted into a Google® survey format and employed for data collection from OHPs in South Africa.[2, 16, 17] Before its distribution to participants, the survey was thoroughly tested through a pilot study among a small group (n = 10) of OHPs in Gauteng employed and working at the University of Pretoria Oral Health Center (UPOHC).

The questionnaire was disseminated electronically to all OHPs enrolled with the SADA and the DPA. The survey link was sent to the OHPs via email and SMS services, with the support of SADA and DPA.

The self-explanatory and closed-ended questionnaire comprised 18 items, categorised into four sections: demographic information, knowledge about oral SCC, attitudes towards oral SCC, and practices related to oral SCC (Appendix 1). The survey evaluated clinical practices and opinions on oral mucosal examination and oral SCC prevention, OHPs barriers to conducting oral mucosal examination, understanding of oral SCC risk factors and diagnostic procedures, and sources of oral SCC information. Responses were provided using multiple-choice questions with several correct answers and a 'yes,' 'no,' or 'unsure' format.

DATA ANALYSIS

Data were analysed using IBM SPSS Statistics version 25. Descriptive statistics were used to summarise the data, including means and standard deviations for continuous variables and frequencies with percentages for categorical variables.

Exploratory comparisons of mean knowledge and practice scores across selected groups were conducted using analysis of variance (ANOVA). These analyses were intended to explore differences in mean scores rather than to establish causal relationships. Assumptions of normality and homogeneity of variance were assessed descriptively. Effect sizes (η^2) were calculated where applicable to provide an estimate of the magnitude of observed differences.

All statistical tests were interpreted cautiously given the non-probability sampling strategy and limited subgroup sizes. Statistical significance was set at $p < 0.05$.

RESULTS

Demographic characteristics of the participants

Out of the 342 individuals invited to take part in the study, 164 OHPs completed the questionnaires, yielding a response rate of 48%. Most of the study population were females (73%) and 80% were aged between 25 and 40 years (Table I). Moreover, 41% of the respondents had 1 to 5 years of work experience, and 63% of them were employed in the public sector.

Table I: Demographic characteristics of the participants

Demographic data	Number (n)	Percentage (%)
Age (in years)		
25 – 40	129	79
41 – 60	32	19
> 60	3	2
Gender		
Male	45	27
Female	119	73
Years of professional experience		
1 – 5	67	40.9
6 – 10	49	29.9
11 – 20	29	17.6
> 20	19	11.6
Work setting		
Dentist in private sector	29	17.8
Dentist in public sector	103	62.8
Dentist in private/academic	14	8.5
Dental therapist	4	2.4
Oral hygienist	14	8.5

Knowledge about oral SCC

As presented in Table II, the majority of participants (76.8%) correctly identified tobacco smoking, alcohol consumption, and advanced age as major risk factors for oral squamous cell carcinoma (SCC).

Most participants (81.7%) accurately recognised that oral SCC is frequently asymptomatic, particularly in its early stages. Additionally, 77.4% correctly reported that oral SCC is not a

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hereditary condition. A substantial proportion of participants (79.9%) demonstrated adequate knowledge of the diagnostic procedures used for the detection of oral SCC. However, when questioned about the most common anatomical sites affected, 48.8% of oral healthcare professionals (OHPs) incorrectly identified the dorsum of the tongue. Nevertheless, 61% of participants were aware of the characteristic features of oral SCC metastasis, notably the presence of hard, painless, and immobile cervical lymph nodes.

The knowledge levels were quantified using a scoring system where complete knowledge was assigned a score of 100% and no knowledge received a score of 0%. The mean knowledge score obtained from the study was 75%.

Table II: Knowledge about oral SCC

	Number (n)	Percentage (%)
Risk factors of oral squamous cell carcinoma		
Tobacco smoking	36	22
Alcohol consumption	1	0.6
HPV infection	1	0.6
Advanced age	0	0
All of the above	126	76.8
Are oral squamous cell carcinoma lesions symptomatic?		
Yes	21	18
Not sure	9	19
No	134	127
Is oral squamous cell a hereditary condition?		
Yes	12.8	11
Not sure	5.5	11.6
No	81.7	77.4
Do you know about investigative procedures used to detect early oral squamous cell carcinoma?		
Yes	131	79.9
Not sure	23	14
No	10	6.1
The most common oral site affected by oral squamous cell carcinoma is the dorsal surface of the tongue?		
Yes	80	48.8
Not sure	14	8.5
No	70	42.7
The most important characteristic of oral squamous cell carcinoma metastasis is a hard, painless fixed lymph node in the neck region		
Yes	100	61
Not sure	36	22
No	28	17

Attitudes toward oral SCC

Table III illustrates the attitudes of oral healthcare professionals (OHPs) toward oral squamous cell carcinoma (SCC). Nearly half of the participants (48.8%) expressed uncertainty regarding the adequacy and currency of their knowledge related to the prevention and early detection of oral SCC. A substantial majority (84.8%) agreed that routine oral examinations should be conducted for patients aged 40 years and older. Furthermore, most participants (92.1%) acknowledged that early detection significantly improves the five-year survival rate of oral SCC.

Table III: Attitude towards oral SCC

	Number (n)	Percentage (%)
Knowledge regarding the prevention and detection of oral squamous cell carcinoma is current and adequate		
Disagree	23	14
Neutral	80	48.8
Agree	61	37.2
Annual oral examinations should be provided to patients 40-years of age and older		
Disagree	17	10.3
Not sure	8	4.9
Agree	139	84.8
Early detection improves five-year survival rate for OC		
Disagree	1	0.6
Not sure	12	7.3
Agree	151	92.1

Practices toward Oral SCC

Table IV presents the practices of oral healthcare professionals (OHPs) related to the prevention and early detection of oral squamous cell carcinoma (SCC). The majority of participants (76.6%) reported routinely examining the oral mucosa during clinical assessments. Additionally, 70.7% indicated that they routinely inquired about current or past tobacco and alcohol use when obtaining patients' medical histories, while 58.5% reported educating patients about these risk factors and providing support for cessation. A substantial proportion of participants (90.9%) reported referring patients with suspicious oral lesions to an oral surgeon for further evaluation. However, only 53.7% of participants had attended continuing professional development (CPD) activities or educational sessions related to oral SCC since qualifying as OHPs.

Table IV: Practices towards oral SCC

	Number (n)	Percentage (%)
Do you examine the oral mucosa routinely?		
Yes	125	76.2
No	9	5.5
Sometimes	30	18.3

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Do you routinely include in your history of the patient, alcohol consumption and tobacco use?		
Yes	116	70.7
No	21	12.8
Sometimes	27	16.5
Do you refer patients with suspicious lesions to an oral surgeon for further evaluation?		
Yes	149	90.9
No	3	1.8
Sometimes	12	7.3
Do you educate patients on adverse effects of alcohol consumption and tobacco use and assist them in cessation?		
Yes	96	58.5
No	21	12.8
Sometimes	47	28.7
Have you attended any educational programs (CPD lectures) on oral SCC?		
Yes	62	37.8
No	88	53.7
Sometimes	14	8.5

Practices were assessed using a scoring system in which a score of 100% represented optimal practice and 0% indicated poor practice. The mean practice score achieved in the study was 67%. No statistically significant association was identified between knowledge and years of professional experience ($p = 0.566$). Similarly, no significant relationship was observed between knowledge and professional group ($p = 0.460$). In contrast, a statistically significant association was found between knowledge and practice ($p = 0.017$).

DISCUSSION

This descriptive, exploratory study examined self-reported knowledge, attitudes, and practices related to oral squamous cell carcinoma (oral SCC among oral health practitioners in South Africa). The findings provide baseline insight into practitioners perceived awareness and stated clinical behaviours, rather than objective measures of screening quality, diagnostic accuracy, referral appropriateness, or health system performance.

The majority of respondents correctly identified tobacco use and alcohol consumption as major risk factors for oral SCC, consistent with findings from previous studies conducted in South Africa and other low- and middle-income settings.[18] This is encouraging, given the high prevalence of alcohol use in South Africa and its established synergistic effect with tobacco in oral carcinogenesis.[18] A substantial proportion of participants also identified human papillomavirus (HPV) as a risk factor. While HPV plays a well-established etiological role in oropharyngeal squamous cell carcinoma, its contribution to oral cavity SCC is limited.[9, 16] The presence of HPV-related items in the questionnaire may therefore reflect broader head and neck cancer awareness rather than oral SCC–specific risk stratification. This distinction is important for accurate risk communication and prevention strategies and has been clarified in the interpretation of the findings.

Although most respondents were aware that early-stage oral SCC may be asymptomatic, nearly half incorrectly identified the dorsal surface of the tongue as a common high-risk site. This finding suggests a potential gap in anatomical risk knowledge that may affect the thoroughness of oral mucosalexaminations. However, as this study relied on self-reported practices, it cannot determine whether oral examinations were performed systematically or whether high-risk sites were consistently examined.

Previous studies have demonstrated discrepancies between reported and observed examination practices, underscoring the need for caution when interpreting self-reported data.[19]

The overall mean knowledge score of 75% suggests moderate to high perceived awareness among respondents, while the mean practice score of 67% indicates variable adherence to recommended practices. The observed difference in practice scores across knowledge levels suggests that higher perceived knowledge may be associated with more favourable self-reported practices. However, this relationship should be interpreted cautiously, as the analyses were exploratory and the measurement instrument was not formally validated following modification.

Encouragingly, most respondents reported referring patients with suspicious lesions to an oral surgeon for further evaluation. While this suggests awareness of appropriate referral pathways, the study does not assess referral timeliness, diagnostic yield, or downstream outcomes. Similarly, although many practitioners reported routinely examining the oral mucosa, this study cannot evaluate the quality or completeness of these examinations.

Notably, more than half of participants reported not having attended continuing professional development (CPD) activities related to oral SCC following qualification. This finding aligns with previous studies conducted in similar settings and highlights a potential area for targeted educational intervention.[20, 21] Rather than indicating deficiencies in clinical competence, this result may reflect limited access to structured post-qualification training opportunities.

This study has important limitations. The use of non-probability sampling limits representativeness, and self-selection bias cannot be excluded. The adapted questionnaire was not subjected to formal psychometric validation, and the scoring system reflects descriptive indicators rather than validated constructs. Additionally, self-reported data are susceptible to recall and social desirability bias. Consequently, the findings should be viewed as hypothesis-generating and should not be used to inform specific screening, referral, or policy decisions without further investigation.

Future research should build on these findings by employing validated instruments, probability-based sampling, and designs that assess observed clinical practices, referral timelines, and structural barriers within the oral cancer care pathway. Such studies would be better positioned to inform implementationstrategies and public health decision-making.

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CONCLUSIONS

Within the limitations of this descriptive, exploratory study, participating oral health practitioners demonstrated generally acceptable self-reported knowledge, attitudes, and practices related to oral squamous cell carcinoma. Nonetheless, gaps were identified in anatomical risk awareness and participation in post-qualification training activities. These findings highlight the need for targeted educational initiatives and further research using validated tools and representative sampling to support early identification and referral of suspicious oral lesions.

ETHICS

This research was approved by the Ethics Committee at the University of Pretoria, Faculty of Health Sciences (319/2023)

CONFLICT OF INTEREST

None

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ABBREVIATIONS

ANOVA – analysis of variance
CPD – Continuing professional development
DPA – Dental Professionals Association
HPCSA – Health Practitioners Council of South Africa
HPV – human papilloma virus
OC – Oral cancer
OHPs – Oral health practitioners
Oral SCC – Oral squamous cell carcinoma
SADA – South African Dental Association
SD – Standard deviation
UPOHC- University of Pretoria Oral Health Centre

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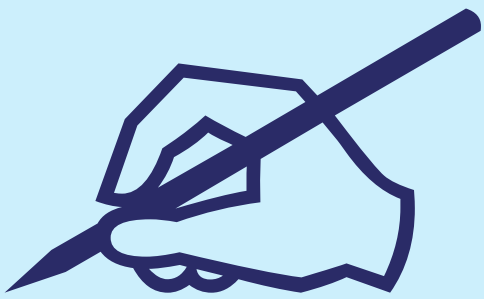
CPD questionnaire on page 122

The Continuing Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.



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Effectiveness of the Tooth Keepers Digital Intervention in Enhancing Oral Health Awareness and Behaviours Among College Students in Durban, South Africa: A Quasi-Experimental Study

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L Naidoo,[1] SC Onwubu[2]

ABSTRACT

Introduction

Poor oral hygiene habits are common among college students in South Africa, contributing to a high prevalence of oral health issues. Digital platforms have shown promise in improving awareness and encouraging positive oral health behaviours.

Aims and Objective

This study evaluated the effectiveness of digital oral health education in promoting awareness and behaviour change among college students in Durban, South Africa.

Methods

A quasi-experimental design was employed with 258 college students. Pre- and post-tests assessed changes in oral health knowledge, awareness, self-efficacy, and self-care behaviours following exposure to the *Tooth Keepers* digital platform. Data were analysed using descriptive statistics, independent t-tests, and chi-square tests.

Results

The findings revealed a significant improvement in knowledge, awareness, and self-efficacy ($p < 0.001$) related to oral health self-care practices after exposure to digital oral health education. Additionally, participants reported significant improvements in their oral hygiene behaviours ($p < 0.001$) after exposure to digital oral health education.

Conclusion

Digital oral health education effectively improves knowledge and self-care practices among college students. This study supports the integration of accessible, technology-based interventions to promote oral health, particularly in diverse and underserved populations.

Authors' information
1. Lesley Naidoo. University of the Western Cape, Cape Town, South Africa. ORCID: https://orcid.org/0000-0002-1774-0705
2. Stanley Chibuzor Onwubu. Chemistry, Durban University of Technology (DUT), Durban, South Africa. ORCID: https://orcid.org/0000-0002-4499-1534

Corresponding Author
Onwubu Stanley Chibuzor
Department of Chemistry, Dental Technology Programme,
Durban University of Technology (DUT),
Durban, South Africa
Email: stanleyo@dut.ac.za

Authors contributions
1. ,Lesley Naidoo, Writing article, data collection, experimental design and development 50%
2. Stanley Chibuzor Onwubu, Writing article, editing, and data analysis 50%

Keywords

Digital oral health education, college students, South Africa, awareness, behaviours, quasi-experimental study

INTRODUCTION

The maintenance of oral health is a fundamental component of one's overall health and state of well-being. Neglecting proper oral hygiene practices can result in a range of health complications such as heart disease, diabetes, respiratory infections, and complications during pregnancy, among others[1, 2] Janakiram and Dye [3] suggest that an individual's oral health is deemed suboptimal when they exhibit dental caries, periodontal disorders, or complete edentulism. According to a recent estimation conducted by Bernabe, Marcenes,[4] a substantial number of individuals, around 3.5 billion people globally, experience the impact of oral disease conditions. Dental disorders provide a substantial public health concern in South Africa, since a considerable number of individuals have dental caries, periodontal disease, and several oral health ailments.[5] Mthethwa, Mahomed[5] showed that the prevalence of dental caries among individuals aged 18-59 years in South Africa is approximately 66.4%. The study further revealed that patients tend to seek treatment for dental caries only when they have symptoms, such as pain, which motivates them to seek relief. This observation suggests a deficiency in knowledge and comprehension of the significance of oral health and the necessity of proactive interventions. In addition, scientific investigations indicate that individuals in their youth frequently underestimate the possible hazards associated with oral conditions, exhibit a perception of reduced vulnerability towards such disorders, and possess little knowledge regarding their prospective progression. In a 2024 study among 12-year-olds in Maputo, for example, researchers found a significant gap between self-perception and actual risk: many teens reported a “negative perception” of their dental health yet displayed suboptimal hygiene habits.[6] Similarly, a Brazilian study examining oral health impacts on daily performance reported:

> *“Young people often do not realise that they need dental treatment until their oral health conditions affect their daily activities.”*[7]

The above underscores that youths generally underestimate these risks, seeking treatment only after symptoms arise.

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Research from Iran highlights that limited oral health knowledge among adolescents is strongly linked to poorer oral behaviours.[8]

Oral disorders are a significant concern as they can adversely impact the quality of life (QoL).[7] For instance, oral health conditions contribute to substantial losses in school and work hours and can interfere with daily activities across various environments, including schools, workplaces, and homes.[1] Despite this, research indicates that many people, particularly young people, prioritise the cosmetic outcomes of tooth brushing over its preventive function against oral diseases.[9] As such, there is a need for oral health intervention that promotes positive behaviour change in the South African context. Nakre and Harikiran[10] emphasise that the most effective strategy for promoting oral health involves the implementation of preventive measures at the community or population level, spanning settings such as schools, neighbourhoods, and even entire nations.

According to the World Health Organisation,[11] oral health education should be integrated into broader health promotion initiatives, with a particular focus on fostering positive habits. Early education plays a crucial role in laying the foundation for healthy behaviours and supports the long-term adoption of effective lifestyle changes.[12] However, much of the existing literature has focused on traditional approaches to oral health promotion, such as classroom-based lectures and printed materials.[13, 14] These conventional methods often suffer from limited user engagement and accessibility, thereby reducing their overall effectiveness and reach.[15]

According to Frontini, Sousa,[16] the use of digital platforms—such as websites, mobile applications, and social media—in oral health education has the potential to effectively reach a broader audience by providing immersive and interactive instructional content. As a result, digital media has emerged as a promising tool for enhancing oral health awareness and encouraging positive health behaviours. Sharma, Mohanty [17] highlight that the increasing accessibility of digital media serves as a valuable health resource, particularly for individuals with limited access to oral health professionals and expertise. Interactive digital interventions have shown efficacy in improving oral health knowledge and promoting behavioural change, thereby playing a vital role in reducing the overall burden of oral diseases.[17] A 2024 randomised controlled trial with elementary students demonstrated that theory-driven school interventions, using multimedia, gamification, and community reinforcement, led to substantial improvements in brushing frequency (up 48.5%), flossing (up 64%), and plaque reduction, highlighting the success of school-based preventive strategies.[18]

Although there is a growing interest in using digital health interventions to promote healthy behaviours and prevent diseases, however, there remains a lack of comprehensive research on the implementation and impact of such interventions within the South African context. This study focuses on promoting oral health knowledge, practices, and self-care behaviours among college students within the South African context. It forms part of an ongoing research and innovation project centred around the Tooth Keepers digital health platform. Tooth Keepers is an interactive online platform that uses multimedia elements to educate users, assess individual risk factors, and offer personalised guidance on oral hygiene, behaviours, and dietary habits. The platform is accessible through both mobile phones and web-enabled devices (http://www.toothkeepers.co.za). College students were chosen for this study because they represent a transitional age group forming lifelong health behaviours, yet often exhibit inadequate oral health knowledge and poor self-care practices, making them an ideal target for preventive digital interventions.[19, 20] The research is, therefore, grounded in the Behaviour Change Techniques (BCT) framework, which emphasises the use of technological interventions to support positive behavioural change.[21] BCT incorporates a range of digital tools – including apps, online programs, and wearable devices – to deliver targeted interventions aimed at modifying health behaviours effectively. The primary objective of the study is to evaluate the effectiveness of Tooth Keepers in enhancing students' oral health awareness, knowledge, and self-monitoring practices.

RESEARCH METHODOLOGY

Research design

The study used a quasi-experimental design, specifically a pre-test/post-test design, to assess the effectiveness of digital oral health education on knowledge, self-efficacy, and behaviour change among the public in South Africa. In a quasi-experimental approach, the researcher manipulates an independent variable without randomly assigning individuals to conditions or ordering of conditions, whilst in post-test method, the dependent variable is measured twice in this design (once before and once after the application of the intervention) [22]

Sampling technique and sample size

The study's sample size was calculated using the Raosoft sample size calculator. It was determined based on a 95% confidence level, a 5% margin of error, a 50% response distribution, and population sizes of 30000 students. While the estimated sample size calculated was 380, only 254 students participated in the study. This constitutes a response rate of 66.8%. All students aged 18 years and above who reside in Durban, South Africa, were considered for the study. A convenience sample process was carried out to target students who showed interest in participating in the study. While more than 380 indicated willingness, 87 did not proceed to the training process and dropped off without completing the second questionnaire. 254 participants completed the research process.

Instrument for data collection

In a quasi-experimental research design following a pre-test post-test approach, data were gathered using structured questionnaires administered before and after the treatment. These questionnaires were specifically designed to assess oral health knowledge, awareness, and behavioural practices. The questions in the questionnaire were closed-ended, presenting two options such as "Yes" and "No," True/False, or Agree/Disagree. Additionally, Likert scales were utilised, ranging from a 1 to 5 rating scale or from "strongly agree" to "strongly disagree," making it easier to analyse the quantitative data. The questionnaire encompassed four sections: 1. Demographics, 2. Oral Health Knowledge, 3. Oral Health Awareness, and 4. Self-Checking and Self-Care Methods. The questionnaire was adapted from previous studies by Slade[23] and Tubert-Jeannin, Riordan,[24] with slight modifications to ensure its appropriateness for the targeted population.

The survey was created using a Google form and emailed to students who expressed their willingness to participate.

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Participants were given a 30-minute time limit to complete the initial part of the pre-test questionnaire. Following this, they received a multimedia oral health primary care promotional presentation based on the Tooth Keepers' oral health journey. This presentation spanned three days, with each day consisting of approximately 20 minutes of content covering various aspects of oral health education, awareness, and self-care practices. The presentation was delivered through the Microsoft Teams video-conferencing application, which allowed for the transmission of digital oral health education materials. After the completion of all three media components, a post-test questionnaire, identical to the pre-test questionnaire, was administered by providing an email link to the participants. All students who completed the initial questionnaire and viewed the multimedia content also completed the post-test questionnaire.

Data analysis

For both the pre- and post-testing of oral health knowledge scores, a standardised questionnaire was employed. In this questionnaire, a rating of 1 was assigned to the correct response, while a rating of 0 was given to an incorrect response. The collected data were then subjected to statistical analysis using SPSS version 28.0, a software by IBM Statistics Inc. based in Chicago, Illinois, USA. The difference in scores before and after the digital oral health training was assessed using the McNemar and Wilcoxon signed-rank tests. A significance level of $P < 0.05$ (two-tailed) was used to determine statistical significance.

Ethical consideration

Ethical approval for the study was obtained from the Biomedical Research Ethics Committee (BM 20/09/16). Furthermore, the study was authorised by the Directorate of Research and the research committee at the Durban University of Technology (IRIC) to be carried out at the university.

RESULTS

3.1 Socio-demographic characteristics

The study recruited a sample of 254 participants in Durban, South Africa. The descriptive statistics in Table 1 showed that the majority of the participants were mostly female (64.2%), within the age group of 18-24 years (55.5%), and mostly in their 1st year of study (48.4%).

Table 1: Socio-demographic characteristics of the participants

Variable	Categories	n (%)
Gender	*Male*	83 (32.7)
	Female	163 (64.2)
Age group	18-24 years	141(55.5)
	25-30 years	95(37.4)
	31-40 years old	18(7.1)
Level of study	1st year	122(48.4)
	2nd year	38(15.0)
	3rd year	55(21.7)
	4th year	24(9.4)
	Unspecified	14(5.5)

3.2 Participants' knowledge of oral health

The data in Table 2 presents the results of oral health knowledge before and after digital oral health education among the study participants. A total of 254 participants were included in the analysis. Before the digital oral health education, only 79.1% of the participants knew that tooth brushing should be done twice a day. However, after the digital oral health education, all participants (100%) responded correctly to this statement. Similarly, before the intervention, only 50.8% of the participants knew that flossing should be done once daily, whereas after the intervention, 98% of the participants responded correctly to this statement.

The results also showed that before the digital oral health education, 72% of the participants believed that it was not necessary to brush the tongue, and 68.1% of the participants thought that it was okay if their gums bled when brushing. However, after the intervention, 92.9% of the participants responded correctly to these statements.

Furthermore, before the intervention, only 48% of the participants knew that they should go for a dental check-up even if they do not have pain, while after the intervention, 93.3% of the participants responded correctly to this statement. Lastly, before the intervention, only 47.2% of the participants believed that brushing before bed is more important than brushing in the morning, while after the intervention, 85.4% of the participants responded correctly to this statement.

Table 2: Assessment of students' level of knowledge before and after the training programme

Statement	Oral health knowledge (n=254)		p
	Pre-training *correct response* n=254 (%)	Post-training *correct response* n=254 (%)	
1. Tooth brushing must be done twice a day	201 (79.1%)	254 (100%)	0.000*
2. Flossing must be done once daily	129 (50.8%)	249 (98%)	0.012*
3. It is not necessary to brush the tongue	183 (72%)	236 (92.9%)	0.004*
4. It is ok if my gums bleed when I brush	173 (68.1%)	236 (92.9%)	0.000*
5. I should go for a dental check-up only when I have pain	122 (48%)	237 (93.3%)	0.000*
6. Brushing before bed is more important than brushing in the morning.	120 (47.2%)	217 (85.4%)	0.000*
7. I can substitute brushing and flossing with a simple mouth wash or rinse	142 (55.9%)	232 (91.3%)	0.000*
8. Teeth are not so important as with new technology teeth are easily replaced	142 (55.9%)	231 (90.9%)	0.000*

$P \leq 0.05$. McNemar test. *correct response: the correct oral health response to the question posed*

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All the differences in correct responses before and after the intervention were statistically significant ($p < 0.05$). These findings indicate that digital oral health education was effective in increasing the oral health knowledge of the study participants.

3.2.1 Distribution of the participants' self-assessment of Knowledge

The data in Table 3 presents the distribution of oral health knowledge scores before and after the digital oral health education program. Before the intervention, 82 participants (32.3%) reported having poor oral health knowledge, while 172 participants (67.7%) reported having good oral health knowledge. After the intervention, only 13 participants (5.1%) in the poor oral health knowledge group remained, indicating a significant improvement in their knowledge level ($p<0.001$*). Among the good oral health knowledge group, 241 participants (94.9%) remained, indicating a high level of oral health knowledge.

Table 3: Distribution of oral health knowledge

	Before	After	P value
Poor	82 (32.3)	13 (5.1)	<0.001*
Good	172 (67.7)	241 (94.9)	

3.3 Participants' oral health awareness

The data in Table 4 shows the expected ideal response and the oral health knowledge of the participants before and after the training for various statements related to oral health. Before the training, a significant number of participants provided incorrect responses to all the statements except for statement 1 (Adults have a total of 32 teeth), where the majority provided the correct response. After the training, there was a significant increase in the number of participants providing correct responses and a decrease in the number providing incorrect responses for all the statements. The improvement in knowledge after the training is statistically significant for all statements ($p < 0.05$). This suggests that the oral health education program was effective in improving the oral health knowledge of the participants.

3.4 Self-Care and Self-Checking Behaviour

The oral health self-care and self-checking behaviour are given in Table 5. It was observed that all of the statements emphasised in Table 5 demonstrated a statistically significant difference, respectively pre- and post-training. For example, the participants' perception of maintaining their teeth, measured by questions (1-4), demonstrates significant improvement in brushing of teeth before going to bed.

Self-care behaviours evaluated by questions (10–13) demonstrated significant increases post-evaluation. In the areas of "Do you look at your mouth, teeth, and gums in the mirror when brushing your teeth" (96.5%), "Do you brush your gums and tongue, when brushing your teeth" (98.4%), "Do you clean your mouth before sleeping" (98.4%), and "Do you floss your teeth" (80.7%), there was a significant improvement in self-care practises.

The respondents' intentions to practise oral self-care evaluated by questions (14–15) reveals significant improvement in the areas of "I should floss my teeth at least once a day" (94.6%), and "I should brush my teeth and gums at least twice a day" (100%). The respondents' capacity to self-evaluate their oral health conditions, evaluated by questions 16 through 18, shows significant improvement in the respondents' self-checking skills after the training. For example, there were improvements in the respondents' ability to detect that their teeth had some brown, black, or white spots.

Table 4: Participants' oral health awareness pre- and post-training

Statements	Expected Ideal response	Oral health awareness (n=254)						P
		Pre-training			Post-training			
		Incorrect n(%)	Correct n(%)	I don't know n(%)	Incorrect n(%)	Correct n(%)	I Don't know n(%)	
1. Adults have a total of 32 teeth	True	9(3.5%)	178(70.1)	67(26.4%)	0	254 (100%)	0	0.001***
2. Swollen bleeding gums are normal	False	21 (8.3%)	180(70.9%)	53(20.9)	19 (7.5%)	235 (92.5%)	0	0.012***
3. Using toothpicks to dig out food from teeth is good for teeth and gums	False	61 (24%)	108(42.5%)	85(33.5%)	4 (1.6%)	250(98.4%)	0	0.004***
4. I must brush teeth very hard to remove food and plaque	False	16 (6.3%)	189(74.4%)	49(19.3%)	9(3.5%)	245 (96.5%)	0	0.001***
5. Brown and black spots on my teeth are ok	False	59 (23.2%)	130(51.2%)	65(25.6%)	0	245 (100%)	0	0.001***
6. White spots on my teeth are ok	False	12 (4.7%)	196(77.2%)	46(18.1%)	0	245 (100%)	0	0.001***
7. Bad breath is usually normal	False	44 (17.3%)	146(57.5%)	64(25.2%)	0	245 (100%)	0	0.001***
8. Pain in teeth from time to time is normal	False	45 (17.7%)	152(59.8%)	57(22.4%)	0	245 (100%)	0	0.001***
9. A small hole (cavity) in my tooth is ok as long as there is no pain	False	70 (27.6%)	143(56.3%)	41(16.1%)	0	245 (100%)		0.001***
10. I should visit a dentist only when I have dental pain or tooth infection	False	93 (36.6%)	146(57.5%)	15(5.9%)	5 (2%)	236 (92.9%)	13 (5.1%)	0.001***

*$P \leq 0.05$ Wilcoxon test.

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Table 5: Participants' oral health self-care and self-checking behaviour

Statement:	Self-care and self-checking behaviour (n=254)									
	Pre-intervention (%)					Post-intervention (%)					P value
	Yes	No	Some Times	Maybe	I don't know	Yes	No	Some times	Maybe	I don't know	
1. Do you brush teeth before sleeping	46.9	19.7	33.5			98.4	1.6	0	0	0	0.000
2. I am able to keep all my teeth for life	32.7	21.7	9.4	32.7	3.5	100	0	0	0	0	0.000
3. I will lose most of my teeth as I get older and may need false teeth	26.8	29.1	7.5	26	10.6	33.1	63.4	0	3.5	0	0.000
4. I will lose some of my teeth in my lifetime and its ok	22	35	5.9	29.5	7.5	31.9	64.2	0	3.9	0	0.000
5. Do you snack at night before sleeping?	35.8	42.5	17.7	3.9		31.1	61.8	7.1	0	0	0.012
6. Energy drinks and soft drinks damage teeth?	66.1	9.8	10.2	10.2	3.5	96.7	3.1	0	0	0	0.000
7. Sour sweets damage teeth	50	20.1	10.6	14.2	5.1	100	0	0	0	0	0.000
8. Do you eat sweets, chocolates, and snacks	70.5	3.9	22	3.5	0	78.7	6.7	13	1.6	0	0.002
9. Do you use any tobacco containing products cigarette, vape, weed	22.4	66.9	8.7	2		31.5	63	5.5	0	0	0.003
10. Do you Look at your mouth teeth and gums in the mirror when brushing teeth	51.6	25.2	23.2	0	0	96.5	0	3.5	0	0	0.000
11. Do you brush your gums and tongue, when brushing teeth	64.6	21.3	12.2	2	0	98.4	1.6	0	0	0	0.000
12. Do you clean your mouth before sleeping	46.9	24	27.2	2.0	0	98.4	1.6	0	0	0	0.000
13. Do you floss your teeth	21.3	54.7	18.5	2.0	3.5	80.7	12.2	7.1	0	0	0.000
14. I should floss my teeth at least once a day	40.2	10.2	20.5	21.7	7.5	94.9	5.1	0	0	0	0.000
15. I should brush teeth and gums at least twice a day	69.7	7.9	12.6	9.8	0	100	0	0	0	0	0.000
16. My teeth has some brown and black or white spots	35	48.4	5.1	9.4	2	63.4	34.6	2	0	0	0.000
17. Is it normal to have pain when eating or drinking cold or hot things	22.4	55.1	9.1	7.5	5.9	20.9	73.6	5.5	0	0	0.000
18. Food gets stuck in my teeth when eating	50.8	19.3	24	5.9	0	67.7	28.3	3.9	0	0	0.000
19. I am not happy with my teeth it could be better	64.2	16.9	9.1	5.9	3.9	96.1	0	3.9	0	0	0.000
20. I will benefit from more knowledge and information on how to keep my teeth in good health for life	78	5.1	5.1	9.8	2	100		0	0	0	0.000

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The intention of the respondents to alter their perspective on oral health, evaluated using questions 19 and 20, showed a marked increase in their intention post-intervention. It was found that the percentage of respondents who seemed dissatisfied with their teeth and thought they could be better rose from 64.2% to 96.1% post-evaluation. The percentage of those who agreed that they would benefit from more knowledge and information on how to maintain their teeth in good health for life rose from 78% to 100% post-intervention.

DISCUSSION

The utilisation of digital platforms for oral health education represents a promising strategy to enhance public awareness and promote positive oral health behaviours. This study provides strong evidence that digital platforms can be highly effective in promoting oral health knowledge, awareness, and self-care behaviours among college students in South Africa. The significant improvements observed in participants' oral health knowledge and behaviours following the Tooth Keepers digital intervention align well with existing research emphasising the promise of technology-based health education. Sharma, Mohanty[17] highlighted that digital oral health education improves knowledge, self-efficacy, and positive behavioural change, which this study corroborates through substantial post-intervention gains across all measured outcomes.

Before the intervention, a considerable proportion of participants demonstrated limited knowledge of key oral health practices such as the recommended frequency of brushing and flossing, the necessity of regular dental check-ups regardless of pain, and the importance of brushing before bedtime. Post-intervention, knowledge levels increased markedly, with correct responses reaching near or full saturation (e.g., 100% awareness of brushing twice daily, 98% understanding of daily flossing). This sharp knowledge gain supports Shirahmadi, Bashirian[18] and Bakhtiar, Hosseini,[25] who also documented the efficacy of digital education in improving students' oral health literacy. For example, in a study involving 70 teenagers, Bakhtiar, Hosseini[25] reported a significant increase in knowledge scores after using multimedia-based oral health education software, with average correct responses improving from 76.64% to 85.86%, which is even lower than our study. These findings reflect the capacity of interactive multimedia platforms like Tooth Keepers to provide accessible, engaging, and personalised education that addresses specific gaps in oral health understanding. The results reinforce the argument that digital technologies can effectively shape health behaviours and facilitate positive oral health outcomes, supporting the observations of Zolfaghari, Shirmohammadi[12] regarding the potential of digital tools in promoting healthy practices.

Behavioural outcomes further reinforce the tool's effectiveness. For instance, brushing teeth before bed – a critical habit often overlooked – rose dramatically from 46.9% to 98.4%. Similarly, self-care behaviours including flossing, brushing gums and tongue, and oral self-examination showed statistically significant improvements. Such shifts in behaviour likely stem from the program's emphasis on self-monitoring and risk awareness, which has been identified by Dahlke, Fair (26) as essential components of successful oral health promotion. In addition, the substantial behavioural shift may be attributed to the enhanced accessibility and engagement afforded by digital platforms, which allow flexible, user-friendly delivery of oral health education.[27] The digital format offers the added advantage of easy access and repeated engagement, overcoming barriers commonly encountered in traditional oral health education.[15] Importantly, the intervention also corrected widespread misconceptions, such as the acceptability of brown or black spots on teeth and bleeding gums during brushing, symptoms often ignored until advanced disease occurs. Awareness of these signs increased from approximately half of the participants recognising their significance pre-intervention to near-universal understanding post-intervention. Similarly, the improvement in understanding effective brushing techniques – from 74.4% to 96.5% – aligns. This aligns with findings from Asimakopoulou and Newton[28] and Blaggana, Grover[29], who emphasised the role of accurate health knowledge in fostering preventive behaviours and early care-seeking attitudes. The high post-intervention intention to adopt recommended oral health practices further supports the Behaviour Change Techniques (BCT) framework guiding this study.[21] By combining education with personalised feedback and goal setting, Tooth Keepers effectively encouraged participants to internalise and act upon oral health information, thus bridging the often-observed gap between knowledge and behaviour.

Despite these positive findings, it is crucial to recognise limitations. The quasi-experimental design and reliance on self-reported data may introduce bias, and the sample's restriction to Durban college students limits wider applicability. However, the results underscore the feasibility and potential of digital oral health interventions within the South African context – a setting marked by significant disparities in healthcare access and knowledge. Future research should expand on this foundation with randomised controlled trials across diverse populations and regions, incorporate culturally adapted content, and explore the long-term sustainability of behavioural changes. Additionally, evaluating the cost-effectiveness and scalability of such interventions will be vital for informing public health policy and integrating digital education into comprehensive oral health strategies.

Overall, this study provides robust evidence that digital oral health education, exemplified by the Tooth Keepers platform, can substantially improve oral health knowledge and self-care behaviours among young adults. Given the burden of oral diseases globally and in South Africa specifically, harnessing digital innovations offers a promising avenue to advance prevention, promote health equity, and reduce oral health disparities.

CONCLUSION

The findings of the study indicate that the digital self-assessment tool has proven effective in improving individuals' awareness of oral health and oral diseases. Therefore, it is imperative to affirm that the utilisation of digital technologies is expected to enhance the extent of oral health knowledge, awareness, and preventative self-care activities among university students. The findings hold significant implications for the design and implementation of oral health education initiatives targeted at students in higher education institutions. These programs aim to enhance accessibility and efficacy, ultimately fostering oral health equity within the context of South Africa.

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Evaluation of factors associated with gingival enlargement during fixed orthodontic treatment

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I Pitso,[1] M Moshaoa,[2] TK Madiba,[3] A Masenge,[4] S Manenzhe[5]

ABSTRACT

Introduction

Gingival enlargement (GE) is a common finding among patients undergoing fixed orthodontic treatment.

Objective

To evaluate the prevalence and clinical severity of gingival enlargement (GE) in patients undergoing fixed orthodontic treatment (OT) at the University of Pretoria Oral Health Center (UPOHC). The study also aims to determine the Plaque Index (PI) among these patients and explore the association of gingival enlargement with various factors, such as the different phases of orthodontic treatment, treatment duration, type of archwire used, age, and gender.

Methods

A cross-sectional study was conducted with patients undergoing fixed OT. Gingival enlargement was assessed using the gingival index proposed by Bokenkamp and Bonhorst (1994), and the plaque index (PI) was measured using O'Leary's method and an examination of clinical features. Variables such as treatment duration, orthodontic stage, type of archwire, and the use of molar bands were evaluated for their potential associations with GE.

Results:

Gingival enlargement was found in 94% of participants, with higher prevalence and severity in cases with prolonged treatment and increased PI. However, there was no significant association between GE and variables such as gender, orthodontic stage, or molar bands ($p>0.05$). A significant link was found between generalised PI and GE severity ($p=0.0001$).

Conclusion

Plaque accumulation emerged as an important factor in GE development during OT, emphasising the importance of optimal oral hygiene practices. Educating patients and implementing preventive strategies may mitigate GE risk and improve OT outcomes.

Clinical relevance

The findings of this study can aid in facilitating the development of treatment protocols aimed at preventing and reducing the occurrence of GE during fixed OT.

Keywords

Gingival enlargement, fixed orthodontic treatment, plaque index, oral hygiene, orthodontic appliances

Authors and affiliations:

1. Dr Itumeleng Pitso, Department of Periodontics and Oral Medicine, School of Dentistry, University of Pretoria, Pretoria, South Africa, E-mail: itumeleng.pitso@up.ac.za. ORCID: https://orcid.org/0009-0006-1748-6010
2. Dr Mpule Moshaoa, Department of Orthodontics, School of Dentistry, University of Pretoria, Pretoria, South Africa, E-mail: mpule.moshaoa@up.ac.za. ORCID: https://orcid.org/0000-0003-0306-3739
3. Prof Thomas K Madiba, Department of Community Dentistry, University of Pretoria, Pretoria E-mail: thommy.madiba@up.ac.za or t hommy.madiba@gmail.com. ORCID: https://orcid.org/0000-0002-0171-0595
4. Mr Andries Masenge,Department of Statistics, University of Pretoria, Pretoria, South Africa. E-mail: andries.masenge@up.ac.za. ORCID: https://orcid.org/0000-0001-8372-2356
5. Dr Shumane Manenzhe, Department of Periodontics and Oral Medicine, School of Dentistry, University of Pretoria, Pretoria, South Africa, E-mail: shumane.manenzhe@up.ac.za. ORCID: https://orcid.org/0009-0002-6633-4957

Corresponding author:
Name: Prof TK Madiba
Address: Oral and Dental Hospital, C/o Steve Biko and Dr. Savage Road, Pretoria, 0001
Tel: +2712 319 2417
Cell: +0845036175
Email: thommy.madiba@up.ac.za or thommy.madiba@gmail.com

INTRODUCTION

Gingival enlargement (GE) is a common finding among patients undergoing fixed OT. The occurrence of GE during fixed OT has been attributed to several factors. Gingival enlargement is an abnormal overgrowth of gingival tissues associated with factors like plaque accumulation, orthodontic appliances, allergic reactions, and hormonal changes related to age and gender.[1] Gingival enlargement is often erroneously used interchangeably with gingival hyperplasia, hypertrophy, and fibrosis.[1] The term GE is preferred because hyperplasia, hypertrophy, and fibrosis are changes observed microscopically in GE but cannot be accurately differentiated clinically. In the initial stages, Gingival enlargement is localized to the interdental papilla and extends to involve marginal and attached gingiva. Eventually, the gingiva may cover part or the whole crown of a tooth.[2] GE may cause functional and aesthetic challenges in those affected, which is often the reason why people seek treatment.

The American Academy of Periodontology (AAP) and the European Federation of Periodontology (EFP) have developed a classification for periodontal disease and conditions.[3] According to the AAP and EFP classification of 2018, GE can be classified under two broad categories: dental plaque biofilm-induced and non-dental plaque biofilm-induced gingival diseases.[3] In the AAP/EFP the classification of GE is based on the causative and/or predisposing factors.[3-5] Gingival enlargement is further categorised based on the extent of involvement into localised (to specific teeth) affecting less than 30% of teeth and generalised affecting more than 30% of the teeth present in the mouth.[3]

The severity of GE can be determined using an index, of which there are various proposed indices[2,6,7] used to

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assess the severity of GE. The gingival index is important for determining the severity of GE. The use of reliable and reproducible indices for the evaluation of GE is invaluable,[1] as they inform treatment. An index for evaluating GE was first described by Kimball in 1939 [8] and later by Harris and Ewalt in 1942.[9] In 1972, Angelopoulos and Goaz described a gingival index that measured only the vertical component of GE. Miller et al. then described an index in 1992 that assessed GE in the vertical and horisontal components.[10] A variety of other indices have been used to measure and determine the severity of GE, like the photographic GE scoring by Ellis et al.[11] The gingival index proposed by Bokenkamp and Bonhorst, 1994 as shown in Table 1,[12] which grades enlargement based on the extent of GE in relation to the tooth surface, is widely used. It has the following advantages: it is non-invasive as it is based on visual inspection of the gingival tissues, it can measure GE in the horizontal and vertical components, it does not require many measurements, and is clinically relevant. This index was developed for clinical application and is easy to apply in everyday clinical practice and research settings as it is reproducible.[12]

Table 1: Gingival index proposed by Bokenkamp and Bonhorst 1994 [12]

Grade	Clinical finding
Grade 0	No GE
Grade I	GE confined to interdental papilla
Grade II	Enlargement of the interdental papilla and marginal gingiva
Grade III	GE covering at least three-quarters of tooth crowns.

Abbreviations: GE: Gingival Enlargement

The clinical manifestations of GE vary, presenting as red, pink, soft, and shiny gingiva that bleeds easily in inflammatory gingival enlargement; and darker red or purple or pale fibrotic gingiva in non-inflammatory GE.[13,14] Inflammatory and non-inflammatory GE can be acute or chronic depending on the causative and predisposing factors. Factors associated with acute forms of GE include: mechanical, chemical, or physical irritation; associated with specific viral, fungal and other bacterial micro-organisms not commonly associated with periodontal disease and mouth breathing.[1]

Chronic GE is mainly associated with the accumulation of dental plaque-biofilm linked to insufficient oral hygiene practices, dental appliances, including orthodontic appliances or prostheses, and mouth breathing.[1, 15] Other factors associated with chronic GE include systemic factors encompassing the use of certain systemic drugs, inflammatory and immune conditions, neoplasms, endocranial and nutritional diseases. The drugs associated with GE include; calcium channel blockers (e.g. Nifedipine, Verapamil, Diltiazen, Amlodipine, Felodipine), immunosuppressants (e.g. Cyclosporine), anticonvulsants (e.g. Phenytoin and Sodium Valproate) and high-dose oral contraceptives.[16,4] Increased hormonal levels during pregnancy have been shown to lead to more pronounced gingivitis and possible marginal enlargement, depending on the level of plaque control prior to pregnancy.[17,18] All factors mentioned promote plaque-induced GE. Thus, plaque-induced GE is the most common form of GE seen clinically, due to the interplay between plaque and several local and systemic factors that modify the plaque-associated disease process.[1]

Clinical studies suggest that orthodontic treatment (OT) may be associated with a decrease in periodontal health or changes involving periodontal tissues which manifest as GE.[6-11] Gingival enlargement is a common finding during OT and is characterised by the formation of true periodontal pockets with clinical attachment loss or pseudo pockets without clinical attachment loss.[19] Most of the causative factors of GE during OT are associated with local irritants such as dental plaque biofilm and calculus.[20, 21] The associated GE seen during OT is considered an inflammatory reaction due to difficulty in performing adequate mechanical plaque control measures, thus inflammatory GE is a more common clinical feature with OT.[22]

Orthodontic appliance predisposes to increased biofilm establishment and subsequent GE amongst patients undergoing orthodontic treatment which can be linked to insufficient oral hygiene measures.[10,11] The duration of fixed OT has been shown to influence GE especially when the treatment time extends to more than 24 months.[23] This has been mainly attributed to reduced patients' motivation towards brushing their teeth and maintaining good oral hygiene with lengthy treatment.[24, 25]

The orthodontic appliances that have been shown to inhibit the efficient removal of the dental plaque biofilm include molar bands, brackets, wires, and other orthodontic attachments due to many mechanical retention sites.[20, 22, 26, 27] Plaque accumulation associated with orthodontic appliances could result in moderate gingivitis and varying degrees of GE.[28] In their study, Almansob and co-workers found the occurrence of GE to be greater in banded molars when compared with bonded molars.[23] The GE associated with fixed OT can be alleviated by thorough oral hygiene instructions and practices before and during OT including professional supportive therapy. Patients should also be kept motivated to maintain good oral hygiene and be educated about the negative effects of increased plaque accumulation.

Other factors reported to have a strong influence on the development of GE during OT include age and gender, with males and younger patients reported to present with increased GE compared to females and older patients.[23] The development of GE amongst males and younger patients was associated with poor plaque control measures.[23,25, 27, 29]

A study by Kasmaei et al.[30] also showed that young patients commonly had challenges maintaining good oral hygiene even with regular oral hygiene instructions before and during fixed OT.[30] Although an association between plaque accumulation and GE has been shown amongst patients undergoing orthodontic treatment,[23, 24, 31] some studies have found varying results.[15, 26, 27] A study by Zachrisson and Zachrisson did not find a direct correlation between plaque accumulation and GE, suggesting other factors at play during fixed OT.[15] In their study, Zachrisson and Zachrisson found that, despite good cleaning and low plaque index, most patients developed generalised moderate GE within one to two months of fixed orthodontic treatment.[15]

Other studies have shown that GE developed within 1-2 months following placement of fixed orthodontic appliances, even when proper oral hygiene measures were maintained.[21, 24, 25, 29] This led to a shift in focus on plaque being the sole risk factor for GE to incorporate other factors, including chemical irritation produced by materials used in orthodontic appliances. During fixed OT, different types of archwires

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are used depending on the different phases of treatment.[32] Titanium Molybdenum Alloy (TMA) archwires have been shown to be most effective and widely used during the finishing stages of fixed OT.[33] Nickel, a common alloy in orthodontic appliances, is one of the most commonly implicated material in GE amongst patients undergoing fixed OT.[19] It is also a component in stainless steel which is incorporated in brackets and arch wires.[34] Nickel is used in the Nickel-Titanium (Ni-Ti) archwires, which are used for fixed OT during the initial leveling and aligning phase. Another study however, found Nickel to influence GE throughout OT, with resultant GE characterized by changes in color, and gingival bleeding upon probing.[35] Hence, it has been postulated that Nickel can influence inflammatory reactions leading to GE throughout orthodontic treatment not just in the initial phase of treatment.[35, 36] The following mechanisms have been considered: the direct interactions between the nickel ions and the gingival tissues resulting in the proliferation of the fibroblasts, leading to GE.[36] In addition, Nickel is a strong biological sensitizer associated with two key hypersensitivity reactions that have been described in the literature.[37] Type I hypersensitivity reaction which occurs within minutes or hours after direct skin or mucosal contact with Nickel and type IV hypersensitivity reaction which is a delayed-type reaction occurring within hours or days after Nickel exposure.[37] The form of GE associated with these reaction does not respond to mechanical dental plaque biofilm removal.[19, 36]

Orthodontic treatment-induced GE shows a specific fibrous and thickened gingival appearance different from fragile gingiva with marginal gingival redness seen in inflammatory gingival lesions not associated with OT.[38] There are no clear defined mechanisms involved in OT associated GE initiation and histopathology.[38, 39] Hence the exact factors leading to GE during orthodontic treatment are not fully understood. This study sought to evaluate the factors associated with GE in patients undergoing fixed OT and also to determine the prevalence of GE in these patients. The results from the study will be valuable in identifying patients at risk for developing GE during fixed OT, enabling better prevention and treatment strategies.

MATERIALS AND METHODS

Study design

This was a cross-sectional descriptive study involving patients undergoing fixed OT from 1 October 2023 to 5 July 2024 at the University of Pretoria Oral Health Centre in the Orthodontic and Periodontic clinics.

Inclusion and Exclusion criteria

Patients undergoing fixed OT at UPOHC, Department of Orthodontics, during the study period were included in the study. The following were excluded from the study: pregnant women and patients taking medications known to cause GE, including calcium channel blockers (e.g., nifedipine, verapamil, diltiazem, amlodipine, felodipine), immunosuppressants (e.g., cyclosporine), anticonvulsants (e.g., phenytoin, sodium valproate), and high-dose oral contraceptives.

Study population and sample size calculation

In the Department of Orthodontics, each registrar is allocated 80 patients for their study program. Based on the combined patient allocation to the three registrars, the initial target sample size was determined to be 240 patients. To account for potential sample loss, the study assumed a 30% loss due to factors such as exclusion criteria, non-attendance, missed appointments, and non-consent to participate in the study.

With an assumed 30% loss, the sample size required to achieve the study's objectives was estimated to be 168 patients.

Data collection

The following data was collected from participants: age, gender, medical history, including medications, type of orthodontic appliances, orthodontic treatment stage, duration, and plaque index were collected as shown in the data collection form Figure 1. In addition, GE was scored and recorded according to an index proposed by Bokenkamp and Bonhorst.[12] The extent and distribution of GE were recorded as localised if less than 30% of teeth were involved and as generalised if more than 30% of teeth were involved.[3]

Patient unique no:				
Age in years:				
Gender:				
Medical conditions				
Medications				
Variables				
Orthodontic treatment stage	Alignment and Levelling	Space closure	Finishing stage	
Treatment duration:	1-4 months [TI]	4-6 months [T2]	7-12 months [T3]	>12 months [T4]
Type of arch wires	Nickel-Titanium (NiTi)	Copper Nickel Titanium Alloy (Copper NiTi)	Stainless Steel (SS)	Titanium Molybdenum alloy (TMA)
Molar bands	Yes		No	
Gingival Characteristics:	Normal	Erythematous	Spongy	Firm
Extent of GE:	Localized: (<30% of sites)		Generalized (>30% of sites)	
Plaque index%:	Localized: (<30% of sites)		Generalized (>30% of sites)	
GE score	GO	GI	Gli	Glii

Figure 1: Data collection sheet

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The gingival characteristics were recorded as either normal, spongy, or erythematous. The presence of dental plaque was assessed using a 2-Tone® disclosing solution and reported using O'Leary's plaque index,[40] see Figure 1 above.

Intra-rater and inter-rater reliability:

A single calibrated examiner, Dr Pitso (IR), performed all clinical examinations. Before the examination of the gingiva, calibration was done with Dr Manenzhe (SC). Intra-rater and inter-rater reliability was assessed by repeating measurements of 10% of the patients selected. Intra-rater and inter-rater reliability were analysed using the Intraclass correlation coefficient (ICC).[41]

Interpretation of the strength of agreement of ICC values was adopted (<0.5 = poor reliability; 0.5-0,75= moderate reliability; 0,75-0,9 = good reliability; >0.9 = excellent reliability).

Inter-rater reliability:
ICC= 0,828, which indicated good reliability and implied consistency in the measurements.

Intra-rater reliability:
ICC value of 0,931 which was an excellent reliability value.

Data Analysis

All data collected was transferred onto a Microsoft Excel spreadsheet. Data analysis was done with SPSS Version 29. Quantitative variables were summarised as proportions frequencies, mean with their standard deviations, range, and percentage. The chi-square and Fisher's exact test were used to evaluate the association between gingival characteristics, the extent of GE, GE score and orthodontic treatment stage, treatment duration, and plaque index. The level of significance was set at $p \leq 0.05$.

RESULTS

Study population and prevalence

Out of the estimated representative sample of 168, there was a 59,5% (n=100) response rate. The age groups ranged from 10 to 43 years old, with a mean age of 21.43. Out of the participants, 65(65%) were females and 35 (35%) males. Gingival enlargement was present in 94 (94%) participants, with a mean of 34.7, and 6 (6%) had no GE. Out of the 94% of participants with GE, 32% was found in males and 62% in females.

There were 52 (52%) adolescents and 48 (48%) adults who participated in the study. Out of the 52% of adolescents, 51% presented with GE, whilst 43% out of 48% of adults had GE.,

Clinical severity and extent of GE:

The total number of teeth that presented with GE of varying severity during OT were 825. Figure 2 shows the GE severity scored using the Bokenkamp and Bonhorst index during fixed OT in percentages. The distribution of the different GE grades for the affected teeth was as follows: GI in 453 teeth (55%), GII in 279 (34%), and GIII in 93 teeth (11%).

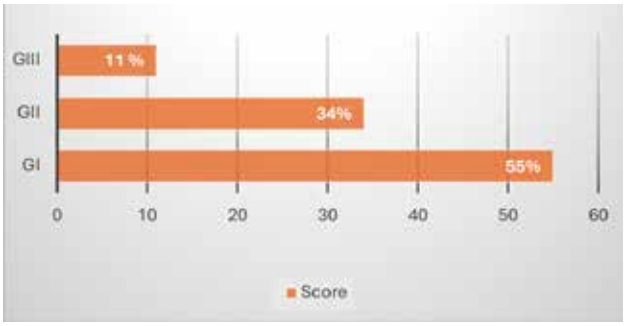

Figure 2: Severity of gingival enlargement in different sites

Figure 2: Severity of gingival enlargement in different sites
The distribution of the different GE grades for the affected teeth among females and males were as follows: females presented with GI at 40% (331 teeth), GII at 20% (164 teeth), and GIII at 8% (69); and males presented with GI at 15% (122 teeth), GII at 14% (115 teeth), and GIII at 3% (24 teeth), as shown in Figure 3.

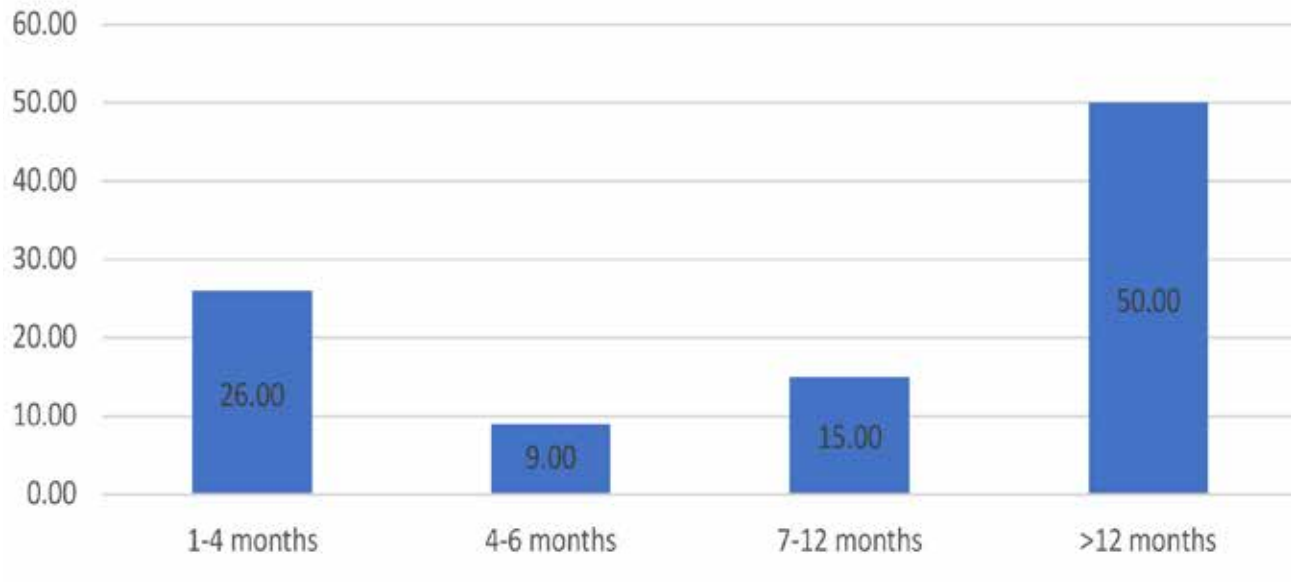

Figure 4: Plaque distribution and treatment duration

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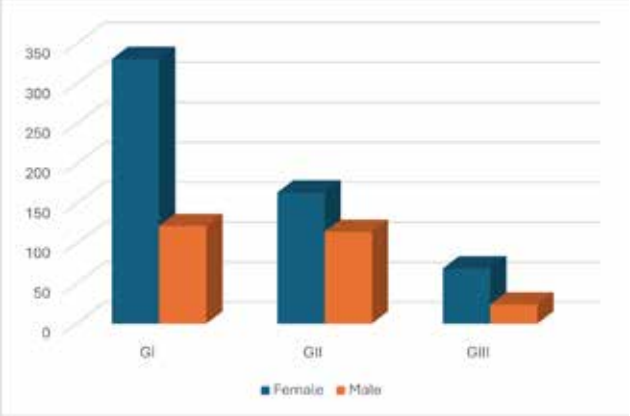

Figure 3: Gender gingival enlargement severity scores
Abbreviations: GI- Grade I gingival enlargement; GII- Grade II gingival enlargement; GIII- Grade III gingival enlargement

The distribution of localised gingival enlargement versus generalised gingival enlargement among the participants revealed a slight predominance of localised gingival enlargement (51%) over generalised GE (49%). It was also observed that participants who have been in treatment for 12 months or more (T4) presented with more generalised GE (57,14 %).

Plaque index

The study found a mean PI percentage of 45.5% . Patients with generalised plaque (83.67%), also exhibited generalised GE as detailed in Table 2. Additionally, adolescents in the study also had a significantly higher generalised plaque distribution (78,8%) compared to their adult counterparts. The participants in the finishing stage and those on treatment for more than 12 months also presented with an increased PI at 53% and 50%, respectively as shown on Figure 4.

The Pearson chi-squared test was conducted at a level of 5% significance to determine the association between the extent of GE and PI. A significant relationship was found between PI and GE (p=0.0001) as shown in Table 2.

Table 2: Association between plaque and gingival enlargement (n=100)

PI	EGE			p- value
	Localized <30% of sites	Generalized >=30% of sites	Total	
Localized <30% of sites	27 52.94	8 16.33	35	p=0.0001
Generalized >=30% of sites	24 47.06	41 83.67	65	
Total	51	49	100	

Orthodontic stage:

Out of all the fixed OT treatment stages, the majority of participants (53%) were in their finishing stage, 31% in the alignment and levelling stage (31%), and 16% in the space closure stage, as displayed in Table 3. The severity of GE varied across the different treatment stages, as illustrated in Figure 5. All levels of severity were most prevalent in the finishing stage, with 53% of sites presenting with GI, 65% with GII, and 74% with GIII.

The results, however, showed no statistically significant association between the extent of GE and the different orthodontic stages (p>0.05).

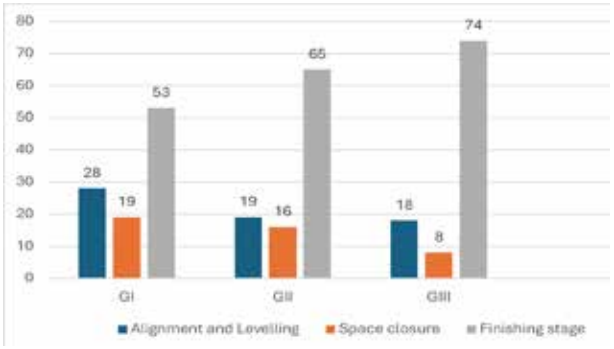

Figure 5: Gingival score severities in the different orthodontic treatment stages

Treatment duration:

Half (50%) of the participants were at T4 (12 months or more) of fixed OT, with 26% at T1 (1- 4 months), 15% at T3 (7-12 months), and 9% of participants at T2 (4-6 months) treatment duration. The patients who had fixed orthodontic treatment for 12 months or more presented with more generalised GE as illustrated in Figure 6. There was no statistically significant association between the extent of GE and the treatment duration (p>0.05).

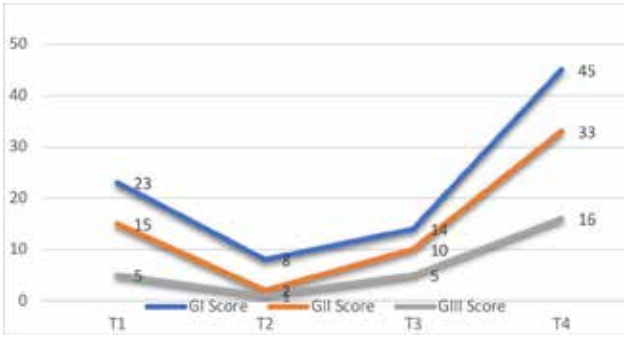

Figure 6: Gingival enlargement scores during the treatment times
Abbreviations: T1- 1-4 Months; T2- 4-6 Months; T3- 7-12 Months; T4- >12 Months

Type of archwire:

In terms of the type of archwire material utilised by the participants, it was found that 43% had stainless steel (SS), 30% had NiTi, 21% had TMA, and 6% had Copper NiTi as shown in Table 3 of the summary of frequencies. Among these, those with TMA archwires had the highest mean plaque index (51.93) followed by those who had SS with a mean of (47.86), and mean PI of 39.48 and 38.95 for Copper NiTi and NiTi respectively, as depicted in Figure 7. There was no statistically significant association between the extent of GE and the different types of archwires (p>0.05).

Table 3: Variables of the study population (n=100)

Variables		n	%
Orthodontic stage	Alignment	31	31
	Space Closure	16	16
	Finishing	53	53

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Treatment duration	T1	26	26
	T2	9	9
	T3	15	15
	T4	50	50
Type of arch wire	NiTi	30	30
	Copper NiTi	6	6
	SS	43	43
	TMA	21	21
Molar bands	Yes	16	16
	No	84	84
Gingival characteristics	Normal	55	55
	Erythematous	15	15
	Spongy	30	30

Abbreviations: T1: 1-4 Months; T2: 4-6 Months; T3:7-12 Months; T4: >12 Months. NiTi- Nickel Titanium; SS- Stainless steel; TMA- Titanium Molybdenum alloy

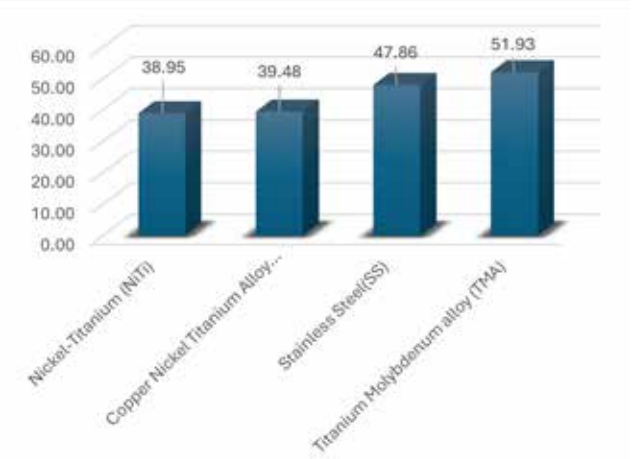

Figure 7 : Mean plaque index values in participants with different archwires

Molar bands:

Participants who had molar bands were 16%, whilst 84% had no molar bands. Within the group of participants with molar bands, a total of 25 teeth were fitted with the molar bands, and only 6% of the sites had GE.

Gingival characteristics:

Majority (55%) of the participants had normal to firm gingival characteristics, while 30% had spongy, and 15 % erythematous gingiva.

DISCUSSION AND CONCLUSION

Discussion

Orthodontic treatment offers patients a functional bite, improved oral health, and a more attractive smile.[42] However, the placement of fixed orthodontic appliances frequently leads to some periodontal side effects, such as gingival enlargement (GE), which may conflict with health and aesthetic treatment goals.[31] Gingival enlargement in OT is mostly due to challenges in maintaining effective oral hygiene around the brackets, wires, and bands, which provide retention areas for plaque accumulation.[43]

This study explored the prevalence and factors associated with GE in patients undergoing fixed OT. The study found a high prevalence of GE in the studied population, with a significant association between GE and plaque index. This finding agrees with other previous studies that have linked GE with poor oral hygiene habits and increased plaque accumulation during fixed OT[23,24,31] and are in contrast with those of achrisson and Zachrisson, who did not find a direct correlation between plaque accumulation and GE, [15] suggesting other factors at play other than just plaque. However, in the current study, no statistically significant association between GE and factors studied (age, gender, type of orthodontic appliances, orthodontic treatment stage, and duration) other than plaque were observed.

There was no statistically significant association observed between GE and demographical factors like gender and age. As was the case in other studies where the association between GE, younger and male patients was found to be statistically significant and attributed to insufficient oral hygiene habits.[23, 25, 27, 29] Data on the distribution of GE severity grades among females and males however, showed females to have a higher prevalence of GE across all GE severity categories when compared to males as indicated in Figure 3. In addition, adolescents were also found to have a higher prevalence of GE (51%). These results suggest that adolescents are more likely to experience GE during OT in comparison to adults. This corroborates findings from studies that found younger patients to have increased GE during OT. [23, 25]

Treatment duration was also found to influence the presence, extent, and severity of GE, with increased GE severity and more generalised GE found in participants who had been on treatment for more than 12 months. This corroborates the results from other studies where it was shown that when patients are on fixed OT for long, the motivation to maintain optimal oral hygiene diminishes, increasing the risk for more plaque accumulation and, consequently, GE.[23-25, 43] Treatment fatigue has been cited as an important factor contributing to poor oral hygiene habits and increased plaque accumulation.[43] Therefore, it is unsurprising that this study found those patients who were on treatment for longer also presented with more severe and generalised GE. It is, therefore, important that patients understand what the treatment entails, the importance of oral hygiene and the duration of treatment to ensure that when the treatment commences, patients are committed and prepared for the long haul.

Interestingly, participants with TMA archwire presented with higher mean PI (59.3) and GE. This finding was attributed to the fact that TMA was mostly used in the finishing stages of treatment, where motivation for maintaining good oral hygiene may have decreased. The effects of TMA on GE may require further exploration to determine if there are direct effects other than plaque and treatment duration contributing to GE in patients with these archwires. Within our study population, 30% of participants had Nickel Titanium (Ni-Ti) and 6% had Copper Ni-Ti archwires a number higher than participants with TMA 21%. This is significant considering that Nickel has been associated with GE during OT as reported in the literature.[35, 44] In this study no such associations were found between archwires containing Nickel and GE nor were they found to increase plaque accumulation when compared to TMA and SS. On the contrary, the archwires containing Nickel were associated with lower mean PI. Furthermore,

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none of the patients with Nickel-containing archwires showed clinical signs of hypersensitivity, such as erythema, erosive or ulcerative lesions, gingival hyperplasia, pain, itching, or burning sensations as reported in the literature.[44, 45] These symptoms have been documented as potential clinical manifestations of nickel allergy in orthodontic patients. Previous studies have indicated that OT does not directly increase the risk of nickel hypersensitivity unless the patient has a history of nickel allergy.[46, 47] Hence, it is recommended that clinicians recognise and diagnose potential allergic reactions promptly to facilitate early intervention and minimise patient discomfort.[48]

Another factor reported to significantly influence the presence of GE during fixed OT is the placement of molar bands.[22, 26, 27] Our findings on plaque retention of molar bands contradict those of other studies. This discrepancy may be primarily due to the fact that only 16% of participants had molar bands. Given the small sample size and limited number of teeth with molar bands, our results should be interpreted with caution and warrant further investigation in future studies.

The GE severity at the tooth level for all 100 participants indicated that the majority of teeth with GE fell under GI, with fewer cases presenting with the more severe GII and GIII. When it came to the extent most participants presented with localised GE. This could explain the majority (55%) of participants presenting with normal to firm gingiva, with the inflammatory reaction limited to the interdental papillae, as seen in GI. Such localised inflammation is expected, given the challenges of effective flossing in patients undergoing fixed orthodontic treatment. Hence, plaque accumulation in this study, remained a significant contributing factor leading to GE during fixed OT. Previous studies have also noted that orthodontic appliances prevent optimal plaque removal, leading to gingival inflammation and GE development during treatment.[14, 22, 23]

This finding emphasises the importance of oral hygiene education and regular professional cleaning to mitigate the adverse effects of plaque accumulation associated with orthodontic appliances. Highlighting the importance of maintaining effective oral hygiene before, during, and after fixed OT. It is therefore important to educate patients on what plaque is and its potential impact on gingival health during OT.

Conclusion

Plaque accumulation emerged as the main contributor to GE in this study, highlighting the necessity of optimal oral hygiene maintenance before and throughout fixed OT. Educating patients on the implications of plaque and providing them with practical plaque control techniques, including antimicrobial mouth rinses, interdental brushes, and powered toothbrushes, which have been shown to improve plaque control in orthodontic patients is critical to reducing GE risks associated with orthodontic treatment. Additionally, frequent follow-up and reinforcement of oral hygiene practices can help address the inflammation and prevent GE in patients undergoing fixed OT.

Although the correlation between GE, gender, and age was not found to be statistically significant, the clinical significance cannot be overlooked. As these observations have implications for treatment approaches and prevention strategies for females and adolescents who are considered for orthodontic treatment. The planned supportive oral hygiene care should be tailor-made to aid their oral hygiene practices and should incorporate the use of visual aids to demonstrate the impact of plaque on gingival health. Such intervention before and during OT could aid and assist with patient compliance as treatment duration was also found to influence the presence, extent, and severity of GE. Adolescents and male patients reported to be less compliant with oral hygiene should receive additional education and monitoring to help them maintain good oral hygiene to prevent GE during OT. Female patients on OT with GE require further exploration, and given the high prevalence and increased severity, they should also be given attention. Furthermore, the timing of OT for females and adolescents may be an important determinant of GE initiation and progression, given the impact of hormonal changes on the gingiva in the different life stages.

Study limitations

This study was limited by the cross-sectional study design and causality cannot be inferred. The study was also limited by the small sample, due to issues pertaining to patient availability. The total number of patients assessed for the study was 100 instead of 168. Notwithstanding the limitations, the study has contributed to the literature concerning this important topic.

Recommendations

Given the strong association between plaque accumulation and GE, comprehensive oral hygiene instructions for patients undergoing fixed OT are essential. This should include techniques for thorough cleaning around brackets, wires, and bands, which are common plaque-retention areas. Regular dental cleanings should be scheduled throughout OT to manage plaque levels effectively and prevent GE. Additional cleanings and referral to Periodontics should be considered for patients with extended treatment duration.

Establish a protocol for assessing GE risk before the initiation of OT, factoring in patients' age and gender, medical history, and oral hygiene habits. This protocol could help in providing individualised preventive care and in identifying patients who may need intensified follow-up during OT.

Future studies should prioritse the development and implementation of standardised protocols for capturing pre-treatment photographs to enhance the accuracy and consistency of baseline imaging. Further research should explore salivary biomarkers, inflammatory cytokines, potential periodontal pathogens, and genetic predispositions, and their associations with gingival enlargement during fixed orthodontic treatment.

Author contribution

All the authors contributed to the study conception and design (Dr Itumeleng Pitso (IR), Dr Mpule Moshaoa (MM), Andries Masenge (AM), Dr Shumane Manenze (SM) and Prof Thomas K. Madiba (TK). Material preparation and data collection was performed by IR. TK analysed the data. Writing of the original draft manuscript, reviewing and editing of the final manuscript was done by all authors (IR, MM, AM, SM and TK). All the authors read and approved the final manuscript (IR, MM, AM, SM and TK).

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Declarations

Ethical approval for the study was granted by the University of Pretoria, Faculty of Health Sciences Research Ethics Committee-Ethics Reference number: 510/2023.

This study was performed in line with the principles of the Declaration of Helsinki.

Consent to participate

Informed consent was obtained from all individual participants included in the study. Written informed consent was obtained from the parents.

Consent for publication

The authors affirm that the participants provided informed consent for publication.

Competing interest

The authors declare there are no competing interests.

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Oral Health and Sustainable Development Goals: Opportunities for interdisciplinary research at a dental school in South Africa

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RZ Adam,[1] R Maart,[2] S Ahmed,[3] TA Vedan[4], R Ahmed[5]

ABSTRACT

Introduction

Oral health continues to be a neglected public health challenge, and is often perceived as a privilege rather than a fundamental right for most of the population. Sustainable Development Goals (SDG) create a foundation for a sustainable future for all, encompassing various fields, including the role of oral health in the human population. Dental research and education are crucial in undertaking challenges associated with promoting a sustainable future for the South African population. This effort requires support by interdisciplinary collaboration with relevant stakeholders across disciplines. Higher education institutions, such as the Faculty of Dentistry at the University of the Western Cape play a pivotal role in advancing SDG research by fostering innovation, cultivating interdisciplinary collaboration, and equipping future professionals with the knowledge and skills necessary to address complex sustainability challenges, ultimately contributing to improved oral health outcomes and overall well-being for the South African population.

Aim and Objective

The aim of the project was to identify opportunities for interdisciplinary research at a dental school to further sustainable development goals.

Design

A quantitative approach was used. A retrospective records-based study was conducted.

Methods

All DHET approved publications from the Faculty of Dentistry, UWC for the period 2013-2023 were analysed. The quantitative data generated through the SDG mapper were tabulated and visualized using simple bar charts and graphs. These visual tools facilitated a comparison between the research output's alignment with the SDG framework and South Africa's Decadal Plan, providing insights into both global and national contributions to sustainable development. Key performance indicators (KPIs) were also developed to measure the extent of the research's alignment with the SDGs.

Results

The analysis reveals that research conducted at the Faculty of Dentistry, UWC contributes to the following SDGs: SDG 3 (Good health and Well-being), SDG 4 (Quality Education), SDG 9 (Industry, Innovation and Infrastructure), SDG, 16 (Peace, justice and strong institutions).

Conclusions

Although the research was linked to a range of SDG goals, the research was conducted by Dentistry staff and so, it suggests that there is opportunity to develop multidisciplinary research. Mechanisms which allow for collaboration across disciplines should be explored.

Keywords

Sustainable Development Goals (SDGs), Oral Health, Interdisciplinary Research, Dental Education, Innovation in Dentistry.

INTRODUCTION

It is estimated that 3.5 billion people suffer from oral diseases globally. These oral diseases including dental caries, periodontal disorders, edentulism, and cancer of the lips and oral cavity cause the greatest burden of oral diseases.[1] In 2021, the approval of the World Health Organisation (WHO) resolution on oral health signified the global recognition of the importance of the role of oral health as a noncommunicable disease and the shift from a traditional curative approach to a more preventive approach. Oral diseases have been shown 'to disproportionately affect the poor, vulnerable, and/or marginalised' communities. The subsequent Global strategy and action plan on oral health 2023-2030 detail the principles necessary for the integration of oral health into noncommunicable diseases and universal health care packages.[2]

Oral diseases are affected by the social determinants of health including access to safe water, hygiene, and sanitation. Similarly, strategies employed by industries such as sugar and tobacco products may affect the choices made by consumers which may affect their health.[2]

Authors' Information

1. Razia Z Adam, Faculty of Dentistry, University of the Western Cape, Cape Town, South Africa rzadam@uwc.ac.za ORCID identifier: 0000-0002-2645-9878.
2. Ronel Maart, Faculty of Dentistry, University of the Western Cape, Cape Town, South Africa. rmaart@uwc.ac.za ORCID identifier: 0000-0002-1560-040X
3. Suwayda Ahmed, Faculty of Dentistry, University of the Western Cape, Cape Town, South Africa. suahmed@uwc.ac.za ORCID identifier: 0000-0001-8174-6928
4. Theesan A Vedan, Faculty of Dentistry, University of the Western Cape, Cape Town, South Africa. tvedan@uwc.ac.za ORCID identifier: 0000-0002-8182-6407
5. Rukshana Ahmed, Faculty of Dentistry, University of the Western Cape, Cape Town, South Africa. rahmed@uwc.ac.za ORCID identifier: 0000-0002-0286-9047

Corrresponding author
Name: Razia Z Adam,
Email: rzadam@uwc.ac.za

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The Sustainable Development Goals are a set of 17 global goals established by the United Nations in 2015, aimed at addressing the world's most pressing challenges by 2030. These goals encompass a broad range of social, economic, and environmental issues, including poverty, hunger, health, education, gender equality, clean water, and climate action, among others. The SDGs promote a holistic approach to sustainable development, emphasizing the interconnectedness of global challenges and the need for collaborative action across all sectors of society. By encouraging countries and organizations to work towards these common objectives, the SDGs strive to create a more equitable, healthy, and sustainable world for current and future generations.

SDG Goal 3 focuses on health, ensures healthy lives and promotes well-being for all across all ages.[3] Although oral health is not specifically mentioned in the 13 indicators of SDG3, it offers oral health an opportunity to align to global health.[4]major problems remain all over the planet, most notably among underprivileged communities of low- and middle-income countries but also in high-income countries. Furthermore, essential oral health care has been a privilege, instead of a right, for most individuals. The release of the Lancet issue on oral health in July 2019 built up some momentum and put oral conditions and dental services in the limelight. Yet, much work is still needed to bridge the gap between dental research and global health and get oral health recognized as a population health priority worldwide. Using the framework proposed by Shiffman, we argue that a global health network for oral health must be harnessed to influence global health policy and drive health system reform. We have identified challenges around 4 key areas (problem definition, positioning, coalition building, and governance The World Health Organisation (WHO) recommended Dentistry include a unified national plan, a single coordination mechanism, and a comprehensive Monitoring and Evaluation framework for implementing the SDG agenda. In addition, the promotion of inter-sectoral cooperation and convergence at all levels is recommended.[3]

Interdisciplinary research in dentistry presents a significant opportunity to advance SDGs, particularly in the domains of health, education, and innovation. Dentistry, by its nature, intersects with public health, biology, materials science, engineering, and social sciences , thereby creating opportunities for collaborative efforts aimed at achieving SDGs. [5–7] For instance, integrating dentistry with public health initiatives can promote SDG 3 (Good Health and Well-being) by addressing oral health disparities, which are often linked to broader social determinants of health.[8] Partnerships with materials science and engineering can lead to the development of sustainable dental materials and practices, contributing to SDG 12 (Responsible Consumption and Production). Additionally, interdisciplinary research can enhance dental education, aligning with SDG 4 (Quality Education) by incorporating various perspectives and knowledge bases, with the aim to prepare future dental graduates to tackle global challenges.

With the explosion and rapid uptake and development of digital dentistry, Artificial Intelligence (AI) and the use of technology to enhance dental education creates an opportunity to impact SDG 9 which focuses on Industry, innovation and infrastructure. Therefore, the integration of interdisciplinary research in dentistry is crucial for making substantial progress towards multiple SDGs, leveraging the unique contributions of various scientific disciplines to create holistic and sustainable solutions.

In response to these recommendations, dental research and education are crucial in undertaking challenges associated with promoting a sustainable future for the South African population. This effort requires support by interdisciplinary collaboration with relevant stakeholders across disciplines. Dental professionals must strive to partner with others outside the profession while recognising the contributions they can make even to the provision of dental services and care.[3] Oral health continues to be a neglected health challenge, and is often perceived as a privilege rather than a fundamental right for most of the population. A suggested holistic approach could help to reinvigorate both policy-level and societal discussions about social impacts on oral health and hence human health and well-being.[9,10] Higher education institutions, such as the Faculty of Dentistry at UWC, play a pivotal role in advancing SDG research by fostering innovation, cultivating interdisciplinary collaboration, and equipping future professionals with the knowledge and skills necessary to address complex sustainability challenges, ultimately contributing to improved oral health outcomes and overall well-being for the South African population.

AIM

The aim of the project was to identify opportunities for interdisciplinary research at a dental school to further sustainable development goals.

OBJECTIVES

- To identify the alignment of oral health research conducted at the Faculty of Dentistry, University of the Western Cape (UWC) with the SDGs
- To explore the potential for interdisciplinary research in the field of dentistry to contribute to the achievement of the SDGs.
- To evaluate the extent to which UWC's dental research can address global health challenges, particularly in under-resourced regions such as South Africa, through the application of innovative and sustainable practices.

METHODOLOGY

This study undertook a comprehensive analysis of research outputs from the Faculty of Dentistry at the University of the Western Cape (UWC) over a ten-year period (2013-2023). The study formed part of a larger study approved by the Humanities and Social Science Research Ethics Committee of the University of the Western Cape (HS22/10/14). The primary data source consisted of all Department of Higher Education and Training (DHET)-approved publications uploaded to UWC's Converis research platform during this timeframe.

The quantitative data generated through the SDG mapper were tabulated and visualized using simple bar charts and graphs. These visual tools facilitated a comparison between the research output's alignment with the SDG framework and South Africa's Decadal Plan, providing insights into both global and national contributions to sustainable development. Key performance indicators (KPIs) were also developed to measure the extent of the research's alignment with the SDGs.

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Validation

To ensure the validity of the findings, a peer review process was conducted with experts in the fields of public health, materials science, and dental education. Their feedback was used to refine the analysis and ensure the accuracy of the SDG alignment categorization. Additionally, the methodology and results were cross-verified with UWC's internal research committees to confirm that the data accurately reflected the institution's research output. By employing this methodology, the study offers a comprehensive understanding of how UWC's dental research aligns with global sustainability initiatives, providing a roadmap for future research efforts aimed at achieving the SDGs.

Categorisation and Processing Methodology/Overview

The method of categorisation and processing was done using a hybrid qualitative and quantitative approach to evaluate and rank the research projects according to their relevance to the various SDGs. A process of categorisation and evaluation was followed, which included data compilation, relevance ranking, scoring, sorting and results, and percentage composition. Each of the respective points will be briefly outlined.

Data Compilation

A draft list of research papers was compiled for the years 2013 to 2023 representing a total of 685 papers. The draft list was split into separate lists for each year and each record was assigned a project identity number for tracking and included information relating to the year, authors and project title. Following this, the lists were checked for correct categorisation by author and year, and duplicate values were removed. This resulted in a final total of 617 papers requiring further processing.

Relevance Ranking

The papers for each year were ranked qualitatively using an evaluation matrix to score their topic for a level of relevance to each of the 17 SDGs. Two researchers (YM & KP) were responsible for the initial ranking and a third researcher (RA) was consulted when there was disagreement or clarity needed. A relevance score was given based on each research paper's topic, as follows: 0 (not relevant); 1 (slightly relevant); 2 (moderately relevant); 3 (relevant); 4 (highly relevant); 5 (extremely relevant). These scoring values were chosen as they were in line with SDG evaluation scores used by other SDG research evaluation tools.[11] Once each of the respective years ranking scores were completed, the data was compiled and tabulated to create a combined list showing the results for all 617 papers.

Scoring

For each of the 17 SDGs the scores per SDG were added up and an average score, per SDG column, was calculated as the total value of the scores divided by the number of results in the column. For ease of further processing, and to remain relatable to the initial assessment scores, the average scores were then rounded to the nearest whole number. The same process was followed to calculate each of the respective years' results.

Sorting and Results

The average rounded scores were sorted from highest to lowest, showing the highest scoring SDGs at the top of the list with lowest scoring SDGs at the bottom. Results that had a final total of 0, for a particular SDG, were ignored. The results were also colour-coded by a final relevance score represented as red (5), pink (4), orange (3), yellow (2) green (1) and grey (0) to aid in the visual identification of their level of importance. The rounded average scores were used to display the results graphically, in the form of radar graphs, representing the visual weighting for the final ranked results; both in terms of the 17 SDGs and the SDG pillars. For the SDG pillars, the results were determined by assessing those SDGs that scored highest (maximum value) for each of the respective groupings pertaining to social (SDG 2, 3, 4, 5, 6, 8, 12, 17, 18), economic (SDG 9, 10, 11, 13) and environmental (SDG 7, 14, 15, 16) factors; as done in similar SDG evaluation tools.[11] The same process was followed to sort and display each of the respective years' results.

Percentage Composition

For additional insight into the ranked results, each results score was broken down further into a percentage matrix showing the weighting related to the percentage makeup of the various scores in determining the final value. This was calculated by counting the total number of times a relevance score was captured, ranging from 0 to 5, and then dividing each relevance score's count by the total number of assessed project records. This number was then multiplied by 100, to convert it to a percentage value, and rounded to 2 decimal places. The total percentage values were then added across all scored relevance values, to ensure they added up to 100%, as a check for correctness. Each year's records count was also cross-checked against the total of the overall added totals. This was done to ensure the correct number of filled totals corresponded to the total number of assessed records; as a further check for correctness. These calculations were done for each of the 17 SDGs. The results were then plotted as a matrix and colour-coded, from dark red (highest) to white (lowest), to visually display the highest to lowest values. The same was done for each of the separate years' results.

Results

The analysis of research conducted by the Faculty of Dentistry at the University of the Western Cape (UWC) between 2013 and 2023 reveals significant alignment with several SDGs. Figure 1 illustrates the alignment scores between UWC Dentistry's research priorities and the SDG's.

The analysis reveals that the majority of UWC's dental research is aligned with SDG 3, focusing on improving public health outcomes (Figures: 1a, 1b). The Rounded Average for SDG 3 is 4, indicating a significant emphasis on addressing health disparities, improving access to dental care, and integrating oral health into broader public health frameworks. There is a strong alignment with SDG 4, particularly in dental education. UWC's contribution to SDG 4 highlights efforts to integrate sustainability principles into dental training, preparing students to tackle global health challenges through preventive care and addressing health inequities. The Rounded Average score for SDG 4 is 3, reflecting substantial contributions in this area.

The university's research in this area shows contributions to SDG 9, emphasizing innovations in dental technologies such as digital dentistry and AI. These technologies improve clinical efficiency and expand access to care, particularly in underserved regions. The Rounded Average score for SDG 9 is 2, indicating a moderate but important focus on advancing healthcare infrastructure.

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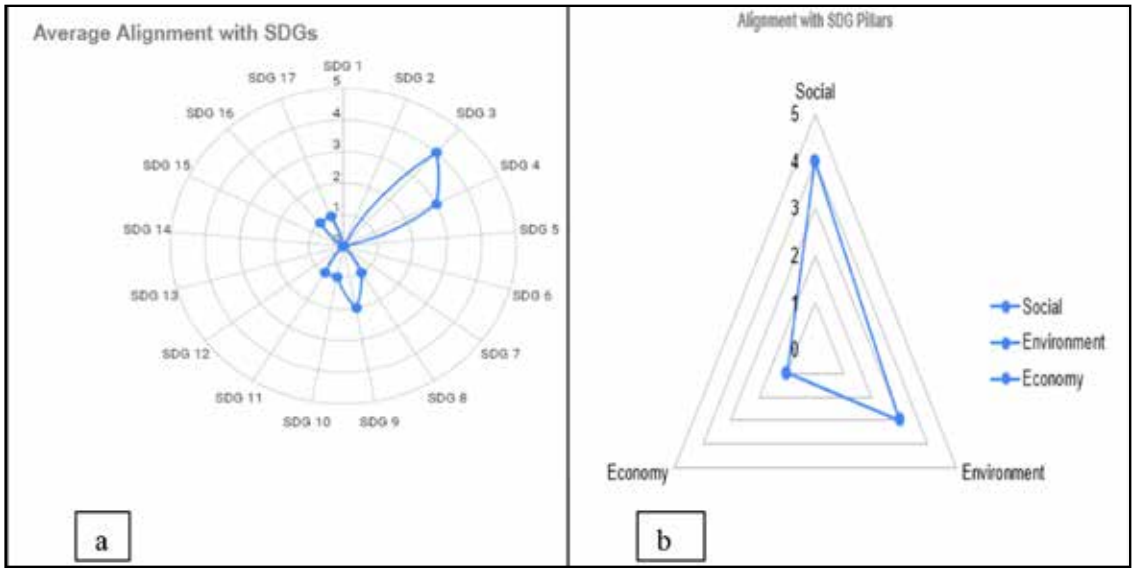

Figure 1: Average alignments of Dentistry,UWC research projects with SDGs

DISCUSSION

Dentistry naturally intersects with public health, biology, materials science, and engineering, opening avenues for integrating oral health into larger sustainability goals. [6] Oral health research aligns with SDG 3 by addressing social determinants of health, such as access to care and the prevention of oral diseases, which disproportionately affect marginalized populations.[8] For example, innovations in preventive care and community-based interventions can directly reduce the burden of oral diseases in underserved communities, thereby supporting healthier populations and reducing healthcare costs.

Advances in dental materials and technologies contribute to SDG 12 (Responsible Consumption and Production) by promoting environmentally sustainable practices. The development of new materials and minimally invasive techniques not only minimizes the environmental impact of dental care but also aligns with global efforts to reduce waste and promote sustainable healthcare. In addition, digital dentistry aligns with SDG 9 by driving innovations in infrastructure and expanding access to care, particularly in remote and low-resource settings. These technologies improve clinical efficiency, enhance patient outcomes, and democratize access to oral healthcare by overcoming geographical and economic barriers.[5]

The potential for oral health to contribute to SDG 4 is evident in the evolution of dental education, where interdisciplinary collaboration between fields such as public health, engineering, and technology fosters innovative approaches to training future dental professionals. UWC's emphasis on integrating sustainability into dental curricula prepares graduates to address global health challenges beyond the clinic, including the promotion of preventive care and the reduction of health inequities. This approach not only equips students with the technical skills necessary for their profession but also cultivates a sense of social responsibility and a commitment to sustainable practices.

Interdisciplinary collaboration is an important feature in academia, which highlights the integration of theories and methods of several disciplines within the scientific field. This reflects in sustainability research, which underscores the multifaceted challenges as it relates to natural, social, and human sciences.[10] Global challenges and complex societal issues require an interdisciplinary approach, which integrates various disciplines to offer an inclusive solution rather than single-discipline approaches. This emphasises the need for higher education institutions to use interdisciplinary research approaches in an effort to further innovation and resolve complex scientific challenges.[12] To effectively address global challenges and multifaceted social issues, an interdisciplinary research approach is necessary, which will promote an added holistic approach rather than single discipline strategies. UWC enables this collaboration as it contributes to various SDG goals; which can lay the foundation for interdisciplinary frameworks which will allow the student population and academics to meaningfully engage with varied perspectives and approaches in global health issues. Evidence of this is found in the collaboration and exploration of innovative designs and teaching in dentistry; by combining expertise in fields such as healthcare, oral health, computer science etc.

The dental faculty of UWC focuses on interdisciplinary research and international collaboration which contributes significantly to SDG 16 by fostering strong institutions and promoting equitable access to health services. By aligning research with international standards and building global partnerships, UWC positions itself as a leader in advocating for the recognition of oral health as a fundamental component of overall health. Reframing oral health as a human right is crucial for addressing existing inequalities in healthcare access, particularly in under-resourced communities, where oral diseases remain a significant yet preventable burden.

However, the integration of oral health into the SDGs faces several challenges, including the lack of explicit policy frameworks that prioritize oral health within national and global health agendas. [13] Governments, academic institutions, and stakeholders must recognize the importance of oral health as an integral part of overall well-being and invest in the necessary infrastructure and resources to support long-term research and policy development. The inclusion of oral health within the SDG framework not only amplifies the impact of dental research but also ensures that the benefits of good oral health are accessible to all, contributing to a healthier and more sustainable future.

The intersection of oral health and the SDGs presents a vital yet underexplored opportunity, especially in South Africa where oral health is often side-lined in policy discussions.

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Despite the absence of explicit references to oral health within the SDG framework, particularly in SDG 3 (Good Health and Well-being), the inclusion of oral health is critical to addressing broader health disparities. This research identifies the significant contributions that interdisciplinary research, particularly within the University of the Western Cape (UWC), can make to global health and sustainability.

One of the significant ways oral health research can contribute to the SDGs is through innovations in materials science. Sustainable dental materials, such as biodegradable composites, not only advance SDG 12 (Responsible Consumption and Production) but also reduce the environmental impact of dental practices.[7] This is particularly relevant as environmental sustainability gains prominence in healthcare discussions. Similarly, advances in digital dentistry and artificial intelligence (AI) align with SDG 9 by driving innovations in infrastructure, particularly in low-resource settings where traditional healthcare models may be inadequate.[5] Digital dentistry not only enhances clinical efficiency but also expands access to care in remote and underserved areas, where traditional dental services may be limited.[14]

Moreover, UWC's focus on interdisciplinary research contributes significantly to SDG 16 by fostering strong institutions and global partnerships. By aligning research with international standards and forging collaborations across borders, UWC positions itself as a leader in promoting peace and justice through equitable access to health services. Oral health, often perceived as a luxury, must be reframed as a human right to address the existing inequalities in healthcare access, particularly in under-resourced communities.[3]

However, the integration of oral health into the SDGs remains limited by several challenges. One of the key limitations is the lack of explicit policy frameworks that prioritize oral health within national and global health agendas.[13] Without these investments, the progress made through research will be insufficient to drive meaningful, systemic change. There is a lack of clear policy framework that prioritizes oral health within national and international health strategies. Policymakers need to recognize the significance of oral health as a fundamental component of overall health and incorporate it into broader health initiatives.[4]major problems remain all over the planet, most notably among underprivileged communities of low- and middle-income countries but also in high-income countries. Furthermore, essential oral health care has been a privilege, instead of a right, for most individuals. The release of the Lancet issue on oral health in July 2019 built up some momentum and put oral conditions and dental services in the limelight. Yet, much work is still needed to bridge the gap between dental research and global health and get oral health recognized as a population health priority worldwide. Using the framework proposed by Shiffman, we argue that a global health network for oral health must be harnessed to influence global health policy and drive health system reform. We have identified challenges around 4 key areas (problem definition, positioning, coalition building, and governance Also, while interdisciplinary research offers many opportunities, it requires sustained investment in infrastructure and resources. Governments and academic institutions must provide adequate funding to support long-term research projects that can address the complex challenges outlined in the SDGs.[6] Despite the clear potential for oral health to contribute to sustainable development, several challenges remain.

Aligning oral health with the SDGs requires a multifaceted and collaborative approach. UWC's commitment to interdisciplinary research offers a blueprint for how dental schools can contribute to sustainable development. By fostering innovation, enhancing education, and advocating for policy changes, the field of dentistry can play a pivotal role in achieving global health goals. Future research should continue to explore the integration of oral health into the SDG framework, with a focus on developing practical strategies that can be implemented at both local and global levels.

Conclusion

The alignment of oral health research with the SDGs represents an important step in addressing global health disparities and promoting interdisciplinary collaboration. This study demonstrates how the University of the Western Cape's research has contributed significantly to the SDGs, particularly SDG 3, SDG 4, SDG 9, and SDG 16. By integrating oral health research with public health, materials science, engineering, and education, UWC has shown that dentistry can play a critical role in achieving sustainable development.

The findings of this research underscore the importance of addressing oral health inequalities, particularly in underserved regions such as Africa, where oral health often remains a neglected priority. Furthermore, interdisciplinary research that incorporates sustainable dental materials, innovative educational approaches, and collaborative frameworks offers a model for how oral health can contribute to broader sustainability goals.

However, significant challenges remain, including the need for policy frameworks that prioritize oral health within national and international health strategies, as well as sustained investments in research infrastructure. Future efforts should continue to explore the integration of oral health into the SDG framework, focusing on practical, locally adaptable solutions that can be implemented in resource-limited settings.

By fostering innovation, enhancing education, and advocating for policy changes, dental schools and researchers can contribute to achieving global health goals and promoting a more equitable future for oral health care.

Conflicts of Interest

There are no applicable conflicts of interests for all authors.

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Oral-health related quality and substance use disorder

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D Smit, S Naidoo[2]

ABSTRACT

Why the work was done: The oral health impact of substance use disorder (SUD) has been comprehensively described, but not as yet been investigated for its effect on oral health-related quality of life (OHRQoL) especially within the South African context. **How the work was done:** A cross-sectional study with a mixed methods approach was applied to investigate the oral health impact of SUD and the objective was to assess OHRQoL of drug users admitted to a treatment centre. A validated questionnaire (OHIP-14) supported by clinical oral examinations was applied to achieve the aim of the research project. A sample of 504 patients enrolled in a treatment programme for SUD within the Western Cape was included in the study. All ethical considerations were adhered to. **What are the main findings:** The physical pain and psychological discomfort dimensions of the instrument showed the highest negative impact on OHRQoL with a mean of 3.51 and 3.4 respectively. A significant difference in OHIP-14 score was detected for those who used alcohol as well as for those who used methamphetamine as a primary drug. Those who used heroin/opiates and methamphetamine had the highest OHIP-14 score. A multivariate regression analysis found that 19% of the variability in the OHIP score could be explained by the combined effect of the risk predictors cigarette smoking, DMFT-score, poly-drug use, level of education, number of extractions needed, active caries and having a medical condition or not. **Why the work is important:** The present study highlighted the drug-specific oral health impact of SUD and reaffirmed dental status and oral health behaviours are poor among these patients. Therefore, oral health professionals as well as staff at treatment centres can play a significant part in placing more emphasis on oral health during treatment for SUD.

BACKGROUND

Substance use disorder (SUD) is the problematic use of alcohol, hallucinogens, opioids, cocaine, cannabinoids, sedative hypnotics, tobacco and other elicit stimulants (Cuberos *et al*., 2020). Oral health burden of disease and SUD are intertwined with South Africa's socio-economic disparities such as the lack of access to basic oral health care (Smit et al., 2017). Aspects such as oral health status and history of substance use have been investigated in previous studies, but there is a paucity of information on the oral health effects of different drug types. The oral health impact of SUD has been comprehensively described outside South Africa (Murphy et al., 2016; Mukerjee et al., 2018; Abdelsalam, 2023), but not as yet been investigated for its effect on Oral Health Related Quality of Life (OHRQoL) especially within the South African context. Oral health status of substance users does have a substantial effect on their quality of life, which can be greatly improved by dental treatment (Van Wijk et al., 2016). In 2017, Antoniazzi et al. (2017) found that crack users and other drug users exerted a negative impact on OHRQoL compared to controls independently of socio-demographic characteristics and tobacco use (Antoniazzi et al., 2017). The association between SUD and OHRQoL in poly-drug users also remains unclear. The present study investigated the oral health status, dental treatment needs, oral health behaviour (OHB) and OHRQoL of patients who were enrolled in a treatment programme for SUD in the Western Cape, South Africa.

Authors' Information
1. Prof Dirk Smit. Chairperson: Department of Community Dentistry. Faculty of Dentistry, University of the Western Cape
2. Sudeshni Naidoo BDS, LDS.RCS, MDPH, DDPH.RCS, MChD, PhD, Dip IRE, DSc. Faculty of Dentistry, University of the Western Cape, South Africa. Email: suenaidoo@uwc.ac.za ORCID Number: 0000-0001-7424-8082 (https://orcid.org/0000-0001-7424-8082

Corresponding Author
Name: Prof Dirk Smit.
Tel: +27 21 937 3148
E-mail: dsmit@uwc.ac.za

MATERIAL AND METHODS

The aim of the study was to investigate the oral health impact of SUD. A cross-sectional study design with a mixed methods approach was applied. A major focus of the study involved a descriptive quantitative component to investigate oral health status, oral health behaviour, dental treatment needs and OHRQoL of participants. This was achieved by using a structured researcher-administered questionnaire and performing oral examinations to measure decayed, missing and filled teeth (DMFT) as well the presence of periodontal disease via the basic periodontal examination (BPE). The OHIP-14, developed by Slade (1997) known for its good reliability, validity and precision was used to investigate OHRQoL. The study population were enrolled adult patients at registered SUD treatment centres in the Western Cape. Sample selection took into consideration the prevalence of SUD as well as the on-point population enrolled for SUD treatment. The sample size was estimated with an 80% power and 5% level of significance and a delta of -0.129. n = 2 {Zα/ES}^2= 2*{1.96/(-0.129)}^2 = 457.00. Finally, 504 patients were included to ensure a robust sample size and to safeguard a decent buffer for data analysis. The exclusion criteria were individuals who were re-entering a treatment programme and who had participated in the study previously. Captured data was exported to Microsoft Excel, Epi Info version 7 (CDC) and STATA (Stata Corp., College Station, TX). Student's t-test was used to investigate differences between group means and proportions respectively and Spearman's rank correlation for associations. Chi Square (χ2) tests were used to test for association and when assumptions were not met, the Fisher's exact test (FET) was applied. P-value for statistical significance was set at 5%. Post-hoc analyses, including Bonferroni, Sidak, and Scheffé tests, were performed. Both univariate and multivariate Poisson regression analyses were done to examine the relationship between various variables and the OHIP-14 overall score. Potential confounding variables such as age, gender and cigarette smoking were controlled in the multivariate regression analysis models. Ethical approval to conduct the study was obtained from the University of the Western Cape (UWC) Bio-Medical Research Ethics Committee (BMREC), City of Cape Town as well as from the Provincial Government of the Western Cape. Participation was anonymous, voluntary, and confidential. The purpose of the study was explained through the study information sheet

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and informed consent was obtained before data collection. All collected data was secured in a locked office and on a password protected computer.

RESULTS

Each of the 14 questions on the OHIP-14 questionnaire, a 5-point Likert scale response format (0 = never, 1 = hardly ever, 2 = occasionally, 3 = fairly often, 4= very often) was given. The sum of the scores was used to calculate a total score as well as the sum for each of the 7 dimensions. Higher scores indicated a poorer OHRQoL and thus a greater negative impact on OHRQoL. The mean OHIP-14 score for the sample was 18.93. The physical pain and psychological discomfort, over the preceding 12 months, showed the highest mean scores, while the functional limitation- and handicap dimensions showed the lowest scores (Table 1).

Those who used heroin/opiates and methamphetamine had the highest OHIP-14 score among all the drug groups. However only methamphetamine users had a significant difference in OHIP-14 compared to the rest of the sample

Table 1: Severity of OHIP-14 for the sample

	OHIP specific dimension score				
Question: In the last 12 months,	**mean**	**median**	**range**	**SD**	**IQR**
FUNCTIONAL LIMITATION	1.94				
1. Trouble pronouncing words	0.81	0	0 – 4	1.22	0 – 2
2. Worsened taste	1.13	1	0 – 4	1.37	0 – 2
PHYSICAL PAIN	3.51				
3. Painful aching in mouth	1.75	2	0 – 4	1.44	0 – 3
4. Discomfort eating food	1.76	2	0 – 4	1.53	0 – 3
PSYCHOLOGICAL DISCOMFORT	3.40				
5. Feeling self-conscious	1.78	2	0 – 4	1.65	0 – 4
6. Feeling tense	1.62	2	0 – 4	1.54	0 – 4
PHYSICAL DISABILITY	2.50				
7. Poor diet	1.17	0	0 – 4	1.44	0 – 2
8. Interrupted meals	1.33	1	0 – 4	1.45	0 – 4
PSYCHOLOGICAL DISABILITY	3.09				
9. Difficult to relaxing	1.36	1	0 – 4	1.46	0 – 2.5
10. Embarrassed	1.73	2	0 – 4	1.65	0 – 3.5
SOCIAL DISABILITY	2.50				
11. Irritable with other people	1.46	1	0 – 4	1.53	0 – 4
12. Difficulty doing your usual jobs	1.04	0	0 – 4	1.37	0 – 2
HANDICAP	2.02				
13. Life less satisfying	1.19	0	0 – 4	1.47	0 – 4
14. Totally unable to function	0.83	0	0 – 4	1.23	0 – 2
Total	19				
	18.93	17	0 - 56	1.23	0 – 2

Table 2: History of primary drug use & cigarette smoking according to OHIP-14 score

		OHIP-14 total score						
		n	%	mean	median	SD	IQR	p-value
Poly-drug use	Yes	323	64	21.36	19	15.7	8 – 34	< 0.0005
	No	181	36	14.61	11	14.0	2 – 23	
Most preferred method of use	Injecting	15	3	22.93	24	10.9	14 – 29	< 0.0005
	Snorting	12	2	16.92	17.5	13.8	3.6 – 22	
	Swallow	113	22	13.05	10	12.6	2 – 21	
	Smoke	364	72	20.67	18	16.0	6 – 33.5	
Duration of addiction	1 – 10 years	204	40	18.81	17	15.5	5 – 29	> 0.05
	11 – 20 years	206	41	19.60	18	15.4	6 – 30	
	21 years and more	94	19	17.75	14	15.5	4 – 29	
	No	316	63	17.97	16	15.0	4 – 28	
Frequency of primary drug use	Daily	317	63	20.35	18	15.1	8 – 30	< 0.005
	Weekly and less	187	37	16.53	12	15.7	2 – 28	

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Table 3 OHIP-14 score for each dimension according to main primary drug use

Main primary drug groups	Alcohol	Cannabis	Mandrax	Opiates	Meth	p-value
FUNCTIONAL LIMITATION			mean OHIP-14 score			
1. Trouble pronouncing words	0.53	0.91	1.02	0.64	0.87	> 0.05
2. Worsened taste	0.66	1.04	1.08	1.60	1.30	< 0.005
PHYSICAL PAIN						
3. Painful aching in mouth	1.37	1.51	1.60	2.48	1.92	< 0.005
4. Discomfort eating food	1.36	1.82	1.73	2.16	1.89	< 0.05
PSYCHOLOGICAL DISCOMFORT						
5. Feeling self-conscious	1.20	2.12	1.52	2.48	1.90	< 0.0005
6. Feeling tense	1.16	1.67	1.52	2.32	1.74	< 0.005
PHYSICAL DISABILITY						
7. Poor diet	0.72	1.16	1.19	1.40	1.33	< 0.05
8. Interrupted meals	0.86	1.22	1.60	1.52	1.49	< 0.005
PSYCHOLOGICAL DISABILITY						
9. Difficult to relaxing	0.92	1.44	1.44	1.20	1.55	< 0.05
10. Embarrassed	1.19	1.84	1.65	2.04	1.90	< 0.005
SOCIAL DISABILITY						
11. Irritable with other people	0.87	1.38	1.71	1.72	1.65	< 0.0005
12. Difficulty doing your usual jobs	0.63	0.98	1.33	1.24	1.14	> 0.05
HANDICAP						
13. Life less satisfying	0.71	1.44	1.19	1.28	1.34	< 0.005
14. Totally unable to function	0.48	0.80	0.96	0.68	0.98	< 0.05
Total OHIP-14 score	12.65	19.40	19.54	22.76	20.98	< 0.0005

OHIP prevalence (prevalence of a negative impact on OHRQoL)

($p < 0.005$). Those who used alcohol as a primary drug had the lowest OHIP-14 score. Methamphetamine users were the most negatively impacted by finding it difficult to relax and feeling totally unable to function (Table 3).

OHIP-14 responses were categorized and classified to signify the presence of a negative impact on OHRQoL if there was at least one response of "fairly often" or "very often". The added percentage of "fairly often" and "very often" responses were used to determine prevalence. Those who were using heroin/opiates showed the highest OHIP prevalence at 80% followed by methamphetamine (68%) while those who used alcohol (46%) and mandrax (50%) showed the lowest prevalence. An association was found between methamphetamine use and OHIP prevalence ($p < 0.005$). The odds of a negative impact on oral health were 1.8 times more among methamphetamine users compared to those who did not use methamphetamine as a primary drug.

The prevalence of a negative impact on OHRQoL of the different dimensions of the OHIP-14 instrument was analysed according to main primary drug groups. The highest negative impact on OHRQoL was felt by opiate users reporting feeling

Table 4: OHIP prevalence according to primary drug use

		OHIP prevalence*		OR	RR	p-value
Main primary drug		Yes	No			
Alcohol	Yes	47 (46%)	55	0.5	0.7	< 0.005
	No	261	141			
Cannabis	Yes	28 (62%)	17	1.1	1.0	> 0.05
	No	280	179			
Heroin/Opiates	Yes	20 (80%)	5	2.7	1.3	> 0.05
	No	288	191			
Mandrax	Yes	26 (50%)	26	0.6	0.8	> 0.05
	No	282	170			
Methamphetamine	Yes	175 (68%)	84	1.8	1.2	< 0.005
	No	133	11			
Entire sample		61%				

*: A binary measure of the proportion of at least one "fairly often" or "very often" response

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Table 5: OHIP prevalence of categories for OHIP-14 dimensions according to main primary drugs

	Main primary drug groups (n = 484)*					n = 504
	Alcohol	Cannabis	Mandrax	Opiates	Meth	Total sample
	n (prevalence in %)					
FUNCTIONAL LIMITATION						***112 (22%)***
1. Trouble pronouncing words	6 (6%)	***7 (16%)***	9 (17%)	1 (4%)	34 (13%)	57 (11%)
2. Worsened taste	5 (5%)	10 (22%)	9 (17%)	**6 (24%)**	59 (23%)	91 (18%)
PHYSICAL PAIN						***206 (41%)***
3. Painful aching in mouth	20 (19%)	12 (27%)	15 (29%)	**13 (52%)**	91 (35%)	155 (31%)
4. Discomfort eating food	24 (23%)	16 (26%)	17 (33%)	**13 (52%)**	93 (36%)	167 (33%)
PSYCHOLOGICAL DISCOMFORT						***212 (42%)***
5. Feeling self-conscious	22 (21%)	**21 (47%)**	17 (33%)	**15 (60%)**	100 (39%)	**184 (37%)**
6. Feeling tense	23 (22%)	14 (31%)	15 (29%)	**13 (52%)**	84 (32%)	154 (31%)
PHYSICAL DISABILITY						***145 (29%)***
7. Poor diet	10 (10%)	10 (22%)	**13 (25%)**	5 (20%)	63 (24%)	103 (20%)
8. Interrupted meals	13 (13%)	9 (20%)	**16 (31%)**	7 (28%)	73 (28%)	119 (24%)
PSYCHOLOGICAL DISABILITY						***201 (40%)***
9. Difficult to relaxing	16 (16%)	12 (27%)	14 (27%)	5 (20%)	**76 (29%)**	126 (25%)
10. Embarrassed	26 (25%)	17 (38%)	19 (37%)	**11 (44%)**	102 (39%)	**181 (36%)**
SOCIAL DISABILITY						***155 (31%)***
11. Irritable with other people	15 (15%)	11 (24%)	**19 (37%)**	7 (28%)	83 (32%)	137 (27%)
12. Difficulty doing usual jobs	9 (9%)	9 (20%)	**14 (27%)**	5 (20%)	52 (20%)	91 (18%)
HANDICAP						***129 (56%)***
13. Life less satisfying	13 (13%)	**13 (29%)**	13 (25%)	3 (12%)	66 (25%)	112 (22%)
14. Totally unable to function	6 (6%)	5 (11%)	**7 (13%)**	0 (0%)	40 (12%)	60 (12%)

*: The main drug groups are the most common drugs being used and represent 96% of the sample (n = 484/504 = 96%)

self-conscience (60%), feeling tense (52%), having a painful aching in the mouth (52%) and having discomfort when eating food (52%) due to problems with their teeth mouth or dentures. Those who were using mandrax reported the highest negative impact related to trouble pronouncing words (17%), poor diet (25%), interrupted meals (31%), irritable with other people (37%), difficulty doing usual jobs (27%) and unable to function at all (13%). Those who used alcohol as a primary drug reported the lowest negative impact for most categories. The values below that are underlined indicates the lowest value in each row while the values that are in bold indicated the highest (Table 5)

The OHIP-14 score was also analyzed according to categories of dental caries severity (DMFT) as well as to the patients who presented with active caries (D > 0) and those who suffered from dental caries (DMFT-score > 0). Those with a DMFT score of 7 and less, had shown an OHIP-14 score of 12.65 which was significantly lower than the rest of the sample.

Dental caries severity and OHRQoL

Mean DMFT score was analyzed according the OHIP prevalence. All the questions, where a negative impact was

Table 6: OHIP-14 score (severity) and dental caries status of the sample

		OHIP-14 total score						
Dental caries status and OHIP-14 score		n	%	mean	median	SD	IQR	p-value
DMFT	0 – 7	138	27	12.65	8	13.3	2 – 20	*< 0.0005*
	8 – 14	161	32	18.60	17	15.0	6 – 28	
	15 – 21	123	24	22.46	20	14.9	11 – 34	
	> 21	82	16	24.88	24	16.7	11 – 40	
Active caries (untreated tooth decay) *	Yes	439	87	19.71	18	15.2	6 – 30	*< 0.005*
	No	65	13	13.72	8	16.1	1 - 24	
Caries prevalence (caries experience) #	Yes	492	98	19.19	17	15.4	5 – 30	*< 0.05*
	No	12	2	8.67	2	11.5	0 – 18.5	

*: D > 0; also referred to as active caries (untreated tooth decay)
#: DMFT > 0; also referred to as caries experience (%)

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Table 7: DMFT score according to presence of negative impact on OHRQoL

Presence of negative impact on OHRQoL over the preceding 12 months n %			DMFT total score mean	median	SD	IQR	p-value		
Functional limitation	**1. Trouble pronouncing any words** because of problems with your teeth, mouth or dentures?	Yes	57	11	17.61	17	7.2	13 – 23	*< 0.0005*
		No	447	89	12.67	12	7.6	7 – 18	
	2. Sense of taste has worsened because of problems with your teeth, mouth or dentures?	Yes	91	18	14.62	14	7.8	8 – 20	*> 0.05*
		No	413	82	12.92	12	7.7	7 – 18	
Physical pain	3. Had **painful aching in your mouth?**	Yes	155	31	15.15	15	7.2	9 – 20	*< 0.0005*
		No	349	69	12.37	11	7.8	7 – 17	
	4. Found **it uncomfortable to eat any foods** because of problems with your teeth, mouth or dentures?	Yes	167	33	15.78	16	7.5	10 – 21	*< 0.0005*
		No	337	67	11.96	11	7.6	6 – 17	
Psychological discomfort	5. **Been self-conscious** because of your teeth, mouth or dentures?	Yes	184	37	15.05	15	7.5	9 – 21	*< 0.0005*
		No	320	63	12.18	11	7.7	6 – 17	
	6. **Felt tense** because of problems with your teeth, mouth or dentures?	Yes	154	31	15.15	15	7.4	9 – 21	*< 0.0005*
		No	350	69	12.38	11	7.8	7 – 17	
Physical disability	7. **Diet been unsatisfactory** because of problems with your teeth, mouth or dentures?	Yes	103	20	16.44	16	7.6	10 – 23	*< 0.0005*
		No	401	80	12.40	11	7.6	7 – 17	
	8. **Had to interrupt meals** because of problems with your teeth, mouth or dentures?	Yes	119	24	16.60	16	7.4	10 – 23	*< 0.0005*
		No	385	76	12.18	11	7.6	7 – 17	
Psychological disability	9. **Found it difficult to relax** because of problems with your teeth, mouth or dentures?	Yes	126	25	15.69	16	7.6	9 – 21	*< 0.0005*
		No	378	75	12.40	11	7.6	7 – 17	
	10. **Been a bit embarrassed** because of problems with your teeth, mouth or dentures?	Yes	181	36	15.58	15	7.4	10 – 21	*< 0.0005*
		No	323	64	11.76	11	7.6	6 – 17	
Social disability	11. **Been a bit irritable with other people** because of problems with your teeth, mouth or dentures?	Yes	137	27	16.06	15	7.4	10 – 21	*< 0.0005*
		No	367	73	12.17	11	7.6	6 – 17	
	12. **Life in general was less satisfying** because of problems with your teeth, mouth or dentures?	Yes	91	18	15.96	15	7.4	10 – 22	*< 0.0005*
		No	413	82	12.62	12	7.7	7 – 17	
Handicap	13. **Felt that life in general was less satisfying** because of problems with your teeth, mouth or dentures?	Yes	112	22	16.01	16	7.8	9 – 22	*< 0.0005*
		No	392	78	12.43	12	7.6	7 – 17	
	14. **Been totally unable to function** because of problems with your teeth, mouth or dentures?	Yes	60	12	15.88	16	6.9	11 – 21	*< 0.005*
		No	444	88	12.87	12	7.8	7 – 18	

Risk predictors for OHRQoL

felt by the participants on their OHRQoL in the preceding 12 months, had a significant higher (< 0.005) mean DMFT score except for the question of a worsened sense of taste (Table 7).

A multivariate regression analysis for OHIP-14 score as the outcome variable was done on: age, sex, cigarette smoking, DMFT score, poly-drug use, highest school grade completed, number of extractions needed, frequency of drug

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use, having periodontal health, having active caries, duration of addiction, and having a medical condition. Nearly a fifth of the variability in the OHIP score was explained by the combined effect of the predictors. Cigarette smoking, DMFT, poly-drug use, highest school grade completed, the number of dental extractions needed, having active caries and having a medical condition were significant predictor variables ($p < 0.05$) (Table 8).

DISCUSSION

The present study is unique with regards to its primary focus on the impact substance use disorder (SUD) has on oral health status (dental caries and periodontal disease) and OHRQoL. The prevalence of impact on OHRQoL of 61%, among substance users, was much higher that 17.5% that was found among the general South African adult population (Ayo-Yusuf et al., 2016). Mukerjee et al. (2018) found that more than half (59%) methamphetamine users reported a painful aching in the mouth, discomfort while eating (63.5%), feeling embarrassed (60.7%) and avoidance of particular foods (56.5%). These findings were slightly higher than the present study, probably on account of different sample distribution. The present study reported on other drug types including alcohol (20% of the sample) and found lower negative impact on OHRQoL. On the other hand, Brown et al. (2021) investigated DMFT- and OHIP-14 scores of 398 psychoactive substance users in Brazil. The results on OHIP-14 severity for almost all the dimensions concurred with the present study. Only the mean OHIP-14 score for psychological discomfort was much higher than the present study (5.0 vs 3.4) and this could be attributed to the fact that the Brown study was done at psychiatric hospitals (Brown et al., 2021). The relationship between dental caries and OHRQoL was also investigated in the present study with those who had a high DMFT score (15 and more) having a worse OHRoL than those with a lower DMFT score (14 and less) ($p < 0.0005$). This finding also concurred with Brown et al. (2021). In the present study, oral health status encompassed the severity and prevalence of dental caries and periodontal disease as well as specific oral health symptoms that were experienced during substance use. Symptoms included grinding teeth, experiencing dental pain, gum problems, stiff facial muscles, a bad taste, a burning sensation in the mouth, increased tooth sensitivity and a dry mouth.

CONCLUSION

The present study highlighted the drug-specific oral health impacts of SUD. The study found that OHRQoL dental status and oral health behaviour is poor among SUD patients. The study considered a multifactorial cascade of risk predictors related to the socio-demographic profile, history of substance use and oral health behaviour of the patient. Evidence from published literaturend an in-depth analysis was incorporated in this model to explain the different contributing factors towards poor oral health of the patient who suffers from SUD.

RECOMMENDATIONS

It is recommended that prior to and during enrolment of patients with SUD the following factors need to be considered: access to oral health care, oral health pre-admission screening, the referral process, oral health profession collaborative partnership, oral health education and behaviour, staff training, nutrition and food products at tuckshops. Dental management should be aligned with substance use treatments and it is recommended that this is done at the initial stage of admission. Pre-admission screening will permit staff to refer the patient for appropriate care. Furthermore, if urgent dental treatment is needed, it can be addressed prior to admittance. A clear referral process must be available during treatment and will require coordination with local private and public dental clinics. Staff at the treatment centre should be aware of the referral channels and processes. Health and oral health education and promotional material needs to be available at all SUD treatment centres. Healthy food choices and educating patients on the association between high sugar intake and dental caries should be included in oral health education material.

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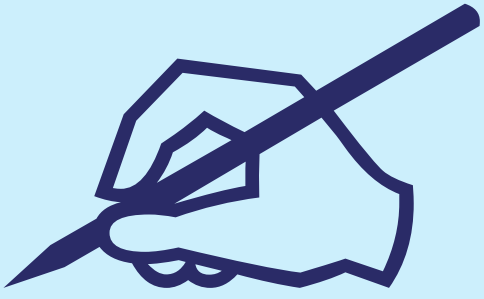
CPD questionnaire on page 122

The Continuing Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.



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Do you Guard your Profession with Jealousy, or Is it Easier to simply be a "Dignified Observer"?

SADJ MARCH 2026, Vol. 81 No.2 P110-P113

LM Sykes[1], S Mpungose[2], CP Owen[3]

ABSTRACT

Background: A noticeable shift is occurring in how medical and dental practitioners advertise their services, moving beyond traditional methods to public platforms and high-profile sponsorships. There is an increased use of intentional and widespread advertising to the general public. Some use media such as flyers and pamphlets displayed in their own or in allied health care providers' waiting rooms, while others target even wider audiences using the more public platforms such as Facebook, YouTube, TikTok, and Instagram. For years dentists have been observing these trends, yet nobody has voiced any concern as to the legality and ethics of this behaviour.

Aim

This prompted the current commentary where we ask the question "Are we as dental practitioners guarding our profession with jealousy, or are we merely standing by, observing, and choosing to remain silent?"

Setting

This paper analyses the South African legal and ethical framework governing professional advertising, identifying significant ambiguities that create "grey areas" exploited through canvassing and touting.

Methods

The literature search and examination of the current postgraduate teaching facilities and opportunities in South Africa was conducted to explore the extent of the crisis in post-qualification education and if this is a factor contributing to this unethical advertising.

Results

A severe shortage of funded specialisation posts and a lack of accredited, practice-relevant micro-credentials have led to a proliferation of unregulated, private courses. These "rogue" courses often operate on a "pay-to-pass" model, providing certificates that practitioners then use to justify misleading claims of expertise.

Conclusions and Contribution

By examining international models and proposing a multi-stakeholder framework for reform, this paper argues that safeguarding the profession requires simultaneous action on two fronts, enforcing clear advertising rules and establishing a robust, quality-assured system for postgraduate lifelong learning.

Authors' information
1. BSc, BDS, MDent, IRENSA, Dip Forensic Path, Dip ESMEA, FCD (Pros) Head of Department of Prosthodontics, University of Pretoria. ORCID: https://orcid.org/0000-0002-2002-6238
2. Dr SK Mpungose. BChD, MChD (UWC), Head Clinical Unit, Department of Prosthodontics, University of Pretoria. ORCID: https://orcid.org/0000-0003-2177-7540
3. Owen, CP. BDS, MScDent, MChD, FCD(SA), Professor Emeritus, School of Oral Health Sciences, Faculty of Health Sciences, University of the Witwatersrand. ORCID: https://orcid.org/0000-0002-9565-8010

Corresponding Author
Name: Leanne M Sykes
Email: Leanne.sykes@up.ac.za

Authors contribution
Leanne Sykes - Primary author – 60%
Sandile Mpungose – Co-author – 30%
Christopher Peter Owen – Co-author-10%

INTRODUCTION

The issue of medical and dental practitioners advertising their services touches on a critical aspect of professional ethics, especially in today›s climate where marketing and self-promotion are ubiquitous. The economic-driven pressure to compete has given rise to new business models, making it increasingly common, and even reasonable, for practitioners to use advertising to publicise their services. However, the intention should not be for them to invite attention to themselves, but rather to inform and benefit the public[1]. As such they need to strike a balance between the need for patient awareness, with their obligations towards maintaining trust and professionalism. Historically, such advertising was prohibited as it was viewed as incompatible with the dignity of the profession as well as compassionate and ethical patient care. This changed largely due to evolving societal attitudes and legislative shifts favouring fair competition. Advertising has now become widespread and generally accepted. This was further fuelled by amendments to the legal and ethical rules of conduct by the Competition Commission, who viewed the standing rules as restrictive, anti-competitive, and not automatically in the best interest of the public. The new rules introduced additional guidelines related to practicing in multidisciplinary settings with other professionals not necessarily registered with the HPCSA, as well as issues related to sharing fees, professional appointments, and ownership of dental practices[2,3]. This commentary analyses the current South African regulatory landscape for advertising and the ethical tensions it creates. It further suggests that a key driver of unethical advertising is a parallel crisis in postgraduate education, where the lack of accessible, formal pathways to advanced training has fostered a market for unaccredited credentials. It proposes an holistic path forward to protect both the public and the integrity of the dental profession.

Part 1: The Legal and Ethical Framework for Advertising: Intent vs. Interpretation

Currently in South Africa, advertising by clinicians is permitted if it conforms to broad legal and ethical rules of

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conduct set out by the Health Professions Council of South Africa (HPCSA).[3] The Council's withdrawal of specific rules on "Making your professional services known" in favour of general principles has created considerable interpretive flexibility. While allowing for modern marketing approaches, this shift has also generated significant grey areas, leaving practitioners unsure of the boundaries between permissible advertising and professional misconduct. These uncertainties and fears of legal transgressions have prevented some clinicians from publicizing themselves.[1] There also appears to be a difference in the outlook between the "seasoned established practitioners" and the new generation of recent graduates. The latter tend to make more use of the vast forms of technology available, such as social media, television, and public events to promote themselves and their services.

The Guidelines on advertising state "*A practitioner shall be allowed to advertise his or her services or permit, sanction or acquiesce to such advertisement: provided that the advertisement is not unprofessional, untruthful, deceptive or misleading or causes consumers unwarranted anxiety that they may be suffering from any health condition. A practitioner shall not canvass or tout or allow canvassing or touting to be done for patients on his or her behalf*".[1,3] These new and broader general ethical rules of conduct have enabled the profession greater leeway in the manner in which they promote their practices. It has also created a number of grey areas that are open to considerable interpretive flexibility and exploitation, which have led to practices that, while not explicitly illegal, clearly violate the spirit of the ethical guidelines.

Despite this over-riding advertising regulation, and the specific reference to canvassing and touting, it raises the question as to what constitutes these practices, and how they differ from permissible advertising.

Canvassing is defined as "*Conduct which draws attention, either verbally or by means of printed or electronic media, to one's personal qualities, superior knowledge, quality of service, professional guarantees or best practice".*

Touting is defined as *"Conduct which draws attention, either verbally or by means of printed or electronic media, to one's offers, guarantees or material benefits that do not fall in the categories of professional services or items, but are linked to the rendering of a professional service or designed to entice the public to the professional practice"*.[1]

1. *Canvassing in Practice:*
A simple internet search reveals numerous general dental practitioners describing themselves with titles such as *"Specialist Implantologist", "World Renowned Expert", or "Dentist to the STARS".* These may imply formal qualifications or recognised accolades that do not exist. Attending a short course does not confer one specialist status. Such descriptors are inherently misleading and constitute clear canvassing.

2. *Touting in Practice*
Touting has become equally widespread. Consider the following documented examples:

A dental practice promises a *"brighter smile"* with clear aligner therapy and offers a 15% discount for signing up, directly tying a material benefit to a professional service.

Another dental practice hosts an "IV booster bar" offering intravenous drips for "hangover cures, anti-ageing products, and libido enhancers," which are designed to attract the public with non-therapeutic benefits, which additionally are not related to the scope of practice of the profession.

The examples above are illustrative of a systemic problem. The existence of rules is meaningless without consistent and visible enforcement. The HPCSA's reactive, complaints-driven approach creates a permissive environment where boundaries are continually tested, undermining the collective professionalism of all practitioners.

Although the HPCSA has published guidelines on social media use and advertising, their vagueness has allowed the current unethical practices to flourish. This problem is not unique to dentistry in SA, as the medical profession too are battling with enforcing legal and ethical advertising standards. In their journal they implicitly state that "While SAMA does publish advertisements for accredited events in its materials, this does not imply endorsement. Medical practitioners should always refer to the legally binding HPCSA rules, which are the primary authority on this matter". They then elaborate on certain of these. In the absence of clarity, the dental profession could follow some of these guidelines .These include that it is acceptable to publish tariffs on advertisements, provided that they are factual; graphics such as anatomical structures or photographs are acceptable, provided that they are not indecent, deceptive, misleading, identifiable or bring the profession into disrepute; excessively large notices or sign boards outside the practice could constitute unprofessional conduct; direct mailing of advertisements/pamphlets with factual information is permissible, however bulk distribution may be construed as unreasonably drawing attention to the practice; practitioners should avoid using phrases such as, "*conditions apply"*, in advertisements unless exact conditions are specified; and clinicians must refrain from allocating themselves titles that suggest certified and recognised skills and training.[4] These guidelines are not explicit or enforceable, thus it remains incumbent on practitioners to exercise caution, ad carry out ethical self-reflection practices in their professional activities.

Part 2: The Problems in the current status of Post-Qualification Education and Micro-Credentialing

The challenges of maintaining professional standards extend beyond advertising into the very foundation of clinical competence and postgraduate education. In South Africa, the pathway to formal specialisation is severely constrained. With very few funded posts available, the prohibitive cost of self-funded positions, combined with significant income loss, creates a critical market gap.[5] This systemic bottleneck has fuelled an explosion of privately-led, post-qualification courses and "diplomas" that promise advanced skills without the rigour of a formal university programme.

These courses are typically not accredited by the South African Qualifications Authority (SAQA) nor endorsed by the HPCSA. Consequently, there is no independent verification of their curriculum quality, the NQF level at which they are pitched, the validity of their assessment methods (if they exist), or the actual competence of both the providers and their "graduates"/attendees. The prevailing perception is that these are commercial ventures operating on a "pay-to-pass" model. This phenomenon directly fuels the unethical

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advertising practices described above, as practitioners use certificates from these unregulated courses to justify self-awarded titles like “expert”, “master”, or “specialist”.

Presumably, the major catalyst is a disconnect between academia and private practice. It is crucial to acknowledge that the proliferation of these unregulated courses is not solely due to malicious intent. A significant catalyst is the perceived and often real mismatch between formal university offerings and the immediate, practical needs of the general dentist in private practice, which is closely linked to patient demands. Approved university micro-credentialing courses are few, can be slow to adapt to new technologies, and may not address the specific business efficiency and clinical requirements of a private practice. The private sector by contrast, is extremely agile, and offers fast, focused, and commercially relevant training, filling a vacuum that the public academic sector has been unable to address.

South Africa is not alone in facing this challenge. Two international responses provide examples of valuable models for reform.

The United Kingdom’s General Dental Council (GDC) has a highly protected title of “Specialist”. However, in order to address the need for advanced work by general practitioners, they introduced the “Restorative Dentist” model. To this end, the Royal Colleges have developed other robust, quality-assured forms of post-qualification training and accreditation. For example, a general dentist can undertake a Diploma from the Royal College of Surgeons (RCS Eng) in Restorative Dentistry. While this does not grant “specialist” status, it is a GDC-recognised credential that provides a clear, verifiable, and ethical pathway for dentists to demonstrate advanced training.[6]

In the United States, Continuing Education (CE) courses and providers are overseen and accredited by the American Dental Association’s (ADA) Continuing Education Recognition Program (CERP) and the Academy of General Dentistry’s (AGD) Program Approval for Continuing Education (PACE) program. This creates a system where dentists can distinguish between a course from an accredited provider (which has met standards for scientific rigour) and one from a non-accredited commercial entity.[7] This empowers practitioners to make informed choices about their education, and practice within ethical and legal boundaries.

A Proposed Framework for Correction in South Africa

Correcting the systemic issues requires a multi-stakeholder approach that is both pragmatic and robust. This entails collaboration between a number of key role players, and implementation of proposed regulatory policies.

1. ***Regulatory Clarity and Enforcement by the HPCSA:*** The HPCSA must explicitly define and regulate the use of terms like “credentialed in”, or “accredited in [a field]” to provide a legitimate way for dentists to advertise additional training without claiming to be specialists.

2. ***Creation of a National Quality Assurance Framework:*** The South African Dental Association (SADA), in partnership with South African Qualifications Authority (SAQA) and the HPCSA, should create a Voluntary Accreditation Council for Dental CE. This body would set minimum standards for curriculum, faculty qualifications, and assessment for private courses. Accredited courses would be eligible to be listed on a public register, giving them credibility.

3. ***Bridging the Academia-Private Practice Divide:*** Universities must be incentivised to develop more agile, relevant, and accessible micro-credentialing programmes. This could involve part-time or short-course formats developed in consultation with private practitioners to ensure they meet market needs.

In addition to the regulatory considerations, the profession needs to maintain their ethical obligations and reputational standing.

Ethical considerations

When determining if clinical skills and training as well as associated advertising is ethical, one needs to evaluate how well advertising adheres to and/or promotes the following key points:

1. **Informed Choice:** Advertising should educate and enable patients to learn about available services, and help them make informed choices about the healthcare options available.

2. **Truthfulness:** Advertisements must be truthful and not misleading. Exaggerated claims about practitioners’ qualifications and expertise, or false promises about treatment outcomes undermines trust in the profession.

3. **Professionalism:** Health professionals are often held to high ethical standards. Advertising should reflect this by avoiding sensationalism or comparing services in a way that could be deemed unprofessional.

4. **Vulnerable Populations:** Care must be taken to avoid exploiting vulnerable populations. Adverts targeting those in distress or with urgent health issues can be seen as predatory.

5. **Promoting non-essential or non-therapeutic treatment:** Clinicians should not advocate or encourage patients to have purely cosmetic procedures or non-therapeutic treatment. With regards to the latter, the scope of a general dentist appears to be drafted in very broad general terms that do not explicitly prevent practitioners from providing these services.

6. **Regulatory Compliance:** Many regions have regulations governing health advertising. Professionals must comply with these to avoid legal issues and maintain ethical standards.

7. **Confidentiality:** Any advertising should respect patient confidentiality and not use patient testimonials or images without consent. In addition, patients need to be told exactly where their images will be displayed, who the potential viewers will be, what will be written about them / their treatment. They need to be comfortable that all forms of possible identification have been removed, and made aware of the possibility that their images could be widely disseminated, and their anonymity cannot be guaranteed.[8]

8. **Focus on Education:** Ethical advertising can emphasize educational content, helping patients understand health

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issues, and promote preventive strategies rather than just offering interceptive services.[3,9]

Balancing these factors is crucial for maintaining the integrity of a health profession, while at the same time effectively communicating with, and empowering patients to make autonomous and educated decisions about their own health and treatment needs.

CONCLUSION

The crisis of unregulated advertising as well as that of unaccredited postgraduate education are two sides of the same coin. Both stem from a regulatory environment that prizes vague principles over specific, enforceable standards, and a system that fails to meet the legitimate educational needs of its practitioners. By learning from international models that combine regulatory clarity for advertising with a voluntary accreditation system for continuing education, South Africa can begin to address this rift. The goal is to create an environment where the pursuit of knowledge enhances clinical competence and public trust, and addresses a real need rather than merely decorating a practice's marketing materials. While it is hoped and presumed that practitioners will strive to maintain good professional practice and base their conduct on core legal and ethical standards and values, not all members of the profession subscribe to this ethos. Many may argue that their advertising and self-promotional strategies are not illegal, offensive, or dishonest. However, from a professional standpoint, we need to question the appropriateness of their behaviour, their target audience, and the ethics of encouraging the public to undergo purely cosmetic, non-essential or non-therapeutic services.

The profession must now choose to either jealously guard the value of its qualifications and ethical standing, or remain mere observers of their progressive devaluation. It is also apposite to remember that The Hippocratic Oath is a pledge all practitioners take wherein they agree to abide by a commitment to *"Exercise my profession to the best of my knowledge and ability for the safety and welfare of all persons entrusted to my care and for the health and well-being of the community"*. Upholding this commitment also requires vigilance in both how we learn and how we present ourselves to the community we serve.

Perhaps it is also time that the profession collectively takes a stand. A multi-faceted approach is imperative to address the identified challenges. It is recommended that the profession pursue significant reforms, including:

- CPD Points Allocations: Implement a more rigorous and transparent system for allocating CPD points to ensure they correspond to the quality and depth of learning.
- Amend Rule 21: Undertake a comprehensive review and reform of Rule 21 to distinguish between medical and dental courses by adding a section specifically addressing the concerns expressed in this paper.
- Revise the credentials needed for appointing entities entrusted with granting CPD points to ensure strict adherence to the rules for awarding points.
- Issue Public Warnings: Direct the South African Dental Journal (SADJ) to consistently publish clear warnings, educating members about the risks of attending unaccredited courses. Where such courses have been identified, the SADJ should publish on the status/lack of credibility

The CPD system as currently administered is failing the profession, but it reforms need more than just administrative improvements. The profession must now speak up or remain silent and become victims of uncaring bureaucracy.

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CPD questionnaire on page 122

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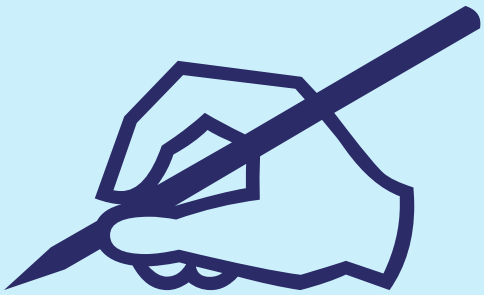

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Managing HIV/AIDS in a Resource Crisis: The potential role of oral health practitioners

SADJ MARCH 2026, Vol. 81 No.2 P114

M Netshiombo[1]

The abrupt withdrawal of funding from the United States President's Emergency Plan for AIDS Relief (PEPFAR) has disrupted critical services for South Africans living with, or at risk of, HIV infection. This funding gap threatens to reverse significant progress achieved under the 90-90-90 targets - which aimed for 90% of people living with HIV to be diagnosed, 90% of those diagnosed to be on treatment, and 90% of those on treatment to achieve viral suppression. Without an urgent and coordinated response from government, progress toward the more ambitious 95-95-95 goals could stall, risking a resurgence of the HIV/AIDS crisis.

In this period of constrained resources, task-shifting, multisectoral collaboration, and interdisciplinary integration must be reimagined to ensure efficient, continuous, and equitable care for vulnerable populations. Oral health practitioners (OHPs) – including oral hygienists, dental therapists, dentists, and specialists – are well positioned to contribute to HIV/AIDS management. The oral cavity is often the first site where clinical signs of HIV infection appear, making OHPs uniquely situated to detect early indicators of disease, monitor immune status, and facilitate timely intervention.

Despite this, oral health practitioners are not formally recognised as authorised providers of HIV testing under the National Department of Health's National HIV Testing Policy (2016). A study in KwaZulu-Natal reported that only 18% of dentists initiate HIV counselling and testing in their clinical settings, citing lack of training and insufficient knowledge as primary barriers[1].

Currently, HIV testing is primarily conducted via self-diagnostic kits or by nurses, doctors, pharmacists, lay counsellors, and community health workers. Initially, antiretroviral therapy (ART) was the sole domain of medical doctors. To improve access, the Nurse-Initiated Management of Antiretroviral Therapy (NIMART) programme was launched, followed by the Pharmacist-Initiated Management of Antiretroviral Therapy (PIMART). These programmes enable specially trained nurses and pharmacists to diagnose HIV, initiate first-line antiretroviral therapy, manage follow-ups, and refer complex cases beyond first-line treatment to medical doctors.

Authors' information
1. Mukhethwa Netshiombo. Affiliation: Public Oral Health Forum
ORCID: https://orcid.org/0000-0001-9163-1972

Corresponding author
Name: Mukhethwa Netshiombo.
Email: mukhethwa.netshiombo@wits.ac.za

Both models reflect the Department of Health's commitment to decentralised care through task-shifting, as advocated by the World Health Organization[2].

In the context of a weakened HIV response due to PEPFAR's withdrawal, South Africa should consider expanding the role of OHPs in HIV prevention, testing, and care. With over 12,000 oral health practitioners nationwide, this largely untapped workforce - within similar frameworks like NIMART and PIMART – could enhance early case detection, support adherence monitoring, and improved access to care.

Equally important is the need for stronger referral pathways between medical and dental services. Poor oral health worsens systemic outcomes in people living with HIV and can undermine quality of life and treatment efficacy. A more integrated approach, in which medical professionals routinely refer patients to oral health providers, would promote comprehensive, patient-centred care.

The estimated 17% funding shortfall left by PEPFAR's exit requires serious budget reprioritisation to prevent disruptions in human resources, diagnostics, and clinical support. As the national HIV/AIDS strategy is reconfigured, oral health professionals must be included as essential contributors.

Key considerations for policymakers and professional bodies include:
1. How should healthcare policies be adapted to formally include OHPs in HIV prevention and treatment efforts?
2. How can training in HIV/AIDS testing, counselling, and management be developed to establish a 'Dental-Initiated Management of Antiretroviral Therapy' (DIMART) cadre??
3. How can HIV testing and follow-up care be incorporated into dental settings - both public and private - including outreach and school-based programmes?

As South Africa navigates a constrained healthcare environment, inclusive task-shifting and integrated service delivery will be essential. Oral health practitioners have a critical, yet underutilised, role to play in sustaining the HIV/AIDS response and preventing avoidable setbacks in the fight against the epidemic.

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What's new for the clinician – summaries of recently published papers (March 2026)

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Edited and Compiled by Prof V Yengopal, Faculty of Dentistry, University of the Western Cape

1. IMMEDIATE VERSUS CONVENTIONAL LOADING IN USERS OF MANDIBULAR OVERDENTURES RETAINED BY NARROW-DIAMETER IMPLANTS: RESULTS FROM A 5-YEAR RANDOMIZED CLINICAL TRIAL

Evidence from multiple randomized controlled trials (RCTs) and systematic reviews confirms that immediate loading does not compromise implant survival in the two-implant protocol[1]. A 2020 meta-analysis of 7 RCTs found no statistically significant difference in implant failure rates between immediate and delayed loading for two-implant mandibular overdentures . This finding is supported by long-term data: a 12-year follow-up study reported cumulative survival rates of 100% for immediately loaded implants and 96% for delayed loading. [1]

Regarding bone health, a 3-year RCT noted that the immediate loading group experienced *significantly lower marginal bone loss* compared to the conventional loading group after 36 months . However, a network meta-analysis suggested that the attachment type influences this outcome, with a bar attachment combined with immediate loading ranking highest for minimizing bone loss.

The primary advantage of immediate loading is the accelerated functional recovery. Patients receiving immediate loading typically receive their final prosthesis within 48 hours, avoiding the use of a removable interim denture. A 1-year RCT on titanium-zirconium narrow-diameter implants demonstrated that while both protocols resulted in high satisfaction, a significant difference was observed at 6 months regarding the *ability to chew* in favour of the immediate loading group.

However, the 3-year RCT by Possebon et al. (2023) provides a critical caveat: while conventional loading patients showed deterioration in masticatory function by year three, immediate loading patients maintained functional evolution, yet they reported *more complaints regarding general oral performance.* Nonetheless, the conclusions drawn from these systematic reviews remain limited due to the scarcity of long-term clinical studies directly comparing both loading protocols in two implant mandibular overdenture (2-IMO) users.

Salybi et al reported on a randomized clinical trial that sought to compare the clinical performance of 2-IMO users rehabilitated with conventional and immediate loading protocols over a five-year follow-up period. Clinical, radiographic, functional, and patient-centred outcomes, as well as prosthetic maintenance events, were evaluated. The null hypothesis tested was that no significant differences would be observed between the two loading protocols during the study period.

Materials & Methods

This randomized clinical trial is a 5-year follow-up of a trial that sought to evaluate mandibular overdentures retained by two implants (2-IMO) users rehabilitated with immediate loading (IL) or conventional loading (CL) protocols using narrow diameter implants (NDIs) from the Facility-Equator system. The trial cohort comprised 20 patients.

Each participant received a conventional maxillary complete denture and a mandibular overdenture retained by two narrow-diameter implants (2.9 × 10 mm) placed in the interforaminal region of the mandible. Participants were recalled for follow-up appointments at 1-, 3-, and 5-years post-treatment for clinical and radiographic evaluations. In addition, prosthetic maintenance appointments were routinely scheduled once per year as part of the standard follow-up protocol. In isolated cases, extra maintenance sessions were conducted when clinically necessary or upon patient demand, which resulted in a higher number of visits for some individuals. At each time point, the following parameters were assessed: i)clinical evaluation of peri-implant health; ii) radiographic assessment of marginal bone loss (MBL) and the posterior area index (PAI) of the mandible; iii) functional and patient-centered outcomes, including masticatory performance (MP) and oral health-related quality of life using the DIDL (Dental Impact on Daily Living) questionnaire. Additionally, prosthetic maintenance events were recorded annually.

Peri-implant health was evaluated through annual clinical examinations of the four surfaces of each implant to monitor the Visible Plaque Index (VPI), Peri-implant Inflammation (PI), Calculus Presence (CP), Probing Depth (PD), and the Bleeding on Probing (BOP).

Marginal bone loss (MBL) and the posterior area index (PAI) of the mandible were analyzed using digital panoramic radiographs by a single calibrated examiner for each parameter. Examiner calibration for radiographic analysis was verified by calculating the Intraclass Correlation Coefficient (ICC) based on two separate measurements performed one week apart. The calibration was considered acceptable with an ICC value ≥ 0.80. MBL was assessed on the mesial and distal faces of each implant using measurement tools within ImageJ software. The outer edge of the implant head served as the reference point for evaluating peri-implant bone levels. The distance between the outer edge of the implant head and the alveolar crest level on both the mesial and distal faces was measured. A clinically contextualized interpretation of marginal bone loss was adopted according to the criteria proposed by Albrektsson et al. (1986), which consider bone loss of 1.0–1.5 mm acceptable during the first year after implant placement and up to 0.2 mm per year thereafter as physiological.

Masticatory function was assessed using the Masticatory Performance (MP) test. During the test, participants were

instructed to chew a standardized artificial test material, Optocal (3.7 g), for 40 chewing cycles, counted by a calibrated examiner. Upon completion, the chewed material was expectorated onto a paper filter, rinsed with water, and left to dry at room temperature for seven days. Once dried, the material was processed through a series of sieves with decreasing mesh sizes (5.6–0.5 mm) using a mechanical sieve shaker for 20 min. Masticatory efficiency (ME) was determined by calculating the percentage of the total sample weight retained on the 5.6 mm and 2.8 mm sieves.

Oral health-related quality of life (OHRQoL) was evaluated using the Dental Impact on Daily Living (DIDL) questionnaire, which comprises 36 questions distributed across five domains: appearance, pain, oral comfort, general performance, and chewing. Each domain score was calculated as the mean of the summed responses within that domain. Final scores were categorized as dissatisfied (<0), relatively satisfied (0–0.69), or satisfied (0.7–1.0).

The prosthetic maintenance events monitored throughout the study included: dislodgement and replacement of the Equator attachment or matrix, prosthesis adjustments and fractures, fabrication of new prostheses, denture tooth fractures, matrix recapture, replacement of O-rings, vestibuloplasty procedures, removal of keratinized mucosa, relining procedures, and re-opening surgeries for prosthetic component replacement. For each follow-up year, the total number of maintenance events, the frequency of each specific event, and the number of patients affected by each type of event within each group were recorded.

Probing depth (PD) was the primary endpoint. All other clinical, radiographic, and patient-centred variables were considered secondary outcomes.

RESULTS

At the 5-year follow-up period, five participants (3 in conventional loading [CL] group; 2 in immediate loading [IL] group) were lost to follow-up, resulting in 15 patients completing the 5-year evaluation: eight in the IL group and seven in the CL group. During the first year, five implants failed, three in the IL group and two in the CL group—resulting in implant survival rates of 90% for the CL group and 85% for the IL group. Following replacement with new Morse taper implants (3.5×9 mm, Neodent), no further implant failures were recorded throughout the 5-year follow-up period. In the CL group, one patient developed peri-implant mucositis on the right implant, with the condition recurring at the 5-year evaluation for the same implant.

In terms of all the clinical, radiographic, masticatory, and oral health–related quality of life outcomes between groups at the 5-year follow-up, statistically significant differences were detected only for MBL ($p=0.01$) and for the masticatory domain of the DIDL questionnaire ($p=0.03$). At 5 years, the IL group showed slightly greater MBL (IL = 0.05 ± 0.80 mm; CL = –0.24 ± 0.70 mm) and reported a more pronounced decline in perceived masticatory capacity (IL = 1.8 ± 2.74 vs. CL = 2.4 ± 3.10).

Longitudinal analyses of MBL revealed overall stability of peri-implant bone levels in both groups over the 5-year follow-up. In the CL group, mean changes at 1, 3, and 5 years were small (–0.09 mm, 0.09 mm, and –0.17 mm, respectively), although significant cumulative remodelling was observed between 3 and 5 years (coef.: 1.02; 95% CI: 0.56–1.48; $p<0.001$) and from baseline to 5 years (coef.: 0.85; 95% CI: 0.14–1.56; $p=0.01$), corresponding to a mean bone loss of –0.08 mm at 5 years. In the IL group, mean changes at 1, 3, and 5 years were also minimal (0.09 mm, –0.00 mm, and 0.05 mm, respectively), but cumulative remodelling was significant both between 3 and 5 years (coef.: 0.93; 95% CI: 0.73–1.13; $p<0.001$) and from baseline to 5 years (coef.: 1.89; 95% CI: 1.73–2.05; $p<0.001$), resulting in a mean bone loss of 0.04 mm at the final follow-up.. Both loading protocols exhibited small changes over time, with the CL group showing greater bone remodelling between 3 and 5 years, whereas the IL group remained more stable across all intervals.

When analyzing the intragroup results for the clinical outcomes, a statistically significant difference in PD was observed in both groups between the first and fifth years ($p=0.00$), with the IL group showing a greater reduction in PD over time. The PAI exhibited significant intragroup changes over the follow-up period. In the CL group, PAI values increased progressively, with statistically significant differences observed between the third and fifth years (26% increase, $p=0.00$), as well as a cumulative gain of 28% from baseline to the fifth year ($p=0.00$). Conversely, the IL group demonstrated a significant increase in PAI starting from the third year, with a 31% increase between the third and fifth years ($p=0.00$) and an overall gain of 28% over the entire five-year period ($p=0.02$). These results indicate a sustained improvement in posterior area index within both groups throughout the study duration.

Although a reduction in the mean domain scores for DIDL was observed, no statistically significant differences were found over the 5-year period in the CL group. In contrast, the IL group demonstrated significant differences between the third and fifth years across all DIDL domains. The "appearance" domain showed a slight improvement in the mean score, increasing from 2.8 to 2.84 ($p=0.00$). The "pain" domain showed a reduction from 2.9 to 1.8 ($p=0.01$). Similarly, the "oral comfort" ($p=0.01$), "general performance" ($p=0.00$), and "mastication" ($p=0.01$) domains also showed significant worsening in their mean scores during this period. When comparing the first and fifth years, only the chewing domain showed a significant decline ($p=0.03$).

The maintenance occurrences recorded over the 5-year follow-up were mainly related to matrix recaptures or replacements, prosthesis adjustments, and O-ring replacements, while major complications were rare. In the CL group, most events occurred at the 4-year follow-up, with fewer occurrences at 5 years, whereas in the IL group the distribution was similar across both periods. Over the five-year follow-up, a total of 136 maintenance events were recorded in the CL group and 159 in the IL group. The IL group was 1.68 times more likely to require O-ring replacement than the CL group (OR:1.68; $p=0.03$), and they also had an 89% lower chance of requiring removal of keratinized tissue (OR: 0.11; $p=0.04$) over the 5-year period. Other maintenance events, such as artificial tooth fracture, prosthesis rebasing, or replacement of matrix, were infrequent (<10%) and showed no significant differences between groups.

CONCLUSION

Although the immediate loading group exhibited reduced probing depth and marginal bone loss, both groups demonstrated similar masticatory performance and posterior area index over the five-year follow-up. Prosthetic maintenance events decreased by the end of the fifth year. However, from the third year onward, patients in the immediate loading group reported greater dissatisfaction with 2-IMO treatment, mainly due to retention and stability issues.

Implications for practice

The trial results offer a mixed bag of outcomes for clinicians to consider. IL performed better with objective and clinically important outcomes such as PD and MBL whilst CL has better OHRQoL outcomes and lesser maintenance issues. Both groups had similar masticatory performance.

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2. IMPACT OF FOUR GINGIVAL RETRACTION TECHNIQUES ON GINGIVAL TISSUE DISPLACEMENT AND SULCUS DEPTH DURING DIGITAL IMPRESSION PROCEDURES

In the past few years, there has been a profound shift in diagnostic and therapeutic workflows within digital dentistry, with intraoral scanners (IOS) now central to clinical practice due to their efficiency, precision, and superior patient comfort. These devices capture three-dimensional images of the oral cavity, enabling the rapid and precise design of prosthetic restorations. However, the reliability of digital impressions is critically dependent on the clarity of the scanned field, a factor that can be severely compromised by the presence of bleeding and soft tissue interference.

The Impact of Bleeding and Fluids on Scan Quality

IOS technology relies on the projection and capture of light, and the presence of oral fluids – particularly blood – alters the optical properties of the scanned surface, degrading image quality. Bleeding, whether from gingival inflammation, trauma, or surgical procedures, introduces reflective and refractive materials that hinder surface detection and the accurate stitching of image data. Recent 2025 technical benchmarks confirm that uncontrolled haemorrhage not only obscures hard tissue margins but also increases the likelihood of scanning errors, such as missing data, artefacts, and distorted anatomy[1]. In fact, the accuracy of intraoral scans can drop by approximately 20% in moist or bleeding conditions. A 2025 systematic review further emphasizes that saliva contamination and visibility issues severely affect the accuracy of IOS for crown preparations with subgingival margins, underscoring that clinically acceptable results are only achievable with proper gingival retraction and a dry field.[1]

To overcome these limitations, effective retraction techniques are indispensable before digital impression-taking, particularly in cases involving subgingival preparations or inflamed tissues. Retraction displaces the gingival tissues, exposes the finish line, and creates a dry, accessible environment for scanning. While traditional methods, such as gingival retraction cords—either plain or impregnated with haemostatic agents—remain effective, the double-cord technique has proven especially valuable in digital workflows for exposing deep margins and ensuring haemostasis. Impregnated cords, typically treated with aluminium chloride or ferric sulphate, promote vasoconstriction and coagulation, improving margin visibility.

Recent innovations have expanded the clinician's armamentarium. A 2025 randomized controlled trial compared various displacement methods and found that impregnated retraction cords provided the greatest horizontal and vertical displacement (0.66 ± 0.04 mm and 0.66 ± 0.008 mm, respectively), followed by a cordless paste (Magic FoamCord), while Expasyl and diode laser troughing were less effective. However, the same study noted that impregnated cords resulted in the most significant loss of gingival height one month post-cementation, suggesting that traumatic pressure should be avoided. Additionally, cordless systems such as Magic FoamCord have demonstrated better haemorrhage control and shorter operating times compared to conventional cords.[1] Another novel 2025 approach, the fully digital pneumatic gingival-retraction scanning (PGR-S) technique, has shown effective retraction, significantly reduced operating time, and improved patient comfort relative to traditional cord methods. Furthermore, a pilot study by Ruggiero et al. (2025) introduced the use of 0.076 mm polytetrafluoroethylene (PTFE) tape for gingival displacement, which allowed for atraumatic retraction and excellent finish line visibility (90% of scans) without the need for tape removal during scanning.

As intraoral scanner technology continues to evolve, with enhanced software algorithms and optical sensors – including the use of short-wave infrared (SWIR) light and artificial intelligence to reduce artefacts from fluids – the fundamental importance of proper field management remains unchanged. Digital workflows still rely on traditional principles of tissue health, visibility, and moisture control to achieve predictable outcomes. Consequently, meticulous bleeding control and retraction protocols are not merely adjuncts to digital dentistry but prerequisites for its success. This body of evidence informs the present study, which aims to evaluate the effectiveness of various gingival displacement techniques by assessing horizontal and vertical displacement, sulcus depth, and gingival height loss (GHL). The null hypothesis posits that no significant differences will be found across these parameters among the different gingival displacement techniques used for digital impressions.

Methodology

This trial from Turkey was conducted following the CONSORT guidelines for randomized clinical trials.

Thirty-two participants requiring full coverage restorations for maxillary premolars were recruited. For inclusion, patients were between 25–40 years; had Maxillary premolars with normal anatomical size, contour, and position, as determined by clinical examination, periodontal probing, and preoperative digital scans. Patients were also

healthy and had healthy gingiva and periodontium around abutments (GI = 0), Good oral hygiene (PI = 0), Pocket depth ≤ 3 mm and Thick gingival phenotype. Smokers were excluded and patients who had Systemic conditions affecting periodontal status such as Diabetes mellitus, Uncontrolled cardiovascular diseases, Autoimmune disorders and Blood disorders were excluded.

At Baseline periodontal indices, including Plaque Index (PI) and Gingival Index (GI), were recorded to confirm oral hygiene suitability. Two weeks before the clinical intervention, all participants underwent professional oral prophylaxis and received individualized oral hygiene instructions. Gingival phenotype was evaluated using a colour-based phenotype probe (Perioscreen™ Probe) to confirm thick phenotype cases

Thirty two participants were randomly assigned to four parallel groups ($n = 8$) according to the gingival retraction technique:

- *Retraction cord with astringent (RCA; Control group)*: Knitted cord impregnated with aluminium chloride (Ultrapak + Viscostat Clear)
- *Cordless paste with astringent (EXP)*: Expasyl.
- *Cordless paste without astringent (MF)*: Magic FoamCord (Coltene Whaledent).
- Laser troughing (LT): *Diode laser (iLase; Biolase Inc.)*

Tooth preparation and tissue management

All abutments were prepared for lithium disilicate glass-ceramic crowns (IPS e.max Press) following standard guidelines. Chamfer finish lines with a depth of 0.8 mm were placed 0.5 mm subgingivally and verified using a periodontal probe.

- Group 1 – Retraction cord with astringent (RCA): Size 1 retraction cord (Ultrapak; Ultradent Inc.) was soaked in aluminium chloride gel (Viscostat Clear; Ultradent Inc.) for 5 min. The cord was packed gently into the sulcus using a cord packer (Ultrapak™ Packers; Ultradent Inc.), avoiding coverage of the finish line. After 5 min, the cord was moistened and removed to minimize bleeding. Total procedure duration was approximately 6–7 min per tooth.

- Group 2 – Expasyl (EXP): Expasyl paste was injected into the sulcus with the cannula tip directed apically and parallel to the tooth axis. A compression cap was placed, and participants were instructed to bite to increase pressure. After 5 min, both the cap and paste were removed, and the sulcus was rinsed. Total duration was 6–7 min per tooth.

- Group 3 – Magic FoamCord (MF)" Magic FoamCord was applied similarly to Expasyl, followed by placement of a Comprecap. After 5 min, the cap and material were removed, and the sulcus was rinsed thoroughly. Total duration was 6–7 min per tooth.

- Group 4 – Diode laser troughing (LT)" Laser troughing was performed using a diode laser (iLase) at a 980 nm wavelength and 0.8 W continuous mode, consistent with parameters shown to effectively remove epithelial tissue in periodontal pockets. The laser fibre tip was inserted 1 mm into the sulcus, keeping it away from the preparation margin. Short, sweeping strokes were used to avoid tissue charring. The tip was regularly cleaned with gauze soaked in 10% hydrogen peroxide during the procedure. Duration was approximately 3–4 min per tooth.

A preoperative scan was obtained using an intraoral scanner (Medit i700W), calibrated before each use. After tooth preparation and gingival displacement, definitive digital impressions were taken immediately to minimize sulcus collapse. Scans were exported in PLY format.

Definitive restorations were fabricated using CAD-CAM workflow (Exocad Dental DB; Exocad). Full-contour lithium disilicate crowns were delivered the same day. Adhesive cementation was performed, and excess cement was carefully removed. Post-cementation digital scans were taken at 7, 15, and 30 days to evaluate tissue changes related to gingival retraction, not prosthetic outcomes, in order to avoid confounding factors such as occlusal load or cement placement.

Outcome assessment

All scans were analyzed using CAD software for the following parameters:

- **Horizontal displacement:** Measured as the horizontal distance from the finish line to the adjacent gingiva
- **Sulcus depth:** Measured as the vertical distance from the finish line to the deepest sulcus point at the same 8 locations.
- **Vertical displacement:** Calculated by superimposing pre- and post-retraction scans at 6 points.
- **Gingival Height Loss (GHL):** Measured at Mesiobuccal (MB) and mesio-palatal(MP) points after superimposing preoperative scans with postoperative scans at 7, 15, and 30 days.

To ensure standardization and minimize variability, all measurements were conducted according to a uniform protocol.

RESULTS

A total of 43 participants were screened for eligibility. Ten individuals were excluded for not meeting the inclusion criteria, and one declined participation, leaving 32 participants who were randomized equally into four study groups ($n = 8$ per group).

The mean age of participants was similar across groups (RCA: 35.2 ± 6.1 years; MF: 34.7 ± 5.8 years; LT: 36.0 ± 6.3 years; EXP: 35.5 ± 5.9 years), with no statistically significant difference ($p = 0.92$). Sex distribution was balanced across groups ($p = 0.88$). Baseline GHL was 0.00 mm among all participants.

Group RCA demonstrated the greatest horizontal displacement (0.72 ± 0.08 mm), vertical displacement (0.68 ± 0.07 mm), and sulcus depth (0.75 ± 0.09 mm). These values were significantly higher than those of the other groups ($p < 0.05$).

Group MF achieved intermediate displacement values (horizontal: 0.60 ± 0.05 mm; vertical: 0.55 ± 0.06 mm), which were significantly higher than Group LT (0.50 ± 0.04 mm; 0.45 ± 0.05 mm) and Group EXP (0.48 ± 0.03 mm; 0.42 ± 0.04 mm). However, sulcus depth values were not significantly different between MF and LT ($p = 1.00$).

Gingival height loss over time

Two-way ANOVA results revealed significant main effects of retraction method ($F = 18.45$, $p < 0.001$) and time ($F = 22.12$, $p < 0.001$) on GHL, as well as a significant interaction between method and time ($F = 5.87$, $p = 0.003$).

Across all groups, GHL progressively decreased from day 7 to day 30 ($p < 0.001$). On day 7, Group RCA recorded the highest GHL (0.28 ± 0.04 mm), which declined to 0.10 ± 0.02 mm by day 30. In comparison, Group EXP consistently exhibited the lowest GHL values across all time points (0.14 ± 0.02 mm at day 7; 0.07 ± 0.01 mm at day 30). Groups MF and LT showed intermediate reductions.

Pearson correlation analysis confirmed strong positive correlations between GHL and horizontal displacement ($r = 0.88$), sulcus depth ($r = 0.87$), and vertical displacement ($r = 0.78$), all statistically significant ($p < 0.001$).

CONCLUSION

Retraction cords produced the greatest displacement and correspondingly higher Gingival height loss (GHL), whereas Expasyl paste demonstrated lower displacement and minimal gingival change. Magic FoamCord and laser troughing yielded intermediate outcomes.

Implications for practice

This trial provides additional data that is useful especially is aesthetic concerns are central to the patients expectations.

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Ethical and Environmental Implications of 3D Printing Waste and Dental Waste on Water and Land Systems.

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R Ahmed,[1] S Ahmed,[2] R Mulder[3]

INTRODUCTION

The integration of three-dimensional (3D) printing technologies into dentistry has expanded clinical capability while simultaneously introducing new environmental waste streams. Alongside conventional dental materials, digital manufacturing processes generate chemical residues, polymer waste, and particulate emissions that contribute to contamination of water and land systems through wastewater discharge, landfill persistence, and material degradation.[1,2,3] Understanding the environmental pathways of both digital and conventional dental waste is therefore essential not only for ecological protection but also for ethical professional practice.[4,5,6]

Dental practice and laboratories generate multiple waste streams that extend beyond clinical settings into broader ecological systems. Inadequate handling and disposal allow various contaminants to enter soil and water environments, posing risks to ecosystems, public health, and future generations.[4,5,6] When environmental harm arises as a predictable consequence of routine professional activity, the issue moves beyond environmental management into the domain of professional ethics.[7,8] The generation and disposal of dental waste must therefore be recognised as ethically significant practices requiring moral scrutiny and accountability.[9,10]

This article examines the composition, clinical handling practices, and environmental pathways of 3D printing and dental waste, with particular emphasis on their impact on water (Sustainable goal 6, 14) and land (sustainable goal 15) systems. It argues that foreseeable environmental harm constitutes an ethical challenge under the HPCSA Booklet 16, titled "Guidelines for the Management of Health Care Waste within contemporary dental practice and proposes an ethics-first sustainability framework to address these concerns.[11]

COMPOSITION AND ENVIRONMENTAL PATHWAYS OF 3D PRINTING WASTE IN DENTAL PRACTICE

Material Composition and Waste Generation

Three-dimensional printing in dentistry relies on photopolymer resins, thermoplastics, polymers, and composite materials that generate multiple forms of waste throughout digital workflows.[1,2] Failed or excess prints – including diagnostic models, surgical guides, interim crowns, and dentures –represent a substantial source of discarded material.[2] Support structures used during fabrication are routinely removed and discarded after printing. Uncured or excess photopolymer resin presents environmental risks due to potential toxicity when improperly handled and disposed.[3] Post-processing procedures introduce additional waste through chemical cleaning solvents such as isopropyl alcohol, while standing and finishing processes generate microplastic particles.[2,3] These materials are frequently non-biodegradable and difficult to recycle, contributing to environmental persistence.[8]

Clinical Handling and Disposal Practices

Within clinical and educational environments, 3D printing waste is often managed without proper personal protective measures through variablility and inconsistent practices.[4,12] Materials are typically stored temporarily in sealed containers; however, segregation between hazardous and non-hazardous waste is not always standardised.[12] Disposal may occur through general waste streams or wastewater systems without adequate treatment or differentiation.[2,3] Limited recycling infrastructure and the absence of clear institutional protocols increase the likelihood of improper disposal.[5] As a result, routine workflows may unintentionally facilitate environmentally harmful outcomes despite intentions to maintain clinical efficiency.[2,4]

Pathways to Land Contamination

Land contamination occurs primarily through landfill disposal of polymer-based materials and chemically contaminated waste[5]. Over time, chemical leaching from resins and solvents can infiltrate soil systems, affecting terrestrial ecosystems and groundwater quality.[6] The persistence of non-biodegradable polymers contributes to long-term environmental accumulation and ecological disruption.[2,3]

Pathways to Water Contamination

Water contamination arises when rinse water containing uncured resin, solvents, or particulate residues enter wastewater systems without adequate filtration or treatment.[6,13] These materials may persist within aquatic environments and contribute to chemical pollution, microplastic accumulation, and ecological toxicity.[2,6] Because such contamination pathways are foreseeable outcomes of routine clinical and laboratory processes, continued practices that permit environmental exposure raise ethical concerns regarding preventable harm and professional responsibility.[7,14]

Authors's information
1. Dr R Ahmed. Prosthodontics Department. University of the Western Cape . ORCHID ID: https://orcid.org/0000-0002-0286-9047
2. Dr S Ahmed. Prosthodontics Department. University of the Western Cape. ORCHID ID: https://orcid.org/0000-0001-8174-6928
3. Prof R Mulder. Prosthodontics Department. University of the Western Cape. ORCHID ID: https://orcid.org/0000-0002-8722-7632

Corresponding author
Name: Dr Rukshana Ahmed
Tel: (021) 9373000
Email: rahmed@uwc.ac.za

Conventional Dental Waste and Environmental Impact on Water and Land Systems

While emerging digital technologies introduce new waste streams, conventional dental materials continue to contribute significantly to contamination of water and land systems through similar environmental pathways.[4,6,15] Biomedical and infectious waste require specialised disposal but may still pose environmental risks where infrastructure is limited.[13] Heavy metals such as mercury, silver, and copper from restorative materials can accumulate in soil and aquatic ecosystems, leading to long-term ecological effects.[6] Plastic consumables contribute to landfill persistence and environmental degradation, while chemical disinfectants and pharmaceutical residues may enter wastewater systems, affecting aquatic health.[6] The cumulative and persistent nature of these materials means that conventional dental waste remains a substantial contributor to environmental pollution affecting both terrestrial and aquatic systems.[4,6,15]

Ethical Analysis: Environmental Harm to Water and Land Systems

The contamination of water and land systems through dental and 3D printing waste reframes environmental degradation as a direct ethical concern within contemporary dental practice.[7,8] The principle of non-maleficence requires professionals to avoid causing harm, extending beyond direct patient care to include environmental harms arising from clinical activities.[7] When pollution of soil and water systems is foreseeable, failure to mitigate these risks challenges the ethical obligation to "do no harm".[7,8]

Beneficence requires balancing clinical and technological advantages with broader environmental consequences.[7,14] Sustainability ethics emphasises responsibility to future generations who inherit the ecological impacts of persistent plastic and chemical waste[14]. Environmental justice highlights that environmental degradation disproportionately affects vulnerable communities with limited waste management infrastructure[7]. Ethical responsibility therefore extends beyond individual clinicians to include institutions, educators, manufacturers, and regulators responsible for shaping environmentally responsible professional practice.[9,10]

Ethics-First Sustainability Framework for Environmentally Responsible Dental Practice

An ethics-first sustainability framework positions environmental stewardship as a core professional obligation. [14] Because environmental harms arise from routine professional decisions rather than isolated incidents, ethical reform must occur at systemic levels including governance, institutional policy, and professional education.[7,10] This framework emphasises moral accountability for environmental harm by recognising pollution of water and land systems as ethically significant outcomes of clinical practice.[7,14] Ethical material stewardship requires consideration of environmental impact alongside cost and clinical performance. [2,3] The precautionary principle supports restraint when environmental risks are known but insufficiently mitigated, while lifecycle ethical evaluation considers environmental impact from material production to disposal.[2,3,5] Institutional governance integrates sustainability into accreditation, policy, and audit systems, and ethics education embeds environmental responsibility as a foundational professional competency within dental curricula.[8,9,10]

The recommendations to dental and printing facilities should include collecting uncured/unused liquid resin as hazardous waste, as it is recommended in the United States under RCRA (40 CFR Part 261).[16,17] The development and modification of current products to become more inline with the twelve principles of green chemistry.[18]

CONCLUSION

The environmental consequences of 3D printing waste and conventional dental waste on water and land systems represent ethical challenges rather than purely technical concerns. Understanding the composition, clinical handling practices, and environmental pathways of these materials strengthens professional awareness of the broader harms associated with dental practice. As dentistry continues to embrace technological innovation, ethical reflection must evolve concurrently to ensure that clinical advancement does not occur at the expense of environmental sustainability. The pollution of water and land systems through foreseeable waste pathways demonstrates that environmental degradation is an ethically relevant outcome of professional decision-making. In contemporary dentistry, environmentally responsible practice is not simply desirable, it is an ethical imperative.

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CPD questionnaire

Oral Health and Sustainable Development Goals: Opportunities for interdisciplinary research at a dental school in South Africa.

1. **Select the CORRECT statement. In the study's assessment of 617 research papers, what criteria were used to assign a relevance score of 5 during the mapping process?**
   - A. The paper mentioned a Sustainable Development Goal (SDG) in the keywords only.
   - B. The research was conducted in collaboration with an international partner from a high-income country.
   - C. The research focus was directly and explicitly linked to the specific SDG being evaluated.
   - D. The paper had a high citation count within the 2013–2023 period.
   - E. The paper was published in a top-tier dental journal with a high impact factor.

2. **Choose the CORRECT answer. According to the results of the mapping exercise (Figures 1a and 1b), which two Sustainable Development Goals showed the highest frequency and strongest alignment within the school's research output?**
   - A. SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption).
   - B. SDG 3 (Good Health and Well-being) and SDG 4 (Quality Education).
   - C. SDG 6 (Clean Water and Sanitation) and SDG 17 (Partnerships for the Goals).
   - D. SDG 1 (No Poverty) and SDG 10 (Reduced Inequalities).
   - E. SDG 3 (Good Health and Well-being) and SDG 16 (Peace, Justice, and Strong Institutions).

3. **Which of the following statements is CORRECT. The manuscript argues that dentistry contributes significantly to **SDG 9** through interdisciplinary collaboration. Which specific field was highlighted as a key partner in achieving this?**
   - A. Social Sciences and Behavioural Psychology.
   - B. Environmental Law and Policy.
   - C. Materials Science and Engineering.
   - D. Agricultural Science and Nutrition.
   - E. Human Resource Management and Labour Relations.

4. **Select the CORRECT statement. The manuscript highlights that oral diseases disproportionately affect "poor, vulnerable, and/or marginalised" communities. To address this within the SDG framework, the study suggests a shift in focus. What is this primary shift?**
   - A. Increasing the number of private dental practices in urban centres.
   - B. Moving from a traditional curative approach to a more preventive, integrated approach.
   - C. Focusing exclusively on high-tech aesthetic dentistry to attract international investment.
   - D. Reducing the duration of clinical training to graduate more dentists faster.
   - E. Prioritizing dental tourism as a means of economic growth for the institution.

Oral health care and edentulism: perspectives of patients attending public health clinics in Harry Gwala and eThekwini districts, KwaZulu-Natal.

5. **Choose the CORRECT answer. What is the correct percentage of rural participants who agreed that they visit a dentist for oral screening and dental advice?**
   - A. 60%
   - B. 7.5%
   - C. 49%
   - D. 10.5%

6. **Select the CORRECT option. Which age group represented majority when reporting having 1-9 missing teeth?**
   - A. 30 to <50 years old.
   - B. <30 years old.
   - C. 50+ years old.
   - D. <18 years old.

7. **Which of the statements regarding reasons to visit a dentist is CORRECT?**
   - A. The majority of participants indicated that they last visited a dentist over 10 years ago (n=272; 35.5%)
   - B. The participants who have never visited a dentist were dominated by the 30 to <50 years old age group.
   - C. 23.8% of participants (n=182) have never visited a dentist.
   - D. None of the above statements.

8. **Choose the CORRECT answer. Which p-values are correct for the reasons why participants desired to replace the missing teeth?**
   - A. Difficulty to chew food (p=0.005)
   - B. Difficulty smiling (p=0.007)
   - C. Feelings of embarrassment (p=0.006)
   - D. Limited consumption of food (p=0.003).

9. **Choose the CORRECT answer. What is the correct percentage of participants who last presented to a public oral health facility for their dental needs?**
   - A. The majority of the participants from all represented locations indicated that they last presented to a public oral health facility for their dental needs at 76.4 %.
   - B. The majority of the participants from all represented locations indicated that they last presented to a public oral health facility for their dental needs at 80 %.
   - C. The majority of the participants from all represented locations indicated that they last presented to a public oral health facility for their dental needs at 75.4 %.
   - D. The majority of the participants from all represented locations indicated that they last presented to a public oral health facility for their dental needs at 86.4 %.

Assessing the Knowledge, Attitudes, and Practices about Oral Squamous Cell Carcinoma: A Survey of Oral Health Practitioners in South Africa

10. **Which option is CORRECT. The risk factors for oral squamous cell carcinoma include:**
    - A. Tobacco and alcohol consumption
    - B. Advanced age
    - C. High-risk human papillomavirus
    - D. All of the above are correct

11. Select the CORRECT answer. The high-risk sites for oral squamous cell carcinoma include:
A. Buccal mucosa
B. Palate
C. Ventral surface of the tongue
D. Labial mucosa

12. Which answer is CORRECT. The oral potential malignant disorders include:
A. Leukoplakia
B. Lichen planus
C. Oral submucous fibrosis
D. All of the above are correct

13. Select the CORRECT statement. When a patient visits your practice with a suspicious lesion and you lack the expertise to perform a biopsy, the most appropriate course of action would be:
A. Refer the patient to a periodontist and oral medicine specialist or maxillofacial and oral surgeon for further management
B. Attempt to take a biopsy even if you are not confident
C. Watch online videos and attempt to take a biopsy afterward
D. Prescribe analgesics, and antibiotics and monitor the patient for any symptoms

Evaluation of factors associated with gingival enlargement during fixed orthodontic treatment

14. Choose the CORRECT answer. Which Gingival Index was used to measure the gingival enlargement in the study?
A. Gingival index proposed by Bokenkamp and Bonhorst
B. Kimbal et. al Index
C. Gingival Index proposed by Miller et al
D. SADA gingival index

15. Which option is CORRECT. What type of study design was employed in this study?
A. Cohort
B. Case Control
C. Longitudinal
D. Cross-sectional

16. Select the CORRECT answer. What was the setting of the study?
A. University of Pretoria Oral Health Centre
B. Sefako Makgatho Oral Health Centre
C. Wits Oral Health Centre
D. Soshanguve Oral health Centre

17. Choose the CORRECT answer. What was the response rate in the study?
A. 20%
B. 59.5%
C. 100%
D. 99.6%

Relationship between Wits appraisal and ANB angle in Black South African individuals

18. Select the CORRECT answer. According to the findings of this study, which one of the following parameters is the most reliable to quantify malocclusion in Black South Africans?
A. ANB angle
B. Gonial angle
C. Interincisal angle
D. Wits appraisal

19. Choose the CORRECT option regarding correlations between the ANB angle and Wits appraisal found in this study?
A. Very strong in the positive groups
B. Weak in the negative groups
C. Moderate in the overall sample
D. Moderate in the positive groups

Effectiveness of the Tooth Keepers Digital Intervention in Enhancing Oral Health Awareness and Behaviours Among College Students in Durban, South Africa: A Quasi-Experimental Study.

20. Select the CORRECT statement. What was the primary objective of the Tooth Keepers intervention study?
A. To assess the impact of diet on oral health
B. To evaluate digital access among students
C. To evaluate the effectiveness of a digital tool in improving oral health knowledge and behaviours
D. To compare oral health between schools and colleges

Ethics: Ethical and Environmental Implications of 3D Printing Waste and Dental Waste on Water and Land Systems.

21. Select the CORRECT answer regarding sources of 3D printing waste. Which of the following represents a major source of waste generated during digital dental workflows?
A. Only final printed restorations
B. Support structures and failed prints
C. Sterilisation pouches only
D. Impression trays exclusively

22. Which statement is CORRECT concerning pathways to water contamination? Water contamination from dental 3D printing processes most commonly occurs through:
A. Airborne aerosol dispersion only
B. Mechanical vibration during printing
C. Wastewater discharge containing uncured resin and solvents
D. Heat generation from printers

23. Choose the CORRECT statement regarding conventional dental waste impact. Which material from conventional dentistry is most associated with long-term ecological accumulation in soil and water systems?
A. Glass ionomer powder
B. Heavy metals such as mercury and silver
C. Dental floss
D. Cotton rolls

24. Which statement below concerning ethical principle applied to environmental harm is CORRECT? Within the ethical analysis presented, the obligation to avoid environmental pollution primarily reflects which bioethical principle?
A. Autonomy
B. Justice only
C. Non-maleficence
D. Veracity

25. When considering an ethics-first sustainability framework, which answer is CORRECT? An ethics-first sustainability framework in dentistry primarily emphasises:
A. Technological innovation regardless of environmental impact
B. Individual clinician responsibility only
C. System-level reforms including governance, education, and policy
D. Reduction of clinical treatment options

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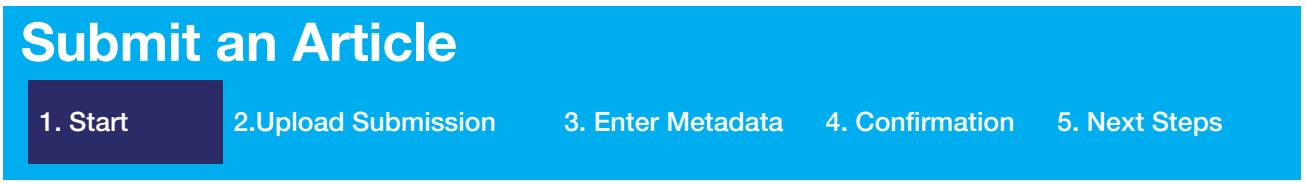

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References: 1. Treatment of stage I-III periodontitis. The EFP S3 level clinical practice guideline. *J Clin Periodontol.* 2020 Jul;47. **2.** Figuero *et al.* 2020. **3.** Bosma, M.L., McGuire, J.A., DelSasso, A. *et al.* Efficacy of flossing and mouth rinsing regimens on plaque and gingivitis: a randomized clinical trial. *BMC Oral Health* 24, 178 (2024). https://doi.org/10.1186/s12903-024-03924-4

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