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Barriers and Facilitators to Digital Technology Adoption in Maxillofacial Practice: A Nigerian Context

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Abstract: The integration of digital technologies into maxillofacial practice represents a paradigm shift with significant implications for clinical outcomes, patient satisfaction and professional efficiency. In the Nigerian context, however, the adoption of such technologies remains nascent and unevenly distributed, constrained by a complex interplay of infrastructural, financial, educational, regulatory and sociocultural forces. This narrative review systematically examines the barriers and facilitators to digital technology adoption in maxillofacial practice within Nigeria, drawing on current global and African literature. Technologies examined include computer-aided design and computer-aided manufacturing (CAD/CAM) systems, three-dimensional (3D) printing, intraoral digital scanning, cone beam computed tomography (CBCT) and artificial intelligence (AI)-assisted diagnostic and prosthetic design tools. Key barriers identified include high acquisition costs, epileptic power supply, limited specialist training, inadequate regulatory frameworks and low institutional investment in health technology infrastructure. Facilitators encompass the growing global accessibility of digital platforms, increasing smartphone and internet penetration, nascent government digitalization policies, growing professional awareness and promising collaborative frameworks between Nigerian universities and international dental technology organizations. The paper advocates for a multi-stakeholder approach involving the government, professional bodies such as the Association of Dental Technologists of Nigeria (ADTN), Dental Technologists Registration Board of Nigeria (DTRBN), training institutions and international partners to accelerate context-appropriate digital technology adoption. Practical strategies for capacity building, phased implementation and policy reform are proposed, along with directions for future empirical research in the Nigerian maxillofacial context.

Keywords: *Digital Technology, Maxillofacial Prosthetics, CAD/CAM, 3D Printing, Nigeria, Dental Technology, Technology Adoption, Barriers, Facilitators, Oral healthcare.*

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I. INTRODUCTION

Maxillofacial practice encompasses a wide spectrum of clinical disciplines, including oral and maxillofacial surgery, maxillofacial prosthetics, dental technology and reconstructive dentistry. Within this continuum, the rehabilitation of patients with acquired or congenital defects of the head, neck and oral cavity demands precision, artistry and technological sophistication. The traditional armamentarium of maxillofacial practice relying heavily on manual impression techniques, conventional casting and analogue fabrication has been progressively challenged by the emergence of digital technologies that promise greater accuracy, reproducibility and efficiency (Wolfaardt et al., 2024).

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Globally, the past two decades have witnessed transformative integration of digital tools in maxillofacial and dental practice. Computer-aided design and computer-aided manufacturing (CAD/CAM) systems, three-dimensional (3D) printing, intraoral digital scanners, cone beam computed tomography (CBCT), virtual surgical planning (VSP) and artificial intelligence (AI)-driven diagnostic tools have become established components of advanced maxillofacial workflows in high-income countries (Ding et al., 2023; Wolfaardt et al., 2024). The global digital dentistry market was valued at approximately USD 6.14 billion in 2024 and is projected to reach USD 15.22 billion by 2034, expanding at a compound annual growth rate (CAGR) of 9.5% (Market.us, 2025). These figures underscore the commercial momentum and clinical confidence invested in digital dental technologies worldwide.

However, the distribution of this digital revolution is profoundly inequitable. In sub-Saharan Africa, including Nigeria, the continent's most populous nation and largest economy, the adoption of digital technologies in maxillofacial practice remains limited, fragmented and largely confined to select academic or private institutions (Tetteh et al., 2019; Adeyemi et al., 2023). Nigeria faces a unique combination of structural, economic, educational and sociocultural challenges that complicate the translation of global technological advances into routine clinical practice. The World Health Organization has noted that over 50% of the population in sub-Saharan Africa lacks access to basic oral healthcare services, a deficiency compounded by severe shortages of skilled dental and maxillofacial professionals (WHO, 2022).

Against this backdrop, the imperative to understand the landscape of digital technology adoption in Nigerian maxillofacial practice becomes evident. Identifying what impedes adoption and what can catalyse it is essential for designing targeted interventions, informing policy and guiding professional development frameworks. This review aims to provide a comprehensive, evidence-based analysis of the barriers and facilitators to digital technology adoption in maxillofacial practice within the Nigerian context. It is intended to inform clinicians, educators, policymakers, professional bodies such as the Association of Dental Technologists of Nigeria (ADTN), the Dental Technologists Registration Board of Nigeria (DTRBN) and international development partners.

II. BACKGROUND AND CONTEXT

➢ *Maxillofacial Practice in Nigeria*

Nigeria's oral health workforce operates within a complex, resource-constrained healthcare environment. The country hosts a network of teaching hospitals, federal medical centres and state hospitals, many of which maintain departments of oral and maxillofacial surgery and dental technology. However, the ratio of oral health professionals to the population remains critically low. According to the WHO, many sub-Saharan African countries, including Nigeria, have fewer than five dentists per 100,000 population, well below the global average (WHO, 2022; Market Data Forecast, 2025). Dental technologists and maxillofacial prosthetists the practitioners responsible for the fabrication of prosthetic devices face even more acute workforce shortages.

The Association of Dental Technologists of Nigeria (ADTN), the principal professional body for dental technologists in the country, has increasingly recognized the need to align Nigerian practice with global digital trends. The Dental Technologists Registration Board of Nigeria (DTRBN) provides the statutory framework for the profession, although ongoing legislative debates such as those surrounding proposed amendments to the enabling Act reflect the evolving professional landscape. Academic institutions such as the Federal University of Technology Owerri (FUTO) and other universities offering dental technology programmes are central to training the next generation of practitioners and, by extension, to shaping their technological competencies.

➢ *Overview of Digital Technologies in Maxillofacial Practice*

The term 'digital technology' in the maxillofacial context encompasses a range of tools and platforms:

- CAD/CAM Systems: Computer-aided design and computer-aided manufacturing platforms enable the digital design and precision milling or printing of prosthetic devices including obturators, orbital prostheses, auricular prostheses, nasal prostheses and dental restorations. These systems dramatically reduce fabrication time and improve dimensional accuracy compared to conventional analogue methods (Hatamleh et al., 2024; Wolfaardt et al., 2022).

- 3D Printing (Additive Manufacturing): Three-dimensional printing allows layer-by-layer fabrication of prostheses, surgical guides, anatomical models and educational tools from digital files. In maxillofacial surgery, 3D printing is used for pre-operative planning, custom implant fabrication and mandibular reconstruction (Nicholas et al., 2023). The dental 3D printing market is projected to reach USD 15.6 billion by 2030, driven by expanding applications and falling material costs (MarketsandMarkets, 2025).

- Intraoral Digital Scanners: These devices replace conventional alginate or polyvinyl siloxane impressions with optical digital scans of the oral cavity, eliminating patient discomfort and providing immediately usable digital files for prosthesis design (Ding et al., 2023).

- Cone Beam Computed Tomography (CBCT): CBCT provides three-dimensional imaging of craniofacial structures at lower radiation doses than conventional CT, enabling precise diagnosis of bony defects, tumour extent and implant site assessment (Wolfaardt et al., 2024).

- Artificial Intelligence (AI): Machine learning and deep learning algorithms are increasingly applied to radiographic interpretation, prosthetic design optimization, material selection and treatment planning in

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prosthodontics and oral surgery (Hassan et al., 2024; Al Hendi et al., 2022).

- Virtual Surgical Planning (VSP): Integrated software platforms allow surgeons and prosthetists to simulate surgical outcomes and prosthetic rehabilitation digitally before any clinical intervention, reducing intraoperative uncertainties (Wolfaardt et al., 2024).

III. METHODOLOGY

This paper is a narrative review of the literature. A systematic search of electronic databases including PubMed/MEDLINE, Google Scholar, ScienceDirect and ResearchGate was conducted using terms such as 'digital technology AND maxillofacial,' 'CAD/CAM AND prosthodontics AND Africa,' '3D printing AND dental AND Nigeria,' 'technology adoption AND oral health AND sub-Saharan Africa,' 'barriers AND digital health AND Nigeria,' and related combinations. Publications from 2010 to 2025 were prioritized, with earlier seminal works included where foundational relevance was established. Grey literature, government reports and professional organization documents were also consulted. Articles were screened for relevance to the Nigerian or broader sub-Saharan African context, with global literature used to contextualize and benchmark findings. A total of 47 sources were reviewed and synthesized thematically under the categories of barriers and facilitators.

IV. BARRIERS TO DIGITAL TECHNOLOGY ADOPTION

➢ *Financial and Economic Barriers*

The high capital cost of digital technology equipment represents perhaps the most pervasive barrier to adoption in Nigeria. CAD/CAM milling units, intraoral scanners, CBCT machines and 3D printers carry acquisition costs ranging from tens to hundreds of thousands of US dollars—sums that are prohibitive for most Nigerian dental laboratories, teaching hospitals and even federal medical centres (Hatamleh et al., 2024; Tetteh et al., 2019). Unlike institutions in Europe or North America, which benefit from insurance reimbursement structures and technology financing schemes, Nigerian healthcare facilities largely operate without such financial scaffolding.

Recurrent costs compound initial investment challenges. Consumable materials for 3D printing biocompatible resins, milling blanks, sintering ovens and software licensing fees represent ongoing expenditures that institutions must sustain. Maintenance contracts and technical servicing requirements for sophisticated equipment also demand foreign currency in a context where the Nigerian naira has experienced significant devaluation (Adeyemi et al., 2023). The limited purchasing power of Nigerian dental technologists in private practice, many of whom operate as sole proprietors with modest revenue streams further restricts individual adoption.

Research on barriers to digital health technology adoption in healthcare settings consistently identifies cost as the primary impediment, particularly in low- and middle-income countries (LMICs) (Nabizadeh et al., 2024; Hassan et al., 2024). A comprehensive umbrella review by Marcolino et al. (2023) found that infrastructure and technical barriers, including cost, constituted the highest relative frequency of occurrence among identified barriers to digital health technology adoption by healthcare professionals globally. This pattern is amplified in the Nigerian context by the structural underfunding of the public health sector.

➢ *Infrastructural Deficits*

Reliable electricity is a prerequisite for operating digital dental equipment. Yet Nigeria's power supply infrastructure is notoriously unstable. Epileptic power supply characterized by prolonged outages, voltage fluctuations and inadequate grid coverage poses a direct threat to the operation of sensitive digital devices and to the integrity of data stored on networked systems (Adair-Rohani et al., 2013). Equipment such as CBCT machines, CAD/CAM milling units and 3D printers are sensitive to voltage irregularities that can cause equipment damage, data corruption and compromised output quality.

Internet connectivity, while improving in urban Nigerian centres, remains inconsistent and expensive, limiting access to cloud-based CAD software, remote technical support, online continuing professional development and teledentistry platforms. Rural and semi-urban facilities where a significant proportion of Nigeria's oral health needs are concentrated face even more severe connectivity challenges (Akinwale et al., 2023; Shekoni et al., 2024). The spatial concentration of functioning digital infrastructure in Lagos, Abuja, Port Harcourt and a few other metropolitan areas creates a pronounced urban-rural digital divide within the country.

Physical space requirements also present barriers. Advanced digital dental suites require dedicated, climatically controlled spaces for equipment storage and operation. Many Nigerian dental laboratories and hospital dental departments operate in cramped, inadequately resourced facilities that cannot accommodate such requirements without significant capital renovation.

➢ *Educational and Training Deficits*

The effective utilization of digital technologies in maxillofacial practice requires a trained and competent workforce. In Nigeria, the curricula of undergraduate dental technology programmes have not kept pace with global digital developments. The majority of training institutions continue to emphasize analogue fabrication techniques, with limited or no formal instruction in CAD/CAM operation, 3D printing workflows, digital impression scanning, or AI-assisted design (Awotidebe et al., 2023). This creates a cohort of graduating dental technologists who are proficient in traditional methods but ill-equipped for digital practice environments.

Postgraduate and continuing professional development (CPD) opportunities in digital maxillofacial technologies are similarly limited within Nigeria. International workshops and

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short courses are financially inaccessible to many practitioners due to tuition costs, travel expenses and visa constraints. The absence of a structured, nationally accredited CPD framework specific to digital dental technologies further impairs the profession's collective upskilling capacity.

This educational gap is not unique to Nigeria; studies from other LMICs, including Uganda and Ethiopia, have documented comparable workforce readiness deficits in digital prosthetics and telemedicine (Yagos et al., 2022; Nigatu et al., 2023). However, the scale of Nigeria's population and therefore the burden of unmet maxillofacial need amplifies the consequences of this training deficit. Hassan et al. (2024) identified psychological and personal issues including lack of confidence and competence with digital tools as among the highest frequency barriers to AI adoption in healthcare, highlighting the critical role of training in facilitating adoption.

- *Regulatory and Policy Gaps*

Nigeria lacks a comprehensive, dedicated regulatory framework for digital health technology in dental and maxillofacial practice. While the National Agency for Food and Drug Administration and Control (NAFDAC) provides oversight for medical devices, the regulatory pathways for the approval, importation and clinical use of advanced dental digital technologies are not clearly defined or consistently enforced (Adeyemi et al., 2023). Practitioners seeking to import CAD/CAM systems or 3D printing materials may encounter protracted customs processes, multiple taxation layers and regulatory ambiguities that deter investment.

At the professional governance level, the DTRBN has not yet issued formal guidelines or standards for digital dental technology practice. The absence of such frameworks leaves practitioners without clear guidance on quality assurance, infection control for digital workflows, data governance, or medico-legal responsibility in digital prosthetic fabrication. This regulatory vacuum may create risk-aversion among both practitioners and institutional administrators contemplating digital investment.

Additionally, national health policy documents such as the National Health Act and the Nigeria Health Sector Renewal Investment Initiative make limited specific reference to oral health digitalization, signalling insufficient political prioritization of this agenda. In contrast, countries such as the United Arab Emirates have explicitly embedded dental digital technology adoption into national health strategies, contributing to accelerated market growth in those settings (Market Data Forecast, 2025).

- *Cultural and Attitudinal Barriers*

Sociocultural factors also influence technology adoption patterns in Nigerian maxillofacial practice. Among practitioners, entrenched professional conservatism, a preference for established manual techniques that have been refined over decades of practice can generate resistance to digital workflow transitions. This resistance is compounded by concerns about job displacement: dental technologists may perceive automated or digitally-assisted fabrication as a threat to artisanal skill sets and economic livelihoods (Hatamleh et al., 2024; Wolfaardt et al., 2024).

From the patient perspective, technology-related health anxiety and unfamiliarity with digital diagnostic tools such as intraoral scanners may engender mistrust or reluctance, particularly among older or rural patients who associate healthcare quality with physical, manual processes. Cultural health beliefs and the strong preference for direct human therapeutic engagement may create subtle friction against the perceived depersonalization that some patients associate with digital interventions (Udenigwe et al., 2022).

At the institutional level, hospital administrators and government health officials may harbour scepticism about the applicability of globally promoted digital technologies to the specific disease burden and resource realities of Nigerian maxillofacial practice a form of contextual mismatch bias that can suppress institutional championship of digital investment.

- *Supply Chain and Maintenance Challenges*

The availability of consumable materials for digital dental technologies including CAD/CAM milling blocks, biocompatible printing resins, scanning sprays and calibration tools is limited and irregular in the Nigerian market. The country's reliance on imported dental materials means that supply chain disruptions, foreign exchange shortfalls, or import policy changes can render even functional equipment inoperable. Local distribution networks for digital dental technology suppliers are underdeveloped, and technical after-sales service is concentrated in a few urban centres, creating significant maintenance vulnerabilities for institutions in other regions (Tetteh et al., 2019).

V. FACILITATORS OF DIGITAL TECHNOLOGY ADOPTION

- *Growing Global Accessibility of Digital Technologies*

Despite the barriers outlined, important global trends are making digital technologies progressively more accessible. The cost trajectories of 3D printers, intraoral scanners, and entry-level CAD software have declined significantly over the past decade, driven by market competition and economies of scale (MarketsandMarkets, 2025). Desktop 3D printers capable of fabricating dental models, surgical guides, and provisional prostheses are now available at price points that approach feasibility for well-resourced Nigerian academic institutions and larger dental laboratories (Nicholas et al., 2023; AMFG, 2024).

Open-source CAD software platforms—including FreeCad and specialized open-source dental design tools—offer pathways to digital design capability without proprietary software licensing costs, reducing the financial entry barrier for students and emerging practitioners. Cloud-based platforms for digital case submission, remote consultation, and virtual articulation are increasingly accessible via smartphone and standard internet connections,

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offering low-cost entry points for digital workflow integration (Eshraghi et al., 2023).

The JMIR rehabilitation study by Dillon et al. (2024) demonstrated that patients receiving prosthetic and orthotic services via digital telehealth platforms reported high satisfaction, suggesting that digital delivery models are both clinically viable and patient-acceptable, even in settings with limited conventional infrastructure a precedent transferable to Nigerian maxillofacial telerehabilitation contexts.

- *Expanding Internet and Mobile Connectivity*

Nigeria has experienced significant growth in mobile internet penetration over the past decade. The Nigerian Communications Commission (NCC) reported over 230 million active mobile subscriptions in 2024, and data costs have declined substantially with the expansion of 4G networks and the emerging rollout of 5G infrastructure in major cities. This connectivity substrate supports several digital health applications relevant to maxillofacial practice, including teledentistry, remote case consultation, digital case documentation, and access to global learning resources (Akinwale et al., 2023; Shekoni et al., 2024).

Mobile health (mHealth) technology uptake studies in Nigeria have demonstrated considerable willingness among both practitioners and patients to engage with digital health tools when connectivity and device availability are adequate. A study by Olamoyegun et al. (2023) found significant mobile phone ownership and willingness to use mHealth services among Nigerian healthcare users, suggesting a foundational digital readiness that could be extended to maxillofacial service delivery contexts.

- *Professional Body Advocacy and Institutional Leadership*

The ADTN, as the professional apex body for dental technologists in Nigeria, occupies a strategically influential position in driving the digitalization agenda. Through presidential communications, professional development programming, annual general meetings and legislative engagement such as positioning the profession within the ongoing DTRBN Act amendment debates the ADTN can create both the normative climate and the structural frameworks necessary to support digital adoption. Establishment of specialty committees focused on digital dental technology, advocacy for curriculum reform in training institutions and partnerships with international digital dental technology bodies are among the mechanisms through which the ADTN can catalyse adoption.

Academic institutions offering dental technology programmes, including FUTO, have the potential to function as incubators for digital competency. The introduction of CAD/CAM and 3D printing modules into undergraduate curricula even at a basic conceptual level exposes future practitioners to digital paradigms, reducing the technology familiarity barrier before they enter clinical practice. Some Nigerian universities have begun exploring additive manufacturing in engineering and medical education contexts, with at least one study from Ladoke Akintola University of Technology, Ogbomoso, documenting the integrative potential of 3D printing in Nigerian medical training (Nicholas et al., 2023).

- *Government Digitalization Policy Frameworks*

The Nigerian government's broader digitalization initiatives provide a contextual opportunity for oral health technology integration. The National Digital Economy Policy and Strategy (NDEPS) 2020–2030 articulates a vision for comprehensive digital transformation across sectors, including healthcare. The Nigeria eHealth Policy and Strategy (2016–2020) and subsequent national health sector investment documents acknowledge the role of technology in improving health service quality and access. Although implementation has been uneven, these policy instruments create normative legitimacy for digital health investment and provide advocacy entry points for dental and maxillofacial professional bodies seeking government partnership and funding support.

International development partners including the World Health Organization, African Development Bank, and bilateral donors have increasingly prioritized digital health capacity building in LMICs. Targeted grant funding, technology transfer agreements, and capacity building partnerships between Nigerian institutions and international dental technology bodies represent available, if underutilized, facilitatory mechanisms (Anibueze et al., 2023).

- *Regional and Pan-African Momentum*

Across sub-Saharan Africa, several countries are demonstrating that digital dental technology adoption is possible in resource-constrained contexts. South Africa has led the continent in CAD/CAM and 3D printing adoption, supported by an explicit government strategy initiated in 2016 that recognized additive manufacturing as a national industrial priority (Gadzala, 2022; STAND, 2024). The Africa 3D and 4D technology market, valued at USD 2.83 billion in 2024, is projected to reach USD 7.32 billion by 2031, growing at a CAGR of 14.8% (JEPA Africa, 2025), indicating continent-wide momentum that Nigeria can leverage through regional knowledge exchange and collaborative procurement strategies.

The STAND organization's vision for transforming prosthetic and orthotic services across sub-Saharan Africa centred on 3D printing, digital knowledge-sharing platforms, and local training capacity offers a model of ecosystem development that is directly applicable to the Nigerian maxillofacial context (STAND, 2024). Pan-African professional forums, shared curriculum development platforms and collaborative research networks represent practical vehicles for Nigeria to participate in this regional digital transition.

- *Evidence Base for Digital Technology Clinical Benefits*

A growing body of clinical evidence supporting the superiority or equivalence at lower resource expenditure of digital techniques over analogue methods constitutes a facilitatory force for technology adoption (Hatamleh et al., 2024; Wolfaardt et al., 2024). Systematic reviews and meta-analyses demonstrating that digitally fabricated prostheses

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achieve comparable or superior fit, aesthetics, and longevity to conventionally fabricated counterparts strengthen the clinical argument for investment. Evidence that intraoral scanning reduces impression material waste and patient discomfort, that CBCT improves surgical accuracy, and that AI-assisted design reduces laboratory processing time collectively builds the case for digital integration (Ding et al., 2023; Hassan et al., 2024).

For resource-constrained settings specifically, the evidence that 3D printing enables the cost-effective fabrication of custom prosthetics at substantially reduced costs compared to imported devices is particularly compelling (AMFG, 2024; Nicholas et al., 2023). When upfront acquisition costs are amortized across large patient volumes as would be feasible in Nigerian teaching hospitals the long-term economic case for digital investment strengthens considerably.

VI. THEORETICAL FRAMEWORK FOR UNDERSTANDING ADOPTION

The Technology Acceptance Model (TAM), originally proposed by Davis (1989) and subsequently extended in multiple forms, provides a useful theoretical lens for understanding digital technology adoption in maxillofacial practice. TAM posits that perceived usefulness and perceived ease of use are the primary determinants of technology acceptance behavior. In the Nigerian context, both dimensions are compromised: practitioners may perceive digital tools as useful in principle but question their practical utility given infrastructural limitations, while the complexity of operating sophisticated digital equipment in resource-constrained settings diminishes perceptions of ease of use.

The Diffusion of Innovations theory (Rogers, 2003) offers complementary insights, particularly its characterization of adopter categories from innovators and early adopters to the late majority and laggards. Evidence suggests that Nigerian maxillofacial practice is currently at a very early adopter stage, with innovators concentrated in a few academic and private centres. Accelerating diffusion requires both the demonstration effect of early adopters (evidence that digital technologies work in Nigerian settings) and the reduction of perceived risk and complexity through training, mentorship, and peer communication networks.

The Consolidated Framework for Implementation Research (CFIR) further helps identify the multilevel determinants of technology adoption, encompassing the intervention characteristics (the technology itself), the outer setting (healthcare system, policy, economy), the inner setting (institutional culture, resources, leadership), individual characteristics (practitioner knowledge, attitudes, and self-efficacy), and the implementation process (training, phased rollout, feedback mechanisms) (Damschroder et al., 2009). A CFIR-informed analysis of digital technology adoption in Nigerian maxillofacial practice highlights the necessity of addressing all five domains simultaneously for sustainable implementation success.

VII. STRATEGIES AND RECOMMENDATIONS

- *Phased Implementation Approach*

Given the significant upfront costs and capacity requirements of full digital workflow integration, a phased, stepwise adoption strategy is recommended for Nigerian maxillofacial institutions. An initial phase might prioritize digital documentation and case communication tools including smartphone-based photographic documentation, digital case records and cloud-based case sharing which require minimal capital investment. A second phase could introduce low-cost, entry-level 3D printing for anatomical models and surgical guides, supported by open-source design software. Full CAD/CAM and high-resolution scanning integration could constitute a later phase, contingent on demonstrated institutional readiness and secured funding.

- *Curriculum Reform and Workforce Development*

The ADTN and the National Universities Commission (NUC) should collaborate with training institutions including FUTO and other universities offering dental technology programmes to revise undergraduate curricula to include foundational digital dental technology competencies. This should encompass theoretical understanding of CAD/CAM principles, practical introduction to open-source dental design software, and exposure to 3D printing workflows. CPD frameworks mandating periodic digital technology training for registered dental technologists should be established by the DTRBN, with recognition of courses offered by international bodies such as the Academy of Digital Technology in Dentistry.

- *Infrastructure Investment and Energy Solutions*

Addressing power supply instability is a prerequisite for reliable digital equipment operation. Institutions contemplating digital technology investment should include solar power systems with battery storage as integral components of their digital infrastructure plans. This approach has been successfully demonstrated in other Nigerian health technology contexts and represents a long-term cost-effective solution to grid unreliability. Strategic partnerships with power sector actors and advocacy for prioritized grid connectivity for health institutions should be pursued at the federal level.

- *Regulatory Framework Development*

The DTRBN, in collaboration with NAFDAC and relevant professional bodies, should develop dedicated guidelines and standards for digital technology use in dental and maxillofacial practice. These should address device approval pathways, data governance and patient privacy in digital workflows, quality assurance standards for digitally fabricated prostheses, and professional liability in AI-assisted practice. Clear, transparent regulatory frameworks reduce adoption risk and encourage institutional investment.

- *Multi-stakeholder Partnerships*

Digital technology adoption in Nigerian maxillofacial practice cannot be achieved through isolated institutional efforts. Multi-stakeholder partnerships involving the ADTN, DTRBN, federal and state governments, international dental

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industry partners, development finance institutions, and diaspora dental professional networks are essential. Partnership models might include equipment donation or concessional loan programmes from international manufacturers, joint venture dental technology centres at teaching hospitals, and technology transfer agreements with universities in countries with established digital dental programmes. The ADTN's presidential platforms and its role in the ongoing DTRBN Act legislative process position it to champion such partnerships at the highest levels of professional and governmental engagement.

- *Research and Evidence Generation*

The Nigerian maxillofacial digital technology literature is sparse, limiting evidence-based advocacy and policy development. There is urgent need for contextually situated empirical research: surveys of digital technology utilization patterns among Nigerian dental technologists and maxillofacial surgeons; cost-effectiveness analyses of digital versus analogue prosthetic fabrication in Nigerian settings; patient satisfaction studies of digitally-facilitated maxillofacial rehabilitation; and implementation science studies of digital technology adoption initiatives. The ADTN, FUTO, and other academic partners should actively pursue such research agendas, with findings published in peer-reviewed journals to build the national evidence base.

VIII. DISCUSSION

The analysis presented in this review reveals a landscape of significant potential constrained by formidable structural barriers. Nigeria's maxillofacial practice community stands at a critical inflection point: the global momentum of digital dentistry, combined with improving domestic digital infrastructure and nascent policy support, creates genuine opportunities for transformative change. Yet the pace and equity of that change will depend on deliberate, coordinated action to address the financial, educational, infrastructural, and regulatory barriers identified.

A comparison with the global digital dentistry trajectory is instructive. In North America, where advanced digital technology has been embedded in maxillofacial prosthodontic practice for over two decades, Wolfaardt et al. (2024) found that an annual mean of 38% of papers published in the Journal of Prosthetic Dentistry from 2011 to 2020 involved clinical use of advanced digital technology—demonstrating how rapidly digital integration has pervaded professional literature and practice in high-resource settings. The Nigerian gap relative to this benchmark is wide but not insurmountable.

The experience of digital health technology adoption in other Nigerian healthcare specialties provides relevant cautionary and optimistic lessons. Studies on telemedicine adoption by Nigerian physiotherapists found that willingness to adopt digital tools was significantly higher among practitioners with prior digital training and access to reliable internet underscoring the mutually reinforcing relationship between training, infrastructure and adoption intent (Awotidebe et al., 2023; Okonkwo et al., 2024). Conversely, barriers such as power instability, connectivity costs, and regulatory ambiguity were consistently cited as adoption inhibitors across Nigerian digital health studies a pattern that mirrors the maxillofacial technology context almost precisely.

The strong advocacy role of professional bodies in driving technology adoption deserves particular emphasis in the Nigerian context. The ADTN's presidential leadership, its legislative engagement with the DTRBN Act amendment process, its committee structures and its annual general meetings represent powerful platforms for normalizing and championing digital practice. International examples such as the American Academy of Maxillofacial Prosthetics' (AAMP) structured deliberation on advanced digital technology, which produced a landmark discussion document informing collective professional strategy (Wolfaardt et al., 2024) demonstrate the transformative potential of organized professional bodies in accelerating digital adoption.

It is important, however, to resist the temptation of uncritical technology boosterism. Digital technologies must be adopted in contextually appropriate ways tailored to Nigerian disease burden patterns, patient population characteristics and resource realities. Not every digital technology that has demonstrated value in high-income country settings will be immediately appropriate or cost-effective in Nigeria. The principle that 'technology should blossom from the needs up, not the top down' (STAND, 2024) offers a valuable corrective orientation: Nigerian maxillofacial professionals must be active architects of their digital futures, not passive recipients of externally designed solutions.

IX. CONCLUSION

The adoption of digital technologies in maxillofacial practice in Nigeria is not a peripheral concern of academic interest alone, it is a matter of clinical urgency, professional competitiveness, and patient welfare. The barriers are real and significant: the financial constraints, infrastructural deficits, educational gaps, regulatory inadequacies and attitudinal resistances documented in this review collectively constitute a formidable adoption challenge. Yet the facilitators are equally real: declining global technology costs, expanding connectivity, growing institutional awareness, professional body leadership, policy-level digitalization commitments, and a continent-wide momentum toward digital health innovation all create genuine pathways forward.

The transformation of Nigerian maxillofacial practice into a digitally empowered field will require sustained, multi-layered intervention. Professional bodies particularly the ADTN must provide visionary leadership and structural frameworks. Academic institutions must modernize curricula and build laboratory capacity. Government must create enabling regulatory environments and invest in health infrastructure. International partners must engage as genuine collaborators rather than vendors. And Nigerian dental technology practitioners themselves must embrace

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continuing education and champion digital adoption within their clinical communities.

This review has sought to provide a comprehensive, evidence-grounded foundation for that collective endeavour. Future empirical research particularly large-scale surveys, implementation science studies, and cost-effectiveness analyses situated specifically in the Nigerian maxillofacial context will be essential to deepen this understanding and inform increasingly precise interventions. The digital future of Nigerian maxillofacial practice is not a distant aspiration; with deliberate action, it is an achievable near-term reality.

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- *Conflict of Interest*

The author declares no conflict of interest.

REFERENCES

[1]. Adair-Rohani, H., Zukor, K., Bonjour, S., Wilburn, S., Kuesel, A. C., Hebert, R., & Mosnier, A. (2013). Limited electricity access in health facilities of sub-Saharan Africa: A systematic review of data on electricity access, sources, and reliability. Global Health: Science and Practice, 1(2), 249–261. https://doi.org/10.9745/GHSP-D-13-00037

[2]. Adeyemi, A. O., Ogunbodede, E. O., & Abiodun-Solanke, I. M. (2023). Digital technology utilization in dental practice in Nigeria: Opportunities and challenges. Nigerian Journal of Clinical Practice, 26(3), 289–297.

[3]. Akinwale, O., Oluwatoyin, A., & Adeleke, K. (2023). Information technology and medicine: Current status, challenges and future prospects of telemedicine in Nigeria. EPRA International Journal of Multidisciplinary Research, 9, 189–190.

[4]. Al Hendi, K. D., Alyami, M. H., Alkahtany, M., Dwivedi, A., & Alsaqour, H. G. (2022). Artificial intelligence in prosthodontics: A review. Bioinformation, 20(3), 238–242. https://doi.org/10.6026/973206300200238

[5]. AMFG. (2024). How can 3D printing benefit underdeveloped countries? Retrieved from https://amfg.ai

[6]. Anibueze, A. U., Talabi, O. T., Talabi, F. O., Aderibigbe, A. A., Zannu, P. N., & Sanusi, B. O. (2023). Using social media-based telemedicine counselling to promote adherence to treatment plans after oral and maxillofacial surgeries in Nigeria. Journal of Information, Communication and Ethics in Society, 31(4), 435–445. https://doi.org/10.1108/jica-04-2023-0023

[7]. Awotidebe, T. O., Fasakin, O. M., Oyewole, O. O., Bello, U. E., Ademoyegun, A. B., Onigbinde, A. T., & Adedoyin, R. A. (2023). Nigerian physiotherapists' knowledge, attitude, and practice of digital physical therapy: A cross-sectional study. Bulletin of Faculty of Physical Therapy, 28(1), 1–8.

[8]. Damschroder, L. J., Aron, D. C., Keith, R. E., Kirsh, S. R., Alexander, J. A., & Lowery, J. C. (2009). Fostering implementation of health services research findings into practice: A consolidated framework for advancing implementation science. Implementation Science, 4(1), 50. https://doi.org/10.1186/1748-5908-4-50

[9]. Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319–340. https://doi.org/10.2307/249008

[10]. Dillon, M., Bishop, K., Ridgewell, E., Clarke, L., & Kumar, S. (2024). Population receiving orthotic/prosthetic services using telehealth in Australia and their experience and satisfaction. Disability and Rehabilitation, 46(6), 1188–1197.

[11]. Ding, H., Wu, J., Zhao, W., Matinlinna, J. P., Burrow, M. F., & Tsoi, J. K. H. (2023). Artificial intelligence in dentistry: A review. Frontiers in Dental Medicine, 4, 1085251. https://doi.org/10.3389/fdmed.2023.1085251

[12]. Eshraghi, A., Phillips, C., & Heim, W. (2023). Business practices efficiency: Impact of integrating digital technology on clinical prosthetics and orthotics practices. Prosthetics and Orthotics International, 47(6), 621–628.

[13]. Gadzala, A. (2022). 3D printing: Shaping Africa's future. Atlantic Council Africa Center Issue Brief. Washington DC: Atlantic Council.

[14]. Hassan, M., Kushniruk, A., & Borycki, E. (2024). Barriers to and facilitators of artificial intelligence adoption in health care: Scoping review. JMIR Human Factors, 11, e48633. https://doi.org/10.2196/48633

[15]. Hatamleh, M. M., Maqableh, A. M., & Al-Wahadni, A. M. (2024). Maxillofacial prosthetics and digital technologies: Cross-sectional study of healthcare service provision, patient attitudes, and opinions. Journal of Prosthodontics, 33(Suppl 1), e13–e21. https://doi.org/10.1111/jopr.13718

[16]. JEPA Africa. (2025). Beyond the blueprint: 3D technology as a catalyst for East African enterprises. Journal of East African Prosperity and Advancement. Retrieved from https://www.jepaafrica.com

[17]. Market Data Forecast. (2025). Middle East & Africa dental consumables market size and forecast 2025–2033. Retrieved from https://www.marketdataforecast.com

[18]. Market.us. (2025). Digital dentistry market to hit US$ 15.22 billion by 2034. Retrieved from https://media.market.us

[19]. MarketsandMarkets. (2025). Innovation and growth redefine the dental 3D printing market. Retrieved from https://www.marketsandmarkets.com

[20]. Marcolino, M. S., Oliveira, J. A. Q., D'Agostino, M., Ribeiro, A. L., Alkmim, M. B., & Novillo-Ortiz, D. (2023). Barriers and facilitators to utilizing digital health technologies by healthcare professionals: An

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26mar1197

umbrella review. npj Digital Medicine, 6(1), 190. https://doi.org/10.1038/s41746-023-00899-4
[21]. Nabizadeh, S., Jalali, M., Kamali, M., Shahabi, S., & Babaee, T. (2024). Barriers and facilitators of receiving prosthetic services in people with lower limb amputation during Covid-19 pandemic: A qualitative study in a developing country. Prosthetics and Orthotics International, 48(2), 230–236.
[22]. Nicholas, A., Oluwaseyi, A., & Olabanjo, O. (2023). Exploring the transformative role of 3D printing in advancing medical education in Africa: A review. Annals of Medicine and Surgery, 85(10), 4913–4919. https://doi.org/10.1097/MS9.0000000000001195
[23]. Nigatu, A., Yilma, T., Gezie, L., Gebrewold, Y., Gullslett, M., Mengiste, S., & Tilahun, B. (2023). Medical imaging consultation practices and challenges at public hospitals in the Amhara regional state, Northwest Ethiopia. BMC Health Services Research, 23(1), 1142.
[24]. Okonkwo, O. C., Ike, S. O., & Obi, I. E. (2024). Telemedicine service adoption during the COVID-19 pandemic: Physicians' experience from Nigeria. Telemedicine and e-Health, 30(3), 805–815. https://doi.org/10.1089/tmj.2023.0262
[25]. Olamoyegun, M. A., Raimi, T. H., Ala, O. A., & Fadare, J. O. (2023). Mobile phone ownership and willingness to receive mHealth services among patients with diabetes mellitus in South-West Nigeria. Nigerian Journal of Medicine, 32(2), 45–52.
[26]. Rogers, E. M. (2003). Diffusion of innovations (5th ed.). New York: Free Press.
[27]. Shekoni, O., Iversen, S., Diaz, G. J., Aune, A., Ubuane, P. O., Imam, Z., & Laerdal, M. (2024). Healthcare workers' perceptions about the use of mobile health technologies in public health facilities in Lagos, Nigeria. SAGE Open Medicine, 12, 20503121231224568. https://doi.org/10.1177/20503121231224568
[28]. STAND. (2024). A vision for revolutionising prosthetics in sub-Saharan Africa. Retrieved from https://stand.ngo
[29]. [29] Tetteh, S., Bibb, R. J., & Martin, S. J. (2019). Maxillofacial prostheses challenges in resource constrained regions. Disability and Rehabilitation, 41(3), 348–356. https://doi.org/10.1080/09638288.2017.1393698
[30]. Udenigwe, O., Okonofua, F. E., Ntoimo, L. F. C., & Yaya, S. (2022). Enablers and barriers to the acceptability of mHealth for maternal healthcare in rural Edo, Nigeria. Dialogues in Health, 1, 100067. https://doi.org/10.1016/j.dialog.2022.100067
[31]. Watson, J., & Hatamleh, M. M. (2014). Complete integration of technology for improved reproduction of auricular prostheses. Journal of Prosthetic Dentistry, 111(5), 430–436.
[32]. Wolfaardt, J. F., Brecht, L. E., Taft, R. M., & Grant, G. T. (2024). The future of maxillofacial prosthodontics in North America: The role of advanced digital technology and artificial intelligence—A discussion document. Journal of Prosthetic Dentistry, 131(6), 1253.e1–1253.e34. https://doi.org/10.1016/j.prosdent.2024.03.016
[33]. Wolfaardt, J. F., Brecht, L. E., & Taft, R. M. (2022). Advanced digital technology in maxillofacial prosthodontics. Journal of Prosthetic Dentistry, 127(2), 345–350. https://doi.org/10.1016/j.prosdent.2020.11.012
[34]. World Health Organization (WHO). (2022). Oral health: Key facts. WHO Fact Sheets. Geneva: WHO. Retrieved from https://www.who.int/news-room/fact-sheets/detail/oral-health
[35]. Yagos, W., Olok, G., Moro, E., Huck, J., & Nirmalan, M. (2022). Use of mobile phones for rehabilitative services among prosthetics users in rural Acholi sub-region of northern Uganda: Findings from a qualitative study. BMC Medical Informatics and Decision Making, 22(1), 145.