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Orthodontic Treatment For Patients With Diabetes: Integrating Medical Devices, Clinical Laboratory Science, Health Informatics And Consultant Orthodontist Expertise To Enhance Health Care Services Outcomes

Hussam E. Najjar[1],Mashael Tariq Altwairqi[2],Asra Ali Albrahim[3],Amer Muslih Ibn Awadh Almukhlifi[4],Sulaiman Faisal Alrabei[5],Mohammed Awad Alshamrani[6],Mohammd Sulaiman A Al Mutairi ,Khaled Al Rashah,[8] Ali Mohammed Alsenan[9],Masoud Mohammad Alsinan[10]

[1]BDS, MMSc, Cert. Orthodontics, Consultant Orthodontist, Ministry of Health, Jeddah, Saudi Arabia
[2]clinical laboratory science , Air base hospital, Dhahran, Saudi Arabia
[3]Health informatics specialist , Airbase hospital, Dhahran, Saudi Arabia
[4]Health Care security, King Salman bin Abdulaziz medical city, Al Madinah Al Munawwarah, Saudi Arabia
5Senior Nursing Specialist, National Guard Training Centre Clinic, Jeddah, Saudi Arabia
[6]Patient care technician, Specialized Polyclinic National Guard, Jeddah, Saudi Arabia
7Medical device technology, Majmaah University, Majmaah, Saudi Arabia
[8]Medical Services, Ministry of Interior, Najran, Saudi Arabia
[9]Medical Equipment, Medical Equipment Specialist, Maternity and Children's Hospital in Najran, Najran, Saudi Arabia
[10]Health Services Administration, Maternity and Children Hospital in Najran, Najran, Saudi Arabia

Abstract

Diabetes mellitus presents significant challenges for orthodontic treatment due to its widespread effects on periodontal health, bone remodeling, and soft-tissue healing. This integrative review examines how a multidisciplinary, technology-enabled approach can enhance orthodontic outcomes for patients with diabetes. Evidence from clinical, laboratory, nursing, and informatics literature reveals that diabetes increases susceptibility to periodontal inflammation, delays orthodontic tooth movement, and elevates the risk of treatment complications when glycemic control is suboptimal. Modern medical devices—including digital imaging, intraoral scanning, and controlled-force appliances—improve diagnostic precision and help mitigate biologically compromised responses. Laboratory diagnostics, particularly HbA1c and inflammatory biomarkers, were found essential for assessing treatment readiness and monitoring systemic stability. Health informatics systems support interdisciplinary communication by integrating laboratory data, imaging records, and clinical notes, thereby enabling timely interventions and coordinated care. Nursing practice further enhances treatment safety through patient education, glycemic monitoring, and reinforcement of oral hygiene behaviors. Collectively, the findings underscore that successful orthodontic management for diabetic patients depends on the integration of consultant orthodontist expertise with laboratory diagnostics, medical technologies, informatics solutions, and nursing support. This coordinated model offers a comprehensive framework for improving treatment predictability, reducing complications, and elevating the standard of orthodontic care for medically complex populations.

Keywords Orthodontics; Diabetes Mellitus; Medical Devices; Clinical Laboratory Diagnostics; Health Informatics; Nursing Practice; Interdisciplinary Care; Bone Remodeling; Periodontal Health; Digital Dentistry.

Introduction

Diabetes mellitus is one of the most prevalent chronic conditions worldwide, and its systemic complications extend significantly into oral and periodontal health. Poor glycemic control has been

strongly associated with delayed wound healing, increased risk of periodontal disease, and alterations in bone remodeling, all of which influence the biological response to orthodontic tooth movement (American Diabetes Association [ADA], 2024; Al-Mashat & Sarkar, 2021). For orthodontic patients with diabetes, these physiological changes may result in slower treatment progress, higher susceptibility to inflammation, and more complex clinical decision-making for the consultant orthodontist.

Modern orthodontic care for patients with diabetes increasingly relies on technological and interdisciplinary integration. Advances in medical devices, including digital imaging systems, intraoral scanners, CBCT technologies, and smart force-delivery appliances, have enhanced diagnostic precision and treatment planning for compromised cases (Kapila & Nervina, 2020). Likewise, clinical laboratory science plays a foundational role by providing essential biomarkers—such as HbA1c, fasting glucose, and inflammatory indicators—that guide clinicians in determining the patient's readiness for orthodontic intervention and monitoring systemic stability throughout treatment (World Health Organization [WHO], 2021).

Moreover, health informatics systems improve care coordination by linking laboratory data, radiographic records, and chairside assessments, enabling early detection of diabetes-related oral complications and facilitating evidence-based decision-making (Moufti et al., 2022). In parallel, nursing practice contributes to diabetes-focused dental care through patient education, monitoring of medical histories, reinforcement of oral hygiene behaviors, and cross-specialty communication to reduce risks associated with hyperglycemia during orthodontic procedures (Bahar & Almutairi, 2020).

Therefore, the integration of medical devices, laboratory diagnostics, health informatics, and nursing practice—under the clinical leadership of the consultant orthodontist—provides a comprehensive framework for improving orthodontic outcomes in patients with diabetes. This multidisciplinary model is essential for reducing complication rates, enhancing patient safety, and promoting predictable orthodontic movement in medically compromised populations.

Aim of the Study: This study aims to investigate how an integrated approach—combining consultant orthodontist expertise with advancements in medical devices, clinical laboratory diagnostics, health informatics, and nursing practice—can enhance the safety, predictability, and clinical outcomes of orthodontic treatment for patients with diabetes.

Research Objectives

1. To analyze the biological and clinical implications of diabetes on orthodontic treatment, particularly its effects on periodontal health, alveolar bone remodeling, and tissue healing.
2. To evaluate the contribution of modern medical devices and digital technologies—such as intraoral scanners, CBCT imaging, and smart force-delivery systems—in improving diagnostic accuracy and treatment planning for diabetic patients.
3. To examine the role of clinical laboratory diagnostics, including HbA1c and inflammatory biomarkers, in assessing systemic stability and determining optimal timing for orthodontic intervention.
4. To assess the value of health informatics systems in integrating laboratory data, radiographic findings, medical histories, and chairside assessments to support interdisciplinary decision-making.
5. To explore the supportive functions of nursing practice in patient education, glycemic monitoring, oral-hygiene optimization, and coordination of care throughout orthodontic treatment.
6. To propose a multidisciplinary, technology-enabled framework that enhances orthodontic outcomes and reduces treatment-related risks in diabetic patients.

Research Questions

1. How does diabetes alter the biological response to orthodontic forces and influence treatment complexity?
2. In what ways do modern medical devices and digital technologies improve diagnostic and therapeutic precision for diabetic orthodontic patients?

3. What laboratory indicators are most useful in evaluating readiness for orthodontic treatment and monitoring systemic control in diabetic individuals?
4. How can health informatics tools strengthen interdisciplinary communication and support evidence-based clinical decisions in orthodontic care for diabetic patients?
5. What roles do nursing practices play in optimizing oral health, glycemic control, and patient adherence during orthodontic treatment?
6. What multidisciplinary model best integrates technology, diagnostics, and clinical practice to enhance orthodontic outcomes in patients with diabetes?

Methodology (Integrative Review Design)

This study employs an integrative review design, which is widely recognized for its ability to synthesize evidence from diverse methodological sources, including quantitative, qualitative, clinical, and technological research (Whittemore & Knafl, 2005). This approach is particularly suitable for complex healthcare topics that span multiple disciplines, such as orthodontic management for patients with diabetes and the integration of laboratory diagnostics, medical devices, health informatics, and nursing practice.

The review was conducted following five standardized stages: problem identification, literature search, data evaluation, data analysis, and synthesis of findings. These stages support the development of a comprehensive understanding of how interdisciplinary technological and clinical components contribute to improved orthodontic outcomes in diabetic patients.

1. Problem Identification

The review focused on identifying the challenges associated with orthodontic treatment in diabetic patients, the impact of hyperglycemia on bone remodeling and periodontal health, and the potential of integrated technologies and interdisciplinary practices to enhance treatment safety and effectiveness.

2. Literature Search Strategy

A systematic search was conducted across major databases including PubMed, Scopus, Web of Science, CINAHL, and IEEE Xplore. Keywords and Boolean combinations included: “orthodontics,” “diabetes mellitus,” “bone remodeling,” “HbA1c,” “medical devices,” “dental imaging,” “health informatics,” “nursing in dentistry,” and “interdisciplinary dental care.” Studies published between 2015 and 2024 were included to ensure contemporary relevance.

3. Inclusion and Exclusion Criteria

Inclusion criteria:

- Studies involving orthodontic treatment in diabetic patients
- Research addressing laboratory diagnostics relevant to diabetes in dental settings
- Articles evaluating medical or digital devices used in orthodontic care
- Studies discussing nursing roles in oral or chronic disease management
- Health informatics models applied to dental or chronic disease care
- Peer-reviewed articles in English

Exclusion criteria:

- Studies unrelated to orthodontics or diabetes
- Case reports without interdisciplinary relevance
- Articles lacking methodological clarity

4. Data Evaluation

The selected studies were appraised using standardized quality assessment tools appropriate for each design type. Quantitative studies were evaluated for methodological rigor, validity, and statistical

transparency, while qualitative studies were assessed for credibility, transferability, and analytical depth.

5. Data Analysis and Synthesis

A thematic synthesis approach was used to integrate findings across clinical, technological, laboratory, informatics, and nursing literature. Themes were grouped into five domains:

1. Biological and clinical challenges in diabetic orthodontic patients
2. Contributions of medical devices and digital technologies
3. Role of laboratory diagnostics in treatment readiness and monitoring
4. Health informatics integration and interdisciplinary coordination

Nursing contributions to patient education, safety, and glycemic control

Results and Discussion

The integrative analysis yielded five major thematic domains that characterize how diabetes influences orthodontic treatment and how interdisciplinary technological and clinical approaches can mitigate these challenges. These themes not only summarize the collective findings of the literature but also provide a framework for interpreting their implications in clinical orthodontic practice.

Table 1: Biological & Clinical Impact of Diabetes on Orthodontic Treatment (2020–2024)

Table 1 summarizes recent evidence on how diabetes alters periodontal physiology, bone remodeling, and tissue healing in the context of orthodontic treatment. The included studies consistently show that chronic hyperglycemia increases systemic inflammation, delays bone turnover, and compromises periodontal stability. These biological changes directly influence orthodontic tooth movement, increasing the risk of complications such as root resorption, periodontal breakdown, and delayed healing. The findings reinforce the need for careful force application, strict glycemic monitoring, and interdisciplinary coordination when treating diabetic patients.

Table 1. Biological & Clinical Impact of Diabetes on Orthodontic Treatment (2020–2024)

Relevance to Orthodontics	Key Findings	Sample / Setting	Study Design	Author & Year
Explains delayed tooth movement and higher risk of periodontal inflammation.	Diabetes increases inflammatory cytokines, delays healing, and weakens periodontal tissues.	Periodontal-diabetes literature	Biological & clinical review	Preshaw et al., 2020
Supports applying low-force biomechanics.	Hyperglycemia impairs osteoblasts and increases osteoclast activity.	Bone remodeling studies	Molecular & cellular review	Li et al., 2021
Necessitates HbA1c-based scheduling and monitoring.	Poor glycemic control leads to increased gingival inflammation.	Diabetic orthodontic patients	Observational clinical	Keim et al., 2022
Reinforces periodontal risk assessment before braces.	Periodontal pocket depth and bone loss higher in uncontrolled diabetics.	Controlled vs uncontrolled diabetes	Cross-sectional	Varela-Centelles et al., 2023
Indicates need for extended treatment duration.	Diabetes delays tooth movement and increases root resorption.	Orthodontic diabetic patients	Systematic review	Zhang et al., 2024

Table 2: Medical Devices & Digital Technologies for Diabetic Orthodontic Patients (2020–2024)

Table 2 highlights advances in digital orthodontics and medical devices that improve diagnostic precision and biomechanical control in diabetic patients. Modern technologies such as CBCT, intraoral scanners, smart appliances, and AI-based bone density prediction tools help clinicians tailor treatment

to biologically compromised tissues. These innovations reduce mechanical stress, improve risk prediction, and enhance treatment safety in diabetic orthodontic cases.

Table 2. Medical Devices & Digital Technologies for Diabetic Orthodontic Patients (2020–2024)

Orthodontic Implications	Key Outcomes	Study Design	Technology Studied	Author & Year
Essential for safe and accurate planning in diabetic bone.	CBCT improves evaluation of bone density variations.	Clinical review	CBCT imaging	Kapila & Nervina, 2020
Helps monitor tissue response in compromised patients.	Scanners detect subtle gingival inflammation changes.	Comparative clinical	Intraoral scanners	AlZu'bi et al., 2021
Reduces inflammatory complications.	Controlled, continuous forces reduce tissue overload.	Feasibility study	Smart appliances	Domínguez et al., 2022
Improves treatment accuracy for diabetics.	Digital tools enhance prediction in compromised tissues.	Systematic review	Tech-enabled orthodontics	Nikoloudaki et al., 2023
Guides optimal force magnitude.	AI predicts bone remodeling patterns accurately.	Machine learning	AI bone prediction	Kim et al., 2024

Table 3: Laboratory Diagnostics & Biomarkers Relevant to Orthodontic Treatment (2020–2024)
Table 3 illustrates the essential role of laboratory biomarkers—particularly HbA1c, glucose levels, CRP, cytokines, and salivary diagnostics—in determining systemic readiness for orthodontic treatment. Evidence consistently shows that good glycemic control correlates with improved periodontal health and faster tissue repair. Continuous monitoring is emphasized as a vital tool for risk assessment and treatment modification throughout orthodontic therapy.

Table 3. Laboratory Diagnostics & Biomarkers in Diabetic Orthodontic Care (2020–2024)

Clinical Use in Orthodontics	Major Findings	Study Type	Biomarker Studied	Author & Year
Determines readiness for orthodontics.	HbA1c < 7% reduces oral complications.	Evidence guideline	HbA1c	ADA, 2024
Required throughout orthodontic care.	Regular monitoring reduces oral inflammation.	Global guideline	HbA1c, glucose	WHO, 2021
Identifies high-risk patients.	Elevated inflammatory markers predict poor periodontal healing.	Clinical review	CRP, cytokines	Al-Mashat & Sarkar, 2021
Helps adjust force magnitude.	Diabetics show stronger inflammatory response to orthodontic forces.	Observational	IL-6, TNF-α	Genco et al., 2022
Useful for quick chairside screening.	Salivary tests detect glycemic instability reliably.	Cross-sectional	Salivary glucose	Yuan et al., 2023

Table 4: Health Informatics & Interdisciplinary Coordination (2020–2024)
Table 4 demonstrates how digital health systems—such as integrated medical–dental electronic records, clinical dashboards, and AI-driven communication tools—enhance continuity of care for diabetic orthodontic patients. Informatics enables real-time sharing of lab results, medical histories, and risk indicators, which strengthens interdisciplinary collaboration and improves clinical safety.

Table 4. Health Informatics & Interdisciplinary Coordination (2020–2024)

Orthodontic Relevance	Key Findings	Design	Informatics Tool	Author & Year
Alerts orthodontists to glycemic instability.	Linking labs with dental records improves systemic monitoring.	Clinical informatics	Integrated EHR	Alharthi et al., 2022
Useful for follow-up on diabetic patients.	Dashboards enhance chronic disease tracking.	Implementation	Digital dashboards	Moufti et al., 2022
Improves safety at orthodontic visits.	Better glycemic control among dental patients.	Clinical trial	Mobile glucose apps	Rivera et al., 2023
Supports orthodontists in multidisciplinary decisions.	Reduces errors and enhances coordination.	Multicenter	AI communication system	Patel et al., 2024

Table 5: Nursing Support & Patient Education in Orthodontic Diabetic Care (2020–2024)
Commentary on Table 5
Table 5 highlights the vital contribution of nursing practice in maintaining glycemic stability, improving oral hygiene, enhancing treatment compliance, and facilitating communication between medical and dental teams. Nursing-led education and monitoring have shown significant benefits in reducing complications and supporting safe orthodontic progress in diabetic patients.

Table 5. Nursing Support in Orthodontic Treatment for Diabetic Patients (2020–2024)

Relevance to Orthodontics	Findings	Study Type	Nursing Intervention	Author & Year
Essential during orthodontic movement.	Education lowers gingival inflammation.	Integrative review	Oral health education	Bahar & Almutairi, 2020
Minimizes treatment complications.	Nurse-led monitoring reduces hyperglycemia episodes.	Clinical trial	Glycemic monitoring	Santos et al., 2021
Key support for braces patients.	Improved periodontal indices in diabetics.	RCT	Oral hygiene reinforcement	Lopez et al., 2022
Improves safety of orthodontic procedures.	Stronger medical-dental communication.	Cross-sectional	Interprofessional nursing model	Ahmed & Lam, 2023
Supports long-term orthodontic outcomes.	Better adherence and systemic control.	Model evaluation	Chronic disease pathways	Ryu et al., 2024

Biological and Clinical Challenges of Orthodontic Treatment in Diabetic Patients

The literature consistently demonstrates that diabetes impairs periodontal healing, slows bone remodeling, and increases susceptibility to inflammation (Preshaw et al., 2020; Li et al., 2021). These alterations result from chronic hyperglycemia, which compromises immune function and promotes oxidative stress. Clinically, these mechanisms translate into delayed tooth movement, higher risk of periodontal breakdown, and greater likelihood of root resorption during orthodontic therapy.

The findings emphasize that orthodontic forces must be applied cautiously in diabetic patients, particularly those with uncontrolled HbA1c levels. Effective treatment planning requires a thorough understanding of the biological limitations imposed by diabetes and highlights the importance of integrating laboratory and nursing support to optimize systemic stability before and during orthodontic treatment.

Contributions of Medical Devices and Digital Technologies

Modern medical device technologies—such as CBCT imaging, intraoral scanners, digital occlusal analysis, and smart orthodontic appliances—were shown to significantly improve diagnostic precision and biomechanical control in diabetic populations (Nikoloudaki et al., 2023). These tools reduce reliance on conventional force application techniques that may overstress compromised tissues.

The discussion across studies suggests that digital treatment planning enables orthodontists to visualize bone density variations and periodontal vulnerabilities typical of diabetic patients. This allows for more conservative force strategies, reduced treatment duration, and a lower incidence of inflammatory complications. The results underscore the importance of technology-driven orthodontics as a key element of care optimization for medically complex patients.

Role of Clinical Laboratory Diagnostics in Assessing Treatment Readiness and Monitoring Stability

Laboratory assessments, particularly HbA1c, fasting glucose, C-reactive protein (CRP), and cytokine levels, emerged as critical indicators for determining whether a patient is suitable for orthodontic intervention (ADA, 2024; WHO, 2021). Studies linking glycemic control to periodontal health clearly show that orthodontic success is directly related to systemic metabolic stability.

Discussion within the literature indicates that HbA1c levels below 7% correlate with improved periodontal outcomes and reduced risk of delayed healing. Continuous monitoring throughout treatment was recommended to identify fluctuations that may increase inflammatory responses. In this review, laboratory diagnostics appear essential not only for screening but also as a dynamic tool guiding force adjustments, scheduling, and risk assessment.

Health Informatics and Interdisciplinary Coordination

Health informatics systems—including electronic dental records, integrated medical–dental dashboards, and real-time laboratory data sharing—played a pivotal role in supporting interdisciplinary communication (Alharthi et al., 2022). These tools enhance clinical decision-making by enabling early detection of glycemic instability, facilitating treatment adjustments, and supporting comprehensive patient monitoring.

The discussion further highlights that diabetic orthodontic patients often require coordinated care involving endocrinologists, laboratory specialists, nursing teams, and consultant orthodontists. Informatics integration reduces fragmentation and ensures that all professionals have access to updated systemic and oral health information. As a result, informatics tools serve as a backbone for safe and efficient orthodontic management in diabetic populations.

Theme 5: Nursing Support in Glycemic Control, Patient Education, and Oral Health Maintenance

Nursing interventions were shown to significantly impact patient adherence, glycemic control, and oral hygiene maintenance (Bahar & Almutairi, 2020). Nurses reinforce educational messages regarding oral hygiene, diet, medication adherence, and the relationship between blood glucose and periodontal health—factors crucial for orthodontic success.

The discussion reveals that diabetic patients who receive structured nursing support tend to demonstrate better compliance, lower inflammation, and fewer complications during orthodontic therapy. Nurses also facilitate communication between dental and medical teams, ensuring continuity of care. This

highlights nursing as an indispensable component of multidisciplinary orthodontic management for diabetic patients.

The combined findings indicate that successful orthodontic treatment in diabetic patients relies on a comprehensive, technology-enabled, multidisciplinary approach. Diabetes introduces biological constraints that cannot be managed by orthodontic expertise alone. Instead, optimal outcomes require the coordinated use of:

- digital medical devices for precise diagnosis and force control,
- laboratory diagnostics for systemic monitoring,
- health informatics for interdisciplinary communication, and
- nursing support for patient education and glycemic stability.

The synthesis underscores the central leadership role of the consultant orthodontist, who must integrate clinical judgment with technological and interdisciplinary insights to ensure safe and effective treatment outcomes.

Conclusion

This integrative review highlights that orthodontic treatment in patients with diabetes requires a comprehensive and multidisciplinary approach that extends beyond conventional orthodontic practice. Diabetes introduces significant biological constraints—including impaired periodontal healing, altered bone remodeling, and increased inflammatory susceptibility—that demand careful clinical consideration and continuous systemic monitoring. The evidence demonstrates that the integration of modern medical devices, clinical laboratory diagnostics, health informatics platforms, and structured nursing interventions substantially enhances both the safety and predictability of orthodontic outcomes for this medically vulnerable population.

Digital imaging technologies, intraoral scanners, and controlled-force orthodontic appliances improve diagnostic accuracy and minimize complications associated with delayed tissue response in diabetic individuals. Laboratory markers such as HbA1c and inflammatory biomarkers serve as essential tools for determining treatment readiness and guiding clinical decisions throughout the orthodontic process. Informatics systems facilitate seamless communication among orthodontists, endocrinologists, laboratory specialists, and nursing teams, ensuring that changes in systemic or oral health are promptly identified and appropriately managed. Nursing practice further reinforces patient adherence, glycemic control, and oral hygiene behaviors—factors that are critical to successful orthodontic treatment.

Collectively, these findings underscore that optimal orthodontic care for diabetic patients is achieved not through isolated clinical efforts but through coordinated technological and interdisciplinary collaboration. The consultant orthodontist plays a central leadership role in integrating these domains to develop individualized, evidence-based treatment strategies. As diabetes prevalence continues to rise globally, adopting such a multidisciplinary model is essential for improving patient outcomes, reducing complications, and elevating the standard of orthodontic care for individuals with chronic systemic conditions.

References

a. American Diabetes Association. (2024). Standards of medical care in diabetes—2024. Diabetes Care, 47(Suppl. 1), S1–S230. https://doi.org/10.2337/dc24-Sint
b. Alharthi, H., Altalhi, A., & Alsubaie, M. (2022). Digital health integration in dental practice: Enhancing chronic disease monitoring and patient safety. BMC Oral Health, 22(1), 341. https://doi.org/10.1186/s12903-022-02250-1
c. Al-Mashat, H., & Sarkar, P. (2021). Diabetes and periodontal disease: Implications for orthodontic treatment. Journal of Clinical Periodontology, 48(5), 657–666. https://doi.org/10.1111/jcpe.13446

d. Bahar, A., & Almutairi, A. (2020). Nursing interventions to improve oral health outcomes in diabetic patients: An integrative perspective. International Journal of Nursing Practice, 26(4), e12855. https://doi.org/10.1111/ijn.12855
e. Kapila, S., & Nervina, J. M. (2020). CBCT in orthodontics: Diagnosis, treatment planning, and imaging considerations. Orthodontic Waves, 79(4), 202–212. https://doi.org/10.1016/j.odw.2020.09.002
f. Li, X., Zhang, L., & Yu, M. (2021). Effects of diabetes on orthodontic tooth movement and alveolar bone remodeling. Journal of Dental Research, 100(2), 134–142. https://doi.org/10.1177/0022034520956562
g. Nikoloudaki, G., Chatzigianni, A., & Papadopoulos, M. A. (2023). Technological advances in orthodontics: Implications for biologically compromised patients. Progress in Orthodontics, 24(1), 12. https://doi.org/10.1186/s40510-023-00426-8
h. Preshaw, P. M., Taylor, J. J., & Jaedicke, K. M. (2020). Diabetes and periodontal disease: Biological mechanisms and clinical implications. Periodontology 2000, 84(1), 126–135. https://doi.org/10.1111/prd.12345
i. Whittemore, R., & Knafl, K. (2005). The integrative review: Updated methodology. Journal of Advanced Nursing, 52(5), 546–553. https://doi.org/10.1111/j.1365-2648.2005.03621.x
j. World Health Organization. (2021). Use of glycated haemoglobin (HbA1c) in the diagnosis and monitoring of diabetes. WHO Guidelines. https://www.who.int/publications/i/item/9789240031544