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REVIEW

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Domains, competences and learning outcomes for undergraduate education in periodontology

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Abstract

Aim: This review is intended to adapt the current conceptual framework in dental education based on four domains to propose a set of competences, learning outcomes and methods of teaching, learning and assessment for undergraduate education in periodontology.

Review: Based on the current framework of competences and learning outcomes recommended by the Association for Dental Education in Europe (ADEE), undergraduate education in periodontology has been updated using the classification and clinical practice guidelines for the diagnosis and treatment of periodontal and peri-implant diseases.

Conclusions: Specific learning outcomes have been proposed within each competence area, that is in Domain I ($n = 10$), Domain II ($n = 13$), Domain III ($n = 33$) and Domain IV ($n = 12$). Teaching methods and learning activities based on the different dimensions of the cognitive process have been proposed. Additionally, 10 key learning outcomes have been proposed as exit outcomes, which implies their accomplishment within the final assessment of any graduating student.

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KEYWORDS
curriculum, dental education, learning outcomes, periodontology, undergraduate

Clinical Relevance

Scientific rationale for study: Within the context of the 19th European Workshop on Periodontology and the Second European Consensus Workshop on Education in Periodontology 'Education in Periodontology in Europe', there is a need to update the competences, learning outcomes and methods of teaching in periodontal undergraduate education.

Principal findings: Specific ($n = 68$) and key ($n = 10$) learning outcomes for undergraduate periodontology have been proposed within each respective domain. Teaching methods and learning activities based on their different cognitive process dimensions have been recommended.

Practical implications: These learning outcomes should be the minimum levels of performance that should be successfully met at the degree-level qualification.

1 | INTRODUCTION

In the mid-1990s, competency-based education was adopted in undergraduate and predoctoral dental education (American Association of Dental Schools (AADS) & American Association of Dental Education (ADEA), 1997; Boyd et al., 1996; Plasschaert et al., 2002). While competence is merely a professional construct reflecting professional behaviour and skills required from clinicians, learning outcomes are largely an educational construct, consisting of a series of individual and objective outcomes shared between dental students and educators, designed to facilitate the learning and assessment process (Cowpe et al., 2010; Field, Cowpe, & Walmsley, 2017). To confirm that graduating European dentists achieve harmonized and comparable competences and learning outcomes during their education, the Association for Dental Education in Europe (ADEE) has outlined and subsequently updated the undergraduate curriculum framework and competence profiles (Cowpe et al., 2010; Field, Cowpe, & Walmsley, 2017; Manogue et al., 2011; Plasschaert et al., 2005). This framework is aligned with the Bologna declaration and provides best academic practices for dental education in Europe (Field, Cowpe, & Walmsley, 2017).

Using the seven domains recommended by the ADEE (Cowpe et al., 2010), the European Federation of Periodontology (EFP) published a consensus paper describing the recommended minimum set of competences ($n = 59$) in periodontology for the undergraduate dental student (Sanz & Meyle, 2010). Subsequently, the ADEE has updated the educational framework for Dental Undergraduate Education and Training, in 2017 (Field, Cowpe, & Walmsley, 2017), reducing the domains from seven to four and including within each domain their respective areas of competence, learning outcomes, and methods of teaching, learning and assessment (Field, Walmsley, et al., 2017) (Table 1). This framework is aimed at ensuring that European dental students upon graduation have acquired the necessary knowledge, skills and attitudes to be able to provide autonomous general dental care. This implies that the graduating student has to meet a number of requirements to provide safe, effective, sustainable and appropriate care for their patients (Domain II) (Field, DeLap, & Manzanares Cespedes, 2017), with a professional behaviour (Domain I) (McLoughlin et al., 2017); delivering care that respects and responds to individual patient preferences, needs and values (Domain III) (Field, Kavadella, et al., 2017); and promoting health, being able to monitor interventions and implementing effective strategies of care at population and community levels (Domain IV) (Gallagher & Field, 2017).

Furthermore, the basis for current clinical periodontology has been established within the last 5 years by the publication in 2018 of a classification for periodontal and peri-implant diseases and conditions proposed by the EFP and the American Academy of Periodontology (AAP) (Caton et al., 2018) and the S3 Clinical Practice Guidelines for the treatment of patients with periodontitis Stages I–III, periodontitis Stage IV and for the prevention and treatment of peri-implant diseases, published in 2020, 2022 and 2023, respectively (Herrera et al., 2022; Herrera et al., 2023; Sanz et al., 2020). In the light of these important changes, there is a need to adapt the previous EFP consensus on undergraduate education in periodontology (Sanz & Meyle, 2010), including not only the current ADEE recommendations for undergraduate education in dentistry (Field, Cowpe, & Walmsley, 2017) but also the 2018 classification and the S3 clinical guidelines, aiming to facilitate the graduating dentist to achieve clinical competences in periodontology using the current standards of evidence-based clinical practice.

This review aims to provide the conceptual framework of modern outcome-based dental education in undergraduate periodontology by updating the competences, learning outcomes and methods of teaching, learning and assessment within the different domains: Domain I (Professionalism), Domain II (Safe and Effective Clinical Practice), Domain III (Patient Centred-Care) and Domain IV (Dentistry in Society).

2 | REVIEW

2.1 | Conceptual framework of modern dental education

In the last 20 years, the ADEE has been publishing educational guidelines (Manogue et al., 2011) encouraging a shift from a teacher-centred (with emphasis on the content delivered by the teacher) to a

TABLE 1 The outlined seven educational domains (I–VII) and major competences by Cowpe et al. (2010), which were updated and simplified into four domains (I–IV) and their defined areas of competence (Field, Cowpe, & Walmsley, 2017), respectively.

Educational domains and major competences in 2009 (Cowpe et al., 2010)		Revised structure of educational domains and their areas of competence (Field, Cowpe, & Walmsley, 2017)	
I	**Professionalism** • 1.1 Professional attitude and behaviour • 1.2 Ethics and jurisprudence	I	**Professionalism** (McLoughlin et al., 2017) • 1.1 Ethics • 1.2 Regulation • 1.3 Professional behaviour
II	**Interpersonal, Communication and Social Skills** • 2.1 Communication	II	**Safe and effective clinical practice** (Field, DeLap, & Manzanares Cespedes, 2017) • 2.1 Evidence-based practice • 2.2 Management and leadership • 2.3 Teamworking and communication • 2.4 Audit and risk management • 2.5 Professional education and training
III	**Knowledge Base, Information and Information Literacy** • 3.1 Application of basic biological, medical, technical and clinical sciences • 3.2 Acquiring and using information	III	**Patient-Centred Care** (Field, Kavadella, et al., 2017) • 3.1 Applying the scientific basis of oral health care • 3.2 Clinical information-gathering and diagnosis • 3.3 Treatment planning • 3.4 Establishing and maintaining oral health
IV	**Clinical Information-Gathering** • 4.1 Obtaining and recording a complete history of the patient's medical, oral and dental state	IV	**Dentistry in Society** (Gallagher & Field, 2017) • 4.1 Dental public health • 4.2 Health promotion and disease prevention • 4.3 Population demography, health and disease • 4.4 Healthcare systems • 4.5 Planning for health and oral health
V	**Diagnosis and Treatment Planning** • 5.1 Decision making, clinical reasoning and judgement		
VI	**Therapy: Establishing and Maintaining Oral Health** • 6.1 Establishing and maintaining oral health		
VII	**Prevention and Health Promotion** • 7.1 Improving oral health of individuals, families and groups in the community		

student-centred educational framework (emphasizing what is being learned by the student). In this framework, the design of dental curricula should be based on the outcomes that students are expected to achieve at the end of the course, rather than on the fulfilment of the educational objectives of the programme. Within this model of outcome-based education, the outcomes should be clearly specified, and the proposed teaching methods and assessment procedures should be aimed at achieving these stated learning outcomes (Harden et al., 1999). This educational framework has been broadly used in medical and healthcare curricula worldwide, and has, as advantages, its transparency and comparability in the educational standards (including international benchmarking), which facilitates the recognition of qualifications and student mobility, improves the coherence in the curricular content because it tries to avoid areas of overlap and provides standard qualifications for a profile of dental graduate. These characteristics are aimed at providing clear information to employers and higher education institutions, thus improving graduate employability (Adam, 2004) through an optimal and unified management of each individual's periodontal and peri-implant health and conditions.

The ADEE has adopted this model of outcome-based education and has proposed a framework for the curriculum planning in Undergraduate Dental Education in Europe based on learning outcomes (Field, Cowpe, & Walmsley, 2017) organized in domains and areas of competence, where each learning outcome is designed and the associated methods of quality assurance are described. This structured view of outcome-based education is adapted in Figure 1 using four concentric circles, where the first level (inner circle) represents the domains as the basis of learning, followed by the areas of competence directly related to each of the domains.

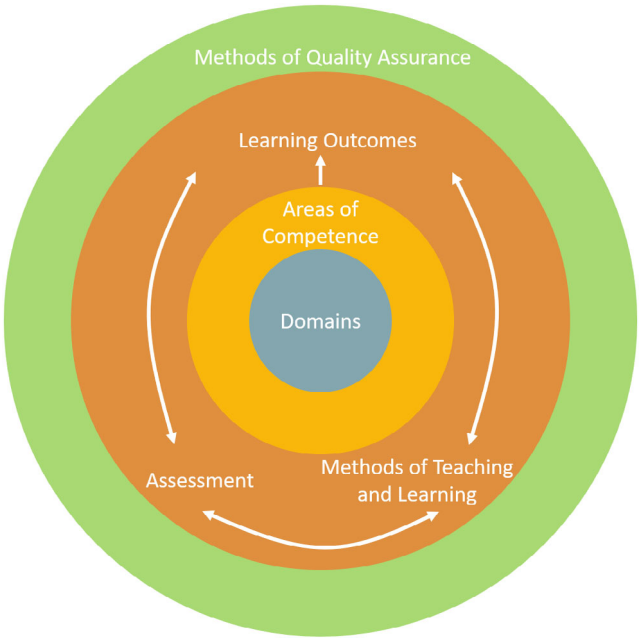

FIGURE 1 Conceptual representation from the basis for learning (domains) to the assurance of the quality of that learning. Each step in the process is crucial to the next, culminating in high-quality education that is measurable and reliable. Adapted from Field, Cowpe, and Walmsley (2017).

Within each area of competence, learning outcomes should be designed following the principles of constructive alignment (Biggs, 1999), in such a way that teaching, learning activities and assessment methods are aligned and aimed to directly support their achievement. Finally, methods of quality assurance, such as student evaluations, peer review and accreditation processes, support the effectiveness of the educational programme, its coherence and the assurance to educators and society that the expected outcomes have been achieved.

Outcome-based education, therefore, provides an attractive and useful way to manage dental education, given the explicit way in which learning outcomes are conceptualized and presented. Competences in dental education have been defined as the aggregate of knowledge, skills and attitudes, appropriate to each of the individual aspects of the dental profession, defined in the profile of the European Dentist (Plasschaert et al., 2007). Competences are also often designated as the minimum acceptable level of performance for a graduating dentist, and as such they should be organized around the patient's needs and the accountability that professionals have for their health and well-being (Sanz & Meyle, 2010). However, the term 'competency' allows for broad interpretations, and it is difficult to assess within the educational environment. In modern dental education, therefore, defining learning outcomes is preferred to competences, since these clearly

TABLE 2 Domain I: Professionalism-related areas of competence (AOCs) and learning outcomes in undergraduate periodontal education.

AOC	Learning outcomes—A graduating dentist *must be able to*
1.1. Ethics	1.1.1. Apply the core moral and ethical principles involved in the provision of periodontal/peri-implant care to individual subjects, populations and communities without prejudice in respect of their age, culture and diversity of background.
	1.1.2. Place the patient at the centre of care and focus on their best interests and values during all interactions, including diagnosis and personalized care. The main goal of periodontal/peri-implant care is the reinstitution of periodontal/peri-implant health to ensure the longevity of the natural dentition/implants and proper masticatory functions.
	1.1.3. Demonstrate respect for patient autonomy, informed consent, confidentiality, as well as colleagues' professional reputation at all times, including on social media.
1.2. Regulation	1.2.1. Apply strategies to minimize possible health risks derived from the use of preventive, diagnostic and therapeutic procedures (i.e., ionizing radiation exposure, antimicrobial resistance due to misuse of antimicrobials).
	1.2.2. Comply with the legislative and administrative processes that impact the practice of periodontology, including infection prevention/control procedures, periodontal/peri-implant diagnosis as well as care, data protection and sustainability regulations.
1.3. Professional behaviour	1.3.1. Demonstrate practical skills, including analytical, problem-solving, planning, communication, presentation, team building and leadership skills.
	1.3.2. Integrate contemporary knowledge and understanding of the broader issues of periodontology (i.e., impact on quality of life and systemic health) and the relevance of these issues in clinical practice.
	1.3.3. Use appropriate professional behaviour towards patients and all team-members in the field of dentistry, medicine and other multi-disciplinary environments.
	1.3.4. Reflect on their own decisions, actions and performance, and be able to apply this to the process of continuing professional development.
	1.3.5. Critique current clinical practices in relation to their environmental impact and encourage realistic/practical solutions to improve sustainability in periodontology.

Note: Adapted from McLoughlin et al., 2017, Duane et al. (2021) and Field et al. (2023).

define what a student is expected to know, understand and/or be able to demonstrate after the completion of a learning process (Adam, 2004; Kennedy, 2006). Learning outcomes should be clearly and unambiguously expressed and should be defined and structured with the aim of aligning teaching, learning and assessment activities. Bloom's taxonomy provides a list of active verbs (e.g. generate, recognize, carry out, evaluate) that describe the level of student's understanding and performance and, hence, this taxonomy is very suitable for defining learning outcomes (Anderson & Krathwohl, 2001). On the contrary, stative verbs, such as know, understand, learn or be aware of, are usually not useful because they do not convey the level of performance required for the student. The final list of learning outcomes should not be long to favour the adjustment of teaching, learning and assessment activities and the fostering of the student's deep learning (Biggs, 2014; Manogue et al., 2011). Furthermore, by reading these learning outcomes, students should be able to know what is the expected level they should achieve.

2.2 | Domains, areas of competence and learning outcomes in the undergraduate curriculum in periodontology

2.2.1 | Domain I: Professionalism

Professionalism is a multidimensional construct with individual, interpersonal and societal dimensions (McLoughlin et al., 2017) and includes commitments to a set of values, standards, behaviours and partnerships, which emphasize good dental practice. Upon graduation, the student is expected to achieve the learning outcomes related to professionalism, as presented in Table 2.

2.2.2 | Area of competence 1.1: Ethics

The core ethical principles, including the primacy of patient welfare, respect for patient autonomy and commitment to social justice, form the basis for dental professionalism (McLoughlin et al., 2017). Additionally, it is an ethical obligation to ensure that the practice of periodontology adheres to the principles related to sustainable dentistry (Duane et al., 2021; Field et al., 2023) and contributes to planetary health by ensuring minimal environmental harm.

2.2.3 | Area of competence 1.2: Regulation

Dentists must have a comprehensive knowledge of, and the skills to comply with, the regulatory systems of the country in which they have been trained/will practice (after graduation) (McLoughlin et al., 2017). This includes legislation and codes of ethics applicable to all aspects of the practice of dentistry, including an enhanced awareness of relevant legislation and regulations related to sustainability (Duane et al., 2021).

2.2.4 | Area of competence 1.3: Professional behaviour

Professional behaviour permeates all aspects of good dental practice, responsibility and accountability and ensures a holistic approach to the provision of high-quality patient care (McLoughlin et al., 2017). Moreover, dentists are encouraged to practice using sustainable approaches (Duane et al., 2021).

2.2.5 | Domain II: Safe and effective clinical practice

Dentists are required to be competent in operative procedures and thereby be capable of providing safe, effective, sustainable and appropriate care for their patients (Duane et al., 2021; Field, DeLap, & Manzanares Cespedes, 2017), while successfully managing and leading a wider oral health team. Upon graduation, the student is expected to accomplish the learning outcomes related to Safe and Effective Clinical Practice, as depicted in Table 3.

2.2.6 | Area of competence 2.1: Evidence-based practice

Patient-centred care should be associated with a contemporaneous evidence base whenever and wherever feasible. The management systems and the quality of care provided should reinforce that this evidence is frequently evaluated and improved (Field, DeLap, & Manzanares Cespedes, 2017).

2.2.7 | Area of competence 2.2: Management and leadership

The key elements of leadership involve team-building, working with strategic objectives and organizational values, and providing effective and appropriate management and resourcing (Field, DeLap, & Manzanares Cespedes, 2017). Overall, effective clinical leadership results in higher quality care. Moreover, graduating dentists are expected to deal with performance issues, effectively audit local performance and confront the needed changes.

2.2.8 | Area of competence 2.3: Teamworking and communication

The graduating dentist is responsible for communicating effectively with patients, the members of the associated healthcare team and

TABLE 3 Domain II: Safe and effective clinical practice-related areas of competence (AOCs) and learning outcomes in undergraduate periodontal education.

AOC	Learning outcomes—A graduating dentist *must be able to*
2.1. Evidence-based practice	2.1.1. Use evidence-based knowledge and critical thinking in daily practice, including health promotion, behaviour change, risk assessment, diagnosis and treatment of periodontal/peri-implant diseases.
	2.1.2. Evaluate critically the validity of claims made by industry and on social media in relation to the clinical and environmental risks, benefits and costs of products, processes and procedures.
2.2. Management and leadership	2.2.1. Implement team work and leadership skills, including the delegation of relevant tasks to dental/oral hygienists and other team members.
	2.2.2. Identify, manage and minimize adverse events to patients and/or staff in the short and long term.
2.3. Teamworking and communication	2.3.1. Communicate effectively, interactively and reflectively with patients and, if appropriate, with their families or caregivers, together with other health professionals involved in the care.
	2.3.2. Provide relevant evidenced-based information to the dental team and patients, using contemporary periodontal terminology, including lay language, if appropriate, when talking to patients.
	2.3.3. Generate a patient–dentist relationship that emphasizes the patient's role and responsibility as a team member to allow effective delivery of periodontal/peri-implant care, and ensure awareness of the importance of long-term compliance.
	2.3.4. Recognize when and how to share information and professional knowledge with the patient and other professionals effectively, in the light of the interactions of periodontal/peri-implant diseases with other systemic diseases/conditions and their treatments.
2.4. Audit and risk management	2.4.1. Carry out a safe clinical practice and provide a safe working environment (i.e., audit, cross-infection control measures, risk management regarding working ergonomics, visual perception and work stress, quality assessments of outcomes of the care provided, and of the protocols, devices, instruments and hazardous material used).
2.5. Professional education and training	2.5.1. Generate time-management skills.
	2.5.2. Recognize their own limitations, as the complexity of advanced periodontal/peri-implant diseases may exceed the competence in general practice and may warrant referral to oral health professionals with specific training.
	2.5.3. List available career choices and training opportunities in periodontology.
	2.5.4. Generate self-learning and methods to acquire knowledge and seek continuing professional education, in order to ensure that clinical skills and evidence-based knowledge are maintained and updated, as scientific and technological advances occur continuously and justify a constant review of the standards of periodontal practice.

Note: Adapted from Field, DeLap, and Manzanares Cespedes (2017), Duane et al. (2021) and Field et al. (2023).

other allied professionals who are involved in patient-centred care (Field, DeLap, & Manzanares Cespedes, 2017).

2.2.9 | Area of competence 2.4: Audit and risk management

In terms of safe and effective patient-centred care, dentists need to identify when and why things are going wrong and what to do in order to prevent adverse events in the future (Field, DeLap, & Manzanares Cespedes, 2017). Moreover, clinical audit is part of the process of measuring and monitoring the quality of care against the set standards or previous performance.

2.2.10 | Area of competence 2.5: Professional education and training

Dentists must demonstrate a lifelong commitment to continuing professional development and maintenance of their knowledge and skills. Therefore, continuous assessment and a willingness to keep up to date with the latest developments and evidence-based practice are mandatory acts after graduation (Field, DeLap, & Manzanares Cespedes, 2017).

2.2.11 | Domain III: Patient-centred care

Regarding patient-centred care, the provided treatment should be respectful and responsive to the patient's preferences, needs, expectations and concerns, ensuring that patient's values guide all clinical decisions (Field, Kavadella, et al., 2017). Moreover, dentists must be aware of the scientific basis of care and should be able to gather and record all relevant information supporting the planning of treatment. Upon graduation, the student is expected to accomplish the learning outcomes related to Patient-Centred Care, as depicted in Table 4.

2.2.12 | Area of competence 3.1: Application of the scientific basis in periodontal/peri-implant health care

This section mainly deals with the scientific knowledge in periodontology that the graduating dentist should acquire to be able to provide the best available, evidence-based, patient-centred therapy.

TABLE 4 Domain III: Patient-centred care-related areas of competence (AOCs) and learning outcomes in undergraduate periodontal education.

AOC	Learning outcomes
3.1. Application of the scientific basis in periodontal/peri-implant health care	A graduating dentist *must be able to* demonstrate an understanding of, and apply, the scientific knowledge base relating to
	3.1.1. The scientific basis of periodontal and peri-implant health, including relevant knowledge of periodontal and peri-implant anatomy and physiology, as well as the needed basic sciences (biochemistry, genetics and molecular biology); this enables him/her to understand periodontal and peri-implant tissues in health and disease and interpret clinical findings.
	3.1.2. The formation of oral biofilms, their structure, composition and pathogenic relevance in periodontal and peri-implant diseases, as well as the host responses against oral biofilms.
	3.1.3. The genetic, systemic (e.g., diabetes) and environmental/life-style (e.g., tobacco smoking) risk factors involved in the pathogenesis of periodontal and peri-implant diseases and conditions.
	3.1.4. The aetiology and pathogenesis of halitosis, as well as its relationship with periodontal and peri-implant diseases.
	3.1.5. The classification of periodontal and peri-implant diseases and related conditions.
	3.1.6. The main associations demonstrated between periodontal or peri-implant diseases and systemic diseases based on epidemiological evidence, their biological and patho-physiological mechanisms, as well as any preventive and therapeutic implications.
	3.1.7. The effects of traumatic occlusal forces on the periodontium and peri-implant tissues.
	3.1.8. The healing processes following tooth extraction and dental implant placement, including osseointegration and integration into soft tissue.
3.2. Gathering clinical information for the diagnosis of periodontal and peri-implant diseases and conditions	To determine diagnosis(es), a graduating dentist *must be able to* effectively
	3.2.1. Identify the chief complaint as well as other concerns of the patient.
	3.2.2. Obtain and interpret the medical and dental history and, if needed, formulate a medical referral.
	3.2.3. Examine the subject extra- and intra-orally, specifically differentiating between health and disease (screening).
	3.2.4. Examine the patient extra- and intra-orally to detect the presence of any type of halitosis.
	3.2.5. Implement a comprehensive periodontal/peri-implant examination including registration of missing teeth, plaque accumulation, inflammation (e.g., bleeding on probing, suppuration), probing depth, recession, clinical attachment levels, furcation involvement and mobility.
	3.2.6. Evaluate the radiographic images in relation to periodontal/peri-implant health and pathology.
	3.2.7.Select the cases that may benefit from advanced diagnostic techniques, both in teeth and implants, such as advanced imaging (e.g., 3D), microbiological, genetic or biochemical diagnostic tools and interpret their results, diagnostic reliability and validity.
	3.2.8.Perform a comprehensive occlusal examination including static and dynamic inter-maxillary positions.
	3.2.9.Establish periodontal and/or peri-implant diagnoses according to the most updated classification.
3.3. Care planning	A graduating dentist *must be able to*
	3.3.1.Develop a comprehensive prevention programme (primordial, primary, secondary and tertiary prevention) to maintain periodontal and peri-implant health.
	3.3.2.Generate a comprehensive periodontal and/or peri-implant treatment plan of limited complexity, establishing a treatment sequence and providing the patient with different therapeutic alternatives, following the most updated clinical treatment guidelines.
	3.3.3.Determine the individual (tooth/implant) and general (subject) prognosis.
	3.3.4.Inform the subject about the diagnoses, the overall treatment plan, its alternative(s), risks and benefits and prognoses, facilitating shared decision making.
	3.3.5.Establish and facilitate an appropriate interdisciplinary treatment plan (e.g., in cases of stage IV periodontitis).

(Continues)

TABLE 4 (Continued)

AOC	Learning outcomes
3.4. Establishing and maintaining periodontal/peri-implant health	A graduating dentist *must be able to* 3.4.1.Manage primordial preventive interventions for peri-implant diseases and manage primary, secondary and tertiary preventive interventions for periodontal and peri-implant diseases. 3.4.2.Develop strategies to achieve adequate supragingival/supramarginal dental biofilm control by the individual, improving the effectiveness of oral hygiene (motivation, oral hygiene instructions) and considering the need for adjunctive therapies for inflammation control. 3.4.3. Provide subjects with strategies to control risk factors (e.g., smoking cessation, improving metabolic control of diabetes, nutritional counselling). Interventions may include patient referral for advanced counselling and pharmacotherapy. 3.4.4. Carry out supra- and/or sub-gingival/sub-mucosal instrumentation performed with hand and/or powered instruments (sonic/ultrasonic) and correct plaque retentive factors. 3.4.5. Determine the need for adjunctive interventions (physical or chemical agents, such as topical, local or systemic antimicrobials) during step 2 of periodontal therapy or non-surgical peri-implant therapy, based on the most updated clinical treatment guidelines. 3.4.6. Evaluate individual response to therapy (re-evaluation) and the need for additional periodontal/peri-implant therapy. In case of need for additional advanced therapy, consider the need to refer the patient for complex treatment to a specialist or appropriately trained dentist. 3.4.7. Manage acute lesions (e.g., endo-periodontal lesions, abscesses and necrotizing periodontal diseases). 3.4.8. Refer to the appropriate specialist/dentist in cases of mucogingival conditions or soft-tissue implant deficiencies/dehiscence (STID) requiring complex surgical procedures. 3.4.9. Refer to the physician in case of genuine extra-oral halitosis, halitophobia and/or systemic conditions affecting the periodontium or peri-implant tissues. 3.4.10. Apply appropriate infection control and pain management strategies prior to, during and after periodontal/peri-implant procedures, including the rational prescription of antimicrobial, analgesic and anti-inflammatory medications. 3.4.11. Implement a personalized supportive periodontal/peri-implant care programme according to individual risk factors, in co-operation with other healthcare professionals.

Note: Adapted from Sanz and Meyle (2010) and Field, Kavadella, et al. (2017).

According to Bloom's taxonomy (Anderson & Krathwohl, 2001), this area of competence corresponds to a low level in the cognitive process dimension because it only requires understanding and remembering the biological mechanisms and processes linking the structure of periodontal/peri-implant tissues and their function. These learning outcomes are usually acquired during the early stages of education. Thereafter, the student must acquire higher order thinking competences through more demanding learning outcomes, such as being able to evaluate the patient's periodontal status (making judgements based on criteria and standards) and to generate an appropriate treatment plan based on the available scientific knowledge (arranging the different elements into a coherent plan). Through this learning process, the student can demonstrate a broad and coherent assimilation of the scientific knowledge.

2.2.13 | Area of competence 3.2: Gathering clinical information for the diagnosis of periodontal and peri-implant diseases and conditions

A graduating dentist must be able to gather the relevant individual information and accordingly determine a diagnosis using the current classification of periodontal and peri-implant diseases and conditions (Table 5). This area of competence requires high levels of cognitive learning to evaluate in a dynamic process the patient's situation and analyse his/her risk profile.

2.2.14 | Area of competence 3.3: Care planning

In this area of competence, according to Bloom's taxonomy, the graduating dentist must undertake the highest level learning outcomes to design an individualized periodontal/peri-implant treatment plan. This is achieved by integrating the needs and demands of the patient collected during the diagnostic phase, and by understanding and applying the available scientific evidence, usually included in the available clinical treatment guidelines. Furthermore, the graduating dentist must discern between being able to treat and then be able to generate a comprehensive periodontal treatment plan, or to refer the patient to another oral health professional (Table 6).

2.2.15 | Area of competence 3.4: Establishing and maintaining periodontal/peri-implant health

To design and apply appropriate strategies to achieve and maintain periodontal/peri-implant health, the graduating dentist must understand

TABLE 5 A graduating dentist must be able to apply the Classification of Periodontal and Peri-Implant Diseases and Conditions (2018), specifically using the references included in the following table.

Topic	References
Decision-making algorithms for clinical practice	(Tonetti & Sanz, 2019)
The classification on periodontal and peri-implant diseases and conditions based on the World Workshop jointly held by the American Academy of Periodontology and European Federation of Periodontology	(Caton et al., 2018)
Periodontal health and gingival diseases	(Chapple et al., 2018)
Periodontitis	(Papapanou et al., 2018)
Acute lesions: i. Endo-periodontal lesions ii. Periodontal abscesses iii. Necrotizing periodontal diseases	(Papapanou et al., 2018)
Other periodontal conditions: i. Periodontitis as a manifestation of systemic diseases ii. Mucogingival conditions (with or without gingival recessions) iii. Occlusal trauma	(Jepsen et al., 2018)
Peri-implant tissue's health and diseases	(Berglundh et al., 2018; Herrera et al., 2023)
Other peri-implant conditions: hard- and soft-tissue deficiencies i. Hard-tissue deficiencies ii. Soft-tissue deficiencies ○ Recession of the peri-implant mucosa ○ Papilla height	(Berglundh et al., 2018)

Note: In case of future updates on this classification, the learning outcomes should be updated.

how to combine knowledge about periodontal/peri-implant health and disease (area of competence 3.1), how to develop a personalized diagnosis and treatment plan (area of competence 3.2 and 3.3) and how to implement the designed periodontal/peri-implant treatment with adequate manual skills and professional behaviour. The graduating dentists should know his/her limitations and, in situations requiring complex and extensive therapies, should be able to refer to the appropriate oral health professionals. Current recommendations by the World Health Organization (WHO) encourage the review and expansion in the training of oral health professionals to provide expanded knowledge and skills in oral health promotion and disease prevention. In line with this, students need to be able to generate prevention measures targeting risk factors (tobacco, alcohol, nutrition, diet, etc.) and be sensitive to the increasing spread of antimicrobial resistance due to the indiscriminate use of antimicrobials in dentistry (WHO, 2022). The graduating dentist must be able not only to implement appropriate therapies and preventive measures but also to explain to the patient the sequence of personalized periodontal/peri-implant treatment, including the compliance by the patient with preventive and periodontal/peri-implant health maintenance measures.

2.2.16 | Domain IV: Dentistry in society

For adequately promoting health, monitoring interventions and implementing effective strategies of care at population and community levels, dentists must understand population demography and oral health trends (Gallagher & Field, 2017). They should engage themselves with projects in health policy, health care systems and with different working environments. In summary, graduating dental students, in order to understand populations, communities and their associated health, are expected to achieve the learning outcomes related to Dentistry in Society (Table 7) and must (1) recognize demographic changes and trends in periodontal/oral/general health and society, which may have implications for their future patient base and care provision; and (2) be aware of the social, political, economic and environmental influences on populations and the health workforce.

2.2.17 | Area of competence 4.1: Dental public health related to periodontology

The graduating dentist should acquire knowledge related to disease prevention and periodontal/peri-implant health and quality of life promotion at individual, community and population levels (Gallagher & Field, 2017).

2.2.18 | Area of competence 4.2: Health promotion and disease prevention

Often, health inequalities are observed along a social gradient, with a higher social position associated with a better health. Graduating dentists should identify the contexts in which people live and implement appropriate interventions to reduce this gradient (Gallagher & Field, 2017). By improving individual and public periodontal/peri-implant health, the treatment needs, in general, will decrease, which will eventually reduce the use of materials and resources and, thereby facilitate the improvement in environmental sustainability (Duane et al., 2021).

2.2.19 | Area of competence 4.3: Population demography, health and disease

Graduating dentists must have knowledge of the global burden of periodontitis/peri-implantitis, population demographics, as well as the

TABLE 6 A graduating dentist must be able to apply the guidelines to the care planning of periodontal/peri-implant diseases and conditions, specifically using the references included in the following table.

Topic	Comment	Authors
Gingivitis	Although there are no S3 EFP clinical guidelines for the treatment of individuals with gingivitis, information coming from the European Workshop on Periodontology in 2014 must be used. Although a Clinical Guideline for the treatment of gingivitis has not yet been developed, its management should be considered similar to what is described in Clinical Guideline for Stage I Periodontitis.	(Chapple et al., 2015; Sanz et al., 2020; Tonetti et al., 2015)
Periodontitis	S3 EFP guideline for the treatment of individuals with periodontitis Stages I–III. S3 EFP guideline for the treatment of individuals with periodontitis stage IV.	(Herrera et al., 2022; Sanz et al., 2020)
Halitosis	Although there are no clinical guidelines for the treatment of patients with halitosis, information coming from the European Workshop and International Workshop of Periodontology in 2014 will be used.	(Sanz et al., 2015; Seemann et al., 2014)
Acute lesions: i. Endo-periodontal lesions ii. Periodontal abscesses iii. Necrotizing periodontal diseases	There are no clinical guidelines for the treatment of patients with acute periodontal lesions.	
Other conditions: i. Periodontitis as a manifestation of systemic diseases ii. Mucogingival conditions (with or without gingival recessions) iii. Occlusal trauma	Although there are no clinical guidelines for the treatment of individuals with these conditions, information coming from the S3 EFP guideline for the treatment of individuals with periodontitis stages I–III, the S3 EFP guideline for the treatment of individuals with periodontitis stage IV and the European Workshop on Periodontology in 2013 will be used.	(Hämmerle & Giannobile, 2014; Herrera et al., 2022; Sanz et al., 2020; Sanz & Simion, 2014; Tonetti & Jepsen, 2014)
Peri-implant diseases	The EFP S3 level clinical practice guideline for prevention and treatment of peri-implant diseases	(Herrera et al., 2023)
Other peri-implant conditions: hard- and soft-tissue deficiencies	Although there are no clinical guidelines for the treatment of individuals with hard-tissue deficiencies, information coming from the 5th EAO Consensus Conference 2018 and the EFP S3 level clinical practice guideline for prevention and treatment of peri-implant diseases will be used.	(Herrera et al., 2023; Sanz et al., 2018)

Note: In case of future updates on these guidelines, the learning outcomes should be updated.

social, general and oral health trends (Gallagher & Field, 2017). Moreover, they should know the implications of this burden of disease on the practice of dentistry and allocation of resources. In an increasingly ageing population, the necessary periodontal/peri-implant health promotion and disease prevention strategies should be implemented to the most vulnerable in society.

2.2.20 | Area of competence 4.4: Healthcare systems

Dentists must have knowledge of (1) public and private healthcare and oral healthcare systems, and (2) how these systems are implemented in the population. In this context, it is significant that graduating students have a broad knowledge of national/European oral health policies, as well as those advocated by the WHO and the United Nations (Gallagher & Field, 2017). Additionally, graduating dentists should acknowledge (1) how treatments are implemented across different levels of the population, and (2) how effectively treatments meet the needs of individual patients and the population.

2.2.21 | Area of competence 4.5: Planning for health and oral health

In terms of gaining experience in planning, graduating students should have the opportunity to explore how to implement strategic planning to address the health needs of different populations and various patient groups (Gallagher & Field, 2017).

TABLE 7 Domain IV: Dentistry in society-related areas of competence (AOCs) and learning outcomes in undergraduate periodontal education.

AOC	Learning outcomes—A graduating dentist *must be able to*
4.1. Dental public health related to Periodontology	4.1.1. Identify the social determinants of health, oral health, quality of life and their impact on the periodontal/peri-implant health of the individuals, families and groups in the society.
	4.1.2. Describe periodontal and systemic diseases and their associated risk factors, which are recognized public health problems.
	4.1.3. Advocate for periodontal/peri-implant and general health with patients and their community, including policy leaders.
4.2. Health promotion and disease prevention	4.2.1. Apply appropriate preventive education interventions, technological innovations and opportunities for prevention and periodontal/peri-implant health promotion at the individual/population level.
	4.2.2. Apply strategies to overcome barriers to receive periodontal care in the disadvantaged, underserved, vulnerable and minority groups and to promote periodontal/peri-implant health at the individual/population level.
4.3. Population demography, health and disease	4.3.1. Analyse the epidemiology of periodontal/peri-implant diseases across different populations in the light of the extension of life expectancy and the growth of the elderly population.
4.4. Healthcare systems	4.4.1. Describe the structure and components of healthcare systems and the roles of public, private and voluntary services in the delivery of periodontal/peri-implant care.
	4.4.2. Discuss the determinants associated with equity of healthcare access, utilization of healthcare systems, quality and outcomes.
	4.4.3. Discuss the importance of the oral healthcare systems and professionals in contributing towards environmental sustainable development goals (https://www.undp.org/sustainable-develoment-goals) and on procedures/strategies that improve accessibility and sustainability.
4.5. Planning for health and oral health	4.5.1. Comply with and contribute to dental public health strategies by understanding the dentist's and other team members' roles in affecting the health and periodontal/peri-implant health of defined populations.
	4.5.2. Debate the importance of collaboration with stakeholders and community-based health and oral health education groups, such as schools and health service providers in other fields.
	4.5.3. Discuss future research needed to inform periodontal/peri-implant health promotion, disease and prevention and the delivery of periodontal/peri-implant care.

Note: Adapted from Gallagher and Field (2017), Duane et al. (2021) and Field et al. (2023).

2.3 | Methods of teaching, learning and assessment

Outcome-based education is constructed by the precise definition of the learning outcomes, using criteria to limit what should be taught, how it should be taught and how to know whether students have learned it appropriately (assessment) (Harden et al., 1999). Outcome-based education, therefore, not only lists the learning objectives but also sets out the level of understanding and skills required to achieve these defined learning outcomes. Therefore, the methods of teaching and learning should be chosen not only for their suitability for learning but also to encourage students to engage themselves more actively in their learning process and thus facilitate the previously defined higher levels of knowledge. Similarly, assessment should be designed to evaluate the acquired knowledge, but also to assess the level of skills and attitudes needed to fully achieve the defined learning outcomes. All these components should be integrated, as they pursue the same objectives and support each other (Figure 1).

Several methods of teaching and learning have been proposed by the ADEE within this framework of outcome-based education (Field, Walmsley, et al., 2017), some pertaining mainly to Domain I, II or IV (productive failure, bricolage, critical reflection, exchange programmes, blockchain learning), while others are more amenable for Domain III (case-based learning, problem-based learning, threshold concepts, tacit and situated learning, role-play, social media, personal inquiry, storytelling, fishbowl learning, etc.).

The literature on assessment methods describes numerous instruments that should form part of the teacher's armamentarium. The ADEE also provides an overview of different methods (Field et al., 2023; Field, Walmsley, et al., 2017). When designing and applying the available assessment method to students, the teacher must keep in mind the expected learning outcomes and metrics that need to be applied. To choose the appropriate assessment method and its application in practice, the teacher must fully understand the assessment process on when, how or for what it should be used. When applying these methods, criteria such as validity, reliability, impact on the student, feasibility, as well as cost, including financial and human cost, should always be taken into account (Shumway & Harden, 2003). In addition, assessment methods should determine how students are studying and, therefore, how they are learning (impact of the assessment method on the student). Hence the importance of using both formative (throughout the course) and summative (at the end) assessment. In formative assessment, the results should be used to provide feedback during learning, which could serve both to improve the learning of individual students and to improve the teaching itself, because the effectiveness of different teaching methods is directly related to their ability to provide formative feedback (Biggs & Tang, 2011).

TABLE 8 Summary proposal of teaching and learning methods shown in blue (but not limited to these) for periodontology according to each of the domains.

Domain	Areas of competence	Productive failure	Bricolage	Threshold concepts	Teachback	Tacit learning	Critical reflection	Situated learning	Role-play	Exchange programmes	Blockchain learning	Social media	Personal enquiry	Story telling	Fishbowl learning
I	1.1. Ethics														
	1.2. Regulation														
	1.3. Professional behaviour														
II	2.1. Evidence-based practice														
	2.2. Management and leadership														
	2.3. Teamworking and communication														
	2.4. Audit and risk management														
	2.5. Professional education and training														
III	3.1. Application of the scientific basis														
	3.2. Gathering clinical information for the diagnosis														
	3.3. Care planning														
	3.4. Establishing and maintaining health														
IV	4.1. Dental public health														
	4.2. Health promotion and disease prevention														
	4.3. Population demography, health and disease														
	4.4. Healthcare systems														
	4.5. Planning for health and oral health														

Note: Adapted from Field, Walmsley, et al. (2017). The detailed proposal aligned according to each learning outcome can be found in Supplementary Information. I: Professionalism; II: Safe and Effective Clinical Practice; III: Patient-Centred Care; IV: Dentistry in Society.

TABLE 9 Summary proposal of assessment methods shown in green (but not limited to these) for periodontology according to each of the domains.

Domain	Areas of competence	Objective structured clinical examination (OSCE)	Clinical grading and feedback	Reflective diaries and portfolios	Longitudinal observation	Feedback	Clinical competencies	Adaptative assessment	Written examination	Oral examination	Spotter tests	Workplace-based assessments	Case-based discussions
I	1.1. Ethics		■	■	■	■		■				■	■
	1.2. Regulation	■	■	■	■			■	■	■		■	■
	1.3. Professional behaviour	■	■	■	■	■		■	■	■		■	■
II	2.1. Evidence-based practice				■			■	■	■		■	■
	2.2. Management and leadership		■		■							■	■
	2.3. Teamworking and communication	■	■		■	■	■					■	■
	2.4. Audit and risk management	■	■		■							■	
	2.5. Professional education and training			■	■	■			■	■		■	■
III	3.1. Application of the scientific basis								■	■			
	3.2. Gathering clinical information for the diagnosis	■	■	■	■		■		■	■	■	■	■
	3.3. Care planning	■	■	■	■		■		■	■	■	■	■
	3.4. Establishing and maintaining health	■	■	■	■		■					■	■
IV	4.1. Dental public health		■					■	■	■		■	■
	4.2. Health promotion and disease prevention		■		■		■					■	
	4.3. Population demography, health and disease							■	■	■			
	4.4. Health care systems							■	■	■			■
	4.5. Planning for health and oral health			■				■	■	■			■

Note: Adapted from Field, Walmsley, et al. (2017). The detailed proposal aligned according to each learning outcome can be found in Supplementary Information. I: Professionalism; II: Safe and Effective Clinical Practice; III: Patient-Centred Care; IV: Dentistry in Society.

Depending on their specific cognitive process dimensions, the different teaching and learning activities and assessment methods can be recommended for each learning outcome. A proposal for this assignment, with the tools outlined by the ADEE, is presented in Tables 8 and 9 and in Appendices 1 and 2. Other different methodologies in addition to those outlined by the ADEE may exist, such as lectures, reading, computer-aided learning, haptic training simulation, instructional video, concept maps, individual and group projects, e-assessment, self-assessment, and so on, with different degrees of effectiveness depending on the learning and teaching environments. Activities can also have other uses; for example, portfolios, although originally introduced as an assessment tool, may also be used to foster learning by stimulating students to reflect on their achievements (Van Tartwijk & Driessen, 2009). It is the responsibility of the teacher to design or select appropriate methods depending on the learning outcomes addressed.

3 | DISCUSSION AND CONCLUSION

This report summarized the recommended learning outcomes in undergraduate education in periodontology after integrating the new trends in periodontal clinical practice derived from the 2018 Classification and recent Clinical Practice Guidelines, and after adapting to the current framework of learning outcomes, organized in domains and areas of competence, as recommended by the ADEE.

The evolution in curriculum design from a teacher-centred to a student-centred philosophy has shifted the emphasis in higher education from teaching to learning. This paradigm shift in dentistry has transformed curricula based on strict educational objectives and organized in sets of disciplines, each with its precise didactic and practical contents, into descriptive learning outcomes, organized in domains and areas of competences. This change requires teachers to adapt to the needed changes in teaching, learning and assessment methods (Adam, 2004). Furthermore, since high cognitive level learning outcomes are often framed as threshold statements, the learning and teaching creativity should not be jeopardized and, therefore, learning outcomes should be designed to allow for an open-ended teaching and learning process (Biggs & Tang, 2011).

While adopting an education-based approach to these high-level learning outcomes may have some complications, it also has several assets. The main benefit is to support and guide the student to achieve a deeper level of learning, by clearly identifying the appropriate activities and tasks to achieve the expected outcome (Biggs, 1999). Moreover, well-designed learning outcomes play a key role in the transparency and reliability of degree programmes because they provide consistency between learning outcomes, teaching and learning activities and assessment procedures, which improves quality assurance and contributes to the Bologna Agenda (European Commission, 2015) by recognizing qualifications across education systems and countries, and by supporting appropriate evaluation and accreditation processes.

Within this educational framework, the proposed areas of competences, learning outcomes, methods of teaching, learning and assessment in undergraduate education in periodontology have been elaborated with the aim to (a) attain a modern graduate in dentistry with deep knowledge in periodontology and with the clinical skills and professionalism to maintain appropriate levels of periodontal and peri-implant health, and (b) provide current periodontal clinical management to all the diseases and conditions defined in the 2018 classification (Caton et al., 2018) and according to the scientific evidence stated in the current clinical practice guidelines to treat the most frequent periodontal and peri-implant diseases (Herrera et al., 2022, 2023; Sanz et al., 2020).

The previously defined learning outcomes have been articulated as learning units or blocks for the various subjects encompassing periodontology. The verbs of each learning outcome can be adapted by the teacher to the appropriate level of knowledge according to the course in which the subject is taught if the content is taught in several courses. However, this list may be also included within the context of a comprehensive dental curriculum. With that purpose, the following *key learning outcomes* are proposed as exit outcomes that every graduating dental student should need to accomplish so that they may be part of the final assessment of the graduating student. These key learning outcomes should be therefore the minimum levels of performance in periodontology to be met at the degree level qualification:

1. To apply legal and ethical principles and appropriate professional behaviour towards patients, colleagues and members of the healthcare team.
2. To communicate effectively and respectfully with patients, their families or caregivers and other healthcare professionals involved in the patient's care, both verbally and in writing.
3. To use evidence-based knowledge and critical thinking in daily practice, including health promotion, behaviour change, risk assessment, diagnosis and treatment of periodontal/peri-implant diseases.
4. To carry out a complete medical and dental history and perform a thorough extra-oral and intra-oral examination on a patient, including recording of a comprehensive periodontal, peri-implant, occlusal and periapical radiographic examination.
5. To interpret relevant information regarding the patient's current periodontal/peri-implant condition to establish a differential diagnosis.
6. To design an appropriate periodontal/peri-implant treatment plan according to the patient's desires, expectancies and periodontal/peri-implant situation.
7. To undertake the practical therapeutic procedures defined within the steps 1 and 2 of periodontal therapy (S3 Level Clinical Practice Guideline) including the needed supra- and subgingival biofilm control.
8. To identify the indications and limitations of complex periodontal therapies defined in step 3 of periodontal therapy and be able to refer the patient to the appropriate specialist/dentist when necessary.
9. To undertake the practical therapeutic procedures for the management of peri-implant mucositis and the non-surgical treatment of peri-implantitis defined in the S3 Level Clinical Practice Guideline for the prevention and treatment of peri-implant diseases and be able to refer the patient to the appropriate specialist/dentist for more complex peri-implant therapies.

10. To develop a plan and apply the basic principles of disease prevention and health promotion for patients with a healthy periodontium or healthy peri-implant tissues and for patients in supportive periodontal/peri-implant care after therapy.

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SUPPORTING INFORMATION

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