

# Development of a Core Curriculum Framework in Cariology for U.S. Dental Schools

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*Abstract:* Maintenance of health and preservation of tooth structure through risk-based prevention and patient-centered, evidence-based disease management, reassessed at regular intervals over time, are the cornerstones of present-day caries management. Yet management of caries based on risk assessment that goes beyond restorative care has not had a strong place in curriculum development and competency assessment in U.S. dental schools. The aim of this study was to develop a competency-based core cariology curriculum framework for use in U.S. dental schools. The Section on Cariology of the American Dental Education Association (ADEA) organized a one-day consensus workshop, followed by a meeting program, to adapt the European Core Cariology Curriculum to the needs of U.S. dental education. Participants in the workshop were 73 faculty members from 35 U.S., three Canadian, and four international dental schools. Representatives from all 65 U.S. dental schools were then invited to review and provide feedback on a draft document. A recommended competency statement on caries management was also developed: "Upon graduation, a dentist must be competent in evidence-based detection, diagnosis, risk assessment, prevention, and nonsurgical and surgical management of dental caries, both at the individual and community levels, and be able to reassess the outcomes of interventions over time." This competency statement supports a curriculum framework built around five domains: 1) knowledge base; 2) risk assessment, diagnosis, and synthesis; 3) treatment decision making: preventive strategies and nonsurgical management; 4) treatment decision making: surgical therapy; and 5) evidence-based cariology in clinical and public health practice. Each domain includes objectives and learning outcomes.

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**D**ental caries is a multifactorial disease process that results in the localized destruction of susceptible dental hard tissue by acidic byproducts resulting from bacterial fermentation of dietary carbohydrates. If allowed to progress, the disease will result initially in the development of non-cavitated caries lesions, which if left untreated

might further progress to cavitation.<sup>1,2</sup> Although dental caries is a largely preventable disease, untreated cavitated caries lesions in permanent teeth are still the most prevalent health condition in the world and in primary teeth are the tenth most prevalent condition,<sup>3</sup> with the possibility of many dental, medical, social, and quality of life sequelae.<sup>4</sup>

Caries management focused primarily on tooth restoration has proven ineffective at controlling the risk of future disease.<sup>5</sup> In fact, maintenance of health and preservation of tooth structure through risk-based prevention and patient-centered, evidence-based disease management, reassessed at regular intervals over time, have been recognized as cornerstones of modern caries management.<sup>6-10</sup> Yet caries risk assessment and management that go beyond restorative care have not always had a strong and organized place in curriculum development and competency assessment in U.S. dental schools, even though improvements have been occurring over the last decades,<sup>9,11</sup> with the development of cariology curriculum programs,<sup>12</sup> implementation of risk assessment protocols,<sup>12</sup> and standardization in cariology nomenclature for use in U.S. dental education.<sup>1,8</sup>

The current Commission on Dental Accreditation (CODA) Accreditation Standards for Dental Education Programs fail to reflect the importance of, and fail to mandate, competence in diagnosis, risk assessment, and management of dental caries as they do for multiple oral diseases such as periodontal, oral-mucosal, pulpal, and others (e.g., CODA standard 2-23 currently does not mention caries).<sup>13</sup> Furthermore, there is a great discord between the recognized need for risk-based caries management and prevention and the infrequent application of these concepts in clinical practice.<sup>14</sup> Although many reasons may explain this lack of implementation,<sup>8</sup> there is no doubt that dental education can help bridge the gap between research and practice to accelerate adoption of evidence-based strategies for the management of dental caries.<sup>11</sup> Survey data regarding cariology curricula being taught in dental schools around the world (e.g., in Europe,<sup>15</sup> Colombia,<sup>16</sup> Brazil,<sup>17</sup> and the U.S.<sup>18</sup>) have been used as a starting point for building a curriculum framework for cariology education based on best available evidence to provide a uniform but flexible platform for what should be included and assessed.

In 2011, a Core Curriculum for Cariology (CCC) for dental schools in Europe was developed under direction of the European Organization for Caries Research (ORCA) and the Association of Dental Education in Europe (ADEE).<sup>18</sup> The European curriculum is divided into five domains or themes, defined as a “broad, critical category of activity for the general dentist” in the American Dental Education Association (ADEA) Competencies for the New General Dentist.<sup>19</sup> Those domains are as follows: the knowledge base;<sup>20</sup> risk assessment, diagnosis, and

synthesis;<sup>21</sup> treatment decision making: preventive strategies and nonsurgical management;<sup>22</sup> treatment decision making: surgical therapy;<sup>23</sup> and evidence-based cariology in clinical and public health practice.<sup>24</sup> Following publication of that core curriculum, efforts have been developing around the world to implement it in various educational systems. For example, in 2014, the Colombian chapter of the Global Alliance for a Cavity-Free Future (ACFF) decided to modify and rework the European CCC to facilitate its adoption by all Colombian dental schools.<sup>25</sup>

The aim of this study was to develop a competency-based core cariology curriculum framework for use in U.S. dental schools. This article reports on the process used to develop the framework on the basis of national and international evidence and consensus on current and future educational needs in the field of cariology. As dental erosion and tooth wear defects are normally taught in the U.S. along with cariology content,<sup>26</sup> these were also included in this framework, as in Europe.

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## Methods

The University of Michigan Institutional Review Board considered this activity to be “not regulated as human subjects research.” The 2015 ADEA Section on Cariology officers (Drs. Margherita Fontana, Sandra Guzmán-Armstrong, and Andrew Schenkel), who became the Curriculum Planning Team (CPT), planned a consensus working agenda with the purpose of initiating discussion on current and future educational needs in the field of cariology in the U.S. and ultimately developing a U.S. curriculum framework. Three phases were planned and carried out as part of this process.

### Phase I: Preliminary Discussions and Information Dissemination

The purpose of this phase was to initiate preliminary discussions during the 2014 Eastern and 2015 Central CAMBRA (Caries Management by Risk Assessment) coalitions’ annual meetings. The CAMBRA coalitions involve groups of schools and other interested parties that meet regionally on an annual basis to discuss topics related to cariology and dental education and practice. The Central CAMBRA coalition meets as part of the Academy of Operative Dentistry Annual Meeting, and the Eastern CAMBRA coalition meets as part of the re-

gional Consortium of Operative Dentistry Educators (CODE) meeting on the East coast.

During the November 2014 Eastern CAMBRA meeting and the February 2015 Central CAMBRA meeting, the proposed planned agenda for developing a U.S. CCC was presented as an opportunity for all attendees to participate in providing feedback regarding the planned process. In addition, the goals and main objectives of the five domains of the European CCC were reviewed, and feedback was received regarding the most beneficial format in which to present this information to U.S. dental educators for future discussion, as well as identifying areas to be considered for inclusion.

## Phase II: Workshop to Develop Curriculum Framework

In preparation for the second phase of this initiative, the CPT reached out at the end of 2014 (with a reminder sent in early 2015) to all U.S. dental school deans (N=65) through the ADEA deans' listserv to invite at least one representative from each U.S. dental school currently involved in teaching cariology/restorative sciences to attend a full-day workshop to develop a U.S. curriculum framework. This format was based on the process successfully followed during development of the European and Colombian core cariology curricula.<sup>18,25</sup> To aid in planning this workshop, the assistance of the organizers of the European and Colombian efforts was secured (Drs. Nigel Pitts, Andreas Schulte, and Stefania Martignon).

The workshop was also announced on the listservs of the ADEA Sections on Cariology, Operative Dentistry, Community and Preventive Dentistry, and Academic Affairs, as well as through the Central, Eastern, and Western CAMBRA coalition networks. The workshop was planned to immediately precede the 2015 ADEA Annual Meeting to facilitate travel and encourage attendance of dental educators. The European CCC publication<sup>18</sup> and editable tables in Word, developed to mimic the ones used in Colombia,<sup>25</sup> were distributed two weeks prior to the meeting to all registered attendees. There was one table for each domain.<sup>18</sup>

For each curricular domain, the European CCC includes "major and supporting competencies," following definitions provided by ADEE. The major competencies were defined as "the ability of a dentist on graduation to provide a particular, but complex, service or task. Its complexity suggests that multiple and more specific abilities (supporting competencies)

are required to support the major competency."<sup>18</sup> The Colombian CCC changed the word "competency" to "main and specific learning objectives" to align with the definitions used in that environment.<sup>25</sup>

For the U.S. version, the CPT decided to rename the European "Major Competencies" as "Objectives" and the "Supporting Competencies" as "Learning Outcomes," following the Colombian pattern, since we felt that the European terms did not exactly meet the definition of a "competency" in the Preamble of the ADEA Competencies for the New General Dentist: "A 'competency' is a complex behavior or ability essential for the general dentist to begin independent, unsupervised dental practice. Competence includes knowledge, experience, critical thinking and problem-solving skills, professionalism, ethical values, and technical and procedural skills. These components become an integrated whole during the delivery of patient care by the competent general dentist. Competence assumes that all behaviors are performed with a degree of quality consistent with patient well-being and that the general dentist can self-evaluate treatment effectiveness" (p. 813).<sup>19</sup>

Thus, the "Objectives" in the U.S. framework describe the core knowledge, abilities, aptitudes, and attributes that the dental student should achieve for that particular domain. The term "Learning Outcomes" was chosen because those qualities support performance of the main objective. The Learning Outcomes are divided into what the graduate dentist should be "capable of" (as used in the Colombian curriculum; meaning "upon graduation the dentist demonstrates sound theoretical knowledge and understanding of the subject together with an adequate clinical experience to be able to resolve clinical problems independently"), "have knowledge of" ("upon graduation the dentist demonstrates sound theoretical knowledge and understanding of the subject together with limited clinical experience"), and "be familiar with" ("upon graduation the dentist demonstrates a basic understanding of the subject but need not have clinical experience"). Each objective may have one, two, or all three of the possible categories of learning outcomes.

A full-day workshop was held in Boston in March 2015 immediately prior to the 2015 ADEA Annual Session. There were 73 participants in the workshop; participants came from 35 U.S., three Canadian, and four international dental schools (Table 1). The workshop began with presentations from Drs. Nigel Pitts, Andreas Schulte, and Margherita Fontana that provided an overview of the European

**Table 1. Institutions that participated in development of the U.S. cariology curriculum framework**

U.S. Institutions	Representative Attended Workshop	Feedback Provided
Nova Southeastern University	X	X
The University of Texas School of Dentistry at Houston	X	X
University of Oklahoma College of Dentistry	X	
University of the Pacific Arthur A. Dugoni School of Dentistry	X	X
University of Iowa College of Dentistry and Dental Clinics	X	X
University of Michigan School of Dentistry	X	X
New York University	X	X
Stony Brook University School of Dental Medicine	X	
Columbia University College of Dental Medicine	X	
University at Buffalo School of Dental Medicine	X	
University of Maryland School of Dentistry	X	
University of California, San Francisco School of Dentistry	X	X
University of Louisville School of Dentistry	X	
Midwestern University College of Dental Medicine–Illinois	X	
Midwestern University College of Dental Medicine–Arizona	X	X
University of Kentucky College of Dentistry	X	
Harvard School of Dental Medicine	X	
University of Washington School of Dentistry	X	X
Indiana University School of Dentistry	X	
LECOM School of Dental Medicine	X	
Virginia Commonwealth University School of Dentistry	X	X
University of Illinois at Chicago College of Dentistry	X	
University of Pittsburgh School of Dental Medicine	X	
Boston University Goldman School of Dental Medicine	X	
University of North Carolina at Chapel Hill School of Dentistry	X	X
University of Colorado School of Dental Medicine	X	
Loma Linda University School of Dentistry	X	
University of Florida College of Dentistry	X	X
Georgia Regents University College of Dental Medicine	X	X
Columbia University	X	
University of Texas Health Science Center at San Antonio School of Dentistry	X	
University of Connecticut School of Dental Medicine	X	
University of California, Los Angeles School of Dentistry	X	
Southern Illinois University School of Dental Medicine	X	
Marquette University School of Dentistry	X	
Non-U.S. Institutions		
Clark College Dental Hygiene (Canada)	X	
School of Dental Medicine Jerusalem (Israel)	X	
McGill University (Canada)	X	
Université de Montréal (Canada)	X	
University of Dundee (UK)	X	X
University of Heidelberg (Germany)	X	X
Universidad El Bosque (Colombia)	X	X

CCC Consensus Workshop, reported on experience in the development and implementation of the curriculum internationally, gave an overview of the present status of U.S. cariology education,<sup>26</sup> and defined the purpose of the workshop. The CPT randomly divided the 73 participants into five groups, based on each of the five European cariology curriculum domains. For each group of approximately 12 participants, a leadership team (chair and note-taker) was assigned

in advance to aid in the process. The domain assignments to the five working groups were as follows: Working Group 1—the knowledge base; Working Group 2—risk assessment, diagnosis, and synthesis; Working Group 3—treatment decision making: preventive strategies and nonsurgical management; Working Group 4—treatment decision making: surgical therapy; and Working Group 5—evidence-based cariology in clinical and public practice.

The tables describing each domain's objectives and learning outcomes were distributed to each group, and the chair and note-takers led the discussion. The main objectives and supportive learning outcomes were accepted, modified, or deleted from the tables and additional ideas included as necessary. A final modified table was presented by each working group to a plenary session. Time for discussion with the other groups was provided to allow further input from all workshop participants. Modified domain tables were distributed to the CPT, chairs, and note-takers at the end of the workshop for their final input and edits.

### Phase III: 2015 ADEA Section on Cariology Program

Following the workshop, the CPT presented the resulting proposed curriculum domains and main objectives at the Section on Cariology program at the 2015 ADEA Annual Session for further discussion and input from a broader audience. This program was cosponsored by the Sections on Operative Dentistry, Community and Preventive Dentistry, and Academic Affairs. A brief introduction to the international implementation of the European CCC was given by Drs. Pitts and Schulte, and the results of the U.S. CCC workshop were presented by Drs. Fontana, Guzmán-Armstrong, and Schenkel, followed by a general discussion.

In the weeks after the ADEA meeting, feedback and comments on the five curricular domains and contents from the workshop and the ADEA program were reviewed, and a first draft of the U.S. document was developed. This draft was then sent to all key representatives (identified by those who had attended either the workshop or the ADEA program or had asked to be identified as such via email) and deans of U.S. dental schools for further review and feedback (Table 1).

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## Results

This collaborative effort resulted in a final consolidated document of the domains, main objectives, and supporting learning outcomes for the cariology curriculum framework for U.S. dental education (Appendix). Underlying the framework is a competency statement the group agreed upon and recommends that U.S. dental schools add to their competency documents: "Upon graduation, a dentist must be

competent in evidence-based detection, diagnosis, risk assessment, prevention, and nonsurgical and surgical management of dental caries, both at the individual and community levels, and be able to reassess the outcomes of interventions over time."

This competency statement is supported by the curriculum framework comprised of five domains, almost identical to the framework of the European CCC. For each domain, there are main objectives, and each objective has associated and expected learning outcomes. This agreed upon curriculum framework is not meant to be prescriptive, and learning outcomes are by no means exhaustive, but rather allow for flexibility in each dental school's teaching and assessment structure.

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## Discussion

This article describes the process of developing a curriculum framework for teaching cariology in U.S. dental schools and a proposed caries management competency statement. This framework is based on the European and Colombian CCC but reflects the competency framework for U.S. dental education. U.S. dental schools either use the ADEA Competencies for a New General Dentist<sup>19</sup> or modify the national competencies into a limited number of school-specific competencies. Given this variability, we decided to construct the curriculum framework around a proposed school competency statement, which could then be adapted by each school. This competency statement is associated with objectives and learning outcomes that appear in the curriculum framework, divided into five domains. The nomenclature used (competency, curriculum domain, objective, learning outcome, be capable of, have knowledge of, and be familiar with) was based on that previously used,<sup>18,25</sup> after adapting it to fit the U.S. educational environment. Furthermore, as this curriculum framework is adapted and implemented by each dental school, there will be a need to map assessment strategies to each of the curriculum components, with assessment methods matching the level of expected learning outcomes.<sup>24</sup>

The process of developing a U.S. cariology curriculum framework was similar to that followed by others<sup>18,25</sup> in that a preliminary survey of cariology teaching in the U.S. was done<sup>26</sup> and used to help determine the cariology content included. However, rather than having to start from nothing and requiring a three-day workshop as was done in Europe,<sup>18</sup> the

availability of the European CCC as a framework for adoption made it possible to accomplish the goals of the U.S. consensus workshop in a single day.

Current accreditation standards for U.S. dental education emphasize the need for schools to foster critical thinking and prepare graduates to be lifelong learners by helping them learn how to identify and incorporate into practice the best available evidence.<sup>13</sup> Thus, as with professionalism, these are not specific domains to cariology. However, given their importance to effective caries management, we decided to retain these objectives in the domain “Evidence-based cariology in clinical and public practice” as was done in the European CCC. This focus on learning to think critically and solve problems based on best available evidence also requires a different way of teaching and assessment.

As helpful as it is to have a U.S. curriculum framework, it is equally important to address the multiple factors that will influence its implementation. These factors need to be considered simultaneously with curriculum framework changes in order to facilitate success. Important implementation factors include the following:<sup>8</sup>

1) The **need for establishment of a well-defined cariology curriculum** that allows the integration of didactic, preclinical, and clinical teaching of all the components needed to support the recommended competency statement on caries management;

2) A **dental health record** that will support a caries lesion severity and activity classification system, a caries risk assessment protocol, and reassessment plan. Recognition of the dynamic nature of the caries disease and the strategies currently available for non-invasive caries lesion management mandates that the classification of caries lesions be descriptive and specific enough to allow monitoring and assessment if the lesion advances over time.<sup>10,27,28</sup> Thus, in an era of nonsurgical as well as tooth-preserving surgical treatments, it is necessary to have electronic dental records that can facilitate careful documentation of the location, severity, and activity of carious lesions and changes over time. Regarding caries risk assessment, it is an essential component in the decision making process for the correct prevention and management of dental caries, as well as for establishing appropriate recall intervals.<sup>6,29</sup> Even when evidence suggests that caries experience is still, unfortunately, the single best predictor for future caries development,<sup>29</sup> the use of structured forms,

although presently having limited validity, should be part of the electronic record. Use of structured caries risk forms aids in the systematic assessment of multiple caries risk factors in practice and objective record-keeping and facilitates patient-centered caries management plans and reassessment over time.<sup>4</sup> To assist with implementation, caries classification systems and risk forms need to be user-friendly and not time-consuming, facilitate translation of findings into treatment planning modules, aid in quality improvement assessments, and have broad acceptance among students and faculty. Once these forms become part of data-gathering in the patient’s personal health record and the information is used in the treatment planning and recall process, dental schools will need to ensure compliance with this process through their quality assurance programs.

3) **Need for clinician/faculty training and calibration.** Having access to the best evidence is not enough to change the practice model of caries management, but it is a start.<sup>8</sup> However, maintaining evidence-based knowledge in every aspect of dental practice can be overwhelming; the volume of information is substantial and frequently difficult to locate, and it may be difficult to separate appropriate science from unreliable information. Thus, dental schools have very important roles in facilitating access to cariology curricular content for clinical and part-time faculty members and in helping clinicians make sense of available evidence. Lack of training and calibration can have devastating effects on any clinical or educational cariology program,<sup>30,31</sup> especially when the program is trying to teach clinicians to manage a disease whose diagnosis and management paradigms have undergone the large shifts that have occurred in cariology. Furthermore, systematic reviews suggest that mere passive dissemination of information is generally ineffective in bringing about change: this information includes educational materials (recommendations for clinical care, including clinical practice guidelines, audiovisual materials, and electronic publications) and attending didactic educational meetings.<sup>32</sup> Therefore, active training programs have to be developed (and resources planned and allocated) to educate practitioners in various aspects of modern caries management, including case discussions and hands-on training activities.

4) **Outcomes assessment** (productivity). Assessment and reimbursement of services, or the lack thereof, are often said to be barriers to the rapid

implementation of advances in dentistry into practice; in fact, if no value is given to procedures or treatment philosophies, they will likely not be adopted.<sup>8</sup> Thus, solutions must be considered to adequately reimburse the clinical time spent performing diagnosis and non-surgical management of dental caries comparable to reimbursement for surgical time. Implementation of school-based diagnostic codes and risk-based codes can facilitate tracking and assessment of behaviors to be enhanced. In addition, assessment of how well a student is progressing towards meeting the proposed caries management competency statement is an essential component of the implementation strategy.

**5) Effective communication between faculty** with responsibilities for the educational processes (determination and delivery of specific content and assessment) for each of the five curriculum domains, including surgical and nonsurgical caries management, is an integral aspect of successful implementation of the framework. Survey data suggest these responsibilities are normally housed in a variety of departments such as restorative dentistry, operative dentistry, preventive dentistry, cariology, and pediatric dentistry.<sup>26</sup> Thus, implementation and assessment of the framework may need to cross departments in order to be successful.

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## Conclusion

This article has described the consensus process used to develop a competency-based U.S. cariology curriculum framework, which can serve as a resource and benchmark for improving the teaching of cariology in U.S. dental schools. As schools assess their cariology education, they should also consider and assess the multiple factors that will influence its implementation, including the need for establishment of a well-defined cariology curriculum; availability of a caries classification system in the electronic health record that allows assessment of caries disease severity and activity, as well as risk assessment, for active monitoring of risk-based caries management strategies and appropriate care at regular intervals over time; evaluating and maintaining evidence-based knowledge in cariology for their faculty members through training and calibration activities, in many cases across multiple departments; and developing reward models to support risk-based nonsurgical caries management activities throughout the didactic and clinical portions of schools' curricula.

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# APPENDIX

## U.S. Cariology Curriculum Framework

### Domain I. The Knowledge Base: Objective and Learning Outcomes

This domain describes the foundation knowledge needed for Domains II-V. A varying depth of knowledge and understanding of each of the aspects of the knowledge base will be required in order to reach the appropriate competence levels.

#### Objective

On graduation, a dentist must be able to demonstrate and apply knowledge and understanding of the biological, medical, basic, and applied clinical sciences related to caries. The dentist must be able to integrate all of this knowledge and understanding in order to recognize caries and other dental hard tissue disorders. The dentist must then be able to make decisions about prevention and management of caries and other dental hard tissue disorders in individuals and populations.

#### Learning Outcomes

With regard to development, growth, and structure of relevant oral tissues, on graduation, a dentist must:

*Have knowledge of:*

- 1.1 Normal development, growth, and structure of the dental and oral tissues (for example, dental hard tissues, pulp, and salivary glands) at the macroscopic, microscopic, and molecular levels.
- 1.2 Developmental disorders of the dental and oral tissues at the macroscopic, microscopic, and molecular levels.

#### Learning Outcomes

With regard to etiology, pathogenesis, and modifying factors of dental caries and other dental hard tissue disorders, on graduation, a dentist must:

*Be capable of:*

- 1.3 Describing and discussing the mechanisms and dynamic processes involved in maintaining a state of health, as well as the host response in caries, erosion, and non-erosive wear at the macroscopic, microscopic, and molecular levels.

*Have knowledge of:*

- 1.4 The role of oral biofilms, diet and nutrition, saliva and other host factors, fluoride, and behavioral/social factors related to caries and other dental hard tissue disorders.
- 1.5 Biochemical events in the biofilm, in saliva, and in dental hard tissues.
- 1.6 Acid and base production, buffering properties, and the effects of saturation in saliva and biofilm.
- 1.7 The role of environmental factors, drugs, and systemic diseases related to caries and other dental hard tissue disorders.

#### Learning Outcomes

With regard to detection, assessment, diagnosis, and risk assessment, on graduation, a dentist must:

*Have knowledge of:*

- 1.8 The physical and biological changes in the structure of dental hard tissues as related to detection, assessment, and diagnosis of caries and other dental hard tissue disorders.
- 1.9 The physical and biological science of radiography and radiographic interpretation as related to detection, assessment, and diagnosis of caries and other dental hard tissue disorders, including safety issues.
- 1.10 The principles of evaluating the performance of current and emerging caries detection, assessment, and diagnostic methods as applied to caries and other dental hard tissue disorders.
- 1.11 The principles of evaluating risk factors, risk indicators, and protective factors associated with risk assessment of caries and other dental hard tissue disorders.

(continued)

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## APPENDIX: U.S. Cariology Curriculum Framework (continued)

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### Domain I. The Knowledge Base: Objective and Learning Outcomes (continued)

#### Learning Outcomes

With regard to behavioral sciences, on graduation, a dentist must:

*Have knowledge of:*

- 1.12 The behavioral sciences including the psychological, sociological, and socioeconomic factors underlying interpersonal skills, communication, and behavior modification.

#### Learning Outcomes

With regard to prevention and management, on graduation, a dentist must:

*Have knowledge of:*

- 1.13 The mechanism of action, composition, properties, limitations, and side effects of commonly available and emerging materials designed for the preventive, nonsurgical, and surgical management of oral tissues. This includes, but is not limited to products, devices, equipment, technologies, and techniques for the preventive nonsurgical and surgical management and treatment of dental caries and other dental hard tissue disorders, at individual, group, and population levels.

#### Learning Outcomes

With regard to epidemiology and research methodology, on graduation, a dentist must:

*Have knowledge of:*

- 1.14 The basics of epidemiology.
- 1.15 The principles of risk assessment (e.g., interpretation of outcomes expressed as sensitivity, specificity, area under the ROC-curves, etc.).
- 1.16 Research methodology and its limitations, including study design, sampling, bias, and statistics.

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### Domain II. Diagnosis, Risk Assessment, and Synthesis: Objectives and Learning Outcomes

This domain is the bridge from fundamental knowledge about dental caries detection, assessment, diagnosis, and risk assessment, to application of this knowledge to clinical situations, culminating with synthesis of patient information to form the basis for development of a caries prevention and management plan for a patient, which needs to be continuously reassessed over time.

#### DIAGNOSIS

Diagnosis is the human professional summation of all signs and symptoms to arrive at an identification of the disease/hard tissue disorder, including the recognition of whether the disease is occurring presently or occurred in the past. To diagnose implies not only finding a lesion (detection) and determining its characteristics (assessment), such as color, surface integrity, clinical staging, etc., but most importantly to decide what this lesion/hard tissue defect represents and if it reflects a disease process that is active, progressing rapidly or slowly, or arrested.

#### Objective

On graduation, the dentist must be capable of detection, assessment, and diagnosis of caries and other dental hard tissue disorders through collecting, analyzing, and integrating data on signs and symptoms of these diseases/conditions. The dentist must also be capable of assessing the activity status of caries lesions on a tooth surface to arrive at an identification of past or present occurrence of caries disease.

## Learning Outcomes

On graduation, a dentist must:

*Be capable of:*

- 2.1 Recognizing normal and abnormal tooth tissue and differentiating between carious and non-carious hard tissue changes or anomalies. This should encompass primary and secondary caries lesion detection utilizing visual, tactile, and radiographic data for both coronal and root surfaces.
- 2.2 Defining and correctly using terminology regarding caries lesion detection (through appropriate visual, tactile, and radiographic means), caries lesion assessment (e.g., stages of the caries process), and caries diagnosis.
- 2.3 Collecting and recording data on the presence of different stages of the caries process, including assessment of lesion activity (signs) and symptoms related to dental caries.
- 2.4 Collecting, analyzing, and integrating data on signs and symptoms of dental erosion or non-erosive tooth wear, in order to arrive at an accurate diagnosis of these conditions.
- 2.5 Assessing the underlying causes of dental caries, dental erosion, or non-erosive tooth wear and the use of such information to make informed treatment decisions (see also Domains III and IV).

## RISK ASSESSMENT

Risk assessment involves an analysis of the probability (prediction) that a patient will have a change in the number, size (depth or width), or activity of caries lesions. The assessment also aims to identify factors associated with the etiology of the disease process (i.e., caries risk factors), factors that are indicators or clinical signs that there is disease present or that there has been disease in the past (i.e., disease indicators), and factors associated with disease prevention and management (i.e., protective factors). Caries risk assessment should be reassessed regularly throughout the life of an individual.

## Objective

On graduation, the dentist must be capable of identifying and estimating the risk of a patient to develop new caries lesions or progression of existing lesions in the future, and the dentist must be able to reassess changes in risk over time. The dentist must also be capable of identifying dental erosion or non-erosive tooth wear and assessing the likelihood of progression. The dentist must have the appropriate depth of knowledge in order to collect, record, and analyze reliable, valid, and clinically meaningful data to enable him or her to categorize patients into different risk categories for caries and, where applicable, for dental erosion or non-erosive tooth wear.

## Learning Outcomes

On graduation, a dentist must:

*Be capable of:*

- 2.8 Selecting the risk factors, disease indicators, and protective factors appropriate to the patient. For example, the patient's medical, oral, and dental history; social history; oral health literacy; oral health behaviors; oral hygiene; knowledge, preferences, and self-efficacy; dietary habits; intraoral biological factors; caries experience (past and current); fluoride exposure and use; systemic health; and new validated risk factors as evidence emerges.
- 2.9 Assigning a risk category, and reassessing this over time, based on information obtained in 2.8.
- 2.10 Communicating the results of risk assessment with patients or others, and providing recommendations to enable patients to reduce the risk of developing new caries lesions and/or progression of existing lesions in the future (see Domains III and IV).

*Have knowledge of:*

- 2.6 The different types of developmental anomalies and differentiation of these conditions from caries and dental erosion or non-erosive tooth wear or anomalies due to genetic disorders.

*Be familiar with:*

- 2.7 Emerging methods for caries lesion, erosion, and non-erosive tooth wear detection, staging, and classification; how to evaluate these devices and the information derived from them; and how to use evidence-based information to make informed treatment decisions (see also Domains III and IV). Examples of emerging caries detection methods are laser fluorescence, optical coherence tomography, and near infrared imaging.

*Have knowledge of:*

- 2.11 How to evaluate the evidence supporting emerging information on risk factors, disease indicators, and protective factors.

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## APPENDIX: U.S. Cariology Curriculum Framework (continued)

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### Domain II. Diagnosis, Risk Assessment, and Synthesis: Objectives and Learning Outcomes (continued)

#### SYNTHESIS

Synthesis is the integration of all appropriate information needed to ensure appropriate continuing management of dental caries, thereby enabling patient-centered, evidence-based clinical decision making for the benefit of a specific patient at a specific time period.

#### Objective

On graduation, the dentist must be capable of synthesizing all relevant information by combining and interpreting findings from risk assessment and diagnostic processes, motivational engagement through motivational interviews or other means, and patients' needs, preferences, and interests; and must be also capable of monitoring, reviewing, and reassessing findings when available.

#### Learning Outcomes

On graduation, a dentist must:

*Be capable of:*

- 2.12 Eliciting and assessing patients' needs, preferences, readiness for change, and interests for the management of caries.
- 2.13 Motivational engagement through motivational interviews or other means.
- 2.14 Making clinical decisions incorporating, when appropriate, findings from monitoring and reassessment of caries. These aspects link to the clinical decision making aspects of Domains III and IV.
- 2.15 Providing treatment options, including referral to specialists for medical and dental care and for other rare disorders of dental hard tissues or medical illnesses causing dental hard tissue disorders.

*Have knowledge of:*

- 2.16 Dental erosion or non-erosive tooth wear, synthesizing all relevant findings from histories and examinations by combining and interpreting them, in order to enable patient-centered and shared clinical decision making.
  - 2.17 Eliciting and assessing patients' needs, preferences, and interests for the management of dental erosion or non-erosive tooth wear.
  - 2.18 Making clinical decisions incorporating, when appropriate, findings from monitoring and reassessment of dental erosion or non-erosive tooth wear. These aspects link to the clinical decision making aspects of Domains III and IV.
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### Domain III. Preventive Therapy, Nonsurgical Therapy, and Clinical Decision Making: Objectives and Learning Outcomes

This domain is concerned with the management of dental caries and other dental hard tissue disorders with an emphasis on long-term preventive care planning, reassessment, and maintenance. It involves applying the principles of prevention of development and progression of dental caries and other dental tissue disorders (non-surgical therapy). These learning objectives apply in different ways to patients of all ages and should be clearly defined in order for outcomes to be evaluated. This domain also includes communication, which is a critical part of the decision making process.

#### COMMUNICATION WITH PATIENT, FAMILY, AND COMMUNITY IN DIFFERENT HEALTH CARE ENVIRONMENTS

#### Objective

On graduation, a dentist must be capable of communicating prevention effectively, interactively, and reflectively with patients. The communication style has to consider the age and the social circumstances of the patient/community and the environment in which this is imparted. In this section, the term "patient" also refers to families and caregivers where appropriate.

### **Learning Outcomes**

On graduation, a dentist must:

*Be capable of:*

- 3.1. Establishing rapport in a trusting patient-dentist relationship.
- 3.2. Helping the patient understand the importance of taking an active role in the preventive process, and involving the patient to promote his or her understanding of the disease, with the goal of enhancing compliance with professional and individual preventive measures as a contribution to future oral health.
- 3.3. Identifying and understanding the psychological, physical, and social factors, including culturally related differences in behaviors that might have an influence on patient compliance and on the outcome of preventive measures implemented and advised.
- 3.4. Evaluating the patient's readiness to change and potential for compliance with the proposed preventive and nonsurgical plan.
- 3.5. Identifying, understanding, and discussing patient expectations, desires, attitudes, needs, and preferences when considering preventive treatment planning.
- 3.6. Obtaining informed consent for delivery of all aspects of preventive care.
- 3.7. Working with other members of the dental and/or medical team, and having a clear knowledge of their roles and responsibilities during preventive care and maintenance.
- 3.8. Making appropriate, timely consultations and/or referrals by exchanging patient information with other dental specialists and/or health care professionals.

### **CLINICAL DECISION MAKING LEADING TO PREVENTIVE AND NONSURGICAL THERAPY**

#### **Objective**

On graduation, the dentist must be capable of clinical decision making to formulate appropriate preventive and nonsurgical therapeutic treatment options, which should be presented to and discussed with the patient to arrive at an individualized (personalized) treatment plan. This includes preventive care strategies according to the needs, risks, and compliance capabilities at the individual, family, and caregiver levels. This nonsurgical disease management should consider not only the site and tooth, but also patient-related factors. This requires an awareness of the potential to change and need to reassess and monitor risk status over time and the ability to systematically evaluate all preventive treatment outcomes at recare/recall intervals and during treatment and to formulate alternative treatment plans when required.

#### **Learning Outcomes**

On graduation, a dentist must:

*Be capable of:*

- 3.14 Educating patients concerning the etiology of dental hard tissue diseases, and encouraging them to assume responsibility for their oral health.
- 3.15 Educating patients concerning dietary habits and other destructive habits relevant to oral health.
- 3.16 Developing a treatment plan that encompasses the most appropriate evidence-based nonsurgical methods for the prevention and management of dental caries for an individual patient, and reassessing this plan over time.
- 3.17 Administering and prescribing preventive chemotherapeutic agents (such as fluorides, antimicrobials, calcium-based strategies) based on risk and according to the best evidence available.
- 3.18 Teaching patients to perform appropriate oral hygiene techniques.
- 3.19 Monitoring the effects of mechanical and chemical plaque control.
- 3.20 Performing dental prophylaxis.
- 3.21 Applying sealants, and evaluating when they need to be reapplied or repaired.
- 3.22 Critical appraisal of new developments and how to integrate them in his or her clinical activities.
- 3.23 Administering and prescribing preventive and chemotherapeutic agents in a personalized manner tailored to the patient's needs and limitations (e.g., for groups with special needs, such as aged or disabled persons or those with systemic or psychiatric diseases).

*Have knowledge of:*

- 3.9 Behavioral factors that facilitate the delivery of preventive dental care.
- 3.10 Patient-related factors influencing the outcome of preventive advice, e.g., expectations, compliance over time, and manual dexterity.
- 3.11 Nonverbal communication skills, e.g., intonation, body language, sitting position, and eye contact.
- 3.12 Behavioral interventions such as motivational interviewing and self-determination theory.
- 3.13 Enabling the patient to recognize the association between oral and systemic diseases.

*Have knowledge of:*

- 3.24 Mechanisms of caries prevention agents (including emerging caries prevention agents) and their methods of application and administration.
- 3.25 Limitations and adverse effects of agents and products used in preventive care.
- 3.26 Destructive and protective role of diet in caries and dental erosion.

## APPENDIX: U.S. Cariology Curriculum Framework (continued)

### Domain IV. Surgical Therapy and Clinical Decision Making: Objectives and Learning Outcomes

This domain is concerned with the management of dental caries and other dental hard tissue disorders with an emphasis on restorative care planning, reassessment, and maintenance, accompanied by continuing preventive and therapeutic care (see Domain III). It involves applying the principles of preservation of dental hard tissues and is aligned with other aspects of restorative dentistry, endodontics, and prosthodontics as far as execution of a restoration or as part of a restorative treatment plan is concerned. This domain recognizes that surgical intervention is considered as a last resort when the preventive (primary and secondary) and nonsurgical therapeutic care options are no longer adequate. Preventive and nonsurgical therapeutic care interventions should be an ongoing intervention based on risk factors, reassessed over time, to maintain the oral health throughout the patient's life.

#### CLINICAL DECISION MAKING LEADING TO SURGICAL THERAPY

##### Objective

On graduation, the dentist must be capable of collecting, interpreting, and synthesizing all relevant information needed to formulate appropriate treatment options, along with risks and benefits and prognosis, which can be presented to and discussed with the patient to arrive at a shared decision for an individualized treatment plan. This requires the ability to decide when it is appropriate for surgical intervention decisions for caries lesions and other hard tissue disorders (e.g., dental erosion or non-erosive tooth wear or tooth fractures) and to understand the consequences and prognosis of such decisions.

##### Learning Outcomes

On graduation, a dentist must:

*Be capable of:*

- 4.1 Selecting the appropriate treatment option based on the best available evidence concerning the range of non-surgical and surgical treatment options and the patient's caries risk.
- 4.2 Continual reevaluation and reflection on the decision making process and application of evidence-based principles regarding the outcomes of surgical intervention.
- 4.3 Recognizing, understanding, and managing the consequences and outcomes of surgical intervention.

#### SURGICAL THERAPY

##### Objective

On graduation, a dentist must be capable of using the best available evidence to provide tooth-preserving surgical treatment of caries lesions based on lesion stage and activity. The graduating dentist must be competent at restoring the loss of dental hard tissue in form and function with consideration of the patient's esthetic desires, while establishing and promoting oral health.

##### Learning Outcomes

On graduation, a dentist must:

*Be capable of:*

- 4.7 Using the best available evidence to provide tooth-preserving surgical treatment of caries lesions based on lesion stage and activity, and be competent at restoring the loss of dental hard tissue in form and function with consideration of the patient's esthetic desires, while establishing and promoting oral health.

*Have knowledge of:*

- 4.4 The reactions of the dentin-pulp complex to the caries disease process and other dental hard tissue disorders with respect to surgical intervention and dental materials used during restorative procedures.
- 4.5 Success and failure rates of restorations.

*Be familiar with:*

- 4.6 Emerging technologies and materials for surgical management of caries and other dental hard tissue disorders.

*Have knowledge of:*

- 4.11 The impact of restorative procedures on mucosa, periodontal tissues, occlusion, and oral function.

*Be familiar with:*

- 4.12 Emerging methods for caries removal, restorative techniques, and materials.
- 4.13 Biomechanics of restorations.

4.8 Identifying which, if any, dental hard tissue needs to be replaced in order to extend the longevity of the tooth, again considering preservation of tooth structure and pulp vitality and the restorability of the tooth.

4.9 Performing and understanding the indications of different techniques of caries tooth structure removal (e.g., partial vs. complete, step-wise excavation, indirect and direct pulp capping) while preserving tooth structure and pulp vitality.

4.10 Selecting and handling appropriate restorative materials, considering physical and chemical properties, biocompatibility, longevity, and patient's caries risk for developing secondary caries if risk factors are not controlled, as well as patient's needs and desires.

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### Domain V. Evidence-Based Cariology in Clinical and Public Health Practice: Objectives and Learning Outcomes

This domain deals with the core skills of evidence-based dental practice in the predoctoral curriculum, which underpins the dual facets of clinical cariology (relating particularly to individuals) and public health cariology (PHC) (relating particularly to groups/communities). It should be emphasized that PHC requires skills in addition to those listed in Domains II-IV. This domain relates to dental caries and other dental hard tissue disorders. Skills in evidence-based dentistry (EBD), which are generic to the predoctoral curriculum as a whole and not only cariology, are integral to lifelong learning and critical thinking skills in dentistry. Clinical cariology for the assessment and management of caries for the individual patient is dealt with in Domains II-IV; PHC is presented in this domain in close relationship to the principles of EBD. It is important that these topics are brought to life by including practical experiences in the clinical and public health environment.

#### EVIDENCE-BASED CARIOLOGY

##### Objective

On graduation, a dentist must understand the benefits of practicing in an evidence-based manner at both the individual and public health levels, have good knowledge and skills in these areas, and apply them to the fields of dental caries and other dental hard tissue disorders.

##### Learning Outcomes

On graduation, a dentist must:

*Be capable of:*

- 5.1 Identifying uncertainty or gaps in understanding.
- 5.2 Formulating a clinical question, and finding the evidence to answer the question, using appropriate resources.
- 5.3 Searching for and using the most appropriate clinical guidelines.
- 5.4 Critical appraisal of evidence for diagnostic methods and therapies.
- 5.5 Evaluating the evidence for new treatment strategies in order to decide on their implementation.
- 5.6 Recognizing the limitations of research methodology and guidelines.

*Have knowledge of:*

- 5.7 The principles of EBD and the hierarchy of evidence.
- 5.8 The methods of communicating EBD to individuals, groups, and populations.
- 5.9 The advantages and disadvantages of guidelines.
- 5.10 Translating research findings into clinical and public health practice.

*Be familiar with:*

- 5.11 The principles of research, including study design, sampling, bias, and biostatistics (related to Domain I).

## APPENDIX: U.S. Cariology Curriculum Framework (continued)

### Domain V. Evidence-Based Cariology in Clinical and Public Health Practice: Objectives and Learning Outcomes (continued)

#### DENTAL PUBLIC HEALTH IN RELATION TO CARIOLOGY

##### Objective

On graduation, a dentist must be capable of preventing and controlling dental caries and other dental hard tissue disorders at the group and community levels. This requires comprehensive understanding of epidemiology, health promotion, and preventive strategies, their integration into oral health care systems, and interaction with other oral disorders, general health, nutrition, and the socioeconomic context.

##### Learning Outcomes

On graduation, a dentist must:

*Be capable of:*

- 5.12 Delivering oral disease prevention for groups.
- 5.13 Assessing health-related behaviors and inducing changes.

*Have knowledge of:*

- 5.14 Managing issues related to individuals' rights and interests, as well as to professionals' rights, duties, and interests.
- 5.15 Recording caries and other dental hard tissue disorders using appropriate indices at different disease levels in a public health setting.
- 5.16 The indices for various oral problems.
- 5.17 The concept of oral health-related quality of life.
- 5.18 The descriptive epidemiology of caries in relation to variables such as age, general health, and socioeconomic status.
- 5.19 The identification of caries risk for individuals and groups in populations.
- 5.20 The assessment of dental treatment needs from a public health perspective.
- 5.21 Oral health advocacy, promotion, and prevention for populations as part of general health promotion.
- 5.22 The organization interaction levels for prevention (individuals, groups, and populations).
- 5.23 The interactions between caries and other oral health problems.
- 5.24 The organization of dental health care and public dental health care.
- 5.25 The role of various health professionals and their interaction in public dental health.

*Be familiar with:*

- 5.26 The application of epidemiological methods in dental public health.
- 5.27 Trends in dental health patterns and treatment needs.
- 5.28 Concepts of health policy and general public health approaches in populations.
- 5.29 International (global) approaches to dental health care systems.
- 5.30 Health economic aspects of oral health programs.