

ORIGINAL ARTICLE

A survey of cariology education in U.S. dental hygiene programs: The need for a core curriculum framework

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Abstract

Objective: Dental hygienists play a key role in dental caries prevention and management. As the evidence of dental caries risk, prevention, and management becomes more complex, it is essential that dental hygiene (DH) programs have a strong cariology curriculum. This project aimed to assess current cariology content in U.S. DH programs, how content is taught, and interest in development/implementation of a common/core cariology curriculum framework.

Methods: Directors of 336 U.S. DH programs were invited to participate in a voluntary online survey using Qualtrics. The survey consisted of 41 items including demographics, details about the program's cariology content, and how it was delivered, and items related to a core cariology curriculum.

Results: The overall response rate used for analyses was 27.3%. Some findings include: 61.6% stated their program had a defined cariology curriculum, 35.2% did not have an individual cariology course, 61.5% had preclinical hands-on experiences in cariology, 79.7% are teaching management strategies related to salivary gland hypofunction, 68.3% are teaching use of silver diamine fluoride (SDF), and 64.2% felt cariology was adequately being taught. Only 17.7% are teaching the International Caries Detection and Assessment System (ICDAS) system. 87.3% indicated support for developing a core curriculum framework for teaching cariology in DH programs.

Conclusions: This study indicated that, although DH programs reported that cariology concepts are being taught both didactically and clinically, discrepancies between concepts taught and the literature exist. Therefore, there is a need to create a more standardized curriculum framework for all U.S. DH programs.

KEYWORDS

caries education, caries prevention and management, curriculum development/evaluation, dental caries, dental hygiene curricula, dental hygiene programs, dental hygiene, ICDAS

1 | INTRODUCTION

Dental hygienists play a key role in health promotion and disease prevention.¹⁻⁴ They are at the forefront, in

private and public settings, of advocacy and delivery of evidence-based strategies to prevent and arrest dental caries lesions.^{2,4} Although clinical responsibilities vary based on individual states' laws and regulations,

these key roles remain constant across the United States.⁵

Dental hygiene (DH) educational programs in the United States are required to provide content that includes oral health education, preventive oral disease counseling, and oral health promotion, as well as ensuring the dental hygienist graduate is competent to establish a dental hygiene care plan that “reflects realistic goals and treatment strategies to facilitate optimal oral health.”^{5,6} Thus, dental hygienists must learn early in their educational training to collect and analyze patient data to establish an evidence-based, person-centered care plan for the prevention and management of the dental caries disease process, non-restorative management of caries lesions, and the promotion of oral health.^{2–6} This is similar to the expectations of educational programs to prepare dentists for caries prevention and management.⁷

To achieve this, DH programs must develop and assess competencies to ensure their graduates have an up-to-date understanding of the caries disease process and are able to implement evidence-based concepts in caries detection, risk assessment, prevention and non-restorative management of caries lesions.^{5–8} However, to date, there has been no assessment of the variability in teaching of cariology content in U.S. DH programs. Therefore, the aims of this study were to investigate: (1) what cariology content was currently being taught in U.S. DH programs, (2) how content was being taught didactically and clinically, and (3) what gaps exist between current teaching and current evidence. (4) Additionally, this study intended to determine if U.S. DH educators would be interested in developing a common framework for a core cariology curriculum to better prepare the future workforce, as it was done for programs educating dentists in the United States.⁷

2 | METHODS

This descriptive cross-sectional study was deemed exempt by the Institutional Review Board (IRB) oversight by the Health Sciences and Behavioral Sciences IRB at the University of Michigan, Ann Arbor, Michigan, in October 2018 (HUM ID 00153737).

2.1 | Procedure

Data concerning cariology teaching were collected via a voluntary, online survey (Qualtrics). Emails were sent to 336 U.S. programs and included a brief summary of the project, aims of the study, and an electronic anonymous link to the survey instrument. Two reminder emails were sent, each 1 month apart. Participants could skip any

questions, and some questions included the option to choose more than 1 answer. Responses were tracked using the Internet provider (IP) address provided through the survey software as well as respondents were asked to report the name of their institution to assure duplicate data were not analyzed.

2.2 | Materials

The questionnaire used was an adapted version of the survey designed by the Section of Cariology of the American Dental Education Association, and used in the investigation period before the development of a core cariology curriculum framework for U.S. dental schools.⁷ The U.S. survey had been based on the one used initially in Europe.⁹ The survey consisted of 41 closed- and open-ended questions associated with teaching cariology in DH. A definition of cariology and diagnosis was provided to the participant. The survey was divided into 4 sets of questions. The first set of questions focused on demographics of the responding school. The second series of questions focused on the current cariology teaching within their DH programs. Questions included cariology-based clinical competencies, presence of clinic or lab experiences, inclusion of additional dental defects (e.g., abrasion, erosion), and the primary textbook recommended with their teaching. The third series of questions focused on specific content regarding cariology teaching. Questions in this section included content of nomenclature, classification systems used, epidemiology, histopathology, etiological role of saliva, diet, caries detection, risk assessment, referral, and caries prevention and management strategies used.

2.3 | Statistical analysis

The data were exported from the website as an SPSS data file (SPSS Version 22.0, IBM Corp released 2013, IBM SPSS Statistics for windows; NY, USA: IBM Corp.). Descriptive statistics such as percentages, frequencies, and means were computed to provide an overview of the responses.

3 | RESULTS

There were 110 submissions, but 18 were excluded after initial review; 5 were incomplete duplicates of subsequent complete submissions, and 13 included submissions with only the first question completed and no other information. Thus, the overall response rate used for analyses was 27.3% (92/336), with 92.3% responding to all questions (85/92), indicating a high quality response.⁹ The

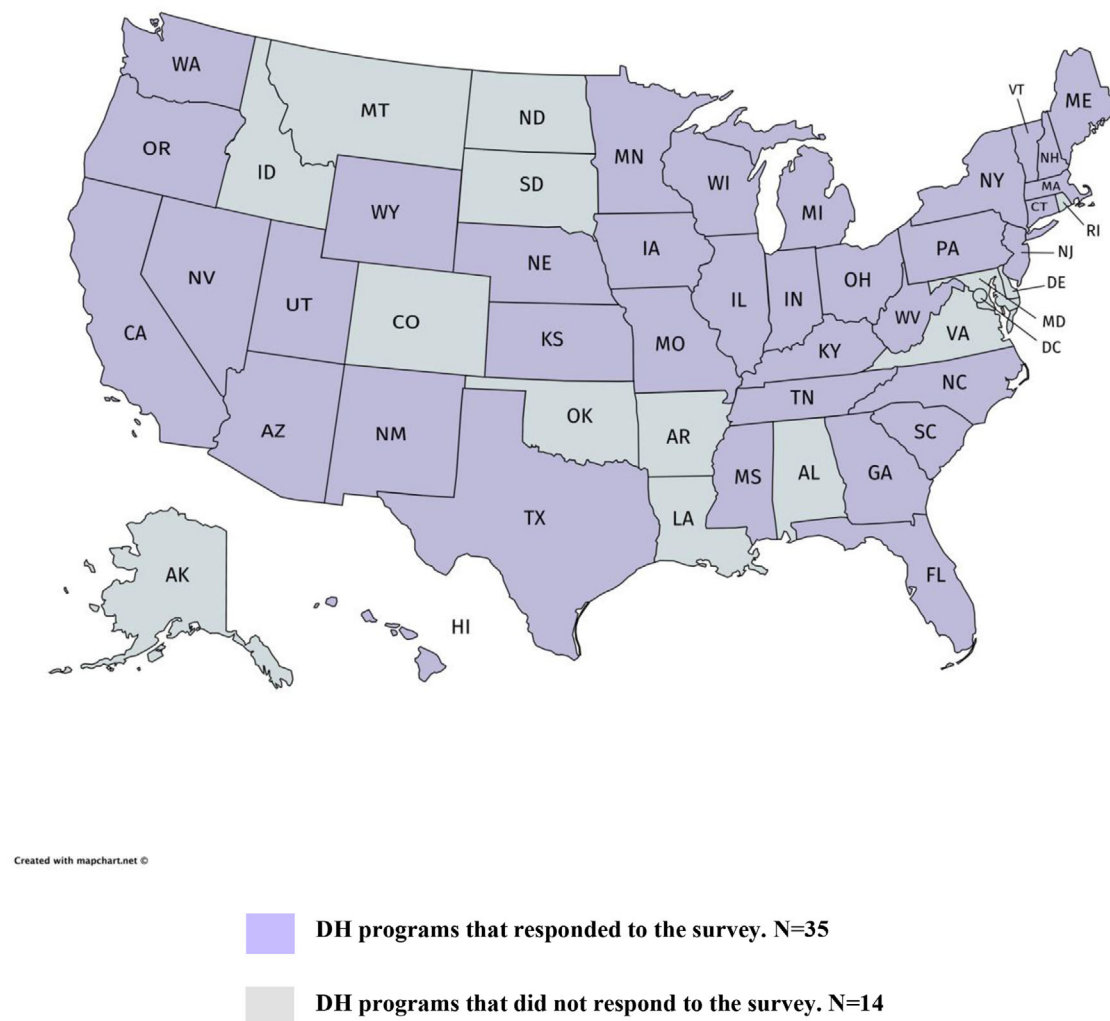


FIGURE 1 Responding U.S. dental hygiene programs

remaining 7 submissions had some skipped questions, which was allowable, as responses to all questions were not mandatory (i.e., all N values are reported along with the responses for each question).

At least 1 survey response was obtained from a DH program in 38 of 50 U.S. states (Figure 1). Among the responding programs, 81.3% awarded graduates an associate degree ($n = 70/N = 86$) and 19.7% a baccalaureate degree ($n = 17/N = 86$). None of the responding programs indicated their conferring degree was a diploma or certificate. About half (59.7%) of respondents indicated their program was in a community college ($n = 55/N = 92$), 16.3% indicated their program was part of a technical or vocational/career school ($n = 15/N = 92$), 13.0% indicated a university or 4-year college school of health sciences ($n = 12/N = 92$), 1.0% indicated a university or 4-year college dental school ($n = 8/N = 92$), 2.1% indicated they were part of a 4-year college ($n = 2/N = 92$).

A total of 87% of respondents indicated their program was a publicly funded institution ($n = 80/N = 92$), where

7.6% indicated the program was in a private for-profit institution ($n = 7/N = 92$), and 5.4% indicated private not-for-profit funding for their program ($n = 5/N = 92$). A total of 81.5% of programs reported following a semester calendar ($n = 75/N = 92$), 9.7% reported following a quarter calendar ($n = 9/N = 92$), 5.4% reported following a term calendar ($n = 5/N = 92$), and 2.1% were on a trimester calendar ($n = 2/N = 92$).

A comprehensive overview of the data concerning what specific cariology content is being taught can be found in Table 1. Respondents were asked whether their cariology curriculum also included defects of dental hard tissues other than dental caries. 100% of those who responded to this question ($N = 83$) indicated the curriculum covered other dental hard tissue defects including dental erosion. Respondents were asked to indicate what specific topics were covered in their cariology education. The most reported (97.5%) topics addressed were clinical and histological appearance of caries lesions and considerations for root caries lesions ($n = 79/N = 81$),

TABLE 1 Percentage of programs indicating that specific cariology topics/concepts are addressed in their cariology curriculum of their DH program

Response to the question: “Which of the following are addressed in the cariology curriculum of your program?”			N = 81^a
Concept addressed	%	n^b	
Clinical and histological appearance of carious lesions	97.5%	79	
Considerations for root caries	97.5%	79	
Epidemiology of dental caries	96.2%	78	
Evidence-based dentistry in caries management	93.8%	76	
Nomenclature in cariology	91.3%	74	
Caries management in populations (public health)	91.1%	72	
Caries associated with restorations (secondary or recurrent lesions)	88.8%	71	
Histopathology of dental caries	79.0%	64	
Considerations for managing caries in different populations (e.g., children, elderly)	56.7%	46	
Interim therapeutic restorations	56.7%	46	
ART- Atraumatic restorative techniques	33.3%	27	
Response to the question: “Which of the following concepts are taught concerning etiology of dental caries?”			N = 80^a
Diet	100.0%	80	
Microbiology/immunology of caries	98.7%	79	
Saliva	98.7%	79	
Genetics	68.7%	55	
Response to the question: “Which concepts, associated with saliva and dental caries, are addressed in your program?”			N = 80^a
Visual analysis (consistency, degree of hydration)	91.2%	73	
Buffering capacity	86.2%	69	
Resting vs. stimulated pH	65.0%	52	
Resting vs. stimulated flow rate	57.5%	46	
Bacterial cultures or other metrics (e.g., ATP screening)	27.5%	22	
Response to the question: “Regarding dental erosion, which of the following is addressed in your program?”			N = 79^a
Etiology	98.7%	78	
Detection and diagnosis	94.9%	75	
Management	92.4%	73	
Epidemiology	74.6%	59	
Physiochemistry	62.0%	49	

(Continues)

TABLE 1 (Continued)

Response to the question: “Regarding behavioral sciences and cariology that are addressed, which are addressed in your program?”			N = 79^a
Choice of appropriate preventive strategies	98.7%	78	
Patient compliance with preventive programs	96.2%	76	
Motivational interviewing	91.1%	72	
Assessment of readiness for behavioral change	81.0%	64	
Response to the question: “Regarding caries detection and diagnosis, which are addressed in your program?”			N = 79^a
Radiographic detection	100.0%	79	
Visual detection	96.2%	76	
Visual detection with magnification	86.0%	68	
Tactile detection	84.8%	67	
Caries activity assessment/diagnosis	67.0%	53	
Non-radiographic technology-assisted detection (e.g., fluorescence-based methods)	46.8%	37	
ICDAS II terminology and criteria	17.7%	14	
Response to the question: “When caries lesion are detected and documented in the electronic health record in the clinic, what terms are used to classify caries lesions?”			N = 79^a
Root caries	86.0%	68	
Non-cavitated (e.g., incipient, white spot) lesion	72.1%	57	
Primary caries	70.8%	56	
Cavitated lesion	67.0%	53	
Watch	65.8%	52	
Secondary caries	64.5%	51	
Active lesion	64.5%	51	
Arrested lesion	55.6%	44	
ICDAS 0: sound lesion	0.08%	7	
ICDAS 1–2: initial lesion	0.08%	7	
ICDAS 3–4: moderate lesion	0.08%	7	
ICDAS 5–6: advanced lesion	0.08%	7	
Other: suspicious lesion, recurrent decay, identified by surface involved (e.g., MO, DO), GV Black	0.07%	6	

^aThe total number of those who responded to each individual question.

^bThe total number of respondents who selected each choice as more than selection was allowed.

96.2% reported teaching epidemiology of dental caries (n = 78/N = 81), and 93.8% reported teaching evidence-based caries management (n = 76/N = 81). The least reported topics (33.3%) were atraumatic restorative techniques (n = 27/N = 81), interim therapeutic restorations,

and considerations for managing caries in different populations, 56.7% ($n = 46/N = 81$). All programs indicated they were teaching concepts concerning diet, microbiology, and saliva (100%, $n = 80/N = 80$; 98.7%, $n = 79/N = 80$; 98.7%, $n = 70/N = 80$, respectively), where fewer programs (68.7%) were integrating genetics into their curriculum ($n = 55/N = 80$). Concerning saliva concepts and cariology, very few programs (27.5%) were teaching concepts related to bacterial culturing ($n = 22/N = 80$), but more than half (57.5%) of the programs were teaching assessment of resting versus stimulated saliva flow rate ($n = 46/N = 80$). Most (86.2%) respondents indicated their concepts concerning saliva and cariology focused on buffering capacity ($n = 69/N = 80$) and visual analysis of the presence of saliva (91.2%, $n = 73/N = 80$). The majority (96.2%) of participants indicated students were taught to detect caries lesions visually ($n = 76/N = 79$), while 84.8% are being taught to detect lesions relying on tactile criteria ($n = 67/N = 79$). A total of 91% of ($n = 74/N = 81$) programs indicated that they are teaching some form of nomenclature in cariology. However, only 17.7% ($n = 14/N = 79$) of respondents reported they were teaching use of the International Caries Detection and Assessment System II (ICDAS II) and other criteria for caries lesion detection and classification.^{10,11}

With regard to how concepts in cariology were being taught, 72.2% ($n = 57/N = 79$) of the respondents indicated they felt cariology concepts were being adequately taught throughout their clinical curriculum, whereas 27.9% ($n = 22/N = 79$) felt cariology concepts were not being adequately taught throughout their curriculum. A total of 64.8% of the responding programs ($n = 59/N = 91$) indicated an overall cariology curriculum existed for their program, which included topics, goals, and objectives. However, 35.2% indicated there was not a clear cariology curriculum ($n = 32/N = 91$). When asked whether cariology was being taught as an individual course or as key topics within other courses, 86.0% of the respondents ($n = 74/N = 86$) indicated cariology concepts were being taught throughout and within multiple courses, and 13.9% of the respondents indicated cariology was being taught as an individual course ($n = 12/N = 86$).

Respondents were asked to list which course(s) taught cariology concepts. Most indicated that cariology concepts were being taught in theory/seminar/concepts courses (50.0%; $n = 37/N = 74$), as well as in clinical courses (39.1%; $n = 29/N = 74$), followed by preventive dentistry/patient education courses (36.4%; $n = 27/N = 74$). Results to this question can be seen in Table 2. In describing preclinical hands-on workshops or lab portions of the cariology curriculum, 61.5% of the respondents ($n = 51/N = 83$) indicated there was such a portion in the curriculum, and 38.6% ($n = 32/N = 83$) indicated there were not preclinical or hands-on portions in the current curriculum. When asked

TABLE 2 Percentage of programs answers to the open-ended question concerning DH courses where cariology concepts are currently being taught

Responses to the question: "If cariology is not an individual course, please describe the course in which cariology concepts are being currently taught."		
		N = 74^a
Course/s theme	%	n^b
Theory/seminar/concepts	50.0%	37
Clinical courses	39.1%	29
Preventive dentistry/patient education	36.4%	27
Community/public health/practicum	29.7%	22
Pre-clinic	28.3%	21
Radiology	20.2%	15
Oral pathology	20.2%	15
Biomaterials	17.5%	13
Oral anatomy/tooth morphology	17.5%	13
Histology and embryology	17.5%	13
Nutrition	12.1%	9
Periodontology	6.7%	5
Biological sciences (biology/microbiology)	4.0%	3
All courses	2.7%	2
Restorative dentistry	2.7%	2
Dental hygiene process of care	2.7%	2
Special patients	1.3%	1

^aNumber of respondents that indicated that cariology is taught throughout multiple courses.

^bNumber of responses indicating which to specific courses cariology is taught.

what textbook was used for teaching cariology concepts, 69.9% of respondents ($n = 58/N = 83$) indicated they had "no primary textbook" that was being used for teaching cariology. Of the 30.1% who responded that a primary text was being used, 72.0% ($n = 18/N = 25$) indicated that *The Clinical Practice of the Dental Hygienist* by Esther Wilkins was being used, 2.0% ($n = 5/N = 25$) indicated using *Dental Hygiene Theory and Practice* by Darby and Walsh, with 8% of the remaining respondents indicating using multiple resources from the literature ($n = 2/N = 25$). A total of 98% of respondents (98.7%; $n = 78/N = 79$) reported caries risk assessment (CRA) was being addressed in the curriculum both in classroom-based theoretical concepts and direct hands-on skills practice in labs, workshops, pre-clinics, and clinics. When asked about what caries prevention and management strategies were being taught, all programs (100%; $n = 79/N = 79$) reported teaching the importance of professional and individual mechanical plaque removal, as well as teaching behavior change for cariogenic diet modification as key topics. A significant number of programs (68.3%) reported teaching preventive strategies focused on the use of silver diamine fluoride (SDF)

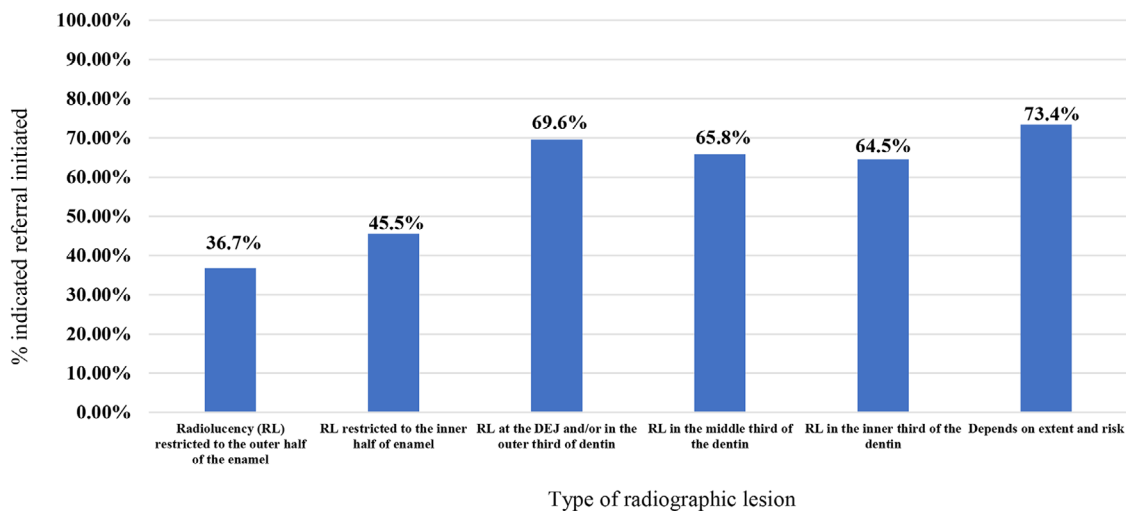


FIGURE 2 Percent response to the question: “What radiographic findings are clinical indications for a referral for operative intervention in your program?”

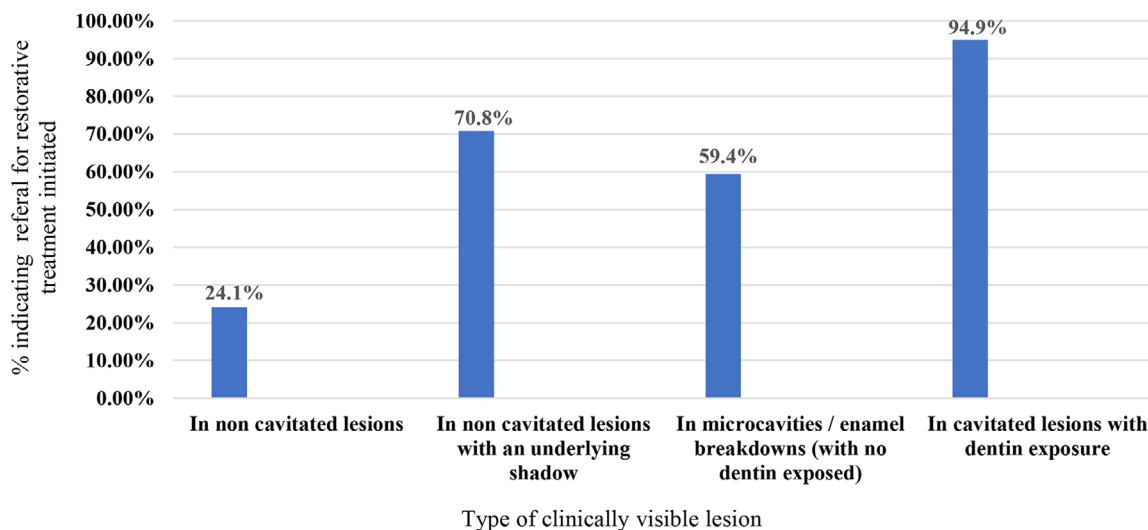


FIGURE 3 Response to the question: “When does your program choose to make a restorative treatment referral decision for a clinically visible lesion?”

($n = 54/N = 79$), pH neutralization (86.0%; $n = 68/N = 79$), or management of salivary gland hypofunction (79.7%; $n = 63/N = 79$). A comprehensive list of the caries prevention and management strategies reported can be found in Table 3.

The most common products taught for the management of caries were professionally applied topical fluorides (100%; $n = 79/N = 79$), pit and fissure sealants (98.7%; $n = 78/N = 79$), over-the-counter fluoride products (97.4%; $n = 77/N = 79$), and use of chlorhexidine gluconate mouth-rinse (94.9%; $n = 77/N = 79$). The least common caries management products taught were 1% chlorhexidine/1% thymol varnish (15.1%; $n = 12/N = 79$), iodine (13.9%; $n = 11/N = 79$), and chlorine mouth-rinse (0.1%; $n = 7/N = 79$).

Respondents were asked to respond to the questions, “What radiographic findings are clinical indications for a referral for operative intervention in your program?” and “When does your program chose to make a restorative treatment referral decision for a clinically visible lesion?” The results of these findings can be found in Figure 2 for radiographical findings and Figure 3 for clinical findings. A total of 36% (36.7%; $n = 29/N = 79$) of respondents indicated they taught students to recommend a referral for operative intervention when a radiolucency seen on a radiograph was restricted to the outer half of the enamel, 45.6% ($n = 36/N = 79$) taught referral for operative treatment when the radiolucency was restricted to the inner half of the enamel. Concerning clinically visible lesions, 24.1% ($n = 19/N = 79$) of the respondents indicated they

TABLE 3 Percentage of programs indicating that specific caries prevention and management strategies are currently being taught in the DH program

Responses to the question: "With regard to non-surgical management strategies (prevention, arrest, and remineralization, which of the following are addressed in the didactic curriculum of your program?)"		
Concept addressed	%	n^b
Professional and individual plaque removal	100.0%	79
Cariogenic diet modification	100.0%	79
Fluoride	100.0%	79
Dental sealants	100.0%	79
Xylitol-based strategies	96.2%	76
Antibacterial strategies	87.3%	69
pH neutralization strategies	86.0%	68
Calcium-based strategies	83.5%	66
Management of salivary gland hypofunction	79.7%	63
Silver diamine fluoride (SDF)	68.3%	54
Responses to the question: "Please indicate which of the following products are discussed in your curriculum and also available in the clinics?"		
Professional applied topical fluoride	100.0%	79
Pit and fissure sealants	98.7%	78
Over the counter fluoride toothpaste	97.4%	77
Chlorhexidine mouth rinse	94.9%	75
Fluoride mouth rinse	86.0%	68
Xylitol (and/or other sugar alcohols)	79.7%	63
Artificial saliva	75.9%	60
High concentration prescription fluoride toothpaste	77.2%	61
Calcium-based strategies (e.g., Recaldent)	62.0%	49
Silver diamine fluoride (SDF)	40.5%	32
Acid buffering products	37.9%	30
Novamin	31.6%	25
Baking soda products	26.5%	21
Chlorhexidine varnish	15.1%	12
Iodine solution	13.9%	11
Chlorine mouth rinse	0.08%	7
Other	0.02%	2

^aThe total number of those who responded to each individual question.

^bThe total number of respondents who selected each choice as more than selection was allowed.

would have the student refer for operative treatment for a non-cavitated lesion, 59.5% ($n = 47/N = 79$) for micro-cavitation and a lesion with enamel breakdown, and 70.9% ($n = 56/N = 79$) for a non-cavitated lesion with an underlying shadow.

Finally, when participants were asked whether they supported the development of a core framework for a DH cariology curriculum, 87.3% ($n = 69/79$) of participants indicated in the affirmative.

4 | DISCUSSION

A recent European publication indicated that dental hygienists are "looking keenly for the creation of a Common Education Framework for Caries."¹² The data from this study demonstrates that the majority of responding DH programs in the United States are also in full support of the development of a core cariology curriculum framework. Current CODA Standards for Dental Hygiene Education Programs standard 2–13 state that U.S. dental hygienists "must be competent in providing the DH process of care which include: (1) comprehensive collection of patient data to identify the physical and oral health status; (2) analysis of assessment findings and use of critical thinking to address the patient's DH treatment needs; (3) establishment of a DH care plan that reflects the realistic goals and treatment strategies to facilitate optimal oral health; (4) provision of patient-centered treatment and evidence-based care in a manner minimizing risk and optimizing oral health; (5) measurement of the extent to which goals identified in the DH care plan are achieved; (6) complete and accurate recording of all documentation relevant to patient care."⁸ Yet, the standards fail to support specific competence in the students' ability, for example, to complete a CRA and successfully manage dental caries lesions non-restoratively. Furthermore, the data from this project show that there is some discord between current concepts and evidence in cariology and some of what was reported as being taught. Specifically, discrepancies were found in 4 distinct cariology domains: 1) nomenclature; 2) detection strategies; 3) management therapies, beyond the use of fluoride, sealants, and diet; 4) and operative treatment referral recommendations.

4.1 | Nomenclature/lesion classification

One of the greatest problems facing cariology has been related to the translation of research associated with caries detection, assessment, diagnosis, risk assessment, and management into clinical practice.¹³ This is further complicated by the misunderstanding surrounding the

array of clinical terms that are used in research, education, and practice to describe caries lesions and the caries process.^{13–17} Between 2002 and 2004, experts were tasked to devise a standardized, logical, and evidence-based system to inform decisions about the detection and classification of dental caries.¹⁰ This classification system would become known as the International Caries Detection and Assessment System (ICDAS).^{10,14,18,19} Including ICDAS, there are many systems used in different parts of the world to classify caries lesions and, in general, they aim to stage caries lesions by levels of severity and/or activity.^{19,20} Understanding the dental caries disease process is necessary to guide practitioners' treatment recommendations, predict treatment outcomes, and provide a consistent and clear language for monitoring and communicating the activity of the caries lesion and/or disease process with individuals and groups.^{10,14–18} The ICDAS Coordinating Committee and others have indicated that the future of research, practice, and education in cariology requires the development of an integrated definition of dental caries and uniform systems for measuring the caries process and resulting caries lesions.^{13,17,19,21} Over the past 10 years several reviews on nomenclature for cariology have been published encouraging world-wide consistency in nomenclature.^{15,17,19} In addition, over the past decade, systems such as the ICDAS have been a focus of cariology research with the goal of translating their validity and their use in clinical practice and education.²¹ Research of the ICDAS system, for example, has supported its accuracy, validity, and intra- and inter-reproducibility.²¹ The current American Dental Association (ADA) caries classification system collapses the 6 ICDAS caries codes into 3 categories: initial (ICDAS 1–2), moderate (ICDAS 3–4), and advanced (ICDAS 5–6) caries lesions, to allow the clinician to document caries lesions based on their severity.²² Yet, few of the DH programs surveyed in this study indicated they include the ICDAS or ADA caries classification system, or other similar systems, in their teaching of dental caries.

Developing a framework for DH educators that would support inclusion of current nomenclature and classification system definitions, and discussions on how to use the various systems for the detection and documentation of caries lesions, will help with adoption of a common language between oral health professionals, which is essential for the development and implementation of optimal evidence-based caries management plans for patients.

4.2 | Caries management strategies: beyond traditional strategies

The information gained from this survey confirmed that evidence-based strategies for caries prevention, such as

fluorides, sealants, effective plaque removal, and sugary diet modification are being emphasized throughout all the responding U.S. DH programs. These traditional caries prevention and management strategies are also an important component of dental school cariology curricula.^{7,11,23–26} The strong evidence supporting the use of fluoride and sealants for prevention and non-restorative management of caries lesions will continue to support teaching of these strategies at the forefront of cariology education.^{26–32}

However, what about other strategies, such as, for example, use of xylitol and/or sugar alcohols, antimicrobials, pH neutralization products, calcium-based strategies, and SDF? In some cases, the evidence supporting a strategy, and what was reported as being taught in DH programs agree. For example, in 2013, the ADA published clinical guidelines for the use of non-fluoridated agents for caries management and prevention, and supported the use of xylitol gums and lozenges, emphasizing their role in stimulating salivary flow, with varied levels of evidence for different products.²⁷ The majority of the DH programs indicated they were teaching and using xylitol-based strategies for the management of dental caries. In other cases, however, there is a discrepancy between what the evidence suggests and what is being taught. For example, most of the hygiene programs indicated they were teaching the use of antimicrobials for caries management, and most indicated teaching use of chlorhexidine mouth rinse, with only 15.1% teaching use of chlorhexidine/thymol varnish. However, the ADA clinical guidelines for the use of non-fluoridated agents for caries management and prevention, and the current ADA guideline for non-restorative management of caries lesions and its associated systematic review, do not support the use of a chlorhexidine mouth rinse for caries prevention or for arrest of non-cavitated lesions.^{29–31} Instead, for management of root caries lesions, these guidelines support the use of 1% chlorhexidine/1% thymol varnish to prevent and/or arrest root caries lesions.^{29–31}

Recently, the availability of SDF in the U.S. market has given clinicians another tool to help arrest caries lesions. Current evidence and ADA guidelines support the use of a 38% SDF solution biannually on advanced cavitated occlusal caries lesions in primary or permanent teeth as an alternative to restorative intervention, and also to arrest non-cavitated or cavitated root caries lesions.^{29–31} However, in this study, although more than half of the responding programs (68.4%; $n = 54/N = 79$) state that they teach information about SDF, less than half (40.5%; $n = 32/N = 79$) reported using it in their teaching clinics.

Even though calcium-based caries management strategies have been promoted as an alternative to fluoride containing products, the most recent ADA guidelines explicitly state that 10% CPP-ACP should not be used as a

substitute for fluoride products for the arrest or reversal of non-cavitated lesions.²⁹ Yet almost 3 quarters of the schools that responded to the survey are teaching these strategies for the management of dental caries. However, due to the nature of the survey, we do not know if these strategies are being taught as a substitute for fluoride products or to be combined with a fluoride regiment. A core curriculum framework could help to promote teaching of best evidence-based approaches, or best use of existing products, and de-incentivize dissemination of non-effective strategies into current teaching practices.

4.3 | Caries detection strategies (clinical and radiographical)

4.3.1 | Tactile detection versus visual detection strategies

In cariology, it is accepted that “the forceful use of a sharp explorer for the sole purpose of detecting caries lesions is highly discouraged in today’s practice of dentistry,” and there is strong evidence that the use of a sharp tool such as an explorer or probe does nothing to improve the accuracy of caries detection, it can damage/cavitate a non-cavitated caries lesion, increasing the risk for further lesion progression.^{26,31–35} In fact, evidence strongly supports that differences in dental hard tissue surfaces as a consequence of the caries disease process can be detected through visual assessment of clean and dry tooth surfaces; therefore, calling into question the use of tactile detection methods as a primary component of the teaching of caries lesion detection.^{31,33} Yet, most respondents in this study indicated that students are still taught to detect caries lesions using primarily tactile detection methods. The authors recognize that it could not be determined exactly how the use of tactile detection methods was being taught, and recommend that future studies include open-ended questions to determine the significance of this finding.

4.3.2 | Radiographic detection strategies

The most common caries lesion detection strategy second to visual detection is through the use of radiographs.^{35,36} All the U.S. DH programs that participated in this study reported teaching caries lesion detection through the use of radiographs. A 2010 systematic review concluded that radiographs are a suitable detection tool for caries lesions in approximal surfaces,³⁷ yet not as suitable for detection of initial occlusal surface lesions.³⁷ Furthermore, the presence of a caries lesion radiographically does not imply the lesion is active, and thus use of radiographs alone for

detection and treatment decision-making could increase the potential for over-treatment.^{38,39}

As the scope of practice for most dental hygienists does not include surgical or restorative intervention for caries lesions, dental hygienists will refer to a dentist for surgical/restorative intervention of caries lesions.⁴⁰ Therefore, it is important for the hygiene student to learn early on when referrals are necessary.⁴⁰ This study reports that a third of the respondents are teaching referral for operative intervention for a radiolucency when it is restricted to the outer/inner half of enamel, and nearly half responded that they would teach referral for a radiolucency that is restricted to the inner half of the enamel. These findings do not reflect current recommendations that stress that lesions that extend into enamel, the dentinoenamel junction, or the outer third of the dentin are most likely initial non-cavitated lesions,²² and that non-cavitated lesions should not be restored as they can be successfully arrested using non-restorative strategies.^{27,29} It is suggested that further research be conducted to assess if DH programs are recommending operative intervention for what we know are lesions that can be treated non-restoratively, or are just referring for confirmation and diagnosis.

Other than the limitations previously discussed, the authors acknowledge there were other limitations of this study. This survey had a 27.3% response rate. Although lower than desired, the results were greater than what has been reported as typical for dental online Web-based surveys.⁹ Additionally, the use of closed-ended questions that do not allow for respondents to expand or clarify a response does not allow to explore reasons or details associated with reported data. We recommend that further studies be completed using qualitative research methods, so further analysis of respondents’ answers can help expand our understanding of cariology teaching within U.S. DH programs.

At a time when it is universally accepted that the guiding principle for the management of dental caries is to preserve as much tooth structure as possible,^{4,6} this is the first survey to assess U.S. DH program’s cariology curricula. In a 2018 report on “Shaping the future of dental education: Caries as a case study”, Pitts and collaborators made a call to redefine the role of the dental hygienist, indicating that it is the responsibility of the educational institution to prepare them for a role that includes more interprofessional collaboration in non-traditional practice settings.¹² It has been projected that, by 2040, oral health care will align more closely to general medical care,⁴¹ and it is predicted that future dental hygienists will be working in more non-traditional practices, such as collaborative practice settings in federal, state, and local health departments and medical/dental clinics, nursing homes, hospitals, schools,⁴² and even as independent practitioners

working with vulnerable populations.⁴² Thus, it is imperative that dental hygienists be knowledgeable in the current standards in the detection, risk assessment, and management of dental caries, and resulting caries lesions.^{1-4,43-45}

5 | CONCLUSION

This study indicated that, although DH programs reported that cariology concepts are being taught both didactically and clinically, discrepancies between some concepts taught and the literature exist. Therefore, there is a need to create a more standardized curriculum framework for all U.S. DH programs, and further discussion about how to achieve this, and how to disseminate and implement it, is necessary.

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CONFLICTS OF INTEREST

None.

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