5-2015

Evaluation Of Current Knowledge Of Genetics Among Dental Students, Residents And Dental Hygiene Students

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EVALUATION OF CURRENT KNOWLEDGE OF GENETICS AMONG DENTAL STUDENTS, RESIDENTS AND DENTAL HYGIENE STUDENTS

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THESIS

Presented to the Faculty of
The University of Texas
Health Science Center at Houston
and
The University of Texas
MD Anderson Cancer Center
Graduate School of Biomedical Sciences
in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE

by

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Houston, Texas

May 2015

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We acknowledge the hard work and dedication of the faculty and staff at The University of Texas Health Science Center at Houston School of Dentistry. The authors are especially thankful to the administrative staff in the Department of Academic Affairs and the Research Office at The University of Texas Health Science Center at Houston School of Dentistry.

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Genetic testing is increasingly available in clinical settings. To provide personalized patient care, dental health professionals must have a greater understanding of genetics. The Commission on Dental Accreditation (CODA) credentials all dental schools in the United States and currently does not mandate genetics training for official approval of programs. There is little information about dental genetics education and no known studies that have evaluated dental students, residents and dental hygiene students' knowledge of human genetics. It is crucial to assess genetics knowledge of this population to ascertain if dental schools are preparing students for the future of personalized dentistry. This study assessed the genetics knowledge of future dental health professionals using a genetic assessment tool at the University of Texas Houston School of Dentistry. Participants included 240 dental students, 64 dental hygiene students, and 89 dental residents. The reference group included 155 medical students and 14 genetic counseling students. The overall response rate was 81%. Of the 15 study groups, 3 out of 12 groups from the dental school population and 2 out of 3 groups from the reference population received a passing score of 70%. Participants with no previous genetic courses scored significantly lower than those with three or four genetics courses ($p<0.01$). Participants who "strongly agree" when asked about the relevancy of genetics to oral healthcare scored significantly higher than those who "strongly disagree" ($p<0.01$). Based on this study, formal genetics education in dental school and dental residency programs is strongly recommended.

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Introduction

The completion of the Human Genome Project in 2003 and subsequent genome-wide studies have led to a greater understanding of the human genome and its role in human genetic conditions[1]. Sequencing and genotyping technology has also improved dramatically resulting in faster and cheaper genetic testing. This has led to increased genetic diagnoses and understanding of the pathogenesis of inherited conditions[2, 3, 4]. These advances will impact the practice of dentistry and require dental health professionals to have a greater understanding of genetics in order to provide better and more personalized patient care [5-8].

There are more than 700 genetic conditions with craniofacial anomalies with many requiring complex dental treatments[1, 9]. Some of these conditions are rare, such as osteogenesis imperfecta and ectodermal dysplasia, while others such as nonsyndromic cleft lip and palate, are relatively common, affecting 4,000 newborns each year in the US alone. Moreover, many common dental anomalies such as hypo/hyperdontia, delayed or premature eruption of dentition, irregular-shaped teeth, enamel/dentin dysplasia and malocclusion have a genetic basis [3,4,9]. Genetic testing for variants that cause these phenotypes will aid in diagnosis and treatment. It is likely in the next decade that genetic testing may lead to personalized dental treatments[7,8].

There have been six studies describing the need for genetics education in dentistry, however the extent to which dental schools have heeded this call is unclear due to a paucity of information regarding integration of genetics into dental school curriculum. Furthermore, all of the available studies pertaining to dental education are not current and provide little information about the genetics knowledge of students who are currently enrolled in dental programs[5,10-13].

In 1977, United States dental schools were surveyed to assess implementation of genetics education. The majority of programs had approximately four hours of genetics instruction built into other established classes as an alternative to a formal genetics course[14]. Only one program

required genetics as a condition for admission[14]. This same study was updated by Dudlicek et al in 2001 with strikingly uniform results. While the hours of integrated genetics education was significantly increased, the survey did not ask about the method of teaching (online versus in person; interactive versus lecture style, etc.) and only a portion of schools reported the amount of time devoted to each topic or the depth of information covered[11]. Furthermore, only 15% of programs offered a course devoted to genetics, exhibiting inconsistency of genetics education amongst programs. Hence, although advancements in genomic technology were burgeoning in the two decades between the two studies, little to no change occurred in the incorporation of genetics in dental school curricula. In 2004, a study surveying the requirements for admission and graduation from 264 dental hygiene schools concluded that no dental hygiene program required genetics as a prerequisite for admission[10].

The Commission on Dental Accreditation (CODA) credentials all dental schools in the United States and currently does not mandate genetics training as part of the official approval of programs[14]. However, restructuring of the curriculum has been proposed to include robust genetics modules[12,13]. A study of three dental programs in 2007 found that they were unable to implement more genetics training due to overcrowding of the curriculum and lack of opportunities to apply genetics in the clinical setting[12]. The Macy Study Report, a three-year project focused on improving the curriculum of dental programs, suggested the core curriculum include several formal genetics courses based on recommendations from the Association of American Medical Colleges[13]. Recommendations addressed short-term, medium and long-term goals which included adding family histories to electronic medical records, utilizing genetic resources for patient care and development of differential diagnoses for genetic oral conditions[13].

A mandate to include genetics education in training curriculum is not unique to dental schools. The Association of American Medical Colleges (AAMC) suggested medical schools

revise core competencies to include genetics training in 2004[16]. The American Association of Colleges of Pharmacy (AACP) in 2008 recommended all pharmacy schools incorporate genetics into the curriculum after several articles cited clinical utility of pharmacogenomics[15]. Both professions have successfully fulfilled these recommendations, with pharmacy schools reporting 92% compliance and approximately 75% of medical schools in the United States and Canada describing some mode of genetics education[16]. The successful addition of genetics into the curriculum of both medical and pharmacy schools can serve as a model for the incorporation of genetics in dental programs across the country.

The incongruences in genetics education reported in the literature appear to also impact how credentialed dental professionals utilize genetics in clinical situations. Experienced dentists cite ambiguity, lack of confirmative research and imperfect testing methods as reason to exclude genetic testing from their practice[8]. Despite studies confirming the validity and importance of genetics in all aspects of medicine, dental professionals have not incorporated genetic evaluation and testing into their standard of care [8,17].

Overall, there is a lack of information about dental genetics education and no known studies that directly evaluate the knowledge of human genetics in dental students, dental hygiene students and dental residents. Therefore, it is crucial to assess their genetics knowledge to ascertain if dental schools are preparing students for the future of personalized dentistry and, if necessary, precisely how current curricula should be revised. This study was designed to assess the amount of knowledge future dental health professionals have regarding basic genetic concepts by administering an in-person genetic assessment tool at one dental school.

Methods

Approval for this study was obtained from the University of Texas Health Science Center Committee for the Protection of Human Subjects (HSC-DB-14-0511). The genetics assessment tool used in this study was developed to assess general genetics knowledge and the ability to recognize common genetic syndromes. It was comprised of 20 multiple choice questions evaluating knowledge of inheritance patterns (5 questions), cytogenetics (2 questions), family history (1 question), testing methods (4 questions) and genetic conditions commonly seen in dental settings (7 questions). This tool was not validated prior to utilization.

Student participants were grouped according to their program and stratified by year of enrollment. Dental resident participants were grouped according to their program but not stratified by year of enrollment. Demographic information was collected on each participant included age, gender, current enrollment year, undergraduate major, number of genetics courses taken as an undergraduate student and the presence or absence of a family history of genetic/familial condition(s). Attitudes towards the relevancy of genetics in dentistry and the perception of how knowledgeable participants were of genetics were determined using Likert scale questions. The demographic section for the dental residents was modified to include where they received their DDS or DMD degree.

The assessment tool was administered to all consenting dental students, dental hygiene students and dental residents at the University of Texas at Houston School of Dentistry from August to November 2014. In addition, second year medical students at the University of Texas at Houston Medical School and genetic counseling students at the University of Texas Genetic Counseling Program were administered the testing tool for comparative analysis. The questions were presented by PowerPoint slideshow in a classroom setting with participants using Turning

Technologies Clicker Response System to record all answers. Participation was anonymous and voluntary.

All of the data was collected, entered and analyzed using Stata® 13 Data Analysis and Statistical Software package. Each multiple-choice question had a value of 5 points for a total of 100 points. A passing score was 70% or greater. Tests with 3 or more unanswered questions were excluded resulting in the exclusion of 74 tests. Multivariate, linear and logistical regression analyses were used to determine whether there was a significant difference in scores by student/resident classification or demographics. P-value of 0.05 was considered significant.

Results

Study population

There were 562 students from the University of Texas at Houston School of Dentistry registered in the fall of 2014: 385 dental students, 75 dental hygiene students and 102 dental residents. Of this group, 393 participated and included 240 dental students, 64 dental hygiene students, and 89 dental residents from six of the seven residency programs (scheduling constraints precluded participation of Oral Maxillofacial Surgery residents). This gave a 70% response rate. Medical and genetic counseling students were used as reference groups for comparative analysis. There were 155 of 240 second-year medical students, 7 of 8 first year genetic counseling students and 7 of 7 eligible second year genetic counseling students included in the study giving response rates of 64%, 88% and 100%, respectively. The overall response rate for the participants and reference groups together was 81%.

Demographics

Complete demographic information is provided in **Table 1.**

Table 1. Demographics of Participants

	Participant Groups, n (%)			
	Dental Students	Dental Hygiene Students	Dental Residents	Reference Population
Age				
<21	5 (2)	4 (5)	0 (0)	1(<1)
21-25	153 (64)	30 (49)	5 (8)	142 (90)
26-30	54 (11)	19 (32)	46 (58)	21 (9)
31-35	14 (7)	5(8)	19 (27)	3 (1)
>35	9 (3)	4 (6)	3 (5)	2(<1)
Sex				
Female	143 (60)	57 (93)	45 (54)	83 (82)
Male	66 (40)	5 (7)	40 (46)	86 (18)
Location of DDS (Residents)				
UT Houston	N/A	N/A	11 (15)	N/A
Texas			11 (15)	
U.S.			39 (53)	
Non- U.S.			13 (18)	
Enrollment Year (Residents)				
First	N/A	N/A	41 (50)	N/A
Second			34 (41)	
Third			7 (9)	
Undergrad Major (Students)				
Bio Sciences	182 (77)	42 (68)	N/A	113 (74)
Non- Bio Sciences	113 (23)	21 (32)		56 (26)
Number of Undergrad Genetics Courses				
0	50 (22)	50 (80)	24 (28)	38 (8)
1	139 (58)	6 (9)	38 (44)	81 (36)
2	41 (17)	4 (7)	18 (19)	24 (10)
3	6 (3)	2 (4)	5 (5)	2 (26)
4	2 (1)	0 (0)	2 (1)	2 (5)
5+	0 (0)	1 (<1)	3 (2)	6 (15)
Family history of genetic condition				
Yes	56 (24)	23 (36)	19 (24)	106 (55)
No	182 (76)	41 (64)	65 (75)	62 (45)
I am knowledgeable of genetics				
Strongly Agree	15 (6)	3 (5)	7 (8)	21 (33)
Agree	87 (38)	16 (27)	48 (53)	78 (49)
Neutral	95 (40)	27 (42)	22 (27)	49 (15)
Disagree	31 (13)	14 (22)	8 (10)	8 (2)
Strongly Disagree	11 (4)	3 (5)	2 (3)	10 (2)
Genetics is relevant to oral health care				
Strongly Agree	59 (23)	21 (34)	29 (34)	28 (33)
Agree	109 (47)	24 (38)	40 (48)	68 (42)
Neutral	52 (23)	15 (22)	11 (11)	46 (19)
Disagree	12 (5)	3 (5)	6 (6)	14 (3)
Strongly Disagree	6 (2)	1 (1)	1 (1)	10 (2)

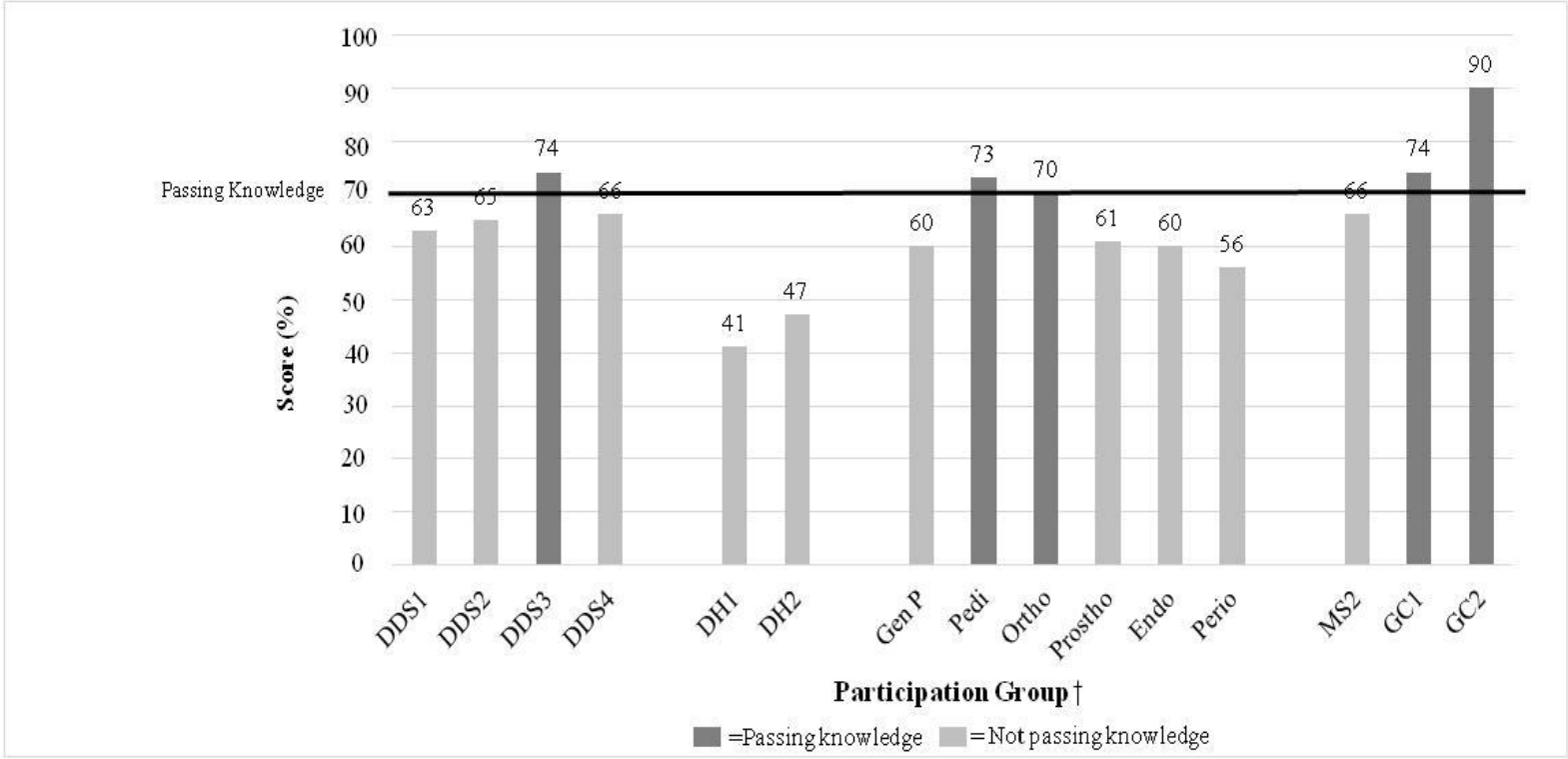
Eighty-seven percent of participants were between the ages of 21 - 30 years, 8% between 31 and 35 years old, 3% were less than 21 years old and 3% were older than 35 years old. A family history of a genetic condition was reported by 37% of all participants. Seventy-two percent of the study population indicated an undergraduate major in the biological sciences. Most dental residents received their DDS or DMD in the United States, with 15% from the University of Texas at Houston School of Dentistry, 15% from another dental school in Texas and 53% from dental schools outside Texas.

Less than a quarter (22%) of dental students and 80% of dental hygiene students did not complete a genetic course prior to enrollment in their current program. One genetics course was completed by 48%, two genetics courses by 16% and 7% reported three or more genetics courses as undergraduate students. Forty-nine percent agreed or strongly agreed that they were knowledgeable of basic genetics concepts and 68% agreed or strongly agreed that genetics is relevant to oral health care.

Assessment Scores

Only five of the 15 groups of dental students and residents, dental hygiene students, genetic counseling students and medical students received an average passing score of 70% (**Fig. 1**).

Figure 1. Overall genetic assessment scores by participant group. †DDS1= 1st Year Dental Students; DDS2= 2nd Year Dental Students; DDS3= 3rd Year Dental Students; DDS4= 4th Year Dental Students; DH1= 1st Year Dental Hygiene Students; DH2= 2nd Year Dental Hygiene Students; Gen P= General Practice Residents; Pedi= Pediatric Residents; Ortho= Orthodontics Residents; Prostho= Prosthodontics Residents; Endo= Endodontics Residents; Perio=



Passing scores were obtained by third year dental students (score = 74%), Pediatric dental residents (73%) and Orthodontics dental residents (70%). Two out of the three reference groups received passing grades: first and second-year genetic counseling students with scores of 74% and 90%, respectively. Second- year medical students, the other reference group, scored 66%. The first- year dental hygiene students received the lowest average assessment score of 41%. The most correct responses (highest scores) were in the cytogenetics category with dental students, dental residents and medical students scoring 91%, 81% and 91%, respectively (**Table 2**).

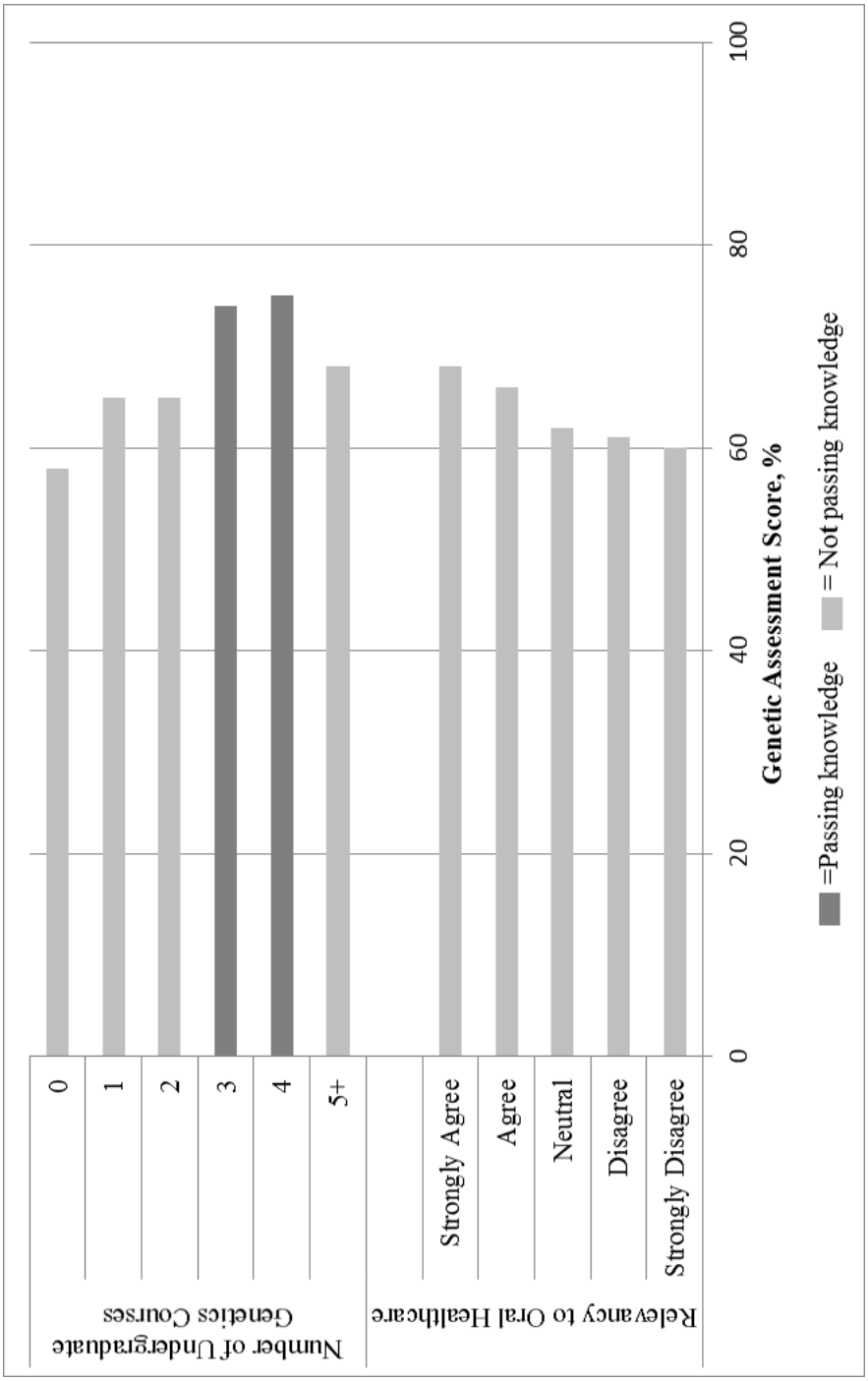
Table 2. Percentage of questions answered correctly, by participant group and category.

	Question Category, (%)				
	Inheritance	Cytogenetics	Family History	Testing Methods	Genetic Conditions
Dental Students					
Dental Students Yr 1	58	90	74	64	59
Dental Students Yr 2	65	88	85	54	64
Dental Students Yr 3	75	99	87	58	73
Dental Students Yr 4	75	99	77	28	72
Overall	**63**	**91**	**79**	**57**	**66**
Hygiene Students					
Dental Hygiene Yr 1	29	63	74	24	48
Dental Hygiene Yr 2	35	58	92	31	55
Overall	**32**	**61**	**81**	**27**	**51**
Dental Residents					
General Practice	53	88	69	44	64
Pediatric	69	85	92	65	75
Orthodontics	73	93	86	54	70
Prosthodontics	58	82	100	52	57
Endodontics	63	67	75	46	65
Periodontics	63	69	54	43	57
Overall	**63**	**79**	**76**	**50**	**64**
Reference Populations					
Medical Students Yr 2	77	91	85	65	52
Genetic Counseling Yr 1	86	86	100	86	57
Genetic Counseling Yr 2	97	100	100	93	80
Overall	**84**	**92**	**93**	**77**	**61**

Dental hygiene students and genetic counseling students had the most correct responses in the family history category with 81% and 100%, respectively. Dental students and dental residents had the most correct responses in the cytogenetics category with 91% and 79%, respectively. Dental students, residents and hygiene students had the most incorrect responses in the testing methods category (57%, 50% and 27% respectively). Medical students and genetic counseling students had the most incorrect responses in the genetic conditions category (52% and 69% respectively).

Medical students correctly answered questions at a significantly higher rate compared to dental students and dental hygiene students in the inheritance category ($p<0.01$). Medical students also correctly answered questions at a significantly higher rate compared to dental residents and dental hygiene students in the testing methods category ($p <0.01$) and significantly higher in the cytogenetic analysis category compared to dental hygiene students ($p <0.01$). Dental students and dental residents correctly answered questions in the genetic conditions category at a significantly higher rate than medical students and dental hygiene students ($p<0.01$). Genetic counseling students scored significantly higher than all other study groups in the inheritance and testing methods categories. ($p<0.01$). The definition of whole exome sequencing (question 10) was incorrectly answered by 73% of participants. Participants with no genetic courses prior to admission to dental school, medical school, dental hygiene program or the genetic counseling program scored significantly lower (58%) than those with three (74%) or four (75%) undergraduate genetics courses ($p<0.01$) (**Fig. 2)**.

Figure 2. Overall genetic assessment scores by demographic category.



There was a trend of decreasing scores with decreasing perception of relevance of genetics in oral healthcare with participants who "strongly agreed" scoring significantly higher (68%) than those who answered "strongly disagree" (60%) ($p < 0.01$) (**Fig. 2**).

Discussion

The purpose of this study was to assess if dental students, hygiene students and dental residents at the University of Texas School of Dentistry at Houston (UTSD) had a passing knowledge of basic genetics concepts and genetic syndromes. Our findings indicate that while most participants do not have a passing knowledge of genetics, increased exposure to formal genetics education is associated with higher genetic assessment scores, although not significant. Overall, participants with multiple genetics courses prior to admission to dental school scored higher on the assessment than those with no previous genetics education. For three of the groups that passed the assessment- third-year dental students, Pediatric dental residents and Orthodontics dental residents- additional methods of learning were examined.

In addition to assessing genetics knowledge of all participants, this study also surveyed medical students and genetic counseling students for comparative analysis. Dental students' knowledge of genetics concepts was comparable to that of medical students when evaluating knowledge of cytogenetics, family history and testing methods. Furthermore, dental students and medical students have similar educational backgrounds, with 68% of dental students reporting an undergraduate major in the biological sciences compared to 77% of all medical students reporting biological sciences as an undergraduate major (**Table 2**). Because comprehension of advanced biological concepts is an essential component for learning genetics, medical schools tailor their genetics curriculum in accordance to students' previous biology background. Thus, if understanding of biology and genetics in medical students is similar to that of dental students, the current teaching methods for genetics used in medical schools may be applicable to dental school curriculum.

Genetics education is not required for dental school accreditation however several genetics topics are covered on the National Boards Dental Examination (NBDE). The NBDE is offered in two portions: Part I covers basic sciences and is generally taken at the end of the second year of dental school and Part II evaluates knowledge of clinical dentistry and is taken at the end of the third year of dental school[18]. Consequently, the average assessment score for third-year dental students of 74% may have been inflated by independent study of genetics in preparation for the NBDE. Although third-year dental students demonstrated a minimally passing knowledge of genetics concepts, fourth-year dental students did not pass the assessment, suggesting that independent study techniques are not sufficient to retain learned information.

Clinical application of genetics may reinforce concepts learned in formal lectures. Pediatric dental residents, who passed the assessment with a score of 73%, were given a lecture by a certified genetic counselor one month before this study which covered basic inheritance patterns and genetic conditions commonly seen in dentistry. Periodontics and Orthodontics residents were given a lecture covering cytogenetics, however Orthodontics residents passed the assessment with a score of 70% and Periodontics residents failed the assessment with a score of 56%. The difference in the ability to pass the genetic assessment between these resident groups may be due to disparate opportunities for clinical application of learned material. Pediatric and Orthodontics dental residents become familiar with genetic counselors and genetic conditions in multidisciplinary settings, such as craniofacial clinics, during their training. This direct interaction with patients coupled with the ability to ask genetics professionals about the management and care of rare genetics conditions in real time facilitates deeper understanding of the material learned in lectures.

While the vast majority of medical schools in the United States integrate genetics into the core curriculum, the modalities utilized by each program differ. The University of Texas at Houston Medical School offers a lecture-style class taught by medical geneticists and certified genetic counselors over a three month period. Lectures are supplemented with weekly small group sessions to simulate clinical scenarios and promote discussions. Medical and dental students share commonalities in their foundational knowledge of biology as well as 3 out of 5 genetic knowledge categories evaluated on the survey. Based on these findings, teaching methods currently employed by medical schools may be suitable for dental schools.

In the spring of 2014, the UTSD began to incorporate genetics education in the curriculum of first and second-year dental students, hygiene students and select dental residency programs under the guidance of a certified genetic counselor. First-year dental students received a one-hour cytogenetics lecture before our assessment and consequently scored significantly higher in this section when compared to all the other categories. Second-year dental students were given a two-hour lecture on genetic testing methods after our assessment. They were then split into small groups and asked to give a 15 minute presentation on a specified genetic condition. Pediatric dental residents were given a lecture on inheritance and genetic conditions prior to our assessment and scored significantly higher in the genetic conditions category when compared to all other residency programs. Endodontics, Periodontics and Orthodontics dental residents were given a one- hour cytogenetics lecture prior to our assessment with no significant results. These methods of genetics education are tailored to the needs of dental students and residents, emphasizing genetic conditions that are commonly observed in the clinical setting or those that have oral/dental manifestations. Dental hygiene students, who scored significantly lower in all areas of the genetic assessment, received a lecture after our assessment with a brief introduction to inheritance patterns and genetic conditions. Their low scores may be due to admission criteria

that are less demanding in comparison to other groups in our study. In the professional setting, dental hygienists spend between 30 to 50 minutes with the patient collecting family history, taking dental radiographs and other pertinent information for a general oral health assessment[27]. Because dental hygienists often serve as the primary recipient of a patient's oral health history, it is critical that they have knowledge of genetics to provide appropriate, personalized care. Based on their genetic assessment scores, dental hygiene students have a lower level of genetics knowledge than dental students and dental residents. Therefore, teaching methods should reflect their education needs differently than those proposed for dental students.

Limitations of this study include technical difficulties associated with the Turning Technologies clicker response system. While each student was given a clicker to record their answers, some responses were not registered, resulting in exclusion of assessments due to incomplete data. In two cases, less than 10% of answers were registered resulting in re-administration of the genetic assessment tool. In a demographic question asking if participants had a positive or negative family history of a genetic condition, the definition of what constituted a genetic condition may have been too vague. As a result, the percentage of participants who answered affirmatively may have been inflated due to participants erroneously citing common conditions such as twinning or hypertension, which have a genetic association that may cause predisposition to disease, but are not consistent with our definition of genetic conditions that generally follow a Mendelian inheritance pattern. Similarly, participants may have over reported the amount of genetics courses taken as an undergraduate student due to unspecific terminology. For instance, participants who reported having 5 or more genetics courses scored lower than those with fewer courses, which may be due to the participants' inclusion of general biology courses that may have briefly covered a section of molecular or non-human genetics. Second-year genetic counseling students were included in our study for comparative analysis and to determine the ease

and/or difficulty of all questions. In the genetic conditions category, second-year genetic counseling students performed poorly in comparison to dental residents and dental students. These results were unexpected given that second-year genetic counseling students scored significantly higher than most groups on all other questions in the assessment. Consequently, these questions may not have appropriately assessed genetics knowledge as intended, leading to skewed scores. Additionally, the questions presented in the genetic assessment were not validated or used in previous studies which led to inadvertent ambiguity.

For many years, studies have recommended genetics education be incorporated into dental schools' core curriculum. The Macy Study Report suggested genetics be taught using multiple, didactic modalities followed by hands-on learning in clinical rotations[13]. Our study confirms the need for genetics education for dental students, dental hygiene students and dental residents. The participants' attitude towards the relevancy of genetics to oral health care was significant in this study. Those who strongly agreed that genetics was relevant to oral healthcare scored higher than those who strongly disagreed with this statement. This result supports the need for clinical application of genetics concepts as understanding the relevancy of genetics in providing personalized dentistry may lead to higher uptake of genetics learning. For instance, polymorphisms in the interleukin 1 beta (IL- 1β) gene are associated with susceptibility to periodontitis[19]. PerioPredict™, a test that analyzes single nucleotide polymorphisms in the IL-1β gene to detect patients who may be at increased risk for periodontitis, is clinically available and provides suggestions for management and risk-reduction strategies based on results[20,21]. Single nucleotide polymorphisms are the most common source of genetic variation, occurring when one base in the DNA sequence is substituted for another base that is present in 1% of the general population. To properly identify patients that are appropriate for this test as well as educate them

on its benefits and consequences, future dental health professionals must be adept in the clinical application of genetics.

The majority of participants from the dental school population (80%) reported having none or only one previous genetics courses before admission, which was correlated with lower genetic assessment scores. Dental school administrations across the country cited lack of time due to oversaturated curricula as a barrier to implementing genetics into the core curriculum[7]. Because many students in our study reported lack of undergraduate genetics courses, we recommend that at least one genetics course as a prerequisite for admission for all dental school programs. This could potentially alleviate time devoted to teaching introductory concepts, allowing instructors to focus more on advanced material at an accelerated pace. Requiring a genetics course for admission may also ensure that students have a more uniform foundation of genetics knowledge to guarantee that learning material is appropriate for all.

In conclusion, as genomic technology advances, it is important for future dental professionals to be proficient in the clinical application of genetics. Genetics coursework should be a requirement for admission to dental programs and implemented into the core curriculum using multiple teaching modalities. In 2009, the Joint Commission on National Dental Examinations announced that the NBDE would be replaced with the Integrated National Board Dental Examination or INBDE[18]. This new exam would expand the competencies needed for evaluating candidates for licensure, with 20% of foundation knowledge devoted to genetics[18]. As a result, programs must establish methods of genetics education that maximize the potential of successfully passing the examination. The precise methods of didactic education may differ, however the standard of genetics education must be uniform for all dental schools in the United States.

Our results are not generalizable to other programs because all participants were recruited from one dental school out of 66 accredited programs in the United States. Future efforts will be made to validate a set of questions to assess knowledge of genetics concepts followed by re-assessment of our study population using more reliable technology. Assessing knowledge of genetics concepts before the material is learned can be insightful when determining how genetics education should be structured for a particular program or group of students. If a genetics assessment is taken after education of basic concepts, it can aide in evaluating the effectiveness of teaching methods. Once a validated method is established, efforts should be made to analyze more dental schools across the country to determine if recurrent themes and patterns support the need for a more uniform curriculum.

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