

Relationship Between Dental Hygiene Students' Performance in an Oral Radiology Course and the National Board Dental Hygiene Examination: A Retrospective Study

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Abstract: Dental hygiene students' performance in oral radiology courses may give an early indication of their readiness prior to taking the National Board Dental Hygiene Examination (NBDHE). The aim of this study was to determine the relationship between dental hygiene students' performance in an oral radiology lecture course and their performance on the NBDHE. Data were collected for all 117 dental hygiene students at Texas A&M University College of Dentistry from 2006 to 2009 who took the NBDHE during their second year of the program. Their final grades and scores on three written section examinations in an oral radiology course taken in their first year were compared with their overall NBDHE scores and raw scores on the oral radiology and case study sections. Moderate correlations ($0.3 < r < 0.5$) were found between the students' overall NBDHE scores and their performance in the oral radiology course, with the strongest correlation with the final grade ($r = 0.488$, $p < 0.01$). Final course grades had the strongest relationship to NBDHE scores in the discipline of radiology, followed by scores in anatomic sciences; the weakest relationship was with scores in pharmacology. This relationship can help identify students who may need extra support in the oral radiology course and other courses to prepare them to succeed when they take the NBDHE. This study also contributes to understanding of the general relationship between dental hygiene program courses and students' success on the clinical licensing exam and will hopefully encourage other programs to assess their students' performance in this way.

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The National Board Dental Hygiene Examination (NBDHE) is a written standardized test that assesses dental hygiene students' ability to understand important information from basic biomedical, dental, and dental hygiene sciences and to apply such information in a problem-solving context.¹ The NBDHE consists of 200 items in 13 disciplines and 150 case-based items that include questions and case studies related to oral radiology.

The oral radiology course in the first year of the dental hygiene program at Texas A&M University College of Dentistry consists of didactic, preclinical laboratory, and clinical sections. The didactic section of the course has three subsections with written examinations that make up 60% of the students' final grade. The three subsections are 1) radiation physics and digital imaging, considered the basic foundation for oral radiology; 2) intraoral

and extraoral technique and advanced imaging systems; and 3) interpretation of radiographic anatomy, developmental and acquired dental disease, radiation biology, and protection.

Previous studies have found that incoming GPA, admission criteria points (which include incoming overall and science GPAs), ACT reading scores, and performance in specific science courses taken as prerequisites or during the program were positive predictors of performance in dental hygiene programs.²⁻⁴ Research has also focused on the influence of mock boards and review courses on passing the NBDHE.^{5,6} In one study, program GPA was found to be a predictor of NBDHE performance, but enrollment in an outside review course was not.⁵ Another study found mock board experience to be most useful in identifying students not at risk, as opposed to those at risk of failing.⁶

Studies attempting to define the best ways to prepare students to take high-stakes licensure exams are not unique to dental hygiene. Among studies seeking predictors of success on the National Board Dental Examination (NBDE), Holmes et al. reported that the Dental Admission Test (DAT) was the best predictor of success on the NBDE.⁷ In a study assessing the utility of an online NBDE review course, dental students reported that the course encouraged them to spend time preparing.⁸ Among studies of predictors in medical licensing, Peterson and Tucker concluded that “performance in the early years of medical school may be more useful than admissions data in predicting performance on licensing examinations and thus help identify medical students at risk for failure.”⁹ In addition, students who previously took an undergraduate anatomy course improved their performance/class rank in medical gross anatomy in medical school.¹⁰

Oral radiology is one of the major disciplines tested on the NBDHE. According to the records of the dental hygiene program director of Texas A&M University College of Dentistry, the number of items tested related to oral radiology between the years 1999 and 2009 varied from 43 to 67, with an average of 54 items or 15.3% of the total 350 items (Table 1). The other top two disciplines tested on the NBDHE were patient assessment (19.7%) and management of dental hygiene care (18.3%). Despite the importance of oral radiology on the NBDHE, there has been no research on the relationship between performance in oral radiology coursework during education and

NBDHE performance. The aim of this study was thus to determine the relationship between dental hygiene students’ performance in an oral radiology lecture course and their performance on the NBDHE. Determining this relationship may help in assessing the effectiveness of the oral radiology course and identifying ways to enhance it.

Methods

The Texas A&M University Institutional Review Board approved the project with IRB protocol number 2015-0250-BCD-EXM. Participants were all 117 dental hygiene students at Texas A&M University College of Dentistry from 2006 to 2009 who subsequently took the NBDHE during their second year of the program. The students’ three written subsection examination scores and final grade in the oral radiology course were compared with their overall score and raw scores on the oral radiology and case study sections on the NBDHE. In the oral radiology course, letter grades were assigned as A \geq 93, B 84 to 92, and C 75 to 83, based on the institutional standard. For performance on the NBDHE, three categories were assigned: \geq 85, 80-84, and $<$ 80.

Statistical analysis was performed using SPSS 23 (IBM Corp., Armonk, NY, USA). Descriptive statistics including minimum and maximum scores, means, and standard deviation were calculated. Pearson correlation coefficient and chi-square tests were used to determine the association between oral radiology course performance and NBDHE scores.

Table 1. Number of items on National Board Dental Hygiene Examination in 13 disciplines from 1999 to 2009 and percentage of total 350 items

Discipline	Test Year											Average	Percentage
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009		
Anatomic sciences	18	18	19	21	19	18	15	16	15	15	16	17.3	4.9%
Physio-biochem-nutrition	11	11	11	11	11	11	11	11	10	11	11	10.9	3.1%
Microbiology-immunology	11	11	10	11	10	10	11	11	12	11	11	10.8	3.1%
Pathology	12	13	14	16	15	12	13	15	13	13	13	13.5	3.9%
Pharmacology	15	15	11	11	12	12	11	10	10	10	10	11.6	3.3%
Patient assessment	60	73	75	69	70	62	68	71	76	67	68	69.0	19.7%
Radiology	43	45	49	48	46	63	56	55	58	67	60	53.6	15.3%
Management of dental hygiene care	60	62	65	62	69	67	63	62	65	56	75	64.2	18.3%
Periodontology	61	47	43	48	43	43	35	29	22	28	22	38.3	10.9%
Preventive agents	20	19	17	20	19	17	16	15	15	16	10	16.7	4.8%
Supportive treatment	18	16	16	13	16	15	10	11	12	13	11	13.7	3.9%
Professional responsibility	0	0	0	0	0	0	17	20	18	19	19	8.5	2.4%
Community health	21	20	20	20	20	20	24	24	24	24	24	21.9	6.3%

Note: Percentages do not total 100% because of rounding.

Results

The students' performance in the oral radiology course and on the NBDHE is shown in Table 2. The didactic section of the oral radiology course includes three subsections with written exams that make up 60% of the final course grade. The remaining 40% of the final grade comes from scores in the preclinical laboratory and clinical sections and were excluded from this study due to their nature as clinical skills. Scores on the first and second subsection exams could be remediated to 70 if the student failed the exam the first time. However, the original score (if <70) was used for this study to ensure the originality and reliability of the oral radiology course scores. Written examinations, which are not released, have the same multiple-choice questions each year. Three oral and maxillofacial radiology faculty members presented the same lectures each year during the study time frame. This consistency helped reduce the potential impact of different styles or quality of teaching.

Pearson's *r* correlation between students' performance in the oral radiology course and on the NBDHE is shown in Table 3. Their overall NBDHE

score was significantly related to their scores in the oral radiology course ($p < 0.01$). Moderate correlations ($0.3 < r < 0.5$) were found between the oral radiology course scores and the overall NBDHE score, with the strongest correlation with the final grade of the course ($r = 0.488$). The NBDHE case study section score had the strongest correlation with the NBDHE overall score ($r = 0.841$, $p < 0.01$).

The correlation between students' final grade in the oral radiology course and their scores for each discipline on the NBDHE is shown in Table 4. The course grade had the strongest relationship with the score in radiology of the NBDHE ($r = 0.428$, $p < 0.01$), followed by anatomic sciences ($r = 0.408$, $p < 0.01$); the weakest relationship was with pharmacology ($r = 0.081$, $p = 0.38$).

The distribution of categorized final grades in the oral radiology course and the overall score on the NBDHE is shown in Table 5. Of the students who received an A as their final grade in the oral radiology course, only 2.8% fell below 80 on the NBDHE. On the other hand, 62.5% of those students who received a C or below scored below 80 on the NBDHE. There was thus a positive and statistically significant relationship between performance in the oral radiology course and the NBDHE overall score.

Table 2. Students' performance in oral radiology course and on National Board Dental Hygiene Examination (NBDHE) (N=117)

Variable		Minimum	Maximum	Mean	Std. Deviation
Oral radiology course	Exam 1	52	100	85.0	9.7
	Exam 2	70	100	89.8	6.9
	Exam 3	70	100	89.0	7.0
	Final grade	80.6	98.4	90.4	3.9
NBDHE	Overall score	71	96	84.5	4.7
	Oral radiology	22	54	39.8	6.6
	Case study	75	124	103.6	10.0

Table 3. Correlation between students' grades in oral radiology course and scores on National Board Dental Hygiene Examination (NBDHE)

Variable		Oral Radiology Course				NBDHE		
		Exam 1	Exam 2	Exam 3	Final Grade	Overall Score	Oral Radiology	Case Study
Oral radiology course	Exam 1	1	0.307*	0.309*	0.735*	0.462*	0.330*	0.356*
	Exam 2	0.307*	1	0.385*	0.662*	0.342*	0.369*	0.241*
	Exam 3	0.309*	0.385*	1	0.644*	0.445*	0.339*	0.475*
	Final grade	0.735*	0.662*	0.644*	1	0.488*	0.428*	0.432*
NBDHE	Overall score	0.462*	0.342*	0.445*	0.488*	1	0.509*	0.841*
	Oral radiology	0.330*	0.369*	0.339*	0.428*	0.509*	1	0.548*
	Case study	0.356*	0.241*	0.475*	0.432*	0.841*	0.548*	1

*Pearson's *r* correlation was significant at 0.01 level (2-tailed)

Table 4. Correlation between students' final grades in oral radiology course and scores in 13 disciplines of National Board Dental Hygiene Examination (N=117)

Discipline	Avg Percent	Corr	Prob
Radiology	15.3%	0.428	<0.0001
Anatomic sciences	4.9%	0.408	<0.0001
Community health	6.3%	0.376	<0.0001
Patient assessment	19.7%	0.362	<0.0001
Physio-biochem-nutrition	3.1%	0.322	0.0004
Pathology	3.9%	0.289	0.0016
Professional responsibility	2.4%	0.242	0.0086
Microbiology-immunology	3.1%	0.220	0.0171
Supportive treatment	3.9%	0.219	0.0175
Periodontology	10.9%	0.216	0.0191
Preventive agents	4.8%	0.197	0.0336
Management of dental hygiene care	18.3%	0.113	0.2254
Pharmacology	3.3%	0.081	0.3836
Total		0.488	<0.0001

Table 5. Distribution of categorized final grade in oral radiology course and overall score on National Board Dental Hygiene Examination (NBDHE), by number and percentage of total participants (N=117)

Course Grade	NBDHE Overall Score			Total
	≥85	80-84	<80	
A (≥93)	28 (77.8%)	7 (19.4%)	1 (2.8%)	36 (30.8%)
B (84 to 92)	34 (46.6%)	27 (37.0%)	12 (16.4%)	73 (62.4%)
C or below (<84)	2 (25.0%)	1 (12.5%)	5 (62.5%)	8 (6.8%)
Total	64 (54.7%)	35 (29.9%)	18 (15.4%)	117 (100%)

Note: Chi-square of the contingency table is 24.3 with $p \leq 0.001$. Percentages may not add up to specified totals because of rounding.

Discussion

Prior to 2012, dental hygiene program directors had access to the NBDHE scores of all their students in each discipline. Since that time, directors do not have access to the scores of students who passed the NBDHE. This study included only those students who were enrolled in the dental hygiene program from 2006 to 2009 and subsequently took the NBDHE in 2008 to 2011. This time frame was used because during that time the program director was able to access all NBDHE scores and the course was presented by the same radiologists using the same lectures and written exams each year.

The NBDHE consists of 350 test items in 13 disciplines with case studies. The disciplines are anatomic sciences, physiology-biochemistry-nutrition, microbiology-immunology, pathology, pharmacology, patient assessment, radiology, management of dental hygiene care, periodontology, preventive

agents, supportive treatment, professional responsibility, and community health.¹ A previous study investigated the relationship between several science course grades in a dental hygiene curriculum and scores reported on the NBDHE taken by 132 students.³ In its results, physiology grades showed the strongest correlation with performance on the NBDHE ($r=0.412$, $p=0.01$) followed by anatomy, microbiology, and human nutrition. Another study found that students' final course grade in oral pathology was a significant predictor of both graduation ($n=146$) and NBDHE success ($n=130$).⁴ In that study, final course grades in oral anatomy and histology were also found to be a predictor of NBDHE success ($n=130$). That study's results suggested that, after admission to the dental hygiene program, final course grades (in oral anatomy and histology and in oral pathology) can significantly predict graduation and NBDHE success. A similar study suggested using medical students' performance in medical gross anatomy to predict their performance on the United

States Medical Licensing Examination (USMLE) Step 1 and identify students who may need more time or tutoring to pass the licensing exam.⁹

In our study, the overall NBDHE score of the 117 dental hygiene students was significantly related to their scores in the oral radiology course. Moderate correlations were found between the overall NBDHE score and scores on the first ($r=0.462$, $p<0.01$), second ($r=0.342$, $p<0.01$), and third exams ($r=0.445$, $p<0.01$) in the oral radiology course. The strongest correlation was found between the final grade in the oral radiology course and the overall NBDHE score ($r=0.488$, $p<0.01$). In light of the significant correlation between performance on the first exam in the oral radiology course and NBDHE performance, educators in our school may use lower scores on the first exam (two months after admission to the program) as an early indicator of students who may need extra guidance and encouragement to adjust their study strategies. Although many variables may affect students' performance on the NBDHE (taken at the end of the second year) after their first-year oral radiology course—e.g., additional teaching materials, question banks from released exams, external tutoring, or adjusting their own study strategies since the first year—those variables were not available for this study and were treated as random effects in this analysis.

Oral pathology and oral radiology courses have similarities: both involve interpretation and diagnosis, and both require a higher level of critical thinking by using discrimination and comparison to differential diagnosis. In addition, both oral pathology and oral radiology are courses that may not have been taken by students before they entered the dental hygiene program, so variations among students are limited. Oral radiology may also rely on memory skills for interpretation of radiographic anatomy, similar to oral anatomy and histology. Therefore, it is not surprising that the results of our study are similar to those of previous studies.^{3,4}

The NBDHE overall score was found to have the strongest correlation with the case study section score ($r=0.841$, $p<0.01$). Such a strong association is not surprising considering that the case study section constitutes 150 of the total 350 items tested. This correlation indicated the importance of the management of case study material on the NBDHE.

We also examined the correlation between the final grade in the oral radiology course and the score in each discipline on the NBDHE (Table 4). The final course grade had the strongest relationship to the

score in radiology of the NBDHE ($r=0.428$, $p<0.01$). It is no surprise that the next strongest correlation was between performance in the oral radiology course and the NBDHE score in anatomic sciences ($r=0.408$, $p<0.01$), and the weakest correlation was with the NBDHE score in pharmacology ($r=0.081$, $p=0.38$) because anatomy is the foundation of oral radiology interpretation but oral radiology has little in common with the pharmacology.

The overall NBDHE scores of the 117 students in this study ranged from 71 to 96 with mean of 84.48 (Table 5). Students' overall NBDHE scores are divided into three categories: ≥ 85 , 80-84, and <80 . A score below 75 is considered a failure on the NBDHE, but a failure score of 80 was used in this study because of the small number of students who failed the test on their first attempt. Only 2.8% of the students who received an A in the oral radiology course had an overall NBDHE score below 80. On the other hand, 62.5% of the students who received a C or below in the oral radiology course had an overall NBDHE score below 80. This result not only indicates that students' performance in the oral radiology course may be useful in predicting their performance on the NBDHE, but also suggests that students who do well in one individual course may be likely to do well on subsequent standardized tests. These findings also support the rationale used by dental school admissions committees when they rely heavily on GPA and DAT scores in making admissions decisions.⁷

Administrators and faculty members of dental hygiene programs are constantly looking for ways to identify potential students who will graduate and pass the NBDHE by assessing their incoming GPA, admission criteria points, ACT reading scores, and performance in other prerequisite courses.²⁻⁴ Monitoring students' course performance in radiology as reported here may improve the likelihood of success by identifying students who need tutoring before challenging the NBDHE. This study was not designed to investigate an exclusive correlation between students' performance in the radiology course and their performance on the NBDHE. Instead, we believe that a positive correlation exists between performance on the NBDHE and performance in many other courses as reported in previous studies.^{3,4}

One limitation of this study is that it did not take into account other variables such as effort, study habits, and preparations that affect students' performance in a course or on an exam. It was also limited to students' performance in an oral radiology course since a comprehensive exploration of the relationship

between other disciplines and the NBDHE would require participation from other course instructors and was beyond the scope of this study. Finally, although the study covered multiple years, it took place at only one dental hygiene program, so its results may not be generalizable to other programs. Future studies that include multiple programs could help to broaden our results and more decisively identify factors related to success.

Conclusion

This study found that the dental hygiene students' performance in their oral radiology course was significantly related to their performance on the NBDHE. This relationship can help us identify students who may need extra guidance and support in the oral radiology course as well as other courses in our program in order to succeed when they take the NBDHE. Our study results could also be used by radiology course directors in other dental hygiene programs to address the importance of oral radiology discipline; to remind them of the necessity of having adequate time and coverage in oral radiology courses; and to encourage them in examining their own students' course performance and how that correlates to their students' NBDHE scores.

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Disclosure

The authors reported no conflicts of interest.

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