

Physiology Education in North American Dental Schools: The Basic Science Survey Series

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Abstract: As part of the Basic Science Survey Series for Dentistry, members of the American Dental Education Association (ADEA) Physiology, Pharmacology, and Therapeutics Section surveyed directors of physiology courses in North American dental schools. The survey was designed to assess, among other things, faculty affiliation and experience of course directors, teaching methods, general course content and emphasis, extent of interdisciplinary (shared) instruction, and impact of recent curricular changes. Responses were received from forty-four of sixty-seven (65.7 percent) U.S. and Canadian dental schools. The findings suggest the following: substantial variation exists in instructional hours, faculty affiliation, class size, and interdisciplinary nature of physiology courses; physiology course content emphasis is similar between schools; student contact hours in physiology, which have remained relatively stable in the past fifteen years, are starting to be reduced; recent curricular changes have often been directed towards enhancing the integrative and clinically relevant aspects of physiology instruction; and a trend toward innovative content delivery, such as use of computer-assisted instruction, is evident. Data from this study may be useful to physiology course directors, curriculum committees, and other dental educators with an interest in integrative and interprofessional education.

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The American Dental Education Association (ADEA) established the Commission on Change and Innovation in Dental Education (ADEA CCI) in 2005 to provide leadership and guide the association's educational change efforts.¹ Over the past decade, repeated calls have been made for curricular reform and increased innovation in dental education.²⁻⁴ In fact, planned and implemented curricular changes have occurred at many dental schools, including the introduction of integrated and systems-based courses.⁵⁻⁷ To aid in such curricular evaluation, from October 2009 until November 2011, the ADEA Physiology, Pharmacology, and Therapeutics Section designed and distributed two surveys to assess the state of pharmacology and physiology instruction in North American dental schools. All U.S. and Canadian faculty directing courses in human physiology or basic pharmacology for dental students were invited to complete the appropriate survey through the ADEA Council of Academic Deans' listserv.

This report will focus on the physiology survey; the results of the pharmacology survey were previously reported.⁸ This Web-based physiology survey was part of the Basic Science Survey Series for Dentistry, an educational research project that has been assessing how the basic sciences are taught to predoctoral dental students.⁸⁻¹⁰

With many dental schools making or planning major basic science curricular changes,^{4,7} a survey of physiology instruction in dental schools is timely and important. Our study was designed to provide information about the effects of these curricular changes on physiology instruction and to enable dental educators to make informed decisions when future changes are being considered. The information gathered on course content and topics of instruction could also assist in formulating a new set of curriculum guidelines, core competencies, and/or foundational knowledge requisites.¹¹⁻¹³ Survey information should help determine which topics may be excluded

because they are outdated or less relevant or should be added because of their emerging importance in the practice of dentistry.

The ADEA curriculum guidelines for physiology are now more than twenty years old.^{14,15} In 2008, the emphasis shifted from discipline-specific to competency-based dental education.¹² General competencies essential for unsupervised and independent performance as a new general dentist were defined, and foundation knowledge guidelines for dental education in support of these competencies were approved by the ADEA House of Delegates in 2011.^{12,13} Changes and improvements in dental physiology instruction must consider the competencies to be developed, methods to enhance the learning process, and ways to evaluate the attainment of these competencies. Surveys to assess the overall status of physiology instruction in predoctoral dental education have been conducted previously, but not since 1997.¹⁶ Therefore, the goal of this survey was to provide an accurate assessment of the current status of the quality and content of physiology instruction for dental students, the extent of integration of basic science and clinical components of the curriculum, and the prevalence of shared instruction in dental physiology courses with other health professions students.

Methods

On October 1, 2009, the academic deans of the sixty-seven U.S. and Canadian dental schools were emailed an invitation to participate in the online survey and asked to forward that invitation to the course director of their physiology courses, course director of an integrated course that included physiology instruction, or a faculty member charged with curriculum development. The survey was posted on SurveyMonkey, and included questions on faculty affiliation and experience of course directors, student contact hours, class size and number of faculty members teaching the course, inclusion of other professional students in the class, topics and content areas of physiology courses, effects of curricular changes on physiology instruction, and use of computer-assisted instruction (CAI). Three reminder emails were sent to the academic deans of those schools that had not responded, requesting them to urge the appropriate individual to participate in the survey.

The survey was closed in November 2011, and the data were analyzed. Responses from three

schools were submitted by multiple course directors and, unless indicated otherwise, are presented as combined data for each school. For example, if either course director replied positively to directing an integrated course, the school was represented as having course integration. The number of schools represented varies slightly in the results because some respondents did not answer every question. Survey respondents did not receive compensation for participation, and this study was determined to be exempt following an Institutional Review Board submission to the West Virginia University Office of Sponsored Programs.

Results and Discussion

When data collection ended, forty-eight faculty members had responded to the survey, representing forty-four of sixty-seven (65.7 percent) U.S. and Canadian dental schools. Therefore, the results presented are a representation of basic physiology instruction in a majority of U.S. and Canadian dental schools.

Faculty Affiliation and Experience of Course Directors

Out of forty-eight respondents, only nineteen (39.6 percent) reported holding their primary appointment in a dental school. Twenty-two respondents (45.8 percent) were affiliated with a medical school, two respondents (4.2 percent) held joint appointments in a medical and a dental school, and five others (10.4 percent) were affiliated with a school of biological sciences, pharmacy, or department charged with teaching a variety of graduate and undergraduate student populations on a health sciences campus (Figure 1). Overall, 60.4 percent (twenty-nine out of forty-eight) of the total responses came from faculty members with primary or joint affiliations with a non-dental school, indicating that physiology education for dental students relies heavily on instruction by faculty with medical or other non-dental school affiliations. This trend of non-dental school faculty teaching dental students has also been documented in other basic science courses, particularly in the anatomical sciences (gross anatomy, neuroanatomy, histology, and embryology).^{9,10,17,18}

Directors of physiology courses (N=45) reported their years of teaching experience in physiology ranged from three to forty-five years, with a mean

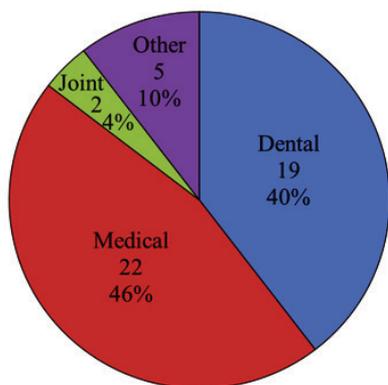


Figure 1. Primary departmental affiliation of dental physiology course directors

Note: Primary affiliation of physiology course directors (N=48) from forty-four schools indicates a heavy reliance on non-dental faculty to teach physiology in predoctoral dental curricula.

Table 1. Years of experience of course directors in dental physiology courses

Years of Experience	Mean	Median	Range
Teaching physiology (N=45)	24.9	27	3-45
Teaching dental students (N=48)	17.8	14	1-40

of almost twenty-five years and a median of twenty-seven years (Figure 2 and Table 1). Three respondents reported either being charged with monitoring the curriculum or serving as a co-course coordinator in an integrative course, but not teaching physiology specifically. The forty-eight respondents also reported their experience teaching dental students, which was substantially lower with 17.8 years of experience on average (median=14 years; range=1-40 years), demonstrated by the positively skewed distribution in Figure 2. These data suggest that the practice of dental schools' recruiting experienced faculty members from other schools, often on the same health sciences campus, to teach physiology has been occurring for some time.^{9,10} Moreover, twenty survey participants have been teaching basic physiology courses for thirty to forty-five years, which suggests a need for recruitment of new course directors to replace faculty members approaching retirement. Due to the existing shortage of faculty in dentistry and other allied health professions, dental schools may have difficulties recruiting and retaining educators in the basic (biomedical) sciences in the near future.¹⁹⁻²³ In fact, some schools have implemented innovative strategies to compensate for the faculty shortage and to continue to maintain the quality of their educational programs.²⁴⁻²⁷

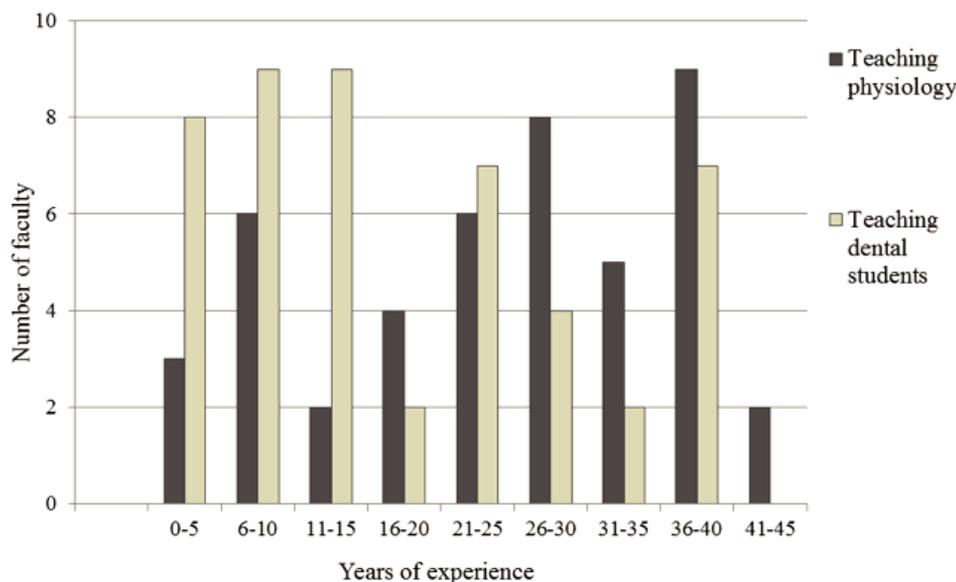


Figure 2. Teaching experience of survey respondents

Note: Distribution of experience levels of survey participants according to years teaching physiology (dark columns) and teaching dental students (light columns). Faculty members demonstrate substantially more experience teaching physiology than teaching dental students.

Contact Hours in Physiology Courses

Course directors were asked to list the total number of contact hours for only their physiology course or the physiology component of their integrated curriculum. On the survey, calculations for students' physiology contact hours were further divided into hours for lectures, laboratories, small-group activities, and assessments, including examinations and/or quizzes. With forty-one of forty-four (93.2 percent) responding dental schools providing student contact hours, physiology instruction ranged between fifteen and 480 hours, with a mean of 91.2 hours and a median of eighty-two hours. In Table 2, these data are compared to previous American Dental Association (ADA) Surveys of Dental Education, and comparisons show that physiology contact hours have remained relatively stable in the past fifteen years with a recent trend toward reduced hours.²⁸⁻³⁰ In fact, Geissberger et al. suggested designating biochemistry, microbiology, and physiology as prerequisites for dental school applicants to decrease student contact hours in these dental courses and utilize faculty members and their expertise more efficiently during predoctoral dental education, which may explain the low student contact hours in physiology courses at certain dental schools.³

Concerning physiology course content, nine of forty-one (22.0 percent) responding schools possessed a separate laboratory component, and these numbers are similar to the 2010-11 ADA Survey of Dental Education, which reported twelve of fifty-eight (20.7 percent) schools contain a physical laboratory session.¹¹ These laboratory components ranged between two and thirty hours and involved cardiovascular and pulmonary laboratories on human patient simulators, interpretation of electrocardiograms (ECGs), or proper methods to take blood pressure and auscultation of the heart and lungs. Moreover, twenty-three out of forty-one schools (56.1 percent) reported that physiology instruction included small-group discussions in addition to traditional lectures. One course director reported that small-group discussions included thirty-five integrated cases, in which physiology was a major component. Every case was discussed in two or three sessions, each lasting about two to three hours. These data indicate a trend of dental schools adopting different methods (case-based, problem-based, and small-group learning) to deliver physiology course content, a trend seen in other biomedical science courses.^{4-7,31-33}

Table 2. Number of contact hours in physiology courses for dental students

	Mean	Median	Range
Current survey (N=41)	91.8	82	15-480
2010-11 ADA survey ¹ (N=58)	97.1	94	34-260
2008-09 ADA survey ² (N=57)	102.5	95	22-312
2003-04 ADA survey ³ (N=55)	102.2	98	45-265
1999-2000 ADA survey ⁴ (N=55)	113.1	98	43-511

Note: Comparison of physiology contact hours with ADA surveys shows contact hours have remained relatively stable over the past fifteen years with a recent trend of reduction.

Sources:

1. American Dental Association. 2010-11 survey of dental education, volume 4: curriculum. At: www.ada.org/1621.aspx. Accessed: August 30, 2013.
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Class Size, Shared Instruction, and Number of Faculty Teaching Physiology

To gain insight into physiology course organization, course directors were asked questions concerning shared instruction, number of students taught, and number of faculty members helping to teach the course. Course directors from fourteen out of forty-three schools (32.6 percent) reported shared instruction with students from other health professions in their physiology courses, with schools reporting sharing instruction with graduate students (eight), medical students (three), and other health professions students, such as physician assistant (three), pharmacy (one), and optometry (two) students. Of these fourteen schools, only two course directors (14.3 percent) had a primary faculty affiliation in a dental school. Interestingly, seventeen out of twenty-nine course directors (58.6 percent) who possessed a non-dental school affiliation reported that their dental physiology courses excluded students from other disciplines. Nevertheless, 32.6 percent of the responding schools reported shared instruction in physiology with other professional students.

These findings are consistent with data regarding interprofessional education presented in a 2010 ADEA report, which reported that 9 percent of U.S.

and Canadian dental schools shared their entire basic science curriculum with other health professions students while 34 percent shared individual courses.² Thus, despite the current interest in promoting a cross-disciplinary approach to health care via inter-professional education, it appears that relatively few dental schools begin this process with shared biomedical science courses.^{9,34-36} Nash reported in 1998 that only four U.S. dental schools shared biomedical science courses with medical students.³⁷ The combination of our survey results, the 2010 ADEA report, and the 2008-09 ADA Curriculum Report suggests shared instruction in physiology has increased.^{2,9,28}

Of the schools where shared instruction was reported, only three out of fourteen had a class size of more than 120 students (Table 3).

Survey respondents were asked how many additional faculty members and teaching assistants were used in the delivery of their courses. The responses showed that physiology courses for dental students were taught by three or more faculty members in thirty-seven out of forty-three schools (86.0 percent; Figure 3). Teaching assistants were assigned to physiology courses in seven out of forty-three schools (16.3 percent).

Table 3. Class size and shared instruction, by number and percentage of total schools

Class Size (number of students)	Number of Schools		
	Total (N=43)	Dental Students Only (N=29, 67.4%)	Dental + Other Students (N=14, 32.6%)
39-80	16 (37.2%)	13 (30.2%)	3 (7.0%)
81-120	20 (46.5%)	12 (27.9%)	8 (18.6%)
121-160	3 (7.0%)	3 (7.0%)	0
161-230	4 (9.3%)	1 (2.3%)	3 (7.0%)

Note: Survey respondents from fourteen out of forty-three schools (32.6 percent) reported that their physiology courses shared instruction with graduate students, medical students, and/or students from other health professions.

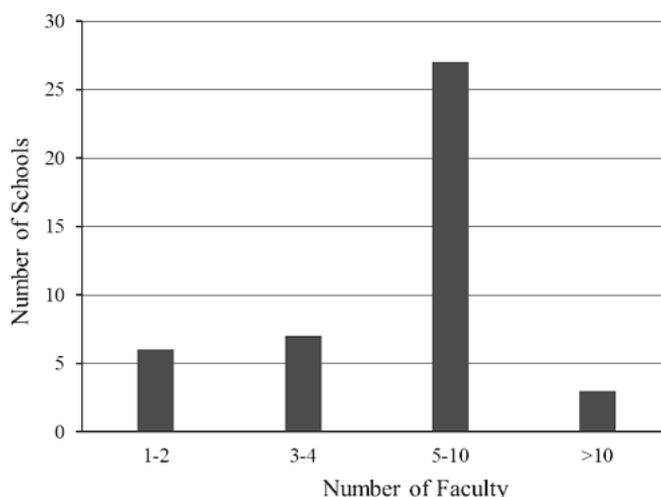


Figure 3. Number of faculty members teaching in dental physiology courses

Note: Course directors from thirty-seven out of forty-three schools (86.0 percent) indicated they assigned physiology instruction to teams of three or more faculty members. Data for schools with two course directors were combined and classified according to the team size reported by both respondents.

Topics and Content Areas in Dental Physiology Courses

In 1980 and 1993, Curriculum Guidelines for Physiology were published in the *Journal of Dental Education*;^{14,15} however, these guidelines did not indicate the core content or time spent on these topics in dental physiology courses. Therefore, part of our study was directed toward these areas. According to the results, variation in physiology course content does exist across dental schools (Figure 4). The majority (89-100 percent) of faculty members reported spending two hours or more on six topics, including renal and body fluids, respiration, circulation, gastrointestinal, endocrine, and neurophysiology. Most of the respondents (88-95 percent) reported spending one hour or more on a second group of topics, which included cell and membrane and muscle physiology. The content area with the least coverage was general principles, in that only 33 percent of schools reported more than two hours of coverage for this topic. Overall, the number of course directors reporting that instruction in general principles, endocrine, neurophysiology, and cell and membrane physiology was covered in another course ranged from 5 to 11 percent.

Effects of Curricular Changes on Physiology Instruction

Course directors from fifteen of forty-three schools (34.9 percent) reported that their physiology instruction was affected by curricular changes in the five years prior to the survey. Some common themes emerged from these reported curricular changes, including the following: 1) greater integration of physiology with biochemistry and neuroscience or with pharmacology and pathology; 2) a change from discipline-based to organ-based or systems-based teaching; and 3) an increase of clinical case scenarios in the delivery of course material. Other trends included a greater focus on topics with direct relevance to dental practice, increase in problem-based learning (PBL) or evidence-based learning, and online assignments for self-directed student learning.

Course directors from two schools reported creating separate courses for dental students instead of shared instruction in a combined medical-dental class. This curricular change reduced the class size and course content, which enabled them to add specific dental clinical correlations. In addition, three out of twenty-eight (10.7 percent) schools that reported no curricular changes indicated that

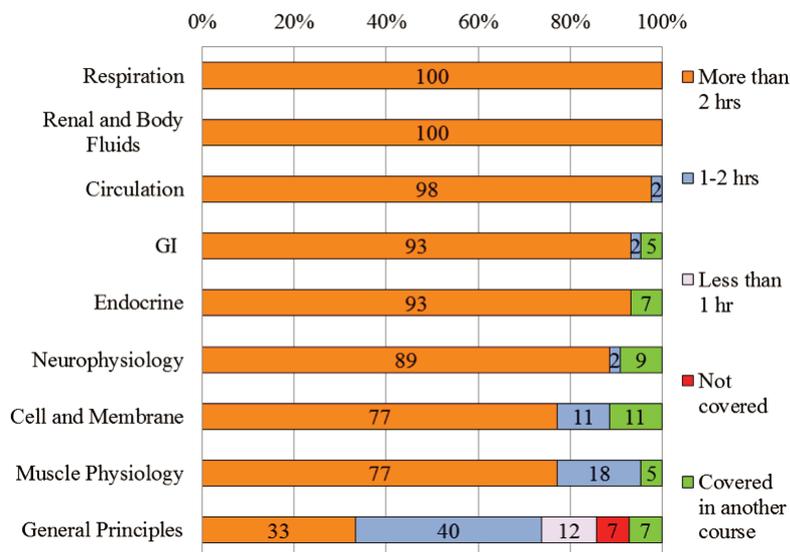


Figure 4. Course content and its emphasis in dental physiology courses

Note: Stacked bar chart shows variation in number of hours teaching specific topics in physiology for dental students. The content areas are listed according to their emphasis as reported by course directors. The number in each time category segment indicates number of responses received expressed as a percentage of the total. For each course content topic, 100 percent represents a total of forty-two to forty-four responses, representing course directors from thirty-nine to forty-one schools.

integrated, systems-based courses were already a part of the curriculum at their school and had been introduced more than five years prior to the survey. Taken together, these changes suggest an increasing trend among dental schools towards integrating basic sciences instruction with the clinical curriculum. Several dental schools have reported independently on the successful introduction and evaluation of integrated courses in their curricula.^{1,2,31,38-40} Overall, the changes are reflective of the steps in the integration ladder articulated by Harden in 2000⁴¹ and consistent with ADEA recommendations.^{1,2} The reported curricular changes had varying effects on contact hours for physiology, ranging between a minimal change to an overall decrease in contact hours.

Course directors were asked to explain the primary method of instruction used in their courses. Twenty-five out of forty-four schools (56.8 percent) reported their courses were primarily lecture-based. Course directors from two out of forty-four schools (4.5 percent) reported the primary methods of instruction were a combination of lectures and either PBL or team-based learning. Two schools indicated their courses were “other” than lecture-based. Some course directors were directing separate lecture-based and problem-based courses, while other respondents were using lectures and clinical cases as the primary methods of instruction in an individual course. Course directors from five schools commented that their courses included PBL groups, case studies, or small-group interactions. These results, and the fact that fifteen of forty-three schools (34.9 percent) reported recent curricular changes, indicate that efforts are ongoing in many schools to include multiple modes of instruction and teaching tools in physiology courses to engage their students.

Survey participants were also asked whether physiology was taught as a stand-alone course, as part of another biomedical course, or in an integrated curriculum. Thirty of forty-two schools (71.4 percent) reported a stand-alone course. Only one out of forty-two schools (2.4 percent) indicated that physiology was taught in another course, while 26.2 percent (eleven of forty-two) indicated it was taught within an integrated curriculum. One course director further indicated that physiology instruction consisted of courses that were a mix of stand-alone and integrated courses. In total, physiology was taught as part of another course or in an integrated curriculum in 28.6 percent of schools (twelve out of forty-two), compared to the 34.9 percent (fifteen out

of forty-three schools) reporting a recent curricular change that affected their course.

Use of CAI Applications

The use of Web-based instruction in biomedical sciences has been reported by a couple of schools,^{42,43} but the long-term benefits to students have not been evaluated. This survey found that CAI is gaining prominence in the teaching of physiology to dental students, with 51.2 percent of schools (twenty-one out of forty-one) reporting use of CAI applications (specialized software, websites, etc.) to engage students in one or more physiology topics. Several faculty members reported using commercially available software such as Blackboard, Sakai, or other secure online systems for posting lectures and course materials and conducting online exams. Faculty members also reported using online interactive tutorials developed in-house for ECG, blood pressure, renal physiology, retinal circuitry, animations for respiratory equations, hemoglobin saturation, pulmonary shunt flow, clotting, signal transduction, diabetes, calculation of renal function, and diagnosis of acid-base disorders. Other faculty members reported using free-ware versions of computer models of the neurophysiological, cardiovascular, and respiratory systems or using cardiovascular simulation software developed in-house or commercially available human patient simulators.

Conclusion

The Basic Science Survey Series for Dentistry is an educational research project that is assessing how the basic sciences are taught to predoctoral dental students.⁸⁻¹⁰ The results of this survey, one in that series, provide useful information about trends in North American courses delivering physiology instruction to dental students. Thirty of forty-two responding schools (71.4 percent) reported that physiology is currently taught as a stand-alone course. The variability of student contact hours in dental physiology courses was considerable (15 to 480 hours), but forty-one schools reported an average of 91.2 hours of content delivery, which is a slight reduction in course hours when compared to previous surveys.^{11,28-30} In fact, a few course directors reported that changes to the dental curriculum had resulted in reduced contact hours for physiology. Moreover, a greater emphasis on integration and introduction

of clinically relevant material may have contributed to the trend towards an overall reduction in contact hours for physiology, as well as the possible difficulty quantifying discipline-specific hours in an integrated course. More than half of the survey respondents (twenty-nine out of forty-eight) were faculty members with primary or joint appointments outside of the dental school, and 32.6 percent of schools (fourteen out of forty-three) reported shared instruction with students from other health professions.

Even with the enormous variation in the instructional hours and heterogeneity in terms of class size, faculty affiliation, and students from different programs of study, the vast majority of schools (~90 percent) agreed on an emphasis of specific content areas in physiology. The greatest emphasis was on renal and body fluids, respiration, circulation, gastrointestinal, endocrine, and neurophysiology. Most respondents (88-95 percent) reported spending one hour or more on cell and membrane and muscle physiology. The content area with the least coverage included general principles in that only 33 percent of respondents reported more than two hours of coverage for this topic, and 14 percent reported that it was either not covered or was covered in another course.

The survey results also indicated that physiology instruction in 28.6 percent of the participating dental schools (twelve out of forty-two) was taught in integrated courses along with other biomedical sciences or that it was part of a systems-based course. Curricular changes were directed towards integration of physiology with other biomedical sciences, with emphasis on the relevance and relationship of physiology to the clinical aspects of dental practice, for example, with the use of clinical cases and PBL. Course directors from four out of twenty-eight schools (14.3 percent) that reported no curricular changes also indicated that they supplemented their lecture-based courses with clinically relevant material. Computer-assisted instruction was utilized for physiology courses in 51.2 percent (twenty-one out of forty-one) of the dental schools participating in this survey. Other published reports also provide evidence of interdisciplinary, integrative, and Web-accessible teaching of physiology to dental students in individual schools, confirming efforts to integrate physiology instruction within the dental curriculum. We hope that the data from this study will be useful to physiology course directors, curriculum committees, and other dental educators with an interest in integrative and interprofessional education.

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