

A Systematic Review of Stress in Dental Students

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Abstract: The aim of this study was to systematically review the available literature on the levels, causes, and impact of stress among dental students. The investigators searched eight electronic databases: Medline, Medline in process, Psychinfo, ERIC, Embase, Cochrane Library, Web of Science, and SCOPUS. Two independent reviewers conducted the selection, data extraction, and quality appraisal for included studies. The investigators then coded both quantitative and qualitative studies using similar codes and pooled results from studies that used the Dental Environment Stress questionnaire to demonstrate dental students' stress levels. The search initially identified 4,720 studies, of which 124 studies were included in the final qualitative synthesis and twenty-one were included in the meta-analysis. Evidence from this research showed that dental students experience considerable amounts of stress during their training. This stress is mainly due to the demanding nature of the training. In addition, studies suggest adverse effects of elevated stress on students' health and well-being. Most of the available literature is based on cross-sectional studies; thus, future longitudinal studies are needed to follow students throughout their curriculum. In addition, further research needs to explore and test stress management interventions.

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Stress is a very broad term that has been used imprecisely to describe different psychological conditions. Among several stress definitions, Lazarus and Folkman distinguish predecessors of stress from consequences of stress and define psychological stress as “a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being.”¹ It has been shown that university students are vulnerable to psychological problems due to the various stressors and demands of their education.² This is especially true for those students in the health care fields who face additional challenges (e.g., providing care for patients, including performing treatments that could cause harm if performed inappropriately) compared to other students.³⁻⁵ Therefore, many studies have focused on understanding medical and dental students' learning experiences. Medical students have to face life-threatening conditions in addition to long

working hours, demanding workload, and intense theoretical education. On the other hand, dental students need to obtain training in both theoretical and surgical aspects of dental care, including performing treatments on patients to qualify as competent dental professionals. In the preclinical years, dental students need to manage laboratory requirements that require a significant amount of time and manual skills. The clinical part of their training requires that students find their patients, be responsible for their care, and perform irreversible dental treatments on those patients, in addition to their clinical requirements and exams, including both internal exams and external licensing exams. All these factors collectively contribute to significant amounts of stress for dental students that put them at additional risk for psychological problems like anxiety, depression, and burnout.^{3,5-7}

As a result, for the last three decades many researchers have investigated stress in dental students.

Numerous studies from various countries have examined the level and sources of stress associated with dental education. Moreover, to improve students' learning environment, researchers have examined the consequences of stress and proposed stress management strategies. In this systematic review, our objectives were to summarize the available literature on stress in dental students to answer the following questions: 1) what are the stress levels in predoctoral dental students? 2) what are the main causes of that stress? and 3) what are the implications of stress on dental students? Although Alzahem et al.⁸ in a previous systematic review also provided an overview of stress in dental students, in this review we analyzed results from included studies based on their outcome, and we also appraised the quality of all included studies. Moreover, we conducted a meta-analysis for studies that assessed dental students' stress levels.

Methods

Search Strategy

The search strategies we used were designed in collaboration with a health sciences librarian. Since the term "stress" was introduced in 1936 by Hans Selye¹ and our aim was to conduct a comprehensive search of the available literature, no limits such as date or language were applied to the initial search. In addition, when conducting the search, we used general synonymous terms for stress as some studies use different symptoms and proxy measures to describe psychological stress.

The medical, psychological, and educational databases we searched were Medline, Medline in Process, Psychinfo, ERIC, Embase, Cochrane Library, Web of Science, and SCOPUS. Each database was searched from the earliest available until December 31, 2010. We used a combination of subject headings and keywords to maximize retrieval. Subject headings were adjusted to reflect the preferred vocabulary of each database, while keywords were kept constant throughout the search process. An example of search terms we used in Medline is "undergrad* or college* or universit* or student* or academic*" AND "dental or dentistry or oral" AND "anxi* or stress* or fear* or frustrat* or distress* or panic* or cope or coping or eustress* or cortisol or hassl* or general adaptation syndrome or emotion*." Additional references were found by systematically examining reference lists of relevant articles and reviews.

Study Selection

After we completed the search in each database, we imported all references and removed duplicates in Endnote (X4).⁹ Initial screening of all the retrieved studies was conducted by two independent reviewers (HE and LM). At this stage, the two reviewers screened the titles and abstracts according to the following inclusion criteria: 1) original empirical studies, 2) that focus on predoctoral dental students, and 3) psychological stress (as defined by Lazarus and Folkman).¹

Next, we retrieved full texts of all the potentially relevant articles obtained from the initial screen. The same reviewers (HE and LM) read the full texts to assess the eligibility of the studies. Studies were excluded if 1) the study population was not predoctoral dental students (such as postgraduate dental students, dentists, dental patients, or other university students); 2) not original studies (such as reviews or editorial letters); or 3) in any language other than English. After completing this selection phase, interrater reliability between the two reviewers was assessed, and Kappa was 0.987 ($p < 0.001$, 95% CI 0.978-0.984). Any disagreement between the two reviewers was resolved by discussion and by consulting the senior authors (CB and PA).

Data Extraction and Quality Assessment

Since we had different study designs, we used more than one quality assessment tool to appraise the methodological quality of the included studies. For descriptive studies we used a modified New Ottawa Scale.¹⁰ In this scale, we used a star system to assess the quality of each study depending on its design (range of 0-4 for cross-sectional studies, 0-6 for cross-sectional studies with sub-group comparison, and 0-8 for cohort studies). For intervention trials, we used the Cochrane Collaboration's Risk of Bias Tool to summarize the risk of bias into low, medium, or high.¹¹ Finally, for qualitative studies, we used a modified Critical Appraisal Skills Program (CASP) tool so that the quality of each item in that scale could be yes, no, or cannot tell.¹² (The quality of all included studies is provided in the tables.) Two independent reviewers (HE and RK) assessed the quality of all retained quantitative and qualitative studies.

The same two reviewers also extracted data from included studies using piloted extraction forms. The forms were initially piloted using ten studies

to ensure that both reviewers agreed and equally understood the items on that form. Data extracted were descriptive study characteristics (publication year, author, country of investigation), methods details (study design, sample size, response rate, participants' year of study, measurements used), and three outcome variables: stress level (low, medium, high), sources of stress (academic, clinical, faculty, and personal factors), and impact of stress (academic, psychological, behavioral, biological). Items in the data extraction sheet regarding outcomes variables were developed based on Tedesco's model of stress,¹³ Lazarus and Folkman's definition of stress,¹ and themes that emerged from screening the included studies. In addition, for studies that utilized the Dental Environment Stress questionnaire (DES),¹⁴ we extracted the mean stress data and its standards of deviation. We contacted primary authors of studies when we were unable to retrieve some information from studies because it was not reported or was not clear in study reports. Data extracted were compared between the two reviewers (HE and RK), and any differences were discussed. Interrater reliability between the two reviewers was calculated, and kappa was 0.89 ($p < 0.001$, 95% CI 0.827-0.926).

Synthesis

We extracted data from included studies based on predefined codes that were piloted in the data extraction sheets, so that both quantitative and qualitative studies were coded using the same variables (codes). We presented results from quantitative and qualitative studies as quantitative data (using frequencies and percentages) in tables and the text of the discussion.

In addition, for our first research objective (the stress level in dental students), we conducted a meta-analysis and pooled results from studies that used the DES to demonstrate stress levels. From all eligible studies in our review, twenty-eight used the DES. For nine of those twenty-eight, there were insufficient data to calculate the overall mean DES and its 95 percent confidence intervals. We contacted authors from those nine studies to request more details; four responded but only two sent their data. Accordingly, seven studies that used the DES were excluded, and a total of twenty-one studies were included in the meta-analysis. We calculated total DES mean score for each study and its 95 percent confidence interval. We then pooled the estimates calculated across studies using a random-effects model based on the

Dersimonian and Laird method.¹⁵ Heterogeneity was tested using Higgins's I^2 . We used STATA statistical package for the meta-analysis.¹⁶

Results

The process of identifying relevant studies is shown in Figure 1. We identified a total of 4,720 studies through searching different databases. We removed 1,641 duplicate studies and then excluded another 2,850 according to our inclusion criteria. We read the full text of the remaining 229 studies and excluded an additional 112 (reasons shown in the figure). Finally, after checking the bibliographies of the eligible studies, we retrieved another seven studies, so the total final number of included studies was 124 studies. All studies were included in the qualitative synthesis, and twenty-one were included in the meta-analysis. For purposes of clarity, studies that examined more than one outcome are repeated in tables and results of each outcome below.

Stress Level

We identified forty-four studies according to our inclusion criteria that assessed stress in dental students (Table 1). Most of these studies were cross-sectional (70.5 percent), a few were cohort studies (20.5 percent), and only four studies (9.1 percent) used qualitative methodologies. In addition, less than half of all these studies were conducted in the United States (40.9 percent).

Researchers have used various instruments to evaluate stress in dental students, but the most common (25 percent of the studies) is the DES.^{7,17-26} The DES, developed by Garbee in 1981, consists of thirty-eight items describing stressors specifically related to predoctoral dental training.¹⁴ The response to each item is rated on a four-point scale (1=not stressful, 2=slightly stressful, 3=moderately stressful, 4=very stressful) with a fifth possible response of "not pertinent." The mean score is calculated for each item of the DES to evaluate stress levels for each stressor; a total score can also be calculated by summing the responses from all items. Many studies have modified the DES to make it applicable to the student population being studied—for instance, eliminating factors related to patients and the clinic when assessing stress in preclinical students¹⁷⁻¹⁹ or excluding items about children and partners in younger populations.^{21,27} Among the other instruments utilized

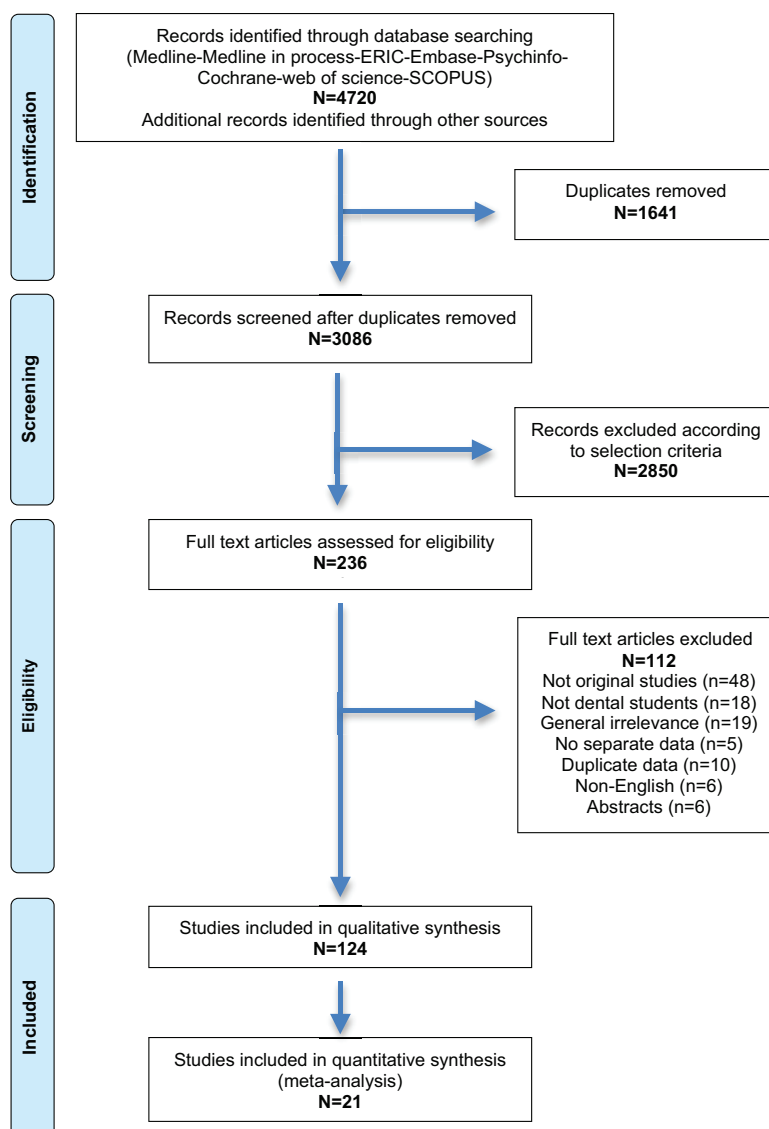


Figure 1. Flow diagram of study selection process

to assess stress levels were the Perceived Stress Scale (20.5 percent), which measures individuals' appraisal of stressful life situations,^{4,17,28-33} and the General Health Questionnaire (11.4 percent),^{7,19,34-36} which has been validated in the general population to measure psychological distress.

Our assessment for stress level from all eligible studies showed that most studies (54.5 percent) consider dental students to experience at least moderate levels of stress; however, it should be noted that 34.1 percent of the studies reported high stress levels in

dental students (Table 2). Figure 2 consists of the forest plot for studies included in the meta-analysis. The results showed that nearly all studies reported total mean DES scores in the range of 2-3, indicating at least moderate stress levels in dental students. Although there are no standardized cut-off mean scores for the DES, scores 2 and higher could suggest presence of elevated stress levels. The pooled total DES mean was 2.34 (95 percent CI 2.22-2.45), and the test of heterogeneity I^2 was significant ($p < 0.001$), indicating differences between stress

Table 1. Descriptive characteristics of studies investigating stress levels in dental students (N=44)

Study ID (first author, year)	Country	Study Design	Sample Size	Response Rate (%)	Dental Student Population (year)	Instrument	Quality Assessment NOS*
Fredericks MA, 1967	US	C-S	86	100	1st	Taylor's personality scale of manifest anxiety	3/6
Dean DH, 1978	US	C-S	19	86.4	Senior	Questionnaire	1/4
Cohen H, 1982	South Africa	C-S	193	97	3,4,5,6	Questionnaire	2/6
Richards VK, 1982	US	C-S	153	61.2	1,2,3,4	Scale of stressful life events	4/6
Yablou P, 1983	US	C-S	204	NR	1,2,3	Holme's social readjustment rating scale	1/6
Musser LA, 1985	US	C-S	298	62	1,2,3,4	Questionnaire	2/6
Cecchini JJ, 1986	US	C-S	160	69.6	1st, senior	Scale of dental stressors	2/6
Tedesco LA, 1986	US	C-S	163	NR	NR	Derogatis symptom checklist	0/4
Sturdevant JR, 1987	US	C-S	263	84.3	1,2,3,4	Derogatis stress profile	3/6
Mozer JE, 1990	US	C-S	127	62	Senior	Questionnaire	3/6
Newton JT, 1994	UK	C-S	271	77.9	1,2,3,4	GHQ	2/6
Yap AU, 1996	Singapore	C-S	137	98	1,2,3,4	DES	2/6
Peretz B, 1997	Israel	C-S	112	93.3	4,5,6	Questionnaire	2/6
Chuang SY, 2002	Taiwan	C-S	254	NR	Senior	Questionnaire	2/6
Humphris G, 2002	Netherlands, UK, Ireland, Germany, Finland	C-S	331	79.1	1st	GHQ, DES	3/6
Naidu RS, 2002	West Indies	C-S	94	83	1,2,3,4,5	DES	4/6
Sanders AE, 2002	Australia	C-S	202	91.8	1,2,3,4,5	DES	4/6
Skelly AM, 2002	UK	C-S	188	100	Applicants,5	Questionnaire	2/6
Tervit SL, 2002	US	C-S	78	NR	3,4	PSS	1/4
Pau AK, 2003	UK	C-S	213	70	1,2,3,4,5	PSS	4/6
Ng V, 2004	Singapore	C-S	110	82.1	1,2,3,4	PSS	4/6
Sugiura G, 2005	Japan	C-S	320	91	2,3,4,5,6	DES	4/6
Sofola O, 2006	Nigeria	C-S	105	76.6	3,4,5,6	DES	4/6
Dumitrescu AL, 2007	Romania	C-S	344	100	1,2,3,4,5,6	PSS	4/6
Morse Z, 2007	Fiji	C-S	115	84	1,2,3,4,5	DES	3/6
Pau A, 2007	England, Romania, South Africa, Australia, US, Greece, Malaysia	C-S	596	69.3	1st	PSS	4/6
Muirhead V, 2008	Canada	C-S	171	62	1,2,3,4	DES	4/6
Naidoo S, 2008	West Indies	C-S	98	96	1st	PSS	4/6
Laurence B, 2009	US	C-S	126	40	1,2,3,4	PSS	1/4
Peker I, 2009	Turkey	C-S	308	66.2	1,2,3,4,5	DES	4/6
Al-Nimer MS, 2010	Iraq	C-S	176	NR	1,2,3,4,5	GHQ	2/6
Fredericks MA, 1969	US	Cohort	85,81	100,95.3	1,2	Taylor's personality scale of manifest anxiety	2/8
Jemmott III JB, 1983	US	Cohort	64	NR	1st	Questionnaire	3/8

Newbury-Birch D, 2002	UK	Cohort	47,53,49	71,2,80,3,79	2,5,after grad	GHQ	3/8
Flores RIC, 2003	Japan	Cohort	94	NR	NR	College life experience scale	3/8
Stecker T, 2004	US	Cohort	24,38	NR	NR	Questionnaire	2/8
Harris MJP, 2005	South Africa	Cohort	37,21	86	Final year,after grad	Visual analogue scale	0/8
Gorter R, 2008	Netherlands, Ireland, Finland, UK	Cohort	331,132	79,1,51	1,5	GHQ, DES	5/8
Birks Y, 2009	UK	Cohort	68,25	62,22,9	1st	PSS	2/8
Silverstein ST, 2010	US	Cohort	383,228	94,1,56	1st	DES, PSS, self-rating of stress levels	5/8
Fredericks MA, 1968	US	Qual-observation	86	100	1st	Qual	CASP** 3/10
Register J, 1986	US	Qual-interviews	2	NR	2,4	Qual	5/10
Pau AKH, 2004	UK	Qual-interviews	20	-	1,2,3,4,5	Qual	10/10
Dahan H, 2010	Canada	Qual-interviews	12	-	NR	1-10 scale	10/10

C-S=cross-sectional study; Qual=qualitative; GHQ=General Health Questionnaire; DES=Dental Environment Stress questionnaire; PSS=Perceived Stress Scale; NR=not reported

*Newcastle-Ottawa Scale score (NOS): Total stars score range is 0-4 for cross-sectional studies with one group, 0-6 for cross-sectional studies with group-subgroup comparison, and 0-8 for cohort studies.

**Critical Appraisal Skills Program (CASP): Total score range is 0-10, numbers reported in table for "yes" items.

levels reported between studies. We initially explored this heterogeneity by conducting subgroup analyses based on differences in educational systems (North American versus non-North American studies) and based on year of publication (years <2000 versus ≥2000). However, these analyses did not explain heterogeneity.

On the other hand, findings from included studies further explained this heterogeneity. Research demonstrated variations in stress levels in dental students according to their demographic characteristics such as age and gender.^{18,26,28,32} However, most of these findings are based on cross-sectional studies, thereby limiting conclusions about the direction of these associations. In addition, findings from previous research indicated that stress levels vary according to students' stage in the curriculum.^{21,37} Although this finding also comes mainly from cross-sectional studies that compared students from different years in the program,^{18,20,21,23,25,26} similar conclusions were provided by the few cohort investigations that reported changes of stress over time. It has been shown that dental students report higher stress levels in their final year when compared to their first-year levels.⁷ In addition, first-year dental students in the United States and United Kingdom tended to demonstrate higher levels of stress at the end of the year when followed over time.^{4,17} Some studies further showed that students at the transition phase to the clinic particularly experience higher stress levels.^{18,21,28,37} However, we could not conduct subgroup analyses according to the previous findings (based on gender or year of study) due to lack of sufficient data from individual studies.

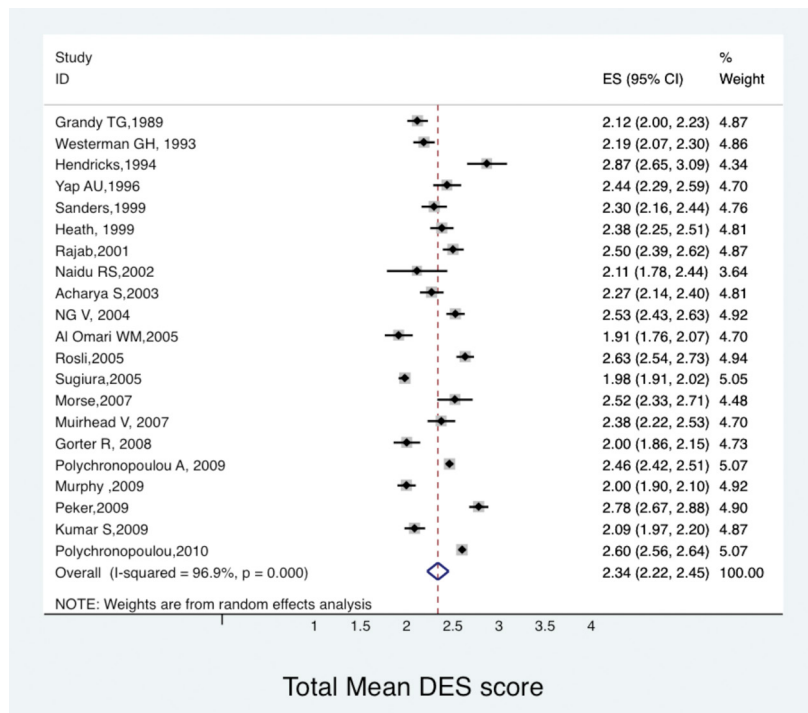
Sources of Stress

Among studies that met our inclusion criteria, fifty-five studies investigated sources of stress in dental students (Table 3). Most of these studies were conducted in North America (45.5 percent), and the great majority used cross-sectional designs (85.5 percent).

Similar to studies that assessed stress levels, most researchers also used the DES to verify sources of stress in dental students (45.5 percent). Studies either used the mean score for each item from the DES or the mean scores for categories that emerged from DES factor analysis^{7,38-40} to report causes of stress. Other self-reported questionnaires used were the Inventory of Dental Education Stressors (IDES)^{41,42} and questionnaires developed by the authors of each study. On the other hand, several researchers used a

Table 2. Results from qualitative synthesis of included studies, by number and percentage of total

	Low			Moderate		High	
Stress level (N=44)	5 (11.4%)			24 (54.5%)		15 (34.1%)	
	Academic		Psychological	Behavioral		Biological	
Stress consequence (N=24)	10 (41.7%)		9 (37.5%)	4 (16.7%)		7 (29.2%)	
	Preclinical Years (n=40)			Clinical Years (n=44)			
Sources of stress (N=55)	Academic	Faculty	Personal	Academic	Clinical	Faculty	Personal
Not reported	1 (2.5%)	15 (37.5%)	14 (35.0%)	1 (2.3%)	5 (11.4%)	13 (29.6%)	11 (25.0%)
Weak	1 (2.5%)	7 (17.5%)	20 (50.0%)	1 (2.3%)	3 (6.8%)	6 (13.6%)	15 (34.1%)
Medium	1 (2.5%)	8 (20.0%)	2 (5.0%)	5 (11.4%)	8 (18.2%)	8 (18.2%)	13 (29.5%)
Strong	37 (92.5%)	10 (25.0%)	4 (10.0%)	37 (84.0%)	28 (63.6%)	17 (38.6%)	5 (11.4%)



ES=mean for each study

Figure 2. Forest plot of the overall mean stress level for studies that used the Dental Environment Stress questionnaire (DES) in a random-effects model meta-analysis

qualitative approach to better understand perceived stressors in the dental environment.^{37,43,44}

We grouped stressors identified from studies investigating sources of stress according to students' stage in the curriculum (Table 2). For preclinical students, most studies identified academic factors as a primary source for students' stress (92.5 percent).

In addition, half of the studies considered personal issues to be a weak stressor (50.0 percent), and there was an almost equal split between studies regarding faculty-related stressors as a medium versus strong factor (20.0 percent and 25.0 percent). For clinical students, again most researchers found that academic factors (84.0 percent) are the main source of stress,

followed by clinical factors (63.6 percent). Faculty and personal issues contributed less to clinical students' stress levels (38.6 percent and 11.4 percent). The most cited academic stressors were examination and grades^{21,40} and the workload⁴⁵⁻⁴⁹ in dental school. Among faculty-related issues reported were rules and regulation in the schools,³⁹ receiving criticism,^{23,39} and inconsistency of feedback from staff.^{45,49} Clinical concerns were primarily related to dealing with difficult patients^{46,50,51} and difficulty of learning some clinical procedures.^{49,52}

Most of the previous research regarding sources of stress described sources at one time point, whereas very few longitudinal studies examined changes in those sources over time. Polychronopoulou and Divaris surveyed 109 Greek dental students through their five-year curriculum in an attempt to understand how sources of stress evolve throughout the curriculum.³⁸ Students' stress from workload and clinical training increased as they progressed in their curriculum, while stress from faculty and administration factors decreased. Two other studies, conducted in the United States, also described variations in sources of stress over time but within the first year of dental school.^{17,53}

Consequences of Stress

We found twenty-four studies that evaluated the effect of stress on dental students (Table 4). The majority of those studies were cross-sectional (70.8 percent), and only two used a qualitative methodology.^{37,54}

Academic performance was the main impact of stress investigated by most studies in this group. Almost half of the twenty-four studies (41.7 percent) reported detrimental effects of stress on dental students' academic achievements,^{13,17,37,55-60} even though two, conducted in Australia²⁴ and the United States,³³ did not support this finding. In addition, 37.5 percent of the studies described various psychological consequences of stress: students reported high levels of burnout,^{7,19,37,41,61,62} as a consequence of chronic stress, and reported mental illness related to mood changes, frustrations, and decreased concentration.^{58,63} Moreover, biological impact of stress was demonstrated by 29.2 percent of the studies. High stress levels were related to students' physical health such as number of times sick, loss of appetite, and digestive problems.^{7,17,58,64} Some other studies also demonstrated a significant association between stress levels and immune function measured by salivary IgA.^{29,65}

Finally, a few studies (16.7 percent) suggested changes in dental students' behaviors like smoking

habits and substance abuse in relation to high stress levels. Gordon and Rayner, in a study of dental students in Africa, described smoking practices and found that students reported "examination stress" and "relaxation" among their reasons to smoke.⁶⁶ Similarly, relaxation and relief of tension were among the commonly reported reasons in Dutch dental students for substance use.⁶⁷ In addition, in a qualitative study, stressed students reported social isolation from family and friends as a manifestation of their stress.³⁷ Although these findings suggest an association between stress and students' quality of life, further research is needed to document and explore these consequences in dental students.

Interventions

Only eight of the eligible studies proposed and tested interventions to help dental students deal with stress during their education (Table 5). All were conducted in the United States, and most were published in the 1980s (62.5 percent), with only two studies published in the last decade.

Two of the early studies examined reducing clinical requirements as a way to decrease stress.^{68,69} Other studies focused more on the individuals, recommending stress management courses to teach students how to deal and cope with high stress levels and demands of dental school.⁷⁰⁻⁷³ From the same perspective, Howard et al. demonstrated the effectiveness of relaxation techniques as part of a University of California wellness program.⁷⁴

Other Studies

Another twelve studies met our inclusion criteria because they investigated stress levels, sources, or impact of stress in dental students, but they were related to specific stressors and did not examine students' stress in the general setting (Table 6). Half of these studies (50.0 percent) were testing biological markers at induced stress periods like exams.⁷⁵⁻⁷⁹ Others assessed dental students' stress levels to evaluate new educational systems.⁸⁰⁻⁸² Similarly, two other cross-sectional studies explored stress in relation to bullying and ethical climate in the dental school environment.^{83,84}

In addition, we identified another twenty studies from the included studies that did not directly measure stress but assessed proxy measures or indicators of stress (Table 7). Among those other psychological outcomes investigated were anxiety and depression,⁸⁵⁻⁸⁸ emotional intelligence,⁸⁹ psycho-

Table 3. Descriptive characteristics of studies investigating sources of stress in dental students (N=55)

Study ID (first author, year)	Country	Study Design	Sample Size	Response Rate (%)	Dental Student Population (year)	Instrument	Quality Assessment NOS*
Martin RT, 1971	NR	C-S	NR	59	NR	Questionnaire	1/4
Dean DH, 1978	US	C-S	19	86.4	Senior	Questionnaire	1/4
Goldstein MB, 19791	US	C-S	63	60	1st	Mod medical instrument	2/6
Garbee WH, 1980	US	C-S	152	35	1,2,3,4	Questionnaire	1/6
Garbee WH, 1981	US	C-S	217	61.8	1,2,3,4	DES	3/6
Sachs RH, 1981	US	C-S	NR	95,99,82	1st	Student concerns inventory	2/6
Cohen H, 1982	South Africa	C-S	193	97	3,4,5,6	Questionnaire	2/6
Richards VK, 1982	US	C-S	153	61.2	1,2,3,4	Scale of stressful life events	4/6
Bjorksten OJ, 1983	US	C-S	181	100	1,2,3	Bjorksten student problem inventory	2/6
Cecchini JG, 1985	US	C-S	160	66	1,4	Dental stressor scale	1/6
Liyod C, 1985	US	C-S	298	62	1,2,3,4	Questionnaire	4/6
Musser LA, 1985	US	C-S	298	62	1,2,3,4	Questionnaire	2/6
Reeve PE, 1985	UK	C-S	219,134	NR	1,2,3,4,5	Questionnaire	0/4
Tedesco LA, 1986	US	C-S	163	NR	NR	Inventory of dental education stressors	0/4
George JM, 1987	US	C-S	300	95.2	1,2,3,4	Questionnaire	2/6
MacInnis WA, 1987	Canada	C-S	NR	NR	1,2,3,4	Delphi technique	1/6
Sgan-Cohen HD, 1988	Israel	C-S	104	72.7	5,6	Questionnaire	3/6
Bradley IF, 1989	Canada	C-S	1255	63	1,2,3,4	Dental student problem questionnaire	2/6
Davis EL, 1989	NR	C-S	46	57.5	1st	Inventory of dental education stressors	0/4
Grandy TG, 1989	US	C-S	263	87.7	3rd	DES	2/6
Westerman GH, 1993	US	C-S	244	90.4	1,2,3,4	DES	3/6
Hendricks SJ, 1994	South Africa	C-S	64	77	3,4,5,6	DES	2/6
Newton JT, 1994	UK	C-S	271	78	1,2,3,4	Questionnaire	2/6
Jacobsen N, 1994	Norway	C-S	95	72	NR	Questionnaire	0/4
Gross AJ, 1996	US	C-S	732	77	1,2,3,4	Inventory of dental education stressors	3/6
Yap AU, 1996	Singapore	C-S	137	98	1,2,3,4	DES	2/6
Peretz B, 1997	Israel	C-S	112	93.3	4,5,6	Questionnaire	2/6
Heath JR, 1999	UK	C-S	201	65	1,2,3,4,5	DES	4/6
Sanders AE, 1999	Australia	C-S	205	93.2	1,2,3,4,5	DES	4/6
Freeman R, 2000	UK	C-S	179	97.3	3 clinical years	Occupational stress indicator	4/6
Rajab LD, 2001	Jordan	C-S	266	92	2,3,4,5	DES	4/6
Naidu RS, 2002	West Indies	C-S	94	83	1,2,3,4,5	DES	4/6
Skelly AM, 2002	UK	C-S	188	100	Applicants,5	Questionnaire	2/6
Acharya S, 2003	India	C-S	256	88.2	1,2,3,4	DES	4/6
Ng V, 2004	Singapore	C-S	110	82.1	1,2,3,4	DES	4/6
Al Omari WM, 2005	Jordan	C-S	144	70.6	3,4,5	DES	4/6
Pohlmann K, 2005	Germany, Switzerland	C-S	161	85.6	4,5	Psychological stress inventory	3/6
Polychronopoulou A, 2005	Greece	C-S	571	94.4	1,2,3,4,5	DES	1/4
Rosli TI, 2005	Malaysia	C-S	325	88.8	1,2,3,4,5	DES	4/6
Sofola O, 2006	Nigeria	C-S	105	76.6	3,4,5,6	DES	4/6
Morse Z, 2007	Fiji	C-S	115	84	1,2,3,4,5	DES	3/6

Muirhead V, 2007	Canada	C-S	171	62	1,2,3,4	DES	3/6
Muirhead V, 2008	Canada	C-S	171	62	1,2,3,4	DES	4/6
Kumar S, 2009	India	C-S	275	74	1,2,3,4	DES	4/6
Murphy RJ, 2009	US	C-S	115	23	1,2,3,4	DES	2/6
Peker I, 2009	Turkey	C-S	308	66.2	1,2,3,4,5	DES	4/6
Polychronopoulou A, 2009	Greece, Croatia, Spain, Slovenia, Sweden, Ireland	C-S	1492	80.9	1,2,3,4,5-6	DES	4/6
Hoyle JD, 1980	US	Cohort	93,82	100,89	1st	Dental school environment scale	2/8
Sgan-Cohen HD, 1989	Israel	Cohort	17,14,23	42.5,35,57.5	4,5	Questionnaire	3/8
Gorter R, 2008	Netherlands, Ireland, Finland, UK	Cohort	331,132	79.1,51	1,5	DES	5/8
Polychronopoulou A, 2010	Greece	Cohort	109-70	97-61	1,2,3,4,5	DES	4/8
Silverstein ST, 2010	US	Cohort	383,228	94.1,56	1st	DES	5/8
Fredericks MA, 1968	US	Qual-observation	86	100	1st	-	CASP** 3/10
Register J, 1986	US	Qual-interviews	2	NR	2,4	-	5/10
Dahan H, 2010	Canada	Qual-interviews	12	NR	NR	Semi-structured interviews	10/10

C-S=cross-sectional study; Qual=qualitative; DES=Dental Environment Stress questionnaire; NR=not reported

*Newcastle-Ottawa Scale score (NOS): Total stars score range is 0-4 for cross-sectional studies with one group, 0-6 for cross-sectional studies with group-subgroup comparison, and 0-8 for cohort studies.

**Critical Appraisal Skills Program (CASP): Total score range is 0-10, numbers reported in table for "yes" items.

logical adjustment,⁹⁰ and psychological functioning.⁹¹ It has been shown that dental students experience higher levels of anxiety than the general population³ and that state and trait anxiety varies over time.⁸⁶ In addition, a study in Iran found that dental patients tended to be more satisfied when treated by students who reported higher emotional intelligence scores.⁸⁹

Discussion

In this systematic review, we provide a comprehensive summary of the literature regarding stress in dental students. Our review is original in that it included a meta-analysis to demonstrate stress levels in dental students. Findings from this systematic review using both quantitative and qualitative analyses demonstrate that dental students experience considerable levels of stress during their training. In addition, the current literature indicates that sources of that stress are mainly related to academic and clinical aspects of dental training. These elevated stress levels have been shown to have an effect on students' academic performance, physical health, and psychological well-being.

The documented stress level experienced by dental students was further highlighted in studies that compared dental students to other student populations. Dental students reported higher stress levels in comparison to medical students⁴ and similar stress levels to other health science students.⁹² Our findings are also in agreement with reviews of studies of medical students. Dyrbye et al. in their systematic review reported that medical students experience high levels of anxiety and depression.⁹³ They also noted that in the medical literature there was very limited research done to explore consequences of psychological distress on medical students. Moreover, in another literature review that specifically investigated stress management in medical education, the authors concluded that although several interventions targeting the individual rather than the educational structure were conducted, most were methodologically weak, which emphasizes the need for future well-designed interventions.⁹⁴ Finally, although our review provides a different view of the literature than that presented in Alzahem et al.'s systematic review of studies of dental students,⁸ our results regarding sources of stress are consistent with theirs in that examination and grades and clinical requirements were the main sources of stress for these students.

This review has several limitations that need to be considered when interpreting our findings. Results

Table 4. Descriptive characteristics of studies investigating consequences of stress in dental students (N=24)

Study ID (first author, year)	Country	Study Design	Sample Size	Response Rate (%)	Dental Student Population (year)	Outcome	Measure	Quality Assessment NOS*
Fredericks MA, 1967	US	C-S	86	100	1st	Academic performance	GPA	3/6
Horton PS, 1978	US	C-S	27	–	NR	Leaving school	Student records	3/6
Cohen H, 1982	South Africa	C-S	193	97	3,4,5,6	Response to stress	Questionnaire	2/6
Tedesco LA, 1986	US	C-S	163	NR	NR	Academic performance	GPA	0/4
George JM, 1987	US	C-S	300	95.2	1,2,3,4	Drug use-health problems	Questionnaire	2/6
MacInnis WA, 1987	Canada	C-S	NR	NR	1,2,3,4	Academic performance	Clinical & didactic GPA	1/6
Davis EL, 1989	NR	C-S	46	57.5	1st	Burnout	Meier burnout assessment	0/4
Jacobsen N, 1994	Norway	C-S	95	72	NR	Dropout	Questionnaire	1/4
Freeman R, 2000	UK	C-S	179	97.3	3 clinical years	Mental and physical ill-health	Occupational stress indicator	4/6
Plasschaert AJM, 2001	Netherlands	C-S	375	62	1,2,3,4,5	Substance use	Questionnaire	2/4
Humphris G, 2002	Netherlands, UK, Ireland, Germany, Finland	C-S	331	79.1	1st	Burnout	MBI	3/6
Sanders AE, 2002	Australia	C-S	202	91.8	1,2,3,4,5	Academic performance	Course grades	4/6
Tervit SL, 2002	US	C-S	78	NR	3,4	Clinical performance	Clinic grade	1/4
Ng V, 2004	Singapore	C-S	110	82.1	1,2,3,4	Immune function	Salivary IgA	4/6
Pohlmann K, 2005	Germany, Switzerland	C-S	161	85.6	4,5	Burnout	MBI	3/6
Badran DH, 2010	Jordan	C-S	307	100	4,5	Burnout	MBI-human services survey	3/6
Gordon NA, 2010	South Africa	C-S	308	NR	NR	Smoking	Questionnaire	2/6
Fredericks MA, 1969	US	Cohort	85,81	100,95.3	1,2	Academic performance	GPA	2/8
Jemmott III JB, 1983	US	Cohort	64	NR	1	Immune function	Salivary IgA	3/8
Cecchini JJ, 1987	NR	Cohort	74	61.7	1st	Academic performance	GPA (technical, didactic, total)	1/8
Gorter R, 2008	Netherlands, Ireland, Finland, UK	Cohort	331,132	79,1,51	1,5	Burnout, physical health	MBI, physical symptoms questionnaire	5/8
Silverstein ST, 2010	US	Cohort	383,228	94,1,56	1st	Performance, leave of absence, health and stress symptoms	GPA, questionnaire	5/8 CASP**
Pau AKH, 2004	UK	Qual-interviews	20	–	1,2,3,4,5	Qual-themes	Semi-structured interviews	10/10
Dahan H, 2010	Canada	Qual-interviews	12	–	–	Qual-themes	Semi-structured interviews	10/10

C-S=cross-sectional study; Qual=qualitative; GPA=grade point average; MBI=Maslach Burnout Inventory; NR=not reported

*Newcastle-Ottawa Scale score (NOS): Total stars score range is 0-4 for cross-sectional studies with one group, 0-6 for cross-sectional studies with group-subgroup comparison, and 0-8 for cohort studies.

**Critical Appraisal Skills Program (CASP): Total score range is 0-10, numbers reported in table for "yes" items.

Table 5. Descriptive characteristics of studies testing stress management interventions in dental students (N=8)

Study ID (first author, year)	Country	Study Design	Sample Size	Dental Student Population (year)	Description of Management	Cochrane Summary Risk of Bias	Quality Assessment
Tisdelle DA, 1984	US	RCT	32	1,2	Stress management training		Medium
Hicks JL, 1985	US	RCT	124	Senior	Reducing clinical requirements		Low
Howard CE, 1986	US	RCT	23	NR	Effectiveness of Synchro-Energizer device		Medium
Dodge WW, 1993	US	RCT	80	Senior	Eliminating clinical requirement		Low
Piazza-Waggoner CA, 2003	US	RCT	26	2nd	Stress management for 1st pediatric procedure		High NOS*
Shugars DA, 1981	US	Cohort	80,41	Junior	Fitness course		4/6
Morse DR, 1982	NR	Cohort	12	1st	Meditation		1/8
Lopez N, 2010	US	Mixed methods	256	1,2,3,4	Peer mentoring program		2/8

RCT=randomized controlled trial; NR=not reported

*Newcastle-Ottawa Scale score (NOS): Total stars score range is 0-6 for cross-sectional studies with group-subgroup comparison and 0-8 for cohort studies.

Table 6. Descriptive characteristics of studies investigating stress in relation to specific stressors in dental students (N=12)

Study ID (first author, year)	Country	Study Design	Sample Size	Response Rate (%)	Dental Student Population (year)	Specific Stressor	Quality Assessment NOS*
Marucha PT, 1998	US	C-S	11	100	NR	Exam	2/6
Rice CD, 1999	US	C-S	164	56	Junior and senior	Accelerated degree program	1/6
Acharya S, 2005	India	C-S	47	69	Final year	Ethical climate in private dental school	2/6
O'Sullivan D, 2007	UK	C-S	50	NR	NR	New restorative assessment system	0/6
Sukotjo C, 2008	US	C-S	70	100	3rd	Prosthodontics in PBL curriculum	3/4
Rowland ML, 2010	Romania, South Africa, Australia, US, Malaysia	C-S	471	71.9	1st	Bullying and intimidation	4/6
Mouton C, 1989	NR	Cohort	46,46,44,44	NR	NR	Exam	4/8
Bosh JA, 1996	Amsterdam	Cohort	28,25,28	70	NR	Exam	2/8
Bosh JA, 1998	Amsterdam	Cohort	28	70	NR	Exam	2/8
Ng V, 2003	Singapore	Cohort	31	96.9	3rd	Exam	3/8
Krahwinkel TH, 2004	Germany	Cohort	38	NR	Internship	Exam	2/8
Sukotjo C, 2007	US	Cohort	70	100	3,4	PBL curriculum	4/8

C-S=cross-sectional study; NR=not reported

*Newcastle-Ottawa Scale score (NOS): Total stars score range is 0-4 for cross-sectional studies with one group, 0-6 for cross-sectional studies with group-subgroup comparison, and 0-8 for cohort studies.

Table 7. Descriptive characteristics of studies investigating other outcomes related to stress in dental students (N=20)

Study ID (first author, year)	Country	Study Design	Sample Size	Response Rate (%)	Dental Student Population (year)	Outcome	Measure	Quality Assessment NOS*
Zucker SB, 1978	US	C-S	NR	NR	1st	Anxiety	Questionnaire	0/4
Goldstein MB, 1980	US	C-S	63	60	1st	Psychological well-being	Questionnaire	2/6
Freeman RE, 1985	UK	C-S	99	100	Clinical	State-trait anxiety	Multiple affect adjective check list	3/6
Lloyd C, 1989	US	C-S	298	61	1,2,3,4	Psychiatric symptomatology	Hopkins symptoms checklist	4/6
Kolosowski-Gager PE, 1989	US	C-S	84	NR	NR	State-trait anxiety	STAI	0/4
Rubenstein LK, 1989	NR	C-S	84	100	1st	State-trait anxiety, depression, general well-being	STAI, BDI, general well-being index	3/4
Henning K, 1998	US	C-S	102	NR	NR	Psychological adjustment	Brief symptom inventory	3/6
Benjakul P, 2000	Thailand	C-S	523	100	1,2,3,4,5,6	Adjustment problems	Mooney problem checklist	2/6
Kieser J, 2000	New Zealand	C-S	102	85	2,3	Anxiety related to clinic	Questionnaire	2/6
Mutlu N, 2002	NR	C-S	261	NR	NR	State-trait anxiety, depression	STAI, BDI	2/6
Barberia E, 2004	Spain	C-S	110	NR	1,3,5	Anxiety level	Inventory of anxiety situations and responses	3/6
Cardoso CL, 2004	Brazil	C-S	35	NR	4	Stress symptoms	Lipp stress symptom inventory	1/6
Peretz B, 2004	Israel	C-S	88	NR	5,6	Level of anxiety prior to treating a child	Visual analogue scale	3/6
Burk DT, 2005	US	C-S	97	71	1st	Severity of problems	Questionnaire	4/6
Azimi S, 2010	Iran	C-S	123	87.9	5,6	Emotional intelligence	Emotional quotient inventory	3/6
Grandy TG, 1984	US	Cohort	40	54.8	1st	State-trait anxiety, depression	STAI, BDI	1/8
Grandy TG, 1988	US	Cohort	86	56.2	3rd	State-trait anxiety, depression	STAI, BDI	2/8
Snelling J, 2003	UK	Cohort	122,120,129	NR	1st	Concerns related to dissection	Questionnaire	4/8
Stewart DW, 2006	Canada	Cohort	28	NR	1st	Psychological functioning and symptoms	Questionnaire	4/8
Schmitter M, 2008	NR	Cohort	96,94	100,97.9	NR	Categories of chronic stress	Tier inventory	3/8

C-S=cross-sectional study; STAI=State-Trait Anxiety Inventory; BDI=Beck Depression Inventory; NR=not reported

*Newcastle-Ottawa Scale score (NOS): Total stars score range is 0-4 for cross-sectional studies with one group, 0-6 for cross-sectional studies with group-subgroup comparison, and 0-8 for cohort studies.

from most studies are based on small cross-sectional descriptive studies that are considered relatively weak evidence. In addition, the instruments we used for quality appraisal are not specifically designed to assess survey studies. However, we modified the NOS and the CASP scales for studies included in our review. Furthermore, as we are reporting the findings of the research the way they were reported, we included studies that used the DES as a measure of stress level. However, it is important to realize that the DES was originally designed to evaluate sources of stress, not a measure of the overall stress level as erroneously used by the majority of the research investigating stress in dental education. Thus, future research needs to consider the use of a more precise measure to evaluate stress level to aid in better understanding dental students' experience and accordingly improving their learning environment. Another limitation regarding the meta-analysis is that errors from each study are accumulated in the pooled estimate. Finally, although we excluded intervention studies and studies related to specific stressors from our analysis, we decided to keep them in the review to provide a comprehensive literature regarding stress in predoctoral dental training.⁹⁵⁻¹³⁶

Our systematic review and meta-analysis add significantly to the previous literature on the subject of stress in dental students and should alert future researchers and dental schools to consider and implement stress management strategies either through changes in the structure of the curriculum or using more individualized approaches to enhance students' well-being and ensure a healthy learning environment. As our research confirms, the main sources of stress for dental students are academic work (including particularly examinations, grades, and workload), clinical care, faculty-related factors, and personal factors. It also confirms that the main effects of stress are felt on academic performance, psycho-emotional well-being, and physical health and on habits such as smoking and alcohol consumption. Finally, we have identified that there have been very few intervention studies aimed at reducing stress or helping dental students manage that stress and that the majority of the few studies performed were done in the 1980s, with little clarity on any benefits from these interventions. Therefore, it is clear from our review that research should now concentrate on developing and testing the effects of various strategies aimed at reducing stress levels in dental students.

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