A Systematic Review of the Relationship Between Lecture Attendance and Academic Outcomes for Students Studying the Human Biosciences

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Abstract

Historically, lecture attendance was considered a predictor of better academic outcomes. However, it is not known whether this is true for the human biosciences or whether it still applies with the introduction of lecture recordings. The aims were to determine (i) any association between lecture attendance and academic outcomes for students studying the human biosciences, and (ii) whether this was altered by the availability of lecture recordings. There were 27 studies of the association between lecture attendance and academic outcomes in 32 courses, and for 24 courses (75%) there was a positive association. The positive association occurred in a similar percentage of undergraduate courses for allied health students and science students (72%) and courses for dental and medical students (82%), who are predominantly postgraduate students. Eleven studies reported the use of lecture recordings with a positive association between lecture attendance and academic outcomes being reported for 11 of the 16 courses (69%). From 16 studies/courses not reporting the availability of lecture recordings, 13 did show (82%) a positive association, and three did not show (18%) an association between lecture attendance and academic outcomes. In conclusion, as most studies show a positive relationship between lecture attendance and academic outcomes, it seems reasonable to continue to provide face-to-face lectures, and encourage students to attend. To date, there is no definitive evidence that the availability of lecture recordings alters the positive relationship between lecture attendance and academic outcomes.

Introduction

There are many factors that predict academic performance at university. These include previous academic performance, psychosocial variables, cognitive capability, and demographics (reviewed in McKenzie and Schwitzer, 2001). In addition, for many years, especially before the introduction of technology into teaching, it was assumed by most teachers that academic performance was related to class attendance with students who attended classes more frequently obtaining better grades as this had been shown in a study by Moore et al. (2003). For college students in the US, a major meta-analysis of 68 studies published prior to 2010 showed that there was a strong relationship between attendance and grades (Credé et al., 2010). The study of Credé et al. (2010) also showed that attendance, irrespective of the specific teaching mode or modes, was a better predictor of grade than any other known predictors of academic performance including entry scores, psychometric testing scores, study habits and study skills. A study by Newman-Ford et al. (2008) showed an association between lecture attendance and academic outcomes in a variety of courses (Newman-Ford et al., 2008).

Although the study by Credé et al. (2010) was not discipline specific, many of the studies included in the meta-analysis related to attendance in psychology classes (Credé et al., 2010), and thus the findings of this analysis may be biased towards psychology. Only 11 published

studies in their review considered the 'sciences' out of a total of 68 studies used in the meta-analysis and showed a positive correlation for these studies, which was slightly stronger for science than non-science classes (Credé et al., 2010). The human biosciences were not considered separately in the meta-analysis (Credé et al., 2010) or in the study by Newman-Ford et al. (2008). Indeed, there have been no reviews relating lecture attendance and academic outcomes that separate the disciplines. The main aim of this review is to determine the relationship of face-to-face lecture attendance and academic outcomes and is restricted to undergraduate and postgraduate students undertaking courses in the human biosciences.

No information on the use of technology is given in the meta-analysis of Credé et al. (2010), and thus it is not clear whether this use influenced the outcome. Forty of the 68 studies combined in the meta-analysis by Credé et al. (2010), were before or in 2000 and probably do not relate to the current teaching/technology environment, including the availability of lecture recordings. Credé et al. (2010) showed that the relationship between class attendance and academic outcomes had not changed over time and speculated that, despite more instructional material being available online in recent years, attendance was still important. It is possible that the ongoing increasing use of technology, especially the availability of lecture recordings, has led to reductions in lecture attendance, as low levels of lecture attendance have been reported in recent studies of lecture attendance with bioscience students when recordings are available (Doggrell, 2019, 2020). It is not known whether the availability of lecture recordings has changed the outcomes for students who do not attend lectures i.e. made them better, the same, or worse. The second aim of this study is to determine the effect of lecture recordings on any relationship between face-to-face lecture attendance and academic outcomes for the human bioscience students.

As previous academic outcomes are a determinant of academic outcomes (McKenzie & Schwitzer, 2001), this review has considered the relationship between lecture attendance and academic performance for both students studying the human biosciences as part of a science degree or as part of an allied health science degree (e.g. nursing), with those of students with high enough grades to study medicine and dentistry at university, predominantly at a postgraduate level. The point for this separation was to consider whether prior academic performance or other differences between the cohorts had any effect on the relationship between lecture attendance and academic outcomes.

Methods

The systematic review followed the standards for systematic reviews (Eden et al., 2011) with the exception that the collection and analysis of papers was undertaken by one person i.e. not in duplicate, as suggested in the guidelines. A PRISMA chart was used to summarise how the studies included in the qualitative synthesis were obtained (Figure 1).

To be eligible for this review, papers had to be of lecture attendance by students studying the human biosciences and have a measure of both lecture attendance and academic outcome.
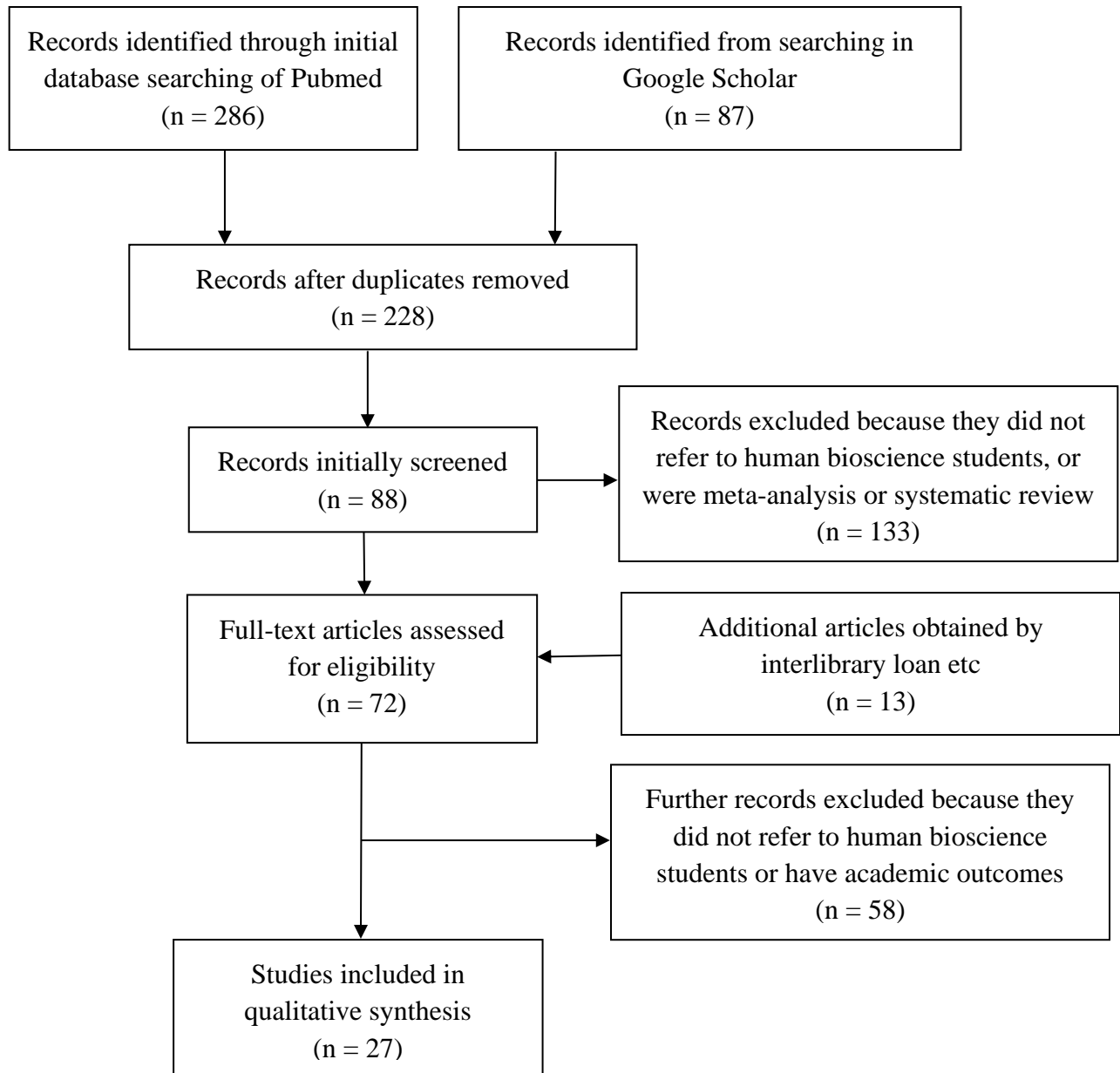
Figure 1: Flow diagram of literature search for review on the association between lecture attendance and academic outcomes

Papers had to have been published in a peer reviewed journal, 1990 to August 2020. For the review, Pubmed was searched for 'university', 'lectures', with 'attendance' or 'non-attendance', and with 'outcomes' or 'performance', and this gave 286 records. A similar search of Google Scholar gave in excess of 10,000 records, and thus to reduce the number of records, additional terms were added singularly; Table 1. English only abstracts were read.

For each paper included in the review, the year of publication, country of origin, student group and numbers, course, attendance measure and outcome, academic outcome measure, availability of lecture recordings, and results of analysing the relationship between attendance and academic outcome were extracted if available in the published paper, and much of this data has been tabulated. As the studies of the relationships between lecture attendance and academic outcomes for students studying the human biosciences were of variable quality, it was decided to include them all with discussions of their strengths and limitations. In this review, positive

or negative correlation coefficients (r) of 0.3 to less than 0.5, 0.5 to less than or equal to 0.7, and 0.7 to 1 are considered weak, moderate, and strong correlations, respectively.

The present review of the relationship between lecture attendance and academic outcomes is limited to courses in human biosciences (anatomy, physiology, biochemistry, pharmacology, and molecular and cellular biology) or courses that contain components of these disciplines. In this review, the term "course" is used to indicate a single unit/course/subject in a degree. The studies in this review have been grouped into those showing a positive relationship, and those that showed no relationship between lecture attendance and academic outcomes. Studies have also been separated into those not reporting and those reporting use of lecture recordings. In the section on the human bioscience students and tables in this review, studies are presented in chronological order.

Results and Discussion

The flow diagram of the information search for the literature review is given in Figure 1. The search produced 377 records; 287 from Pubmed for 'university', 'lectures', with 'attendance' or 'non-attendance', and with 'outcomes' or 'performance'. Google Scholar was searched by adding additional terms (Table 1).

Table 1. Distinct records obtained from Google Scholar by adding terms.

Term added	Number of records	Term added	Number of records
Anatomy	1	Biology	11
Biological science	1	Nursing	3
Physiology	20	Medical student	18
Pharmacology or therapeutics	7	Pharmacy student	19
Biochemistry	7	Dental student	0

The author read the English only abstracts, and downloaded both the papers relevant to the review, and those papers which had abstracts that did not give enough information to determine whether they would be relevant to the review or not. Most of the Pubmed search records were not relevant to the review as they concerned disciplines other than the human sciences. Meta-analysis and systematic reviews were read but excluded from the present review. If the meta-analysis, systematic reviews or full-text articles read cited additional articles, these were collected and assessed for eligibility. Twenty-seven studies of 32 individual courses are included in this review.

The studies are reported as being prior to 2000 or 2000 onwards to indicate those studies likely to have occurred prior to, or in the current teaching/technology environment including the use of lecture recordings, respectively. Studies were also separated into those undertaken by allied health or biological science students, which mainly represent undergraduate students and those undertaken by dental and medical students, who are high achieving, predominantly postgraduate students. Attendance was measured in a variety of ways in these studies. When the measure used was a survey this may not reflect the whole class. The limitations of other methods of measuring attendance are discussed for individual studies.

Prior to 2000, studies of allied health or biological science students reporting a positive relationship between lecture attendance and academic outcomes

All three studies of allied health and science students studying the human biosciences prior to 2000 (Hamen & Kelland, 1994; Gatherer & Manning, 1998; Brown et al., 1999), reported positive relationships between lecture attendance and academic outcome (Table 2), but did not report the use of lecture recordings (Table 2). In the first study, the multiple choice questions used in the exam were derived from reading assignments in a required textbook (Hamen & Kelland, 1994). Thus, in this study, the students had access to all the material of the course without attending lectures, which may have affected their lecture attendance. In this study, attendance was recorded by sign-up, rather than self-reported, and this is a strength. The authors reported that the students cooperated well, only rarely signing the name of a friend or a fictitious person (Hamen & Kelland, 1994). Another strength of this study was that it was a large cohort studied over 5 semesters under similar learning and teaching standards. However, as the average levels of attendance were very high in this study, this limited the ability to compare with low or non-attending students e.g. the least attending student in the 1990 cohort attended 75% of lectures.

The other two pre-2000 studies showing a positive relationship (Gatherer & Manning, 1998; Brown et al., 1999) lacked details on how attendance records were made. Thus, in one of the studies it was not clear how attendance records were made and how many students were excluded for not having an attendance record (Gatherer & Manning, 1998) and in the other study there were no details of the methodology used to collect attendance records (Brown et al., 1999). One of the studies reported that learning support facilities such as audio-visual aids and computer-assisted learning, in addition to the library were available to the students (Gatherer & Manning, 1998) whereas the other study did not report on available resources (Brown et al., 1999). Sub-cohort analysis in one of the studies showed that female students had higher attendance and better performance than male students (Gatherer & Manning, 1998).

2000 onwards, studies of allied health and science students studying the human biosciences

Studies not reporting the use of lecture recordings and showing a positive relationship between lecture attendance and academic outcomes

None of the four studies of allied health and science students studying the relationship between lecture attendance and academic outcomes in the human biosciences 2000 onwards (Table 2) reported the use of lecture recordings. This does not necessarily mean that lecture recordings were not used, just that they were not reported.

A 2003 study of a large non-major course in biology showed a weak association between attending lectures and academic outcomes (Grisé & Kenney, 2003). One unique feature of this study was that grade point average (GPA) was used as the covariate in the analysis of covariance (ANCOVA), to eliminate previous academic performance as a factor. This is a major strength of the study as it eliminated this GPA as a factor in the association between lecture attendance and academic outcome, by using ANCOVA. However, a weakness of this study is that correlation coefficients and significance levels are not given.

Table 2: Studies not reporting the use of lecture recording showing a positive association between lecture attendance and academic outcomes for allied health and science students studying the human biosciences

Year, country	Students, course	Attendance measure	Attendance outcome	Academic outcome measure	Association between attendance and outcome	Reference
1994, USA	556 students of biological science in nursing, pharmacy or physical education courses	Sign-up	Average = 85%	Exam mark	Absenteeism and exam mark; Linear regression; r = - 0.33	Hamen and Kelland
1998, UK	152 students taking cell biology	Not given	66 students attended ≥ 7 of 9 lectures	Short answer question exam	Linear regression; r = 0.34; p < 0.005 by t-statistic High attending students (≥ 7 of 9 lectures) performed better in the examination than those that attended ≤ 3 lectures.	Gatherer and Manning
1999, Canada	76 students in pathotherapeutics	Attendance records	Number of missed classes	Grades	Absenteeism and grades; Linear regression; r = - 0.34 and – 0.45	Brown et al.
2003, USA	608 in non-major biology	Sign-up then ID swipe	5 categories; 1) 0-435 minutes 2) 436-870 minutes and so forth	Grade	Adjusted for GPA in ANCOVA: Category 1, 64% Category 5, 74%	Grisé and Kenney
2003, USA	> 1400 students in introductory science units; introductory biology, environmental science, human anatomy and physiology, and introductory physics	Survey	Percentage of classes attended	Grade	Linear regression: r = 0.78	Moore et al.
2003/6, USA	263 students in introductory biology	Recorded at class	Average course attendance rate	Exam mark	Attendance rate of 84%, average score of 85; 68% attendance, 72 score; 36%, 49. Linear regression; r = 0.63	Moore
2009, Australia	126 nursing students in pathophysiology	Survey	82% responded to survey and 62% attended lectures	End-of-semester examination	Linear multiple regression controlling for age and ethnicity; lecture attendance more than 80% and outcome; β = 0.21, P = 0.011	Salamonson et al.

The studies undertaken by Moore et al. (2003), showing a positive relationship started with a 2003 editorial, reporting the results from students in several courses who had been surveyed about lecture attendance. In 2003 and 2006, Moore published more details from one of these courses. The cohort was diverse, but all the students had academic aptitude ratings below that required for direct entry into degree courses and were being prepared for entry into degree courses. Attendance was recorded at each class. The examination covered material presented in lectures and in assigned reading from the prescribed textbook (Moore et al., 2003; Moore, 2006). One of the strengths of this study of students in Introductory Biology is that it does have an even distribution of attendance. Thus, unlike many of the other studies in this review, this study is not comparing high attendees with a few poorly attending students.

The last study 2000 onwards not reporting the use of lecture recording and showing that lecture attendance was associated with better academic was from Australia in 2009 (Salamonson et al., 2009). A major strength of this study is that it used multiple, rather than linear regression, controlling for student age and ethnicity; thus, removing these as confounding factors. However, student entry scores could still have been a confounding factor. A limitation is that students were divided into those that attended less than, equal to, or more than 80% of lectures, which may have had a bearing on outcome of the analysis and could have been overcome by using individual attendance values in the analysis.

Studies reporting the use of lecture recordings and showing a positive relationship between lecture attendance and academic outcomes

Five studies of six courses 2000 onwards, reporting the availability of lecture recordings, have shown a positive relationship between lecture attendance and academic outcomes for students in the human biosciences (Fernandes et al., 2008; Soto & Anand, 2009; Horton et al., 2012; Doggrell, 2018; Doggrell, 2019; Table 3). Only one of these studies used a survey to determine attendance (Fernandes et al., 2008) with the others using sign-in (Soto & Anand, 2009; Horton et al., 2012; Doggrell, 2018; Doggrell, 2019), which is probably a more accurate measure of attendance. However, the sign-in in one of these studies (Doggrell, 2018) was limited to one lecture, which is probably a poor measure of attendance overall.

In a study with pharmacology students studying for a science degree, using online lectures instead of attending lectures was associated with a lower final mark. However, lecture attendance did translate into a better outcome in the final mark (Fernandes et al., 2008). A limitation to this study is that results combining non-attending and lecture attending students are not given. A complication of this study was that 30 of the students reported had to use online lecture recordings because of timetable clashes making lecture attendance impossible. As discussed by the authors, the use of self-reporting of lecture attendance may have overestimated lecture attendance (Fernandes et al., 2008).

In another study, for 2004, but not 2005, students had access to digitally videotaped lectures on a CD-ROM, and, as the relationship between lecture attendance and outcomes was similar for both years, lecture recordings were not considered to be a factor (Soto & Anand, 2009). A limitation of this study is not having data about the uptake of the videotapes.

Table 3: Studies reporting the availability of lecture recordings showing a positive association between lecture attendance and academic outcomes for allied health and science students studying the human biosciences.

Year, country	Students, course	Attendance measure	Attendance outcome	Academic outcome measure	Association between attendance and outcome	Reference
2008, Australia	295 students studying pharmacology in a science degree	Survey	86% responded to survey and 79% usually attended both lectures	Final mark	Students' t-test; lecture attending students had higher final mark (70%) than vs non-attending students (59%)	Fernandes et al.
2009, USA	184 cell biology students in a biology major	Collection of quizzes (2004) or sign in (2005)	Perfect, good (89-80%), fair (79-70%) or poor (69% or less)	Pass rates	Chi-square (x^2) = 32.8, $p \leq 0.05$ for lecture attendance between passing and failing students	Soto and Anand
2012, Australia	141 students studying physiology in a science degree	Survey	120 (85.1%) students responded; number of lectures attended out of 21	Practical, tutorial, exam and overall grade	Linear regression; Practicals, r = 0.29 Tutorials, r = 0.35 Exam grades, r = 0.21 Overall grades, r = 0.35	Horton et al.
2018, Australia	797 nursing students studying bioscience and 926 studying pharmacology at two campuses over two years	Attendance at lecture 10 or 11	Bioscience: 2014; 364 non-attending, 75 non-attending; 2015, 320 non-attending, 38 attending Pharmacology: 2014; 430 non-attending, 75 attending; 2015; 375 non-attending, 36 attending	Grade, overall mark, exam mark, ongoing assessment mark	Student's unpaired t-test; attending students had higher grades and marks than non-attending students	Doggrell
2019, Australia	39 biomedical science students studying pharmacology	Sign-in at lectures	(i) Attendance at < or ≥ 50% of lectures (ii) Regression line analysis of outcome vs % attendance	Overall mark, combined exams, assignment	Student's unpaired t-test; Overall mark and examination mark, but not assignment mark, were higher for attending than non-attending students Linear regression; overall mark, r = 0.32, examination mark, r = 0.36, assignment, r = 0.20	Doggrell

A third study showing a positive association between lecture attendance and some academic outcomes was a 2012 study of a physiology course (Horton et al., 2012). After the completion of the course, students were surveyed on lecture attendance and this showed a weak correlation ($r > 0.3$) between lecture attendance for overall grades and tutorials. For the students who passed the exam, those that attended fewer than 11 out of 21 lectures, reported a greater use of lecture recordings than those who attended more lectures: < 11 lectures, 37% of 15 students used recordings; ≥ 11 lectures, 10% of 85 students used recordings (Horton et al., 2012). A limitation of this study was that 21 students were excluded because they did not complete the assessment, and their poor attendance may have contributed to failure to complete the course.

Two further Australian studies of students with access to lecture recordings studying pharmacology have reported a positive association between lecture attendance and academic outcomes. The first was with nursing students who were also studying bioscience and was performed at two campuses over two years (Doggrell, 2018). The second study was of biomedical science students studying pharmacology, and the major limitation of this study was that it was a small group of students (Doggrell, 2019).

Studies reporting the use of lecture recordings and not showing a relationship between lecture attendance and academic outcomes in some courses

There are three studies that report the availability of lecture recordings but do not show a relationship between lecture academic outcomes in all courses (Hidayat et al., 2012; Davis et al., 2012; Doggrell, 2020; Table 4). Two of the studies had the limitation that they were using surveys rather than actual lecture attendance (Hidayat et al., 2012; Davis et al., 2012), whereas the other study measured attendance both by survey and sign-in (Doggrell, 2020). A limitation to the study of Hidayat et al., 2012 is that they did not have a range of attendance to use in the analysis of the association between lecture attendance and academic outcomes.

A strength of the study of Davis et al., 2012 was the differences between classes were not related to entrance scores, as there was no difference in these for the students in all 4 courses (Davis et al., 2012). The measure of attendance in this study was to divide the students into three groups rather than using the raw data to give a range of attendance, and thus this study is not comparable with most of the other studies of attendance and academic outcomes, which use a range of attendance levels. A major difference in the study of Davis et al., 2012, to most of the other studies reported in this review, is that the population may not have been representative of the class, as of the 79% of students who responded to the survey, only 38-61%/class volunteered their ID numbers and were included in the analysis. Because of this the numbers in each class was small e.g. only 15 students in the 3rd year pharmacology course volunteered their ID. Another difference between the study of Davis et al., 2012. and other studies reported in this review, is that many of the students were not able to attend lectures because of timetable clashes, which is an unusual circumstance, and not common in universities.

The study by Doggrell (2020), is the only one that has measured lecture attendance both by sign-in and survey. This study showed that the finding of no correlation between lecture attendance and academic outcomes was consistent between methods (Doggrell, 2020).

Table 4: Studies reporting the use of lecture recordings and not showing a positive relationship between lecture attendance and academic outcomes for allied health and science students studying the human biosciences

Year, country	Students, course	Attendance measure	Attendance outcome	Academic outcome measure	Association between attendance and outcome	Reference
2012, USA	135 pharmacy students studying biomedical science or therapeutics	Survey	16 of 75 first year students missed more than eight hours of 36 hours of lecturing in biomedical science, and 20 of 60 students missed more than eight hours of 39 hours of lecturing in therapeutics	GPA	Higher GPAs for students who did not miss more than eight hours of lecturing in biomedical science, but not in therapeutics	Hidayat et al.
2012, Australia	Biomedical science students; 132 and 78 in 2nd and 3rd year biochemistry courses, and 142 and 48 in 2nd and 3rd year pharmacology courses, respectively	Survey	Attended all lectures, missed one/two lectures week or did not attend lectures	Exam marks	Higher marks for those who attended all lectures, but only significant for 2nd year pharmacology course	Davis et al.
2020, Australia	Medical laboratory science students; 41 in 2017, 64 in 2018	(i) Sign-in (ii) Survey	(i) Percentage of lectures attended (ii) Points; 0 for 'no' attendance, 1 for 'sometimes' and 2 for 'most weeks' or 'weekly'	Overall mark, examination, and ongoing assessment	Pearson's association correlations (i) were not significant: overall mark, 0.25 and -0.02; examination, 0.28 and 0.05; ongoing assessment, 0.19 and -0.19 in 2017 and 2018, respectively (ii) were not significant	Doggrell

Dental and medical students

There were no published studies relating to attendance at lectures and outcomes for dental and medical students from 1990-2002. From 2003 onwards, there have been 11 studies of the association between attending lectures in the human biosciences and academic outcomes with nine showing a positive relationship, and two studies showing no relationship between lecture attendance and academic outcomes (Table 5). Only two studies reported the availability of lecture recordings, with one of each showing an association and no association.

Positive relationship between lecture attendance and academic outcomes

Most of the nine studies showing a positive relationship between lecture attendance and academic outcomes (Table 5) had limitations. Some studies excluded students who did not attend tests (Khan et al., 2003) and/or had incomplete attendance data (Hamdi, 2006) and this may have skewed the results. One study had a small sample size (BinSaeed et al., 2009), and this may also have affected the results.

Correlation analysis is a good way to determine associations and was used in several (Hamdi, 2006; Jaykaran et al., 2011; Stegers-Jager et al., 2012; Demir et al., 2012; Al Khaja et al., 2019) but not all the studies (Khan et al., 2003; BinSaeed et al., 2009; Selvig et al., 2014; Popovic et al., 2018). Three studies showed moderate associations ((Hamdi, 2006; Jaykaran et al., 2011; Stegers-Jager et al., 2012), one study showed moderate to weak associations (Al Khaja et al., 2019) and one study showed a weak association between lecture attendance and academic outcomes (Demir et al., 2012). In addition, one of the studies using correlation analysis was able to show that the students had better outcomes for the lectures they attended than for the ones they skipped, and that this was true for both the first-time and repeat takers (Demir et al., 2017).

A recent study from Bahrain suggests that there is weak association between attendance at lectures amongst medical students in a pharmacology course integrated in their 2nd, 3rd and 4th years (Table 5). Overall, the association was very weak with an r value of 0.28 (Al Khaja et al., 2019). A complication of this study is that associations are described as weak when they are lower than 0.30, which is considered to be the cut-off for weak associations by some, but not others (https://www.dummies.com/education/math/statistics/how-to-interpret-a-correlation-coefficient-r/ and http://www.statstutor.ac.uk/resources/uploaded/pearsons.pdf. respectively).

In some of the studies not using correlation analysis, questions can be asked about their results. For instance, a 2014 USA study suggested that there was a significant difference between 'always' and 'rare' attendance, the cumulative histology marks were high and similar for both groups (90% vs 87%; Selvig et al., 2014).

Some of the studies used a lecture attendance register of some sort (Khan et al., 2003; Hamdi, 2006; Jaykaran et al., 2011; Demir et al., 2012; Popovic et al., 2018; Al Khaja et al., 2019) whereas others used self-reported/surveys of lecture attendance (BinSaeed et al., 2009; Stegers-Jager et al., 2012; Selvig et al., 2014). As one study failed to give the percentage of students who answered the survey (Selvig et al., 2014), it is not known whether the sample is likely to be representative. As self-reports/surveys can lead to recall bias (BinSaeed et al., 2009), it is probable that registers give a more accurate measure of attendance than self-reported/surveys of this.

Table 5: For dental and medical students studying the human biosciences, studies showing a positive association or no association between lecture attendance and academic outcomes

Year, country	Students, course	Attendance measure	Attendance outcome	Academic outcome measure	Association between attendance and outcome	Reference
Studies with a positive association						
2003, Pakistan	272 medical students in anatomy, physiology and biochemistry	Register	177 attended $\geq 75\%$ of the lectures	Term tests	Failure rates: 31% in those attending $< 75\%$ of lectures; 11% for those attending $\geq 75\%$ of the lectures; $P < 0.02$ Chi square test	Khan et al.
2006, Saudi Arabia	214 in medical pharmacology in 2 classes over 4 semesters	Sign-up at every lecture	Percentage absenteeism	Test scores	Correlation coefficients (r) ranged from -0.383 to -0.495 for the 4 cohorts	Hamdi
2009, Saudi Arabia	300 medical students	Questionnaire	251 responses	GPAs available for 172 students	Those with history of absenteeism had lower GPA (3.75) than those without (4.02): $p < 0.02$ by Chi-square test	BinSaeed et al.
2011, India	141 second year medical students studying pharmacology	Attendance register	Attendance at $< 70\%$ or $\geq 70\%$ of lectures	Cumulative marks for theory and practicals and preliminary exam	Marks were higher for those attending $\geq 70\%$ (122 marks) than $< 70\%$ (108): unpaired t-test, $P = 0.0067$ Pearson's correlation coefficient (r) = 0.578	Jaykaran et al.
2012, the Netherlands	410, 1st year medical students studying pathophysiological systems	Survey using Likert scale	74% responses	Grades	Pearson's correlation coefficient (r) = 0.34	Stegers-Jager et al.
2012, Turkey	235, 150 first time takers and 89 repeat takers in 2nd year medical students in physiology	Attendance chart	First-time takers, 53% vs repeat takers, 36%	Exam	For both cohorts, more correct answers from attended than skipped lectures, by Man-Whitney test. Spearman's correlation, r_s, was 0.251 for first-time takers ($P < 0.01$) and 0.223 for repeat takers ($P = 0.04$)	Demir et al.
2014, USA	170 medical students/year studying histology	Online survey for 3 years	Likert scale	Cumulative score	"Always" attended, 90% score was significantly higher by Tukey's B post hoc testing than "Moderate", 87% and "Rare" attendance, 87%	Selvig et al.
2018, Montenegro	91 medical students enrolled in physiology; 42 without lecture recordings	20% of mark for attendance and participation in lectures and practicals	70% responded	Formative and summative assessment	Combined percentage lecture attendance results for with and without lecture recordings: Formative test score, r = 0.67; Summative test score, r = 0.56	Popovic et al.
2019, Bahrain	2nd (177), 3rd (141) and 4th (152) year medical students studying pharmacology	Attendance register	2nd year attendance declined from 79 to 51%, 3rd year from 53 to 38%, 4th year from 33 to 22%	MCQ score in pharmacology	Mean score of pharmacology performance per percentage of students' attendance. Correlation coefficients ranged from 0.26 – 0.35 in 1st year, 0.31 – 0.49 in 2nd year, 0.31-0.44 in 3rd year, and was 0.28 overall	Al Khaja et al.
Studies with no association						
2012, West Indies	63 students in 1st-year Fundamental of Disease and Treatment	Sign-in sheets; pre- and post-attendance rule at 80% of lectures	Pre- attendance rule, 88%: Post rule, 94%	Unit score	Increased attendance not associated with increased unit score Pre-attendance rule: 56.4%: post-rule, 55.8%	Cohall & Skeete
2016, USA	190 dental students in basic science	Survey	146 students responded	Grades	Infectious diseases: attendance, 78%; mark, 83%; r = -0.15. Medicine II; attendance, 88%; mark 58%, r = -0.055. Epidemiology, 88%; mark, 95%, r = -0.007	Azab et al.

A 2018 study from Montenegro compared students with access to lecture recordings, and those without access, and showed no difference between groups in their association between lecture attendance and academic outcomes (Popovic et al., 2018). A major difference between this and other studies is that a component of marks was given to attendance, which may have contributed to the high attendance observed in this study and skewed the correlation analysis. Of these nine studies showing a positive relationship between lecture attendance and academic outcomes, seven did not indicate whether lecture recordings were available (Khan et al., 2003; Hamdi, 2006; BinSaeed et al., 2009; Jaykaran et al., 2011; Stegers-Jager et al., 2012; Demir et al., 2014; Al Khaja et al., 2019) and two reported the availability of lecture recordings (Selvig et al., 2014; Popovic et al., 2018).

No association between lecture attendance and academic outcomes

A 2012 study from the University of the West Indies, that did not show an association between lecture attendances and outcomes, acknowledged that the high baseline of 88% attendance may have limited the likelihood of observing improved outcomes by increasing attendance (Cohall & Skeete, 2012).

A 2016 United States study evaluating the attendance of second-year dental students, was unable to show any association with grades (Azab et al., 2016). A limitation to this study, discussed by the authors, is that attendance was self-reported based on recall, and may be an overestimate. A major limitation to this study was that attendance was high for all subjects, making it difficult to discriminate between levels of attendance using regression analysis.

Of these two studies showing a negative relationship between lecture attendance and academic outcomes, one did not indicate whether lecture recordings were available ((Cohall & Skeete, 2012) and one did (Azab et al., 2016).

Combining the results

Percentage of courses showing associations

For 25 of the 32 courses studied (75%), there was a significant positive association between attending lectures and academic outcomes for students studying the human biosciences, whereas eight did not show an association (25%). The positive association occurred in 72% of undergraduate courses for allied health students and science students and 82% of courses for dental and medical students, who are predominantly postgraduate students. As the Odds ratio was not significantly different for the association between the results for allied health/science students versus dental/medical students, the association is considered similar. Thus, there is reasonable evidence supporting continuing with face-to-face lectures for both undergraduate and postgraduate students and encouraging them to attend lectures in the human biosciences. However, as noted in several papers, there is no consistency in the relationship between lecture attendance and academic outcomes, as some students who missed lectures due to illness or sports did well, but others that attended every lecture did not (Hamen & Kelland, 1994) and some students who attend class regularly have poor grades (Moore et al., 2003).

It is not known whether the findings with students studying human bioscience courses extend to other courses they may be undertaking. Thus, one of the nursing studies, showing a positive association between lecture attendance and academic outcomes for pathotherapeutics, was

unable to show such a correlation for four nursing theory courses and one of two health assessment courses (Brown et al., 1999).

Prior to the general availability of lecture recordings, when textbooks and practicals were the main source of material, other than lectures, it was considered that it was the repeated and extensive contact with information in lectures, which led to the improved academic outcomes with lecture attendance (Credé et al., 2010). As discussed in many of the papers in the present review, from their studies, it is impossible to state whether regular attendance was associated with slightly higher scores or whether the better students simply chose to attend class more frequently. However, it is possible that attending lectures per se, is a factor in determining academic outcomes. In the multi-disciplinary meta-analysis by Credé et al. (2010), they showed that taking Grade Point Average into consideration reduced the strength of the association between lecture attendance and academic outcomes for 9,243 students in 33 studies, however it did not fully explain the association, and an association remained (Credé et al., 2010).

Further discussion of studies not showing an association between attending lectures and academic outcomes

For the allied health and science students, there were three studies not showing an association between attending lectures and academic outcomes (Hidayat et al., 2012; Davis et al., 2012; Doggrell, 2020). Two of these studies found no association in some, but not all the courses investigated (Hidayat et al., 2012; Davis et al., 2012). Thus, Hidayat et al. (2012), showed there was an association between lecture attendance and academic outcomes for the pharmacy students in their therapeutics course, but not in their biomedical sciences course (Hidayat et al., 2012). A limitation to this study was not having a range of attendance levels to use in the analysis of the association between lecture attendance and academic outcomes. The other study not showing an association between lecture attendance and academic outcomes for all the courses studied was for three out of four courses (Davis et al., 2012). However, it should be noted that the study was unusual, in that some students had timetable clashes with other lectures or practicals, and this was the main reason for non-attendance at lectures (Davis et al., 2012). For dental and medical students, there were also two studies not showing an association between lecture attendance and academic outcomes. Both studies had high attendance (Cohall & Skeete, 2012; Azab et al., 2016), which makes it difficult to discriminate between levels of attendance and academic outcomes.

Effect of the availability of lecture recordings on the relationship between lecture attendance and academic outcomes

Previous studies have considered the effect of the availability of lecture recordings on academic outcomes, but few have considered the interaction between the availability of lecture recordings, in addition to face-to-face lectures, and academic outcomes for human bioscience students or other students. These existing studies have given mixed results as to whether the use of lecture recordings alone improves academic outcomes. One study in a human bioscience course showed that the use of lecture recordings was associated with better outcomes for those that viewed more online lectures (Guy et al., 2018). Most studies of other students studying the biosciences have showed no association between use of lecture recordings and grades/attainment (Bollmeir et al., 2010; Barco et al., 2011; Franklin et al., 2011; Leadbeater et al., 2013; Azab et al., 2016; Edwards & Clinton, 2019; Doggrell, 2020). Other studies have shown that accessing lecture recordings was negatively associated with academic performance

(nursing students, Johnston et al., 2013; biology students, Simcock et al., 2017; medical students, McNulty et al., 2019; biomedical science students, Doggrell, 2019).

One of the aims of this study was to investigate whether the availability of lecture recordings affected the association between lecture attendance and academic outcomes for students of the human biosciences. For the students studying the human biosciences, five of the seven studies reporting the availability of lecture recordings showed a positive association between lecture attendance and academic outcomes in seven courses (Fernandes et al., 2008; Soto & Anand, 2009; Horton et al., 2012; 3rd-year pharmacology, Davis et al., 2012; bioscience and pharmacology, Doggrell, 2018; Doggrell, 2019) but not in five courses in two studies (three courses in Davis et al., 2012; Hidayat et al. 2012; Doggrell, 2020). Three of the 10 studies of medical and dental students reported the use of lecture recordings, and one reported no association (Azab et al., 2016), and two reported an association between lecture attendance and academic outcomes (Selvig et al., 2014; Popovic et al., 2018). Thus, for the 16 courses with lecture recordings available, eleven (69%) did show and five did not show (31%) an association between lecture attendance and academic outcomes. In comparison, for the 16 studies not reporting the availability of lecture recordings, 13 did show (81%) and three did not show (19%) an association between lecture attendance and academic outcomes. As the Odds ratio was not significantly different for the percentages with an association in the absence and presence of lecture recordings, the association is considered similar. Thus, there is no definitive evidence that the availability of lecture recordings alters the relationship between lecture attendance and academic outcomes.

Only one study considered the interaction of lecture recording with lecture attendance and academic outcomes. This study showed that the availability of lecture recordings was associated with a decrease in lecture attendance and an increase in failure rates (Fernandes et al., 2008).

Conclusions

In concluding, most studies have shown a positive association between lecture attendance and academic outcomes, and this is evidence supporting continuing with face-to-face lectures for students in the human biosciences and encouraging students to attend lectures.

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