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Abstract

Anatomy and physiology (AP) are subfields of biology that are gatekeeper courses for the health professions. This exploratory study used multilevel binary logistic regression to determine if age/gender and race/ethnicity were used as predictors of success, while the term offered and the identification number were specified as random effects. Two models were used. Those earning the grades of A, B and C were defined as successful for both models. Those earning the grades of D and F and those who withdrew (W) were defined as successful for one model, while the other model had the withdrawals removed. Ethnicity and gender predicted success in both models, with Native Americans and African Americans being less likely to succeed than Caucasians with the withdrawn students included. The model without withdrawn students was similar, except Hispanic students were also less likely to succeed than Caucasians. Females were more likely to succeed than males in both models. Efforts to retain equity in AP pedagogy should be prioritized.

Introduction

Much literature exists to support ethnic disparities and disproportionate representation in STEM (Science, Technology, Engineering, and Mathematics) fields at collegiate and professional levels. The American Psychological Association (APA) reports that ethnic disparities exist in academic achievement in which African Americans, Hispanics/Latinos, Native Americans, and Southeast Asians consistently underperform compared to Caucasians and other Asian ethnic groups (2020), disparities that mirror those in socioeconomic status (SES) and healthcare (APA, 2020). The report goes on to outline that such disparities are evident during the K-12 education years, and are reflected in such benchmarks as: reading and mathematics scores, and rates of disciplinary action, suspension, expulsion, graduation and dropout (APA, 2018). This is important as performance in high school STEM classes have been shown to predict success in postsecondary STEM performance (Redmond-Sanogo, Angle, & Davis, 2016).

Stereotype threat is defined as the anxiety experienced by stigmatized groups that their behavior may confirm negative stereotypes (academic performance in this context), and has been implicated in the under-representation of minorities in STEM fields (Beasley & Fischer, 2012; Smedley, Myers & Harrell, 1993). Such anxiety may be explained by the experience of negative stereotypes of minorities as being intellectually inferior (Beasley & Fischer, 2012; Smedley, Myers & Harrell, 1993; Torres & Charles, 2004). Negative stereotypes of STEM performance also exist for girls and women, which adversely affect their career interests resulting in a "leaky pipeline" (King, 2016). It has been demonstrated that women tend to be better at solving problems in homogenous (i.e., women only) than in groups with men present (Inzlicht & Ben-Zeev, 2000), and the interaction of ethnicity and gender has also been shown to increase stereotype threat in women of African American, Asian, and Hispanic women (Beasley & Fischer, 2012). Hence, perception of one's ability to succeed is affected by the perceived lens of dominant social groups, and can have adverse effects on academic outcomes. As the course analyzed in the present study is a second-year course, minority students hypothetically face the aforementioned challenges in addition to the academic, developmental, and existential challenges unique to sophomores (Lemons & Richmond, 1987).

Academic performance in biology tends to be an exception to the leaky pipeline phenomenon, where disparities have been reported to be closing (Luckenbill-Edds, 2002). Anatomy and physiology (AP) are subfields of biology that are unique in that they provide prerequisite knowledge for applied health science fields, such as kinesiology, nursing, nutrition, and other health science disciplines. Age has been investigated as a predictor of success in nursing courses, with more 'mature' students performing better than their younger counterparts (El Ansari, 2002; van Rooyen, Dixon, Dixon, & Wells, 2006). This provides a rationale for age as a predictor of

success, as anatomy and physiology (AP) are gatekeeper courses for nursing. Performance in AP has been shown to determine success in such fields as nursing (Brown, White & Power, 2017), and female students have been reported to perform better than males for AP in at least one study (Anderton, Evers & Chivers, 2016). Hence, the latter study appears to be an exception to the disadvantageous trend of stereotype threat experienced by women in STEM disciplines. In summary, as performance in AP has a downstream effect on acceptance into health science disciplines, administrative and teaching stakeholders should identify those who may be at higher risk of failure or withdrawal in order to address necessary interventions. This in turn ensures the maintenance of a diverse workforce in health professions in the region, which is crucial for maintaining quality of health care for underserved populations (Cohen, Gabriel & Terrell, 2002).

Objective

The objective of this study was to determine what demographics predict success in anatomy and physiology 1 (AP1). This course covered terminology in anatomy, cells, tissues, as well as the integumentary, muscular, nervous and skeletal systems. The predictors were age, gender, and ethnicity/race. As some students repeated the course, participant ID number was specified as a random effect. The term offered was also specified as a random effect, as performance of students within a semester could potentially be correlated, for example by being taught by the same instructor, or any other situations unique to that semester.

The outcome was the binary variable of success. The grades of A, B, and C were defined as successful, and the grades of D, F, and W (withdrawal) were defined as unsuccessful. While students withdraw for different reasons, students often do it to avoid the grades of D and F (Congos & Schoeps, 1993) and it is considered to be an adverse outcome for several reasons. For example, withdrawal may delay the graduation timeline of the withdrawing student (Nicholls & Gaede, 2014). Withdrawal can be costly to the institution, and also to other potential students, due to improper allocation of classroom spaces. However, the data was also analyzed with the withdrawals removed from the unsuccessful group in order to compare the results of both models.

The institution from which the data were obtained is in the United States, and is reported to have a student body with the following demographics: 66% Caucasian, 17% Hispanics, with African Americans, Asians, and others comprising the remaining 17%. The institution is also reported to be 51% female, and 49% male, and is regarded to have a more diverse demographic than its host city. With the exception of gender, course demographics appear to be comparable to those of the institution. Descriptive statistics are found in Table 1.

Table 1. Descriptives

Variable	Predictors/Outcome	Levels	n	% of Total
Age	Level 1 Predictor	17-25	1671	84.1%
		25-30	167	8.4%
		Older than 30	148	7.5%
Gender	Level 1 Predictor	Female	1520	76.5%
		Male	466	23.5%
Race/Ethnicity	Level 1 Predictor	Asian	127	6.4%
		African American	98	4.9%
		Caucasian	1364	68.7%
		Hispanic	310	15.6%
		Native American	54	2.7%
		Pacific Islander	33	1.7%
Term Offered	Contextual variable	Fall 2012	417	21%
		Fall 2013	379	19.1%
		Fall 2014	311	15.7%
		Summer 2014	18	0.9%
		Fall 2015	292	14.7%
		Spring 2015	107	5.4%
		Summer 2015	41	2.1%
		Fall 2016	254	12.7%
		Spring 2016	135	6.8%
		Summer 2016	32	1.6%
Success	Outcome	Success	1378	69.4%
		Unsuccessful (Failure)	261	13.1%
		Unsuccessful (Withdrawal)	347	17.5%

Data Retrieval

This study was approved by the local Institutional Review Board in compliance with the declaration of Helsinki. The data were cleaned and analyzed using R version 3.4.1 (R Core Team, 2017). This dataset was blinded and participants were assigned fake identification (ID) numbers by the institution's Office of Data Management before being sent to the researcher. Initially, there appeared to be 3,284 participants in this dataset. However, upon visual inspection of the identification numbers and other demographics, many of the cases appeared to be redundant during the same semester. The *unique* function (R Core Team, 2017) of the *base* package was then used on the identification column to find the overall number unique participants for descriptive purposes. Students that repeated the course were retained for analysis in all semesters, and hence 1,986 attendances were analyzed. The rationale for this decision is because many students that withdrew retook the class (sometimes more than once), and were successful. Upon cleaning the dataset, there were 1,815 cases (students) with the withdrawals included, and 1,578 cases with the withdrawals removed (see Table 1). Using the *describe* function from the *psych* package (Revelle, 2017), it was found that there were 171 students who repeated the class over the ten-semester period in the dataset that included the students that withdrew, and 61 who repeated the class when the withdrawals were removed. Tables 1 and 2 retain all 1,986 attendances across multiple semesters, as the statistical method does not rely on independence of observations as an assumption. This is addressed in the following section.

Method

The statistical method used to analyze the data was multilevel binary logistic regression, with Caucasian males aged 18-25 years old used as the baseline demographic. The multilevel method is suitable for the nested nature of the data, where performance of students in a particular semester could be correlated for several reasons. As aforementioned, there were students that failed or withdrew, who took the class at subsequent semesters. This therefore violates the assumption of the independence of observations, to which a multilevel statistical method is robust (Field, Miles & Field, 2012). The semester and ID number were therefore specified as random effects. The multilevel binomial logistic regression was used via the *glmer* function in the *lme4* package (Bates, Maecheler, Bolker, & Walker 2015). In order to determine which demographic variables predicted success, a total of six models were created. A model was created using random intercepts for the ID number and the semesters in which they were taught. The following were then added to create four other models: ethnicity, gender, the interaction between ethnicity and gender, and age. The *anova* function in the base package was then used to compare all models (R Core Team, 2017), and the *confint* function from the base package was used to acquire confidence intervals for the final viable model (see Results below). The *icc* function in the *sjstats* package (Ludecke, 2018) was used to acquire the intraclass correlation (ICC) for the final model, and an effect size was obtained using the *r.squaredGLMM* function from the *MuMIn* package (Barton, 2018). This process was completed with the withdrawals included, as well as with withdrawals removed.

Results

In this study, a multilevel statistical method was used to analyze the data, because students were nested in different semesters. Additionally, students that withdrew attempted the class in subsequent semesters, thereby violating the assumption of the independence of observations. Based on Table 3, the ICC of the random effect of the semester in this study were not equal to zero, indicating that this hypothesis was true. Although students retook the class on subsequent semesters, those that repeated did not have an effect, as the ICC for the random effect of the ID number was 0. Marginal pseudo R^2 was .03 for both models, suggesting that ethnicity and gender had a small-to-medium effect on success. Conditional pseudo R^2 describes variance explained by both fixed and random (i.e., semester) effects (Barton, 2018), and was at least .13, underscoring the effect that the semester had on success.

The null hypothesis of the effect of ethnicity and gender on success was rejected when withdrawals were included. The model did not improve when the ethnicity/gender interaction and age were included. These results are summarized in Tables 3 and 4. The null hypothesis of the effect of ethnicity and gender was also rejected when the withdrawals were removed. This model did not improve when the ethnicity and gender interaction, and age were added. These results are also summarized in Tables 3 and 4. Table 2 is included for the convenience of the reader, and includes only predictors that rejected the null hypotheses (i.e., were statistically significant) for both models.

Table 2. Aggregated Descriptives

Ethnicity	Gender	Success	Failure	Withdrawal	TOTAL
Caucasian	Male	212	48	44	304
Native American		8	3	2	13
Asian		20	5	3	28
African American		13	9	5	27
Hispanic		58	12	15	85
Pacific Islander		5	3	1	9
TOTAL		316	80	70	466
Caucasian	Female	769	112	179	1060
Native American		22	10	9	41
Asian		67	13	19	99
African American		45	10	16	71
Hispanic		145	32	48	225
Pacific Islander		14	4	6	24
TOTAL		1062	181	277	1520

Discussion

The objective of this study was to determine if race/ethnicity, gender, and age predicted success in an anatomy & physiology course. Results were more or less consistent whether or not withdrawals were included. Congruent with literature in STEM education research, ethnicity predicted success in this AP course. As previously stated, Caucasian males aged 18-25 were used as the baseline group. Native Americans were less than half as likely to succeed, and African Americans were half as likely to succeed, with or without the students that withdrew. The model comparisons are reported below in Table 3.

Table 3. Model Comparisons

Model	DF	AIC	BIC	LL	Deviance	Chisq	Chi DF	ICC
With withdrawn students								
ID Number	2	1141.5	1152.7	-568.74	1137.5			0
Semester	3	1518.1	1534.9	-756.1	1512.1	0	1	.1
E**	8	1512.7	1557.5	-748.4	1496.7	15.4	5	
E + G**	9	1506	1556.4	-744	1488	8.7	1	
E + G + E x G	14	1513.5	1591.8	-742.8	1485.5	2.5	5	
E + G + E x G + A	16	1516.7	1606.2	-742.4	1484.7	0.8	2	
Without withdrawn students								
ID Number	2	1049.4	1060.2	-522.7	1045.4			0
Semester	3	1404.6	1420.8	-699.3	1398.6	0	1	.12
E**	8	1394.4	1437.6	-689.2	1378.4	20.2	5	
E + G**	9	1389.5	1438.1	-685.7	1371.5	6.9	1	
E + G + E x G	14	1396.9	1472.5	-684.5	1368.9	2.6	5	
E + G + E x G + A	16	1399.8	1486.2	-683.9	1367.8	1.1	2	

Note: E = Ethnicity, G = Gender, A = Age, DF = degrees of freedom; AIC = Akaike's Information Criterion; BIC = Bayesian Information Criterion; LL = Log Likelihood; Chisq = Chi square; Chi DF = Chi square degrees of freedom; ICC = interclass correlation; $^{**}p < .01$.

The only difference between the models was that Hispanics were 70% as likely to succeed as their Caucasian counterparts in the model without withdrawals (see odds ratio and 95% confidence intervals in Table 4), whereas there were no differences in the model with withdrawals. This is congruent with previous research that has found ethnic disparities in similar settings (Beasley & Fischer, 2012; National Science Foundation, 2017). The marginal pseudo R^2 represents the variance explained by the fixed factors in this study (i.e., ethnicity for the model with students that withdrew, and ethnicity and gender for the model without those students; Barton, 2018). Where the effect size (i.e., marginal pseudo R^2) is concerned, the reader is urged to make note of the practical significance of these findings. Even though several groups were less likely to succeed than their Caucasian counterparts, this small effect as well as the confidence intervals (Table 4) would suggest that those groups are not too different from their Caucasian counterparts in terms of success; this is especially reflected

with the bivalence of the Hispanic students' outcomes between the two models. However from a face value standpoint, Table 2 shows that almost half of female Native American attendances, and more than half of male African American attendances either withdrew or failed. Such findings are critical not only for AP1 as STEM course, but its status as a gatekeeper course for the health professions. Enrollment and success in such courses have profound downstream social outcomes, as equitable ethnic and cultural representation is crucial in the American healthcare professions. Such diversity lends itself to improving a culturally competent healthcare workforce, access to underserved populations, widen the healthcare research agenda, and diversify related professions, such as health administration and policy (Cohen, Gabriel & Terrell, 2002).

Table 4. Summary Table

	Exp(B)	95% CI	Marginal Pseudo R^2	Conditional Pseudo R^2
With withdrawn students				
Intercept			.03	.13
Native American**	0.3	0.2 – 0.7		
Asian	0.8	0.5 – 1.4		
African American*	0.5	0.3 – 1		
Hispanic	0.7	0.5 – 1.1		
Pacific Islander	0.5	0.2 – 1.3		
Female**	1.6	1.2 – 2.1		
Without withdrawn students				
Intercept	7.1	4.2 - 13.8	.03	.16
Native American***	0.3	0.1 - 0.6		
Asian	0.8	0.4 - 1.3		
African American**	0.5	0.3 - 0.9		
Hispanic**	0.7	0.5 - 1.0		
Pacific Islander	0.5	0.2 - 1.2		
Female**	1.5	1.1 - 2.1		

*p < .05; **p < .01; ***p < .001.

Women were 1.5 times as likely to succeed, concordant with the findings of Anderton and colleagues (2016). In this sample, the number of women was more than three times the number of men. Although the reasons for this outcome are unknown, possible explanations could include a reduction of stereotype threat for female students; this seems viable given the campus demographics. Whether male students experience stereotype threat is another possibility that may be explored. Eighteen percent of women withdrew from the course, while 15% of men withdrew. However, relative to failure, there was a higher percentage of women that withdrew, when compared to men (see Table 2). Intuitively, it would appear that women prefer to withdraw rather than fail the course, but this is an assumption at best. As the reasons for these findings are currently unknown, more research should be done to ascertain the experiences of women and men in similar classroom settings. Finally, the present findings contradicted those of previous studies that found a difference in age (El Ansari, 2002; van Rooyen, Dixon, Dixon, & Wells, 2006), as it was not a predicting factor in the present study.

Suggestions to Improve Equity in the Anatomy and Physiology Learning Space

The institution is a vital component of this process as they may be able to guide students and instructors to information and resources. Gregg-Jolly and colleagues (2016) reported that sophomore STEM students respond favorably to a campus culture of open communication and social support in a liberal arts college setting. Contributions to this culture included supportive relationships with faculty and advisors, peer mentorship, clear class expectations, a second-year retreat, and the role of a science center as an informal hub for peer interaction and mentorship. In summary, students in AP should perform favorably on a student-centered campus where collegiality, open communication, and sharing of ideas thrive in a STEM context.

Additionally, methods such as supplemental instruction (SI) have been effective with improving student outcomes. Benefits of SI include its proactive nature and facilitate socialization amongst students of varying abilities and backgrounds (Hurley, Jacobs & Gilbert, 2006). However, SI requires personnel to be trained and can be expensive (Dawson, van der Meer, Skalicky & Cowley, 2014), but concepts that make SI successful, such as peer mentoring may be incorporated into the classroom by creative instructors. The institution can promote success in AP by implementing training programs geared toward effective pedagogy.

Tanner (2013) provides excellent commentary concerning strategies that instructors may employ in order to create an inclusive environment for all students. For example, instructors will include communication at the beginning of a course that conveys equitable treatment and access to information for all students. For example, learning names conveys a welcoming learning environment to all students, as does the incorporation of culturally diverse and relevant examples where appropriate (Tanner, 2013). Discussion of historic and contemporary scholars, and their contributions to the theory and application of anatomy and physiology is one method to demonstrate the diversity of contributors to these fields of science. Such examples provide contexts to students of underrepresented groups that the contributors to science are a diverse group of people.

Instructors may also incorporate the use of several strategies of learning for students, such as active learning, watching videos, drawing diagrams, reflective writing, and discussion (Tanner, 2013). In other words, the class should be structured in such a way to allow multiple methods of access to course content in order to accommodate diverse learning styles. For example, Freeman and colleagues (2007) have found success in introductory biology using varied active learning strategies, including clickers, cards, and study groups (i.e., peer mentoring). Process-oriented guided-inquiry learning (POGIL) has been shown to be effective at improving learning outcomes and student satisfaction (Brown, 2010), and incorporates several of the aforementioned strategies. Hence, the instructor is advised to apply humanistic socializing and teaching principles, in addition to providing multiple active learning pathways for students to learn AP course content.

Limitations and Considerations for Future Research

There are several limitations of this study. Firstly, this study was exploratory, that used an archival dataset and was not an experimental design. Cases with missing demographic data were removed from the analysis, which could potentially affect the outcomes of this study. There is poor generalizability of these findings, as the data was retrieved from one institution.

Although results are congruent with similar studies in terms of ethnicity, one major finding of this study is that women were as likely to succeed when the withdrawals were included and 1.5 times as likely to succeed when the withdrawals were removed. While this is congruent with the findings of Anderton and colleagues (2016), further studies of this type should be done to confirm the veracity of these findings. Additionally, qualitative methods using interviews or focus groups could be invaluable to lending insight into the experiences of students in STEM classes with a majority of women. Opportunities to examine stereotype threat and the 'sophomore slump', their potential interactions, and other unforeseen factors should be explored.

Conclusion

In this study, ethnicity and gender predicted success in AP regardless if withdrawals students were retained or removed from the predictive model. Native American and African American students were less likely to succeed than Caucasian students, whereas Asians and Pacific Islanders were equally as likely to succeed. Hispanic students were less likely to succeed with the withdrawals removed, but just as likely with inclusion of withdrawals. Women were more likely to succeed in AP than men. Although there are indications that ethnicity and gender had no more than a medium effect upon success, efforts to improve equity within AP classrooms remain critical.

Recommendations

Although there are indications that ethnicity and gender had no more than a medium effect upon success, efforts to improve equity within AP classrooms remain critical.

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