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RESEARCH ARTICLES

A Meta-Analysis of the Validity of the Pharmacy College Admission Test (PCAT) and Grade Predictors of Pharmacy Student Performance

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Objectives. Compare the validity of the Pharmacy College Admission Test (PCAT) and prepharmacy grade point average (GPA) in predicting performance in pharmacy school and professional licensing examinations.

Methods. To quantitatively aggregate results across previous studies of the validity of the PCAT, the Hunter and Schmidt psychometric meta-analytic method was used. Relevant research articles were gathered from multiple databases. Correlations between the PCAT and GPAs or individual course grades were the most commonly presented data.

Results. The PCAT and prepharmacy GPA were positively correlated with first, second, and third year GPA and National Association of Boards of Pharmacy Licensure Examination (NABPLEX) scores, with validities ranging from 0.25 (N=244; k=3) to 0.51 (N=1,454, k=18) for first-year GPA.

Conclusion. Both PCAT scores and prepharmacy GPA were moderate to strong predictors of grades earned in pharmacy programs and scores on licensing examinations. Development of additional predictors may improve the accuracy of admissions decisions.

Keywords: Pharmacy College Admission Test (PCAT), National Association of Boards of Pharmacy Licensure Examination (NABPLEX), admission, grade point average (GPA), performance

INTRODUCTION

There are currently 89 pharmacy programs in the United States, and each is confronted with evaluating a large number of applicants each year. Given the importance of producing effective professionals for the health and wellbeing of the public, selecting top-quality students who will master their training is of critical importance. The Pharmacy College Admission Test (PCAT) is a standardized test used by pharmacy programs to select students. The PCAT is considered by most pharmacy programs and in 2003 was required by 51 pharmacy programs as a piece of information for making admissions decisions.[1]

The PCAT has been used since 1974 but not without controversy. Opinions are mixed about its effectiveness. Some scholars have variously argued either in favor of or against the use of the PCAT.[2] Positions against the PCAT run counter to the stance of the American Association of Colleges of Pharmacy (AACP) which endorses the use of PCAT scores as a part of pharmacy admissions decisions.[3] This mix of opinions is understandable given the range of validity study findings reported in the literature. Correlations between PCAT scores and GPA have ranged from a low of $r = -0.09$[4] to a high of $r = 0.68$.[4] Unfortunately, many of the validity studies have employed small samples from programs with highly selective admissions policies. Of critical importance is the predictive validity of the PCAT, the validity of alternative predictors (ie, prepharmacy grades and the SAT), and the investigation of the sources of correlation variability across studies. Addressing all of these issues is the objective of this study.

The PCAT was first used on a national level in 1975.[5] In the fall of 2004, some of its content and structure was altered. The PCAT now includes an essay portion. The verbal section now contains sentence completion items and no longer specifically tests one's knowledge of antonyms. The biology section now includes items intended to assess knowledge of microbiology, and the quantitative section now includes precalculus and calculus. The number of verbal, biology, and reading comprehension items has been increased while the quantitative and chemistry sections have been reduced. Overall, the total number of multiple-choice items has decreased from approximately 300 multiple-choice items to 280.

These changes notwithstanding, the PCAT continues to be a measure of ability and knowledge with multiple-choice items spread across the following 5 domains: ver-

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bal, quantitative, biology, chemistry, and reading comprehension. The PCAT yields individual scale scores and can be used to generate an overall score. Other standardized admission tests have experienced similar changes without a significant decrement in predictive validity. Furthermore, the predictive validity of the former version of the PCAT provides a valuable point of comparison for the predictive validity of the current version. The primary purpose of pharmacy programs is to train students to acquire the necessary knowledge and skills to practice as pharmacists. The most visible measure of student performance is the direct demonstration of recently acquired knowledge and skills through performance on examinations, papers, and presentations, and in practice (eg, clerkships). One reasonable measure of this knowledge is grades obtained in pharmacy programs. The PCAT is specifically designed to measure abilities necessary to complete the content of pharmacy programs and, in addition to the more traditional verbal and quantitative content, contains content that covers biology, chemistry, and scientific reading passages. Another measure of knowledge is successful performance on the North American Pharmacist Licensure Examination (NAPLEX), formerly known as the National Association of Boards of Pharmacy Licensure Examination (NABPLEX). Passing this examination is a prerequisite to practicing as a pharmacist. Although the 2 licensing examinations differ substantially, we include analyses of performance on the NABPLEX because it does provide information about the extent to which the PCAT predicts subsequent performance on a measure of acquired knowledge in the domain of pharmacy. Since the key index of performance is the acquisition of knowledge and skill, we would expect the PCAT to be a valid predictor of performance across all programs and measures of knowledge acquisition. This hypothesis is based on considerable prior research that has demonstrated the relationship between measures of cognitive ability (eg, Miller Analogies Test [MAT], General Aptitude Test Battery [GATB], Graduate Record Examination [GRE], Wonderlic, Graduate Management Admission Test [GMAT]) and learning, both in work and educational settings.

There is considerable direct evidence that standardized tests predict important graduate-level educational outcomes. Previous large-scale meta-analyses have demonstrated that the GRE,[6] Law School Admission Test (LSAT),[7] MAT,[8] and Medical College Admission Test (MCAT)[9] are all valid predictors of student performance in graduate or professional school. Some of these studies have demonstrated that the tests are also predictive of important criteria in addition to grades, such as degree attainment, faculty ratings, research productivity, number of citations after the attainment of a PhD, job performance, evaluations of creativity, and evaluations of career potential.[6,8] On the basis of these studies alone, expecting that the PCAT would be a valid predictor of student performance would be reasonable.

There is considerable evidence that cognitive ability measures predict knowledge and skill acquisition.[10-12] These findings are directly relevant to pharmacy education since the objective of a pharmacy program is to teach knowledge and skill. Similarly, a vast amount of empirical evidence demonstrates that measures of cognitive ability predict success in formal training programs across a range of occupations.[13-15] These findings are important for 2 reasons. First, educational settings are formal training programs. Second, the later phase of many pharmacy programs is, effectively, on-the-job training in an internship setting.

Overall, the results are expected to indicate that the PCAT is a valid predictor of classroom performance as well as performance on the pharmacy professional licensing examination (NABPLEX). We also expect that much of the observed variability will be attributable to sampling error across studies. Care was taken to ensure that each analysis was based on independent samples. Analyses were conducted for the following academic performance criteria: pharmacy grade point average for the first, second, and third year of pharmacy school; performance in a course (biochemistry, physiology, organic pharmaceutical chemistry, law, orientation to disease states, physical pharmacy, pharmaceutics, pharmacokinetics, drug literature, pharmacology, clinical pharmacy, pharmacotherapeutics, pharmacy health care, pharmaceutical sciences, management and behavioral sciences, and a grade in an unspecified third-year class) and performance on 5 subscales from the pharmacy professional licensing examination (NABPLEX).

METHODS

Creation of the Meta-Analytic Database

We gathered studies involving prediction of pharmacy school performance by the PCAT from several sources. To identify relevant research, *PsychINFO* (1887-2003), *International Pharmaceutical Abstracts* (*IPA*) (1970-2004), and *ERIC* (Education Research Information Center, 1966-2003) database searches were combined with a search of *Dissertation Abstracts International* (1861-2002) and *Medline* (1966-2003) using the search terms "PCAT" and "Pharmacy College Admission Test." The citation lists within all articles, dissertations, and technical reports were also examined

to identify additional relevant studies. Unreported effect sizes were computed from available information when possible. Since electronic database searches can miss relevant articles, we also hand searched the *American Journal of Pharmaceutical Education*, *Journal of Pharmacy Teaching*, and *Educational and Psychological Measurement* for additional articles that included PCAT validity information. When a study appeared to be relevant but did not contain enough information, the lead author was contacted and the needed information was requested. The data examined in this study were taken from 20 studies.[4,16-34]

Data Coding and Analysis

To quantitatively aggregate results across previous studies of the validity of the PCAT, we utilized the Hunter and Schmidt psychometric meta-analytic method.[35] Meta-analysis is a particularly powerful method for clarifying research in an area. By statistically aggregating research on a topic, it increases the amount of information that can be brought to bear on a single question. To summarize the literature, we began by computing the average, sample-size weighted correlation across all studies (r_{obs}). For each estimate, the corresponding standard deviation of the observed correlations was also calculated (SD_{obs}). Selection of students on the basis of a predictor (eg, PCAT, prepharmacy GPA) results in restriction of range, which in turn attenuates estimates of predictive validity. To address this issue of restriction of range, corrections are often employed. The most basic of these requires estimates of test score standard deviations for applicants and admitted students. Unfortunately, almost no sample standard deviations were reported in the primary studies. An alternative to SD-based corrections for restriction of range would be to utilize selection ratios for specific schools at each point in time.[36] However, this is likely to result in overcorrection, as many of the assumptions do not hold in applied settings (eg, true top-down selection). Although doing so almost certainly resulted in underestimating PCAT validity, the decision was made not to correct for restriction of range as the alternatives would have either been misleading or based on minimal information. As such, the estimates provided here are likely to be underestimates of the actual relationship.

Corrections for criterion unreliability were made for grades, however. These were based on internal consistency estimates of grade reliability.[37-39] Since NABPLEX licensing examination scores resulted in important real-world outcomes that are based on an imperfectly reliable measure, no corrections were made for the unreliability in the NABPLEX.

Correcting the sample-size weighted-mean observed correlation and the standard deviation of observed correlations results in more accurate estimates of the relationship between 2 variables and permits evaluation of whether the variability in observed correlations is due to systematic biases or reflects the existence of substantive moderators. Furthermore, correcting the SD of observed correlations for the often massive differences in sample sizes across studies yields a more accurate estimate of whether the differences observed in the literature are merely the result of sampling error.

The standard deviation of true validity (SD_ρ) is also used to compute the 90% credibility interval, which is used as an indicator of the likelihood that the true relationship generalizes across situations. Credibility intervals are specific to meta-analysis. Unlike confidence intervals, which examine the extent to which a finding may be due to sampling error, credibility intervals are a test of moderator effects across samples and situations. In other words, a good question is whether the differences in the observed correlations are due to real moderator effects or simply to sampling error and other statistical artifacts. The credibility interval is an estimate of the range of real differences after accounting for the fact that sampling error may be due to some of the observed differences. If the lower 90% credibility value is greater than zero, one can have some confidence that a relationship generalizes across those situations examined in the study.[35] In our meta analysis, if the lower bound of the 90% credibility interval is greater than zero, but there is variance in the correlations after corrections, it can be concluded that the relationships of the PCAT with other variables are positive across situations, although the actual magnitude may vary somewhat across settings. However, the remaining variability may also be due to uncorrected statistical artifacts (eg, differential restriction of range), other methodological differences, and unidentified moderators. This point is of particular importance in this study since much of the remaining variability may be due to unexamined artifacts.

In articles with sample overlaps, the larger or more complete data were included in the meta-analysis, and the matching articles were excluded. When grades for a set of individual classes were reported as a criterion measure, correlations were averaged across courses or ratings. For the class grade criterion, validities were aggregated across different types of specific classes. This combining was done because there were not sufficient data to examine all of the different types of classes separately. This analysis provides an estimate of the typical validity one would obtain from the PCAT for predicting performance in any given class in a pharmacy program.

Although the reliability of coded meta-analytic data is generally high,[6,40-41] steps were taken to ensure the accuracy of the coding. First, all article coding and data entry done by one author was checked by a second coder. Second, the first author examined a random sample of 5 articles for accuracy. Sorting of data for inclusion in each meta-analysis was based on the consensus of the authors. No analysis included more than one correlation from the same sample of individuals and independence of samples was not violated.

Correlations between the PCAT and GPAs or individual course grades were the most commonly presented data. The mixture of grade and course information necessitated categorization decisions. Individual grade criteria were analyzed by combining all individual courses into a single analysis. For studies that reported correlations for several specific course grades, the correlations were first averaged within the study and then added to the meta-analysis. This analysis creates an average validity for pharmacy classes. Individual course grade analyses were conducted to maximize the information value of the database so that studies that did not report GPA could also be included to provide some information about the predictive validity of the PCAT. Separate analyses by specific courses were not conducted because of a lack of sufficient information. We also report the validity of the SAT subtests.

RESULTS

The meta-analytic results are presented in 3 sections. The first section describes the results for the overall grade-point average criteria, namely first-year grade point average, second-year grade point average, and third-year grade-point average. The second section examines the results for specific subject courses within the pharmacy curriculum, while the third section examines the results for the NABPLEX professional licensing examinations.

For all meta-analyses, we report the mean, sample-size weighted correlation computed across all studies (r_{obs}) as well as the standard deviation of observed correlations across all studies (SD_{obs}). We also report the residual standard deviation of the correlations, after corrections for statistical artifacts (SD_{res}) as well as the operational validity coefficient (ρ) and the standard deviation for the true validities (SD_{ρ}). Large SD_{ρ} values indicate that other variables are likely to act as moderators of the validity of the predictor. SD_{ρ} is also used to calculate 90% credibility intervals. If the lower bound of this interval does not contain zero, it is likely that the predictor will remain valid across those situations computed in the meta-analysis.

Validities for Grade-Point Average

Meta-analytic estimates of predictive validity for other standardized tests commonly range from 0.35 to 0.40 for predicting grade point averages.[6-9] The predictive validity of the PCAT scales were at least as good if not better, reaching estimates of 0.51 for the Math Reasoning score on the PCAT with first-year GPA. The validity of the PCAT subtest scores, prepharmacy GPA, and SAT subtest scores as related to grade-point average are reported in Table 1. The validity of the PCAT was somewhat lower for grades earned later in pharmacy programs. However, the validity did not decline to zero and remained a moderate predictor of second- and third-year GPA. Much of the variability across studies appeared to be due to sampling error differences. Estimates of the standard deviation of corrected correlations were generally small and no 90% credibility interval included zero. Of course, those analyses based on a small number of studies should be interpreted with more caution.

Validities for Individual Courses

The validities of PCAT scores and prepharmacy GPA for individual subject courses are presented in Table 2. The pattern of validities for individual subjects is largely similar to those observed for overall GPA. PCAT-Chemistry (N=535, k=5, ρ=0.40) and prepharmacy GPA (N=1,148, k=6, ρ=0.41) were most strongly related to performance in individual courses. The strong relationship between PCAT-Chemistry and individual course grades is likely due to the heavy emphasis on chemistry in pharmacy training. PCAT-Verbal exhibited the lowest validity for grades in individual courses (N= 525, k= 5, ρ= 0.16).

Validities for Current Grade Point Average

Three studies reported validities for "current GPA."[16-18] Due to the lack of specific information about the timeframe, these validities were examined separately. The goal was to preserve as much of the information available in the literature as possible. The validities of PCAT scores and prepharmacy GPA for current GPA are also presented in Table 2. The pattern of validities for current GPA is also largely similar to those observed for overall GPA. PCAT-Chemistry scores (N=888, k=3, ρ=0.38) and prepharmacy GPA (N=747, k=3, ρ=0.54) were most strongly related to current GPA. PCAT-Verbal scores exhibited the lowest validity with respect to current GPA (N= 888, k= 3, ρ= 0.23).

Validities for Professional Licensing Examinations

The validities of PCAT scores and prepharmacy GPA for the NABPLEX examinations are reported in

Table 1. Meta-Analyses of Correlations Between Predictors and Grade Point Averages of First-, Second-, and Third-Year Pharmacy Students

	N	k	r_{obs}	SD_{obs}	SD_{res}	ρ	$SD_ρ$	90% cred.
1st Year Pharmacy								
Grade Point Average								
PCAT-Verbal	2,811	32	0.28	0.11	0.05	0.31	0.06	0.21 to 0.41
PCAT-Quantitative	1,666	18	0.30	0.10	0.03	0.41	0.04	0.34 to 0.48
PCAT-Biology	2,811	32	0.39	0.13	0.09	0.43	0.09	0.28 to 0.58
PCAT-Chemistry	2,811	32	0.45	0.11	0.07	0.49	0.07	0.37 to 0.61
PCAT-Reading	2,811	32	0.32	0.14	0.10	0.35	0.11	0.17 to 0.53
PCAT-Arithmetic	1,454	18	0.43	0.11	0.05	0.47	0.06	0.37 to 0.57
PCAT-Math Reasoning	1,454	18	0.47	0.11	0.06	0.51	0.06	0.41 to 0.61
PCAT-Total	2,829	22	0.45	0.12	0.12	0.50	0.11	0.32 to 0.68
Pre-Pharmacy GPA	2,810	23	0.45	0.11	0.08	0.50	0.09	0.35 to 0.65
SAT-Verbal	244	3	0.23	0.04	0.00	0.25	0.00	0.25 to 0.25
SAT-Math	244	3	0.31	0.05	0.00	0.34	0.00	0.34 to 0.34
2nd Year Pharmacy								
Grade Point Average								
PCAT-Verbal	309	4	0.20	0.06	0.00	0.22	0.00	0.22 to 0.22
PCAT-Quantitative	309	4	0.29	0.08	0.00	0.32	0.00	0.32 to 0.32
PCAT-Biology	309	4	0.40	0.09	0.00	0.44	0.00	0.44 to 0.44
PCAT-Chemistry	309	4	0.42	0.01	0.00	0.46	0.00	0.46 to 0.46
PCAT-Reading	309	4	0.41	0.07	0.00	0.45	0.00	0.45 to 0.45
PCAT-Arithmetic	309	4	0.24	0.06	0.00	0.27	0.00	0.27 to 0.27
PCAT-Math Reasoning	309	4	0.27	0.08	0.00	0.30	0.00	0.30 to 0.30
Pre-Pharmacy GPA	764	6	0.40	0.12	0.09	0.44	0.10	0.28 to 0.60
PCAT-Total								
SAT-Verbal	244	3	0.24	0.08	0.00	0.26	0.00	0.26 to 0.26
SAT-Math	244	3	0.25	0.03	0.00	0.28	0.00	0.28 to 0.28
3rd Year Pharmacy								
Grade Point Average								
PCAT-Verbal	1,132	6	0.22	0.03	0.00	0.24	0.00	0.24 to 0.24
PCAT-Quantitative	1,132	6	0.31	0.10	0.07	0.34	0.08	0.21 to 0.47
PCAT-Biology	1,132	6	0.30	0.10	0.07	0.33	0.08	0.20 to 0.46
PCAT-Chemistry	1,132	6	0.35	0.04	0.00	0.38	0.00	0.38 to 0.38
PCAT-Reading	1,132	6	0.29	0.07	0.01	0.32	0.02	0.29 to 0.35
PCAT-Arithmetic	574	5	0.35	0.08	0.01	0.38	0.01	0.36 to 0.40
PCAT-Math Reasoning	574	5	0.33	0.12	0.09	0.36	0.10	0.20 to 0.52
PCAT-Total								
Pre-Pharmacy GPA	1,367	8	0.45	0.12	0.10	0.50	0.11	0.32 to 0.68
SAT-Verbal	711	4	0.27	0.05	0.00	0.30	0.00	0.30 to 0.30
SAT-Math	711	4	0.24	0.03	0.00	0.26	0.00	0.26 to 0.26

N=number of subjects; k= number of studies; r_{obs} = sample-size weighted-mean observed correlation; SD_{obs} = observed standard deviation; SD_{res} = residual standard deviation; ρ = operational validity; $SD_ρ$ = standard deviation of true validity; 90% cred. = 90% credibility interval. Sources of data used to calculate N, k, r_{obs}, SD_{obs}, SD_{res}, ρ, $SD_ρ$, and 90% cred. for Tables 1-3 were references 3;19-34;43-44.

Table 2. Meta-Analyses of Correlations Between Predictors and Pharmacy Course Grades, and Current Grade Point Average

	Overall Grade in a Course								Current Grade Point Average							
Predictors	**N**	**k**	**r_{obs}**	**SD_{obs}**	**SD_{res}**	**ρ**	**$SD_ρ$**	**90% cred.**	**N**	**k**	**r_{obs}**	**SD_{obs}**	**SD_{res}**	**ρ**	**$SD_ρ$**	**90% cred.**
PCAT-Verbal	525	5	0.15	0.08	0.00	0.16	0.00	0.16 to 0.16	888	3	0.21	0.01	0.00	0.23	0.00	0.23 to 0.23
PCAT-Quantitative	535	5	0.25	0.16	0.13	0.28	0.14	0.05 to 0.51	888	3	0.31	0.09	0.07	0.34	0.08	0.21 to 0.47
PCAT-Biology	535	5	0.30	0.12	0.09	0.33	0.10	0.17 to 0.50	888	3	0.32	0.08	0.06	0.35	0.06	0.25 to 0.45
PCAT-Chemistry	535	5	0.36	0.10	0.04	0.40	0.05	0.32 to 0.48	888	3	0.35	0.04	0.00	0.38	0.00	0.38 to 0.38
PCAT-Reading	525	5	0.29	0.14	0.11	0.32	0.12	0.12 to 0.52	888	3	0.29	0.06	0.04	0.32	0.04	0.25 to 0.39
PCAT-Arithmetic	399	4	0.22	0.06	0.00	0.24	0.00	0.24 to 0.24								
PCAT-Math Reasoning	399	4	0.28	0.07	0.00	0.31	0.00	0.31 to 0.31								
Pre-Pharmacy GPA	1,148	6	0.37	0.14	0.13	0.41	0.14	0.18 to 0.64	747	3	0.49	0.01	0.00	0.54	0.00	0.54 to 0.54
SAT-Verbal	244	3	0.20	0.04	0.00	0.22	0.00	0.22 to 0.22								
SAT-Math	244	3	0.22	0.06	0.00	0.24	0.00	0.24 to 0.24								

N=number of subjects; k= number of studies; r_{obs} = sample-size weighted-mean observed correlation; SD_{obs} = observed standard deviation; SD_{res} = residual standard deviation; ρ = operational validity; $SD_ρ$ = standard deviation of true validity; 90% cred. = 90% credibility interval. Sources of data used to calculate N, k, r_{obs}, SD_{obs}, SD_{res}, ρ, $SD_ρ$, and 90% cred. for Tables 1-3 were references 3;19-34;43-44.

Table 3. Meta-Analyses of Correlations Between Predictors and Pharmacy Course Grades, and Current Grade Point Average, N=244; k=3

	NABPLEX Examination				
Predictors	**Pharmacy**	**Pharmaceutical Calculations**	**Pharmacology**	**Pharmaceutical Chemistry**	**Pharmacy Practice**
PCAT-Verbal	0.37	0.19	0.39	0.39	0.36
PCAT-Quantitative	0.31	0.44	0.16	0.28	0.15
PCAT-Biology	0.43	0.23	0.40	0.48	0.33
PCAT-Chemistry	0.52	0.35	0.37	0.56	0.23
PCAT-Reading	0.41	0.26	0.40	0.34	0.42
PCAT-Arithmetic	0.27	0.41	0.22	0.28	0.17
PCAT-Math Reasoning	0.31	0.39	0.16	0.29	0.17
Pre-Pharmacy GPA	0.16*	0.09	0.22	0.18	0.09
SAT-Verbal	0.38	0.23	0.34	0.31	0.32
SAT-Math	0.30	0.36	0.23	0.20	0.24

*N=509, k=4

Except as labeled, all values are sample-size weighted-mean observed correlations, k= number of studies, N= number of subjects. Sources of data used to calculate N, k, r_{obs}, SD_{obs}, SD_{res}, ρ, $SD_ρ$, and 90% cred. for Tables 1-3 were references 3;19-34;43-44.

Table 3. The operational validities of PCAT scores were high across all NABPLEX subscales, although somewhat lower for the pharmacy practice scale. The highest operational validity was observed for PCAT-Chemistry scores in relation to performance on the pharmaceutical chemistry scale (N= 244, k= 3, ρ= 0.56). Prepharmacy GPA exhibited relatively low operational validity across all NABPLEX scales with a maximum for the pharmacology scale (N= 244, k= 3, ρ= 0.22) and a minimum for the pharmacy practice scale (N= 244, k= 3, ρ= 0.09) and the pharmaceutical calculations scale (N=244, k=3, ρ=0.09). All of these analyses are based on a comparatively smaller sample size and should be followed up with additional research.

DISCUSSION

Overall, our findings indicate that the PCAT is a valid predictor of performance in pharmacy programs. Furthermore, our results indicate the value of assessing specific knowledge that is directly relevant for performance. Performance on individual components of the PCAT, including the chemistry, biology, quantitative, and calculations scales, were valid predictors of student performance and showed strong relationships with scores on the NABPLEX. Finally, much of the variability observed in the literature appeared to be due to sampling error. Previous research has found differential validity for specific ability measures when the measures are used to predict specific courses of performance in specific disciplines.

One important limitation of this meta-analysis is that the studies included are not truly predictive studies. The PCAT was used for admission decisions; thus, some criterion contamination might have occurred. However, such effects are unlikely since few faculty members retain students' PCAT scores in their memory. Indeed, one of the motivations for this study was that some faculty members do not believe that standardized test scores are terribly important.[2] Furthermore, previous research has found little difference in validities between truly predictive and quasi-predictive validity designs.

No corrections were made for restriction of range in these data, although such restriction almost certainly occurred (ie, students are selected on the basis of PCAT scores as well as prepharmacy GPAs, which correlate strongly with PCAT scores). This restriction of range results in an underestimate of the predictive power of the PCAT. Ideally, future research would examine the effect of multivariate restriction of range on PCAT score validities.[42,43] Although much of the variability across studies could simply be attributed to sampling error, some of the remaining variability is likely due to differential restriction of range. Ironically, those schools that are more selective and make more use of PCAT scores are more likely to obtain smaller validity estimates. This additional source of artifactual variability will contribute to perceptions that the validity of the PCAT varies across institutions.

An important question in pharmacy education is whether the PCAT is more valid than other alternative tests, including the ACT and the SAT. Although this study only provides limited information about the SAT, the PCAT appears to be a better predictor for performance in pharmacy school. The data presented here provide some direct evidence to answer questions raised about the validity of the PCAT relative to other predictors.[2] However, we would expect that a combination of SAT scores with more domain-specific knowledge measures, like scores on the SAT II tests, would yield results comparable to those of the PCAT. The validities of the individual PCAT scales are often of lower validity than prepharmacy GPA, but in combination appear to match prepharmacy GPA in predictive power.

Even at their current levels, the predictive relationships are quite powerful. Norwood et al[2] found that the most frequently mentioned weakness of the PCAT was a perception that its predictive validity is too low. The relationship between correlations and actual outcomes is not always easy to visualize. Reframing correlations in terms of correct and incorrect decisions is sometimes useful.[44] Although more complex frameworks exist, this approach can be illuminating. For example, assume that across all applicants to pharmacy programs, 70% would obtain at least passing grades the first year of the program. This establishes a base rate of success for the applicant population. On average, use of the PCAT total score with a correlation of 0.5 with first-year grades would increase the pass rate from 70% to 91% if schools selected the top 20% of the applicant group. In other words, a relatively selective school could realize at least a 21% increase in the number of passing students by using PCAT scores alone. Such gains are far from trivial. At the same time, obtaining even better results is desirable to further improve admissions decision-making.

Unaddressed by this study is the importance of other individual difference variables, including personality and interests, which are likely to have stronger relationships with the motivational aspects of academic success (eg, persistence). Expanding the predictor space to include better assessments of non-cognitive variables would be a valuable step in improving the quality of student admissions. Current assessments of non-cognitive individual differences are often not standardized and of poor quality (eg, letters of recommendation, personal statements). If based on a careful analysis of the "job" of pharmacy students, standardized rating forms for letters of recommendation and even the creation of biodata and situational judgment tests could be productive and would likely yield substantial increases in predictive validity.

Similarly, expanding the conceptualization of student performance to include other measures beyond grades and licensing examinations would be desirable. Grades are clearly important and reflect one of the core objectives of pharmacy education: acquiring knowledge. However, grades are the end product of a great deal of largely unobserved student behaviors. Furthermore, some aspects of student success (eg, communication per-

formance) may have important relationships to professional success. Development of a taxonomy of pharmacy student performance dimensions would be a valuable contribution.

All of the evidence obtained here points to the PCAT as a valid predictor of pharmacy student performance. The most substantial results were for first-year GPA. Although the other analyses are based on comparatively smaller sample sizes, the validity of the PCAT remains substantial even in the absence of corrections for restriction of range. It is, of course, not a perfect predictor of student success, and the development of additional predictors that emphasize non-ability determinants of student performance is likely to be of value. However, these measures would be best used to compliment existing predictors rather than replace them. In summary, the PCAT predicts performance across several years of pharmacy training and, in comparison to other standardized admission tests (eg, the SAT, GRE, GMAT and MAT), is an atypically strong predictor of performance on licensing examinations.

CONCLUSIONS

Our meta-analyses of the existing literature on validity have shown that both PCAT scores and prepharmacy GPA are valid predictors of academic performance across the first 3 years of pharmacy education, and of performance in individual classes and licensing examinations. Our results suggest that use of the PCAT and prepharmacy GPA in the admissions process is likely to substantially increase the number of high-performing pharmacy students. Significant unexplained variation in the performance of pharmacy students does remain, and other predictors of pharmacy student performance, such as standardized rating forms for letters of recommendation and situational judgment tests, may further increase our ability to understand and predict the performance of pharmacy students. Skepticism over the PCAT's validity in pharmacy school admission appears to be in error.

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