RESEARCH

Predicting Pharmacy Curriculum Outcomes Assessment Performance Using Admissions, Curricular, Demographics, PCOA Pre-Test, and Preparation Data.

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ABSTRACT

Objective. To examine which factors (i.e., a cumulative PCOA pre-test, PCAT scores, GPA, program progression, studying/preparation, and admissions and demographic variables) best predict students’ performance on the Pharmacy Curriculum Outcomes Assessment (PCOA).

Methods. Two classes of third-year pharmacy students completed a 100-item locally-created PCOA pre-test “PCOA Prep” cumulative knowledge test in the fall semester and then in the spring completed a 200-item NABP PCOA test and a study habits and confidence survey. A retrospective review of students’ demographics data, pre-pharmacy admission variables, and pharmacy school factors were collected. Correlation and regression analyses were conducted to evaluate which factors predicted students’ PCOA total scaled score and Areas 1-4 scores.

Results. 179 students were included. The majority were female (55%), White (54%), 28 (+/- 5.4) years old, with an average score of 80.7% (+/- 7.79) on the PCOA Prep test. The stepwise multiple linear regression model for the PCOA total scaled score (adjusted $R^2=0.6125$) included the PCOA Prep test,
cumulative GPA at the end of the didactic curriculum, race/ethnicity, PCAT (Pharmacy College Admission Test) verbal, PCAT biology, and a class identifier. Including the PCOA Prep test explained more variance than the model without the test (adjusted $R^2=0.5306$).

**Conclusions.** This study revealed that student performance on a locally created cumulative knowledge test best predicted the PCOA Total Scaled Score. These results offer insights into additional contributing factors that influence students’ PCOA performance and how colleges/schools of pharmacy could identify at-risk students who may need knowledge remediation prior to Advanced Pharmacy Practice Experiences.

**Keywords:** assessment, evaluation, PCOA, benchmarking

**INTRODUCTION**

The 2016 Accreditation Council for Pharmacy Education (ACPE) doctor of pharmacy accreditation standards require Colleges and Schools of Pharmacy to administer the Pharmacy Curriculum Outcomes Assessment (PCOA) (standard 24) to all students prior to starting Advanced Pharmacy Practice Experiences (APPEs). The PCOA, which was developed by the National Association of Boards of Pharmacy (NABP) was designed to measure student’s progress in the didactic curriculum and “APPE readiness”. NABP developed the standardized assessment and because all schools and colleges of pharmacy are required to offer the test, a program’s results can be systematically compared across schools for benchmarking. It is reported that the benchmarking allows schools to monitor areas of curricular improvement as a result of peer comparisons. Other reported purposes of the PCOA are that the test offers students an opportunity to review content and programs can use the results to identify students who may need remediation. Although ACPE is not currently requiring the PCOA as a high stakes test, the benchmarking and use in program pharmacy accreditation may impact stakeholders’ perceptions of its purpose. As a result, there is some uncertainty in the Academy about how the results are used and the utility of engaging in PCOA preparation.

Prior to the mandatory PCOA requirement, the 2007 ACPE standards encouraged the periodic use of comprehensive knowledge and performance-based summative assessments, which resulted in the
University of Oklahoma College of Pharmacy’s creation and seven year use of six locally developed summative knowledge examinations. These “integrated examinations” were embedded into the final examinations of the pharmacy practice courses offered in each semester of the first three didactic years out of four (six tests total) and were worth 10% of the overall course grade. The college’s course coordinators, along with the assessment and curriculum committees, identified the most important content in the required didactic courses and created the integrated examinations’ objectives and tests questions, which were different than courses’ lecture objectives and test questions. After the release of the 2016 ACPE Standards, the college decided that since time, effort, and resources were dedicated to creating the six integrated examinations, the tests would be repurposed as a PCOA/APPE preparation tool since the PCOA test lacked student preparation/study resources and students could benefit from focused content review and structured feedback prior to APPEs and the PCOA test. Five of the six integrated examinations were combined into one 100-item multiple-choice cumulative knowledge test called the “PCOA Prep” to be administered during the fall semester finals week of the third professional year (P3) and would account for 10% of the overall grade for a Pharmacy Practice VI course that semester. Students were informed that the goal of the PCOA Prep test was to help them refresh their cumulative knowledge of course content from the past three years to help them prepare for their impending APPEs. They were also told that a second goal was to get them accustomed to preparing for and completing a large cumulative test (PCOA) over their didactic coursework.

Although previous research revealed an association with students’ PCOA Total Scaled Score and third year students’ GPA (grade point average); PCAT (Pharmacy College Admission Test) reading and first year pharmacy GPA; cumulative pharmacy GPA and the Health Sciences Reasoning Test; gender, PCAT score, pre-pharmacy science GPA, pharmacy didactic GPA; and PCAT and cumulative GPA, no studies examined the impact of a PCOA preparatory tool/practice test on PCOA scores. Although one study examined the factors related to pre-pharmacy, pharmacy, and demographic factors related to Pre-NAPLEX test scores, the study did not evaluate the relationship between the Pre-NAPLEX and NAPLEX. Therefore, the purpose of the current study was to examine the relationship among PCOA
Prep scores, the didactic curriculum (GPA and course remediation), demographic variables, admissions criteria (undergraduate GPA, PCAT scores), amount of study preparation for the PCOA, and student PCOA knowledge confidence (self-awareness) to third year students’ performance on the PCOA examination.

METHODS

Third year (P3) pharmacy students in the class of 2017 (N=99) and the class of 2018 (N=80) at the University of Oklahoma College of Pharmacy completed a 100-item local PCOA Prep cumulative knowledge test the week before fall final examinations. The test was worth 50 points and accounted for 10% of their overall P3 Pharmacy Practice course grade. The test did not include content from the spring P3 semester since the PCOA Prep was a P3 fall test and students were not exposed to that spring course work yet. The PCOA Prep creation and rationale was explained to the P3 students at the beginning of the P3 fall semester and they were given PCOA Prep objectives four weeks prior to the test. Students were encouraged to study and were told that the goal of test was to help them prepare for the PCOA examination, which would be a new experience for them. To help students answer the PCOA Prep test objectives and prepare for the examination, all previous courses’ (P1-P2) lecture handouts, slides, and videos were made available to students on Desire2Learn® (D2L) (Desire2Learn, Inc., Ontario, Canada). All of the PCOA Prep test questions were loaded into D2L and each of the 100 PCOA Prep Examination questions in D2L were tagged to four areas: 1) the PCOA Prep test objective, 2) Bloom’s Taxonomy (high or low level), 3) one of the 15 CAPE Outcomes abbreviated terms,11 and 4) one of the ACPE Appendix 1 terms.2 After students completed the fall PCOA Prep examination, they received their test grade that semester and in the spring semester they received a test report card (a locally developed report card created by exporting D2L test data called “Test Tracker”) that outlined their performance on the four tagged areas. Students were educated on what the four tags represented, were encouraged to review the PCOA Prep test report card results, and to study areas of weakness using course videos and/or notes prior to the PCOA examination scheduled for the week before spring final examinations. Students were also
encouraged to complete the formative quizzes available on the National Association of Boards of Pharmacy’s (NABP) website and review the four PCOA content areas prior to taking the PCOA examination. The PCOA was administered in the first week of May to the P3 students in 2016 and 2017 respectively. Students were informed that the college would incentivize the PCOA and that they would receive bonus points in the P4 fall seminar course. The bonus points were based on a scale that coincided with a percent score (e.g., 50-59 = 1 point; 60-69 = 2.5 points; 70-79 = 5 points; 80-89 = 7.5 points; and 90-99 = 10 points). The scale was based on the P4 Seminar Course Coordinator’s request to offer an amount of points that would motivate students but not so many points that it would create a large impact on the overall course grade.

After completion of the PCOA examination, all 179 students were then invited to complete an 12-item survey regarding their demographics, the amount of time they spent studying for the PCOA Prep and PCOA tests (0, 1-5, ≥6 hours which were arbitrary cut points selected to reflect no studying, a single study session, or longer/multiple study sessions), study methods they used for both tests (assessed because although the PCOA Prep was a study method, the college wanted to know what other ways students prepared for the PCOA), the perceived utility of the fall PCOA Prep (scale 1=strongly disagree to 5=strongly agree) and study objectives (scale 1=not at all useful to 5=very useful), and confidence in each of the four PCOA Areas (scale 1=not at all confident to 5=very confident). The last question was an open-ended question that solicited overall comments. The questionnaire was administered after completion of the spring PCOA test. Student participation in the survey was not blinded and was voluntary. All students were invited to complete the survey as part of a quality improvement project and were told that the college was evaluating if it should continue to offer the PCOA Prep. The survey was administered prior to students receiving their PCOA scores. IRB approval for this project was received and categorized as an expedited study (IRB #8806).

**Data Collection and Analyses**

To gather the factors related to performance on the PCOA examination, institutional databases and the Pharmacy College Application Service (PharmCAS) (Liaison International, LLC, Stone Mountain,
GA) were used to perform a retrospective review of student records. Three categories of data were collected: 1) demographics including age at PCOA test date, gender/sex, and race/ethnicity; 2) pre-pharmacy and admissions including undergraduate science GPA, undergraduate cumulative GPA, graduate coursework, PCAT attempts, PCAT composite score and section scores (biology, chemistry, quantitative, reading, and verbal); and 3) didactic curriculum including history of remediation or delay in graduation, and cumulative GPA at end of didactic program.

To statistically analyze the factors related to PCOA performance, continuous variables were summarized using means, standard deviations, minimum and maximum. Categorical variables were summarized using frequency number and percent. Dummy coding of categorical variables was done as follows: Sex/gender (0=male, 1= female); Race/ethnicity (0=White; 1=All others); Graduate Coursework (0=None, 1=At least one credit hour); PCAT attempts (0=Only one attempt; 1=More than one attempt); Remediation (0=No courses remediated, 1=One or more courses remediated); Delay in Graduation (0=Graduated on-time, 1=Delayed due to academic or personal).

Bivariate correlations were examined using zero-order Pearson correlation coefficient (r) for continuous variables and point biserial for dichotomous variables. Confidence intervals (95% CI) were added to show to precision of the correlation coefficient. Stepwise regression was used to model the linear relationships between PCOA scores and multiple variables. Stepwise selection adds and removes candidate variables until a best fit model is achieved. Standard regression diagnostics were performed including residual analysis and checks for multicolinearity. Parameter estimates from the final model and adjusted $R^2$ (a$R^2$) were reported. Additionally, both type II semi-partial correlations (representing the unique correlation between predictor and PCOA score after controlling for other variables in the model) and type II squared semi-partial correlations (representing the proportion of variance that is uniquely explained by the predictor after accounting for other model predictors) were reported.

One-way analyses of variance (ANOVA) were performed with Tukey adjustments for multiple comparisons to examine mean PCOA scaled score differences between groups on variables of interest.
All analyses were performed using SAS software, Version 9.4 of the SAS System for Microsoft Windows (SAS Institute Inc., Cary, NC, USA.). The a priori significance level was set at 0.05.

RESULTS

Demographics

Table 1 reports the demographic, pre-pharmacy and pharmacy academic characteristics of the 179 P3 students in the study. All students from the classes of 2017 and 2018 were included in this analysis. The median age was 28 years old at the time of the PCOA administration and participants were mostly female (55%) and white (54%). The PCOA study habits and perception survey was administered to all 179 students. One-hundred-sixty-eight (94%) of students completed the survey with the remaining 11 completing some, but not all survey questions.

Study preparation and methods for the PCOA Prep and PCOA

The amount of time students reported studying for the PCOA Prep and PCOA examinations differed. Eighty-two percent of students reported any amount of studying for the PCOA Prep compared to 73% for the PCOA examination, p<0.001. Rates of studying less than 5 hours were similar for both the PCOA Prep and PCOA examinations with 49% and 51%, respectively; however, students reported studying more than 5 hours for the PCOA Prep and PCOA examination less frequently with 33% and 21%, respectively. Students used a variety of study methods to prepare for the PCOA: 53% used the lecture objectives provided for the PCOA Prep examination; 20% used content and topic areas for the PCOA listed on the NABP website; 3% watched course lecture videos; and 22% studied course handouts, slides, and notes.

Student perception of PCOA Prep examination

Four percent of students strongly agreed and 27% agreed that the PCOA Prep examination increased their comfort level in taking the PCOA examination, whereas 8% strongly disagreed and 17% disagreed. Forty-five percent of students reported neutrally indicating it made no change in their comfort level.
When asked how useful the PCOA Prep examination was as a tool for helping them prepare for the PCOA examination, a majority (62%) of students reported the PCOA Prep provided average or above usefulness. Forty-two percent reported it as average usefulness, 19% reporting it as useful, and 1% said the PCOA Prep was very useful. However, 29% found very little use in it and 10% reported it not at all useful.

**Relationship between PCOA content area scores and students self-reported confidence in knowledge of content areas**

Students self-reported their level of confidence in knowledge of PCOA content areas. The largest number reporting little to no confidence was Area 1 (basic biomedical sciences) with 22%, followed by Area 2 (pharmaceutical sciences) and 3 (social, behavioral, and administrative sciences) with 11%, and Area 4 (clinical sciences) with 8%. Average level of confidence was most frequently selected for each content area (area 1: 56%; area 2: 62%; area 3: 55%; and area 4: 49%). The area with the largest percent of students reporting confident to very confident was in area 4 with 42%, followed by area 3 with 35%, area 2 with 27% and area 1 with 22%.

Table 2 reports the students’ confidence level and average scaled score for PCOA content areas. The 22% who reported no to little confidence in their knowledge of basic biomedical sciences had a mean (SD) of 345.2 (60.4). Compared to them, the mean score increased by 31.5 points for those reporting average confidence and an additional 56.6 points for those reporting confident or very confident levels. All three pairwise comparisons were significant (p<0.05) using Tukey procedure following a significant result using a one-way ANOVA, p<0.05.

Average scores for the pharmaceutical sciences content area did not have as large of increases across confidence levels. Those reporting little to no confidence scaled score average was 367.7 with an increase of 11.2 point for those with average confidence and an additional 30.3 points for those reporting confidence or very confidence. Significant differences (p<0.05) were found between the high confidence group compared to both low and average confidence, but not between the two lowest groups (p=0.70).
No significant differences were found in social, behavioral and administrative sciences average scores between confidence levels. The range on average scores between low and high confidence groups was 31.9 points. Lastly, students reporting little to no confidence in their knowledge of clinical sciences had an average scaled score of 351.6, which was significantly different (p<0.05) from than those reporting confident to very confident in their knowledge whose average was 44.1 points higher. No other differences were significant for area 4.

**PCOA Total Scaled Score**

Table 3 reports the relationships between pre-pharmacy, demographic, didactic program, and select survey variables with the PCOA total scaled score. Out of the 19 variables examined individually, 13 were found to be significantly correlated with PCOA total scaled score. The largest was the PCOA Prep examination (r=0.66) followed by cumulative didactic GPA (r=0.57) and PCAT Composite Score (r=0.51).

The first linear regression analysis (reported as Model 1) included all variables for consideration except for the PCOA Prep examination results. This analysis was performed to show the maximum amount of variance that could be explained without the PCOA Prep examination results. The final model for analysis 1 included cumulative didactic GPA (13% of unique variance explained), course remediation (1%), race/ethnicity (4%), and PCAT Verbal (7%), Biology (1%) and Chemistry (1%). The selection process allowed for either the PCAT Composite or the five PCAT area tests to be included for consideration. Despite the PCAT Composite having a higher correlation with PCOA total scaled score, the regression model included three area tests, which collectively explained more variance than the Composite alone. Class identifier (2017 vs. 2018) had a significant bivariate relationship with PCOA total scaled score and was found significant in some adjusted models. Here it was included as a nuisance variable to maintain parity with other models. This model accounted for 53% of the variance in the PCOA total scaled score (p<0.05).

Model 2 added PCOA Prep as a variable to consider in the stepwise model selection. The final model accounted for 61% of the variance, an increase of 8 percentage points from model 1. The PCOA
Prep explained the largest amount (9%) of unique variance in the model, with cumulative GPA decreasing to account for only 1%. The second largest predictor was PCAT verbal (5%) followed by PCAT biology (4%). In the final model, race/ethnicity accounted for only 2% of uniquely explained variance. Class identifier was kept as a control variable, but in this model it was significant (p=0.04).

The PCOA Prep and cumulative didactic GPA were correlated, r= 0.68 (95% 0.60-0.75). However, a three variable partial correlation analysis between the PCOA Prep examination and PCOA total scaled score while controlling for cumulative GPA resulted in a Pearson partial correlation of 0.46. By reversing it and controlling for PCOA Prep, the partial correlation between cumulative GPA and PCOA total scaled score was only 0.22. Additionally, multicolinearity was examined in both model 1 and 2. Neither model had a tolerance less than 0.1 nor a variance inflation greater than 2.2, indicating all variables included in the final models explained a unique proportion of variance.

**PCOA Area Scores**

Table 4 reports the multiple variable linear regression results from modeling each PCOA Area Score. Only variables included in any of the final models were reported. The $aR^2$ for these models were collectively lower than the PCOA Total Score’s $aR^2$ of 0.6125; the lowest was Area 1 ($aR^2 = 0.3792$) with Area 2 being the highest (0.5495). Significant relationships were found between the in-house PCOA Prep examination and each PCOA Area Score, though its proportion of unique variance explained varied depending on the Area: lowest for Area 3 (3%) and highest for Area 2 (17%). It remained the strongest predictor in each model, except for Area 3 where PCAT Verbal explained 6% of unique variance compared to PCOA Prep’s 3%.

Collectively across the models, six variables were found to have a negative relationship with at least one PCOA Area Scores. Demographically, being female resulted in decreased Area 1 scores and being non-white resulted in decreased Area 2-4 scores. Higher undergraduate science GPAs resulted in a decreased Area 3 score, students who took the PCAT more than once had a decrease in Area 1 scores, and PCAT Quantitative was associated with decreased Area 4 scores. Study preparation had a role in two Area models. Students who studied less than 5 hours had a decrease in Area 1 scores compared to
students who did not study. Additionally, students who studied more than 5 hours had an increase in Area 3 scores compared to those who did not study. The remaining variables reported in Table 4, mostly of which are academically-related, all had some degree of a positive relationship with at least one PCOA Area Score.

**Post-Hoc Analysis**

A post-hoc analysis was performed on gender/sex and race/ethnicity to determine if differences exist on observed PCOA SS, pre-pharmacy and didactic-related variables. T-tests were used to examine differences between males and females, and one-way ANOVAs for race/ethnicity with Dunnett tests for pairwise differences between each minority and the control group (set to white). Post-hoc Dunnett tests were chosen as it adjusts for 5 simultaneous comparisons to a control group. With six race/ethnicity groups, a total of 15 pairwise comparisons could be made thus resulting in very conservative tests if using Bonferroni or Tukey multiple comparisons (MCP).

No differences in observed scores were found between sex/gender groups for PCOA Overall SS, Area 2-4 SS, PCOA Prep examination, PCAT Composite, and PCAT Chemistry, Quantitative, and Reading subtests. Females scored lower for PCAT Biology (p=0.0069) and PCAT Verbal (0.0245), and slightly lower on PCOA Area 1 (p=0.0685). However, females had a higher cumulative didactic GPA than males, p=0.0019.

Fifty-four percent of students reported race/ethnicity as white, followed by 29% reported as Asian. The remaining 17% students reported as American Indian (2%), Black (6%), Hispanic (2%), or Two or More Races (7%). These small, disproportionate numbers often resulted in underpowered statistics to determine if differences in mean scores on selected variables existed. Some differences were noted; however, the direction often varied with the minority scoring higher or lower than majority. Differences were found on mean scores for PCAT Chemistry (Asian > White), PCAT Quantitative (Asian > White), PCAT Verbal (underpowered to detect which differed), PCOA Overall SS and Area 4 (Asian < White, Black < White), and PCOA Areas 2 and 3 (Asian < White). No differences in mean scores were
found in the remaining variables: PCAT Biology, PCAT Reading, PCAT Composite, PCOA Area 1, Cumulative Didactic GPA, and PCOA Prep.

DISCUSSION

Since the recent PCOA requirement was implemented in 2016, uncertainty exists about how PCOA scores for students and for programs will be used in the future, which can be stressful for both students and programs. In addition to this uncertainty, questions also exist about whether schools/colleges should help prepare students for the PCOA. If NABP’s intent for the PCOA was to measure APPE readiness, then schools/colleges helping students prepare for the PCOA would ultimately help them reinforce their knowledge prior to APPEs, which would provide a benefit to students beyond PCOA performance. Students may forget some content over the span of the program due to lack of repetition or perceived lack of relevance. Therefore, encouraging them to study the most important content determined by the college/school’s faculty members prior to the PCOA test (the semester before) should help give students a head start remediating any deficient knowledge and increase the likelihood of retrieving that content for future use on APPEs and the PCOA. As a result, studying for the PCOA is not grounded in only studying for the test, but for reviewing essential content needed for APPEs.

Another area of uncertainty is whether colleges/schools of pharmacy should use the PCOA as a measure of their program’s curricular effectiveness. One disadvantage of use the PCOA as a metric for curricular effectiveness is that there are a limited number of test questions per content area. Therefore, student’s poor performance in a given area may not be related to a curricular weakness, but instead may be related to sampling, where students may not remember specific aspects of course content versus being weak overall in a course. A more complete measure of curricular effectiveness could include colleges/schools of pharmacy tagging their course assessment questions to whether they are high or low level on Bloom’s Taxonomy and to the CAPE outcome and ACPE standard the questions address. This would allow schools/colleges of pharmacy to map their curriculum and evaluate how often the content is assessed in a course, what level it is assessed at, if it is assessed across the curriculum, and how well
students perform on the content areas in aggregate. Schools/colleges may discover that the content is not assessed in a course, is not longitudinally assessed, or is not assessed at a level that advances across the curriculum. These data could then be compared to the PCOA Prep and PCOA results to provide a more comprehensive picture of students’ knowledge.

The goals of this study were to evaluate factors related to student performance on the PCOA in order to better understand how to help students reactivate/retrieve prior knowledge/refresh content knowledge and prepare for the PCOA test and APPEs. While previous literature reported pharmacy GPA, undergraduate GPA, PCAT scores, and demographic variables influenced PCOA performance, this study evaluated the impact of three new variables on PCOA scores, 1) PCOA pre-test scores (PCOA Prep), 2) number of PCAT attempts, and 3) student self-reported confidence in PCOA knowledge (self-awareness, confidence, and metacognition). The study results revealed that the PCOA Prep could predict success on the PCOA, which may be most beneficial for predicting at-risk students who may have knowledge deficits. Being able to predict these knowledge deficits would allow for earlier identification and remediation of content knowledge to ultimately improve APPE preparedness.

**PCOA Prep test.** The overall regression model that accounted for 61% of variance in the PCOA Total Scaled Score included one of the variables not previously reported in the literature, the PCOA Prep test. The variable that accounted for the greatest proportion of unique variance in the stepwise multiple linear regression model for the PCOA Total Scaled Score was the college’s locally created PCOA pretest, the PCOA Prep, where nine percent of the variance was explained. Another finding related to the PCOA Prep study variable is that although students reported on the survey that they did not find the PCOA Prep test useful when taking the PCOA test, it was the most correlated with PCOA scores. This score may help programs identify at-risk students with knowledge deficits that may limit their performance on the PCOA and APPEs. The earlier programs can identify at-risk students, the earlier they can help students remediate their knowledge so they can successfully complete the program requirements.

**PCAT admissions variables.** The PCAT Attempts was a variable that was associated with Area 1 scores. Students who took the PCAT more than once did worse on the Basic Biomedical Sciences Area
1 by 20 points. Number of PCAT attempts was a unique variable in this current study and not previously evaluated in previous PCOA studies. These results may suggest that students who need to take the PCAT multiple times struggle with standardized tests or have knowledge deficits. The PCAT Verbal and PCAT Biology scores were two additional admissions variables that were positively associated with the PCOA Total Scaled Score, explaining five and four percent of the unique variance respectively. In addition to the overall PCOA score, the PCAT Verbal score was also positively associated with AREA 2, 3 and 4 scores. The PCAT Biology score was positively associated with the Area 1, 2 and 4 scores, the PCAT Chemistry was associated with the Area 2 score, and PCAT Quantitative score was positively associated with the PCOA Area 4 score. Overall, colleges and schools of pharmacy who want to screen for at-risk students for the PCOA and APPEs could use the PCAT results to identify students, with the exception of the PCAT Verbal section, since the section was retired by the National Association of Boards of Pharmacy. In the future this regression model will need to be re-evaluated with students who completed the new PCAT.

**Student confidence.** Students’ self-reported level of confidence in knowledge of each of the four PCOA areas was another outcome assessed in this study. The results revealed that students’ metacognition/self-awareness of their level of confidence in the four PCOA test areas was an accurate self-assessment; as students who had little to no confidence in areas 1, 2, and 4 had lower scores than students who had high confidence in those three areas. Previous reports in the literature indicate that students lack self-assessment skills, as seen in low correlations between students’ self-assessment and actual performance or achievement. In contrast, the third year students in this current study demonstrated accurate self-awareness; students with low confidence in a PCOA Area (1, 2 and 4) earned low scores. This finding offers programs an additional strategy for assisting students with knowledge remediation prior to APPEs. When determining how to prepare for the PCOA and for APPEs, students may feel overwhelmed with the amount of prior content they need to study. Encouraging or requiring students to self-assess their confidence can offer them insight into whether they need to study a topic area more since metacognition is related to planning, monitoring, and evaluating. Coupled with a knowledge
pre-test may help students focus on how much more to study and what to focus on specifically. Programs may also want to consider strategies for supporting knowledge remediation, since academic at-risk students who accurately self-assess that they have low confidence may not translate that assessment into increased study time in a given area.\textsuperscript{15}

**Didactic curriculum.** The cumulative GPA at the end of the didactic curriculum was significantly associated with the PCOA Total Scaled Score. While this variable was positively associated with the overall score, as seen in previous PCOA studies, the PCOA Prep test explained a greater portion of the variance. Therefore, although a student’s GPA at the end of the didactic curriculum may help programs identify at-risk students, a better screening tool for at-risk students may be to offer a cumulative knowledge test. One study in Science found that students who read a passage and then took a test retained more than students who repeatedly studied material or drew detailed diagrams that documented what they learned, therefore highlighting the importance of retrieval practice to enhance learning.\textsuperscript{14} Ultimately, students should take tests if they want to know how well they know given content. Tests like the PCOA Prep help students identify what they know and what they don’t know, which can lead to strategic studying approaches for the future.

**Demographics.** The demographic results revealed gender/sex accounted for two percent of the unique variance for the Area 1 Basic Biomedical Sciences model where being female was associated with a decreased score. A difference in gender/sex was also noted in another PCOA study that found a significant difference on the gender/sex variable, which is why we collected this variable for analysis.\textsuperscript{8} The demographic results also revealed that race/ethnicity accounted for two percent of the unique variance for the overall PCOA Total Scaled Score with the PCOA Prep model. Although previous PCOA studies did not find race/ethnicity differences on the PCOA test, one study found a difference on Pre-NAPLEX test scores,\textsuperscript{10} which is why we collected this variable for analysis. In addition to the PCOA Total scaled score, being a minority was associated with a decrease in predicted scores in Area 2 (pharmaceutical sciences), 3 (social, behavioral, and administrative sciences), and 4 (clinical sciences) scores, however, race/ethnicity accounted for no more than 2% of the unique variance in these models.
Additional research is needed to further evaluate the impact of race/ethnicity and gender/sex on the PCOA test.

**Limitations.** There were two main limitations to the current study. First, the study was conducted at a single institution, which may limit the generalizability of the results. Second, the PCOA Prep was a local examination created at the University of Oklahoma and is not available to other colleges and schools of pharmacy. However, the test could be created by asking content experts within a college/school of pharmacy to identify the five most important content areas in a given course and write an objective and related test question for each important area. If every course offered approximately five test questions, a 100-item multiple-choice test could be created. Programs could also recycle a limited number of existing test questions from courses to create a cumulative knowledge examination. Creating this preparatory examination should not be resource or time intensive, especially if programs are currently using electronic testing.

**CONCLUSION**

This study revealed that student performance on a locally created cumulative knowledge test best predicted the PCOA Total Scaled Score. These results offer insights into additional contributing factors that influence students’ PCOA performance and how colleges/schools of pharmacy could identify at-risk students who may need knowledge remediation prior to APPEs. While early preparation may help increase PCOA scores, it is important to emphasize that engaging in early PCOA preparation and assessment allows students more time to remediate knowledge deficiencies so that they can retrieve and use that knowledge while on APPEs. Programs may also want to evaluate additional predictors of PCOA performance including the number of PCAT attempts and student PCOA content area confidence, since these were correlated with PCOA Total Scaled Scores.

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Table 1. Demographic, Pre-Pharmacy, and Pharmacy Academic Characteristics

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<th>Characteristics</th>
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<td>81 (45)</td>
</tr>
<tr>
<td>Age (years) at PCOA Examination</td>
<td>28.0 (5.4)</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
</tr>
<tr>
<td>Majority</td>
<td>97 (54)</td>
</tr>
<tr>
<td>White</td>
<td>97 (54)</td>
</tr>
<tr>
<td>Minority</td>
<td></td>
</tr>
<tr>
<td>American Indian or Alaska Native</td>
<td>4 (2)</td>
</tr>
<tr>
<td>Asian</td>
<td>52 (29)</td>
</tr>
<tr>
<td>Black or African American</td>
<td>10 (6)</td>
</tr>
<tr>
<td>Hispanic or Latino</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Two or more races</td>
<td>13 (7)</td>
</tr>
<tr>
<td>Undergraduate Science GPA</td>
<td>3.27 (0.48)</td>
</tr>
<tr>
<td>Undergraduate Cumulative GPA</td>
<td>3.44 (0.36)</td>
</tr>
<tr>
<td>Graduate credit hours earned prior to admission</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>166 (93)</td>
</tr>
<tr>
<td>At least one hour</td>
<td>13 (7)</td>
</tr>
<tr>
<td>Number of PCAT Attempts</td>
<td></td>
</tr>
<tr>
<td>One</td>
<td>97 (54)</td>
</tr>
<tr>
<td>More than one</td>
<td>82 (46)</td>
</tr>
<tr>
<td>PCAT Composite Score</td>
<td>413 (10)</td>
</tr>
<tr>
<td>PCAT Verbal</td>
<td>413 (17)</td>
</tr>
<tr>
<td>PCAT Biology</td>
<td>418 (15)</td>
</tr>
<tr>
<td>PCAT Chemistry</td>
<td>420 (18)</td>
</tr>
<tr>
<td>PCAT Quantitative</td>
<td>409 (15)</td>
</tr>
<tr>
<td>PCAT Reading</td>
<td>407 (16)</td>
</tr>
<tr>
<td>Course Remediation</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>162 (91)</td>
</tr>
<tr>
<td>One or more courses</td>
<td>17 (10)</td>
</tr>
<tr>
<td>Graduation</td>
<td></td>
</tr>
<tr>
<td>On-Time</td>
<td>173 (97)</td>
</tr>
<tr>
<td>Delayed (Academic or Personal)</td>
<td>6 (3)</td>
</tr>
<tr>
<td>Cumulative GPA at end of didactic program</td>
<td>3.34 (0.46)</td>
</tr>
<tr>
<td>PCOA Prep Examination</td>
<td>80.7 (7.79)</td>
</tr>
</tbody>
</table>
Table 2. Survey of Self-Reported Confidence in Knowledge, Study Habits and Results of PCOA Content Areas
Scaled Scores*

<table>
<thead>
<tr>
<th>PCOA Content Area</th>
<th>Percent of responses</th>
<th>Mean (SD) PCOA Area 1 Ss&lt;sup&gt;A&lt;/sup&gt;&lt;sup&gt;B&lt;/sup&gt;C&lt;sup&gt;C&lt;/sup&gt;</th>
<th>Mean (SD) PCOA Area 2 Ss&lt;sup&gt;B&lt;/sup&gt;C&lt;sup&gt;C&lt;/sup&gt;</th>
<th>Mean (SD) PCOA Area 3 Ss&lt;sup&gt;C&lt;/sup&gt;</th>
<th>Mean (SD) PCOA Area 4 Ss&lt;sup&gt;C&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area 1: Basic Biomedical Sciences</td>
<td></td>
<td>345.2 (60.4)</td>
<td>376.7 (65.1)</td>
<td>433.3 (81.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22%</td>
<td>56%</td>
<td>22%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area 2: Pharm. Sciences</td>
<td></td>
<td>367.7 (56.8)</td>
<td>378.9 (54.7)</td>
<td>409.2 (59.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11%</td>
<td>62%</td>
<td>27%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area 3: Social, Behav. &amp; Admin. Sciences</td>
<td></td>
<td>365.0 (45.2)</td>
<td>385.6 (55.5)</td>
<td>396.9 (54.8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8%</td>
<td>49%</td>
<td>42%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area 4: Clinical Sciences</td>
<td></td>
<td>351.6 (37.1)</td>
<td>378.7 (52.0)</td>
<td>395.7 (47.4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11%</td>
<td>55%</td>
<td>35%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*<sup>n</sup>=168 due to 11 (6%) missing in survey

<sup>A</sup>Using Tukey multiple comparison procedure (MCP), statistical difference found between ‘No to Little Confidence’ versus ‘Average Confidence’

<sup>B</sup>Using Tukey MCP, statistical difference found between ‘No to Little Confidence’ versus ‘Confident to Very Confident’

<sup>C</sup>Using Tukey MCP, statistical difference found between ‘Average Confidence’ versus ‘Confident to Very Confident’

SS=Scaled Score
Table 3. Stepwise Multiple Linear Regression modeling PCOA Total Scaled Score

<table>
<thead>
<tr>
<th>Variable Category</th>
<th>Variable</th>
<th>Zero-Order Correlation&lt;sup&gt;a&lt;/sup&gt; (95% CI) with PCOA Total SS</th>
<th>Model 1: Excluding PCOA Prep</th>
<th>Model 2: Including PCOA Prep</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Semi-partial Correlations&lt;sup&gt;b&lt;/sup&gt; [Squared&lt;sup&gt;c&lt;/sup&gt;]</td>
<td>Adjusted R²=0.5306</td>
<td>Adjusted R²=0.6125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parameter Estimates (Intercept= -443.00)</td>
<td>Semi-partial Correlations</td>
<td>Parameter Estimates (Intercept= -428.50)</td>
</tr>
<tr>
<td>PCOA Prep</td>
<td>In-house PCOA Prep examination</td>
<td>0.66 (0.56–0.73)*</td>
<td>NA</td>
<td>0.31 [0.09]</td>
</tr>
<tr>
<td></td>
<td>Cumulative GPA at end of didactic program</td>
<td>0.57 (0.47–0.67)*</td>
<td>NA</td>
<td>0.99 [0.01]</td>
</tr>
<tr>
<td>Didactic Curriculum</td>
<td>Remediation of any course</td>
<td>-0.19 (-0.33–0.04)*</td>
<td>0.36 [0.13]</td>
<td>17.82</td>
</tr>
<tr>
<td></td>
<td>Graduation delayed</td>
<td>-0.11 (-0.25–0.04)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>0.04 (-0.10–0.19)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Demographic</td>
<td>Gender/sex</td>
<td>-0.05 (-0.19–0.09)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Race/Ethnicity</td>
<td>-0.26 (-0.39–0.12)*</td>
<td>0.20 [0.04]</td>
<td>-19.79</td>
</tr>
<tr>
<td></td>
<td>Undergraduate Science GPA</td>
<td>0.29 (0.15–0.42)*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Undergraduate Cumulative GPA</td>
<td>0.24 (0.09–0.37)*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Graduate Credit Hours</td>
<td>0.11 (-0.04–0.25)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>PCAT Attempts</td>
<td>-0.28 (-0.41–0.14)*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>PCAT Composite Score</td>
<td>0.51 (0.39–0.61)*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Admissions</td>
<td>PCAT Verbal</td>
<td>0.46 (0.34–0.57)*</td>
<td>0.27 [0.07]</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>PCAT Biology</td>
<td>0.36 (0.22–0.48)*</td>
<td>0.14 [0.02]</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>PCAT Chemistry</td>
<td>0.30 (0.16–0.43)*</td>
<td>0.09 [0.01]</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>PCAT Quantitative</td>
<td>0.14 (-0.01–0.28)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>PCAT Reading</td>
<td>0.28 (0.14–0.41)*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Study Habits</td>
<td>Studied ≤5 hours for PCOA</td>
<td>-0.17 (-0.31–0.03)*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Studied &gt;5 hours for PCOA</td>
<td>0.10 (-0.05–0.24)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Class Identifier (included to control for)</td>
<td>0.21 (0.07–0.35)*</td>
<td>0.07 [0.00]</td>
<td>6.68*</td>
</tr>
</tbody>
</table>

<sup>a</sup>Pearson correlation coefficient for continuous variables and point biserial correlation for dichotomous; represents the bivariate relationship with predictor and PCOA total scaled score

<sup>b</sup>Semi-partial (part) correlations represent the correlation between the predictor and PCOA total scaled score after controlling for other predictors in the model

<sup>c</sup>Squared semi-partial correlations represent the proportion of variance that is uniquely explained by the predictor after accounting for other predictors in the model

<sup>d</sup>denotes statistical significance of p<0.05

<sup>e</sup>denotes the variable is not significant in model but included for parity with other models presented
<table>
<thead>
<tr>
<th>Variable</th>
<th>Modeling PCOA Area 1: Basic Biomedical Sciences</th>
<th>Modeling PCOA Area 2: Pharmaceutical Sciences</th>
<th>Modeling PCOA Area 3: Social, Behav. &amp; Admin. Sciences</th>
<th>Modeling PCOA Area 4: Clinical Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>NA</td>
<td>-354.2</td>
<td>NA</td>
<td>-724.74</td>
</tr>
<tr>
<td>In-house PCOA Prep examination</td>
<td>0.20 [0.04]</td>
<td>2.90</td>
<td>0.41 [0.17]</td>
<td>3.33</td>
</tr>
<tr>
<td>Cumulative GPA at end of didactic program</td>
<td>0.14 [0.02]</td>
<td>36.36</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Graduation delayed</td>
<td>0.10 [0.01]</td>
<td>55.37</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gender/Sex</td>
<td>0.14 [0.02]</td>
<td>-24.51</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td>-</td>
<td>-</td>
<td>0.14 [0.02]</td>
<td>-15.44</td>
</tr>
<tr>
<td>Undergraduate Science GPA</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Graduate Credit Hours</td>
<td>-</td>
<td>-</td>
<td>0.10 [0.01]</td>
<td>26.31</td>
</tr>
<tr>
<td>PCAT Attempts</td>
<td>0.10 [0.01]</td>
<td>-20.15</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PCAT Verbal</td>
<td>-</td>
<td>-</td>
<td>0.20 [0.04]</td>
<td>0.74</td>
</tr>
<tr>
<td>PCAT Biology</td>
<td>0.17 [0.03]</td>
<td>1.01</td>
<td>0.20 [0.04]</td>
<td>0.81</td>
</tr>
<tr>
<td>PCAT Chemistry</td>
<td>-</td>
<td>-</td>
<td>0.14 [0.02]</td>
<td>0.46</td>
</tr>
<tr>
<td>PCAT Quantitative</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Studied ≤5 hours for PCOA</td>
<td>0.10 [0.01]</td>
<td>-17.71</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Studied &gt;5 hours for PCOA</td>
<td>-</td>
<td>-</td>
<td>0.10 [0.01]</td>
<td>17.75</td>
</tr>
<tr>
<td>Class Identifier (included to control for)</td>
<td>0.10 [0.01]</td>
<td>15.63</td>
<td>0.14 [0.02]</td>
<td>18.37</td>
</tr>
</tbody>
</table>
Appendix 1. PCOA Prep Examination Objectives

FALL P1
PHARMACY PRACTICE 1
1. Interpret a prescription and select the language best worded for a patient’s understanding of the directions.
2. Given a medical abbreviation, match it with the appropriate diagnosis.
3. Given mg/kg dose and/or strength of liquid medication, determine volume of dose and volume of prescription to dispense.

PHARMACEUTICS 1
1. Describe methods to enhance a drug’s solubility in a solvent.
2. Identify the processes of drug elimination from the body.
3. Select assay techniques used to characterize a drug molecule.

BIOCHEMISTRY
1. Identify primary, secondary, tertiary and quaternary structures of proteins.
2. Identify the basic properties of enzymes and Michaelis-Menten kinetics.
3. Identify the conditions that affect the rate of enzyme-catalyzed reactions.
4. Identify amino acids as essential, ketogenic or glucogenic and their sources.

PHARMACY MATH
1. Calculate common pharmacy math problems involving percent strength, ratio strength, and other expressions of concentrations and convert between the different expressions.
2. Calculate common pharmacy math problems involving percent strength, percent weight-volume, percent weight-weight, and percent volume-volume.

HUMAN PHYSIOLOGY
1. Apply the Frank Starling mechanism to explain changes in cardiac output.
2. Given a patient taking a cholinergic antagonist, identify how it will affect the cardiovascular system, eyes, and gastrointestinal tract.
3. Match the changes in hormone levels during the menstrual cycle and the effects they have on the female reproductive system.

SPRING P1
PHARMACY PRACTICE 2
1. Identify the brand/generic names and indications/common uses/adverse effects for the top 200 drugs, including the following products: Pravachol, Levaquin, Glucotrol XL, Bumex, Cardizem, Procardia, Isoptin, Isordil, Cozaar, Advair, Prinivil, Xalatan, Minocin.
2. Classify the information gathered about a patient as subjective or objective when completing a SOAP note.

PRINCIPLES OF DRUG ACTION 1
1. Compare the strengths of the four main types of chemical bonding that influence molecular interactions of a drug.
2. Evaluate a drug’s comparative efficacy and potency based on dose-response curves as it relates to drug-receptor interactions.
3. Identify the characteristics of phase II drug metabolism reactions and the enzymes involved in carrying out those reactions.

PRINCIPLES OF DRUG ACTION 1
1. Identify therapeutic or adverse reactions to agonists or antagonists affecting the adrenergic receptor.
2. Identify therapeutic or adverse reactions to cholinergic or anticholinergic drug.
3. Identify the biological actions of prostaglandin E and prostacyclin and rank inhibitors of prostaglandin synthesis in order of potency.

IMMUNOLOGY
1. Given a patient describing a reaction to a drug, identify the type of allergic reaction.
2. Based on the ACIP, select the best immunization recommendation.
3. Given a patient with rheumatoid arthritis, identify the efficacy limitations for recombinant biological.

DRUG INFORMATION SYSTEMS
1. Identify characteristics that distinguish credible versus biased sources of online medical information.
2. Given a drug information question, select the most appropriate commonly available print information resources.
3. Given an excerpt from a drug information source, select the appropriate response to a medication information question.

**PHARMACUETICS 2**
1. Explain the role of starch in tablet formulations.
2. State the advantages of transdermal drug delivery.
3. Describe various vaginal drug delivery systems.

**P2 FALL**
**PHARMACY PRACTICE 3**
1. Identify pharmacologic mechanism(s) of action and adverse effects of adrenergic agents, anticholinergic, and cholinergic agents.
2. Identify pharmacologic mechanism(s) of action for alpha- and/or beta-blocking agents.
3. Identify a specified drug for an adverse effect.

**BIOTECHNOLOGY**
1. Given an allelic variation in cytochrome P450 genes identify how it leads to altered drug metabolism.
2. Identify the basic changes to antibody proteins used to create chimeric and humanized monoclonal antibodies.
3. Identify the key concepts in solid phase peptide synthesis (SPPS).
4. Identify how knockout mouse models are used to both understand gene-disease associations as well as the role of specific genes in drug metabolism.

**PHARM & HEALTH CARE MGMT 1**
1. Select the basic provisions, components, and eligibility criteria for Medicare program.
2. Compare the public health approach to the clinical treatment approach for the natural history of disease.
3. Identify the perspective used in decisions by healthcare providers, third-party insurers, and government health programs.
4. Explain 2 problems that Managed Care Organizations (MCOs) were developed to resolve and demonstrate how the three competing objectives of MCOs contribute to the solutions.

**CLINICAL COMMUNICATIONS**
1. Select the statement that best verbalizes empathy toward patients.
2. List and classify the seven types of drug therapy problems.
4. Given a question, identify as closed-ended, leading, open-ended, and probing.
5. Select the most appropriate way to verify a patient’s knowledge before, during, and after a counseling session.

**PHARM CARE GENERAL HEALTH MODULE**
1. Identify pharmacokinetic alterations (i.e., absorption, distribution, metabolism, excretion) noted in selected populations (e.g., pediatrics, geriatrics, obesity, women).
2. Integrate subjective and objective information to arrive at an assessment of a patient with subjective complaints, electrolyte abnormalities and an acid/base disorder.
3. Given a patient case, develop a pharmaceutical care plan to treat diarrhea.
4. Match the mechanism of action, efficacy, pharmacokinetics, or adverse effects to the antiemetic agents. Select the appropriate antiemetic agent to treat different categories of emesis.

**PHARMACOKINETICS**
1. Calculate a creatinine clearance using the Cockcroft-Gault method and select the appropriate dose of a medication based on provided dosing recommendations.
2. Given specific patient data and pharmacokinetic equations, calculate the decay time of serum drug concentrations.
3. Given specific patient information (height, weight, serum creatinine) and pharmacokinetic profile of a drug (kel and Vd), determine renal clearance for aminoglycosides and vancomycin using IBW, ABW or DW as indicated.
4. Calculate basic pharmacokinetic parameters such as volume of distribution, kel, t(1/2), clearance.
5. Using pharmacokinetic data, calculate an intravenous infusion rate.

**P2 SPRING**

**7222 PHARMACY PRACTICE 4**
1. Given a patient’s medical history and medication regimen, determine the medication that should be discontinued due to safety issues.
2. Accurately perform fundamental pharmacy math calculations.
3. Select a therapeutic alternative to a prescribed medication.

**7713 PHARM & HEALTH CARE MGMT 2**
1. Given a health care system providing various pharmacy goods and service, select the outcomes that could be used to evaluate the service.
2. Identify characteristics of strategic planning in organizations.
3. Describe and/or compute ratios for analyzing a company’s profitability, liquidity, or solvency.

**PATIENT ASSESSMENT**
1. Contrast physical exam findings for Bell’s palsy with an acute stroke.
2. Identify proper ways to obtain the following vital signs: blood pressure, pulse, respirations and temperature.
3. Identify signs and symptoms of common pathologic conditions of the skin.

**7824 CARDIOLOGY MODULE**
1. Identify the mechanism of action of anti-platelets (clopidogrel, prasugrel), anticoagulants (direct and indirect; warfarin, fondaparinux, enoxaparin, dabigatran, rivaroxaban), and fibrinolytics (abciximab, alteplase, bivalirudin).
2. Identify the pharmacokinetics of anti-platelets (clopidogrel, prasugrel), and anticoagulants (direct and indirect; warfarin, fondaparinux, enoxaparin, dabigatran, rivaroxaban).
3. Given a patient case, select the appropriate treatment for a heart failure exacerbation.

**7833 RESPIRATORY/RENAL MODULE**
1. Given a patient with COPD, select the appropriate medication regimen for the patient’s COPD stage.
2. State and apply the Cockcroft-Gault equation for estimating creatinine clearance when provided specific patient parameters and laboratory values.
3. Given renal dosing guidelines for a drug, select the appropriate dosage regimen based on the patient’s calculated creatinine clearance.
4. Given a patient’s estimated glomerular filtration rate, classify their chronic kidney stage according to the National Kidney Foundation.
5. Given a patient’s level of asthma control, select the preferred therapies with classification, based on the Stepwise Approach in the EPR-3 Guidelines for the Diagnosis and Management of Asthma.
6. Identify first line therapy for mild persistent asthma.

**7891 DERMATOLOGY MODULE**
1. Based on the patient’s history and the type of injury, select the appropriate recommendation for a tetanus vaccination using the CDC guidelines.
2. Given a patient case, identify counseling points that should be discussed on the use of topical corticosteroid formulations.
3. Select the most appropriate treatment for a patient with eczema, psoriasis or acne based on guidelines discussed in class.

**P3 FALL**

**PHARMACY PRACTICE 5**
1. Select and/or modify antiplatelet or anticoagulant therapy to optimize outcomes in a patient with atherosclerosis or atrial fibrillation.
2. Select and/or modify therapy to achieve goal blood pressure according to patient characteristics and history.
3. Select and/or modify diabetes therapy to avoid adverse outcomes and/or correct hypoglycemia according to patient characteristics and history.

**LAW & ETHICS**
1. Describe the legal standard of care for a pharmacist in processing prescriptions and medication orders.
2. Identify violations of the Controlled Substances Act.
3. State the “legitimate medical purpose” and “corresponding responsibility” doctrine.
4. Identify the elements of a professional malpractice action against a pharmacist.

**BIOSTATISTICS**
1. Given a study description, select the most appropriate statistical test.
2. Given a confidence interval for an observed sample mean, select the best interpretation of the results.
3. Identify the roles of alpha (α), beta (β), and power in inferential statistical testing.

**ENDOCRINOLOGY MODULE**
1. Create and/or modify a therapeutic plan using insulin to manage type 1 or type 2 diabetes.
2. Given a patient case, recommend a contraception method based on the relative effectiveness of the products and the return to fertility for the woman.
3. Given a patient case, select the best treatment dose, schedule, or therapeutic plan for prevention or treatment of osteoporosis.
4. Define the FDA pregnancy risk categories.

**GASTROENTEROLOGY/RHEUMATOLOGY MODULE**
1. For medications used to treat gastroesophageal reflux disease, match the drug with its mechanism of action.
2. Differentiate therapy used to treat hyperuricemia from that used to treat acute attacks of gout.
3. State the major adverse effects for the drugs used to treat inflammatory bowel disease (IBD).
4. Identify a hormone or enzyme as a product of the exocrine or endocrine pancreas.

**INFECTIOUS DISEASES MODULE**
1. Identify the spectrum of activities of antibiotics.
2. Select appropriate antibiotic therapy based on organism susceptibility (*Pseudomonas aeruginosa, Enterococcus faecalis, E. coli, methicillin-resistant Staphylococcus aureus [MRSA], Haemophilus influenzae*) and knowledge of drug pharmacology.
3. Select appropriate empiric antibiotic therapy (based on usual organism susceptibility) for anaerobic and atypical bacteria.