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Short Communications

# A needs assessment of pharmacokinetic skills performed on advanced pharmacy practice experiences by student pharmacists

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ABSTRACT

*Introduction:* Pharmacokinetic (PK) calculations are an important competency for pharmacy students, however, there is little to guide which medications should be included in pharmacy curricula. Additionally, many new medications require therapeutic drug monitoring (TDM)—but not PK calculations—to ensure safe use. The objectives of this study were to quantify which medications are most frequently encountered by pharmacy students during advanced pharmacy practice experiences (APPE's) and to what extent PK calculations or TDM were completed by students while on APPE's at the University of New England.

*Methods:* Fourth-year students were surveyed upon completion of their advanced pharmacy practice experiences (APPE's).

*Results:* Pharmacokinetic calculations occurred most frequently on institutional rotations. Vancomycin and aminoglycosides were the two most common medications pharmacy students were asked to perform PK calculations for while on APPE's. Therapeutic drug monitoring occurred most frequently on institutional rotations. Therapeutic drug monitoring also occurred more often than pharmacokinetic monitoring on ambulatory care rotations.

*Conclusions:* Pharmacokinetic calculations as well as therapeutic drug monitoring requiring no calculations were both commonly encountered by student pharmacists while on APPE rotations. Changes to clinical guidelines have impacted the types of medications students are expected to have proficiency with, and more broadly defined therapeutic drug monitoring competencies may be important for ambulatory care APPE's.

## Introduction

The recent approval and implementation of the Accreditation Council for Pharmacy Education (ACPE) Standards 2016 has led to the adoption of new curricular outcomes for colleges and schools of pharmacy.[1] These outcomes, published by the Center for Advancement of Pharmacy Education (CAPE) in 2013, reflect a focus on designing curriculums to provide "practice-ready" entry-level graduates through the inclusion of skill and attitudinal outcomes in addition to knowledge-based ones.[2] While the CAPE outcomes are helpful in outlining broad learning outcomes, the Standards 2016 Appendix 1 includes broad didactic content areas that are considered "central to a contemporary, high-quality, pharmacy education." Within these, the topic of clinical pharmacokinetics (PK) is defined as

> application of basic pharmacokinetic principles and mathematical models to calculate safe and effective doses of drugs for individual patients, and adjust therapy as appropriate though the monitoring of drug concentration in biological fluids.[1]

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The inclusion of clinical pharmacokinetics in the PharmD curriculum is supported by growth in a demand for PK services within the health care system and by a joint taskforce of American Society of Health-System Pharmacists (ASHP) and the Accreditation Council for Pharmacy Education (ACPE) that identified PK skills as a core entry-level skill for practicing pharmacists.[3,4] Looking ahead, as the clinical service of pharmacists increases, the American College of Clinical Pharmacy (ACCP) has called for mandatory residency training as a prerequisite for entry into pharmacy practice by 2020.[5] If the profession adopts this approach to post-graduate training, pharmacy programs must ensure their graduates are properly trained to meet the needs of a post graduate year 1 (PGY-1) residency program. Similar to the ACPE Standards, the ASHP accreditation guidelines for PGY-1 residency programs include patient specific care as a core competency and include pharmacokinetics as an example of such care.[6] Garris et al.[7] suggest that PGY-1 residency applicant's prior experience on APPE resulted in high self-reporting of experience with pharmacokinetics prior to the start of PGY-1 residencies. These findings suggest PK skills are an expected area of competency in the workforce for new graduates.

It is clear that clinical pharmacokinetics remains a relevant topic in current pharmacy curricula, however, there is little literature to guide which medications remain relevant to current clinical practice. A search of ERIC-EBSCO and Medline databases using "curriculum" AND "pharmacokinetics" revealed a total of eight and 99 published papers in each database, respectively. Of these, 20 were related to education in the pharmacy profession; three were published prior to 1980 and have little relevance to the curricular outcomes currently.[8–10] Ten investigated teaching methods within a PK course,[11–20] one study by Gerber et al.[21] reviewed a teaching methodology used in a pediatric pharmacy course but did include references to specific medications (digoxin and enoxaparin). Two studies evaluated assessment techniques, one evaluated weekly quizzes[22] and another evaluated the use of Objective Structured Clinical Examination (OSCE) to assess competence in learning outcomes including pharmacokinetics but it did not detail specific medications.[23] Of the remaining studies, two investigated post-graduate PK experience[7,24] and the remaining two documented curricular content. A survey of PharmD curricula by Pancobro[25] in 1987 concluded a significant number of schools required PK coursework; however, no specific content was reported. Spruill et al.[26] published a survey on the curricular content of pharmacokinetic courses in U.S. colleges of pharmacy indicating there is large variation in delivered content and instructional design. Results of their national survey documented high inclusion rates ( > 65%) for content areas including vancomycin, aminoglycosides, theophylline, phenytoin, and digoxin. Moderate inclusion rates (35–65%) were reported for content areas including lithium, cyclosporine, procainamide, valproic acid, phenobarbital, and carbamazepine.

Currently, there is a paucity of literature describing the expectations of content knowledge for APPE rotations and therefore little to inform the inclusion of content in didactic courses. The purpose of this study is to quantify the incidence of pharmacokinetic calculations and more general therapeutic drug monitoring on APPE rotations, identify the medications most frequently associated with performance of pharmacokinetic calculations and quantify the type of APPE rotations during which these calculations and therapeutic drug monitoring take place.

## Methods

A survey instrument with three sections consisting of eight questions was developed and received exempt approval by the University of New England Institutional Review Board. Fourth-year pharmacy students at the University of New England, a private non-profit university, were contacted via email during the last week of their last APPE block and were provided a link to fill out an electronic survey via Google Docs. A follow-up email was sent out after one week requesting anyone who did not fill out the survey to do so. Email addresses were collected from respondents to ensure duplicate responses could be removed and respondents were not able to view other responses upon completing the survey. Lastly, a verbal announcement was made to the class during their mandatory board review course to increase survey response rates. The Office of Experiential Education provided details on the location of each respondent's APPE rotations for analysis.

Section one of the survey consisted of two questions to determine the frequency of performance of pharmacokinetic calculations and therapeutic drug monitoring by fourth-year pharmacy students. Pharmacokinetic calculations were defined by the investigator as "performing a mathematical calculation to determine either an empiric regimen (dose or frequency) or in response to plasma level on a patient." Therapeutic drug monitoring (TDM) was defined by the investigator as "determining either an empiric regimen or interpreting a plasma level on a patient without the use of calculations (i.e., nomogram use and infusion protocols)." These definitions were derived from the definitions included in the ACPE Standards 2016.[1] A focus group of local pharmacists reviewed the definitions for clarity and understanding and provided feedback to improve accuracy of the descriptions. Additionally, examples were provided along with each definition to help in clarifying what types of tasks were considered PK calculations versus TDM (Table 1).

Section two of the survey focused on pharmacokinetic calculations and included the following four questions asking students to: (1) identify the medications for which calculations were performed; (2) self-rate their confidence in their calculation abilities for each medication; (3) identify the type of APPE rotation on which they were requested to perform calculations, and (4) identify when during the year they performed the calculations (which APPE block of eight possible blocks).

The last section focused on therapeutic drug monitoring activities and included two questions that identified the type APPE rotation on which they were requested to perform therapeutic drug monitoring and when during the year they had to perform therapeutic drug monitoring (which APPE block of eight possible blocks).

Continuous variables are described using mean and standard deviation: categorical variables are described using median and inter-quartile range. Comparisons between continuous variables were conducted using a student-*t* test and categorical variables were compared using $X^2$ or Fisher's Exact. Statistical significance was defined a priori as $p < 0.05$. Statistical analysis was conducted