

RESEARCH ARTICLES

Pharmacy Informatics Syllabi in Doctor of Pharmacy Programs in the US

Brent I. Fox, PharmD, PhD,^{a,b} Rachel Bongiorno Karcher, PharmD,^{c,d} Allen Flynn, PharmD,^e and Sandi Mitchell, MSIS, BSPHarm^{f,g}

^aDunn School of Pharmacy, Shenandoah University

^bHarrison School of Pharmacy, Auburn University*

^cSchool of Pharmacy, University of Maryland

^dMed-IQ, Baltimore, MD*

^eDepartment of Pharmacy, Saint Joseph Mercy Health System

^fDepartment of Pharmacy, The Johns Hopkins Hospital

^gmaxIT Healthcare, Westfield, IN*

Submitted November 6, 2007; accepted January 28, 2008; published August 15, 2008.

Objectives. To assess pharmacy informatics education, identify current competencies, and develop a foundational set of recommendations.

Methods. Accredited pharmacy programs were contacted. Data were collected using a mixed-mode procedure. Didactic and experiential syllabi were analyzed for compliance with informatics competencies in Accreditation Council for Pharmacy Education (ACPE) Standards 2007.

Results. Thirty-two of 89 schools responded; 25 provided syllabi (36% response rate, 28% submission rate). Twenty-seven didactic and 9 experiential syllabi were received. The syllabi contained a diverse mix of educational content, some of which represented pharmacy informatics content as defined by ACPE. Schools are teaching clinical system terminology, applications, and evaluation.

Conclusions. Many professional programs are not providing instruction in pharmacy informatics. There may be confusion within the academy/profession between *pharmacy informatics* and *drug information practice*. Much work is required for programs to become compliant with the ACPE 2007 pharmacy informatics competencies.

Keywords: informatics, information, technology, curriculum

INTRODUCTION

Medical informatics has been defined as “the field of information science concerned with the analysis and dissemination of data through the application of computers”¹ and as “the scientific field that deals with biomedical information, data, and knowledge – their storage, retrieval, and optimal use for problem-solving and decision-making.”² Although medical informatics dates back to the mid-1900s^{2,3} and medicine and nursing both have professional associations focused on informatics,^{4,5} informatics is still a relatively new area within pharmacy.

As a profession, pharmacy deals in the commodity of knowledge – knowledge about patients, medications, disease states, and the medication-use process. Institutional and community pharmacy have a long history of using

computing technology to manage medication and reimbursement processing.⁶ We assert that there is a role for pharmacy informatics. Although various associations have slightly different definitions,^{7,8} we define pharmacy informatics as “the scientific field that utilizes a systems approach to medication-related data and information - including its acquisition, storage, analysis, and dissemination - in the delivery of optimal medication-related patient care and health outcomes.” Furthermore, information technology (IT) and pharmacy informatics are intricately linked because IT tools provide the infrastructure for information management to support pharmacy informatics.

Many pharmacists practice informatics on a daily basis. Technologies like computerized prescriber order entry (CPOE), clinical decision support (CDS), electronic prescriptions (eRx), and bar code systems are some of the technologies now used in practice. Nevertheless, past data suggest few professional pharmacy programs provide formal pharmacy informatics education.⁹ The present study aims to update and expand on previous work that described pharmacy informatics academic activity in 2004.

Corresponding author: Brent I. Fox, PharmD, PhD. Address: Auburn University Harrison School of Pharmacy, 207 Durstan Hall. Auburn University, AL 36849. Tel: 1-334-844-8348. Fax: 1-334-844-8353. E-mail: foxbren@auburn.edu

*Indicates author’s current affiliation.

Several leading professional organizations have highlighted the need for informatics-trained clinicians. The Institute of Medicine's (IOM) Quality Chasm report emphasizes that healthcare professionals practice in a flawed system that leads to errors and patient deaths.¹⁰ As a follow-up to this report, the IOM convened a multi-disciplinary summit of health profession leaders to identify strategies for reforming clinical education. Five IOM core competencies, one of which is utilizing the tools and techniques of informatics, were identified for all healthcare professionals.¹¹

As educators, we should recognize that professional associations have concluded that the need for IT specialists in healthcare is growing, but the number of professionals trained in informatics is not increasing fast enough to meet the demand.¹² Therefore, AMIA has begun an initiative to provide informatics education and training for 10,000 healthcare professionals by 2010.¹³ The International Medical Informatics Association (IMIA) has published consensus international recommendations in health informatics and medical informatics education that include the development of coursework in health and medical informatics as part of educational programs in medicine, nursing, health care management, dentistry, pharmacy, public health, health record administration, and computer science.¹⁴ The American Society of Health-Systems Pharmacists' (ASHP) 2015 Initiative acknowledges the importance of pharmacy informatics by focusing specifically on the pharmacist's ability to utilize information technologies in practice to improve medication-related outcomes. ASHP seeks to, "increase the extent to which health systems apply technology effectively to improve the safety of medication use."¹⁵ Additionally, ASHP has recently formed a membership section for informatics.¹⁶

Pharmacy programs accredited by the Accreditation Council for Pharmacy Education (ACPE) are required to meet ACPE's Standards and Guidelines for Curriculum.¹⁷ ACPE's Standards 2007, published February 17, 2006, and effective July 1, 2007, contains specific language regarding informatics. The Standards specifically acknowledge IOM's 5 core competencies as requirements and, in Guideline 12.1, specifically state that pharmacy graduates must be able to "demonstrate expertise in informatics."¹⁸ According to ACPE, informatics competencies include "basic terminology (data, information, knowledge, hardware, software, networks, information systems, information systems management); reasons for systematic processing of data, information and knowledge in health care; and the benefits and current constraints in using information and communication technology in health care."¹⁸ (See Table 1.)

Table 1. Classification Categories for Pharmacy Informatics Content

Informatics Level I	Basic Terminology (data, information, knowledge, hardware, software, networks, information systems, information systems management)
Informatics Level II	Reasons for systematic processing of data, information, and knowledge in healthcare
Informatics Level III	Benefits and current constraints in using information and communication technology in healthcare

Recognizing that informatics is now a requirement in pharmacy education, we set out to determine what informatics content was being taught in ACPE-accredited pharmacy programs. Specifically, this study had 3 objectives: to identify and analyze the current state of informatics education, to identify current competencies in informatics education, and to develop a core set of recommendations for teaching informatics. The study objectives were to be met through review and analysis of syllabi from existing informatics courses and clerkships within ACPE-accredited pharmacy programs.

METHODS

A protocol was submitted to the Shenandoah University Human Subjects Review Board (HSRB) and approved for involvement of human subjects. Using data from a previously published study, a list of existing pharmacy informatics courses in 89 pharmacy programs recognized as regular members of the American Association of Colleges of Pharmacy (AACCP) was created. The course list was updated in late January 2006 using the methods previously described.⁹

An invitation letter to participate in the study and preaddressed, stamped return envelope were sent to each of the 89 schools identified. In the event that the study investigators identified an informatics course, the course names (and instructor, when available) were included in the invitation letter. If the instructor's name was known, it was also used as the mailing address on the invitation letter. For pharmacy programs that did not have an identified informatics course, or if the instructor for an existing course could not be identified, the letter and envelope were addressed to the head of the pharmacy practice department, or the nearest equivalent within the school's organizational structure.

Individuals who elected to participate were asked to submit informatics syllabi from existing courses and

clerkships. Invitation letters were mailed in February 2006. Two reminder e-mails were sent to all letter recipients 2 weeks and 4 weeks after the initial letter mailing.

Any reply, including a reply indicating that informatics was not taught, was counted as a response. Responders were given 3 options for submitting their syllabi: using the envelopes that were provided, attached to an e-mail, or via a Web-based submission site posted on a university server.

In the first step of the syllabi review, each author independently analyzed all submitted documents. The authors compared submitted syllabi to the informatics competencies detailed in Guideline 12.1 of ACPE's Standards 2007. In this phase of independent analysis, each author compared the syllabus information (objectives, reading assignments, lecture topics, projects, assessments, etc) to the Standards and categorized the syllabi into 1 of 5 content categories. Those syllabi content categories were: (1) meets ACPE Level I requirements only; (2) meets ACPE Level I and Level II requirements only; (3) meets all ACPE requirements for Level I, II and III; (4) includes drug information content without informatics content; and (5) does not include drug information or informatics content. For the purposes of this study, *drug information* was defined as activities relating to "the provision of unbiased, well-referenced, and critically evaluated information on any aspect of pharmacy practice."¹⁹

The second step of the syllabi review process was conducted via multiple conference calls to reconcile any categorization variation among the authors. Where differences existed, each investigator presented rationale for their categorization based on specific examples in the submitted syllabi. To complete this step, the investigators continued to compare their individual categorizations with the syllabi content and the ACPE standards until unanimous agreement was reached for categorizing each syllabus.

Once the content categorization process was completed, themes were extracted to identify the content currently taught in informatics courses. Competencies were developed from specific course objectives taken directly from submitted course documentation. The investigators then used content from the submitted, categorized syllabi and ACPE Guideline 12.1 for informatics to develop foundational, core competencies for informatics education. Additionally, the investigators drew upon other resources and individual experiences in developing these foundational competencies.^{3,15,17,18,20-23} Information from these other resources was primarily used to supplement information identified during the syllabi review. Specifically, the authors reviewed these resources and

identified informatics skills and abilities that, based on their experience, doctor of pharmacy graduates should be able to perform. The authors discussed the applicability of these skills and abilities to acute and ambulatory care pharmacy practice. The skills and abilities that the authors agreed upon as most applicable to these practice areas are listed in Table 2.

RESULTS

Responses were received from 32 of the 89 schools surveyed (36% response rate). Of those 32 responses, 25 included syllabi information. No invitation letters or reminder e-mails were returned due to incorrect addresses. The methods of transmission for responses included 8 responses through regular mail, 14 through e-mail, and 10 through the Web. Although a few responses were received within 1 to 4 weeks after the study collection period concluded, the late responses were not expected to differ from responses received prior to the submission cutoff date and were therefore included in the data analysis. The 5 late submissions underwent the same review process as the other syllabi.

Responses from the 25 programs that provided course content information included syllabi materials for 27 didactic courses and 9 experiential clerkships. This represents 28% of the population invited to participate. Seven other responses received explained that either informatics was not yet being taught (n=4) or informatics was being taught as an integrated part of the overall pharmacy curriculum (n=3). Table 3 depicts the number of syllabi in each of the 5 study categories. Almost half of the syllabi submitted were for drug information courses. Syllabi for informatics courses were evenly distributed across the 3 escalating levels of informatics content. One course is represented in both the Informatics Level I and Drug Information categories. Six syllabi were received for courses that were not classified by the investigators as courses in informatics or drug information.

Table 1 summarizes the 3 categories of informatics course content level (Levels I, II, and III) as described in the ACPE standards. Courses with Level I content include information on "basic terminology," which encompasses technology terms, informatics terms, and healthcare informatics terms.¹⁸ For technology, the wide range of terms includes hardware, software, and communication protocol principles. Within informatics, the basic understanding of data, data management, project life cycles, and standards are included. For healthcare informatics, common terms include healthcare coding schemas, ontologies, national project acronyms, and trends.

Level II course content includes "reasons for systematic processing of data, information and knowledge in

Table 2. Suggested Core Competencies for Pharmacy Informatics Education^a

Informatics Level I	Informatics Level II	Informatics Level III
<p>ACPE 2007 Standards:</p> <p>Terminology</p> <p>1. Learn Basic Terms <i>Recognize</i> basic informatics terminology and definitions in relation to healthcare information systems (eg, data, information, hardware, software, CPOE, EMR)</p> <p>2. Explain the Concept <i>Define</i> pharmacy informatics and <i>discuss</i> the role of pharmacy informatics in healthcare delivery, including security, privacy, and confidentiality issues, and <i>identify</i> the current and potential roles for pharmacists in this field</p> <p>3. Understand the Need <i>Discuss</i> why the adoption of healthcare information systems is now being called for by those who seek to improve the American healthcare system (eg, United States Department of Health and Human Services, Institute of Medicine)</p>	<p>ACPE 2007 Standards:</p> <p>Systematic Approaches</p> <p>1. Compare Applications <i>Distinguish</i> between the uses, implementation difficulty and overall level of adoption of various medication-management information technology applications including, for example, the electronic medical record (EMR), computerized prescriber order entry (CPOE), clinical decision support (CDS), ePrescribing (e-Rx), computerized intravenous pumps, bar coding at the point of care (BPOC), and automated dispensing machines (ADMs)</p> <p>2. Perform System Analysis <i>Analyze</i> the hardware requirements, software functionality and system integration potential of a proposed new medication-management tool</p> <p>3. Standardize a Process <i>Map</i> a current healthcare work process and <i>measure</i> at least one determinant of the current process. <i>Compare</i> the present process map to a predicted future state process map and <i>analyze</i> the likely impact(s) that the new process will have on the selected measure.</p>	<p>ACPE 2007 Standards:</p> <p>Benefits and Constraints</p> <p>1. Assess Limitations and Barriers <i>Assess</i> existing limitations and barriers to the successful use of the most prevalent medication-use information systems (eg, CPOE, CDS, ADM, BPOC), including security, privacy, and confidentiality issues based on published scientific literature and available business information</p> <p>2. Design and Build <i>Design</i> and <i>build</i> a new relational database tool or another novel software tool to collect, track, share and report on a medication management process (eg, Crash cart replenishment database) using standard project management techniques</p> <p>3. Evaluate Competing Systems <i>Evaluate</i> the strengths and weaknesses of at least two pharmacy or medication-management information systems that are in direct competition with one another and <i>justify</i> the selection of one system for implementation. Include an analysis of the organization and its present needs and an assessment of all the competing vendors in the marketplace including an estimate of return on investment. Make a complete business case for the selected system as part of the final selection report.</p>

^aIdentified during the syllabus review and augmented by other sources and professional experience

healthcare.”¹⁸ This encompasses a general understanding of end user information needs in healthcare and how those needs might be met. The importance of data standards, information quality, information retrieval, and the applicability of clinical information and scientific evidence to decision-making are addressed in Level II. These courses focus on the relationship between design and implementation of information systems and technologies as a method to improve the safety, quality, and efficiency of care.

Level III content refers to courses that discuss the “benefits and current constraints in using information and communication technology in healthcare.”¹⁸ These courses are intended to develop analytical, evaluative, and practical informatics skills. Healthcare information technology project management skills, including definition of scope, planning, implementation and evaluation of results, are included. Level III courses force students to grapple with the challenge of achieving specific outcomes from information technology through an analysis of the people, processes, and problems involved.

Of the informatics syllabi submitted, 4 courses were identified as clerkships. The clerkship courses did not differ considerably from the didactic courses, with 1 clerkship course providing level I informatics content, 1 providing level II content, and 2 courses providing level III content. Several of the didactic courses indicated that class discussion was incorporated into traditional lectures. Using only the collected syllabi, it was not always possible to determine whether the courses were required or elective in nature; however, few of the informatics courses appeared to be required for graduation. Only 2 of the course syllabi specified required texts, while some of the syllabi indicated supplemental and/or required readings. Assessment methods emphasized student participation and project-based assignments (eg, written papers, presentations), although traditional assessment methods, such as examinations and quizzes, were also used. Approximately half of the informatics courses used group projects and half required verbal presentations. The clerkship courses used projects, presentations, and discussions as assessment methods.

Table 4 lists specific competencies from the submitted course syllabi, while Table 2 provides suggested foundational competencies. The competencies are separated into the relevant course content level and further divided into domains describing common themes. As described in the Methods, the investigators developed the suggested foundational core competencies in Table 2 based on themes extracted from the course syllabi and from personal experiences as they related to ACPE Guideline 12.1.

DISCUSSION

Healthcare informatics appears to be firmly established and accepted as an integral component of our healthcare system. Recognition of pharmacy informatics as an important specialty of pharmacy also appears to be increasing within professional associations. However, in our replication of previously published research (conducted prior to initiating this study), only 29 of 80 pharmacy programs with online course information included pharmacy informatics in their online curricula descriptions. This compares to 24 pharmacy programs with identifiable pharmacy informatics courses in 2004.⁹ This increase in identifiable pharmacy informatics courses may indicate ongoing course development efforts to meet ACPE’s Standards 2007. This is a positive, albeit modest sign of progress. However, the results of our syllabus review suggest that formal pharmacy informatics instruction has not made its way into the pharmacy curricula at a majority of colleges of pharmacy. Additionally, our results suggest that many of the existing informatics courses may not comply fully with the curricular guidelines for pharmacy informatics, as defined in ACPE’s latest standards.¹⁸

Our syllabus review indicates that 39% (14 of 36) of submitted informatics courses include components of the informatics competencies found in the new ACPE standards. We believe this is an excellent start toward the development and adoption of pharmacy informatics into the professional pharmacy curriculum. At the same time, these data demonstrate that more work is needed to ensure that all pharmacy students have informatics training prior to graduation.

Interestingly, in our efforts to collect and analyze informatics syllabi, we received more drug information

Table 3. Categorization of Course Syllabi Submissions (N =36^a)

Pharmacy Informatics Courses			Drug Information	Neither Drug Information Nor Informatics ^b
Level I	Level II	Level III		
4	5	5	16	6

^aDoes not include the 4 schools where pharmacy informatics was not taught or the 3 schools where pharmacy informatics was taught as an integrated part of the overall pharmacy curriculum

^beg, pharmacoconomics

Table 4. Pharmacy Informatics Competencies^a

Informatics Level I: ACPE 2007 STANDARDS: TERMINOLOGY		
1. Learn Basic Terms	2. Explain Concepts	3. Understand the Need
Review network systems, servers, and machine room characteristics	[Discuss] the basics of information technology	Demonstrate understanding of the role of information technology and pharmacy practice
Review computer hardware and software	Define py informatics and key terms; discuss role of py informatics	Understand the role of information databases and pharmacy
Define, interpret, or apply hardware and software terms correctly	Discuss the relationship of privacy and security to healthcare, and appreciate the importance of the privacy of electronic medical records	Understand the role of automation and pharmacy practice
Define information tech and computer literacy	Discuss the integration of information technologies into pharmacy practice	Describe the role of portable technology and pharmacy practice
Identify the difference between systems and applications software, know what an operating system is	[Describe] information systems applications in administrative functions such as claims processing, human resource management, and strategic decision support	Discuss the use of computer technology in pharmacy
Knowledge of pharmacy computer system database structure	Describe the role of RxNorm, HL7, SNOMED, and other vocabularies/ standards	Discuss the impact of information technology on pharmacy, as it affects pharmacists, pharmacists, and hospital administrators Describe the many informational resources that computer technology and the Internet have made available and their use in the healthcare field
Informatics Level II: ACPE 2007 STANDARDS: SYSTEMATIC APPROACHES		
1. Compare Applications	2. Perform System Analysis	3. Standardize a Process
Identify critical questions needed to analyze and evaluate information technology	Review the software development process	None
Compare and contrast the different types of telehealth	How to evaluate information systems needs for a health care application	
Information systems applications clinical functions such as electronic medical records, computerized provider order entry, and clinical decision support	How to evaluate the ability of existing information technology to fulfill a need	
Informatics Level III: ACPE 2007 STANDARDS: BENEFITS AND CONSTRAINTS		
1. Assess Limitations and Barriers	2. Design and Build	3. Evaluate Competing Systems
Describe the challenges encountered when conducting database research	Discuss and develop databases	Develop and use appropriate tools to evaluate and select such systems
Describe uses, potential benefits and limitations, ethical issues, and barriers to implementation to various information technology applications	Demonstrate the ability to develop and use, or install and use a commercially developed clinical documentation application	Building an information technology strategic plan
Describe benefits and limitations to computerized provider order entry (CPOE) systems and pharmacy information systems	How to conduct an information systems applications development and project management process	
Discuss key marketplace issues concerning the use of these systems	Electronic Medical Record implementation strategies	
Describe challenges to implementing such systems		
Physician Order Entry challenges		
Knowledge of hospital and pharmacy information systems and specialty software including interface issues		

^aTaken directly from submitted syllabi; Brackets indicate authors' additions

syllabi than informatics syllabi. Specifically, 44% (16 of 36) of the syllabi received fit the study definition of drug information.¹⁹ In response to the large number of drug information syllabi received, we reviewed our data collection procedures to ensure that we did not receive drug information syllabi because they were requested by name in the invitation letters. We compared the drug information syllabi received to the letters sent to the respective institutions. In 14 instances, the letters did not name a specific course. All 14 of these courses were classified as drug information. One course syllabus requested by course name (the course name included the word “informatics”) in the invitation letter was classified as both Informatics Level I and drug information. Another course requested by name (which also included the word “informatics” in the course title) was classified as drug information only. Based on this comparison of what was requested and received, it was determined that the study sample did not include drug information syllabi because we specifically asked for them. This apparent confusion between the definitions and disciplines of drug information practice and informatics practices concerns the authors.

Because informatics education has recently become a requirement for all pharmacy students in professional programs, it is critical that a clear distinction be made between drug information and informatics. We chose not to define informatics within our invitation letters because we hoped to determine existing conceptions of informatics by reviewing course syllabi. Our syllabi review suggests that drug information practices may be mistakenly considered synonymous with informatics practices. According to accepted definitions, informatics is not synonymous with drug information. Additionally, the 2 domains are addressed separately in ACPE Standards 2007.

A commonly accepted definition describes drug information as a systematic process for delivering well-referenced, critically evaluated information in pharmacy practice.¹⁹ The practice of drug information focuses on the process of information retrieval from the scientific literature, analysis, and dissemination to the ultimate decision-maker. Unlike drug information, informatics focuses on the role of pharmacists in the design, development, implementation, and use of automated information systems for medication-use processes. This growing focus on the intersection of people, process, and information technology to improve the safety and efficacy of medication use and the performance of the healthcare system overall is the domain of informatics.

These survey results highlight an important issue. It is difficult to distinguish the practice of drug information science from that of informatics. Because informatics is novel, it is obligatory for pharmacy informaticists to re-

solve this confusion. We have made an attempt to clarify the differences between drug information and informatics in Figure 1. When limiting the scope of consideration only to what can be understood about drug action and dosage-form performance in humans, we suggest that there is a continuum from the relative uncertainty addressed by basic research to the relative certainty of drug use in practice. Pharmaceutical research investigates, analyzes, and reports data and findings. Drug information science takes the output of pharmaceutical research, evaluates and interprets its meaning for patient care, and then disseminates informed summaries and reliable drug knowledge. Pharmacy informatics manages the output from drug information specialists within computer information systems. Pharmacy informatics integrates reliable drug and dosage-form knowledge into the medication-use cycle and presents it to clinical decision-makers in interpretable forms that improve outcomes.

For example, consider the role of the pharmacy informaticist with regard to so-called “smart,” computerized infusion pump systems. Smart pumps use customized drug libraries that include upper and lower safe dose and infusion rate parameters. The pharmacy informaticist has a role in selecting, implementing, and operating smart infusion pump systems. However, before the pharmacy informaticist can act, important precursors must transpire. First, drugs must be brought to market. Second, final dosage forms for drug administration must be determined. Third, reliable sources of facts regarding safe and effective concentrations, rates, clinical uses and precautions must be available to construct the smart pump drug library. Only when these precursors are completed may the pharmacy informaticist work within patient care settings to finally implement and manage smart pump technology.

Our syllabus review revealed that some existing informatics courses provide instruction that meets the new ACPE guidelines. Indeed, several excellent informatics courses have been developed. The examples in Table 4, taken directly from syllabi we received, reflect ACPE’s focus on the tools, context, challenges, and implications of using information and information technology in pharmacy and in healthcare. For pharmacy educators, we

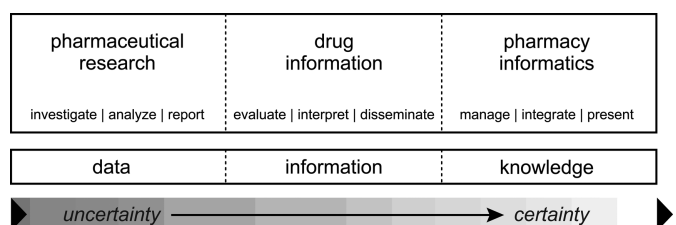


Figure 1. An illustrative depiction of the relationship between drug information and pharmacy informatics.

believe the examples in Tables 2 and 4 provide a useful foundation for the development and refinement of new or existing informatics courses.

Based on the results of this research, some of the existing informatics courses will require changes to meet the ACPE guidelines. Furthermore, the apparent absence of informatics courses indicates that many professional pharmacy programs will be starting from scratch as they build informatics into their curricula. Therefore, much remains to be done to help US educators meet the new guidelines for informatics course content. In particular, colleges of pharmacy must begin to address the many information technologies that are available for managing the medication-use cycle. Pharmacy students should be taught to readily recognize important clinical information system acronyms like "CPOE" (computerized physician order entry) just as they are taught to recognize clinical acronyms such as "DVT" (deep vein thrombosis). Pharmacy programs should educate students in the processes, challenges, benefits, and dangers of deploying information systems in the healthcare environment.

Colleges of pharmacy have a unique opportunity to creatively address informatics content in their curricula. Ideally, collaborative opportunities will be identified as schools and colleges integrate informatics concepts into existing curricula by incorporating informatics content into existing courses or developing introductory courses. In fact, a potential shortage of educators available to teach informatics may necessitate a collaborative approach that includes multiple pharmacy programs in a combined effort to meet this challenge. Pharmacy educators should also look to informatics education in other disciplines, such as medicine and nursing, for guidance on incorporating informatics into existing curricula. Other disciplines may also provide collaboration opportunities that impress upon students the multidisciplinary nature of healthcare. We are hopeful that these collaborative efforts will lead to excellent opportunities to introduce future pharmacists to the multidisciplinary, patient-centered, systematized pharmacy profession that they will soon join. Meanwhile, pharmacists currently working in informatics must do a better job of publicizing the nature and scope of the responsibilities they have. Informatics practitioners are now called to participate in the development of a curriculum that will ensure continued advancement of this new pharmacy practice domain.

With regard to instructional techniques and assessment methods, although limited due to the design of the study, a few important findings were noted. Assessment methods appeared to emphasize student participation and project-based assignments over traditional examinations. The use of project-based assessments, especially group

projects, is beneficial since project management is a necessary skill for pharmacists working in the informatics field. Few of the courses specified required readings, a finding not surprising due to the novel nature of informatics in education. Courses should incorporate published literature for students to have access to the most recent information in this rapidly changing field. About a quarter of the informatics courses submitted were clerkship courses. Clerkships offer an excellent way to give pharmacy students exposure to informatics topics, especially the higher level content (levels II and III) and to promote informatics as a potential career path. Since it is difficult for many schools to have required clerkship experiences, it is likely informatics content will still need to be incorporated into didactic courses in order to reach all students and meet ACPE standards.

While this paper has focused on the incorporation of informatics education into professional pharmacy programs, it is important to point out the growing number of informatics residencies. We believe the emergence of informatics residencies is another sign of the growing recognition of the importance of this field to the profession of pharmacy and to healthcare. It is our hope that through their incorporation of informatics in the curricula pharmacy programs will prepare a group of graduates who pursue specialized training in informatics.

Limitations

There are 3 primary limitations of this study. Although we used multiple methods to increase the number of responses, we only received responses from approximately a third of all ACPE-accredited programs. Several of these responses consisted of communication to indicate that informatics was not taught at the respondent's institution. It is possible that some of the nonresponders did not respond because informatics was not taught at their program. However, some programs that are widely known for their expertise in informatics did not participate. As a survey, it is possible that our sample does not fully reflect the population of informatics courses in ACPE-accredited pharmacy programs.

Our results are based on our review of syllabi received. Therefore, our ability to draw conclusions about the state of informatics education is limited by the clarity, depth, and explicitness of the syllabi. The syllabi contained substantial variability in the information provided. For example, a syllabus containing only lecture titles did not provide as much information as a syllabus including the specific topics discussed during each session, or the projects, activities, or assignments for the course. Therefore, the opportunity exists for errors of both commission and omission in our categorization of informatics courses.

A final limitation is related to our observation of the apparent misconception among many respondents that drug information and informatics are synonymous. Although our invitation letter specifically requested informatics courses, it is possible that some respondents submitted syllabi for the courses that most closely aligned with informatics. In this case, the respondent could have been fully aware of the difference between drug information and informatics, but chose to submit drug information syllabi as the closest course offered at their institution. Therefore, it is possible that pharmacy educators' conception of informatics is more closely aligned with ACPE's standards than the data here demonstrate.

CONCLUSIONS

It is incumbent on our nation's professional pharmacy programs to prepare future pharmacists to approach their professional practice as drug safety experts and medication knowledge-workers who must utilize information technology and automation in order to create a safer, more effective medication-use system. Thirty-nine percent of existing informatics courses met, at least on one level, the new guidelines set by ACPE Standards 2007 for informatics. Our research also identified a potential misconception among pharmacy educators regarding the domains of informatics and drug information. Drawing upon these data, we presented sample competencies from current informatics educational activities. Additionally, we suggested core competencies from this research project and from our own educational and professional efforts in the area of pharmacy informatics.

ACKNOWLEDGEMENTS

The authors would like to thank everyone in our nation's colleges and schools of pharmacy who participated in the study. We also extend a sincere thank you to Leigh Bauserman and Terra Walker of Shenandoah University for their work on the project web site.

The ideas expressed in this manuscript are those of its authors and in no way represent the position of Saint Joseph Mercy Health System of Ann Arbor, Michigan, or the position of Trinity Health, Inc.

REFERENCES

1. PubMed Medical Subject Heading (MeSH) database. National Center for Biotechnology Information, National Library of Medicine, National Institutes of Health. Available at: <http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?CMD=search&DB=mesh>. Accessed April 17, 2006.
2. Shortliffe EH, Perreault LE, Wiederhold G, Fagan LM. *Medical Informatics: Computer Applications in Health Care and Biomedicine*. 2nd ed. New York, NY: Springer-Verlag; 2001.
3. Felkey BG, Fox BI, Thrower M. *Health Care Informatics: A Skills-based Resource*. Washington DC: American Pharmaceutical Association; 2005.
4. American Medical Informatics Association, Available at: <http://www.amia.org>. Accessed October 15, 2006.
5. American Nursing Informatics Association, Available at: <http://www.ania.org>. Accessed November 1, 2006.
6. Speedie SM, McKay AB. Pharmacy systems. In: Shortliffe EH, ed. *Medical Informatics: Computer Applications in Health Care*. Reading, MA: Addison-Wesley; 1990.
7. American Society of Health-System Pharmacists. ASHP statement on pharmacist's role in informatics. *Am J Health-Syst Pharm*. 2007;64:200-3.
8. Pharmacy Informatics. Available at: http://www.himss.org/ASP/topics_pharmacyInformatics.asp. Accessed August 4, 2008.
9. Flynn AJ. The current state of pharmacy informatics education in professional programs at US colleges of pharmacy. *Am J Pharm Educ*. 2005;69(4):Article 66.
10. Committee on Quality of Healthcare in America. *Crossing the Quality Chasm: A New Health System for the Twenty-First Century*. A report of the Institute of Medicine. Washington, DC: National Academy Press; 2001.
11. Greiner AC, Knebel E, eds. *Health Professions Education: A Bridge to Quality*. A report of the Institute of Medicine. Washington, DC: National Academy Press; 2003.
12. American Health Information Management Association, Building the Work Force for Health Information Transformation. Available at: http://www.ahima.org/emerging_issues/Workforce_web.pdf. Accessed March 1, 2006.
13. 10x10 program. American Medical Informatics Association, Bethesda, Maryland. Available at: <http://www.amia.org/10x10/>. Accessed September 3, 2006.
14. Recommendations of the International Medical Informatics Association (IMIA) on education in health and medical informatics. *Methods Inf Med*. 2000;39:267-77.
15. American Society of Health-System Pharmacists 2015 Initiative. Available at: <http://www.ashp.org/2015>. Accessed April 26, 2006.
16. American Society of Health System Pharmacists. American Society of Health System Pharmacists Announces New Membership Section for Informatics. Available at: <http://www.ashp.org/news/ShowArticle.cfm?id=15820>. Accessed June 27, 2006.
17. Accreditation Council for Pharmacy Education. Accreditation Standards and Guidelines for the Professional Program in Pharmacy Leading to the Doctor of Pharmacy Degree (ACPE Standards 2000). Chicago, IL; 1997.
18. Accreditation Council for Pharmacy Education. Accreditation Standards and Guidelines For The Professional Program in Pharmacy Leading to the Doctor of Pharmacy Degree (ACPE Standards 2007). Chicago, IL; 2006.
19. Malone PM, Kier KL, Stanovich JE, eds. *Drug Information: A Guide for Pharmacists*. 3rd ed. NY: McGraw-Hill; 2006: 840.
20. Blander J, Bergeron B. *Clinical Management Systems: A Guide for Deployment*. Healthcare Information Management Systems Society. Chicago, IL; 2004.
21. Austin CJ, Boxerman SB. *Information Systems for Healthcare Management*. 6th ed. Foundation of the American College of Healthcare Executives. Chicago, IL: Health Administration Press; 2003.
22. Griffith JR, White KR. *The Well-Managed Healthcare Organization*. 5th ed. Foundation of the American College of Healthcare Executives. Chicago, IL: Health Administration Press; 2002.
23. Newell LM, Christensen D. Who's counting now? ROI for patient safety IT initiatives. *J Healthcare Inform Manage*. 2003;17:29-35.