RESEARCH ARTICLES

Pharmacogenomics in the Curricula of Colleges and Schools of Pharmacy in the United States

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Objectives. To assess the breadth, depth, and perceived importance of pharmacogenomics instruction and level of faculty development in this area in schools and colleges of pharmacy in the United States.
Methods. A questionnaire used and published previously was further developed and sent to individuals at all US schools and colleges of pharmacy. Multiple approaches were used to enhance response.
Results. Seventy-five (83.3%) questionnaires were returned. Sixty-nine colleges (89.3%) included pharmacogenomics in their PharmD curriculum compared to 16 (39.0%) as reported in a 2005 study. Topic coverage was <10 hours for 28 (40.6%), 10-30 hours for 29 (42.0%), and 31-60 hours for 10 (14.5%) colleges and schools of pharmacy. Fewer than half (46.7%) were planning to increase course work over the next 3 years and 54.7% had no plans for faculty development related to pharmacogenomics.
Conclusions. Most US colleges of pharmacy include pharmacogenomics content in their curriculum, however, the depth may be limited. The majority did not have plans for faculty development in the area of pharmacogenomic content expertise.

Keywords: pharmacogenomics education, pharmacogenetics education, curriculum

INTRODUCTION

Two policy resolutions passed by the 2008 American Association of Colleges of Pharmacy (AACP) House of Delegates recommended increased focus on the advancement of education in biotechnology. The first pertained to the curricular implications of biotechnology and personalized medicine. It focused on the responsibility of pharmacy curricula to address up-to-date issues associated with biotechnology advances in tailored medicine.[1] Specific competencies discussed in this policy are cell and system biology, bioengineering, genetics/genomics, proteomics, nanotechnology, cellular and tissue engineering, bio-imaging, computational methods, and information technologies. The second policy pertained to faculty development in biotechnology areas. This policy stated that "faculty development programs and collaborative research and teaching strategies should be expanded such that faculty at colleges and schools of pharmacy are prepared to lead and contribute significantly to education and research. . ." in the above areas.

Though colleges and schools of pharmacy (hereafter colleges of pharmacy) are likely working to address the educational needs surrounding the emergence of pharmacogenomics and other biotechnology areas, it appears that AACP members believed policy resolutions might ensure preparation of pharmacy students and faculty members for future roles in the application of biotechnology and pharmacogenomics to patient care. Determining how many colleges of pharmacy already meet the intent or have systems in place to implement these resolutions would provide valuable data for longitudinal assessment of these issues.

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Prior to June 2004, Latif and McKay evaluated the depth and extent to which pharmacogenetics and pharmacogenomics content (hereafter referred to as pharmacogenomics) was being taught in colleges of pharmacy in the United States.[2] Their investigation was initiated as a result of the *Core Competencies in Genetics Essential for all Health-Care Professionals* document distributed by the National Coalition for Health Professionals Education in Genetics (NCHPEG) and recommendations from the 2001-2002 AACP Academic Affairs Committee.[3,4] The AACP Committee identified the need to include pharmacogenomics content in pharmacy curricula ''because most drug effects are determined by the interplay of several gene products that govern the pharmacokinetics and pharmacodynamics of medication.''[3] The committee believed that pharmacogenomics would change the practice of pharmacy by using a patient's genotype to guide dosing decisions in order to potentially improve medication effectiveness while reducing toxicity. Latif and McKay's investigation concluded that there was awareness of the need to increase the level of instruction in these areas among the colleges of pharmacy.[2]

The progress of pharmacogenomics and other biotechnology areas of inquiry over the last 40 years highlight the growing importance of the AACP resolutions. In the 1970s, Robert Smith's work with debrisoquine and Michel Eichelbaum's work with sparteine led to the discovery of a CYP2D6 genetic polymorphism, the frequency of which was enough to make it relevant to the general population and the use of a variety of drugs.[5] Over the next decade, drug response was recognized to often be determined by multiple genes as well as other factors. This new information led the focus from pharmacogenetics, the effect of a single gene on drug therapy, to the broader subject of pharmacogenomics, drug treatment based on the effects of many genes.[6] The evolution in focus to understand the entire genetic makeup of humans helped lead to the Human Genome Project (HGP).[7]

Initiated in 1990, the HGP set out to map the entire human genome to gain information regarding the ''structure, organization and characteristics of human DNA.''[8] The knowledge gained from the HGP has helped to identify individuals and families at risk for disease and can be used to ease the burden of diagnosis and treatments for various diseases. For example, the use of genetic information can be used in determining warfarin dosing when oral anticoagulation is needed. With this information, individuals at risk may avoid the adverse clinical consequences that may arise from underdosing or overdosing when traditional fixed dose approaches are used.[9] Other DNA tests have been found useful in identifying patients who would benefit from pharmacogenomic therapies such as those with cancers, deep vein thrombosis, and inflammatory diseases.[10]

Even with the advancements made in the understanding of pharmacogenomics, many health care providers continue to feel unprepared to speak with their patients regarding the correlation between genetics and their disease.[8] The pharmacist's role in the use of pharmacogenomics for application in patient care is evolving and is yet to be elucidated fully, though the profession is active in conducting research and promoting understanding of the variable drug response due to genetics.[6] For example, committees formed at the national level have developed core competencies with respect to genetics over the last decade, and colleges of pharmacy have worked to address the educational needs of the emergence of pharmacogenomics.[11] Further, the standards and guidelines from the Accreditation Council for Pharmacy Education (ACPE) in the professional programs of pharmacy include requirements for the incorporation of content on the genetic basis of disease and drug action, individualized drug dosages, drug metabolism alteration, and principles of genomics and proteomics in relation to drug development and disease.[12]

The purpose of this study was to describe the reported breadth and depth of pharmacogenomics instruction in United States colleges of pharmacy, the opinions of survey respondents as to the value of specific course content and sufficiency of education in these area, and the reported level of faculty development relative to these areas: and to compare results to those from an earlier publication.

METHODS

Colleges of pharmacy (n = 109) were eligible to participate if they were in the United States and regular or associate members of AACP in 2008-2009. Colleges that were not on the roster of AACP members were excluded. The authors' Human Subjects Protection Program Institutional Review Board granted exempt status for the study.

This was a descriptive study using a revised and expanded questionnaire from a previous study by Latif and McKay.[2] A pretest was conducted by sending the questionnaire to 5 pharmacy faculty members around the country known to be associated with programs where pharmacogenomics and pharmacogenetics content was covered. They were asked for comments on its utility and clarity. Based on their comments, the questionnaire was further refined and then sent to AACP for approval of its use as an endorsed survey. After submission, the authors were notified by AACP of a grant from the CDC for a project called ''Pharmacogenomics Education Program (PharmGenEd™): Bridging the Gap between Science and

Practice" (http://pharmacogenomics.ucsd.edu). This program aims to build a shared curriculum that meets the needs of US colleges of pharmacy. The appropriate individual from this group was contacted and the questionnaire was revised further, with their assistance, to help identify colleges interested in participation in the development of the curriculum and those interested in using it once completed.

AACP sent an initial e-mail to 109 deans in January 2009 requesting the name of an appropriate member of the faculty for questionnaire completion. Nonresponding deans were contacted 3 weeks after the original e-mail and up to 3 total times by 1 of the investigators via e-mail and/or phone requesting the information. Upon receiving the contact name from the dean, an e-mail was sent to the identified individual stating the purpose of the study and requesting participation. A subject disclosure form was included as an attachment to the e-mail. Contacts who failed to respond were sent a follow-up e-mail 10 and then 20 days after the originating e-mail. A final phone call was also placed to nonrespondents. A message requesting participation and contact information was left if there was no answer.

The questionnaire included requests for descriptive information related to the college, whether pharmacogenomics coursework was taught in the PharmD curriculum, and if so, whether specific topics were covered. Information on the depth (estimated number of hours) of instruction and the respondents' views on the importance of the specific topic areas to the education of doctor of pharmacy candidates were also requested. Respondents were questioned as to the availability of pharmacogenomics research resources, the number and type of faculty involved in teaching, and whether a development plan was in place or being created to provide faculty the opportunity to stay current in the field. Respondents were asked for their perception of their own and other schools' level of pharmacogenomic instruction. Respondents were also asked if they would be interested in having access to and collaborating on the shared pharmacogenomics curriculum. Although this study focused on PharmD curriculum, questions pertaining to pharmacogenomic curriculum for other graduate programs (MS, PhD) and groups (physicians, nurses, students other than those listed) were explored.

The impact of nonresponse error on the questionnaire was determined using approaches to evaluate response trends among subgroups of individuals responding after different contacts to determine whether later respondents differ systematically from earlier respondents and whether this poses problems for generalizing results.[13] A $p < 0.05$ was considered an indicator of significant difference.

To assess the breadth of course content in colleges of pharmacy, 16 topics pertaining to the domains of genetic basis of disease and 9 ethical, social, and economic implication items were described. Respondents were asked to choose between 1 of 3 answers regarding whether the content was covered: yes, no, or unsure. In addition, all respondents were asked to rate the importance of the topics for the curriculum for PharmD candidates. Response options were not important, neutral, important, or unsure.

A password protected Excel (Microsoft, Redmond, Wash) file was maintained to track all communications and progress for the study. Another Excel file was maintained to input questionnaire responses. No direct link was made between the final responses, institution, and/or individual responding. Descriptive statistics were used for reporting the data and for comparisons to previous study results.

RESULTS

Ninety of 109 (82.6%) deans responded with an appropriate contact name. Of the 90 e-mails and instruments then sent, 75 (83.3%) questionnaires (68.8% of total college deans contacted) were returned by e-mail or fax. There were 48 private (44%) and 61 public (56%) colleges of pharmacy among the 109 contacts and the response rate (n = 75) from each was the same, with 33 (44%) private and 42 (56%) public colleges of pharmacy. No significant differences ($p = 0.23$) were found between responding subgroups using Churchill's approach.[13]

Table 1 provides the summary of relevant demographic and pharmacogenomics teaching-related items along with those of Latif and McKay when similar items existed. Respondents from 69 colleges (92.0%) reported that pharmacogenomics coursework was taught at their institution. Of these, 67 (89.3% of total) taught it at the PharmD level. Graduate programs in 3 (4.3%) of the respondents' colleges in the current study offer MS degrees and 7 (10.1%) colleges offer PhD degrees focused on pharmacogenomics.

Multiple faculty members (51, 73.9%) rather than a single individual (17, 24.6%) provided the majority of pharmacogenomic instruction at colleges of pharmacy; 15 (21.7%) colleges were reported to require specific prerequisite course work. Fifteen (21.7%) of the colleges taught this subject matter as a standalone course, 50 (72.5%) included it as part of other required didactic coursework, and 24 (34.8%) taught it as an elective didactic course. Pharmacogenomics subject matter was taught throughout all of the first 3 professional years of the curriculum by 13 (18.8%) of the colleges, but overall the content emphasis appeared to be in the second year, with 53 (76.8%) having taught the coursework in that year. The

Table 1. Demographics and Pharmacogenetic Instruction Data of Respondents to a Survey on Pharmacogenetics and Pharmacogenomics Education in US Colleges of Pharmacy (N = 75)

	No. (%)	Latif & McKay, %[c]
Is pharmacogenetics/pharmacogenomics taught at your school?		
Yes	69 (92.0)	78.0
No	6 (8.0)	22.0
At what academic level(s) is subject taught?[a,b] (multiple choice)		
PharmD	67 (97.1)	39.0
MS	11 (15.9)	
PhD	27 (39.1)	
Certificate	0 (0.0)	
Other	1 (1.4)	
Is there a graduate program focused on this subject?[a,b] (multiple choice)		
MS	3 (4.3)	
PhD	7 (10.1)	
Is coursework available for additional groups?[a,b] (multiple choice)		
Pharmacist	8 (11.6)	
Pharmacy Preceptor	10 (14.5)	
Physicians	5 (7.2)	
Nurses	4 (5.8)	
Students (other)	23 (33.3)	
Where does the subject reside in the PharmD curriculum?[a,b] (multiple choice)		
Stand-alone required didactic course in the area	15 (21.7)	9.8
Included as part of other required didactic course(s)	50 (72.5)	46.3
Required didactic laboratory component	2 (2.9)	
Elective didactic coursework (stand-alone or mixed)	24 (34.8)	2.4
Required experiential rotation	1 (1.4)	
Elective experiential rotation	7 (10.1)	
No response		
What year does the subject coursework reside?[a,b] (multiple choice)		
1st year	44 (63.8)	
2nd year	53 (76.8)	
3rd year	35 (50.7)	
What are the estimated required didactic hours?[a]		
≤10 hours	28 (40.6)	
11 to 30 hours	29 (42.0)	
31 to 60 hours	10 (14.5)	
>60 hours	0 (0.0)	
No response	2 (2.9)	
Do you have a prerequisite course for this stand-alone required coursework?[a]		
Not applicable (we don't have one)	34 (49.3)	
No prerequisite courses required	15 (21.7)	
Required prerequisite	15 (21.7)	12.2
No response	5 (7.2)	
What faculty resources are available to teach subject coursework?[a,b] (multiple choice)		
A single faculty member teaches all of the coursework	17 (24.6)	7.3
Multiple faculty are involved in teaching the coursework	51 (73.9)	68.3
Volunteer or paid faculty from outside the college/school teach	14 (20.3)	
Other	2 (2.9)	
What is the present state of pharmacogenomics instruction at most schools of pharmacy?		
Very Good	0 (0.0)	2.4
Good	2 (2.7)	9.8

(*continued*)

Table 1. Continued.

	No. (%)	Latif & McKay, %[c]
Adequate	20 (26.7)	36.6
Poor	40 (53.3)	31.7
Not at all adequate	6 (8.0)	7.6
No response	7 (9.3)	
What is the present state of pharmacogenomic instruction at your school?		
Very Good	7 (9.3)	
Good	12 (16.0)	
Adequate	30 (40.0)	
Poor	19 (25.3)	
Not at all adequate	3 (4.0)	
No response	4 (5.3)	
What are your school's plans for this coursework over the next 3 years?		
No plans to change the number of hours	32 (42.7)	
Increase the number of hours	35 (46.7)	
Decrease the number of hours	1 (1.3)	
No response	7 (9.3)	
Does your school have plans to hire additional faculty to teach this subject?		
Post study 1st year (FY 2009-10, 2004-05)	7 (9.3)	17.1
Post study 2nd year (FY 2010-11, 2005-06)	6 (8.0)	17.1
Post study 3rd year (FY 2011-12, 2006-07)	2 (2.7)	14.6
Don't know	39 (52.0)	
No response	21 (28.0)	
Does your school plan to:		
Develop a center of excellence in the next 5 years	9 (12.0)	
Develop a research focus in this subject over the next 5 years	10 (13.3)	
Work with industry or other schools to provide external instructors	8 (10.7)	
Other	8 (10.7)	
No response	40 (53.3)	
Is your school interested in accessing shared curriculum?[d]		
Yes	53 (70.7)	
No	3 (4.0)	
Maybe	13 (17.3)	
No response	6 (8.0)	
Does your school:		
Currently have faculty development program for this subject	6 (8.0)	
Have plans for a faculty development program for this subject	6 (8.0)	
Have no plans for faculty development program for this subject	41 (54.7)	
Other	9 (12.0)	
No response	13 (17.3)	
Does your pre-pharmacy requirements include coursework in:		
Molecular biology	22 (29.3)	
Genetics	17 (22.7)	
No response	36 (48.0)	

[a] Only the responses of those colleges/schools that taught pharmacogenomics/pharmacogenetics were included in question 2 (N = 69.)
[b] Select all that apply, percentage may be greater than 100.
[c] Percentage available only for questions asked.
[d] The survey was approved by AACP and partially funded by the CDC via a grant to Dr. Grace M. Kuo's (University of California-San Diego) research team. This team is developing the PharmGenEd program (''Pharmacogenomics Education Program: Bridging the Gap between Science and Practice'') for use by colleges and schools around the country.

depth of content coverage for more than 80% (n = 57) of the colleges was less than 30 didactic hours of instruction throughout the entire program.

In order to assess the availability of pharmacogenomic resources, respondents were asked to identify current resources and plans for developing new resources over the next 5 years (Table 2). Of the 75 respondents, 33 (44.0%) housed a pharmacogenomics research center within their college, or had an interdisciplinary research center accessible elsewhere; 10 (13.3%) had a department focused on this area in their college. Nineteen were going to develop a center of excellence and/or a research focus in the area in the next 5 years. Respondents from 15 (20.0%) colleges indicated plans to hire additional faculty in this area within the next 3 years. Others did not know (39, 52.0%) or did not respond to the question (21, 28.0%).

When asked about the current state of pharmacogenomics instruction, the majority of respondents believed the status at other colleges was poor or not at all adequate (46, 61.3%). However, only 22 (29.3%) believed their own school had a poor or not at all adequate state of instruction in this area.

Table 3 provides a summary of the core competencies taught within the curriculum and the level of importance respondents placed on each. The items on the questionnaire pertaining to these competencies were revised slightly from the one used by Latif and McKay to match the September 2007 NCHPEG Core Competencies for all Healthcare Professionals revisions.[11] The 20 items for the genetic basis of disease were reduced to 16 items for this study; however, the 9 items under the ethical, social, and economic implications domain remained the same. Eleven (68.8%) of the 16 genetic basis of disease items but only 2 (22.2%) of the 9 ethical, social, and economic implications were being addressed in the majority of colleges.

Only 9 (56.2%) of the 16 genetic basis of disease topics and the same 2 (22.2%) ethical, social, and economic implication items were considered important for instruction to PharmD students by more than 50% of respondents. The genetic basis of disease domain had 4 topics that were covered in curricula at a 20% higher rate than the percentage of respondents considering the topic area important. These were: (1) how identification of disease-associated genetic variations facilitates development of prevention, diagnosis, and treatment options; (2) the importance of family history in assessing predisposition to disease; (3) the influence (or lack thereof) of ethnicity in genetic polymorphisms and associations of polymorphisms with drug response; and (4) specific methods of genotyping and phenotyping.

Although 35 (46.7%) colleges plan to increase the number of coursework hours dedicated to pharmacogenomic instruction, faculty development was not high on the agenda, with 41 (54.7%) having no current plans for such development programs. The majority of respondents indicated they were interested in having access to (66, 88.0%) and/or collaborating (51, 68.0%) on the shared pharmacogenomics curriculum that is being developed with the CDC grant.

DISCUSSION

The purpose of this study was to assess the breadth and depth of pharmacogenomics content instruction, the importance of these topics as perceived by respondents, and whether faculty development was available relative to these areas in US colleges of pharmacy. The results,

Table 2. Status of Pharmacogenomic Resources in US Colleges of Pharmacy as Reported by Respondents to a Survey on Pharmacogenetics and Pharmacogenomics Education

	Currently Available, No. (%)		Future Plans, No. (%)
A research center housed within the college/school of pharmacy	16 (21.3)	Develop a pharmacogenetics/ pharmacogenomic center of excellence in the next 5 years?	9 (12.0)
An interdisciplinary research center housed elsewhere in which college/school of pharmacy faculty participate	17 (22.7)	Develop a pharmacogenetics/ pharmacogenomic research focus in the next 5 years (including adding faculty)?	10 (13.3)
A department or division focused on this area in the college/school of pharmacy	10 (13.3)	Work with industry or other colleges/schools in your University to provide instruction of these topics in your program?	8 (10.7)
Other	11 (14.7)	Other	8 (10.7)
No response	21 (28.0)	No response	40 (53.3)

Table 3. Summary of Core Competencies Taught and Their Perceived Importance in US Colleges of Pharmacy Responding to a Survey on Pharmacogenetics and Pharmacogenomics Education

	Coverage in Curriculum (Percent) n = 69			Curriculum Importance (Percent) n = 75			
Genetic Basis of Disease	**Yes**	**No**	**Unsure**	**Important**	**Neutral**	**Not Important**	**Unsure**
Basic genetic concepts and terminology	94.2	0.0	2.9	74.7	5.3	2.7	0
How identification of disease-associated genetic variations facilitates development of prevention, diagnosis, and treatment options	87.0	4.3	5.8	66.7	9.3	4.0	0.0
The importance of family history in assessing predisposition to disease	82.6	8.7	4.3	56.0	18.7	2.7	0.0
The interaction of genetic, environmental, and behavioral factors in predisposition to disease, onset of disease, response to treatment, and maintenance of health	76.8	17.4	2.9	65.3	0.7	2.7	1.3
The contribution of genetic variability to inter-individual variations in drug response	91.3	5.8	0.0	74.7	4.0	2.7	1.3
The drugs/drug classes/clinical situations where pharmacogenetic testing is likely to be most useful clinically	87.0	7.2	2.9	74.7	4.0	2.7	1.3
Important issues in pharmacogenetic study design, particularly those that differ from nongenetic clinical studies	21.7	52.2	21.7	18.7	40.0	6.7	12.0
Use of information technology to obtain credible, current information about pharmacogenetics	52.2	26.1	17.4	48.0	22.7	4.0	4.0
Pharmacogenetic testing is like all other clinical testing in that it will not have 100 percent reliability, but rather is used along with other clinical information	63.8	14.5	18.8	52.0	24.0	2.7	1.3
The influence (or lack thereof) of ethnicity in genetic polymorphisms and associations of polymorphisms with drug response	87.0	1.4	8.7	62.7	7.3	2.7	0.0
The potential physical and/or psychosocial benefits, limitations, and risks of genetic information for individuals, family members, and communities	63.8	18.8	14.5	52.0	20.0	2.7	6.7
Regulatory issues that may result from pharmacogenetics being incorporated into Phase II and III testing	31.9	44.9	18.8	28.0	28.0	14.7	9.3
The informed-consent process for pharmacogenetic testing, including appropriate information about the potential risks, benefits, and limitations of the test in question	21.7	52.2	21.7	32.0	28.0	9.3	6.7
The resources available to assist clients seeking genetic information or services, including the types of genetics professionals available and their diverse responsibilities	17.4	56.5	21.7	28.0	29.3	10.7	8.0
One's professional role in the referral to genetics services, or provision, follow-up, and quality review of pharmacogenetic tests	17.4	56.5	20.3	42.7	18.7	10.7	6.7
Specific methods of genotyping and phenotyping	56.5	21.7	14.5	30.7	29.3	13.3	4.0

(*continued*)

Table 3. Continued.

Genetic Basis of Disease	Coverage in Curriculum (Percent) n = 69			Curriculum Importance (Percent) n = 75			
	Yes	No	Unsure	Important	Neutral	Not Important	Unsure
Ethical, Social and Economic Implications							
The reasons for and benefits of genetic services	49.3	31.9	14.5	46.7	22.7	8.0	2.7
Advocacy against attempts to ascribe behavioral tendencies (social behavior) to patients on the basis of pharmacogenetic/pharmacogenomic information	20.3	55.1	17.4	33.3	20.0	12.0	9.3
The ethical, legal and social issues related to pharmacogenetic/genetic testing and recording of genetic information (eg, privacy, the potential for genetic discrimination in health insurance and employment)	53.6	31.9	7.2	53.3	17.3	8.0	0.0
Employment of clinical, humanistic, and economic outcomes research relative to pharmacogenomic interventions and services to insure appropriate and cost effective treatment of disease	23.2	50.7	18.8	37.3	30.7	6.7	4.0
Basic assessment and evaluation strategies to assess pharmacy-related services directed toward the provision of pharmacogenetic/pharmacogenomic services and education either for the individual patient or public at large	13.0	60.9	17.4	33.3	33.3	8.0	4.0
Public policy issues, including regulatory statements and issues, aimed at pharmacogenetic/pharmacogenomic services and interventions	29.0	50.7	11.6	41.3	26.7	8.0	2.7
Educational programs for the public as related to pharmacogenetic/pharmacogenomic services and interventions	13.0	65.2	14.5	32.0	33.3	8.0	5.3
Differentiation between clinical diagnosis of disease and identification of genetic predisposition to disease (genetic variation is not strictly correlated with disease manifestation)	59.4	27.5	7.2	58.7	14.7	2.7	4.0
Factors that influence the client's ability to use genetic information and services, for example, ethnicity, culture, related health beliefs, ability to pay, and health literacy	27.5	50.7	14.5	36.0	30.7	6.7	4.0

where applicable, were also to be compared to those determined previously by Latif and McKay.

In the current study, 69 of 75 (92.0%) colleges were reported to be teaching pharmacogenomics within any their programs, and 67 (89.3%) colleges were teaching it within their current PharmD curriculum. This is up from 78% of programs providing this content in any program found by Latif and McKay, and 39% providing it in the PharmD curriculum.

Findings in this study with regard to who provides instruction is consistent with Latif and McKay's findings of 28 (68.3%) multiple and 3 (7.3%) single faculty members responsible for instruction. Thus, the content tends to be handled in team taught courses rather than provided by a single faculty member with expertise in the areas. There was an increase in the number of colleges requiring specific prerequisite coursework (15, 21.7%) compared to the previous study (5, 12.2%).

In pharmacogenomics, organization of the content was similar to what was found by Latif and McKay where 4 (9.8%) of their responding colleges taught it as a standalone course, 19 (46.3%) included it as part of another didactic course, and 1 (2.4%) taught it as a standalone elective. This is also what would be expected relative to who teaches because incorporation into other courses might lend itself to team teaching.

Latif and McKay found that 20 (49%) colleges of pharmacy planned to hire at least 1 additional faculty member in this area within the 3 years following their survey. Fifteen (20.0%) of the responding colleges planned to hire faculty members in this area within the next 3 years. Though this might indicate a reduction in interest, it might also reflect that more content is already being taught by faculty hired in recent years.

Pharmacogenomics instruction appeared to be provided in roughly similar percentages of postgraduate programs (11, 15.9% MS; 27, 39.1% PhD) as found by Latif and McKay (16, 39% Masters/PhD/other). Graduate programs in 3 (4.9%) of the respondents' colleges in the current study offered MS degrees and 7 (10.1%) colleges offered PhD degrees in pharmacogenomics related areas.

With regard to breadth of content coverage, Latif and McKay evaluated 2 domains of competencies. They found 11 (55%) out of their 20 items of genetic basis of disease and 3 (33.3%) of the 9 items from ethical applications and social and economic implications were being addressed by the majority of the respondents' colleges. In this study, 11 of 16 (69%) of the first domain were covered by more than 50%, but only 2 of 9 of the second domain. Though there is considerable coverage of some pharmacogenomics related topics, many were not covered at all by many colleges. Since the competencies were developed by AACP and a national organization suggesting core competencies for all health care professionals, there is room to expand pharmacogenomics topics taught in the curriculum.[3,11]

The primary finding of this study is that the majority of colleges of pharmacy are now providing some level of pharmacogenomic instruction within their curriculum, indicating an increased awareness of the need to do so, and thus demonstrating alignment with AACP recommendations about including this material within the PharmD curriculum. The secondary finding is the somewhat limited focus in faculty development for this subject matter.

Increased awareness of pharmacogenomics over the last 5 years, and emphasis on the area from AACP, ACPE, and the NCHPEG core competencies, are likely contributing factors in the differences between the 2 studies. Over the past 5 years, considerable attention to pharmacogenomics-related topics has been given by many journals and the lay press.[14] For example, in 2005 Moridani noted the word pharmacogenomics or pharmacogenetics had been included in 5 journal titles.[10] This emphasis helps increase the awareness of its potential value to patient care.

On the other hand, perceptions of the respondents relative to the state of instruction at other colleges of pharmacy declined (poor or not at all adequate, 46, 61.3%) compared to those found by Latif and McKay, where almost half of the respondents believed that the level of instruction was average (36.6%) or better (12.2%). Perhaps respondents believe that the quality of instruction is not adequate because of the advances in pharmacogenomics over the last 5 years. Interestingly, the respondents' opinions of their own college were much better, perhaps due to greater knowledge of efforts being made at their campus than elsewhere.

Although colleges plan to increase the number of coursework hours, there appears to be some disconnect between plans to increase coursework hours without preparing, hiring, or developing faculty members to teach this subject. Plans for developing a pharmacogenomic center of excellence and research focus, as well as working with industry, could contribute to a lack of need for faculty development since these options would likely include having faculty members who are knowledgeable on the subjects available for mentoring others as needed. No questions were asked to better understand this disconnect, leaving room for further investigation.

There were several potential limitations to this study. One relates to identification of the most appropriate individual to answer the questionnaire. Though deans would likely know the appropriate contact, it is possible that the selected individual may not have been the best person to provide the most accurate data. Another potential limitation is that some of the responses may have been simply a "best guess." The survey instrument limitations stated by Latif and McKay hold true for this study as well.[2] Since the content areas for the questionnaires in both studies were based on AACP's Academic Affairs Committee recommendations and NCHPEG suggested core competencies, they may have missed content that would be considered important by some college of pharmacy faculty for their curriculum. For example, one respondent suggested that other content such as proteomics, which allows for the bigger picture of discovering biomarkers for diagnosis, prognosis, and treatment of human disease, should be considered in the development of pharmacogenomic curricula. A few respondents provided comments about the way questions were asked. For instance, concern was expressed that the questionnaire may have been geared towards non-integrated teaching and one observed that responses regarding importance of content would vary depending on the type of faculty member responding to the items. Even with these limitations, the results suggest continued progress and academic enhancements in the area of pharmacogenomics.

Though it was not the intent of this study to be prescriptive about course content in the area of pharmacogenomics and pharmacogenetics, the results provide information on what the respondents believe is being taught in their colleges and schools of pharmacy. This

information might be useful to committees contemplating content additions or deletions for their curriculum. There are many challenges associated with determining what must and should be in a pharmacy curriculum, and most often these challenges relate to adding more with a relatively fixed number of hours available for teaching. Knowing what other colleges may be teaching and what some faculty consider important may have some utility.

CONCLUSION

This study assessed the breadth, depth, and perceived importance of pharmacogenomics instruction and of faculty development in colleges of pharmacy. In the previous study by Latif and McKay, 32 (78.0%) colleges responding were providing some pharmacogenomic instruction within their programs (PharmD, MS, PhD), though only 39% provide the subject matter to PharmD students. With increased awareness of the need to teach this subject, 69 of 75 (92.0%) of colleges responding to this study were now teaching pharmacogenomics within 1 or more of their programs and 67 (89.3%) colleges were teaching it within their PharmD curriculum. There was a general consensus among the respondents that teaching pharmacogenomics is becoming increasingly important in the practice of pharmacy, but there was limited emphasis on faculty development in the area.

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