Journal of the American Pharmacists Association 57 (2017) 120–125

Contents lists available at ScienceDirect

Journal of the American Pharmacists Association

journal homepage: www.japha.org

COMMENTARY

Pharmacogenomics competencies in pharmacy practice: A blueprint for change

Mary W. Roederer*, Grace M. Kuo, David F. Kisor, Reginald F. Frye, James M. Hoffman, Jean Jenkins, Kristin Wiisanen Weitzel

ARTICLE INFO

Article history:
Received 3 March 2016
Accepted 23 August 2016

ABSTRACT

The emerging use of genomic data to inform medication therapy populates the medical literature and provides evidence for guidelines in the prescribing information for many medications. Despite the availability of pharmacogenomic studies, few pharmacists feel competent to use these new data in patient care. The first pharmacogenomics competency statement for pharmacists was published in 2002. In 2011, the Pharmacogenomics Special Interest Group of the American Association of Colleges of Pharmacy led a process to update this competency statement with the use of a consensus-based method that incorporated input from multiple key professional pharmacy organizations to reflect growth in genomic science as well as the need for pharmacist application of genomic data. Given the rapidly evolving science, educational needs, and practice models in this area, a standardized competency-based approach to pharmacist education and training in pharmacogenomics is needed to equip pharmacists for leadership roles as essential members of health care teams that implement clinical utilization strategies for genomic data.

Advances in pharmacogenomic discovery are urging rapid and effective translation of genomic science into clinical practice, with more than 137 medications now containing pharmacogenomic data in their U.S. Food and Drug Administration prescribing information.[1] This heightened rate of scientific discovery is driving change in practice, and clinicians consistently recognize the clinical impact of genomic data. As a profession, pharmacy has long assumed a valued role in the leadership of therapeutic drug monitoring (e.g., pharmacokinetics) and pharmacotherapy services owing to pharmacy's specialized training and an established practice record in medication management. In the same way, pharmacists are uniquely qualified to be on the front line of efforts to translate pharmacogenomic data into clinical practice across multiple diverse practice settings.[2]

The pharmacist's role in pharmacogenomics

The pharmacist's role as a practice-based leader in pharmacogenomics is becoming clearer as an increasing number of pharmacists are engaging in clinical pharmacogenomics practice. Indeed, pharmacists are rapidly emerging as professional trailblazers in this area.[3-5] The Clinical Pharmacogenetics Implementation Consortium (CPIC)[6] guidelines provide clinically useful guidance to enable the use of genetic laboratory test results for drug therapy recommendations in practice for 40 drug-gene pairs. CPIC is a pharmacist-led initiative, and many of the published guidelines have been developed and authored by pharmacists.[6]

There is a clear consensus among national pharmacy organizations regarding the important role of the pharmacist in applying pharmacogenomics to patient care. In 2011, the American Pharmacists Association (APhA) issued a white paper encouraging the development and integration of pharmacogenomics into pharmacy practice through medication therapy management (MTM).[4] More recently, the American

Disclosure: The authors declare no relevant conflicts of interest or financial relationships.

Funding: James Hoffman's contributions to this paper were supported by American Lebanese Syrian Associated Charities and National Institutes of Health grants CA 21765 and R24GM115264-01. Kristin Weitzel's contributions to this paper were supported by National Institutes of Health/National Center for Advancing Translational Science University of Florida Clinical and Translational Science Awards UL1 TR000064 and IGNITE Network grant U01 HG007269.

* **Correspondence:** Mary W. Roederer, 1011 Genetic Medicine Building, Mason Farm Road, CB# 7361, Chapel Hill, NC 27599-7361.
E-mail address: mary.roederer1@gmail.com (M.W. Roederer).

http://dx.doi.org/10.1016/j.japh.2016.08.014
1544-3191/

Key Points

Background:

- Pharmacists believe pharmacogenomic data is part or will be a part of pharmacotherapy management in the near future.
- Pharmacist competencies for pharmacogenomics elucidate a framework for a basic knowledge to provide essential pharmacotherapy recommendations based on available genomic data.

Findings:

- The Clinical Pharmacogenomics Working Group (CPIC) create and update guidelines for using available genomic data to influence medication use.
- The updated pharmacogenomics competencies provide a launching pad for educational efforts for both students and practicing pharmacists.

Society of Health-Systems Pharmacists (ASHP) developed a formal policy statement on the pharmacist's role in clinical pharmacogenomics.[5] The ASHP statement describes a need for all pharmacists to have a basic understanding of the use of pharmacogenomic data for patient care and for pharmacists with specialized expertise to lead the implementation of pharmacogenomics. The ASHP Residency Directory (http://ashp.org) currently recognizes 3 post-graduate year 2 (PGY2) pharmacogenetics specialty residencies that are accredited or seeking accreditation, and the number of pharmacists with specialized training in this area is growing.

With guidelines available and national organizations releasing statements elucidating the pharmacist as a clinician integral to the use of pharmacogenomic data, clinical pharmacogenomics is also becoming the standard of care in some practice environments and its applications are expected to grow. In a recent survey of health system pharmacy directors, pharmacogenomic testing was used in 7% of hospitals.[7] In a report on the future of pharmacy practice, 79% of participants expect that at least 1 academic medical center in their area will have a pharmacy-based pharmacogenomics service within the next 5 years.[8]

Pharmacy at a crossroads in pharmacogenomics

Despite these advances, practicing pharmacists consistently report feeling ill-prepared to evaluate pharmacogenomic test results and discuss implications of these results with patients and other health care professionals.[9-12] This perceived lack of competency is supported by published descriptions that show a lack of formal training and understanding among pharmacists regarding pharmacogenomics knowledge and document its limited inclusion in pharmacy education.[13,14] In the present paper, we argue that the profession of pharmacy is at a crossroads within clinical pharmacogenomics. Although pharmacists are being recognized as leaders in clinical pharmacogenomics, both within and outside of pharmacy, individual pharmacists consistently report being underprepared to assume practice-based responsibilities in pharmacogenomics, pointing to significant clinical and educational gaps within the profession.

There is an urgent need for the profession to address these gaps through development and dissemination of educational and clinical practice models that can equip practicing pharmacists, new graduates, and students with the knowledge and skills needed to integrate pharmacogenomic data into individualized medication therapy choices in the current patient care paradigm.

An essential step in meeting this need is the development of current practice-based pharmacogenomic educational competencies. Pharmacist competencies for pharmacogenomics were last updated in 2002.[14] In a manner similar to that employed by other health care professionals to systematically address pharmacogenomics, the creation of practice-based pharmacogenomic competencies fulfills a need to identify the core areas of knowledge, skill, and attitudes required for pharmacist proficiency in this area.[15,16] Moving forward, the maintenance and widespread dissemination of such competencies will be essential to create a dynamic professional "blueprint" that can be used to standardize and improve education and practice expectations for pharmacists in clinical pharmacogenomics.[17-19] Furthermore, leading this competency development and revision process from within the profession allows the unique perspective and background of pharmacists to consistently be at the forefront of revised pharmacogenomics competencies.[14,15]

Using a systematic process to update pharmacist competencies

In 2011, the National Institutes of Health National Human Genome Research Institute (NHGRI) invited pharmacy education stakeholders, including representatives from 11 national pharmacy organizations, other medical associations, government agencies, and colleges and schools of pharmacy, to participate in such a process to explore needs for pharmacist education in the era of genomics.[15] This meeting resulted in plans to address perceived gaps in pharmacist education around pharmacogenomics, including the need for developing updated pharmacist competencies in pharmacogenomics and increasing pharmacy contributions to established educational and practice-based resources in this area, such as NHGRI's Genetics and Genomics Competency Center (G2C2; www.g-2-c-2.org).[16]

As with the 2002 competencies, the American Association of Colleges of Pharmacy (AACP) Pharmacogenetics/Pharmacogenomics Special Interest Group (SIG) was charged to lead this process. In 2012, a SIG subcommittee analyzed the needs for pharmacist competencies and assembled an updated competencies inventory, which included the need for increased coverage of the clinical applications of genomics to MTM.

Based on the desired outcome that "pharmacy graduates should possess competent knowledge and skills to seek coordination and collaboration of care with an interdisciplinary team of health professionals when assessing genetic information," the AACP SIG led a systematic process to revise the existing competencies. This process was conducted from 2012

Table 1
Pharmacist competencies in pharmacogenomics and sample clinical practice activities

Competency domain and pharmacist-specific knowledge	Example pharmacist activity or responsibility
Basic genetic concepts	
1. To demonstrate an understanding of the basic genetic and genomic concepts and nomenclature.	Translate genotype data into phenotypic categories to develop clinical recommendations to optimize medication use for patient care.
2. To recognize and appreciate the role of behavioral, social, and environmental factors (lifestyle, socioeconomic factors, pollutants, etc.) to modify or influence genetics in the manifestation of disease.	Educate patients and health care providers about family history, genomic risk, and pharmacogenomic test results as they relate to health behaviors.
3. To identify drug- and disease-associated genetic variations that facilitate development of prevention, diagnosis, and treatment strategies; to appreciate differences in testing methodologies and the need to explore these differences in drug literature evaluation.	Interpret and document drug response–related family history information (e.g., in electronic health records and family history software programs).
4. To use family history (minimum of 3 generations) in assessing predisposition to disease and selection of drug treatment.	
Genetics and disease	
1. To understand the role of genetic factors in maintaining health and preventing disease.	Educate patients and health care providers about genetics and complex disease risk assessment, and recommended screening for early detection and diagnosis.
2. To assess the difference between clinical diagnosis of disease and identification of genetic predisposition to disease (genetic variation is not strictly correlated with disease manifestation).	Educate health care providers and others about the potential use of and strategies for handling incidental findings with pharmacogenomic test results.
3. To appreciate that pharmacogenomic testing may also reveal certain genetic disease predispositions (e.g., Apo E4 polymorphism).	
Pharmacogenetics and pharmacogenomics	
1. To demonstrate an understanding of how genetic variation in a large number of proteins (e.g., drug transporters, metabolizing enzymes, receptor targets) influence pharmacokinetics and pharmacodynamics related to pharmacologic effect and drug response.	Recommend drug therapy changes that integrate pharmacogenomic, pharmacokinetic, and pharmacodynamic data to optimize patient care.
2. To understand the influence of ethnicity in genetic polymorphisms and associations of polymorphisms with drug response.	Educate health care providers on the influence of genetic variance on pharmacokinetics-based dosing regimens.
3. Recognize the availability of evidence-based guidelines that synthesize information relevant to genomic and pharmacogenomic tests and selection of drug therapy (e.g., Clinical Pharmacogenetics Implementation Consortium).	Educate patients and health care providers on the influence of ethnicity on pharmacogenomic recommendations.
	Apply pharmacogenomic drug dosing guidelines in practice and guide health care providers on their appropriate use and interpretation.
Ethical, legal, and social implications	
1. To understand the potential physical and psychosocial benefits, limitations and risk of pharmacogenetic and pharmacogenomic information for individuals, family members, and communities, especially with pharmacogenetic and pharmacogenomic tests that may relate to predisposition to disease.	Serve as a resource for institutions and providers regarding best practices for interpreting and returning incidental findings with the use of pharmacogenomic and genomic testing.
2. To understand the increased liability that accompanies access to detailed genomic patient information and maintain their confidentiality and security.	Educate patients and health care providers about privacy and other potential concerns with pharmacogenomic and genomic data.
3. To adopt a culturally sensitive and ethical approach to patient counseling regarding genomic and pharmacogenomic test results.	
4. To appreciate the cost, cost-effectiveness, and reimbursement by insurers relevant to genomic or pharmacogenomic tests, for patients and communities.	
5. To identify when to refer a patient to a genetic specialist or genetic counselor.	

to 2013 and included: 1) searching the medical literature to identify, review, and critically analyze existing competency statements in genomics or pharmacogenomics for health care providers[14,17-19]; 2) examining existing health care professional competencies to develop a revised framework for pharmacists in the area of genomics[19]; 3) seeking consensus from a professional panel composed of 9 pharmacy organizations to gain approval of the competencies; and 4) seeking approval of the larger AACP SIG body. These steps were successfully carried out with unanimous approval from the pharmacy organizations in July 2012 and final approval by the AACP SIG in July 2013. Table 1 summarizes the competencies and provides real-world examples of pharmacist activities and clinical responsibilities when these competencies are put into practice.

Applying a competency-based approach to meet current professional needs

Although this revision and the future maintenance of pharmacogenomics competencies are important steps toward creating a much-needed framework for education, dissemination and adoption of these competencies will be required to meet the significant educational and practice-based needs in this area. These needs span multiple settings and target audiences, including both student pharmacists and practitioners.

For student pharmacists, the need for a competency-based approach to teaching pharmacogenomics is underscored by recent changes to American Council on Pharmaceutical Education Accreditation Standards and Key Elements for the

Professional Program in Pharmacy Leading to the Doctor of Pharmacy Degree, which require colleges and schools of pharmacy to teach pharmacogenomics in their curricula beginning with the 2016-2017 academic year.[20] Despite this requirement, few resources exist to support faculty in teaching clinical pharmacogenomics, and there are a limited number of clinical faculty who have received formal training in pharmacogenomics. To meet these needs, a number of individual schools and colleges of pharmacy have developed shared curricular or train-the-trainer approaches, such as PharmGenEd,[21-24] Manchester University certificate training program,[25] the University of Pittsburgh's Test2Learn program,[26] and the University of Florida (UF) Health Personalized Medicine Program graduate and certificate courses in pharmacogenomics.[27]

For pharmacists, professional competencies can be used to demonstrate a knowledge foundation for practice needs in pharmacogenomics. Although program content and individual emphasis on the current competency areas varies, a systematic approach to educating practitioners has been adopted by many institutions, including St. Jude Children's Research Hospital, Vanderbilt University, Mayo Clinic, and the UF Health Personalized Medicine Program.[28-31] Pharmacy and medical associations have led national efforts to meet practitioner needs in this area, including APhA, ASHP, and the American Medical Association. These programs extend to the state level, with, for example, the Indiana Pharmacists Alliance and Manchester University now offering a certificate training program centered on the revised competencies. Increasing numbers of postgraduate specialized residency training programs also provide practice-based opportunities for pharmacists to develop further specialized knowledge and skills in pharmacogenomics or to focus on a specific therapeutic area (e.g., oncology).

We feel strongly that educational and professional development programs built on a standardized competency-based framework will be most effective in advancing clinical practice and strengthening the potential pool of pharmacy faculty members, clinicians, and preceptors trained to provide education in this unique scientific area. To support and streamline such efforts, educators and practitioners can rely on existing resources for pharmacogenomics education (Table 2). For example, many pharmacogenomics teaching materials are available within NHGRI's G2C2 website. All materials indexed by G2C2 undergo pharmacist peer review, and program content is mapped to the current pharmacogenomics competencies. Increasing awareness of these types of resources can assist large-scale competency-based educational efforts.

Moving from competence to clinical implementation

To achieve the vision of pharmacists as leaders within pharmacogenomics, however, it is essential that pharmacists' education, training, and professional development extend beyond merely demonstrating competency. Many barriers to implementation and adoption of clinical pharmacogenomics lie beyond the classroom within professional practice. Although practice-based resources, such as CPIC guidelines, provide much-needed guidance for clinical decisions, there is a continued need to equip pharmacists to lead the development and implementation of viable and sustainable clinical pharmacogenomics practice models.[4,5] Examples of such practice models that incorporate the pharmacist as the clinical pharmacogenomics expert are emerging across all practice settings, but most quickly in the community pharmacy and health system environments.

There are a number of published reports that provide examples of pharmacist-driven pharmacogenomics services in the community pharmacy. O'Connor et al. evaluated the implementation of pharmacogenomics services in community pharmacy and showed that these services could be a component of MTM.[32] As in other pharmacist-led patient care

Table 2
Educational and practice-based resources for pharmacogenomics

Resource	Website	Description
Evaluation of Genomic Applications in Practice and Prevention	http://www.egappreviews.org/default.htm	Primarily focused on genomic medicine implementation; evidence reports for a limited number of pharmacogenomic gene-drug pairs
Genetics/Genomics Competency Center	http://g-2-c-2.org	Categorized educational resources in genetics and genomics and pharmacogenomics for health care educators and clinicians
Global Genetics and Genomics Community	http://g-3-c.org/en	Online learning portal, including interactive cases demonstrating the link between genetics and genomics and health
National Human Genome Research Institute	http://www.genome.gov	Information for health care professionals and patients on genetics and pharmacogenomics, including terminology, videos, and illustrations
PharmGKB (Pharmacogenomics Knowledge Base)	http://www.pharmgkb.org/	Database of research findings about the impact of genetic variation on drug response for clinicians; links to other subspecialty society guideline recommendations (e.g., Dutch Pharmacogenomics Working group); the Clinical Pharmacogenomics Implementation Consortium (http://www.pharmgkb.org/page/cpic) provides free peer-reviewed guidelines with supplemental information and updates
Clinical Pharmacogenetics Implementation Consortium (CPIC) Guidelines	https://www.cpicpgx.org	Standardized guidelines generated by a complete evidence-based review of the literature to provide actionable prescribing decisions when genetic laboratory results are available
Dutch Pharmacogenomics Working group	https://www.pharmgkb.org/page/dpwg	Composed of clinicians and scientists working to develop pharmacogenetics-based therapeutic recommendations
PharmGenEd	https://pharmacogenomics.ucsd.edu/	Educational materials (including recorded lectures and handouts) focused on clinical applications of pharmacogenomics for health care students and practitioners

services, reimbursement for the pharmacist's time to interpret and counsel patients about pharmacogenomic test results remains a challenge. However, studies have shown that prescribers value the pharmacist's input and are receptive to pharmacist recommendations.[32-35] Practice models for pharmacogenomic testing in the community pharmacy are beginning nationwide implementation into mainstream pharmacy establishments, with community pharmacists performing buccal swab testing, receiving test results, interpreting the results, and communicating the results to prescribers.[36,37]

Various examples of clinical pharmacogenomics practice models are available from the health system perspective, including pharmacist-led consultation-based services to interpret and apply pharmacogenomic test results in oncology, cardiology, pain management, and other areas.[2,29] Although some of these models use a "reactive" approach, with interpretation and guidance provided after a pharmacogenomic test result, others illustrate a "preemptive" array-based approach to pharmacogenomics. In a preemptive testing model, multiple genes are tested and systematically included in the electronic health record to prospectively inform medication choices.[28,29] Moving forward, progression of the science that has provided for a substantial decrease in the cost of the array-based chips will continue to drive the use of the technology and exponentially increase the availability of genomic data within health systems. Having many patients with pharmacogenomic data will necessitate increased adoption of a systematic and preemptive approach, much like the need for renal dosing when serum creatinine is routinely tested and reported.

Pharmacists are carving out significant leadership roles within these practice models, and pharmacogenomics represents an important niche and emerging practice-based specialty for our profession. In addition to the need for a standardized competency-based approach to pharmacogenomics education, efforts that support identification and dissemination of best practice models for integrating clinical pharmacogenomics into standard practice and health information technology systems will continue to be essential.[28-30,32]

Conclusion

The profession of pharmacy is faced with significant educational, practice-based, and implementation challenges within clinical pharmacogenomics. Adoption and maintenance of current practice-based competencies for pharmacogenomics provides a defined and standardized framework to measure the knowledge, skills, and attitudes of students and practitioners. This competency framework can also serve as a launch pad for the continued growth of educational and practice-based resources for students and practitioners alike. Scientific evaluation and dissemination of clinical practice models in pharmacogenomics will serve to normalize the use of these data to optimize medication therapy and stimulate the rapid uptake of clinical and technologic systems to allow safe, effective, and broad use of pharmacogenomics within pharmacist-directed patient care.

An important limitation of the current competencies is that they can realistically highlight only the baseline educational and practice needs in pharmacogenomics as identified today. In a rapidly emerging area of patient care such as genomic medicine, the knowledge and skills required for pharmacists to be leaders in pharmacogenomics will continue to see significant changes and growth in coming years. Continued resource investment for maintaining the competencies and developing professional curricula and practice models that reflect the constant advances in pharmacogenomic discoveries will be necessary for ongoing effective translation of genomic science into clinical care, with pharmacists as prepared and essential members of the health care team.

References

1. U.S. Food and Drug Administration. Table of pharmacogenomic biomarkers in drug labeling. Available at: http://www.fda.gov/drugs/scienceresearch/researchareas/pharmacogenetics/ucm083378.htm. Accessed September 2, 2015.
2. Crews KR, Cross SJ, McCormick JN, et al. Development and implementation of a pharmacist-managed clinical pharmacogenetics service. *Am J Health Syst Pharm*. 2011;68(2):143–150.
3. Owusu-Obeng A, Weitzel KW, Hatton RC, et al. Emerging roles for pharmacists in clinical implementation of pharmacogenomics. *Pharmacotherapy*. 2014;34(10):1102–1112.
4. Reiss SM, American Pharmacists A. Integrating pharmacogenomics into pharmacy practice via medication therapy management. *J Am Pharm Assoc*. 2011;51(6):e64–e74.
5. American Society of Health-Systems Pharmacists. Statement on the pharmacist's role in clinical pharmacogenomics. *Am J Health Syst Pharm*. 2015;72(7):579–581.
6. Relling MV, Klein TE. CPIC: Clinical Pharmacogenetics Implementation Consortium of the Pharmacogenomics Research Network. *Clin Pharmacol Ther*. 2011;89(3):464–467.
7. Pedersen CA, Schneider PJ, Scheckelhoff DJ. ASHP national survey of pharmacy practice in hospital settings: dispensing and administration—2014. *Am J Health Syst Pharm*. 2015;72(13):1119–1137.
8. Ja T. *Pharmacy forecast 2015-2019: strategic planning for pharmacy departments in hospitals and health systems*. Bethesda, MD: ASHP Research and Education Foundation; 2014.
9. McCullough KB, Formea CM, Berg KD, et al. Assessment of the pharmacogenomics educational needs of pharmacists. *Am J Pharm Educ*. 2011;75(3):51.
10. Formea CM, Nicholson WT, McCullough KB, et al. Development and evaluation of a pharmacogenomics educational program for pharmacists. *Am J Pharm Educ*. 2013;77(1):10.
11. Roederer MW, van Riper M, Valgus J, Gnafl G, McLeod H. Knowledge, attitudes, and education of pharmacists regarding pharmacogenetic testing. *Person Med*. 2012;9(1):19–27.
12. Stanek EJ, Sanders CL, Taber KA, et al. Adoption of pharmacogenomic testing by US physicians: results of a nationwide survey. *Clin Pharmacol Ther*. 2012;91(3):450–458.
13. Murphy JE, Green JS, Adams LA, Squire RB, Kuo GM, McKay A. Pharmacogenomics in the curricula of colleges and schools of pharmacy in the United States. *Am J Pharm Educ*. 2010;74(1):7.
14. Johnson JA, Bootman JL, Evans WE, et al. Pharmacogenomics: a scientific revolution in pharmaceutical sciences and pharmacy practice. Report of the 2001/02 Academic Affairs Committee. *Am J Pharm Educ*. 2002;66:12s–15s.
15. Ferro WG, Kuo GM, Jenkins JF, Rackover MA. Pharmacist education in the era of genomic medicine. *J Am Pharm Assoc*. 2012;52(5):e113–e121.
16. Calzone KA, Jerome-d'Emilia B, Jenkins J, et al. Establishment of the genetic/genomic competency center for education. *J Nurs Sch*. 2011;43(4):351–358.
17. Calzone KA, Jenkins J, Prows CA, Masny A. Establishing the outcome indicators for the essential nursing competencies and curricula guidelines for genetics and genomics. *J Prof Nurs*. 2011;27(3):179–191.
18. Rackover MA, Goldgar C, Wolpert C, Healy K, Feiger J, Jenkins J. Establishing essential physician assistant clinical competencies guidelines for genetics and genomics. *J Physician Assist Educ*. 2007;18(2):48–49.
19. Genetic Alliance; The New York-Mid-Atlantic Consortium for Genetic and Newborn Screening Services. *Understanding Genetics: A New York, Mid-Atlantic Guide for Patients and Health Professionals*. Washington, DC: Genetic Alliance; 2009 Jul 8. APPENDIX Q, National Coalition for Health Professional Education in Genetics (NCHPEG): Principles of Genetics for Health Professionals. Available at: https://www.ncbi.nlm.nih.gov/books/NBK115543/. Accessed October 19, 2016.
20. Accreditation Council for Pharmaceutical Education (ACPE). *Accreditation standards and key elements for the professional program in pharmacy*

leading to the doctor of pharmacy degree; 2015. Available at: https://www.acpe-accredit.org/pdf/Standards2016FINAL.pdf. Accessed February 2, 2015.
21. Kuo GM, Ma JD, Lee KC, et al. Institutional Profile: University of California San Diego Pharmacogenomics Education Program (PharmGenEd): bridging the gap between science and practice. *Pharmacogenomics*. 2011;12(2):149–153.
22. Lee KC, Ma JD, Kuo GM. Pharmacogenomics: bridging the gap between science and practice. *J Am Pharm Assoc*. 2010;50(1):e1–e14.
23. Lee KC, Ma JD, Hudmon KS, Kuo GM. A train-the-trainer approach to a shared pharmacogenomics curriculum for US colleges and schools of pharmacy. *Am J Pharm Educ*. 2012;76(10):193.
24. Lee KC, Hudmon KS, Ma JD, Kuo GM. Evaluation of a shared pharmacogenomics curriculum for pharmacy students. *Pharmacogenomics*. 2015;16(4):315–322.
25. Kisor DF, Bright DR, Chen J, Smith TR. Academic and professional pharmacy education: a pharmacogenomics certificate training program. *Person Med*. 2015;12(6):563–573.
26. Adams SM, Anderson KB, Coons JC, et al. Advancing pharmacogenomics education in the core PharmD curriculum through student personal genomic testing. *Am J Pharm Educ*. 2016;80(1):3.
27. Weitzel KW, McDonough CW, Elsey AR, et al. Use of personal genotype data in pharmacy education: effects on student learning and attitudes in a pharmacogenomics course. *Am J Pharm Educ*. [Epub ahead of print].
28. Hoffman JM, Haidar CE, Wilkinson MR, et al. PG4KDS: a model for the clinical implementation of pre-emptive pharmacogenetics. *Am J Med Genet C Semin Med Genet*. 2014;166C(1):45–55.
29. Weitzel KW, Elsey AR, Langaee TY, et al. Clinical pharmacogenetics implementation: approaches, successes, and challenges. *Am J Med Genet C Semin Med Genet*. 2014;166C(1):56–67.
30. Pulley JM, Denny JC, Peterson JF, et al. Operational implementation of prospective genotyping for personalized medicine: the design of the Vanderbilt PREDICT project. *Clin Pharmacol Ther*. 2012;92(1):87–95.
31. Bielinski SJ, Olson JE, Pathak J, et al. Preemptive genotyping for personalized medicine: design of the right drug, right dose, right time–using genomic data to individualize treatment protocol. *Mayo Clin Proc*. 2014;89(1):25–33.
32. Ferreri SP, Greco AJ, Michaels NM, et al. Implementation of a pharmacogenomics service in a community pharmacy. *J Am Pharm Assoc*. 2014;54(2):172–180.
33. Kisor DF, Bright DR, Conaway M, Bouts BA, Gerschutz GP. Pharmacogenetics in the community pharmacy: thienopyridine selection post-coronary artery stent placement. *J Pharm Pract*. 2014;27(4):416–419.
34. O'Connor SK, Ferreri SP, Michaels NM, et al. Making pharmacogenetic testing a reality in a community pharmacy. *J Am Pharm Assoc*. 2012;52(6):e259–e265.
35. Padgett L, O'Connor S, Roederer M, McLeod H, Ferreri S. Pharmacogenomics in a community pharmacy: ACT now. *J Am Pharm Assoc*. 2011;51(2):189–193.
36. Johnson JA, Weitzel KW. Advancing pharmacogenomics as a component of precision medicine: how, where, and who? *Clin Pharmacol Ther*. 2016;99(2):154–156.
37. Haga SB, Moaddeb J, Mills R, Patel M, Kraus W, Allen LaPointe NM. Incorporation of pharmacogenetic testing into medication therapy management. *Pharmacogenomics*. 2015;16(17):1931–1941.

Mary W. Roederer, PharmD, BCPS, Adjunct Assistant Professor, UNC Eshelman School of Pharmacy, Chapel Hill, NC

Grace M. Kuo, PharmD, MPH, PhD, Professor of Clinical Pharmacy, Adjunct Professor of Family Medicine and Public Health, University of California, San Diego, CA

David F. Kisor, BS, PharmD, Professor and Chair, Department of Pharmaceutical Sciences, Manchester University College of Pharmacy, Natural and Health Sciences, Fort Wayne, IN

Reginald F. Frye, PharmD, PhD, Professor and Chair, Department of Pharmacotherapy and Translational Research, University of Florida College of Pharmacy, Gainesville, FL

James M. Hoffman, PharmD, MS, BCPS, Associate Member, Pharmaceutical Sciences, St. Jude Children's Research Hospital, and Associate Professor, Clinical Pharmacy, University of Tennessee Health Science Center, Memphis, TN

Jean Jenkins, PhD, RN, FAAN, Clinical Advisor, Genomic Healthcare Branch, National Human Genome Research Institute, National Institutes of Health, Bethesda, MD

Kristin Wiisanen Weitzel, PharmD, FAPhA, Clinical Associate Professor, Department of Pharmacotherapy and Translational Research, University of Florida College of Pharmacy, Gainesville, FL