



Cleveland Clinic integrates genetic information into EHR. Page 2



Mount Sinai integrates pharmacogenetics into their treatment plans. Page 2



Mayo Clinic pharmacogenetics plan improves depressive symptoms. Page 3



St. Jude incorporates pharmacogenetic information into pediatric care. Page 3

# Pharmacogenetics In Practice Today

Thinking about implementing pharmacogenetic testing into your facility's work flow? You're in good company. Numerous medical facilities across the country have implemented pharmacogenetic testing, including health care industry trend-setters such as Mayo Clinic and St. Jude Children's Research Hospital.

The adoption of personalized prescribing through pharmacogenetic testing is expected to grow as healthcare providers learn the importance of knowing a patient's unique genetics before prescribing. Pharmacogenetic testing refers to testing for specific genetic variants that could have an impact on drug response. The U.S. Food and Drug Administration has recognized this testing as playing an important role in avoiding potentially dangerous side effects and optimizing drug dosing. Inside you'll find a summary of well-respected hospitals and research organizations that already have a pharmacogenetic testing program in place.



Recent research has shown pharmacogenetic testing to be an aspect of personalized medicine with potentially untapped benefits.

3 of 4

patients have genetic variations affecting their response to medications.

75%

of the top 200 drugs prescribed in the U.S. are metabolized by highly genetically variable liver enzymes.

100

number of drugs that feature FDA guidance about pharmacogenetic testing on the product label.



# Personalized medicine in practice



Brigham and Women's  
Hospital  
Boston, Massachusetts

Brigham and Women's Hospital is among the first in the U.S. to offer patients pharmacogenetic consultations. Their Pharmacogenetics Consultation Service (PCS) offers specialized genetic testing and consultation designed to improve the safety and efficacy of selecting medications.<sup>1</sup> The PCS team is comprised of clinical geneticists, pharmacists, and molecular genetic pathologists who provide recommendations to help reduce adverse reactions and suggest dosing alternatives to the patients' doctor. These experts agree that genetic and genomic information should be taken into consideration when prescribing medications such as warfarin (Coumadin), azathioprine (Imuran), or mercaptopurine (Purinethol) among many others.



Cleveland Clinic  
Cleveland, Ohio

Cleveland Clinic launched the Center for Personalized Healthcare in 2011 to establish an evidence-based system for individualizing care by incorporating unique patient characteristics, including but not limited to genetic and family health history information, into the standard medical decision-making process.<sup>3</sup> Using MyFamily, a web-based tool integrated into the clinic's EHR, a patient's family health history is used as a resource for genetic, environmental and behavioral risks to identify those with a high probability of developing disease. Complementing MyFamily, the Personalized Medication Program was created for the purpose of identifying gene-drug interactions for integration into clinical practice. For example, the clinic has successfully implemented the gene-drug pairs HLA-B\*57:01-abacavir and TPMT-thiopurines into patient care. Researchers predict the Cleveland Clinic personalized medical care program may be used as a model for large-scale integration of the practice.<sup>3</sup>



Cincinnati Children's  
Hospital Medical Center  
Cincinnati, Ohio

The Genetic Pharmacology Service at Cincinnati Children's Hospital Medical Center uses pharmacogenetic testing to help clinicians customize patient care. The hospital offers tests for variations in three CYP450 drug-metabolizing enzymes (CYP2D6, CYP2C9 and CYP2C19) and a separate enzyme known as TPMT.<sup>2</sup> These enzymes process medications used in a number of different specialties, including psychiatry, pain management, cardiology and oncology. The Genetic Pharmacology Service also maintains a secure database of genotyping results that can be used by clinicians for patient care in the event that the patient requires future medications metabolized by variant enzymes. The goal: provide prescribing clinicians with state-of-the-art information to improve the effectiveness and safety of the medications prescribed to the children's hospital's patients.



Icahn School of Medicine  
at Mount Sinai  
New York City, New York

At the Icahn School of Medicine at Mount Sinai, physicians have utilized a new data management and analysis platform called CLIPMERGE, which is an advanced software application that analyzes patient data, both genetic and clinical, and decides whether there is an adverse drug reaction risk.<sup>4</sup> CLIPMERGE, which stands for CLinical Implementation of Personalized Medicine through Electronic Health Records and GENomics, records and analyzes patient information and compares it to data on certain medications, analyzing the likelihood of the drug being effective or causing side-effects due to that patient's genetic makeup. When a patient is prescribed a medication by their physician for whom CLIPMERGE has recorded information, the software generates and sends a message, in real time, to the physician to let them know. The CLIPMERGE system works in conjunction with the BioMe Platform, which is an ongoing hospital-based population research study.<sup>5</sup> BioMe participants undergoing routine care at Mount Sinai Health System can have their DNA tested for differences in genes that may suggest greater risk of side effects or chance of increased benefit from certain medications.

# Personalized medicine in practice



Mayo Clinic  
Rochester, Minnesota

Mayo Clinic, a preeminent research group known for medical breakthroughs, has realized the benefits of pharmacogenetics testing and has integrated the practice into its treatment plans. In September 2013, Mayo Clinic and a private genetics testing lab announced a clinical study that provides additional evidence for the effectiveness of pharmacogenetic testing for selecting psychotropic medications. The study showed the ability of pharmacogenetics to identify individuals who are likely to have a favorable outcome with specific pharmacotherapies.<sup>6</sup> A four-fold greater improvement in depressive symptoms was observed in the participants group with the highest severity genetic interactions that received prescriptions based on their genetics, compared to those who did not receive genotype-based treatment.



Ohio State University  
Columbus, Ohio

Ohio State University (OSU) has multiple initiatives dedicated to pharmacogenomics research. The Center for Pharmacogenomics at OSU's College of Medicine focuses on the discovery of genetic variants that serve as biomarkers guiding successful drug therapy in individual patients.<sup>7</sup> The approach of OSU researchers spans from basic biomedical sciences to clinical implementation applicable to many common diseases, including cardiovascular disorders, cancer and infectious diseases, to address urgent needs for improved therapy. A 2013 Pharmacogenomics journal article also reported on OSU's Wexner Medical Center using clinical decision support tools to integrate information from the patient's EMR, such as orders for medications, with genomic variant data.<sup>8</sup> These triggered "best practice alerts," or recommendations for or against the use of specific medications. Similar to the function of drug allergy reminders in the EMR, genetic knowledge could be automated into the system to reduce patient risk and maximize drug efficacy.



St. Jude Children's  
Research Hospital  
Memphis, Tennessee

St. Jude Children's Research Hospital is famous for its dedication to patient care and its embrace of innovative strategies, strategies that now include a pharmacogenetics testing program (PG4KDS). St. Jude's program involves testing for variants in the genes CYP2D6, CYP2C19, TMPT and SLCO1B1 and tying those genotypes to 14 high-risk drugs in the EHR.<sup>9</sup> Testing results showed that 78 percent of children tested had at least one high-risk genotype.<sup>10</sup> St. Jude offers pharmacogenetic consults in the context of a comprehensive approach to pharmaceutical care integrated into clinical practice areas such as oncology, general hematology, bone marrow transplantation, and ambulatory care.



Center for Personalized  
Therapeutics—  
The University of Chicago  
Chicago, Illinois

The 1,200 Patients Project at the University of Chicago's Center for Personalized Therapeutics seeks to make information gleaned from pharmacogenetic testing a more routine part of clinical practice.<sup>11</sup> The researchers are collecting DNA samples from 1,200 patient participants then testing for hundreds of DNA markers potentially impacting drug responses or side effects.<sup>12</sup> That information is then immediately accessible to the patients' physicians through a secured informatics database. Based on the project data, there is a strong interest among doctors and their patients for incorporating pharmacogenetic information into their treatment plans. According to a GenomeWeb report, physicians in the study disclosed that about 40 percent of the time they believed they were making a more informed decision based on the available pharmacogenetic information. Also, 98 percent told the researchers that they would be very likely to enroll another patient in the program.<sup>13</sup>

# Personalized medicine in practice



University of Maryland  
Medical Center and  
Baltimore Veterans Administration  
Medical Center  
Baltimore, Maryland



Vanderbilt  
University  
Nashville, Tennessee

In 2013, the University of Maryland Medical Center (UMMC) and Baltimore Veterans Administration Medical Center (VAMC) launched a personalized medicine initiative focusing on patients with coronary artery disease.<sup>14</sup> Patients undergoing treatment at UMMC and Baltimore VAMC now can enroll in a long-term therapy program tailored to their specific genetic makeup. The patients are specifically tested for variants in the CYP2C19 gene, which processes the common antiplatelet drug clopidogrel. The researchers report successes in implementing the program and anticipate developing additional initiatives based on other drug-gene pairs.<sup>14</sup>

Vanderbilt researchers are regularly discovering new links between genetics and medications. They are also one of the first academic medical centers to put pharmacogenomics into practice with their Pharmacogenomic Resource for Enhanced Decisions in Care and Treatment program (PREDICT).<sup>15</sup> Josh Peterson, M.D., MPH, assistant professor of Medicine and Biomedical Informatics at Vanderbilt University School of Medicine, estimated that genetic testing conducted to date has helped avoid severe gene-drug interactions in hundreds of patients.<sup>15</sup>

## References

1. Pharmacogenetics Consultation Service - Medication Safety and Efficacy: Brigham and Women's Hospital; [cited 2015]. Available from: [http://www.brighamandwomens.org/Medical\\_Professionals/education/publications/ppd/2008/PharmGen\\_Safety.aspx](http://www.brighamandwomens.org/Medical_Professionals/education/publications/ppd/2008/PharmGen_Safety.aspx).
2. Genetic Pharmacology Service: Cincinnati Children's Hospital Medical Center; [cited 2015]. Available from: <http://www.cincinnatichildrens.org/service/g/genetic-pharmacology/about/>.
3. Teng K, DiPiero J, Meese T, Doerr M, Leonard M, Daly T, et al. Cleveland Clinic's Center for personalized healthcare: setting the stage for value-based care. *Pharmacogenomics*. 2014;15(5):587-91. Epub 2014/05/07. doi: 10.2217/pgs.14.31. PubMed PMID: 24798715.
4. The Charles Bronfman Institute for Personalized Medicine: Icahn School of Medicine at Mount Sinai; [cited 2015]. Available from: <http://icahn.mssm.edu/research/institutes/institute-for-personalized-medicine/innovation-and-technology/clipmerge-program/information-for-patients>.
5. The Charles Bronfman Institute for Personalized Medicine - BioMe Platform: Icahn School of Medicine at Mount Sinai; [cited 2015]. Available from: <http://icahn.mssm.edu/research/institutes/institute-for-personalized-medicine/innovation-and-technology/biome-platform>.
6. Joint Assurex Health and Mayo Clinic Study Demonstrates Clinical Utility of Assurex Health's Pharmacogenomic Test to Guide Treatment of Major Depressive Disorders: Assurex Health; 2013 [cited 2015]. Available from: <http://assurexhealth.com/joint-assurex-health-and-mayo-clinic-study-demonstrates-clinical-utility-of-assurex-healths-pharmacogenomic-test-to-guide-treatment-of-major-depressive-disorders/>.
7. OSU College of Medicine Center for Pharmacogenomics (C-PGx): Ohio State University [cited 2015]. Available from: <http://pharmacogenomics.osu.edu/8063.cfm>.
8. Sturm AC, Sweet K, Manickam K. Implementation of a clinical research pharmacogenomics program at an academic medical center: role of the genetics healthcare professional. *Pharmacogenomics*. 2013;14(7):703-6. doi: 10.2217/pgs.13.46. PubMed PMID: 23651015; PubMed Central PMCID: PMC3796352.
9. Non-Therapeutic Protocol PG4KDS: Clinical Implementation of Pharmacogenetics: St. Jude Children's Research Hospital; [cited 2015]. Available from: <http://www.stjude.org/pg4kds>.
10. Hoffman JM, Haidar CE, Wilkinson MR, Crews KR, Baker DK, Kornegay NM, et al. PG4KDS: a model for the clinical implementation of pre-emptive pharmacogenetics. *American journal of medical genetics Part C, Seminars in medical genetics*. 2014;166C(1):45-55. doi: 10.1002/ajmg.c.31391. PubMed PMID: 24619595; PubMed Central PMCID: PMC4056586.
11. Center for Personalized Therapeutics - 1200 Patients Project: Center for Personalized Therapeutics - University of Chicago; [cited 2015]. Available from: <https://cpt.uchicago.edu/page/1200-patients-project>.
12. O'Donnell PH, Danahey K, Jacobs M, Wadhwa NR, Yuen S, Bush A, et al. Adoption of a clinical pharmacogenomics implementation program during outpatient care—initial results of the University of Chicago "1,200 Patients Project". *American journal of medical genetics Part C, Seminars in medical genetics*. 2014;166C(1):68-75. Epub 2014/03/13. doi: 10.1002/ajmg.c.31385. PubMed PMID: 24616296; PubMed Central PMCID: PMC4000170.
13. Ashford M. Early Data from UChicago's 1,200 Patients PGx Project Show High Physician Adoption. *GenomeWeb* [Internet]. 2014. Available from: <https://www.genomeweb.com/clinical-genomics/early-data-uchicago-1200-patients-pgx-project-show-high-physician-adoption>.
14. Shuldiner AR, Palmer K, Pakyz RE, Alestock TD, Maloney KA, O'Neill C, et al. Implementation of pharmacogenetics: the University of Maryland Personalized Anti-platelet Pharmacogenetics Program. *American journal of medical genetics Part C, Seminars in medical genetics*. 2014;166C(1):76-84. Epub 2014/03/13. doi: 10.1002/ajmg.c.31396. PubMed PMID: 24616408; PubMed Central PMCID: PMC4066997.
15. Snyder B. Meeting explores PREDICT's vast potential. *Reporter: VANDERBILT UNIVERSITY MEDICAL CENTER'S WEEKLY NEWSPAPER* [Internet]. 2012; 2015. Available from: <http://www.mc.vanderbilt.edu:8080/reporter/index.html?ID=12942>.