

# Pharmacogenetic Testing (for Indiana Only)

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[Instructions for Use](#)

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## Application

This Medical Policy only applies to the state of Indiana.

## Coverage Rationale

The use of pharmacogenetic Multi-Gene Panels to guide therapy decisions is proven and medically necessary for antidepressants and antipsychotics medication when all of the following criteria are met:

- The individual has a diagnosis of major depressive disorder or generalized anxiety disorder; and
- The individual has failed at least one prior medication to treat their condition; and
- The Multi-Gene Panel has no more than 15 relevant genes (see [Table 1](#))

The use of pharmacogenetic Multi-Gene Panels for genetic polymorphisms for any other indication, including but not limited to pain management, cardiovascular drugs, anthracyclines, or polypharmacy, is unproven and not medically necessary for evaluating drug-metabolizer status due to insufficient evidence of efficacy.

Examples of these Panels include, but are not limited to the following:

- GeneSight® Analgesic
- GeneSight® ADHD
- Pain Medication DNA Insights®
- PharmacoDx
- SureGene Test

## Definitions

**Multi-Gene Panel:** Genetic tests that use next-generation sequencing to test multiple genes simultaneously. Also called Multi-Gene test, multiple-gene Panel test and multiple-gene test (National Cancer Institute Dictionary of Genetics).

**Panel:** A group of laboratory tests that are performed together to assess a body function or disease (Medicare, 2019 and McGraw Hill, 2002).

## Applicable Codes

The following list(s) of procedure and/or diagnosis codes is provided for reference purposes only and may not be all inclusive. Listing of a code in this policy does not imply that the service described by the code is a covered or non-covered health service. Benefit coverage for health services is determined by federal, state, or contractual requirements and applicable laws that may require coverage for a specific service. The inclusion of a code does not imply any right to reimbursement or guarantee claim payment. Other Policies and Guidelines may apply.

CPT Code	Description
0029U	Drug metabolism (adverse drug reactions and drug response), targeted sequence analysis (i.e., CYP1A2, CYP2C19, CYP2C9, CYP2D6, CYP3A4, CYP3A5, CYP4F2, SLCO1B1, VKORC1 and rs12777823)
0078U	Pain management (opioid-use disorder) genotyping panel, 16 common variants (i.e., ABCB1, COMT, DAT1, DBH, DOR, DRD1, DRD2, DRD4, GABA, GAL, HTR2A, HTTLPR, MTHFR, MUOR, OPRK1, OPRM1), buccal swab or other germline tissue sample, algorithm reported as positive or negative risk of opioid-use disorder
0173U	Psychiatry (i.e., depression, anxiety), genomic analysis panel, includes variant analysis of 14 genes
0175U	Psychiatry (e.g., depression, anxiety), genomic analysis panel, variant analysis of 15 genes
81479	Unlisted molecular pathology procedure

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## Description of Services

Pharmacogenetics encompasses variation in genes that encode drug-metabolizing enzymes, drug transporters, and drug targets, as well as other specific genes related to the action of drugs. A slight variation in the deoxyribonucleic acid (DNA) sequence can result in a subtle change in a protein which translates into major differences in how the protein functions. The study of variations in DNA sequence as related to drug response is referred to as pharmacogenetics, and pharmacogenetic testing involves genotyping to detect relevant variants. Genetic variations can be associated with suboptimal drug response, for example poor efficacy or adverse events.

A pharmacogenetic test is meant to guide treatment strategies, patient evaluations and decisions based on its ability to predict response to treatment in particular clinical contexts. An overview of many aspects of pharmacogenetics and its application in specific clinical settings is provided by the National Academy of Clinical Biochemistry (NACB) Laboratory Medicine Practice Guidelines (2010). When testing is targeted to evaluate an individual's response to a specific drug, typically only one gene is analyzed. For warfarin, also known as coumadin, two to three genes are tested. However, laboratories have developed Multi-Gene Panels that include more than two genes in order to proactively evaluate an individual's possible response to many drugs. This policy is designed to address Multi-Gene Panel testing.

## Clinical Evidence

### Anxiety and Depression

The Pharmacogenomics Knowledge for Personalized Medicine database (PharmGKB) is a NIH-funded resource that provides information about how human genetic variation affects response to medications, and provides a centralized resource of international gene-drug professional society prescribing guidelines, FDA label information on gene-drug recommendations, and evidence based clinical curations (Whirl-Carillo et al., 2012).

Table 1 lists genes that can inform antidepressants and antipsychotics that are found in PharmGKB with an evidence level of 2B (moderate evidence of an association) or better (PharmGKB, 2019a and 2019b).

**Table 1: Antidepressant and Antipsychotic Drugs and Associated Genes**

Drug	Gene(s)	Select Associated References
Sertraline	<i>CYP2C19, CYP2D6, COMT, TXNRD2</i>	<ul style="list-style-type: none"> <li>CPIC Guideline for CYP2D6 and CYP2C19 Genotypes and Dosing of Selective Serotonin Reuptake Inhibitors (Hicks et al., 2015)</li> </ul>
Citalopram	<i>CYP2C19, SLC6A4, GRIK4, HTR2A, FKBP5, COMT, TXNRD2</i>	<ul style="list-style-type: none"> <li>CPIC Guideline for CYP2D6 and CYP2C19 Genotypes and Dosing of Selective Serotonin Reuptake Inhibitors (Hicks et al., 2015)</li> <li>Polymorphisms in GRIK4, HTR2A, and FKBP5 Show Interactive Effects in Predicting Remission to Antidepressant Treatment (Horstmann et al., 2010)</li> </ul>
Escitalopram	<i>CYP2C19, SLC6A4, COMT, TXNRD2</i>	<ul style="list-style-type: none"> <li>CPIC Guideline for CYP2D6 and CYP2C19 Genotypes and Dosing of Selective Serotonin Reuptake Inhibitors (Hicks et al., 2015)</li> <li>Interaction between serotonin transporter gene variants and life events predicts response to antidepressants in the GENDEP project (Keers et al., 2011)</li> </ul>
Fluoxetine	<i>FKBP5, COMT, TXNRD2</i>	<ul style="list-style-type: none"> <li>Polymorphisms in GRIK4, HTR2A, and FKBP5 Show Interactive Effects in Predicting Remission to Antidepressant Treatment (Horstmann et al., 2010)</li> </ul>
Paroxetine	<i>CYP2D6, HTR1A, FKBP5, COMT, TXNRD2</i>	<ul style="list-style-type: none"> <li>CPIC Guideline for CYP2D6 and CYP2C19 Genotypes and Dosing of Selective Serotonin Reuptake Inhibitors (Hicks et al., 2015)</li> <li>Polymorphisms in GRIK4, HTR2A, and FKBP5 Show Interactive Effects in Predicting Remission to Antidepressant Treatment (Horstmann, et al., 2010)</li> <li>SSRI response and HTR1A (Yevtushenko et al., 2010)</li> </ul>
Fluvoxamine	<i>CYP2D6, COMT, TXNRD2</i>	<ul style="list-style-type: none"> <li>CPIC Guideline for CYP2D6 and CYP2C19 Genotypes and Dosing of Selective Serotonin Reuptake Inhibitors (Hicks et al., 2015)</li> </ul>
Venlafaxine	<i>CYP2D6, FKBP5</i>	<ul style="list-style-type: none"> <li>Polymorphisms in GRIK4, HTR2A, and FKBP5 Show Interactive Effects in Predicting Remission to Antidepressant Treatment (Horstmann et al., 2010)</li> </ul>
Amitriptyline	<i>CYP2C19, 2D6</i>	<ul style="list-style-type: none"> <li>CPIC Guideline for CYP2D6 and CYP2C19 Genotypes and Dosing of Tricyclic Antidepressants (Hicks et al., 2017)</li> </ul>
Nortriptyline	<i>CYP2D6</i>	<ul style="list-style-type: none"> <li>CPIC Guideline for CYP2D6 and CYP2C19 Genotypes and Dosing of Tricyclic Antidepressants (Hicks et al., 2017)</li> </ul>
Clomipramine	<i>CYP2C19, 2D6</i>	<ul style="list-style-type: none"> <li>CPIC Guideline for CYP2D6 and CYP2C19 Genotypes and Dosing of Selective Serotonin Reuptake Inhibitors (Hicks et al., 2015)</li> </ul>
Doxepin	<i>CYP2C19, 2D6</i>	<ul style="list-style-type: none"> <li>CPIC Guideline for CYP2D6 and CYP2C19 Genotypes and Dosing of Tricyclic Antidepressants (Hicks et al., 2017)</li> </ul>
Imipramine	<i>CYP2C19, 2D6</i>	<ul style="list-style-type: none"> <li>CPIC Guideline for CYP2D6 and CYP2C19 Genotypes and Dosing of Tricyclic Antidepressants (Hicks et al., 2017)</li> </ul>
Olanzapine	<i>ANKK1, DRD2, MCR4, HTR2C</i>	<ul style="list-style-type: none"> <li>Genetic variation and the D2 dopamine receptor: implications for the treatment of neuropsychiatric disease (Mickey et al., 2016)</li> <li>Pharmacogenetic Associations of Antipsychotic Drug-Related Weight Gain: A Systematic Review and Meta-analysis (Zhang et al., 2016)</li> </ul>
Clozapine	<i>ANKK1, DRD2, MCR4, HTR2C</i>	<ul style="list-style-type: none"> <li>Genetic variation and the D2 dopamine receptor: implications for the treatment of neuropsychiatric disease (Mickey et al., 2016)</li> <li>The combined effect of CYP2D6 and DRD2 Taq1A polymorphisms on the antipsychotics daily doses and hospital stay duration in schizophrenia inpatients (Kurylev et al., 2018)</li> <li>Pharmacogenetic Associations of Antipsychotic Drug-Related Weight Gain: A Systematic Review and Meta-analysis (Zhang et al., 2016)</li> </ul>

Drug	Gene(s)	Select Associated References
Risperidone	<i>CYP2D6, ANKK1, DRD2, MCR4, HTR2C</i>	<ul style="list-style-type: none"> <li>DPWG Guideline for risperidone and CYP2D6 (Swen et al., 2011)</li> <li>Genetic variation and the D2 dopamine receptor: implications for the treatment of neuropsychiatric disease (Mickey et al., 2016)</li> <li>Pharmacogenetic Associations of Antipsychotic Drug-Related Weight Gain: A Systematic Review and Meta-analysis (Zhang et al., 2016)</li> </ul>
Mirtazapine	<i>CYP2D6, FKBP5</i>	<ul style="list-style-type: none"> <li>Multicenter study on the clinical effectiveness, pharmacokinetics, and pharmacogenetics of mirtazapine in depression (Jaquenoud Sirot et al., 2012)</li> <li>Polymorphisms in GRIK4, HTR2A, and FKBP5 Show Interactive Effects in Predicting Remission to Antidepressant Treatment (Horstmann et al., 2010)</li> </ul>
Desipramine	<i>CYP2D6</i>	<ul style="list-style-type: none"> <li>CPIC Guideline for CYP2D6 and CYP2C19 Genotypes and Dosing of Tricyclic Antidepressants (Hicks et al., 2017)</li> </ul>
Trimipramine	<i>CYP2C19, 2D6</i>	<ul style="list-style-type: none"> <li>CPIC Guideline for CYP2D6 and CYP2C19 Genotypes and Dosing of Tricyclic Antidepressants (Hicks et al., 2017)</li> </ul>

Up to 42% of variance in therapy response for major depressive disorders (MDD) can be explained by genetic variation, which has led to the development of pharmacogenetic tests to inform the use of certain psychiatric medications. Prospective randomized clinical trials have been performed to validate the clinical validity and utility of a number of pharmacogenetics (PGx) multi-gene panels.

A prospective, two arm evaluation of the clinical utility of Genesight® Psychotropic in guiding treatment decisions for major depressive disorder (MDD) was conducted. The meta-analysis performed by Brown et al. (2020) calculated the overall mean effect of symptom improvement and relative risk ratio (RR) of response and remission referencing four studies and 1,556 patients. When care was guided by combinatorial pharmacogenetics results, significant patient outcomes were reported as compared with MDD patients who received unguided treatment (symptom improvement  $\Delta=10.08\%$ , 95% CI: 1.67-18.50;  $p=0.019$ ; response RR=1.40, 95% CI: 1.17-1.67;  $p<0.001$ ; remission RR=1.49, 95% CI: 1.17-1.89;  $p=0.001$ ). The authors summarized that for MDD patients who have had at least one medication failure, GeneSight Psychotropic® guided treatment demonstrated significant clinical utility.

Bousman et al. (2019) conducted a systematic review of the literature and meta-analysis of prospective, randomized controlled trials (RCTs) on the use of PGx multi-gene panels that had included a decision support tool to guide clinicians in the use of the results for MDD. RCTs were evaluated using the Cochrane criteria. A total of five RCTs representing 1,737 patients were identified. Individuals receiving PGx testing with physicians utilizing a guided decision support tool ( $n=887$ ) were 1.17 times more likely ( $p=.005$ ) than the treatment as usual (TAU) group ( $n=850$ ) to report symptom remission. Similarly, Rosenblat et al. (2018) conducted a meta-analysis on the use of PGx multi-gene panels to guide treatment of MDD. Article databases were searched up to December 2017 on the human clinical utility of pharmacogenetics for the treatment of MDD. Four randomized clinical trials and two open-label controlled cohort studies were included. The outcomes analyzed were response and remission between PGx and TAU groups. The pooled risk ratio for overall treatment response was 1.36 in favor of PGx guided treatment compared to TAU, and 1.74 for PGx for remission when compare to TAU. The studies were heterogeneous across population, criteria, and PGx testing used.

Menchon et al. (2019) examined the influence of patient characteristics such as age, baseline severity, and duration of episode on the clinical utility of PGx testing for psychiatric drugs from the AB-GEN study, a randomized 12-week long study comparing TAU to PGx guided therapy selection in 280 adults with MDD. The primary outcomes analyzed were the Patient Global Impression of Improvement (PGI-I) scale and the Hamilton Depression Rating Scale (HAM-D17). Patients generally showed no difference in sustained response at the 12-week end point between the TAU and PGx group (Perez, et al., 2017). However, the PGx group had a higher response rate than TAU, and when subjects were removed whose physicians did not follow the genetic testing recommendations, the response rate improved further. Side effects were less in the PGx group by 6 weeks, and this was maintained at week 12. The primary dependent variable identified was the number of previously failed medication trials. In the Menchon et al. (2019) reanalysis by patient demographics, additional important variables were identified. Age was important as PGx testing significantly improved outcomes in those under age 60, but not over age 60. Outcomes were also improved in those with moderate to severe depression, but not those with mild depression. Genetic testing improved PGI-I in one year or

less from diagnosis, but not HAM-D17. The effect on HAM-D17 was not significant until the cutoff from time of diagnosis was increased to five years. After this, however, a null effect was seen, and individuals who were more than five years from their diagnosis were actually worse off in the PGx arm than TAU. To determine which type of patient is most likely to benefit from pharmacogenetic testing for psychiatric therapies, more prospective, randomized trials are needed.

GUIDED is a 24-week RCT conducted between April 2014 and February 2017 comparing active treatment groups guided by PGx information, to active treatment groups receiving usual care (TAU) for MDD (Greden et al., 2019). Sixty sites participated, and patients were referred to the study when it was self- or clinician- reported to have inadequate response to at least one antidepressant. The average number of medications failed in the cohort was three, making this a difficult to treat population. Genotyping was for eight genes, *CYP1A2*, *CYP2C9*, *CYP2C19*, *CYP3A4*, *CYP2B6*, *CYP2D6*, *HTR2A*, and *SLC6A4* and results were evaluated and reported using a proprietary pharmacogenetic algorithm from Assurex Health. Participants were blinded to the study arm, but clinicians were not, since they needed to consult the PGx results to guide treatment. Using the results to guide treatment was not mandated. Patients were assessed at 4, 8, 12, and 24 weeks using the HAM-D17, which was administered by blinded raters. A total of 1167 enrolled patients made it through week 8 with 607 in TAU and 560 in PGx guided. HAM-D17 scores decreased in the TAU arm by 24% and in the PGx arm by 27%, but the difference was not statistically significant. Treatment response, defined as  $\geq 50\%$  decrease in depression, was greater in the PGx arm (26%) than TAU (20%). The depression remission rate, defined as score of  $\leq 7$  for HAM-D17, was 10% with TAU and 15% with PGx ( $p=.007$ ). Additionally, at week eight, there was no difference between the groups in reported side effects. When patients taking incongruent medications were evaluated as a separate cohort, those who switched to congruent medications by week eight experienced significantly fewer side effects. Medication prescriptions that aligned with PGx results at baseline were 77% in the TAU group and 79% in the PGx group. By week 8, the PGx group increased to 91%, and the TAU group was unchanged. After eight weeks, clinicians in the TAU arm were unblinded and could use the PGx results if they chose. A total of 913 participants completed through week 24 with 456 in TAU and 457 in the PGx guided arm. Overall, in the PGx group, HAM-D17 scores decreased by 43% at week 24 relative to baseline. Response and remission increased by 70% and 100%, respectively, from week 8 to week 24. While the primary outcome being analyzed, symptom improvement at week eight was not different between the two groups, there was significant difference in response and remission in the PGx group on other measures.

A panel of ten genes with select polymorphisms combined with a proprietary algorithm, the NeuroIDgenetix<sup>®</sup> Test, was the subject of a RCT to evaluate clinical utility for guiding treatment for depression and anxiety (Bradley et al., 2018). Genes included *CYP1A2*, *CYP2C9*, *CYP2C19*, *CYP2D6*, *CYP3A4*, *CYP3A5*, *SLC6A4*, *COMT*, *HTR2A*, and *MTHFR*. Participants were identified from 20 independent clinical sites in the US that represented psychiatry, internal medicine, family medicine, and obstetrics and gynecology. A total of 685 patients were included in the study, ranging in age from 19 to 87, and all had a diagnosis of depression or anxiety using the DSM-V criteria and verified by the MINI Psychiatric Interview. Most were female (73%) with diagnoses of depression ( $n=246$ ), anxiety ( $n=235$ ) or both ( $n=204$ ). Participants were either 'New to Treatment' (newly diagnosed or taking medications for less than 6 weeks) or 'Inadequately Controlled' with medications as defined by lack of efficacy or treatment discontinuation due to adverse events or intolerability; although the authors did not report the distribution. PGx testing was performed in all subjects but was only shared with the physicians of those in the PGx arm. Patients were assessed at 4, 8, and 12 weeks using the HAM-D17 and the Hamilton Rating Scale for Anxiety (HAM-A), with their physicians blinded to the results. Adverse events were captured via the Adverse Drug Event form developed by external psychiatric consultants, and a blinded clinician ranked the adverse events on a severity scale. The PGx testing group showed a greater response and remission rate with odds ratios of 4.72 and 3.54 respectively, than the TAU group at 12 weeks. In the anxiety group, those that received testing had a higher response rate at 8 and 12 weeks with an odds ratio of 1.76, compared to the TAU group. Physicians made at least one medication change in 81% of those receiving testing than the control group (64%) at the two-week time point when results were returned to physicians. No difference was found in adverse drug events between the two treatment groups. In a post-hoc analysis on the 'Inadequately Controlled' cohort remission rates (42% vs. 27%,  $p=0.03$ ) and response rates (62% vs. 44%,  $p=0.01$ ) response rates were greater with PGx than TAU.

Jung et al. (2017) conducted a genome-wide association study (GWAS) in Generalized Anxiety Disorder (GAD) to identify potential predictors of venlafaxine XR treatment outcome. Ninety-eight European American patients participated in a venlafaxine XR clinical trial for GAD, with Hamilton Anxiety Scale (HAM-A) response/remission at 24 weeks as the primary outcome measure. All participants were genotyped with the Illumina PsychChip, and 266,820 common single nucleotide polymorphisms (SNPs) were analyzed. Although no SNPs reached genome-wide significance, eight SNPs were marginally associated with treatment response/remission and HAM-A reduction at week 12 and 24 ( $p<0.00001$ ). The authors concluded that several identified genes may indicate markers crossing neuropsychiatric diagnostic categories. The authors acknowledged that the limitations of this study include small sample size and the lack of statistical power for a GWAS. Areas for future

research include the replication of results with larger samples sizes to increase statistical power and further elucidate the treatment effects of antidepressant venlafaxine XR on GAD.

Researchers enrolled 528 (outpatients and inpatients) from 18 hospitals and associated mental health centers in Spain from July 2014 to June 2015 in the AB-GEN study, a 12-week, double-blind, parallel, multi-center RCT to evaluate the effectiveness of PGx testing for drug therapy guidance for MDD. Patients with a CGI-S  $\geq 4$  and requiring antidepressant medication de novo or changes in their medication were randomized to a PGx or TAU group. PGx testing was conducted by Neuropharmagen, and results were reported using their web-based clinical decision support tool. Thirty genes and relevant single nucleotide polymorphisms were analyzed. The primary endpoint was measuring a sustained response on the Patient Global Impression of Improvement (PGI-I) of  $\leq 2$  within the 12-week follow-up. Follow up was conducted by phone, and the interviewer was blinded to the participant's study arm. A patient was considered to have a sustained response with a PGI-I score of 2 or less if they reported their condition to be "much better" or "very much better." Only 280 of 528 patients completed the study. A difference in sustained response was not observed between PGx and TAU at 12 weeks. Overall the PGx group had a much higher response rate, and this improved when removing the patients whose physicians did not follow the PGx recommendations. Effects were greatest in patients who had failed up to three prior medications. Of those who reported side effects at baseline, the PGx group was more likely to report fewer side effects than the TAU group (Perez et al., 2017). This study is interesting as it uses real world practices and clinicians, a heterogeneous population with variable disease states and prior treatment failures, and clinicians could choose to not follow the PGx recommendations. Additional studies are needed to replicate these findings across larger, ethnically diverse study groups.

Perlis et al. (2017) reported on a propensity-score matched case-control analysis of health claims data from a US payer that examined the longitudinal claims of individuals with a mood or anxiety disorder. Claims from individuals who had received the Genecept pharmacogenetic ten gene test from Genomind were compared to case-matched controls who matched on gender, age, and diagnosis who did not receive testing. Diagnoses that were included were depressive disorders, any anxiety diagnosis, bipolar disorder, and any substance abuse diagnosis. Co-morbidities that were accounted for in the analysis included hyperlipidemia, low back pain, hypertension, migraine and other headaches, diabetes mellitus, and any mental health visit. Of the 1,639 individuals who received genetic testing, it was possible to match 817. Patients who had PGx testing had 40% fewer emergency room visit for any cause and 58% fewer hospitalizations for any cause. There was no difference between the groups in the number of psychiatric medications prescribed, or mood disorder related inpatient hospitalizations. Selection bias, since this was an observational study, was a physician that ordered genetic testing might, in theory, be more aggressive in patient management. The study's authors concluded that randomized prospective clinical trials are needed to further validate the clinical utility of genetic testing for psychiatric disorders.

## Cardiovascular Disease

Two hundred and eleven patients from the University of Florida (UF) who underwent percutaneous coronary intervention (PCI) were included in a study to analyze the benefits of genotype-guided prescribing of pharmacogenetic drugs and examine the clinical utility of multigene panel testing. Genotype data for five genes (CYP2C19, CYP2D6, CYP2C9, VKORC1, SLCO1B1) was compiled from this cohort. Seventy-seven percent of UF patients exhibited at least one actionable phenotype for these five genes; 32% had opportunities for genotype-guided prescribing of medications. The data was then used as parameter estimates in a simulation model to predict genotype-guided opportunities among privately insured beneficiaries in the MarketScan database who had undergone PCI with at least one and five years of follow-up data (N=105,547 and N=12,462, respectively). Fifty percent of the individuals who had undergone PCI with over 1 year and 68% with over five years of follow-up were taking at least one Clinical Pharmacogenetic Implementation Consortium (CPIC) A/B drug in addition to prescribed antiplatelet therapy. A 39% and 52% incidence of genotype-guided prescribing opportunity at one and five years, respectively, was projected. The authors hypothesized that panel-based testing at the time of PCI could result in genotype-driven prescribing decisions in 1/3 of patients, thereby improving therapy outcomes beyond that of CYP2C19 alone for antiplatelet therapy (Rouby et al., 2020).

The real-world clinical utility of pharmacogenetic testing for managing cardiovascular disease was studied by Billings et al. (2018). A retrospective cohort of individuals was identified through pharmaceutical, medical and laboratory claims data from a national health insurer from January 2011 through September 2015. Baseline data and outcomes were measured over a 12-month period. Individuals who received PGx testing that included *CYP2C19*, *CYP2C9*, *VKORC1*, *F5*, *F2*, and *MTHFR* were matched to controls based on demographics and diagnoses. Pharmacogenetic testing was ordered at the physician's discretion and was not influenced by the study. The total number of individuals tested was 11,060 and 178,096 matched controls were identified. Outcomes evaluated through claims data included pharmacy costs, medical costs, emergency room visits, outpatient visits, emergency room stays, controlling for demographics, coverage type, low income, cardiovascular

disease and other co-morbidities, such as diabetes. The PGx test group appeared significantly more likely to experience stroke, pulmonary embolism, deep vein thrombosis, or a composite event than the control group. Real world pharmacogenetic testing did not appear to improve outcomes based on claims analysis.

## Anthracyclines

PharmGKB curators (PharmGKB) found evidence of 2B (moderate evidence) or better with the following genes and clinical impact related to anthracyclines; *NQO1*, *GSTP1*, *PNPLA3*, *SLC28A3*, *HAS3*, *SLC28A3*, *CBR3*, and *CYP19A1*. In addition, the Canadian Pharmacogenomics Network for Drug Safety (CPNDS) (Aminkeng et al., 2016) found additional strong clinical evidence for *RARG* and *UGT1A6*.

Anthracyclines are an important category of chemotherapeutic agents for hematological and solid tumors but are associated with a high rate of anthracycline associated cardiotoxicity (ACT) that can result in symptoms during therapy or even years after therapy is completed. Sagi et al. (2018) conducted genotyping of 26 genes and 70 single nucleotide polymorphisms (SNPs) associated with anthracycline metabolism and retrospective review of medical records of 622 pediatric acute lymphoblastic leukemia (ALL) and 39 osteosarcoma (OSC) patients treated between 1989 and 2015 in Hungarian pediatric oncology centers. Patients with comorbidities such as Down syndrome or prior cardiac findings were excluded. Blood samples were taken on ALL patients in remission. All patients were followed by echocardiography routinely during and after treatment, and retrospective chart review examined the following categories; at baseline (used as a control), in the acute phase, during oral maintenance, at the end of treatment, 2-3 post diagnosis, 5-10 years after diagnosis, and 10-15 years post diagnosis. SNPs in *ABCC2*, *NQO1*, *SLC22A6*, and *SLC28A3* were associated with decreased fractional shortening and ejection fraction, particularly in the 5-10-year period after diagnosis. *NQO1* SNP rs1043470 T was associated with lower left ventricular function in the acute phase and 5-10 years post diagnosis. *CYP3A5* rs4646450 TT was found in 17% of ALL individuals with anthracycline associated cardiotoxicity (ACT) with a fractional shortening less than 28, and appeared to be more prominent in ACT overall, particularly in boys and the ALL group. Additional studies are needed that are prospective with long term follow up to further understand how pharmacogenetic testing can contribute to understanding ACT.

NCCN Guidelines for Pediatric ALL recommend testing TPMT and NUDT15 prior to or in the setting of excessive toxicity with thiopurine therapy but do not include any recommendations for pharmacogenomics testing prior to anthracyclines (NCCN, 2020).

## Pain Management

Muriel et al. (2019) conducted a six-month, observational, prospective study on the use of pharmacogenetic testing for 88 patients involved in long term opioid deprescription treatment of non-cancer related pain in the Pain Unit of Alicante General Hospital in Spain. Visits were monitored and analyzed based on various genotypes. Visits included baseline, follow-up and final, and other parameters tracked were opioid rotation or discontinuation, adverse drug events and suspected adverse drug reactions (ADRs). Genotyping consisted of the following genes and variants using RT-PCR: *OPRM1* (A118G), *ABCB1* (C3435T), *COMT* (G472A), *OPRD1* (T921C) and *ARRB2* (C8622T). Five patients were lost to follow up. The remaining participants were 64% female and 100% Caucasian. In the baseline visit, a median of 6 adverse events were recorded including dry mouth, constipation, sleep disruption, and depression. There was no difference recorded in ADRs from baseline through final visits. A total of 1659 ADRs were reported in 359 visits for this cohort, and the most common by system classification were psychiatric (21%) and gastrointestinal (20%). At the baseline visit, ADRs varied between *OPRM1* genotypes, with individuals who were AA at that A118G locus having, on average, two or more ADRs than AG/GG patients. Nausea and other gastrointestinal ADRs followed this same pattern. *COMT* genotyping was similar; with AA/GG patients have more ADRs, and those that were *COMT* AG less likely to have loss of libido, skin redness, vomiting, or sexual dysfunction. The *OPRD1* genotype also showed less association with sexual dysfunction and reproductive system disorders. The authors were surprised that the number of ADRs did not change over the course of the study, and they also noted that the use of antidepressants increased from the beginning to end of the study. Antidepressants can have similar ADRs to opioids, so this may be a confounding variable. The authors found value in the PGx testing as a predictor of who may experience nausea and gastrointestinal discomfort and highlights the potential promising use of PGx in opioid management.

## General Pharmacogenetic Multi-Gene Panel Testing

Aranz et al. (2019) analyzed the benefits of pharmacogenetic testing of CYP variants for the purpose of adjusting clinical doses of frequently used antipsychotics. Results for patients using pharmacogenetics information (PI) were compared with patients who were treated as usual. Two hundred and ninety patients from three hospitals in Spain with

schizophrenia/schizoaffective/delusional disorders requiring medication were randomized for PI (PharmG+ arm) or treatment as usual (PharmG-arm). Recruitment began when initial treatment was started or when a change in antipsychotic treatment was deemed necessary. One hundred twenty-three patients were genotyped using the commercial Brainchip pharmacogenetic test; 167 patients were treated as usual by adhering to standard clinical practices. Positive and negative scale for schizophrenia (PANSS) and UKU- side effect rating scores were gathered at the beginning and again at 12 weeks to assess effectiveness of treatment. PANSS/UKU values were rated by clinical psychiatrists who were also blinded to the patient's arm. No statistically significant differences were observed in side effects between the two groups. When patients had their dose adjusted based on PharmG+ data (n=123), there was a larger reduction in side effects than those in the PharmG- group but this was not statistically significant (p>0.05). PharmG+ patients who were carriers of CYP2D6 UMs (ultra metabolizer) or PMs (poor metabolizer) variants showed statistically larger improvements in global, psychic and other UKU side effects as compared to PharmG- (p=0.02, p=0.05 and p=0.01, respectively). The authors concluded that pharmacogenetics interventions may enhance safety by decreasing the side effects of antipsychotic treatments, however the study did not find evidence of greater efficacy. The researchers also concluded that the results were not unexpected as treatment success may be influenced by more than genomic profiles and describe the effect of drug metabolism as a key factor.

Medication management is a critical service for polypharmacy patients. Kim et al. (2018) conducted an observational study of Medication Management Therapy (MTM) patients and the role of pharmacogenetic testing on a cohort of patients identified in the Magellan Health database. Inclusion criteria included being eligible for MTM services, taking six or more chronic medications for three or more chronic conditions, and incurring Medicare-mandated medication costs in the quarter prior to enrollment. The study consisted of one standard treatment as usual MTM arm, which is counseling by a pharmacist by phone, an intervention arm of MTM plus a clinical decision support tool to aid in managing polypharmacy (CDST), and an intervention arm that added PGx testing to MTM and CDST. PGx testing included the genes *CYP2D6*, *CYP2C19*, *CYP2C9*, *CYP3A4*, *CYP3A5*, and *VKORC1* and was performed at Genelex. After the initial MTM call, pharmacists would collect demographic information, active medications, and a history of adverse drug events. After the MTM group exceeded 100 patients, patients were assigned to either the CDST arm or the PGx arm based on whether or not their birth year was odd (PGx) or even (CDST). Patients who were assigned to the PGx arm were contacted by phone by the MTM counselor with instructions and a buccal swab kit was mailed. There were 104 in the MTM arm, 103 to the CDST arm, and 135 to PGx. However, 77 patients failed to return the buccal swab and were reassigned to the CDST arm, so only 58 patients were available for the PGx arm. On average, patients were 77 years old and took 11 medications. The baseline therapeutic indications were similar across all arms, and on average three drug therapy problems (DTP) were identified per participant. Blinded clinical pharmacists ranked the DTPs and considered the seriousness in 31% of PGx patients compared to only 4.9% of non-PGx patients. The more serious a DTP was considered, the more likely it was a prescriber would accept therapy change recommendations, particularly in the PGx group, where the odds ratio for accepting a change was 2.39, compared to 1.95 in the other groups. The authors concluded that MTM enhanced with a CDST or PGx did not improve the number of DTPs identified, but both helped pharmacists identify DTPs better, and PGx testing made recommendations more acceptable to the ordering clinician. More studies are needed to demonstrate the clinical utility of general PGx testing in patients with polypharmacy.

Borobia et al. (2018) reported on the implementation of a PGx testing program in 2014 at La Paz University Hospital (LPUH) in Madrid. LPUH is a 1,308-bed tertiary-care teaching hospital of the Spanish NHS serving a population of ~600,000 people. The goal of the study was to implement PGx into clinical practice and evolve from an *ad hoc* strategy linked to a prescription to a proactive practice, where genetic information would be obtained prior to a prescription in at risk populations. The targeted populations were at risk for inflammatory bowel disease, psoriasis, transplant patients, high cardiovascular disease risk, leukemia, and colorectal cancer. The authors utilized a 180 SNP panel (PharmArray) for testing. Ordering providers would submit a recommendation and request for testing to a centralized Pharmacogenetic Testing Unit who would evaluate the request based on patient demographics, if the requested marker fell into one of three categories. Category A was for pre-emptive screening of an actionable marker, such as HLA-B5701 for abacavir response. Category B was for drugs with a well-defined protocol for treating certain diseases, such as TPMT for thiopurine response for treatment of inflammatory bowel disease. Category C was for drugs without a well-defined protocol. In this situation, the pharmacogenetics unit would evaluate the therapeutic issue and determine if a pharmacogenetic test would be clinically useful. From January 2014 through December 2016, the Pharmacogenetic Testing Unit received 2,539 consultation requests. The most common tests were TPMT and MTHFR. There were 1,939 requests for treatment selection that had well defined protocols and 711 for drugs with pharmacogenetic treatment recommendations for certain diseases or had poorly defined recommendations. Of these, 600 were found appropriate and approved, and 32% had a molecular profile that impacted the drug. In this sub-group, 58% (107) had a dose adjustment as a result. The total cost of the program was estimated at 216 € (\$254) per patient, and 91% of physicians surveyed said they would now use pharmacogenetics regularly.



O'Donnell et al. (2014, 2017) implemented a PGx testing program, The 1200 Patients Project, at the University of Chicago to adult patients who were regularly taking at least one prescription drug, but not more than six. Patients could be referred by a care provider or self-referred to the program. After participating in an informed consent process, patients were tested for PGx variants using a commercially available multi-gene PGx testing panel (Sequenom ADME). Overall, 868 patients that completed PGx testing had 2,279 patient encounters that were reviewed. Four medical specialties and seventeen providers represented all clinic visits; executive health, nephrology, hepatology, and pulmonology. The most prevalent medications included aspirin, atorvastatin, hydrochlorothiazide, lisinopril, and amlodipine. Of all medications on active patient drug lists, 34% had associated alerts (n=2,869) that included green (21%), cautionary yellow (13%), and high-risk red (0.5%). The remaining medications had no actionable pharmacogenetic information. Of the 2,869 alerts provided green alerts were viewed 40% of the time, and 4% had medication changes documented. Yellow alerts were viewed 66% of the time, and 5% had medication changes documented. Red alerts were viewed 89% of the time, and 24% had medication changes documented. Nearly half of all medication changes were for omeprazole and atorvastatin. Simvastatin and rabeprazole had the highest overall percentage of changes influenced by the PGx test results. The authors note that limitations to this study include the small number of providers involved and the modest response to actionable alerts with only 60 medication changes out of 405 possibly actionable red and yellow alerts. In addition, the providers included in the study were also co-investigators which may highlight a bias toward pharmacogenetics, and they knew their behavior was being examined, which may have altered their choices from what they would have done if they had not known their choices were being monitored.

The [Clinical Pharmacogenetics Implementation Consortium \(CPIC®\)](#) is an international consortium that study the use of pharmacogenetic tests for patient care (CPIC, 2020). The CPIC develops guidelines to assist health care providers to understand how genetic tests optimize patient therapy. CPIC's guidelines, processes and projects have been endorsed by several professional societies including the Association for Molecular Pathology ([AMP](#)), the American Society for Clinical Pharmacology and Therapeutics ([ASCPT](#)) Board of Directors and the American Society of Health-System Pharmacists ([ASHP](#)). As of September 2019, the CPIC has published guidelines for 19 genes and 47 drugs (Smith et al, 2020).

## Clinical Practice Guidelines

### *International Society of Psychiatric Genetics (ISPG)*

ISPG updated the guidelines on genetic testing (ISPG, 2020). Their recommendation regarding pharmacogenetic testing is as follows:

- Pharmacogenetic testing should be viewed as a decision-support tool to assist in thoughtful implementation of good clinical care. HLA-A and HLA-B testing prior to use of carbamazepine and oxcarbazepine, is recommended in alignment with regulatory agencies and expert groups. Evidence to support widespread use of other pharmacogenetic tests at this time is still inconclusive, but when pharmacogenetic testing results are already available, providers are encouraged to integrate this information into their medication selection and dosing decisions. Genetic information for CYP2C19 and CYP2D6 would likely be most beneficial for individuals who have experienced an inadequate response or adverse reaction to a previous antidepressant or antipsychotic trial.

### *National Academy for Clinical Biochemistry (NACB)*

According to the NACB (2010), pharmacogenetic testing is not currently recommended for general population screening.

## U.S. Food and Drug Administration (FDA)

This section is to be used for informational purposes only. FDA approval alone is not a basis for coverage.

Laboratories that perform genetic tests are regulated under the Clinical Laboratory Improvement Amendments (CLIA) Act of 1988. More information is available at:

<https://www.fda.gov/medicaldevices/deviceregulationandguidance/ivdregulatoryassistance/ucm124105.htm>.

(Accessed August 17, 2020)

## References

- Aminkeng F, Ross CJ, Rassekh SR, et al. Recommendations for genetic testing to reduce the incidence of anthracycline-induced cardiotoxicity. *Br J Clin Pharmacol*. 2016;82(3):683–695.
- Antidepressants. PharmGKB.
- Antipsychotics. PharmGKB.
- Aranz M, Gonzalez-Rodriguez A, Perez-Blanco J, et al. A pharmacogenetic intervention for the improvement of the safety profile of antipsychotic treatments. *Transl Psychiatry*. 2019; 9:177.
- Billings J, Racska PN, Bordenave K, et al. The impact of real-world cardiovascular-related pharmacogenetic testing in an insured population. *Int J Clin Pract*. 2018 Jun;72(6):e13088.
- Borobia AM, Dapia I, Tong HY, et al. Clinical implementation of pharmacogenetic testing in a hospital of the Spanish National Health System: Strategy and experience over 3 years. *Clin Transl Sci*. 2018 Mar;11(2):189-199.
- Bousman CA, Arandjelovic K, Mancuso SG, et al. Pharmacogenetic tests and depressive symptom remission: a meta-analysis of randomized controlled trials. *Pharmacogenomics*. 2019 Jan;20(1):37-47.
- Bradley P, Shiekh M, Mehra V, et al. Improved efficacy with targeted pharmacogenetic-guided treatment of patients with depression and anxiety: a randomized clinical trial demonstrating clinical utility. *J Psychiatr Res*. 2018 Jan;96:100-107.
- Brown L, Vranjkovic O, Li J, et al. The clinical utility of combinatorial pharmacogenomics testing for patients with depression: a meta-analysis. *Pharmacogenomics*. 2020 Jun; 21(8):559-569.
- Greden JF, Parikh SV, Rothschild AJ, et al. Impact of pharmacogenomics on clinical outcomes in major depressive disorder in the GUIDED trial: a large, patient- and rater-blinded, randomized, controlled study. *J Psychiatr Res*. 2019 Jan 4;111:59-67
- Hicks JK, Bishop JR, Sangkuhl K, et al. Clinical Pharmacogenetics Implementation Consortium (CPIC) Guideline for CYP2D6 and CYP2C19 genotypes and dosing of selective serotonin reuptake inhibitors. *Clin Pharmacol Ther*. 2015;98(2):127–134.
- Hicks J K, Sangkuhl K, Swen J et al. Clinical Pharmacogenetics Implementation Consortium Guideline (CPIC) for CYP2D6 and CYP2C19 genotypes and dosing of tricyclic antidepressants: 2016 update. *Clin Pharmacol Ther*. 2017 Jul;102(1):37-44.
- Horstmann S, Lucae S, Menke A, et al. Polymorphisms in GRIK4, HTR2A, and FKBP5 show interactive effects in predicting remission to antidepressant treatment. *Neuropsychopharmacology*. 2010;35(3):727–740.
- International Society of Psychiatric Genetics (ISPG) Genetic Testing Statement. Available at: <https://ispg.net/genetic-testing-statement/>.
- Jaquenoud Sirot E, Harenberg S, Vandel P, et al. Multicenter study on the clinical effectiveness, pharmacokinetics, and pharmacogenetics of mirtazapine in depression. *J Clin Psychopharmacol*. 2012 Oct;32(5):622-9.
- Jung J, Tawa EA, Muench C, et al. Genome-wide association study of treatment response to venlafaxine XR in generalized anxiety disorder. *Psychiatry Res*. 2017 Aug; 254:8-11.
- Keers R, Uher R, Huezio-Diaz P, et al. Interaction between serotonin transporter gene variants and life events predicts response to antidepressants in the GENDEP project. *Pharmacogenomics J*. 2011 Apr;11(2):138-45.
- Kim K, Magness JW, Nelson R, et al. Clinical utility of pharmacogenetic testing and a clinical decision support tool to enhance the identification of drug therapy problems through medication therapy management in polypharmacy patients. *J Manag Care Spec Pharm*. 2018 Dec;24(12):1250-1259.
- Kurylev AA, Brodyansky VM, Andreev BV, et al. The combined effect of CYP2D6 and DRD2 Taq1A polymorphisms on the antipsychotics daily doses and hospital stay duration in schizophrenia inpatients (observational naturalistic study). *Psychiatr Danub*. 2018 Jun;30(2):157-163.
- McGraw-Hill Concise Dictionary of Modern Medicine. Test panel. (2002). <https://medical-dictionary.thefreedictionary.com/test+panel>. Accessed July 17, 2019.
- Medicare Claims Processing Manual Chapter 16 - Laboratory Services January 11, 2019. <https://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/downloads/clm104c16.pdf>. Accessed July 17, 2019.
- Menchón JM, Espadaler J, Tuson M, et al. Patient characteristics driving clinical utility in psychiatric pharmacogenetics: a reanalysis from the AB-GEN multicentric trial. *J Neural Transm (Vienna)*. 2019 Jan;126(1):95-99.

Mickey BJ. Genetic variation and the D2 dopamine receptor: implications for the treatment of neuropsychiatric disease. *Pharmacogenomics*. 2016 Jul;17(11):1207-1210.

Muriel J, Margarit C, Barrachina J, et al. Pharmacogenetics and prediction of adverse events in prescription opioid use disorder patients. *Basic Clin Pharmacol Toxicol*. 2019 Apr;124(4):439-448

National Academy for Clinical Biochemistry, (the Academy of the American Association for Clinical Chemistry) Laboratory Medicine Practice Guidelines: Laboratory Analysis and Application of Pharmacogenetics to Clinical Practice 2010.

National Cancer Institute Dictionary of Genetics Terms. <https://www.cancer.gov/publications/dictionaries/genetics-dictionary/def/multigene-test>. Accessed July 17, 2019.

National Comprehensive Cancer Network (NCCN). Clinical Practice Guidelines in Oncology. Pediatric Acute Lymphoblastic Leukemia. Version 1.2020.

O'Donnell PH, Danahey K, Jacobs M, et al. Adoption of a clinical pharmacogenomics implementation program during outpatient care—initial results of The University of Chicago “1200 Patients Project.” *American Journal of Medical Genetics Part C, Seminars in Medical Genetics*. 2014;166(1):68-75.

Pérez V, Salavert A, Espadaler J, et al. Efficacy of prospective pharmacogenetic testing in the treatment of major depressive disorder: results of a randomized, double-blind clinical trial. *BMC Psychiatry*. 2017 Jul 14;17(1):250.

Perlis RH, Mehta R, Edwards AM, et al. Pharmacogenetic testing among patients with mood and anxiety disorders is associated with decreased utilization and cost: a propensity-score matched study. *Depress Anxiety*. 2018 Oct;35(10):946-952.

Rosenblat JD, Lee Y, McIntyre RS. The effect of pharmacogenomic testing on response and remission rates in the acute treatment of major depressive disorder: a meta-analysis. *J Affect Disord*. 2018 Dec 1;241:484-491.

Rouby N, Alrwisn A, Langae T, et al. Clinical utility of pharmacogene panel-based testing in patients undergoing percutaneous coronary intervention. *Clin Transl Sci*. 2020 May; 13(3): 473-481.

Sági JC, Egyed B, Kelemen A, et al. Possible roles of genetic variations in chemotherapy related cardiotoxicity in pediatric acute lymphoblastic leukemia and osteosarcoma. *BMC Cancer*. 2018;18(1):704. Published 2018 Jul 3.

Smith DM, Peshkin BN, Springfield TB, et al. Pharmacogenetics in practice: estimating the clinical actionability of pharmacogenetic testing in perioperative and ambulatory settings. *Clin Transl Sci*. 2020;13(3):618-627.

Swen JJ, Nijenhuis M, de Boer A, et al. Pharmacogenetics: from bench to byte—an update of guidelines. *Clin Pharmacol Ther*. 2011 May;89(5):662-73.

Whirl-Carrillo M, McDonagh EM, Hebert, EM, et al. Pharmacogenomics knowledge for personalized medicine. *Clin Pharmacol Ther*. 2012 Oct;92(4):414-7.

Yevtushenko OO, Oros MM, Reynolds GP. Early response to selective serotonin reuptake inhibitors in panic disorder is associated with a functional 5-HT1A receptor gene polymorphism. *J Affect Disord*. 2010 Jun;123(1-3):308-11.

Zhang JP, Lencz T, Zhang RX, et al. Pharmacogenetic Associations of Antipsychotic Drug-Related weight gain: a systematic review and meta-analysis. *Schizophr Bull*. 2016;42(6):1418–1437.

## Policy History/Revision Information

Date	Summary of Changes
08/01/2021	<p><b>Template Update</b></p> <ul style="list-style-type: none"> <li>Replaced content sub-heading titled “Professional Societies” with “Clinical Practice Guidelines” in <i>Clinical Evidence</i> section</li> </ul> <p><b>Coverage Rationale</b></p> <ul style="list-style-type: none"> <li>Updated list of examples of unproven and not medically necessary pharmacogenetic Multi-Gene Panels for genetic polymorphisms; removed “NeuroIDgenetix”</li> </ul> <p><b>Supporting Information</b></p> <ul style="list-style-type: none"> <li>Archived previous policy version CS149IN.01</li> </ul>

## Instructions for Use

This Medical Policy provides assistance in interpreting UnitedHealthcare standard benefit plans. When deciding coverage, the federal, state or contractual requirements for benefit plan coverage must be referenced as the terms of the federal, state or contractual requirements for benefit plan coverage may differ from the standard benefit plan. In the event of a conflict, the federal, state or contractual requirements for benefit plan coverage govern. Before using this policy, please check the federal, state or contractual requirements for benefit plan coverage. UnitedHealthcare reserves the right to modify its Policies and Guidelines as necessary. This Medical Policy is provided for informational purposes. It does not constitute medical advice.

UnitedHealthcare may also use tools developed by third parties, such as the InterQual® criteria, to assist us in administering health benefits. The UnitedHealthcare Medical Policies are intended to be used in connection with the independent professional medical judgment of a qualified health care provider and do not constitute the practice of medicine or medical advice.