

PHARMACOGENOMIC (PGX) TESTING: A HANDOUT FOR B.C. PATIENTS

Pharmacogenomic (PGx) testing

Pharmacogenomics is the science of how a person's genes affect their response to medications. Many factors, including our age, sex, weight, and even our genes, determine whether medications work well, are not likely to work, or are likely to cause side effects. **Pharmacogenomic (PGx) testing gives your healthcare provider more information about how you process certain medications. Most commonly, PGx testing works by assessing how fast your body can process medications as determined by your genes.**

The results of the PGx testing are put in a report that tells your healthcare professional how fast or slow your body metabolizes (breaks down) medications based on your genes. The different speeds at which genes tell the body to process medications are referred to as “metabolizer types” and they range from slow to very fast (see Figure 1). Knowing your metabolizer type helps healthcare professionals predict your risk for side effects, determine dosage, and even predict if a different medication would be better for you.

Learn more about what PGx is and how it works in this [video](#) produced by The Hospital for Sick Children in Toronto.

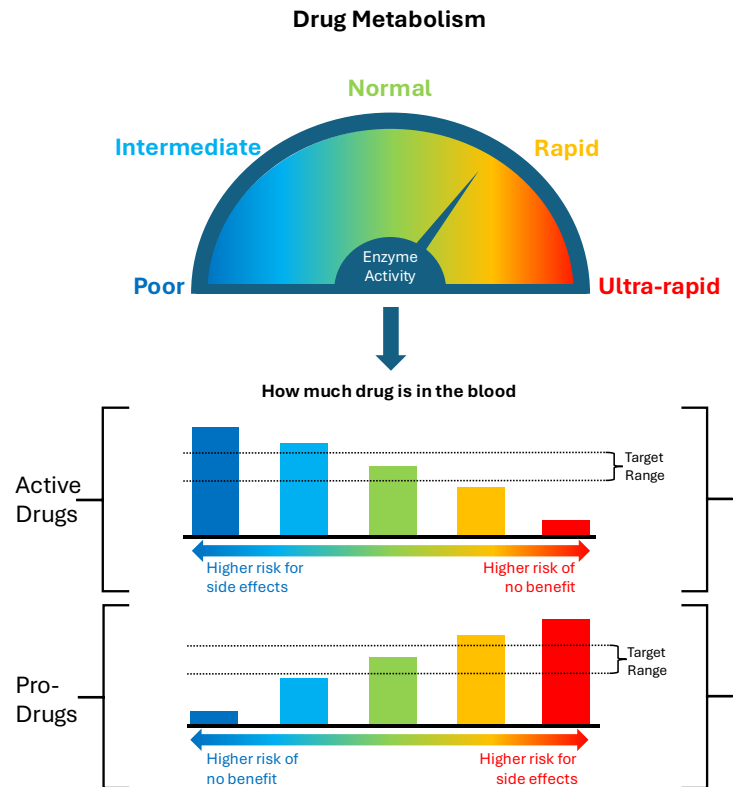
What can PGx testing tell me?

PGx testing can tell you how fast or slow your genes tell your body to process certain medications.

This information along with your age, sex, and other factors, can help your healthcare provider choose a medication or dosage that is likely to work for you. If the test shows that you process a medication at a normal rate, this could reassure you and your provider that your treatment is on track.

Unlike other types of genetic testing, PGx testing is not intended to tell you if you have or are at risk of certain diseases or conditions. PGx testing cannot tell you which medication to try first or which specific medication is best. **It is a tool that can guide decisions between medications and dosages.**

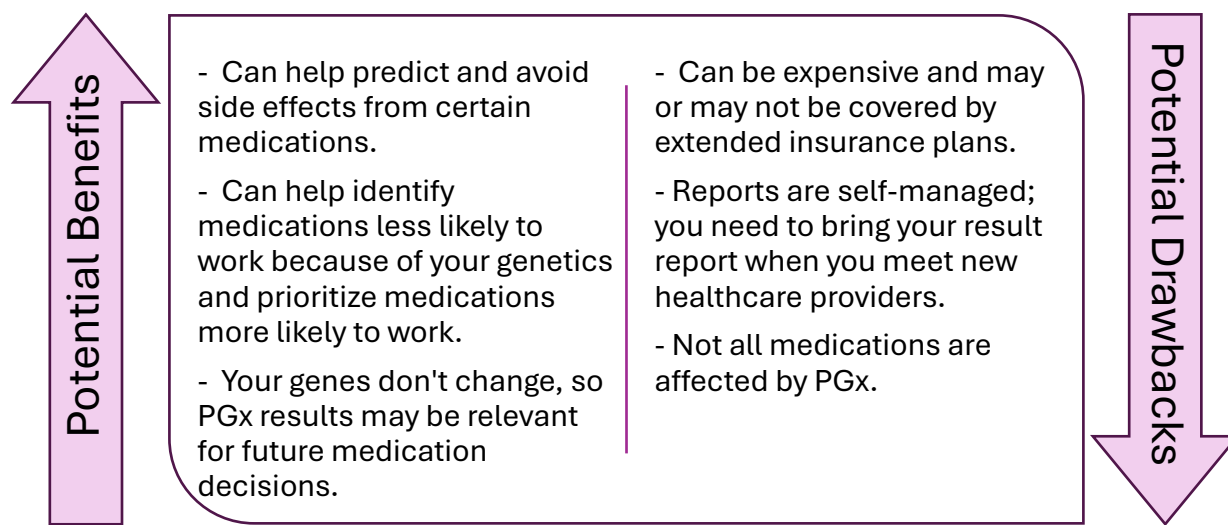
PGx testing is not and cannot be used to determine ancestry or family lineage.



PGx testing tells your provider how fast you process certain medications. Your healthcare provider can use this information to predict if there will be too much, too little, or the right amount available in your blood. This figure is modified with permission from Dr. Chad Bousman.

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Potential benefits and drawbacks



PGx, privacy, and genetic discrimination - What do I need to know?

Canada's Genetic Non-Discrimination Act (2017) makes it illegal for any person (or company) to collect, use, ask about, or disclose your genetic test results without your consent. You never have to disclose genetic test results to an employer or insurance company, for example.

If you are concerned about how a company might protect your privacy and secure your data, contact the testing company directly to ask about their storage protocols and safeguards. You may wish to choose a company whose laboratory and data are stored in Canada to ensure Canadian laws apply to the company and your data. Learn more about things to consider with [Direct-to-consumer genetic testing and privacy - Office of the Privacy Commissioner of Canada](#):

Paying for PGx testing

PGx testing is typically not covered by Canada's public health system. Your PGx test may be a tax-deductible medical expense; ask the company to confirm. A common price for PGx testing is around \$500. Most companies accept payment by credit card or debit card/cash. Several private insurance companies offer partial or full coverage, but you should contact your extended benefits provider to find out:

- Which specific tests (if any) your insurance covers
- How much of the test cost your insurance covers
- If the test is only covered for certain health conditions
- If you need a doctor's note or prescription to order the test, and
- If your insurance company has specific ordering or reimbursement procedures you must follow.

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Picking a PGx test

ACRONYM DICTIONARY

AMP – Association for Molecular Pathology

CAP – College of American Pathologists

CLIA – Clinical Laboratory Improvement Amendments

CPIC – Clinical Pharmacogenomics Implementation Consortium

CPSBC – College of Physicians and Surgeons of British Columbia

DPWG - Dutch Pharmacogenomics Working Group

FDA – (US) Food and Drug Administration

WCDA – Western Canada Diagnostic Accreditation Alliance

Many PGx tests are available in Canada through private companies. Apply these criteria when shopping for a PGx test:

- 1. The test should be based on research evidence.** Look for tests that use guidelines from the following organizations: CPIC, DPWG, and/or FDA.
- 2. The test should be performed in a certified laboratory.** Canadian labs should be certified by the College of Physicians and Surgeons of British Columbia (CPSBC) or an equivalent college for the province. Accreditation from WCDA, CAP, or CLIA is a bonus. American labs should be accredited by CAP / CLIA.
- 3. The test company should be very clear about their methods.** They should tell you which genes they test, how they test, and the guidelines and evidence they use to translate findings into prescribing recommendations for healthcare providers.
- 4. The test company should be supportive.** The company should offer test result interpretation and consultation with a physician, genetic counsellor, pharmacist, or other professionals with sufficient experience in pharmacogenomics (PGx).

BC's Ministry of Health has created a booklet called "[Pharmacogenomics Testing Guidance for Patients](#)" which may also be helpful as you decide whether to buy a PGx test.

See a list of PGx tests available in Canada [here](#)

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Common medications that may appear on PGx tests

Pick a test that includes the genes related to the medications you are interested in. CPIC bases the following list on drug-gene pairs with extensive evidence. **Always check the most recent CPIC information at clnpgx.org/cpic/pairs.**

If you're considering one of these drugs...	...make sure the PGx test includes these genes!
Antimicrobial (to fight off infectious diseases): amikacin, dapson, gentamicin, methylene blue, neomycin, netilmicin, nitrofurantoin, paromomycin, peginterferon alfa-2a, peginterferon alfa-2b, primaquine, streptomycin, tobramycin, voriconazole	CYP2C19, G6PD, IFNL3, MT-RNR1
Anti-nausea: ondansetron	CYP2D6
Antiretroviral (to treat human immunodeficiency virus (HIV)): abacavir, atazanavir, efavirenz	CYP2B6, HLA-A, UGT1A1
Cancer: azathioprine, capecitabine, fluorouracil, mercaptopurine, rasburicase, tamoxifen, thioguanine	CYP2D6, DPYD, G6PD, NUDT15, TPMT
Cardiology (heart): clopidogrel, warfarin	CYP2C19, CYP2C9, CYP4F2, VKORC1
Cholesterol: atorvastatin, fluvastatin, lovastatin, pravastatin, rosuvastatin, simvastatin	ABCG2, SLCO1B1, CYP2C9
Epilepsy (seizure): carbamazepine, fosphenytoin, oxcarbazepine, phenytoin	CYP2C9, HLA-A, HLA-B
General anesthetics and muscle relaxants (for surgery): desflurane, isoflurane, methoxyflurane, sevoflurane, succinylcholine	CACNA1S, RYR1
Gout: allopurinol	G6PD, HLA-B
Immunosuppressants (to prevent organ rejection): tacrolimus	CYP3A5
Migraine and headache: rizatriptan, sumatriptan	CYP2D6
Opioid pain relievers: codeine, hydrocodone, tramadol	CYP2D6
Painkillers / pain relievers: flurbiprofen, celecoxib, ibuprofen, meloxicam, piroxicam	CYP2C9
Proton pump inhibitors (for acid reflux and gastric ulcers): dexlansoprazole, lansoprazole, omeprazole, pantoprazole	CYP2C19
Mental health medications (for depression, ADHD, and other conditions): amitriptyline, atomoxetine, carbamazepine, citalopram, clomipramine, desipramine, doxepin, escitalopram, fluvoxamine, imipramine, nortriptyline, paroxetine, sertraline, trimipramine, venlafaxine, vortioxetine	CYP2B6, CYP2C19, CYP2D6

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Where can I go to learn more about PGx testing?

- BC & Canada-specific resources:
 - BC Ministry of Health's Pharmacogenomics Testing Guidance for Patients Booklet: https://www2.gov.bc.ca/assets/gov/health/health-drug-coverage/pharmacare/pgx_testing_policy_for_patients.pdf
 - Genetics Education Canada: Knowledge Organization: Direct-to-Consumer Genetic Testing: <https://geneticseducation.ca/resources-for-clinicians/genomic-technologies/direct-to-consumer-testing/gecko-on-the-run-9>
- Videos about PGx:
 - This Canadian video, produced by The Hospital for Sick Children in Toronto, gives a quick overview of what PGx is and how it works. Note: the research opportunity mentioned is no longer recruiting. <https://www.youtube.com/watch?v=4532ns1Mqsl>
 - This American video, produced by All of Us Research Program, is a good example of what a patient's PGx testing journey might look like: <https://www.youtube.com/watch?v=oaOSGmhU5-w>
- Frequently Asked Questions:
 - The USA's National Human Genome Research Institute (NHGRI) has a Pharmacogenomics FAQ page: <https://www.genome.gov/FAQ/Pharmacogenomics>