Personalized Psychiatry and Neurology

Review

Convergence of Pharmacoeconomics and Pharmacogenomics of Antipsychotics: A Review of Pharmacogenetic Diagnostic Tests

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Abstract: Pharmacogenetic testing (PGx) of polymorphisms that alter the expression of genes associated with the distribution and response to antipsychotics (APs) can replace the "trial and error" method in AP dosage adjustment and reduce the risk of AP-induced adverse drug reactions (ADRs). This narrative review demonstrates the growing commercial interest in the pharmacogenomics and pharmaco-economics of PGx. However, the significant heterogeneity of pharmacogenetic panels and the lack of unified interpretation standards substantially hinder the implementation of PGx as an advanced tool in personalized psychiatry. The conducted review demonstrates not only technological and commercial progress in the field of PGx for APs but also a complex of interrelated problems that require resolution for the successful translation of this method from the realms of scientific research and commercial services into the routine clinical practice. Although the development of PGx for identifying at risk patient groups aligns with Russia's new healthcare development strategy, numerous barriers impede its implementation into psychiatric practice. One such barrier is the lack of data on the convergence of pharmacogenomics and pharmacoeconomics of APs. Removing this barrier can facilitate the development and real-world clinical implementation of diagnostic pharmacogenetic test systems as a key to a new era of personalized, cost-effective, and safe therapy for mental disorders.

Keywords: *pharmacogenetic testing; psychopharmacotherapy; protein transporter; antipsychotic; pharmacogenetics; pharmacoeconomics; personalized medicine; psychiatry.*

1. INTRODUCTION

Pharmacoeconomics and pharmacogenomics are two rapidly developing fields of medical knowledge that are increasingly converging (**Figure 1**). Pharmacoeconomics is an independent science that studies the relationship between costs and the efficacy, safety, and quality of life associated with alternative treatment regimens using drugs [1, 2]. Pharmacogenomics is the science that studies the influence of an individual's genome on their response to drugs [3, 4]. Their convergence is generating growing clinical and scientific interest, as it has been increasingly recognized in recent decades that pharmacogenetic biomarkers, which predict the efficacy and toxicity of psychotropic drugs, can cost-effectively improve the burden and outcomes of mental disorders [5, 6, 7].

Numerous Russian and international studies have shown that broader use of pharmacogenetic testing (PGx) in real-world psychiatric practice enables screening for polymorphisms in genes encoding key metabolic enzymes and transporter proteins for a wide range of psychotropic drugs, including antipsychotics (APs), antidepressants (ADs), mood stabilizers, and anticonvulsants [8-11]. PGx aimed at identifying genetic biomarkers of individual sensitivity to APs is developing at a faster pace [12, 13]. This is because APs are the most frequently prescribed group of psychotropic drugs. A comparative analysis by Vaskova L.B. et al. demonstrated that in the treatment of schizophrenia, approximately 50% of prescribed drugs are APs [14]. Jameson A. et al. conducted a study involving 243 patients, where the authors showed that two-thirds (164) of the patients received APs metabolized via CYP2D6 [15].

The development of PGx for identifying at-risk patient groups aligns with Russia's new healthcare development strategy [16], which positions pharmacogenetics as the cornerstone of personalized medicine in general and personalized psychiatry in particular. This document places special emphasis on scientific and technological advancement, including the implementation of new medical and advanced technologies—such as pharmacogenetics and predictive genetics—developed by scientific, medical, and educational organizations. The strategy is designed to reduce risk, primarily by minimizing adverse drug reactions (ADRs) and treatment failure (therapeutic resistance and pseudo-resistance) through the exclusion of unsuitable medications at the prescribing stage. Consequently, a particular focus is placed on the predictive (pre-emptive) variant of PGx (**Table 1**).

In the long term, the convergence of pharmacogenomics, pharmacoeconomics and artificial intelligence (AI) can enable the economically justified use of results from both pre-emptive and reactive types of PGx in AI-based clinical decision support systems. This will enhance the accuracy of diagnosis and treatment of mental disorders using APs [17–19]. Furthermore, the development of domestic pharmacogenetic diagnostic test systems is crucial for strengthening human resource potential and technological sovereignty in Russia's healthcare sector [20, 21]. The new national Healthcare Development Strategy in our country [16] can help overcome existing barriers to PGx adoption by healthcare authorities, clinicians (psychiatrists), patients with mental disorders, and their family members (**Figure 2**).

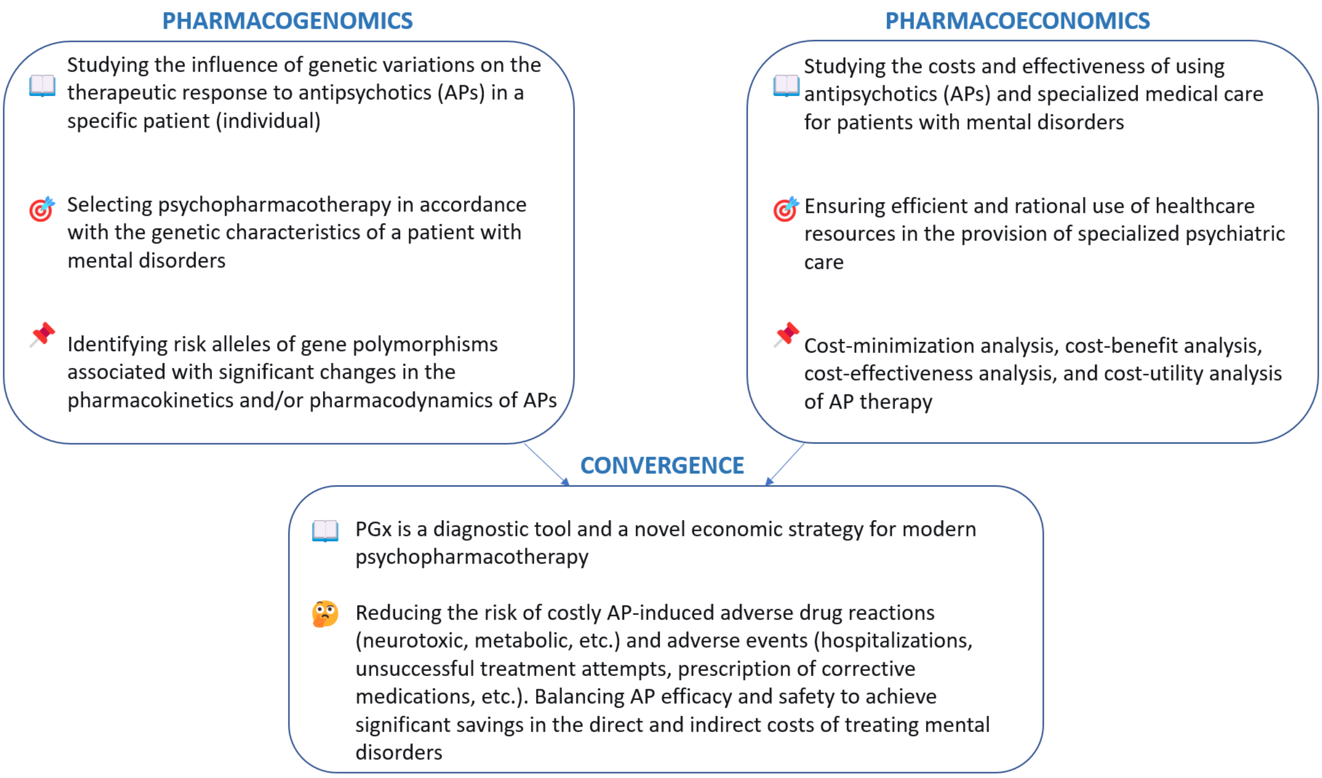

Figure 1. Convergence of Pharmacoeconomics and Pharmacogenomics.

Note: *PGx – pharmacogenetic testing; AP – antipsychotic.*

Table 1. Types of pharmacogenetic testing [14, modified by the authors].

Parameter **Type of study**	**Pharmacogenetic testing (PGx)**	
	Proactive (pre-emptive)	**Reactive (confirmatory)**
Objective of the study	Identification of homozygous and heterozygous carriers of non-functional/low-function/high-function risk alleles in candidate genes associated with significant changes in the pharmacokinetics and/or pharmacodynamics of APs	Confirmatory investigation of homozygous and heterozygous carriage of risk alleles in candidate genes associated with impaired pharmacokinetics and/or pharmacodynamics of APs
Timing of the study	Before AP prescription or at therapy initiation (during the dose titration stage). Conducted prior to the development of AP-induced ADRs	After long-term AP use or following therapy initiation (after the dose titration stage). Conducted after the development of AP-induced ADRs and/or therapeutic resistance and/or pseudo-resistance to APs

Note: *PGx – pharmacogenetic testing; AP – antipsychotic; ADR – adverse drug reaction.*

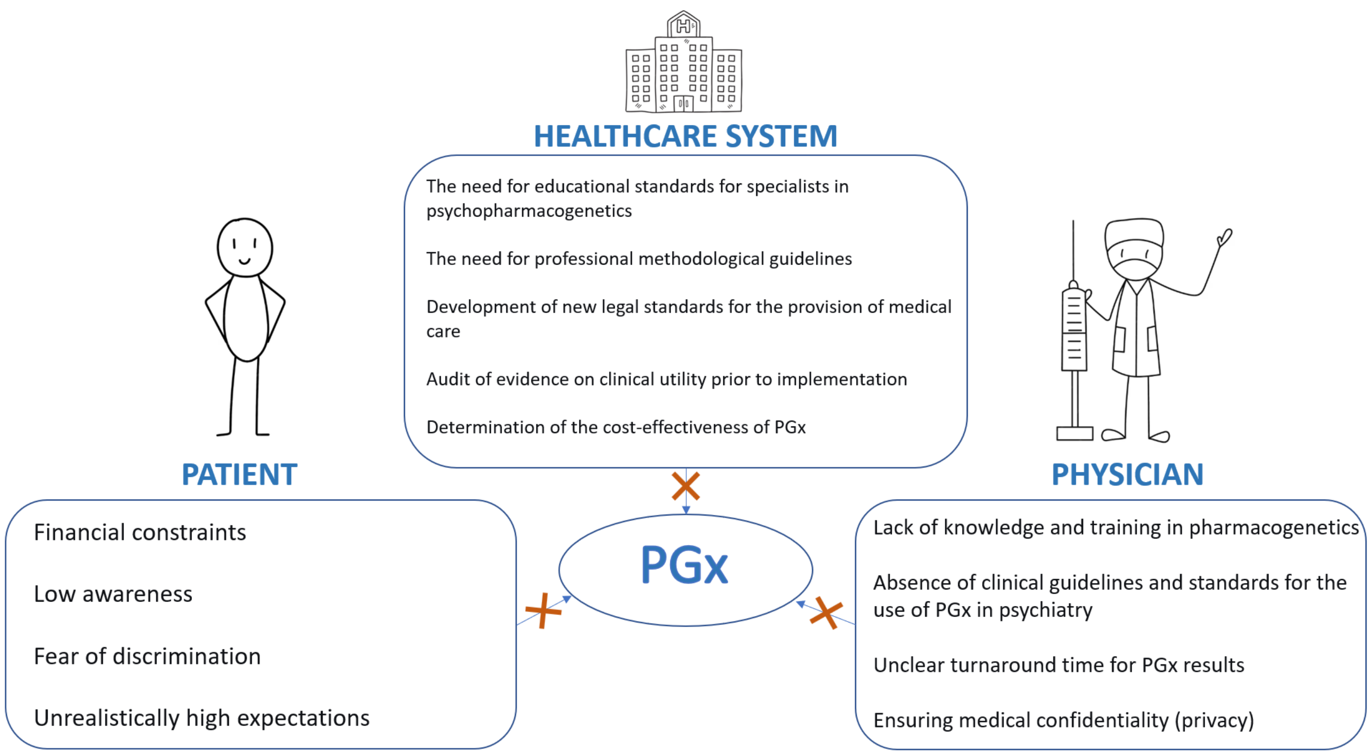

Figure 2. Barriers to the implementation of pharmacogenetic testing in psychiatric practice.
Note: *PGx – Pharmacogenetic Testing.*

The issue of implementing PGx into real-world clinical practice can be viewed from different perspectives. From the psychiatrist's standpoint, the main barriers are a lack of knowledge and training in pharmacogenetics and the absence of clinical guidelines incorporating PGx results. Consequently, practicing physicians face difficulties in interpreting the findings. Furthermore, due to a scarcity of validated PGx studies, psychiatrists tend to place greater trust in the routine "trial and error" method when selecting APs [22]. The time required to perform PGx and await its results can delay decisions on therapeutic strategies for patients with mental disorders, which is a significant factor in outpatient settings [23–25]. From the patients' perspective, the main factors hindering PGx adoption are cost [24], fear of discrimination (e.g., in employment) [26, 27], and inflated expectations regarding PGx. Patients hope that PGx will identify the "ideal" AP that will cure them and become disappointed when they receive ambiguous recommendations or the expected therapeutic effect is not achieved. Low awareness of pharmacogenetics among patients and their family members fosters fear of the unknown, which impedes PGx utilization and necessitates additional time from physicians to explain the importance of this laboratory diagnostic method [24, 28, 29]. From the healthcare system's perspective, a barrier is the insufficient preparation of the legal and regulatory framework for implementing PGx into psychiatric practice [30].

Table 2. Clinical guidelines from expert communities on pharmacogenetic testing for selected antipsychotics [36, modified by the authors].

Drug	**Gene, OMIM ID**	**Information on PGx**				**Dosage recommendations**	**Level of evidence**	
		FDA	**EMA**	**HCSC**	**PMDA**		**CPIC**	**PhamGKB**
Aripiprazole	*CYP2D6*, 124030	Required	Required	Required	ND	–	B	1A
Clozapine	*CYP2D6*, 124030	Required	ND	ND	ND	DPWG	B/C	ND
	HTR2C, 312861	–	–	–	–	–	C	3
	CYP1A2, 124060	–	–	–	–	–	–	3
Haloperidol	*CYP2D6*, 124030	ND	ND	ND	ND	DPWG	B/C	1A
Olanzapine	*CYP2D6*, 124030	ND	Informative	ND	ND	DPWG	ND	3
	HTR2C, 312861	–	–	–	–	–	C	3
Perphenazine	*CYP2D6*, 124030	Required	ND	ND	Required	ND	B/C	ND
Pimozide	*CYP2D6*, 124030	Mandatory testing	ND	ND	ND	ND	A/B	ND
Risperidone	*CYP2D6*, 124030	Informative	НД	Informative		DPWG	B	1A/3
	DRD2, 126450	–	–	–	–	–	C	3/4
	HTR2C, 312861	–	–	–	–	–	C	3
Thioridazine	*CYP2D6*, 124030	Required	ND	ND	ND	ND	B/C	3
Zuclopenthixol	*CYP2D6*, 124030	ND	ND	ND	ND	DPWG	B/C	1A

Note: PGx – pharmacogenetic testing; ND – no data; CPIC – Clinical Pharmacogenetics Implementation Consortium [37]; PharmGKB – The Pharmacogenomics Knowledge Base [47]; FDA – U.S. Food and Drug Administration [38]; EMA – European Medicines Agency [42]; HCSC – Health Canada, Santé Canada; PMDA – Pharmaceuticals and Medical Devices Agency [44]; DPWG – The Dutch Pharmacogenetics Working Group [41].

Table 3. Classification of evidence levels used by different expert communities for pharmacogenetic testing.

CPIC Level [37]	PharmGKB Level [47]	Level of evidence	Description	Clinical significance
A	1A	High	There are CPIC and/or FDA clinical guidelines, supported by ≥1 publication	PGx data must be considered before prescribing the corresponding AP
	1B	High/moderate	There are ≥2 independent publications, but no official guidelines	PGx data should be considered before prescribing the corresponding AP, when available
A/B	1A/1B/2A/2B	A full review of available data is required to assess the evidence level, but the inclusion of this AP in the PGx panel is likely to be justified	Preliminary analysis indicates that the final CPIC level will be A or B	PGx may be useful when prescribing the AP
B	2A	Moderate	The variant belongs to important pharmacogenes (VIP genes) ClinPGx [61], supported by ≥2 publications	PGx may be useful when prescribing the AP
	2B	Moderate/weak	Not included in the ClinPGx VIP gene list, but there are ≥2 publications	PGx may be useful when prescribing the AP
B/C	2A/2B/3	A full review of available data is required to assess the evidence level, but the clinical utility of including this AP in the PGx panel likely remains uncertain	Preliminary analysis indicates that the final CPIC level will most likely be either B or C	PGx may be of limited utility when prescribing the AP
C	3	The evidence level may vary	There is limited data supporting the gene-AP association	PGx is of low informational value
C/D	3/4	The evidence level may vary	Preliminary analysis indicates that the final CPIC level will most likely be either C or D	PGx is of low informational value
D	4	The evidence level may vary	The gene-AP association is not confirmed	PGx is not recommended for clinical decision-making

Note: *PGx – pharmacogenetic testing; ND – no data; CPIC – Clinical Pharmacogenetics Implementation Consortium [37]; PharmGKB – The Pharmacogenomics Knowledge Base [47]; FDA – U.S. Food and Drug Administration [38]; AP – antipsychotic; VIP – very important pharmacogenes.*

However, in recent years, there has been a trend towards the legal recognition and regulation of PGx in Russia. This is governed by regulatory acts, including Federal Law No. 323-FZ of 21.11.2011 [31], Orders of the Russian Ministry of Health No. 1094n of 24.11.2021 [32], No. 575n of 02.12.2012 [33], No. 66n of 03.08.2012 [34], Letter of the Russian Ministry of Health No. 17-4/10/2-6989 of 06.10.2017 [35], and others [36]. For evidence-based selection or adjustment of antipsychotic (AP) therapy, it is advisable to rely on the recommendations of the Clinical Pharmacogenetics Implementation Consortium (CPIC) [37] and the U.S. Food and Drug Administration (FDA) [38], which utilize the predictive value of genetic information on gene-gene and drug-drug interactions [39, 40].

On the one hand, various countries around the world utilize their own criteria for assessing the clinical value of PGx biomarkers. These include The Dutch Pharmacogenetics Working Group (DPWG) [41], the European Medicines Agency (EMA) [42], The Canadian Pharmacogenomics Network for Drug Safety (CPNDS) [43], Japan's Pharmaceuticals and Medical Devices Agency (PMDA) [44], the French national pharmacogenetics network (Réseau national de pharmacogénétique, RNPGx) [45], and the Pharmacogene Variation Consortium (PharmVar) [46].

On the other hand, there are methodological difficulties in implementing PGx into real-world psychiatric clinical practice, stemming from currently unresolved issues related to ethical and legal standards, as well as the standardization processes for routine PGx. From the perspective of healthcare system organization and administrative regulation, an audit of currently available PGx panels and their clinical utility for the personalized assessment of AP efficacy and safety is crucial for the implementation of PGx in psychiatric practice. Unfortunately, the clinical guidelines from expert communities on PGx (**Table 2**) remain highly heterogeneous [36].

For example, the level of evidence for the *CYP2D6*-risperidone and *DRD2*-risperidone associations in the PharmGKB database varies depending on the analyzed single nucleotide variants (SNVs) and haplotypes of the respective genes. For the *CYP2D6* gene, one clinical annotation indicates an association between specific *CYP2D6* haplotypes (*1, *1xN, *3, *4, *5, *6, *10, 14) and risperidone with a high level of evidence (Level 1A) [48].

In contrast, another annotation reports that a different set of *CYP2D6* haplotypes (1, *87, *88, *89, *90, *91, *93, *94, *95, *97, *98) demonstrates only a weak association (Level 3) [49]. For the *DRD2* gene, five clinical annotations in PharmGKB (rs1800497, rs1799978, rs1799732, rs4436578, rs2514218) identified an association with risperidone corresponding to evidence Level 3 [50, 51, 52, 53, 54]. However, for the SNVs rs1800497 and rs1799978, two other annotations classified the same association as Level 4 [55, 56]. The existence of different evidence levels for the same genetic variants underscores the heterogeneity of published data and indicates the need for cautious interpretation of PGx results. Specifically, for *CYP2D6*, the clinical significance of the association with risperidone depends on the haplotypes being compared [57], while for *DRD2* rs1800497, the data remain contradictory, which currently limits its utility for making therapeutic decisions in AP selection.

Different expert communities employ distinct approaches to evaluating pharmacogenetic data (Table 3). The PharmGKB system is primarily focused on the quantitative assessment of accumulated annotations and the degree of reproducibility of associations between genetic variants and drug response [58, 59].

In contrast, CPIC is mainly centered on providing pharmacotherapeutic recommendations for a wide range of drugs in combination with a patient's genotype or predicted phenotype [60]. Consequently, a high PharmGKB level (e.g., 1B or 2A) does not always correspond to a CPIC Level A, as a statistically significant association does not necessarily imply clinical utility for PGx. The intermediate levels (A/B and B/C) reflect the dynamic nature of evidence evaluation and highlight that the status of a specific gene-drug pair may change as new data accumulates and recommendations are revised. In a clinical context, CPIC Levels A and B hold the greatest significance, as they suggest the possibility of modifying AP therapy based on PGx results. In contrast, Levels C and D should currently be viewed primarily as investigational, not warranting the routine use of PGx in AP selection [37]. The data presented in Table 3 underscore the necessity of distinguishing between statistical association and clinical applicability, and demonstrate the importance of expert interpretation in the implementation of PGx into psychiatric practice.

The objective of this narrative review is to analyze the available PGx panels in Russia and abroad, adapted or partially adapted for assessing genetically determined changes in the pharmacokinetics and pharmacodynamics of APs, from the perspective of their content and cost.

2. MATERIALS AND METHODS

We analyzed domestic and international open publications from the eLibrary and PubMed databases for the period 2020–2025, as well as publicly available information on the official websites of domestic and international genetic laboratories. The search was conducted using keywords in Russian and English. Statistical data processing was performed using Microsoft Excel (USA, version 2016).

3. RESULTS

We identified and analyzed publicly available information on five domestic laboratories offering diagnostic medical services for PGx of APs, including two laboratories affiliated with state institutions and three commercial laboratories (**Table 4**).

Table 4. Examples of Russian laboratories conducting pharmacogenetic testing for antipsychotics.

City	Laboratory/ Institution	Genes analyzed	Target drugs	Price	Service name	Website
Saint Petersburg	V.M. Bekhterev National Medical Research Center for Psychiatry and Neurology, Laboratory of Individual Genetics, Institute of Personalized Psychiatry and Neurology	*CYP1A2* *CYP3A4* *CYP2C9* *CYP2C19* *CYP2D6* *ABCB1*	Antipsychotics of 1st, 2nd and 3rd generations	2,200 RUB ($27.95) 3,000 RUB ($38.12) 4,000 RUB ($50.83) 4,000 RUB ($50.83) 4,000 RUB ($50.83) 2,100 RUB ($26.68) Total cost: 19,300 RUB ($247.27)	Analysis of common genetic variants in the *CYP1A2* (1 SNV), *CYP2C9* (2 SNVs), *CYP2C19* (3 SNVs), *CYP2D6* (3 SNVs), *CYP3A4* (3 SNVs), *ABCB1* (1 SNV) genes.	https://bekhterev.ru/clinic/stoimost-uslug/
Saint Petersburg	V.A. Almazov National Medical Research Center, Central Clinical Diagnostic Laboratory	*CYP3A5* *CYP2C9* *CYP2C19* *ABCB1*	ND	3,200 RUB ($40.66) 2,800 RUB ($35.58) 1,400 RUB ($17.94) 1,500 RUB ($19.22) Total cost: 8,900 RUB ($114.02)	Detection of polymorphisms in the *CYP2C19, CYP2C9, CYP3A5, ABCB1* genes	https://www.almazovcentre.ru/?page_id=12415
Moscow (branches nationwide)	Invitro	ND	Aripiprazole Clozapine	44,990 RUB ($573.77)	Pharmacogenetic panel «Personalized Therapy» (PGx Comprehensive Panel)	https://www.invitro.ru/analizes/for-doctors/856/
Moscow (branches nationwide)	Gemotest	ND	*Basic:* Chlorpromazine Haloperidol Olanzapine Thioridazine *Expanded:* Aripiprazole Chlorpromazine Clozapine Fluphenazine Haloperidol Olanzapine Quetiapine Risperidone Thioridazine Trifluoperazine	14,390 RUB ($183.01) 17,650 RUB ($225.10)	Antidepressants and Antipsychotics (Basic), Antidepressants and Antipsychotics (Expanded)	https://gemotest.ru/moskva/catalog/genetika/farmakogenetika/antidepressanty-i-neyroleptiki-rasshirennyy/
Moscow (branches nationwide)	Genomed	*CYP2C9* *CYP2D6*	ND	8,400 RUB ($107.13) 6,000 RUB ($77.30)	Pharmacogenetics: cytochrome *CYP2D6* (SNVs); Pharmacogenetics: cytochrome *CYP2C9*	https://price.genomed.ru/analysis/view?id=652

Note: *ND – no data; CYP – gene encoding the corresponding cytochrome P450 isoenzyme; ABCB1 – ATP-Binding Cassette Subfamily B Member 1, gene encoding the P-glycoprotein transporter.*
The exchange rate at the time of information search was 1 USD = 78.65 RUB. Service prices are indicated as of 01.01.2026.

The variability in the genes and their SNVs analyzed is notable. State medical institutions (e.g., the V.M. Bekhterev National Medical Research Center for Psychiatry and Neurology and the V.A. Almazov National Medical Research Center in St. Petersburg) have published information on the genes studied on their official websites. In contrast, private network laboratories (e.g., Gemotest, Invitro) do not disclose this information. The private laboratory Genomed offers PGx for APs analyzing only the two most common SNVs (rs35742686 and rs3892097) of the *CYP2D6* gene and (rs1799853 and rs1057910) of the *CYP2C9* gene. The Gemotest laboratory offers expanded and basic PGx panels for ADs and APs, including aripiprazole, haloperidol, quetiapine, clozapine, risperidone, trifluoperazine, thioridazine, olanzapine, chlorpromazine, and fluphenazine. However, it is unclear which specific genes and SNVs are included in these PGx panels.

The Invitro laboratory offers an expanded PGx panel focused on two APs (aripiprazole and clozapine), but the cost of PGx at this laboratory is the highest among the analyzed Russian laboratories, amounting to 44,990 RUB or $573.77.

Publicly available information on laboratories conducting PGx for APs in European countries is limited (**Table 5**). Consequently, we analyzed two laboratories located in Austria and the United Kingdom. In the Austrian laboratory, the spectrum of genes analyzed is quite broad and includes: seven genes encoding AP P-oxidation isoenzymes; one gene encoding a glucuronidation isoenzyme; and one gene encoding a transporter protein. However, the specific AP targets and the price of the tests are not indicated. On the official website of the British laboratory, information on the genes analyzed is absent, but 13 AP targets are listed.

Table 5. Examples of laboratories conducting pharmacogenetic testing for antipsychotics in European countries.

Country	Laboratory/ Institution	Genes analyzed	Target drugs	Price	Service name	Website
Austria	Diatech Pharmacogenetics srl	*CYP3A4* *CYP3A5* *CYP2B6* *CYP2C9* *CYP2C19* *CYP2D6* *CYP4F2* *UGT1A1* *ABCG2*	ND	ND	Myriapod® NGS PGX Sign Panel	https://www.diatechpharmacogenetics.com/en/myriapod-ngs-pgx-sign-panel/
United Kingdom	AttoPGx	ND	Aripiprazole Brexpiprazole Clozapine Haloperidol Iloperidone Lurasidone Olanzapine Paliperidone Pimozide Quetiapine Risperidone Thioridazine Zuclopenthixol	£299 (31,512.65 RUB; $401.89)	PGx for mental health and ADHD	https://www.attodiagnostics.com/services/pgx/

Note: *ND – no data; CYP – gene encoding the corresponding cytochrome P450 isoenzyme; UGT – gene encoding the corresponding UDP-glucuronosyltransferase; ABCG2 – ATP-Binding Cassette Subfamily G Member 2.*
The exchange rate at the time of information search was 1 USD = 78.65 RUB. Service prices are indicated as of 01.01.2026.

The most extensive information on PGx is presented on the official websites of laboratories in the North American region (**Table 6**), including 9 laboratories in the USA and 1 laboratory in Canada. However, the official website of the Canadian laboratory lacks information on the genes analyzed. In contrast, the spectrum of genes analyzed in American laboratories is quite broad, encompassing not only genes encoding AP P-oxidation and glucuronidation enzymes and AP transporter proteins but also genes encoding some of the targets of AP action. Although some laboratories do not specify AP targets on their websites, these PGx panels enable the assessment of individual sensitivity to a wide range of APs and other psychotropic drugs, including ADs and mood stabilizers.

Table 6. Examples of laboratories conducting pharmacogenetic testing for antipsychotics in the North American region.

Country	Laboratory/ Institution	Genes analyzed	Target drugs	Price	Service name	Website
Canada	Biron	ND	Aripiprazole Asenapine Brexpiprazole Cariprazine Chlorpromazine Clozapine Fluphenazine Haloperidol Loxapine Lurasidone Olanzapine Paliperidone Perphenazine Pimozide Quetiapine Risperidone Trifluoperazine Zuclopenthixol	$349 (27,365.36 RUB)	Mental health PGx test	https://www.biron.com/en/genetics/dna-test-mental-health-adhd/
USA	Immuogenomics	*CYP1A2* *CYP3A4* *CYP3A5* *CYP2B6* *CYP2C9* *CYP2C19* *CYP2D6* *ABCB1* *VKORC1*	Bromperidol Chlorpromazine Cyamemazine Droperidol Haloperidol Fluphenazine Levomepromazine Promazine Perphenazine Prochlorperazine	ND	Pharmacogenomics (PGx)	https://www.immunogeno.com/services-4-1
USA	Gene By Gene	*CYP1A2* *CYP3A4* *CYP2B6* *CYP2C19* *CYP2C9* *CYP2D6* *UGT1A4* *UGT2B15* *ADRA2A* *SLC6A4* *HTR2A*	Aripiprazole Aripiprazole Brexpiprazole Chlorpromazine Clozapine Haloperidol Iloperidone Lauroxil	ND	Phamacogenomics (PGx)	https://www.geneby-gene.com/about-us
USA	Quest Diagnostics	*CYP3A4* *CYP3A5* *CYP2B6* *CYP2C9* *CYP2C19* *CYP2D6* *CYP4F2* *ABCG2* *F5*	ND	ND	Pharmacogenomic panel with Coriell Life Sciences (CLS); Pharmacogenomics panel	https://www.questdiagnostics.com/healthcare-professionals/clinical-education-center/faq/faq206
USA	Medical Diagnostic Laboratories	*CYP1A2* *CYP3A4* *CYP3A5* *CYP2B6* *CYP2C9* *CYP2C19* *CYP2D6* *ABCB1, ITGB3*	Aripiprazole Brexpiprazole Clozapine Iloperidone Perphenazine Pimozide Risperidone Thioridazine	ND	Pharmacogenomics Solutions test panel	https://www.mdlabs.com/our-laboratory

Continuation of Table 6

Country	Laboratory/ Institution	Genes analyzed	Target drugs	Price	Service name	Website
USA	Fulgent Genetics	*CYP2B6* *CYP2C8* *CYP2C9* *CYP2C18* *CYP2C19* *CYP2D6* *CYP3A4* *CYP3A5* *CYP4F2* *UGT1A1* *UGT1A4* *ABCB1* *ABCG2*	Aripiprazole Brexpiprazole Iloperidone Pimozide	ND	Pharmacogenetic testing	https://www.fulgentgenetics.com/pgx
USA	Sanford Health	*CYP2B6* *CYP2C19* *CYP2D6*	Aripiprazole Brexpiprazole Pimozide	ND	Pharmacogenomics (PGx)	https://imagenetics.sanfordhealth.org/pharmacogenomics/
USA	ARUP laboratories	*CYP3A4* *CYP3A5* *CYP2B6* *CYP2C9* *CYP2C19* *CYP2D6* *UGT2B15* *ANKK1* *COMT* *DRD2* *GRIK4* *HTR2A* *HTR2C*	ND	ND	Pharmacogenetics panel for psychotropics	https://www.aruplab.com/testing/pharmacogenetics
USA	Genomind	*DRD2* *HTR2C* *MC4R*	Aripiprazole Asenapine Brexpiprazole Cariprazine Clozapine Lurasidone Olanzapine Paliperidone Quetiapine Risperidone Ziprasidone	ND	Pharmacogenetic (PGx) testing	https://genomind.com/solutions/pharmacogenetic-testing/

Note: *ND – no data; CYP – gene encoding the corresponding cytochrome P450 isoenzyme; UGT – gene encoding the corresponding UDP-glucuronosyltransferase; ABCB1 – ATP-Binding Cassette Subfamily B Member 1, gene encoding the P-glycoprotein transporter; ABCG2 – ATP-Binding Cassette Subfamily G Member 2; VKORC1 – Vitamin K epoxide reductase complex subunit 1; ADRA2A – Adrenoceptor Alpha 2A; SLC6A4 – Solute Carrier Family 6 Member 4, gene encoding the serotonin transporter (5-HTT, SERT); HTR2A – 5-Hydroxytryptamine Receptor 2A, gene encoding the corresponding type of serotonin receptor (5-HT); F5 – Coagulation Factor V; ITGB3 – Integrin Subunit Beta 3; DRD2 – Dopamine Receptor D2; GRIK4 – Glutamate Ionotropic Receptor Kainate Type Subunit 4; ANKK1 – Ankyrin Repeat and Kinase Domain Containing 1; COMT – Catechol-O-Methyltransferase; MC4R – Melanocortin 4 Receptor.*
The exchange rate at the time of information search was 1 USD = 78.65 RUB. Service prices are indicated as of 01.01.2026.

Table 7. Examples of laboratories conducting pharmacogenetic testing for antipsychotics in the Australia and New Zealand region.

Country	Laboratory/ Institution	Genes analyzed	Target drugs	Price	Service name	Website
Australia	Genomic Diagnostics	*CYP1A2* *CYP3A4* *CYP2D6*	Aripiprazole Brexpiprazole Chlorpromazine Clozapine Haloperidol Olanzapine Quetiapine Risperidone Zuclopenthixol	$199 (15,603.75 RUB)	Pharmacogenomics test (PGx Test)	https://www.genomicdiagnostics.com.au/tests/pharmacogenomics
Australia	Laverty Pathology	*CYP1A2* *CYP3A4* *CYP2D6*	Brexpiprazole Chlorpromazine Clozapine Haloperidol Olanzapine Quetiapine	$197 (15,446.92 RUB)	Pharmacogenomics test	https://www.laverty.com.au/tests/pharmacogenomics
Australia	myDNA	ND	Aripiprazole Brexpiprazole Chlorpromazine Clozapine Haloperidol Olanzapine Quetiapine	$149 (11,683.21 RUB)	Mental health medication test kit	https://www.mydna.life/pharmacogenomics-testing/
Australia	Genetics Australian Clinical Labs	*CYP1A2* *CYP3A4* *CYP3A5* *CYP2C9* *CYP2C19* *CYP2D6* *VKORC1*	Antipsychotics	$140 (10,977.51 RUB)	Antipsychotics predictor	https://www.clinical-labs.com.au/doctor/specialists-services/pharmacogenetic-testing/

Note: *ND – no data; CYP – gene encoding the corresponding cytochrome P450 isoenzyme; VKORC1 – Vitamin K epoxide reductase complex subunit 1. Service prices are indicated as of 01.01.2026. The exchange rate at the time of information search was 1 USD = 78.65 RUB.*

Table 8. Examples of laboratories conducting pharmacogenetic testing for antipsychotics in the African region.

Country	Laboratory/ Institution	Genes analyzed	Target drugs	Price	Service name	Website
RSA	Next Biosciences	ND	Aripiprazole Brexpiprazole Chlorpromazine Clozapine Haloperidol Iloperidone Lurasidone Olanzapine Quetiapine Risperidone Thioridazine Trifluoperazine Ziprasidone Zuclopenthixol	4,900 ZAR ($298.74; 23,418.72 RUB)	PharmaGene	https://next-bio.co.za/divisions/patients/health/pharmagene

Note: *Service prices are indicated as of 01.01.2026. The exchange rate at the time of information search was 1 USD = 78.65 RUB.*

4. DISCUSSION

In the Australia and New Zealand region, offers for PGx of APs were found on the official websites of four Australian laboratories (**Table 7**). Among these, only one laboratory did not provide information on the genes analyzed. The laboratory Genetics Australian Clinical Labs offers the broadest spectrum of analyzed genes. However, none of the Australian laboratory test for SNVs in genes encoding transport proteins responsible for AP efflux across the blood-brain barrier (BBB).

In the African region, publicly available information was found for one laboratory located in the Republic of South Africa, which offers PGx for 14 APs (**Table 8**). However, the specific genes analyzed and their SNVs are not presented on the laboratory's official website.

This narrative review demonstrates the growing commercial interest in the pharmacogenomics and pharmacoeconomics of PGx for APs. However, the significant heterogeneity of PGx panels (**Tables 4-8**) and the lack of unified interpretation standards substantially hinder the implementation of PGx as an advanced tool in personalized psychiatry. They also impede the transition of PGx from a commercial service to routine clinical psychiatric practice. As shown in **Table 2**, even leading global consortia (CPIC, PharmGKB) exhibit heterogeneity in the levels of evidence and recommendations for the same gene-drug pairs. This problem is even more pronounced in the commercial PGx panels we analyzed (**Tables 4-8**): laboratories often do not disclose the complete list of analyzed genes and their SNVs, nor the algorithms used to form the clinical interpretation of PGx results. The absence of a unified national or industry standard for PGx panels for AP therapy in mental disorders creates a risk of obtaining conflicting results and disorienting both the physician and the patient. A significant price disparity is observed (**Figure 3**): in Russia, from 6,000 RUB to 44,990 RUB; in foreign countries, from $140 (10,997.51 RUB) to £299 (31,512.65 RUB; $401.89). The median cost of PGx for APs in Russia (**Figure 4**) was 14,390 RUB, which is not much lower than the analogous figure abroad (15,604 RUB). However, this comparison is highly conditional because the number of genes analyzed and their SNVs varies widely between domestic and international PGx panels.

Analysis of the cost distribution for PGx in Russia revealed a substantial difference between prices in public (budget) medical organizations and commercial laboratories. Furthermore, an analysis of the available information highlights a structural difference in the transparency of their offerings. State medical institutions provide open and detailed information on the genes analyzed, typically offering PGx for individual genes upon a clinician's request.

Additionally, a patient can obtain a detailed interpretation of PGx results from a clinical pharmacologist/psychiatrist involved in developing the PGx panel and possessing relevant expertise [62]. Commercial laboratories more frequently offer comprehensive PGx panels. However, open access to the full list of analyzed genes/SNVs and the methodological basis is often unavailable. Consequently, a direct comparison of the «breadth of coverage» is difficult, and the higher price of commercial PGx panels may reflect not only an expanded genetic scope but also the laboratory's marketing strategy or costs associated with scaling operations.

The conducted review demonstrates not only technological and commercial progress in the field of PGx for APs but also a complex of interrelated problems that require resolution for the successful translation of this method from the realms of scientific research and commercial services into the routine clinical practice of psychiatrists. Despite the growing number of offerings, there remains a deficit of research confirming that the use of specific PGx panels reliably improves clinical outcomes of a personalized therapeutic approach (e.g., increases remission rates, shortens the time to find effective therapy, reduces the number of hospitalizations) compared to standard (routine) «trial and error» practice [63–65]. In the review by Gurevich E.K. [66], four studies were analyzed, three of which associated PGx with AP treatment efficacy and a lower incidence of ADRs in patients with major depressive disorder and schizophrenia spectrum disorders.

Pharmacoeconomic studies [67, 68] adapted to the Russian healthcare system are especially pertinent. These should assess not only the cost of the PGx panel but also the cumulative savings from preventing severe AP-induced ADRs, reducing disability, and mitigating the costs of correcting ineffective treatment. An important unresolved issue is determining the optimal composition of a PGx panel, that is, the threshold beyond which expanding the spectrum of analyzed genes ceases to substantially increase clinical benefit while continuing to drive up the cost of PGx.

The absence of unified standards for generating reports and the clinical interpretation of PGx results is compounded by a deficit of relevant competencies among practicing psychiatrists in the field of pharmacogenetic data. This raises a key question: «Is the current training of psychiatrists sufficient, or is a mandatory multidisciplinary consultative model involving a psychiatrist, a clinical pharmacologist, and a geneticist necessary?». An important task for personalized psychiatry is bridging the «digital divide» by implementing mandatory educational modules on pharmacogenetics into the systems of continuous medical education in Russia and abroad. Special attention should be paid to developing informed consent protocols. These protocols should, in an accessible manner, explain to patients with mental disorders the possibilities, limitations, and potential ethical risks of PGx [69].

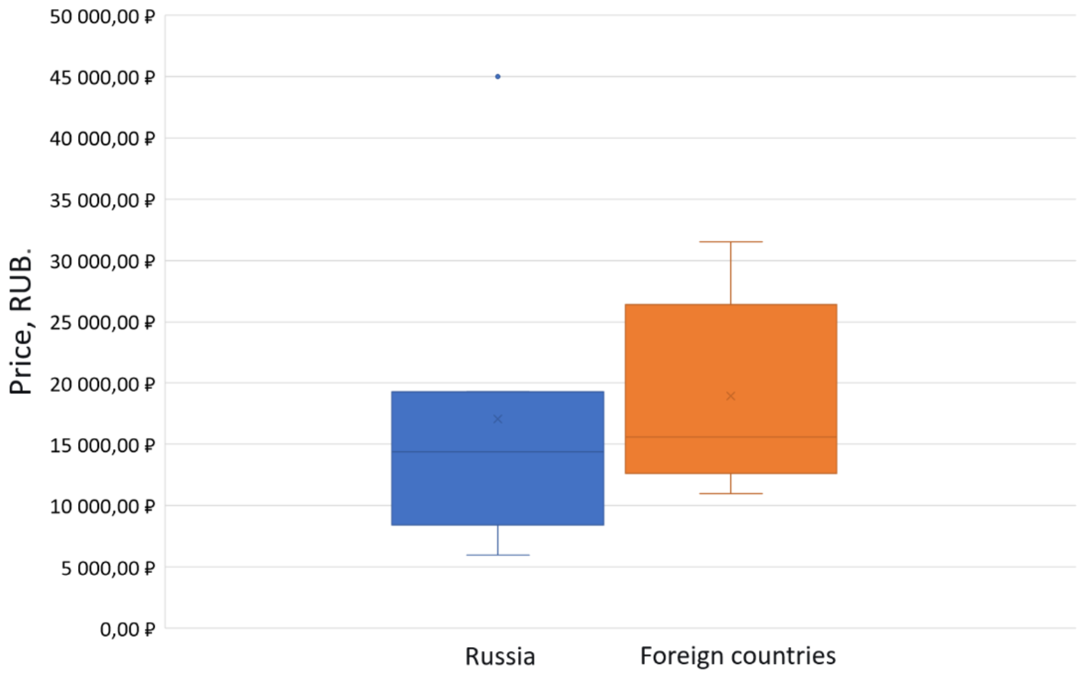

Figure 3. Comparison of the median cost of pharmacogenetic testing for antipsychotics in Russia and in foreign countries.

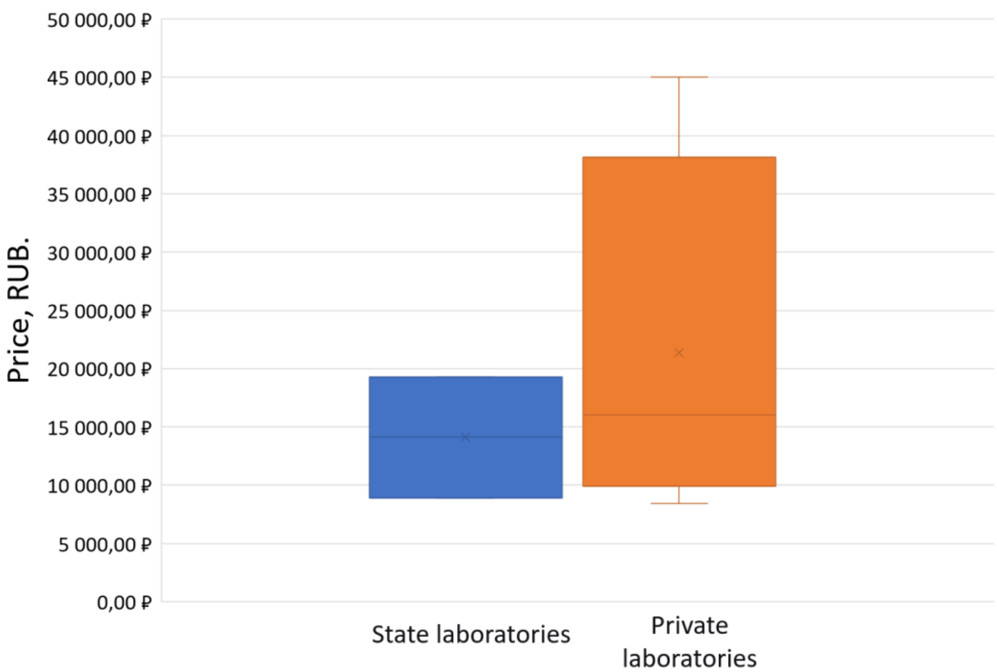

Figure 4. Comparison of the median cost of pharmacogenetic testing for antipsychotics in Russian laboratories.

For the widespread implementation of PGx for psychotropic drugs, a number of practical issues must be resolved: the turnaround time for PGx, which should not delay the initiation of AP therapy in acute conditions; the logistics of sample collection and transport of biomaterial, especially in remote regions of the country; and funding models (within the framework of Mandatory Health Insurance (MHI) and/or Voluntary Health Insurance (VHI)). In the future, a key step will be the inclusion of PGx in clinical guidelines and standards of psychiatric care for specific nosologies (e.g., in the therapy of treatment-resistant forms of schizophrenia), which will require the consolidation of the evidence base. The development and implementation of an external quality assessment system for laboratories performing PGx for psychotropic drugs is also necessary.

Considering the results of genetic association studies and genome-wide association studies (GWAS) from the last decade, the ethnic and racial orientation of PGx is crucial. This is because the frequencies of minor alleles (MAFs) for most pharmacogenetic genes vary widely not only across different countries but also among different racial and ethnic groups within a single country [70]. However, assessing whether this aspect is considered in the offerings of domestic and foreign state and commercial laboratories is currently not possible, due to the lack of information on the analyzed SNVs on the overwhelming majority of their official websites. The economic damage and social consequences of mental disorders depend on the safety and efficacy of pharmacotherapy [71]. The development of domestic PGx panels for assessing the safety and efficacy of AP therapy can help improve therapeutic and social outcomes of mental disorders. It can also reduce the direct and indirect economic costs borne by territorial mandatory health insurance funds for the treatment and rehabilitation of patients with mental disorders who require long-term AP prescriptions.

5. CONCLUSIONS

This narrative review highlights current issues regarding the pricing and «diagnostic breadth» of available Russian and international PGx panels for identifying patients with mental disorders who are at high risk of developing therapeutic resistance and/or AP-induced ADRs. Large-scale future studies are needed to qualitatively assess the convergence of pharmacogenetics and pharmacoeconomics in PGx.

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