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Views of Patients and Healthcare Providers on Pharmacogenetic Screening for Antipsychotic Medications

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ABSTRACT

Antipsychotic medications, commonly used to manage psychosis, often cause side effects that can range from mild to severe, and patients frequently require multiple medication trials to achieve an effective drug and dose. To address these challenges, there is growing interest in precision medicine approaches. Pharmacogenetics examines how individual genetic differences affect drug metabolism and therapeutic response. Recent clinical studies suggest that pharmacogenetic testing may help improve treatment outcomes and reduce adverse drug reactions. Understanding the perspectives of key stakeholders regarding the acceptability of this testing is therefore essential. This pilot investigation is part of the 'GEMS' (Genetics and Environment in Mental Health Study) project, which explores pharmacogenetic testing in psychosis. Data were collected via a participant survey, co-designed with patients, completed by 22 patient-participants, and semi-structured interviews conducted with 11 clinicians who had experience using pharmacogenetic test results in clinical care. Both patients and clinicians generally expressed positive attitudes toward pharmacogenetic testing. Clinicians emphasized, however, that such testing represents only one element within the broader, multifactorial process of individualized prescribing. Both groups suggested that pharmacogenetic reports could be made more user-friendly to improve patient comprehension. Some participants reported that the reports encouraged more collaborative decision-making, although this effect was not consistent. Clinicians noted that pharmacogenetics offers both retrospective and prospective benefits by reducing uncertainty and minimizing trial-and-error in prescribing. Nonetheless, barriers such as limited accessibility, challenges in understanding the reports, and logistical issues were identified. Among patients and clinicians familiar with pharmacogenetic testing for antipsychotic selection, overall acceptability is high. Pharmacogenetics holds promise for supporting more personalized prescribing, though practical and systemic barriers need to be addressed before widespread adoption can occur.

Keywords: Personalized medicine, Pharmacogenetics, Psychosis, Mental health, Psychiatry, Antipsychotics

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Introduction

Psychosis refers to a cluster of psychiatric symptoms, such as hallucinations and delusions, that disrupt normal thought processes and emotional perception. It can present in a variety of mental disorders, with schizophrenia being one of the most severe and chronic forms, affecting roughly 1% of the population in the UK [1].

In the UK, the National Institute for Health and Care Excellence (NICE) recommends antipsychotic medications as the primary treatment for both psychosis and schizophrenia [2]. A wide array of antipsychotics exists, each with its own risk profile for adverse effects. Despite this, around 30% of individuals with schizophrenia fail to respond to initial antipsychotic therapy [3, 4], and clinicians currently cannot predict which patient will respond best to a particular drug or dose [5]. Consequently, treatment often relies on iterative "trial-and-error" prescribing to achieve therapeutic effectiveness while minimizing side effects.

Adverse drug reactions (ADRs)—including weight gain, fatigue, cognitive slowing, or sexual dysfunction [6]—as well as lack of insight [7], frequently contribute to poor adherence. For instance, more than half of patients with

schizophrenia are estimated to be non-adherent to prescribed psychotropics [8]. Non-adherence carries significant clinical risks, with discontinuation nearly doubling rates of rehospitalization compared to patients who maintain treatment [9]. Given these challenges, patient perspectives on antipsychotics are often ambivalent, with medications seen as "the least worst option," reflecting the constant trade-off between symptom management and tolerability [10]. Qualitative studies further suggest that patients frequently feel under-informed, insufficiently involved in decision-making, and constrained in their ability to make choices about treatment, which can foster feelings of disempowerment [11, 12].

The variability in individual treatment response has motivated the development of personalized prescribing strategies. Tools such as the Psymatik Treatment Optimizer provide individualized recommendations by ranking 32 antipsychotics based on 14 patient-prioritized side-effect concerns [13]. While this approach facilitates personalized decision-making, it does not account for other important factors—such as genetics, age, sex, or ethnicity—and its clinical utility remains largely untested.

Pharmacogenetics offers a complementary approach by examining how genetic variation affects drug metabolism (pharmacokinetics) and drug response (pharmacodynamics). The cytochrome P450 (CYP) enzyme family plays a key role in metabolizing many antipsychotics [14]. CYP2D6, for example, has more than 100 genetic variants [15] and is responsible for metabolizing approximately one-quarter of all medications, including most antipsychotics [16]. CYP1A2 and CYP3A4 also metabolize several antipsychotics, including clozapine and quetiapine [17, 18]. Genetic variation is widespread: almost all individuals may respond atypically to at least one drug, and nearly 24% of patients have previously received a medication for which their genetics predict atypical metabolism [19].

Pharmacogenetic testing identifies an individual's metabolizer status, informing dose adjustments or alternative treatments. Poor metabolizers have diminished enzyme activity, resulting in slower drug clearance, higher plasma drug levels, and increased risk of side effects. Conversely, ultrarapid metabolizers metabolize drugs quickly, potentially reducing efficacy. Tailoring medication based on metabolizer status can therefore enhance safety and treatment outcomes.

While pharmacogenetics is already widely used in oncology to reduce toxicity and optimize efficacy [20], its application in psychiatry is emerging. The PREPARE trial—a multicenter, international randomized study—found that a 12-gene pharmacogenetic panel decreased adverse drug reactions by 30% across multiple medical specialties ($p = 0.008$) [21]. Within psychiatric populations, pharmacogenetic-guided treatment was associated with a 34.1% reduction in ADRs ($p = 0.049$), 41.2% fewer hospitalizations ($p < 0.001$), and 40.5% fewer readmissions ($p = 0.15$) [22]. Meta-analytic data in depression also indicate that pharmacogenetic-informed prescribing increases the likelihood of symptom remission by 40% compared to standard treatment ($p = 0.001$) [23].

Specifically for psychosis, an 11-gene panel reduced PANSS scores significantly in Chinese men with schizophrenia compared to standard care (74.2% vs. 64.9%; $p < 0.001$) [24]. However, a Danish study found no significant difference in antipsychotic persistence between patients offered CYP-testing and those receiving structured monitoring [25]. Evidence suggests that broader gene panels may offer greater clinical utility, but overall, the literature on pharmacogenetics in antipsychotic prescribing remains mixed. Limitations such as small sample sizes (~400 participants per study) and limited diversity may explain inconsistencies and highlight the need for further research [26].

Evidence-based guidelines, such as those issued by the Clinical Pharmacogenetics Implementation Consortium (CPIC) and the Dutch Pharmacogenetics Working Group (DPWG), now recommend incorporating genetic information into prescribing decisions across several fields, including oncology, cardiology, and mental health [27, 28]. Similarly, the US Food and Drug Administration (FDA) has increasingly integrated pharmacogenetic considerations into drug labeling [29].

As pharmacogenetic testing becomes more widely used and supported by clinical evidence, understanding stakeholder acceptability—particularly among patients and clinicians—is essential. Reviews suggest that most psychiatric patients recognize the value of pharmacogenetic testing and would choose to undergo it if offered [30]. Another systematic review examining clinician and patient perspectives in psychiatry identified perceived barriers including limited knowledge, financial costs, and the time required for test implementation, yet there was optimism regarding pharmacogenetics' potential to advance precision medicine, reduce adverse drug reactions, and eventually become routine practice [31]. Notably, this review did not include studies conducted in the UK. A recent UK public survey assessing attitudes toward pharmacogenomics more broadly found that 85% of adults

believe the National Health Service (NHS) should provide pharmacogenetic testing where appropriate [32]. These developments are increasingly feasible given falling testing costs [33] and evidence supporting the cost-effectiveness of pharmacogenetic-guided antipsychotic prescribing [26, 34-36].

Despite these insights, relatively few studies have directly recruited patients or clinicians with personal experience of pharmacogenetic testing. For instance, Virelli *et al*. (2023) [37] reported generally positive attitudes among patients whose psychotropic medications were guided by pharmacogenetic results, including increased confidence in adjusting their treatment. Conversely, Liko *et al*. (2020) [38] found more mixed responses among patients with depression, with some finding the testing useful while others felt the reports did not provide clear prescribing guidance. Importantly, both studies were conducted in North America, highlighting the need to examine perspectives within the UK context, where healthcare delivery and systems differ substantially.

Pharmacogenetic information may also influence the interaction between patients and clinicians in prescribing decisions. When test results are explained to patients, they may gain a better understanding of their treatment and become more actively engaged in medication choices. Discussion of pharmacogenetic findings can foster a collaborative approach, supporting shared decision-making in which patients and clinicians contribute jointly to drug selection and dosing [39]. Conversely, if results are applied without patient explanation, these benefits may not materialize. Therefore, understanding not only the use of pharmacogenetic testing but also how it is communicated is crucial to evaluating its acceptability and impact on care.

In this pilot study, we examine the perspectives of UK mental health patients and clinicians regarding pharmacogenetic testing, focusing specifically on those who have recently received or provided test results. Our aim is to explore experiences with pharmacogenetic-guided treatment, assess its influence on the management of psychosis, and gather insights on implementing such testing into routine clinical practice.

Materials and Methods

Study setting

This study forms part of the larger 'Pharmacogenetics: Genetics and Environment in Mental Health' (GEMS) project (IRAS ID: 193707), a multi-site, prospective initiative examining how reactive—and occasionally pre-emptive—genotyping of CYP1A2, CYP2D6, CYP2C19, and CYP3A4 can inform psychotropic drug prescribing for patients with psychosis, in accordance with evidence-based CPIC and DPWG guidelines [40, 41]. GEMS also investigates how pharmacogenetic-guided prescribing affects patient quality of life and the incidence of adverse drug reactions [42].

Within this context, the present study explored perceptions of pharmacogenetic testing as a tool for guiding prescribing. Semi-structured interviews were conducted with clinicians, while patient views were captured via a survey. Prior GEMS work, as well as studies involving general medicine clinicians [43] and forthcoming GEMS findings [44], have already reported survey-based data on clinician attitudes to pharmacogenetics, both broadly and specifically regarding antipsychotics. Building on this, in-depth interviews were employed to gain richer insights from clinicians, whereas a survey was deemed the most efficient approach to gather preliminary perspectives from patients. Ethical approval was granted by the NHS Health Research Authority (REC reference 19/LO/1403).

Clinician interviews

Participants

Clinician- and patient-participants in GEMS are referred to hereafter as "clinicians" and "patients," respectively. Terminology was discussed with collaborators from the SideBySide Network, a group of individuals with lived experience of mental health conditions, including psychosis. The majority preferred the term "patient," which was therefore adopted, acknowledging ongoing debate in the mental health field [45].

Eligible clinicians included consultant psychiatrists, general practitioners, pharmacists, junior doctors, nurse prescribers, advanced clinical practitioners, and other prescribers of antipsychotic medications within the UK NHS. To participate, clinicians needed experience ordering pharmacogenetic tests, discussing results with patients, and applying these findings to prescribing decisions. It should be noted that pharmacogenetic testing is not yet nationally available in the UK; initiatives like GEMS represent one of the first opportunities for clinicians and patients to engage with pharmacogenetic-informed prescribing in UK mental health services. For inclusion in

the semi-structured interviews, clinicians had to have received at least one pharmacogenetic report containing actionable recommendations (minor or major prescribing considerations) and discussed these with a patient.
To capture a diverse range of perspectives, purposive sampling was employed across NHS services in England. Thirty clinicians were invited by email (YW; RA), with thirteen initially agreeing to participate. Two subsequently did not respond to scheduling attempts, three declined (citing lack of time, no reason, or absence of pharmacogenetic discussion), and the remainder did not reply. All participating clinicians provided consent for audio-recording, transcription, and anonymized use of quotations in publications.

Interview design
The clinician interview guide was developed to explore three areas: (a) the interpersonal process of discussing pharmacogenetic reports with patients, (b) the influence of these reports on prescribing decisions and treatment outcomes, and (c) perceptions of value, feasibility, acceptability, and barriers to implementation. The guide was piloted and refined early in the study to encourage more detailed responses.

Data collection
Interviews, lasting 30–45 minutes, were conducted via Microsoft Teams. The interviewer (YW) had no prior involvement in GEMS and no previous contact with participating clinicians. The GEMS study manager attended in a supervisory capacity, with their camera turned off. Following each interview, the interviewer recorded reflective notes summarizing key observations and methodological reflections, which were used to contextualize the subsequent analysis.
Clinician sex was collected through the GEMS database; additional demographics such as age and ethnicity were not recorded.

Data analysis
All interviews were transcribed and analyzed using thematic analysis in NVivo software [46]. Initial coding captured the content of the interviews, followed by iterative refinement to reflect deeper interpretations. Codes were examined for patterns and connections, which informed the development of themes and sub-themes. This iterative process included merging or discarding sub-themes, renaming themes, and documenting analytic decisions via memos. Analysis was further supported by discussions with other team members throughout the coding process.

Participant survey
Participants
Patients eligible for this study were adults (≥18 years) diagnosed with a psychotic disorder (ICD-10 F20–F31) and either currently prescribed or intending to start an antipsychotic medication. Inclusion required that participants had previously received and discussed their pharmacogenetic report as part of the GEMS intervention. All participants consented to have their survey responses transcribed and for anonymized quotations to be used in publications.
The survey was offered to patients across all 12 NHS sites participating in GEMS. At the Camden and Islington Boroughs site (North London NHS Foundation Trust), researchers personally invited patients to take part, with 60% agreeing to complete the survey. No additional follow-up was conducted to determine reasons for non-participation.

Survey development
The survey was co-created in collaboration with the SideBySide Network, a group of individuals with lived experience of mental health conditions, including psychosis. Between November 2023 and February 2024, three co-design workshops were held involving both PPIE contributors and researchers. Drafts were shared with colleagues for feedback and refinement.
This instrument was tailored specifically for the GEMS study to capture patient perspectives on pharmacogenetic testing. It was not a validated measure but rather an exploratory tool intended to gather a wide spectrum of views. The survey focused on four key areas: (a) motivations for joining GEMS, (b) involvement in decisions regarding medication, (c) understanding of pharmacogenetic information, and (d) perceived barriers to implementing

pharmacogenetic-guided prescribing. The final survey comprised 18 items in a mix of Likert-scale, multiple-choice, yes/no, and open-text formats, and required approximately 10–15 minutes to complete.

Data collection

Surveys were administered by M.R.B. and R.A., either immediately following the patients' three-month GEMS follow-up session or via a separate Microsoft Teams appointment. Informed consent was obtained from all participants prior to survey completion. Responses were recorded verbatim, with automated transcription applied for most participants. All data were securely stored in Qualtrics. Data collection spanned February 2024 to February 2025. Demographic information—including sex, age, education, ethnicity, psychiatric diagnoses, and current medications—was obtained as part of the broader GEMS study. Ethnicity was self-reported using standard UK Census categories (White; Black, Black British, Caribbean or African; Asian or Asian British; Mixed or multiple ethnic groups).

Data analysis

Given the combination of quantitative and qualitative items, analysis incorporated both descriptive statistics and content analysis. Quantitative data from Likert-scale and multiple-choice questions were analyzed using RStudio (Version 4.4.0, 2022.12.0), with results presented as means, medians, standard deviations, and ranges. Descriptive analyses also examined patients' perceptions of pharmacogenetics in shared decision-making and the clarity of the GEMS study process. Open-ended responses were systematically coded to identify themes, and representative quotes were extracted to illustrate key findings.

Results and Discussion

A total of 22 patients and 11 clinicians contributed data. Clinician characteristics are summarized in **Table 1**, while patient demographics are shown in **Table 2**. Numerical results are presented to two decimal places.

Table 1. Clinician characteristics.

Clinician ID	Job title	Location of NHS trust	Type of service	Number of patients with pharmacogenetic reports	Sex
1	Consultant Psychiatrist	London	Rehab and Rehabilitation	11	F
2	General Practitioner	South-west England	General Practice	1	M
3	Consultant Psychiatrist	London	Adult Community Mental Health Service	5	F
4	Consultant Psychiatrist	London	Research Team	15	F
5	Consultant Psychiatrist	London	Rehab and Rehabilitation	3	M
6	Consultant Psychiatrist	London	Community Team	6	F
7	Consultant Psychiatrist	London	Community Team	3	M
8	Consultant Psychiatrist	London	Inpatient Ward	9	M
9	Consultant Psychiatrist	South-west England	Unknown	6	M
10	Consultant Forensic Psychiatrist	Midlands	Inpatient Forensic Ward	5	M
11	Consultant Psychiatrist	South-west England	Adult Community Mental Health Service	6	M

Table 2. Patient demographics.

Sample characteristics	n	%	M	SD (±)	Range
Sex					
Male	10	45.00			
Female	12	55.00			
Age (years)	22		38.59	12.36	22–65
Highest level of education					
Secondary education	1	4.55			
Tertiary (e.g., apprenticeships)	11	50.00			
Further education (university)	6	27.30			

Postgraduate	4	18.20			
Years in Education	22		15.25	2.07	12–20
Ethnicity					
Black, Black British, Caribbean or African	1	4.55			
Asian or Asian British	3	13.60			
Mixed or multiple ethnic groups	1	4.55			
White	17	77.30			
Primary diagnosis					
Schizophrenia	3	13.60			
Bipolar disorder	6	27.30			
Personality disorder	1	4.55			
Other psychotic disorder	10	45.50			
Other mood disorder	2	9.09			
Antipsychotic taken					
Aripiprazole	3	13.64			
Clozapine	1	4.55			
Olanzapine	3	13.64			
Quetiapine	1	4.55			
Other Antipsychotic	5	22.72			
Polypharmacy	4	18.18			
None	5	22.72			
Duration of Illness (years)	22		12.05	9.99	0–28
Site recruited					
South East England	7	31.82			
Inner London	15	68.18			

Abbreviations: *n*, number of participants; %, percentage of sample; M, mean average; SD (±), standard deviation. *Definitions:* Under Antipsychotic Taken, "Other" includes the following antipsychotics: risperidone, zuclopenthixol, amisulpride, paliperidone, lurasidone, flupentixol, haloperidol, cariprazine, and promazine. "Polypharmacy": the patient is taking 2 or more of these antipsychotics. "None": the patient is being considered for an antipsychotic.

The findings are presented across six sections, combining patient and clinician responses to identify points of agreement and divergence in perspectives:

1. Patient Motivations for Participation
2. Overall Perspectives on Pharmacogenetics
3. Experiences with the Pharmacogenetic Report
4. Patient-Clinician Interactions
5. Clinical Value Attributed to Pharmacogenetics
6. Implementation Challenges

Patient motivations for participation

When asked why they chose to join GEMS, many patients cited personal experiences of dissatisfaction with previous antipsychotic treatments. One participant remarked, "I was curious … I have tried various drugs, and none really worked" (Patient-16), while another noted, "I haven't had much success with medication, so the study interested me" (Patient-14).

Five participants joined based on recommendations from healthcare professionals, and three expressed a desire to contribute to research, with one commenting that the study allowed them to "give a little bit back" (Patient-10).

Overall perspectives on pharmacogenetics

Patients generally expressed optimism regarding pharmacogenetics. One participant described GEMS as likely to "help so many people in the future" (Patient-3). Clinicians reported observing similar positive attitudes among patients:

"They're all glad to have done it and think it has value. I don't think anyone has been negative about it." (Clinician-11)

Clinicians also highlighted the complexities involved in prescribing, noting that pharmacogenetic information represents only one aspect of medication management. They emphasized that patient care must consider holistic factors beyond drug metabolism:
"You need to think about someone's social situation […] the rate of metabolism is just one factor, probably quite small compared with other matters." (Clinician-2)
Several clinicians cautioned that awareness of pharmacogenetic variations does not guarantee improved outcomes, but it may help explain one component of how a medication affects an individual:
"I think it's a good thing to do, but it's not necessarily the Holy Grail solution." (Clinician-11)
Some patients echoed this sentiment, suggesting that pharmacogenetic testing might not be a priority for individuals primarily focused on daily functioning:
"A lot of people are just trying to function, so it's not a priority." (Patient-20)

Experiences with the pharmacogenetic report
Emotional response to the report
Fifteen of the twenty-two patients requested a copy of their genetic report, primarily to enhance their personal understanding. Participants expressed a desire to comprehend how enzymes influence medication:
"I wanted to try and understand the relationship between enzymes and medication." (Patient-15)
"I just wanted to know what was happening in my body." (Patient-8)
For clinicians, the report offered increased confidence in selecting better-tolerated medications, providing a sense of scientific justification:
"[The pharmacogenetic report] helps predict treatment outcomes, potential side effects, and most importantly, guide dose calculations—whether escalating or starting cautiously." (Clinician-7)

Comprehension of the report
Patients rated their understanding of the genetic report on a 1–10 scale (1 = no understanding, 10 = complete understanding), with 14 responses averaging 7.29 (SD ±3.15; median = 8). Clinicians observed that comprehension varied depending on patients' cognitive abilities:
"It's about tailoring the amount of information to what patients want and asking them." (Clinician-10)
Both groups agreed that the report's technical language and formatting could be simplified to improve usability:
"…only one person could really fully read it, so it needs to be more user-friendly." (Clinician-5)
"…a glossary or summary highlighting key points could help both patients and clinicians understand it better." (Patient-20; Clinician-7)

Patient-clinician interactions
Both patients and clinicians described instances in which the pharmacogenetic report influenced the dynamics of clinical consultations, though this effect was not universal. One patient noted that genetic testing could make prescribing "more bespoke and thoughtful" (Patient-20), suggesting that pharmacogenetic results can foster person-centered discussions and enhance patient involvement in decisions about medications.
Clinicians reported similar observations, highlighting the potential for more collaborative consultations:
"Going forward, this could make consultations more collaborative because the individual feels included and less frustrated at having to try multiple medications before finding one that works." (Clinician-4)
"Patients feel more empowered and better informed." (Clinician-10)
When asked specifically about pharmacogenetics' role in shared decision-making, 15 patients expressed strong confidence in its usefulness, four were moderately confident, and three were uncertain. Clinicians also felt that personalizing treatment in this way could make prescribing feel more collaborative:
"I enjoyed how pharmacogenomic information helps personalize treatment beyond the standard guidelines." (Clinician-3)
However, one clinician reported that, although the report might lend legitimacy to prescribing decisions, they had not observed a noticeable change in patients' attitudes in practice (Clinician-8).

Clinical value attributed to pharmacogenetics
Supporting evidence-based prescribing

Both patients and clinicians reflected on the trial-and-error nature of conventional antipsychotic prescribing. One patient commented on the lack of scientific guidance in psychiatry:
"I was surprised by how unscientific psychiatry is." (Patient-20)
A clinician similarly acknowledged that prescribing recommendations can be somewhat arbitrary and that patients often do not receive clear explanations:
"Recommendations can be quite blind, and patients aren't always given the rationale behind decisions." (Clinician-10)
Some clinicians felt that pharmacogenetics could provide a more rational, evidence-based approach:
"Previously, we were prescribing somewhat blindly, but now we have more intelligence to guide decisions." (Clinician-4)

Medication adjustments
Six patients reported changes to their medications after receiving their pharmacogenetic results, including antipsychotics as well as other drugs mentioned in the report, such as antidepressants or analgesics. One patient sought an increased Olanzapine dose, explaining that "25 mg was not working" (Patient-9). The pharmacogenetic data gave clinicians the evidence to adjust the dose to 30 mg/day, in line with international guidelines [47]. Another patient reported switching from Diazepam to Lorazepam based on the report (Patient-8).
Clinicians also described how the reports informed their prescribing decisions:
"We changed the patient's treatment to valproate and quetiapine, partly guided by the report, which indicated quetiapine as more suitable than haloperidol or risperidone." (Clinician-3)
Among patients whose medications were adjusted, three were moderately satisfied, two very satisfied, and one neutral; none reported negative experiences. Nonetheless, some discrepancies were noted:
"There were medications that had been tolerated reasonably well, but as a poor metabolizer, you might have expected worse side effects." (Clinician-11)
One patient similarly reflected:
"I am not unhappy with the study, just with the changes made." (Patient-14)
In some cases, predicted genetic compatibility did not align with perceived treatment outcomes, as one patient noted:
"Fluoxetine was predicted to suit me, but I haven't noticed any positive changes."

Retrospective insights
For fifteen patients, pharmacogenetic results did not prompt medication changes. One patient commented:
"The report showed my current medication is optimal for me." (Patient-16)
Even when no adjustments were required, clinicians found the reports useful for confirming ongoing prescribing decisions:
"It's relevant even if patients are already on medications they tolerate well." (Clinician-6)
Pharmacogenetic information also validated prior clinical judgments, confirming clinicians' "hunches" (Clinician-3):
"I reduced the dose for one patient because they were a slow metabolizer and not tolerating the medication well." (Clinician-4)
Patients similarly appreciated explanations for previous medication failures:
"I thought the medication failure was in my head, but the report shows 'in black and white' why it wasn't working." (Patient-16)
These examples illustrate how pharmacogenetics can offer retrospective insights, both validating previous prescribing and explaining past treatment outcomes.

Predictive utility
The pharmacogenetic report was also valued for its potential to guide future prescribing decisions. One clinician noted that knowing a patient's rapid metabolizer status enabled them to create "a proactive plan" for possible relapse, such as prescribing a higher venlafaxine dose more promptly (Clinician-7). Similarly, the report can serve as a reference for future healthcare providers if the patient is readmitted:
"Whenever there's a need to prescribe psychotropic medication, the GP or prescriber can consult this report and select drugs that the patient metabolizes normally." (Clinician-9)

Patients also reported that the information increased their confidence about future treatments:
"I feel very safe knowing the information I have … for any future medication decisions." (Patient-3)
Clinicians suggested that the report is particularly valuable for patients early in their treatment journey, as many long-term patients have already reached effective medications through trial-and-error prescribing:
"It would be most useful earlier in someone's care, rather than after years of trying different treatments." (Clinician-11)
Reflecting this, one patient remarked:
"I wish a study like this had been available years ago. I could have saved myself a lot of time and unsuitable medications." (Patient-16)

Implementation challenges
Accessibility
The most frequently mentioned barrier by patients was accessibility. Physical limitations were cited, for example, patients being unable to provide samples if homebound:
"It's difficult to give a sample if you are housebound." (Patient-1)
One suggestion to overcome this was deploying outreach teams to collect samples from patients in need (Patient-2). The complexity of the reports was also noted as a barrier, with one patient stating:
"The language is quite technical," making it challenging for individuals with complex needs to understand (Patient-8).
Another highlighted that some patients may not clearly perceive the benefits, potentially discouraging participation (Patient-3).
Clinicians highlighted that general awareness is low; many people do not know pharmacogenetic testing is an option. One clinician commented:
"If the public became more aware and demanded this test before prescriptions, it might put pressure on the government." (Clinician-9)
Limited clinician knowledge was also identified as a challenge. Patients reported instances of healthcare professionals, such as GPs, not fully understanding the reports (Patient-8). Clinicians acknowledged that formal training in pharmacogenomics is lacking:
"Postgraduate training does not cover pharmacogenomics at all." (Clinician-3)
To address this, some clinicians suggested having accessible expert support to guide them in interpreting results (Clinician-4). In the GEMS study, clinicians were able to receive assistance from the research team when reviewing reports.

Patient consent
Clinicians raised concerns about obtaining patient consent, noting that some individuals may be hesitant due to fears or paranoia surrounding genetic testing:
"Some patients simply won't want it, worried about being genetically profiled." (Clinician-11)
A patient echoed this, observing that people could feel anxious about giving DNA or blood samples (Patient-19). Clinicians noted that saliva samples are generally better accepted than blood because they are "less invasive" and "less painful" (Clinician-8). Both saliva and blood sampling options were offered within the GEMS study.

Logistical barriers
Clinicians highlighted that the cost of pharmacogenetic testing represents a practical consideration:
"Cost is an element I think needs to be thought about. We have to be pragmatic." (Clinician-7)
Some noted that more robust evidence demonstrating the clinical benefits of pharmacogenetics could help secure NHS funding and broaden access. Practical issues were also raised, such as staffing for sample collection and transport to laboratories (Clinician-8), as well as the need to expand testing facilities (Clinician-9). Turnaround times for reports posed additional challenges. Early participants in GEMS experienced significant delays, sometimes "months and months at the beginning" (Clinician-1), meaning clinicians had to make prescribing decisions without guidance:
"I do not have the luxury to wait for 3 months for a report to make my clinical decisions." (Clinician-3)
Time pressures in clinics further limited opportunities to discuss the reports thoroughly:

"We're often rushed with four or five patients waiting… it's a shame we do not have time to explain everything properly." (Clinician-4)

This could affect patient comprehension, as clinicians felt the reports were not always fully explained. Some patients similarly reported inadequate discussions:

"He [the GP] did not really understand the report and did not have time to go through it properly." (Patient-20)

This study explored UK patients' and clinicians' attitudes toward pharmacogenetic testing, focusing on individuals who had recently undergone testing. While opinions varied in detail, overall attitudes were largely positive, supporting prior findings that patients generally view pharmacogenetic testing favorably [37, 38]. Notably, patients in this study expressed higher confidence levels than previously reported [38], which may reflect recent advances in pharmacogenetic applications [48].

Pharmacogenetics and collaborative care

Most patients reported that pharmacogenetic testing could enhance shared decision-making. Several participants felt that the reports fostered more patient-centered consultations, improving their understanding of treatment options. Clinicians also observed increased patient empowerment following pharmacogenetic testing. However, some clinicians expressed more neutral perspectives, reflecting variability in attitudes. Despite this, the overall outlook remained positive regarding the potential for pharmacogenetics to support collaborative care.

These findings indicate that pharmacogenetic testing may positively influence patient-clinician interactions, but further research with larger, more diverse populations is needed to fully understand its impact on relationships and communication in clinical settings.

Perceived clinical utility of pharmacogenetic testing

Both survey and interview data highlighted the usefulness of pharmacogenetics across the care continuum. Patients and clinicians reported that the test results supported identification of appropriate medications and dosing. Clinicians suggested that pharmacogenetics may be especially valuable for new patients, potentially reducing unnecessary medication changes. This aligns with previous findings in Early Intervention in Psychosis (EIP) services, where 80% of patients underwent changes in medications metabolized by CYP2D6, yet pharmacogenetic testing is not routinely available [49]. Implementing pharmacogenetics earlier could improve initial treatment experiences, reduce trial-and-error prescribing, and minimize adverse drug reactions [50]. Future studies should compare experiences of antipsychotic-naïve patients with long-term users to assess the impact of early testing.

The retrospective value of pharmacogenetics was also highlighted. Both this study and prior research [38] found that results helped patients understand past treatment responses, even when no current changes were made. Patients reported feeling validated in their previous experiences with medications that were ineffective or poorly tolerated.

The prospective utility of pharmacogenetics was evident as well. Reports could inform future prescribing decisions and guide medication adjustments throughout a patient's care journey. Overall, pharmacogenetic testing was perceived as beneficial at multiple stages: retrospectively, for current management, and prospectively.

Clinicians, however, emphasized that pharmacogenetics is only one component of a broader clinical picture. While generally optimistic about its value, they highlighted the importance of integrating genetic insights with biological, psychological, and social considerations. Managing patient expectations is crucial, as there were instances where the pharmacogenetic recommendations did not perfectly align with clinical presentation.

Overall, participants viewed pharmacogenetics positively, regarding it as a tool to optimize prescribing, guide dosage decisions, and reduce the risk of adverse drug reactions [21, 22].

Barriers to pharmacogenetic testing

Accessibility emerged as the most frequently cited barrier. Both patients and clinicians noted that some individuals might face difficulties providing a sample—for instance, due to physical limitations—or could struggle with the complexity of genetic information. Nevertheless, many patients reported a good understanding of their genetic report and their discussions with clinicians, with some expressing curiosity to learn more about their genetics. No clinician in this study reported substantial difficulty in explaining the reports. This suggests that, while comprehension may vary, healthcare professionals and researchers should not underestimate patients' ability or interest in understanding how genetics relates to their medication.

A few clinicians highlighted potential inequalities in access, noting that public awareness of pharmacogenetics remains limited, which may reduce demand and hinder NHS implementation. To increase adoption, efforts are needed to make information about pharmacogenetics more widely available. Both patients and clinicians emphasized the importance of ensuring reports are user-friendly, with simplified formats and clear summaries to enhance understanding.

Consistent with prior research [37], concerns were raised about clinicians' ability to interpret pharmacogenetic reports. Lack of training in pharmacogenetics is a recognized issue, not only from patient perspectives but also among clinicians themselves. Unpublished survey data support these findings, indicating that many clinicians feel uncertain and underprepared in this area [44]. As pharmacogenetics becomes more accessible through direct-to-consumer genetic testing [51], clinicians may increasingly encounter results from outside the healthcare system, highlighting the need for ongoing professional development and patient education initiatives.

Cost and limited research evidence were also cited as barriers to implementation, echoing previous studies [30, 31]. However, the price of pharmacogenetic testing continues to decrease [33], and there is growing evidence demonstrating its cost-effectiveness [26, 34, 52]. For example, Morris *et al.* [53]. found that, across 108 studies covering 39 medications, 71% indicated pharmacogenetic testing was either cost-saving or cost-effective [53]. This expanding evidence base, especially regarding the economic benefits of pre-emptive testing—which can inform prescribing decisions over many years—may help address clinicians' concerns about costs.

Strengths and limitations

To our knowledge, this is the first UK study examining the perspectives of both patients and clinicians with direct experience of pharmacogenetic testing for antipsychotics. A notable strength of the patient survey is its co-design with people who have lived experience of psychosis, an approach often missing in previous research [37, 38]. This collaboration ensured that the survey addressed relevant concerns and was sensitive to participants' experiences. Its concise format (approximately 10 minutes) likely minimized fatigue and encouraged completion.

Despite these strengths, several limitations exist. Both surveys and interviews relied on retrospective recall. To reduce recall bias, surveys were administered at the end of a three-month follow-up or shortly thereafter, and clinicians were encouraged to refer back to reports during interviews. Sample sizes were small (22 patients, 11 clinicians), especially compared to the wider GEMS study (over 600 patients and 200 clinicians). Future research should aim to collect acceptability data from larger, more representative samples.

The patient sample included too few participants from minority ethnic backgrounds to fully capture diverse perspectives, despite the broader GEMS study comprising 36% participants from minority groups. Sampling bias is also possible: clinicians who volunteered for interviews may already hold favorable views toward pharmacogenetics, and patients who completed the additional survey may be more engaged with their treatment, potentially skewing findings positively. Severely unwell patients are less likely to participate in research [54], meaning these results may not generalize to all individuals taking antipsychotics.

Overall, while this study provides valuable insights into the experiences of patients and clinicians with pharmacogenetic testing, findings should be interpreted cautiously. Further research with larger, more diverse populations is needed to validate and extend these results.

Clinical implications

The generally favorable attitudes of both patients and clinicians toward pharmacogenetic testing, alongside growing evidence supporting its use in psychosis management [24], highlight the need to prioritize resources in this area.

The findings also underscore a gap in healthcare professionals' confidence regarding pharmacogenetics, indicating a pressing need for additional education and training. Clinicians require guidance not only in interpreting genetic reports but also in effectively communicating results and applying them to treatment decisions. While core pharmacogenetics concepts should be included in medical education, traditional curricula may struggle to keep pace with the rapid evolution of the field. Alternative approaches, such as up-to-date online resources (e.g., GeNotes; Genomics Education, 2024) [55] or the Pharmacogenomics Knowledgebase [56], could be more actively promoted to enhance awareness and support clinicians in delivering informed pharmacogenetic care.

Managing expectations is another key consideration. Disappointment may arise if patients or clinicians assume pharmacogenetics guarantees improved outcomes. It is important to emphasize that genetic information is only

one of many factors affecting medication response, alongside age, co-prescribed drugs, and other clinical considerations. Furthermore, pharmacogenetic guidance complements other treatment modalities, such as psychotherapy, rather than serving as a standalone solution.

Future research

Building on this preliminary survey, future work could focus on developing a validated tool to systematically assess patient perceptions of pharmacogenetics, facilitating comparisons across different clinical settings and populations. Collecting data on reasons for non-participation would provide valuable insights into barriers to engagement.

Larger, more diverse samples are needed to explore whether perceptions of pharmacogenetics vary across demographic or ethnic groups. For example, different populations carry distinct CYP alleles, such as the CYP2D6*10 variant associated with reduced enzyme activity, which is prevalent in African, South Asian, and East Asian populations, reaching 58.7% frequency in East Asians [57]. Investigating whether the presence of actionable genetic variants influences perceptions of pharmacogenetics or affects its cost-effectiveness could address the broader challenge of diversity in pharmacogenetic research [37, 38].

Future studies should also examine the role of pharmacogenetic testing in fostering collaborative treatment discussions. Measuring patient involvement in medication-related decisions and trust in clinicians before and after testing would enable meaningful comparisons. Preliminary findings from this study suggest that pharmacogenetic discussions may support more shared decision-making, strengthen patients' sense of agency, and improve engagement. Further research is needed to determine the most effective ways to communicate test results in clinical consultations to maximize these benefits.

Conclusion

Patients and clinicians in this study generally found pharmacogenetic testing for antipsychotic prescribing acceptable, indicating its potential to enhance treatment personalization and precision psychiatry. Broader research with larger and more diverse cohorts is required to capture a wider range of perspectives. These findings contribute to the growing body of evidence demonstrating positive attitudes toward pharmacogenetics in mental health care, supporting its integration into clinical practice.

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References

1. Bebbington PE, McManus S. Revisiting the one in four: the prevalence of psychiatric disorder in the population of England 2000–2014. Br J Psychiatry. 2020;216(1):55–7. doi:10.1192/bjp.2019.196
2. National Institute for Health and Care Excellence. Psychosis and schizophrenia in adults: prevention and management [CG178]. 2014 [cited 2025 Mar 28]. Available from: https://www.nice.org.uk/guidance/cg178
3. McCutcheon RA, Pillinger T, Mizuno Y, Montgomery A, Pandian H, Vano L, et al. The efficacy and heterogeneity of antipsychotic response in schizophrenia: a meta-analysis. Mol Psychiatry. 2021;26(4):1310–20. doi:10.1038/s41380-019-0502-5
4. Taylor DM, Barnes TR, Young AH. The Maudsley prescribing guidelines in psychiatry. John Wiley & Sons; 2025.
5. Davis JM, Chen N. Dose response and dose equivalence of antipsychotics. J Clin Psychopharmacol. 2004;24(2):192–208. doi:10.1097/01.jcp.0000117422.05703.ae
6. Angadi NB, Mathur C. Prevalence and severity of adverse drug reactions among patients receiving antipsychotic drugs in a tertiary care hospital. Int J Nutr Pharmacol Neurol Dis. 2020;10(3):144–8. doi:10.4103/ijnpnd.ijnpnd_9_20

7. Kim J, Ozzoude M, Nakajima S, Shah P, Caravaggio F, Iwata Y, et al. Insight and medication adherence in schizophrenia: an analysis of the CATIE trial. Neuropharmacology. 2020;168:107634. doi:10.1016/j.neuropharm.2019.05.011
8. Semahegn A, Torpey K, Manu A, Assefa N, Tesfaye G, Ankomah A. Psychotropic medication non-adherence and its associated factors among patients with major psychiatric disorders: a systematic review and meta-analysis. Syst Rev. 2020;9(1):17. doi:10.1186/s13643-020-1274-3
9. Vinkers CH, Kupka RW, Penninx BW, Ruhé HG, van Gaalen JM, van Haaren PC, et al. Discontinuation of psychotropic medication: a synthesis of evidence across medication classes. Mol Psychiatry. 2024;29(8):2575–86. doi:10.1038/s41380-024-02445-4
10. Morant N, Azam K, Johnson S, Moncrieff J. The least worst option: user experiences of antipsychotic medication and lack of involvement in medication decisions in a UK community sample. J Ment Health. 2018;27(4):322–8. doi:10.1080/09638237.2017.1370637
11. Bjornestad J, Lavik KO, Davidson L, Hjeltnes A, Moltu C, Veseth M. Antipsychotic treatment–a systematic literature review and meta-analysis of qualitative studies. J Ment Health. 2020;29:513–23. doi:10.1080/09638237.2019.1581352
12. Kaar SJ, Gobjila C, Butler E, Henderson C, Howes OD. Making decisions about antipsychotics: a qualitative study of patient experience and the development of a decision aid. BMC Psychiatry. 2019;19(1):309. doi:10.1186/s12888-019-2304-3
13. Pillinger T, Howes OD, Correll CU, Leucht S, Huhn M, Schneider-Thoma J, et al. Antidepressant and antipsychotic side-effects and personalised prescribing: a systematic review and digital tool development. Lancet Psychiatry. 2023;10(11):860–76. doi:10.1016/S2215-0366(23)00262-6
14. Lynch TOM, Price AMY. The effect of cytochrome P450 metabolism on drug response, interactions, and adverse effects. Am Fam Physician. 2007;76(3):391–6.
15. Murphy LE, Fonseka TM, Bousman CA, Müller DJ. Gene-drug pairings for antidepressants and antipsychotics: level of evidence and clinical application. Mol Psychiatry. 2022;27(1):593–605. doi:10.1038/s41380-021-01340-6
16. Ravyn D, Ravyn V, Lowney R, Nasrallah HA. CYP450 pharmacogenetic treatment strategies for antipsychotics: a review of the evidence. Schizophr Res. 2013;149(1-3):1–14. doi:10.1016/j.schres.2013.06.035
17. Pardiñas AF, Nalmpanti M, Pocklington AJ, Legge SE, Medway C, King A, et al. Pharmacogenomic variants and drug interactions identified through the genetic analysis of clozapine metabolism. Am J Psychiatry. 2019;176(6):477–86. doi:10.1176/appi.ajp.2019.18050589
18. Menus Á, Kiss Á, Tóth K, Sirok D, Déri M, Fekete F, et al. Association of clozapine-related metabolic disturbances with CYP3A4 expression in patients with schizophrenia. Sci Rep. 2020;10(1):21283. doi:10.1038/s41598-020-78474-0
19. McInnes G, Lavertu A, Sangkuhl K, Klein TE, Whirl-Carrillo M, Altman RB. Pharmacogenetics at scale: an analysis of the UK Biobank. Clin Pharmacol Ther. 2021;109(6):1528–37. doi:10.1002/cpt.2122
20. Relling MV, Dervieux T. Pharmacogenetics and cancer therapy. Nat Rev Cancer. 2001;1(2):99–108. doi:10.1038/35101056
21. Swen JJ, van der Wouden CH, Manson LE, Abdullah-Koolmees H, Blagec K, Blagus T, et al. A 12-gene pharmacogenetic panel to prevent adverse drug reactions: an open-label, multicentre, controlled, cluster-randomised crossover implementation study. Lancet. 2023;401(10374):347–56. doi:10.1016/S0140-6736(22)01841-4
22. Skokou M, Karamperis K, Koufaki MI, Tsermpini EE, Pandi MT, Siamoglou S, et al. Clinical implementation of preemptive pharmacogenomics in psychiatry. EBioMedicine. 2024;101:105009. doi:10.1016/j.ebiom.2024.105009
23. Brown LC, Stanton JD, Bharthi K, Maruf AA, Müller DJ, Bousman CA. Pharmacogenomic testing and depressive symptom remission: a systematic review and meta-analysis of prospective, controlled clinical trials. Clin Pharmacol Ther. 2022;112(6):1303–17. doi:10.1002/cpt.2748
24. Kang Z, Qin Y, Sun Y, Lu Z, Sun Y, Chen H, et al. Multigenetic pharmacogenomics–guided treatment vs treatment as usual among hospitalized men with schizophrenia: a randomized clinical trial. JAMA Netw Open. 2023;6(10):e2335518. doi:10.1001/jamanetworkopen.2023.35518

25. Jürgens G, Andersen SE, Rasmussen HB, Werge T, Jensen HD, Kaas-Hansen BS, et al. Effect of routine cytochrome P450 2D6 and 2C19 genotyping on antipsychotic drug persistence in patients with schizophrenia: a randomized clinical trial. JAMA Netw Open. 2020;3(12):e2027909. doi:10.1001/jamanetworkopen.2020.27909
26. Saadullah Khani N, Hudson G, Mills G, Ramesh S, Varney L, Cotic M, et al. A systematic review of pharmacogenetic testing to guide antipsychotic treatment. Nat Ment Health. 2024;2(5):616–26. doi:10.1038/s44220-024-00240-2
27. Muldoon M, Beck M, Sebree N, Yoder R, Ritter S, Allen JD, et al. Real-world implementation of DPYD and UGT1A1 pharmacogenetic testing in a community-based cancer center. Clin Transl Sci. 2024;17(2):e13704. doi:10.1111/cts.13704
28. Hulshof EC. Treatment optimisation and pharmacogenetics of systemic and intraperitoneal chemotherapy in colorectal cancer. Doctoral dissertation, Leiden University; 2023.
29. US Food and Drug Administration. Table of pharmacogenomic biomarkers in drug labeling. Washington, DC: US FDA; 2022.
30. Tamaiev J, Bergson Z, Sun X, Roy D, Desai G, Lencz T, et al. Patient attitudes toward pharmacogenetic testing in psychiatric treatment. Curr Behav Neurosci Rep. 2023;10(2):30–40. doi:10.1007/s40473-023-00256-5
31. Jameson A, Fylan B, Bristow GC, Sagoo GS, Dalton C, Cardno A, et al. What are the barriers and enablers to the implementation of pharmacogenetic testing in mental health care settings? Front Genet. 2021;12:740216. doi:10.3389/fgene.2021.740216
32. Magavern EF, Marengo G, Sivathasan C, Mezzanzanica M, Wright AJ, Keen J, et al. A United Kingdom nationally representative survey of public attitudes towards pharmacogenomics. QJM An Int J Med. 2025;hcaf035. doi:10.1093/qjmed/hcaf035
33. Berndt ER, Goldman DP, Rowe J. Economic dimensions of personalized and precision medicine. University of Chicago Press; 2019.
34. Herbild L, Andersen SE, Werge T, Rasmussen HB, Jürgens G. Does pharmacogenetic testing for CYP450 2D6 and 2C19 among patients with diagnoses within the schizophrenic spectrum reduce treatment costs? Basic Clin Pharmacol Toxicol. 2013;113(4):266–72. doi:10.1111/bcpt.12093
35. Kurylev AA, Andreev BV, Kolbin AS, Limankin OV. CYP2D6 genotyping in the daily routine of a psychiatric hospital–pharmacoeconomic evaluation. FARMAKOEKONOMIKA Mod Pharmacoeconomics Pharmacoepidemiol. 2018;11(1):19–26. doi:10.17749/2070-4909.2018.11.1.019-026
36. Carrascal-Laso L, Franco-Martín MÁ, Marcos-Vadillo E, Ramos-Gallego I, García-Berrocal B, Mayor-Toranzo E, et al. Economic impact of the application of a precision medicine model (5SPM) on psychotic patients. Pharmacogenomics Pers Med. 2021;14:1015–25. doi:10.2147/PGPM.S320816
37. Virelli CR, Ebrahimi M, Mohiuddin AG, Tomasi J, Lisoway AJ, Herbert D, et al. User experiences of pharmacogenomic testing and opinions among psychiatry patients. J Pers Med. 2023;14(1):22. doi:10.3390/jpm14010022
38. Liko I, Lai E, Griffin RJ, Aquilante CL, Lee YM. Patients' perspectives on psychiatric pharmacogenetic testing. Pharmacopsychiatry. 2020;53(06):256–61. doi:10.1055/a-1183-5029
39. Stacey G, Felton A, Hui A, Stickley T, Houghton P, Diamond B, et al. Informed, involved and influential: three I's of shared decision making. Ment Health Pract. 2015;19(4):31–5. doi:10.7748/mhp.19.4.31.s20
40. Bousman CA, Stevenson JM, Ramsey LB, Sangkuhl K, Hicks JK, Strawn JR, et al. Clinical pharmacogenetics implementation consortium (CPIC) guideline for CYP2D6, CYP2C19, CYP2B6, SLC6A4, and HTR2A genotypes and serotonin reuptake inhibitor antidepressants. Clin Pharmacol Ther. 2023;114(1):51–68. doi:10.1002/cpt.2903
41. Beunk L, Nijenhuis M, Soree B, de Boer-Veger NJ, Buunk AM, Guchelaar HJ, et al. Dutch pharmacogenetics working group (DPWG) guideline for the gene-drug interaction between CYP2D6, CYP3A4 and CYP1A2 and antipsychotics. Eur J Hum Genet. 2024;32(3):278–85. doi:10.1038/s41431-023-01347-3
42. Varney L, Abidoph R, Bramon E, Cotic M, Khani NS, Murtough S. Pharmacogenetics: genetics and environment in mental health study (GEMS). 2024.
43. Just KS, Steffens M, Swen JJ, Patrinos GP, Guchelaar HJ, Stingl JC. Medical education in pharmacogenomics—results from a survey on pharmacogenetic knowledge in healthcare professionals within

the European pharmacogenomics clinical implementation project ubiquitous pharmacogenomics (U-PGx). Eur J Clin Pharmacol. 2017;73(10):1247–52. doi:10.1007/s00228-017-2292-5
44. Panconesi D, Murtough S, Cotic M, Saadullah Khani N, Varney L, Richards-Brown M, et al. Pharmacogenomics to optimise psychotropic prescribing: a survey of mental healthcare professionals' perceptions, knowledge, and educational needs. Forthcoming. 2024.
45. Priebe S. Patients in mental healthcare should be referred to as patients and not service users. BJPsych Bull. 2021;45(6):327–8. doi:10.1192/bjb.2021.40
46. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3(2):77–101. doi:10.1191/1478088706qp063oa
47. Medicines Complete. Joint formulary committee. Br Natl Formulary [Internet]. London: BMJ Pharm. Press; 2023 [cited 2024 Aug 28]. Available from: http://www.medicinescomplete.com
48. Singh P. Pharmacogenomics advances: customizing drug therapies for individual patients. J Adv Res Pharm Sci Pharmacol Interv. 2023;6:21–7.
49. Yeisen RA, Bjornestad J, Joa I, Johannessen JO, Opjordsmoen S. Experiences of antipsychotic use in patients with early psychosis: a two-year follow-up study. BMC Psychiatry. 2017;17(1):299. doi:10.1186/s12888-017-1425-9
50. Patel R, Oduola S, Callard F, Wykes T, Broadbent M, Stewart R, et al. What proportion of patients with psychosis is willing to take part in research? A mental health electronic case register analysis. BMJ Open. 2017;7(3):e013113. doi:10.1136/bmjopen-2016-013113
51. Tafazoli A, Guggilla RK, Kamel-Koleti Z, Miltyk W. Strategies to improve the clinical outcomes for direct-to-consumer pharmacogenomic tests. Genes. 2021;12(3):361. doi:10.3390/genes12030361
52. Virelli CR, Mohiuddin AG, Kennedy JL. Barriers to clinical adoption of pharmacogenomic testing in psychiatry: a critical analysis. Transl Psychiatry. 2021;11(1):509. doi:10.1038/s41398-021-01600-7
53. Morris SA, Alsaidi AT, Verbyla A, Cruz A, Macfarlane C, Bauer J, et al. Cost effectiveness of pharmacogenetic testing for drugs with clinical pharmacogenetics implementation consortium (CPIC) guidelines: a systematic review. Clin Pharmacol Ther. 2022;112(6):1318–28. doi:10.1002/cpt.2754
54. Jameson A, Faisal M, Fylan B, Bristow GC, Sohal J, Dalton C, et al. Proportion of antipsychotics with CYP2D6 pharmacogenetic (PGx) associations prescrib222ed in an early intervention in psychosis (EIP) cohort: a cross-sectional study. J Psychopharmacol. 2024;38(4):382–94. doi:10.1177/02698811241238283
55. Richards-Brown M, Wei Y, Abidoph R, Varney L, Cotic M, Murtough S, et al. Patient and clinician perspectives on pharmacogenetic testing for antipsychotics. Front Pharmacol. 2025;16:1689300.
56. Whirl-Carrillo M, Huddart R, Gong L, Sangkuhl K, Thorn CF, Whaley R, et al. An evidence-based framework for evaluating pharmacogenomics knowledge for personalized medicine. Clin Pharmacol Ther. 2021;110(3):563–72. doi:10.1002/cpt.2350
57. Zhou Y, Ingelman-Sundberg M, Lauschke VM. Worldwide distribution of cytochrome P450 alleles: a meta-analysis of population-scale sequencing projects. Clin Pharmacol Ther. 2017;102(4):688–700. doi:10.1002/cpt.690