



From Precision Tools to Governed Clinical Services: A Scoping Review of Health-System Conditions for Implementing Precision Medicine, and a GCC-Adaptable Readiness Framework

من الأدوات الدقيقة إلى الخدمات السريرية المحكومة: مراجعة نطاقية لشروط النظم الصحية لتطبيق الطب الدقيق وإطار جاهزية قابل للتكيف لدول مجلس التعاون الخليجي

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Abstract:

Objectives: To map the health-system conditions reported in the implementation literature for delivering precision medicine, organize them into a seven-domain readiness framework, and translate the synthesis into evidence-informed, locally adaptable guidance for health-system leaders in Saudi Arabia and the Gulf Cooperation Council (GCC). **Study Location:** A global PubMed/MEDLINE evidence base, with a dedicated subset analysis of studies set within Gulf Cooperation Council health systems. **Methodology:** A scoping review followed the Arksey and O'Malley framework and PRISMA-ScR reporting guidance. Of 8,000 records identified through a structured PubMed/MEDLINE search (strategy version D) with targeted supplementary searches, screened using AI-assisted prioritization with human decisions, 533 advanced to full-text eligibility assessment. Included studies were charted against a pre-specified seven-domain readiness framework and synthesized narratively, without formal risk-of-bias appraisal. **Results:** Of 533 records advanced to full-text eligibility assessment, 332 studies were included. Evidence was concentrated in pharmacogenomics (57%) and in North America and Europe (about 60% combined); AI-enabled, multimodal, and preventive precision medicine were sparsely represented (4 studies). The most frequently addressed domains were workforce capability (76%), clinical-workflow integration (73%), and digital infrastructure (64%); strategic leadership was least addressed (35%). A GCC subset of 21 studies, mostly readiness surveys, was identified. Precision medicine is implemented when a validated result changes a defined clinical decision through a governed, interoperable, workforce-supported, financed, and equitable pathway. **Recommendations:** Health-system leaders should define the clinical decision a tool will change before acquiring it, embed results into clinical workflow and decision support, finance the service rather than the test alone, and select use cases through

a transparent, locally validated matrix. The seven-domain framework offers an adaptable, evidence-informed starting point for GCC health systems, pending local validation.

Keywords: Precision medicine, Pharmacogenomics, Implementation science, Health-system readiness, Gulf Cooperation Council.

الملخص:

الأهداف: تهدف هذه الدراسة إلى مسح الشروط التنظيمية لتطبيق الطب الدقيق ضمن النظم الصحية كما ورد في أدبيات التطبيق، وتنظيمها في إطار جاهزية مكون من سبعة مجالات، وترجمة هذا التوليف إلى توجيهات قائمة على الأدلة وقابلة للتكيف محلياً لقادة النظم الصحية في المملكة العربية السعودية ودول مجلس التعاون الخليجي. **مكان الدراسة:** قاعدة أدلة عالمية مستخرجة من قاعدة بيانات PubMed/MEDLINE، مع تحليل فرعي مخصص للدراسات التي أجريت ضمن النظم الصحية لدول مجلس التعاون الخليجي. **المنهجية:** أجريت مراجعة نطاقية وفق إطار Arksey و O'Malley وإرشادات PRISMA-ScR. ومن بين 8000 سجل تم تحديدها عبر استراتيجية بحث منظمة في PubMed/MEDLINE (النسخة D) مع عمليات بحث تكميلية موجّهة، خضعت للفرز بمساعدة الذكاء الاصطناعي مع قرارات بشرية نهائية، تقدّم 533 سجلاً لتقييم الأهلية بالنص الكامل. وتم تصنيف الدراسات المدرجة وفق إطار جاهزية مسبق التحديد يضم سبعة مجالات، وتم توليف النتائج بأسلوب وصفي دون تقييم رسمي لخطر التحيز. **النتائج:** من بين 533 سجلاً تقدّم لتقييم الأهلية بالنص الكامل، أدرجت 332 دراسة. تركّزت الأدلة في علم الصيدلة الجينية (57%) وفي أمريكا الشمالية وأوروبا (نحو 60%)؛ في حين كان تمثيل الطب الدقيق المعتمد على الذكاء الاصطناعي والمتعدّد الأنماط ضعيفاً جداً (4 دراسات فقط). وكانت أكثر المجالات تناولاً هي القدرة الوظيفية للكوادر (76%)، وتكامل سير العمل السريري (73%)، والبنية التحتية الرقمية (64%)؛ بينما كانت القيادة الاستراتيجية أقل المجالات تناولاً (35%). وتم تحديد مجموعة فرعية من 21 دراسة من دول مجلس التعاون الخليجي، معظمها مسوحات جاهزية. ويتحقّق تطبيق الطب الدقيق عندما تُغيّر نتيجة مُثبتة قراراً سريرياً محدّداً عبر مسار محكوم ومتكامل تقنياً ومدعوم بالكوادر ومستدام مادياً وعادل. **التوصيات:** ينبغي على القادة الصحيين تحديد القرار السريري الذي ستُغيّره الأداة قبل اعتمادها، ودمج النتائج في سير العمل السريري وأنظمة دعم القرار، وتمويل الخدمة لا الفحص فقط، واختيار حالات الاستخدام عبر مصفوفة شفافة يتم التحقّق منها محلياً. ويُقدّم إطار المجالات السبعة نقطة انطلاق قائمة على الأدلة وقابلة للتكيف لنظم دول الخليج، رهناً بالتحقّق المحلي منه.

الكلمات المفتاحية: الطب الدقيق، علم الصيدلة الجينية، علم التطبيق، جاهزية النظام الصحي، مجلس التعاون الخليجي.

1. Introduction

Precision medicine proceeds from a durable clinical insight: patients differ in genetically and biologically meaningful ways, and those differences should inform how they are diagnosed and treated. The category is broad. It includes pharmacogenomics and pharmacogenetics, clinical and rare-disease genomic sequencing, precision oncology and molecular diagnostics, biomarker-guided care, multimodal approaches that combine genomic, clinical, laboratory, and imaging data, validated clinical artificial intelligence and risk-prediction tools, and preventive or wellness-oriented personalized services. What unites these is not a single technology but a claim: that a more precise characterization of the patient can be turned into a better decision.

The scientific case for that claim is comparatively mature. The organizational case is not. Turning a precision tool into routine care requires far more than a laboratory result or a model output. It requires someone accountable for the decision, a workflow that delivers the result to the right clinician at the right moment, an information system that stores and re-uses long-lived data, a workforce that can interpret and act, a financing model that survives beyond a pilot grant, and safeguards for consent, privacy, equity, and ancestry representation. These are administrative and managerial problems, and they sit squarely within the remit of health-system leadership.

This review is therefore framed at the level of the care pathway rather than the technology: the operative question is not whether precision medicine works in principle, but what a health system must have in place before a validated result can safely and sustainably change a clinical decision. The research problem, the study's objectives, and the theoretical and methodological frameworks used to address that problem are set out in the sections that follow.

2. Research Problem

Precision medicine's scientific foundations are well established, but the organizational and managerial conditions required to deliver it safely and sustainably inside a health system are not. The problem this study addresses is the absence of consolidated, decision-useful guidance for health-system leaders: the implementation literature is fragmented across modalities (pharmacogenomics, oncology, genomics, digital and AI-enabled tools), is growing faster than administrators can synthesize it, and offers no shared structure for diagnosing organizational readiness before a precision-medicine investment is made.

This gap carries a direct cost to society. Health systems that acquire precision-medicine technologies without first securing governance, workforce capability, interoperable data infrastructure, sustainable financing, and equity safeguards risk producing pilots that demonstrate clinical promise but never reach routine care, wasting scarce resources and delaying benefit to patients. The problem is acute for Saudi Arabia and the wider Gulf Cooperation Council, where genomics and precision medicine have become explicit national strategic priorities, but where local implementation evidence remains thin and existing global guidance was not built with Gulf governance, financing, and population characteristics in mind. Addressing this problem by mapping the global implementation evidence into an adaptable readiness framework directly serves the societal goal of translating scientific advances into equitable, sustainably delivered clinical services for Gulf populations rather than isolated technology showcases.

3. Importance of the Study

This study is important on two levels. Scientifically, it consolidates a fragmented implementation literature, spanning pharmacogenomics, clinical genomics, precision oncology, digital and AI-enabled tools, and preventive personalized health, into a single, pre-specified seven-domain readiness framework, and it does so using a transparent, auditable, AI-assisted screening and charting methodology applied to a substantial evidence base of 332 included studies. This contributes a structure that future implementation researchers can test, refine, or revise, rather than another isolated modality-specific review.

Practically, the study speaks directly to health-system leaders, policymakers, and clinical administrators who must decide how to invest in precision medicine under conditions of limited local evidence. By identifying which organizational conditions the global literature most and least addresses, by distinguishing observed implementation outcomes from conceptual recommendation, and by translating the synthesis into a staged, GCC-adaptable implementation pathway, the study gives Saudi and Gulf health-system leaders a structured starting point for deciding what must be in place, and in what sequence, before a precision-medicine service is commissioned. This reduces the practical risk of acquiring technology without an operating model and supports more efficient allocation of scarce governance, workforce, and financial resources toward services capable of reaching sustained clinical use.

4. Study Objectives

This study pursues the following specific objectives:

1. To map, through a systematic scoping methodology, the organizational, governance, workforce, digital, financial, and equity conditions reported in the global literature for implementing precision medicine in health-care delivery settings.
2. To organize these conditions into a pre-specified, evidence-informed readiness framework spanning seven domains.
3. To characterize the included evidence by modality, geography, and study design, and the relative frequency with which each readiness domain is addressed, distinguishing observed implementation outcomes from conceptual or recommendation-based literature.
4. To synthesize cross-cutting implementation patterns and dependencies among the seven domains.
5. To translate the synthesis into a staged, locally adaptable implementation pathway and practical recommendations for health-system leaders in Saudi Arabia and the Gulf Cooperation Council.

5. Theoretical Literature of the Study

This review is anchored in two complementary bodies of theory: scoping-review methodology and implementation science.

Methodologically, the study follows the scoping-review framework originally proposed by Arksey and O'Malley (2005), as subsequently refined by Levac, Colquhoun, and O'Brien (2010) and formalized in the JBI methodological guidance for scoping reviews (Peters et al., 2020). This family of frameworks treats a scoping review as appropriate when a research question is broad, the relevant evidence is heterogeneous in design and terminology, and the

aim is to map the extent, range, and nature of available evidence rather than to pool effect estimates. Reporting follows the PRISMA Extension for Scoping Reviews, PRISMA-ScR (Tricco et al., 2018), which specifies the items required for transparent reporting of search, screening, and charting decisions.

Substantively, the interpretation of findings draws on three implementation-science constructs, used here as interpretive lenses rather than as a priori coding instruments. The Consolidated Framework for Implementation Research (Damschroder et al., 2009) supplies a multi-level vocabulary, spanning intervention characteristics, the outer and inner organizational setting, the individuals involved, and the implementation process, for understanding why an intervention succeeds or fails to embed in routine practice. Proctor and colleagues' taxonomy of implementation outcomes (Proctor et al., 2011), distinguishing constructs such as adoption, feasibility, fidelity, and sustainability from clinical-effectiveness outcomes, underpins this review's insistence on separating implementation evidence from clinical or analytical-validity evidence when charting and synthesizing. Weiner's theory of organizational readiness for change (Weiner, 2009), which conceptualizes readiness as a function of both organizational commitment and change-efficacy, provided the conceptual basis for treating “readiness” as a multi-domain organizational property rather than a single attribute, motivating the seven-domain structure (strategic leadership, governance, workforce, digital infrastructure, clinical workflow, finance, and equity) that organizes the present review's charting, synthesis, and resulting framework.

6. Review of Previous Studies

Before presenting this review's own findings against the seven-domain framework (Section 8), this section characterizes the existing implementation literature that was identified, screened, and retained, organized thematically by selection outcome, study design and modality, geography, and the documented reasons for exclusion. Read together, these characteristics expose where the existing evidence is concentrated and where it is thin, the gap that motivates the present synthesis.

6.1 Selection of Records (PRISMA-ScR Flow)

Of 8,000 records identified and screened at title and abstract, 533 advanced to full-text eligibility assessment. Of these, 106 could not be retrieved (code E4) and were excluded, leaving 427 full-text reports assessed. A further 95 were excluded with reasons, giving 332 studies included in the synthesis (Figure 1). The single largest exclusion category was non-retrieval of the full text, which alone accounted for just over half of all exclusions; this is an access limitation rather than an eligibility judgment and is revisited in the limitations (Section 9.6).

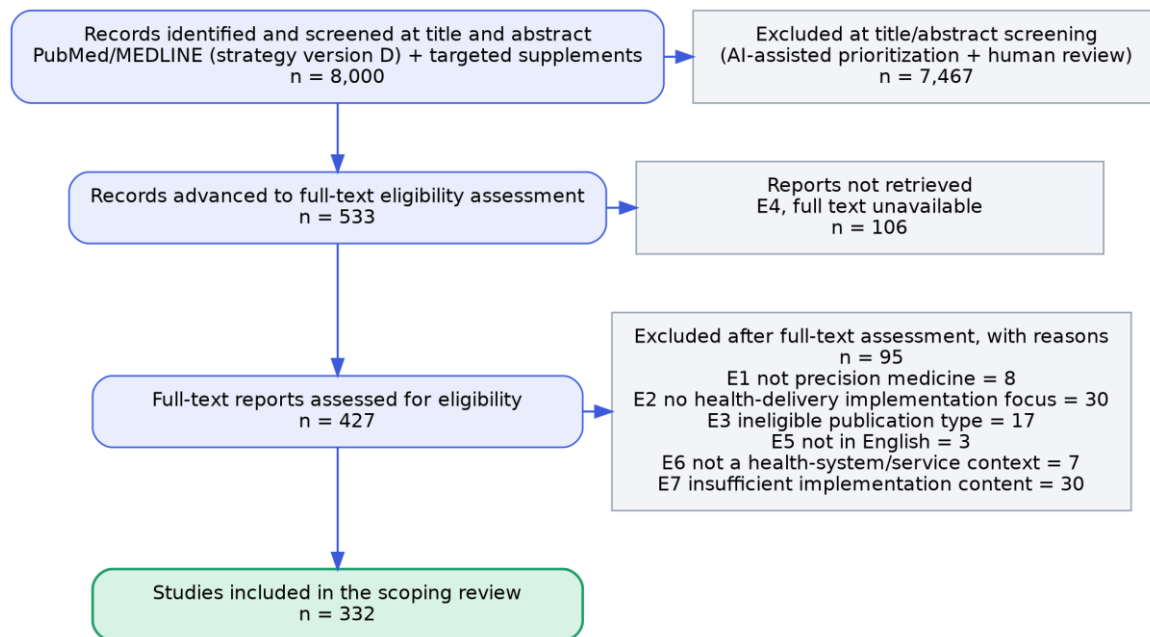


Figure (1): PRISMA-ScR flow of records through identification, title/abstract screening, full-text retrieval and eligibility assessment, and inclusion. Counts are verified from the final charting dataset.

6.2 Characteristics of Included Evidence by Design and Modality

Included studies span 2015 to mid-2026, with output rising over the period and concentrated in recent years (52 studies in 2022, 59 in 2025, and 37 in a partial 2026 window). Two features of this evidence shape how the results in Section 8 should be read. The first is its character: primary empirical studies account for only 189 of 332 included studies (57%), with the remainder made up of frameworks or perspectives (99; 30%), systematic or scoping reviews (27; 8%), and policy analyses (14; 4%). Because frameworks and perspectives are the single largest design category, a substantial share of what is written about precision-medicine implementation is argued rather than observed. The second feature is concentration: the evidence clusters tightly by modality and geography.

By modality, pharmacogenomics and pharmacogenetics dominate (189; 57%), followed by general or national precision-medicine implementation (93; 28%) and precision oncology and molecular diagnostics (30; 9%). Clinical genomics and rare-disease sequencing (11; 3%) and, especially, digital, multimodal, or AI-enabled precision medicine (4; 1%) are sparsely represented. The corpus therefore speaks most directly to pharmacogenomic services; claims about AI-enabled, multimodal, or preventive precision medicine rest on a thin empirical base and are treated cautiously throughout.

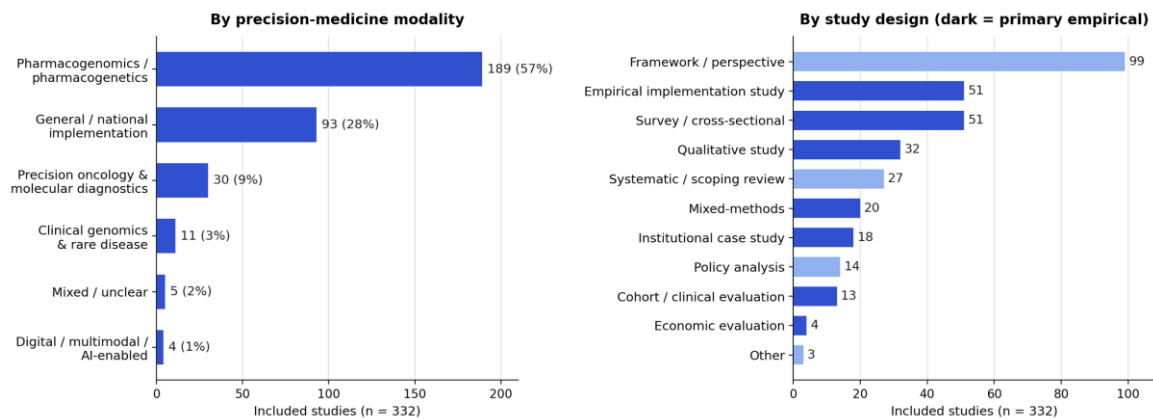


Figure (2): Distribution of included studies (n = 332) by precision-medicine modality (left) and by study design (right). In the design panel, darker bars denote primary empirical study types; lighter bars denote frameworks/perspectives, reviews, and policy analyses.

Table (1): Characteristics of included evidence, computed from the final charting dataset. Percentages are of included studies; modality and region categories follow the normalization rules in Section 7.7.

Characteristic	Value (included studies, n = 332)
Total included studies	332 (of 533 records advanced to full-text assessment; 201 excluded)
Publication period	2015–2026; rising output (2022: 52; 2025: 59; 2026 partial: 37)
Primary empirical studies	189 (57%)
Non-primary sources	Frameworks/perspectives 99 (30%); systematic/scoping reviews 27 (8%); policy analyses 14 (4%); other/unclear 3 (1%)
Empirical design breakdown	Empirical implementation 51; surveys/readiness 51; qualitative 32; mixed-methods 20; institutional case 18; cohort/clinical 13; economic evaluations 4
Dominant modality	Pharmacogenomics/pharmacogenetics 189 (57%)
Other modalities	General/national 93 (28%); precision oncology & molecular diagnostics 30 (9%); clinical genomics & rare disease 11 (3%); digital/multimodal/AI 4 (1%); mixed/unclear 5 (2%)
Leading regions	North America 144 (43%); Europe 56 (17%); multi-country 29 (9%); GCC 21 (6%); Asia 18 (5%); setting not reported 30 (9%)
Readiness domains per study	Mean 4.2 (range 1–7)

6.3 Geographic Concentration and the GCC Evidence Gap

By region, North America (144; 43%) and Europe (56; 17%) account for about 60% of included studies, with a Gulf Cooperation Council subset of 21 studies (6%), 18 from Asia, and limited representation from Latin America, Africa, and other settings. Thirty studies did not report a specific national setting. This concentration means the implementation literature speaks predominantly to the conditions of high-income, early-adopter health systems; how far those conditions transfer to Gulf systems is addressed directly in Section 9.5.

6.4 Full-Text Exclusion Profile

Table (2) presents all full-text exclusion codes and counts. Non-retrieval (E4) accounted for 106 of 201 exclusions. Of the 95 excluded after a full-text read, the most common reasons were absence of a health-delivery implementation focus (E2; 30) and insufficient implementation content in otherwise on-topic narrative or clinical reviews (E7; 30).

Table (2): Full-text exclusion codes and counts (n = 201). Codes are reported as applied in this review; E4 reflects retrieval access rather than an eligibility judgment.

Code	Definition as applied	n
E1	Not precision-medicine implementation in a health-care setting	8
E2	No health-delivery implementation focus (basic-science, technical, analytical-validation, or clinical-efficacy only)	30
E3	Ineligible publication type without chartable implementation content	17
E4	Full text not retrievable	106
E5	Not in English or unusable conference record	3
E6	Not a health-system or service-delivery context (e.g., biobank or research-data infrastructure)	7
E7	Insufficient implementation content (e.g., narrative or clinical reviews not developing implementation conditions)	30
Total	Excluded records	201

Three patterns in this body of previous studies motivate the analysis that follows. The evidence is heavily weighted toward pharmacogenomics and away from AI-enabled, multimodal, and preventive precision medicine. It is concentrated in North American and European systems, leaving the Gulf Cooperation Council represented by only 21 studies, mostly readiness surveys rather than evaluated services. And conceptual frameworks and perspectives constitute the single largest design category, meaning a substantial share of the literature argues rather than observes. These gaps directly motivate the domain-level results presented in Section 8 and the GCC-adaptable framework presented in Section 9.

7. Methodology

7.1 Design and Reporting

We conducted a scoping review following the framework of Arksey and O'Malley, the methodological refinements of Levac and colleagues, and the JBI guidance for scoping reviews, and we report it in accordance with the PRISMA Extension for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018). A scoping review was chosen because the question is broad, the evidence is heterogeneous in design and modality, and the aim is to map conditions and identify patterns rather than to estimate the effect of a single intervention. A completed PRISMA-ScR checklist is provided in Appendix D. The theoretical constructs that inform the interpretation and synthesis of charted data are presented in Section 5 (Theoretical Literature of the Study).

7.2 Eligibility Criteria

Studies were eligible if they addressed one or more organizational, governance, operational, workforce, digital, financial, or equity conditions for implementing a precision-medicine tool in a health-care delivery setting, in any country, and were available in English. Eligible source types included primary empirical implementation studies, qualitative studies, surveys and readiness assessments, mixed-methods studies, economic evaluations, institutional case studies, systematic or scoping reviews, policy analyses, and frameworks or perspectives.

Studies were excluded if precision medicine was not the implemented focus; if they were purely basic-science, biomarker-discovery, analytical-validation, or clinical-efficacy or diagnostic-accuracy studies with no delivery or organizational dimension; if they were ineligible publication types without chartable implementation content; if the full text could not be retrieved; if they were not in English; if they did not concern a health-system or service-delivery context; or if they contained insufficient implementation content to chart.

7.3 Information Sources and Search Approach

The primary source was PubMed/MEDLINE, searched with a structured strategy (version D) combining precision-medicine concepts with implementation, organizational, and health-system terms. Targeted supplementary searches addressed financing and sustainability and ethical and bioethical governance, where the primary strategy was expected to under-retrieve. The PubMed/MEDLINE search (strategy version D) was run on 24 June 2026, with the targeted supplementary searches conducted in the same period; the applied limits were English language and a publication window from 1 January 2015 onward. The version-D query returned 7,895 records. Combined with the targeted supplementary searches for financing and sustainability and for ethical and bioethical governance, and after de-duplication by PubMed identifier (PMID), 8,000 records were taken to title-and-abstract screening. The full version-D search string, the stepwise search-development log (versions B to D with hit counts at each step), and the search record are provided in Appendix A. Of these 8,000 records, 533 advanced to full-text eligibility assessment and 332 were included (Section 6.1; Figure 1). We did not search Scopus, Web of Science, CINAHL, or grey-literature sources comprehensively; this is stated as a limitation rather than described as a comprehensive multi-database search.

7.4 AI-Assisted Prioritization and Screening

Title-and-abstract screening used a transparent, auditable two-step process. Large-language-model assistants (Claude Opus 4.8 and ChatGPT 5.5) were used to prioritize and triage records against the eligibility criteria, producing, for each record, a numeric priority score, a provisional include or exclude suggestion, and a confidence flag; the assistants were instructed using the study's pre-specified eligibility criteria (Section 7.2), and the operating protocol is set out in Appendix B. Every one of the 8,000 records was then reviewed by a single human reviewer, who made the final title-and-abstract decision. The AI outputs were used only to order and triage records for human review, not to decide them; records flagged as low-confidence or uncertain were prioritized for closer human scrutiny, and no record was included or excluded on an AI suggestion alone. The 533 records that advanced were each read in full by the same reviewer. The AI step was used for prioritization only and was not treated as a substitute for human eligibility judgment. Records advancing past title-and-abstract screening were carried into full-text eligibility assessment.

7.5 Full-Text Screening, Charting, and Exclusion Coding

Each record entering full-text assessment was retrieved where possible and read against the eligibility criteria. For included studies, a structured charting register captured country and health-system setting, study design, precision-medicine modality, the readiness domains addressed, barriers, enablers, key findings for the framework, and notes. Data extraction was AI-assisted (Claude Opus 4.8 and ChatGPT 5.5), with each charted item linked to a verbatim supporting snippet from the source, and was verified by the human reviewer against the full text before entry; the complete charted register for all 332 included studies is provided in Appendix C. Records were excluded with one of the following documented codes: E1, not precision-medicine implementation; E2, no health-delivery implementation focus (basic-science, technical, analytical-validation, or clinical-efficacy only); E3, ineligible publication type without chartable implementation content; E4, full text not retrievable; E5, not in English or unusable conference record; E6, not a health-system or service-delivery context (for example, biobank or research-data infrastructure); and E7, insufficient implementation content (for example, narrative or clinical reviews that do not develop health-system implementation conditions).

7.6 Seven-Domain Framework Coding

Charted content was coded deductively against a pre-specified seven-domain readiness framework: (1) Strategic Leadership and Readiness; (2) Governance and Policy; (3) Workforce Capability and Change Management; (4) Digital Infrastructure and Interoperability; (5) Clinical Workflow and Service Integration; (6) Finance and Sustainability; and (7) Patient Access, Equity and Ethics. A study could be assigned to more than one domain. Because the framework was applied as an a priori coding structure, the frequency with which studies map to a domain reflects research attention and the framework's own categories; it does not, by itself, establish the importance, quality, causal weight, or implementation success of that domain, and it does not validate the framework.

7.7 Modality and Country Normalization

Free-text modality and country fields were normalized using transparent, pre-specified rules. Modality was assigned to one high-level category by leading descriptor and supporting keywords: pharmacogenomics/pharmacogenetics; clinical genomics and rare disease;

precision oncology and molecular diagnostics; biomarker-guided care; digital, multimodal, or AI-enabled precision medicine; general or national precision-medicine implementation; or mixed/unclear. Country was mapped to region (North America; Europe; GCC; other Middle East and North Africa; Asia; Oceania; Latin America; Africa; multi-country or international), with the GCC identified explicitly. Records that could not be classified were retained as mixed, unclear, or not reported rather than forced into a category, and the rules are reported so that the normalization can be reproduced or revised.

7.8 Synthesis and Handling of Heterogeneous Evidence

Synthesis was narrative and structured by the seven domains and by cross-cutting patterns. Evidence types were distinguished throughout, and findings reported by frameworks, perspectives, or reviews are presented as recommendations or synthesis rather than as observed implementation outcomes; observed barriers, enablers, costs, uptake, and workflow effects are attributed preferentially to primary empirical studies. Consistent with scoping-review methodology, and given the heterogeneity of designs, no formal risk-of-bias or certainty appraisal was performed; the trade-off is that the review maps the breadth and nature of the evidence but cannot grade the strength of individual findings.

8. Results

8.1 Distribution Across the Seven Readiness Domains

Studies were coded against the seven readiness domains, with multiple domains permitted per study (mean 4.2; range 1–7). Among the 332 included studies, the most frequently addressed domains were Workforce Capability and Change Management (252; 76%), Clinical Workflow and Service Integration (243; 73%), and Digital Infrastructure and Interoperability (212; 64%), followed by Finance and Sustainability (197; 59%), Patient Access, Equity and Ethics (181; 55%), and Governance and Policy (176; 53%). Strategic Leadership and Readiness was least frequently addressed (116; 35%) (Figure 3).

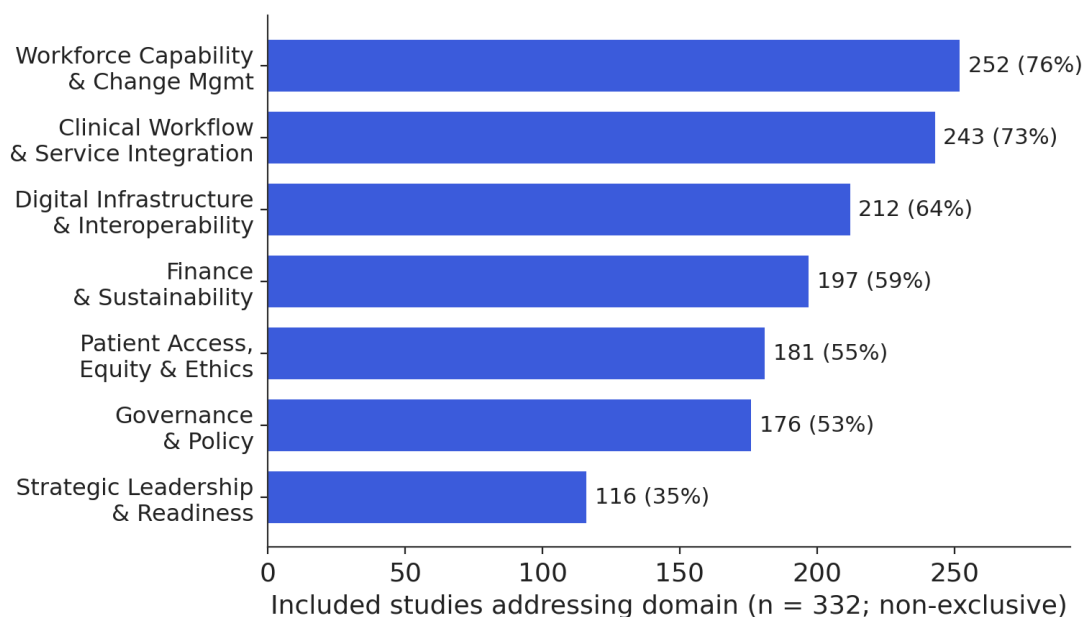


Figure (3): Number of included studies (n = 332) addressing each readiness domain. Domains are non-exclusive; a study may address several. Frequency reflects research attention and the framework's categories, not importance, quality, or implementation success.

The high frequency of workforce, workflow, and digital domains is best read as a statement about where the implementation literature concentrates its attention, not as a ranking of which conditions matter most. The comparatively low frequency of explicit strategic-leadership content is notable: many studies describe operational barriers in detail while saying little about the executive sponsorship and institutional strategy that determine whether those barriers are ever resolved.

8.2 Domain-by-Domain Synthesis

The domains are interdependent, and the most consistent message across the empirical studies is that failure in one domain disables the others. A workflow cannot function without an interoperable result; a trained workforce cannot act without a defined decision point; and a governed, well-built service still collapses if it is not financed beyond the pilot. The following synthesis treats each domain in turn but emphasizes these connections. Representative empirical examples are drawn preferentially from implementation studies and institutional case studies (Caraballo et al., 2017; Hicks et al., 2018; Duarte et al., 2021); framework and review

sources are used for synthesis rather than as evidence of outcomes (Pritchard et al., 2017; Mai et al., 2024).

Clinical Workflow and Service Integration. This is the domain where precision medicine most visibly succeeds or fails. Empirical pharmacogenomic programs repeatedly locate the decisive problems at the points of ordering, result return, interpretation, and the hand-off to a changed prescribing decision (Caraballo et al., 2017; Cicali et al., 2019). Programs that embedded results and alerts at the point of prescribing reported faster, more reliable decision change; those that delivered results outside the workflow saw them ignored. The recurring lesson is that the unit of implementation is the pathway from test to decision, not the test.

Workforce Capability and Change Management. The most frequently reported barrier across the corpus is limited clinician self-efficacy in interpreting and acting on genomic or pharmacogenomic results, compounded by unclear role boundaries among prescribers, pharmacists, laboratory staff, and genetic counsellors (Brown-Johnson et al., 2021; Aquilante et al., 2020). Enablers include structured training, embedded pharmacist or genetic-counsellor roles, and decision support that reduces the interpretive burden at the moment of care. Education alone is insufficient when responsibility for the decision is undefined; role clarity and protected time matter as much as knowledge.

Digital Infrastructure and Interoperability. Genomic and biomarker data are long-lived and re-usable, which makes structured storage, interoperability, and integrated decision support distinctive requirements rather than optional enhancements (Aquilante et al., 2020; Caraballo et al., 2017). Empirical programs repeatedly describe results stranded in unstructured fields, absent discrete result locations in the electronic record, and decision support that is difficult to build and maintain. Where clinical decision support was integrated, it was the single most cited enabler of reliable decision change (Jiang et al., 2022; Duong et al., 2020).

Finance and Sustainability. Economic evaluations and program reports distinguish the cost of the test from the cost of the service, and it is the latter that determines sustainability (Najafzadeh et al., 2017; Abushanab et al., 2024; Ghanbarian et al., 2023). Several programs that demonstrated acceptability and clinical benefit nonetheless identified financing, reimbursement, and out-of-pocket cost as the binding constraint on spread, with pilots lapsing when grant funding ended. Cost-effectiveness evidence exists for specific pharmacogenomic applications but is uneven across modalities and settings.

Patient Access, Equity and Ethics. Equity and ethics are addressed in just over half of included studies, but more often as consent, privacy, and access concerns than as analyzed inequities with implementable solutions. Recurrent themes include out-of-pocket cost as a barrier to equitable access, the underrepresentation of non-European ancestries in the genomic evidence and reference data underpinning many tools, and the handling of incidental and uncertain findings (Brown-Johnson et al., 2021). The ancestry-representation problem is directly relevant to any system serving populations not well represented in existing datasets.

Governance and Policy. Governance is frequently asserted to matter and less frequently analyzed in operational detail. Where it is, the reported needs are clear accountability for approval, data use, consent, and liability; an evidence-review process for deciding which tools enter care; and policies that keep pace with algorithm and panel change (Pritchard et al., 2017). National and institutional policy analyses describe ambition more often than they describe functioning accountability structures.

Strategic Leadership and Readiness. Although least frequently addressed, strategic leadership recurs in the studies that take a whole-system view as the precondition for the rest:

an accountable executive sponsor, an explicit strategy linking precision medicine to clinical priorities, and organizational readiness to absorb change (Duarte et al., 2021; Pritchard et al., 2017). Multisite programs attribute durable implementation to sustained leadership and a defined operating model rather than to the technology itself.

Table (3): Domain-by-domain synthesis of the strongest reported barriers and enablers, the predominant evidence type, and representative examples. Barriers and enablers are reported from the included literature; representative examples cite included studies and are illustrative, not exhaustive.

Readiness domain	Strongest reported barriers	Strongest enablers	Predominant evidence type	Representative examples
Strategic Leadership and Readiness	Absent executive sponsorship; no explicit strategy; weak organizational readiness	Accountable sponsor; strategy linked to clinical priorities; defined operating model	Frameworks/perspectives; multisite case studies	Duarte 2021 (IGNITE multisite); Pritchard 2017
Governance and Policy	Unclear accountability for approval, data, consent, liability; policy lag behind tool change	Evidence-review process; ratified data, consent, and algorithm-change policies	Policy analyses; frameworks	Pritchard 2017
Workforce Capability and Change Management	Low clinician self-efficacy; unclear role boundaries; training gaps	Structured training; embedded pharmacist/genetic-counsellor roles; role clarity; protected time	Surveys; qualitative; empirical implementation	Aquilante 2020; Brown-Johnson 2021
Digital Infrastructure and Interoperability	Results in unstructured fields; no discrete result location; hard-to-maintain CDS	Discrete structured results; interoperability; integrated clinical decision support	Empirical implementation; institutional case studies	Aquilante 2020; Caraballo 2017
Clinical Workflow and Service Integration	Failures at ordering, result return, interpretation, and hand-off	Point-of-care result delivery and alerts; defined ordering and action steps	Empirical implementation; mixed-methods	Caraballo 2017; Cicali 2019
Finance and Sustainability	Financing/reimbursement gaps; out-of-pocket cost; pilots lapse after grants	Costed service model; reimbursement pathway; demonstrated cost-effectiveness for specific uses	Economic evaluations; program reports	Najafzadeh 2017; Abushanab 2024 (Qatar)
Patient Access, Equity and Ethics	Cost-related access barriers; ancestry underrepresentation; uncertain/incidental findings	Access planning; consent and privacy safeguards; population-relevant evidence	Qualitative; surveys; reviews	Brown-Johnson 2021; Hicks 2018

8.3 Cross-Cutting Implementation Patterns

What stands out across the domains is how tightly they are coupled. The studies that look closely at why a programme worked, or stalled, keep returning to the same dependencies. Governance, accountability, and workflow move together: a service with no named clinician answerable for the decision, and no route for deciding what enters care, does not produce reliable decisions however good the underlying test. The data impose a second demand, because genomic and biomarker results are long-lived and meant to be re-used; they need a place to live in the record and a way to resurface at the next prescribing moment, which is what sets precision medicine apart from one-off diagnostics. Workforce education runs into a third dependency, since training clinicians to read a result accomplishes little if no one is clearly responsible for acting on it. Money is a fourth and recurring one: programmes that funded the test but not the service around it tended to lapse when the grant did, which is why several otherwise successful pilots did not survive. Equity, consent, privacy, access, and ancestry

representation form a fifth thread that is easy to file under ethics and treat as peripheral, and that for systems serving populations the reference data underrepresent is anything but. The last pattern ties the others together: pilots stall when they sit outside the institution's operating model, and they scale when leadership, governance, financing, and infrastructure are aligned around them. The recurring mistake is to run implementation as a project that ends rather than a service that has to be kept running.

One caveat applies to all of it. These patterns come overwhelmingly from high-income, early-adopter systems, which fill most of the corpus. The conditions they identify were largely observed where resources, infrastructure, and workforce were already comparatively strong, so whether they transfer cleanly to lower-resource or emerging systems is an open question rather than a settled result, and one this review can frame but not answer.

9. Conclusion and Discussion of Results

9.1 Principal Findings

This review maps a large but lopsided literature. Most of it sits in pharmacogenomics and in high-income North American and European systems; a striking share of what is published is conceptual rather than observed, with frameworks and perspectives forming the largest single design category; and the evidence thins out almost to nothing for AI-enabled, multimodal, and preventive precision medicine. Within that body of work the conditions for implementation recur in a stable pattern, clustering around workforce capability, clinical-workflow integration, and digital infrastructure, with financing and equity as the persistent constraints and governance and strategic leadership as the preconditions that are talked about least and probably matter most. The firmest cross-study finding, though, is not about any one domain. It is that the domains stand or fall together: precision medicine is implemented when they are aligned around a defined clinical decision, and it fails when any one of them is missing.

Stated plainly, and consistent with the pattern across the included studies: precision medicine is not implemented when a health system acquires a test, an algorithm, a sequencing platform, or a risk score. It is implemented when a validated result changes a defined clinical decision through a governed, interoperable, workforce-supported, financially sustainable, and equitable care pathway.

9.2 A Service-Centred Implementation Model

These findings imply that precision medicine should be governed as a clinical service, not as a laboratory installation, a software deployment, a research study, or an innovation showcase. Each of those framings predicts a characteristic failure observed in the literature: the laboratory framing produces accurate results that never reach a decision; the software framing produces tools that are not embedded in a pathway; the research framing produces pilots that end with the grant; and the innovation framing produces prestige acquisitions without an operating model. A service framing instead demands a defined population and decision, an accountable owner, an integrated workflow, sustainable financing, monitoring, and equity safeguards. The framework below operationalizes that stance.

9.3 The GCC-Adaptable Precision-Medicine Implementation Readiness Framework

We propose the seven domains as an evidence-informed readiness framework. It is not validated; it organizes what the literature reports and requires local testing before it is relied upon for decisions. Table (4) specifies, for each domain, the core question for leaders, the minimum readiness requirement, the common failure mode, a practical indicator, and what a mature system would have in place.

Table (4): The GCC-adaptable precision-medicine implementation readiness framework. The framework is evidence-informed, not validated; the indicators are proposed and require local definition and testing.

Domain	Core question for leaders	Minimum readiness requirement	Common failure mode	Practical indicator	Mature-system state
Strategic Leadership and Readiness	Which clinical problems justify this, and who owns the strategy?	Accountable executive sponsor and a strategy linked to clinical priorities	Prestige acquisition with no operating model	Named sponsor; documented strategy and objectives	Precision medicine embedded in the clinical and digital strategy

Domain	Core question for leaders	Minimum readiness requirement	Common failure mode	Practical indicator	Mature-system state
Governance and Policy	Who is accountable for approval, data, consent, and liability?	Approval and evidence-review pathway; data, consent, and algorithm-change policy	Ambition stated; accountability undefined	Ratified policies; functioning review committee; audit trail	Standing governance with periodic evidence review and de-implementation
Workforce Capability and Change Management	Do clinicians know when to act, refer, or override, and whose role is it?	Defined roles plus competency-based training	Education without role clarity; unsafe or unused results	Trained, competency-assessed staff; defined responsibilities	Sustained competencies, embedded specialists, protected learning time
Digital Infrastructure and Interoperability	Can a result reach the decision point and be re-used over time?	Discrete structured results, interoperability, and clinical decision support	Results stranded in unstructured fields	Result reaches point of care via CDS; data interoperable	Longitudinal, interoperable data with maintained, governed CDS
Clinical Workflow and Service Integration	Who orders, when does the result appear, and what changes?	Defined pathway: order, result, interpretation, action, follow-up	Failures at hand-offs; results without action	Mapped pathway; audited turnaround and action steps	Routine, audited pathway with re-analysis where relevant
Finance and Sustainability	Can the service, not just the test, be funded over time?	Costed multi-year model and a reimbursement pathway	Pilot lapses when grant funding ends	Secured funding; tracked cost and reimbursement	Sustainable reimbursement and total-cost-of-service monitoring
Patient Access, Equity and Ethics	Does the tool perform fairly, and do benefits reach all patients?	Population-validity check, consent and privacy safeguards, access plan	Inequitable benefit; loss of trust; ancestry mismatch	Subgroup performance checked; access and consent monitored	Equity and ancestry assessment built into commissioning and monitoring

The framework is paired with a staged implementation pathway (Figure 4) that orders the work from use-case selection through governance, the clinical pathway, infrastructure, workforce, and finally scaling, financing, and monitoring, with a feedback loop for periodic evidence review and de-implementation. The sequence reflects the literature's central lesson that infrastructure and workforce investment are wasted without a defined use case and an accountable operating model established first.

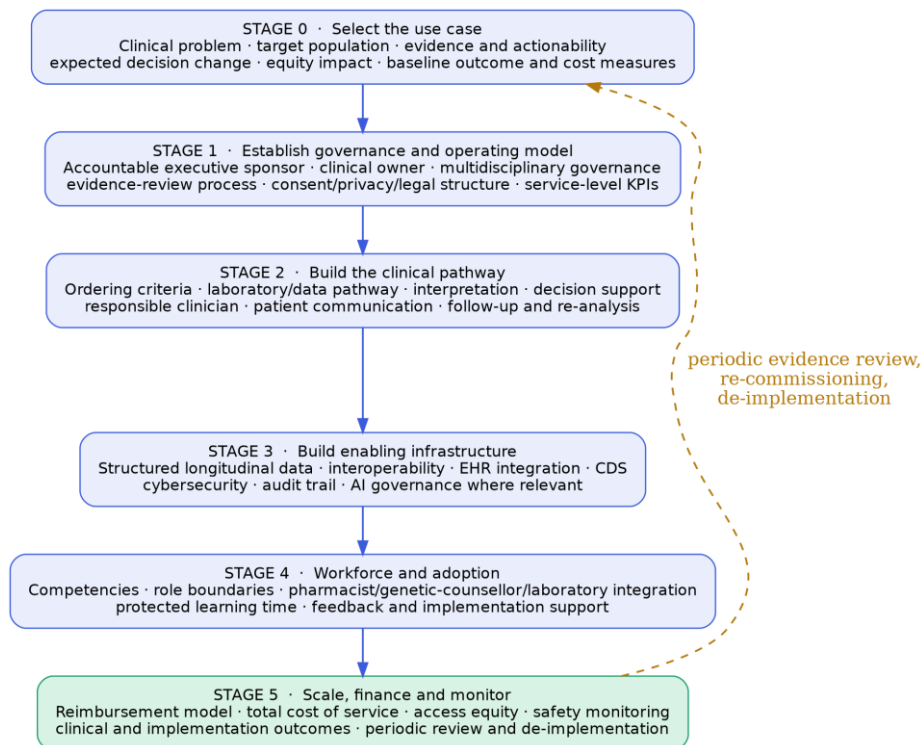


Figure (4): Staged precision-medicine implementation pathway. Stages are sequential but iterative; the dashed return path denotes periodic evidence review, re-commissioning, and de-implementation.

Stage 0: Select the use case. Clinical problem; target population; evidence and actionability; expected decision change; equity impact; baseline outcome and cost measures.

Stage 1: Establish governance and operating model. Accountable executive sponsor; clinical owner; multidisciplinary governance; evidence-review process; consent, privacy, and legal structure; service-level KPIs.

Stage 2: Build the clinical pathway. Ordering criteria; laboratory and data pathway; interpretation; decision support; responsible clinician; patient communication; follow-up and re-analysis where relevant.

Stage 3: Build enabling infrastructure. Structured longitudinal data; interoperability; EHR integration; clinical decision support; cybersecurity; audit trail; AI governance where relevant.

Stage 4: Workforce and adoption. Competencies; role boundaries; pharmacist, genetic-counsellor, laboratory, and clinician integration; protected learning time; feedback and implementation support.

Stage 5: Scale, finance, and monitor. Reimbursement model; total cost of service; access equity; safety monitoring; clinical and implementation outcomes; periodic evidence review and de-implementation.

9.4 Extending the Framework Beyond Genomics

Although the evidence base is concentrated in pharmacogenomics, the framework is modality-general because its governing principle is. Pharmacogenomics, rare-disease sequencing, precision oncology, molecular diagnostics, multimodal prediction, clinical AI, and preventive risk stratification differ in their inputs but share a single requirement for safe adoption: a technology should enter care only through a validated, accountable, monitored service pathway. For clinical AI and multimodal tools in particular, where this corpus is thin, the same domains apply with added weight on external validation, population calibration, drift monitoring, and algorithm-change governance. The review does not provide strong empirical evidence on these modalities, and that gap is itself a finding: systems adopting AI-enabled precision medicine are doing so ahead of the implementation evidence and should treat the framework's safeguards as requirements rather than aspirations.

9.5 GCC Implications

The GCC subset comprises 21 of the 332 included studies. Within this review's own charting it is dominated by readiness surveys and policy analyses, with only a handful of evaluated services, so what follows is an evidence-informed reading of where the Gulf evidence currently sits rather than a claim about what will work. The surveys in this subset tend to pair clear clinician interest with low self-rated preparedness and limited supporting infrastructure (Alharthi, 2025), and the regional policy literature describes national ambition, including established genomic programmes, more fully than it describes functioning clinical services (Qoronfleh et al., 2020). Two studies show that the next step is feasible in the region: a United Arab Emirates cardiovascular pharmacogenomics pilot demonstrated service-level implementation in a multiethnic population (Al-Mahayri et al., 2022), and a Qatar analysis carried out a local cost-effectiveness evaluation (Abushanab et al., 2024). Both are early and modality-specific, but they make the point that Gulf systems can generate their own implementation and economic evidence rather than importing it wholesale.

We therefore frame Gulf guidance as adaptable principles rather than a single prescription, and we do not flatten the GCC into one system: Saudi Arabia, the United Arab Emirates, Qatar, Kuwait, Bahrain, and Oman differ in governance, financing, workforce, data, and delivery structures. A credible regional agenda would distinguish national from GCC-level functions; consider centralized commissioning and evidence review where scale is needed; develop regional data standards and secure interoperability; invest in local genomic and ancestry evidence so tools are calibrated to Gulf populations; build workforce pipelines including pharmacists and genetic counsellors; establish locally legitimate consent, family-implication, privacy, and data-sharing governance; align public and private financing and reimbursement; and run phased pilots tied to measurable clinical pathways while avoiding prestige-driven acquisition without service readiness.

Rather than nominating one modality as the universal entry point, we propose that each system select use cases through a transparent matrix weighing disease burden, actionability, operational feasibility, data readiness, workforce capacity, equity impact, and cost. For several Gulf systems, pharmacogenomics may be a pragmatic early candidate because of its workflow maturity, but this should follow from the matrix, not substitute for it.

9.6 Strengths and Limitations

The principal strength is a transparent, auditable process: a documented search and screening workflow, AI-assisted prioritization with human decisions, full-text charting with source-linked verification, and a pre-specified coding framework, applied to a substantial included evidence base. The limitations are equally clear, and several constrain interpretation. The search was PubMed-centred with targeted supplements rather than a comprehensive multi-database and grey-literature search, so relevant evidence in other databases and in non-indexed sources was likely missed. The review was restricted to English. Full-text non-retrieval was high (106 of 533 records; just over half of all exclusions), which both reduced the included set and may have biased it toward more accessible, often open-access, sources. The evidence is uneven by geography and modality, with pharmacogenomics and high-income early-adopter systems predominating, which risks publication bias toward successful adopters and limits transferability. Conceptual frameworks and perspectives form the largest design category, so much of the literature is recommendation rather than observation; we have distinguished these throughout, but the distinction depends on accurate classification. No formal risk-of-bias or certainty appraisal was performed, consistent with scoping-review methodology, so individual findings are mapped but not graded. Screening, full-text assessment, and charting were performed by a single reviewer supported by AI-assisted prioritization rather than by two or more independent reviewers, so no inter-rater reliability statistic could be computed and reviewer subjectivity or error cannot be excluded, although every decision was logged, timestamped, and source-linked for auditability. Finally, the seven-domain framework is evidence-informed, not validated, and the GCC guidance is interpretation requiring local testing. Domain frequencies reflect research attention and the framework's own categories, not importance or implementation success.

9.7 Conclusion

Across a large and uneven literature, the implementation of precision medicine resolves to a service problem. The decisive conditions are not the test, the algorithm, or the platform, but the governed pathway that turns a validated result into a defined clinical decision, supported by an accountable owner, an integrated workflow, an interoperable record, a capable workforce, sustainable financing, and equity safeguards. The evidence is strongest for

pharmacogenomics in high-income systems and thin for AI-enabled, multimodal, and preventive precision medicine, so confident claims should track that distribution. For Gulf systems, the seven-domain readiness framework and staged pathway offer an evidence-informed, adaptable structure for moving from technology acquisition to governed clinical service, provided it is validated locally and applied through transparent, use-case-specific selection rather than as a single prescription.

10. Recommendations

Table (5) sets out evidence-informed actions for health-system leaders. Each action is labelled by its evidence basis: actions directly reported in empirical implementation studies; convergent cross-study syntheses; and GCC-specific proposals requiring local validation. The labels are deliberately conservative: where the basis is synthesis or proposal, the action is a reasoned recommendation, not a demonstrated outcome.

Table (5): Evidence-informed actions for health-system leaders implementing precision medicine, classified by evidence basis. “Reported empirical evidence” denotes actions observed in primary implementation studies; “cross-study synthesis” denotes convergent patterns; “GCC proposal” denotes interpretation requiring local validation.

Evidence-informed action for health-system leaders	Domain(s)	Evidence basis
Define the clinical decision a precision tool will change before acquiring it; specify population, action, accountable clinician, and follow-up	Workflow; Leadership	Cross-study synthesis
Embed results and clinical decision support at the point of prescribing or care, not in separate reports	Workflow; Digital	Reported empirical evidence
Create a discrete, structured location for genomic/biomarker results in the electronic record	Digital	Reported empirical evidence
Define roles and provide competency-based training for prescribers, pharmacists, laboratory staff, and genetic counsellors	Workforce	Reported empirical evidence
Establish an evidence-review and approval pathway with clear accountability for data, consent, and liability	Governance	Cross-study synthesis
Cost and finance the service, not just the test; secure a reimbursement pathway before scaling	Finance	Reported empirical / economic evidence
Assess tool performance across relevant ancestries and plan for equitable access and uncertain findings	Equity	Cross-study synthesis
Appoint an accountable executive sponsor and link precision medicine to clinical strategy	Leadership	Cross-study synthesis
Monitor clinical and implementation outcomes and build in periodic review and de-implementation	Governance; Finance	Cross-study synthesis
For AI-enabled and multimodal tools, require external validation, population calibration, drift monitoring, and algorithm-change governance	Digital; Governance	Cross-study synthesis (sparse direct evidence)
Select use cases through a transparent matrix (burden, actionability, feasibility, data, workforce, equity, cost) rather than nominating a universal entry point	Leadership	GCC proposal requiring local validation
Develop regional data standards, secure interoperability, and local genomic/ancestry evidence; distinguish national from GCC-level functions	Digital; Governance	GCC proposal requiring local validation
Build local workforce pipelines (including pharmacists and genetic counsellors) and locally legitimate consent and data-sharing governance	Workforce; Equity	GCC proposal requiring local validation

11. Declarations

Funding

None.

Conflicts of Interest

None declared.

Data Availability

The complete evidence base underpinning this review is contained within this manuscript. Appendix C provides the full bibliographic list and evidence-charting dataset for all 332 included studies (citation, PMID, country and health-system setting, study design, precision-medicine modality, readiness domains addressed, and key implementation findings); because

the in-text citations are representative rather than exhaustive, Appendix C constitutes the complete list of the 332 included studies. Appendix A documents the full search strategy, the version B-to-D development log, and the search record. Appendix B documents the AI-assisted screening and charting protocol. Appendix D provides the completed PRISMA-ScR checklist. No separate supplementary files are required; all supporting materials are included as appendices to this manuscript.

Ethics Statement

This study is a secondary analysis of published literature; no human-subjects approval was required.

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Appendix A. Full Search Strategy and Search Log

Database searched. The review was PubMed/MEDLINE-centred. PubMed/MEDLINE was the primary and only bibliographic database searched with a structured strategy, supplemented by targeted term-level searches (below). Scopus, Web of Science, CINAHL, and grey-literature sources were not searched comprehensively; this is stated as a limitation in Section 9.6 and the review is not described as a comprehensive multi-database review.

Dates and limits. The final (version D) PubMed search was run on 24 June 2026, with the targeted supplementary searches conducted in the same period. Applied limits were English language and a publication window from 1 January 2015 onward. The 2015 start reflects the launch of the current wave of national precision-medicine implementation programmes.

A.1 Final search string (PubMed strategy version D)

```
G1 = ("precision medicine"[tiab] OR "personalized medicine"[tiab]
      OR "personalised medicine"[tiab] OR pharmacogenom*[tiab]
      OR pharmacogenetic*[tiab])

G2 = (implement*[tiab] OR "organizational readiness"[tiab]
      OR "organisational readiness"[tiab] OR "change management"[tiab]
      OR "clinical workflow"[tiab] OR "scale up"[tiab] OR rollout[tiab])

FULL: G1 AND G2
      AND ("2015/01/01"[Date - Publication] : "3000"[Date - Publication])
      AND (english[Language])
```

Records returned by version D: 7,895

A.2 Search-strategy development log

The query was developed iteratively from an initial oversized version to the final screenable version. Hit counts are count-only checks recorded during development; only the final version D was retrieved for screening. These development counts document the narrowing process and are not part of the PRISMA record flow.

Version / step (concept-group change)	PubMed hits
Version B (initial, committed to repository)	117,943
Version C (G2 tightened + equity-rescue clause)	82,361
Equity-rescue clause removed	81,685
genomic*[tiab] removed from G1	50,751
adopt* and integrat* removed from G2	23,856
genomic* removed from G1 and adopt*/integrat* removed from G2	16,498
All MeSH and genomic* removed; G2 phrases only	~9,031–10,166
G1 title/abstract only + G2 core	8,884
G1 title/abstract only + G2 narrowest	8,829
Version D (final): G1 without "genomic medicine" + G2 core	7,895

A.3 Key search-development decisions

To keep the corpus screenable by a single reviewer, "genomic medicine"[tiab] and all MeSH terms were removed from the final query (the broad "Genomics"[MeSH] term was the single largest driver of volume). The pharmacogenom* and pharmacogenetic* title/abstract terms were retained as the specific anchor for pharmacogenomics implementation literature that does not use precision-medicine phrasing; implement* was retained as the G2 anchor. This prioritization of precision-medicine-specific phrasing over generic genomics terminology is a disclosed scope-narrowing tradeoff (Section 9.6). During development, the equity anchor Popejoy and Fullerton (2016) was specifically checked because

commentary papers lacking an explicit implementation verb were at risk of being missed; equity and ethics material was retained through the targeted supplementary searches below.

A.4 Targeted supplementary searches

Because the precision-medicine-anchored main query was expected to under-retrieve two areas, targeted term-level PubMed searches were run for (i) financing and sustainability and (ii) ethical and bioethical governance. These were exploratory top-up searches; their exact strings were not separately archived. Records surfaced by them entered the same de-duplication and screening pipeline as the main search and are reflected in the screened total.

A.5 Deduplication and record flow

Records were de-duplicated by PubMed identifier (PMID). The version D search (7,895 records) combined with the targeted supplementary searches, after de-duplication, gave 8,000 records for title-and-abstract screening. The record flow was: 8,000 identified and screened at title and abstract; 533 advanced to full-text eligibility assessment; 106 not retrieved (code E4); 427 full texts assessed; 95 excluded after assessment; 332 studies included. This flow is shown in Figure 1 and detailed in Section 6.

Appendix B. AI-Assisted Screening and Charting Protocol

Tools. Two large-language-model assistants, Claude Opus 4.8 and ChatGPT 5.5, were used to support screening and charting. They were used as prioritization and extraction aids only; all eligibility and inclusion decisions were made by the human reviewer.

Reviewer. A single human reviewer (the author) performed all screening decisions. The reviewer made every title-and-abstract include or exclude decision on the 8,000 screened records, read every one of the 533 full-text records personally, and verified every charted data item against its source before entry.

B.1 Title-and-abstract prioritization

Each of the 8,000 de-duplicated records was processed by the assistants against the pre-specified eligibility criteria (Section 7.2). For every record the assistants returned three fields: a numeric priority score, a provisional include or exclude suggestion, and a screening-confidence flag (high, medium, or low). These outputs were used only to order and triage records for human review; they were recorded in the register as the `priority_score` and `screening_confidence` fields. The single reviewer then examined every record in a custom screening application that displayed the title, abstract, and the assistants' outputs, and recorded the final decision. The reviewer retained full authority to override any suggestion, and no record was included or excluded on an AI suggestion alone.

B.2 Handling of uncertain records

Records flagged as low-confidence or uncertain were prioritized for closer human scrutiny rather than being resolved automatically. Every decision, including each override, was logged with its reason and a timestamp to produce an auditable trail.

B.3 Full-text charting

For each included study, data extraction was AI-assisted with the same tools. Each charted item was linked to a verbatim supporting snippet from the source, and the reviewer verified every item against the full text before entry. The charted fields are those reported in Appendix C: country and health-system setting, study design, precision-medicine modality, readiness domains addressed, barriers, enablers, and key implementation findings.

B.4 Eligibility criteria supplied to the assistants

The assistants were instructed with the study eligibility criteria (Section 7.2): include records addressing one or more organizational, governance, operational, workforce, digital, financial, or equity conditions for implementing a precision-medicine tool in a health-care delivery setting, in any country, in English; exclude records where precision medicine was not the implemented focus, purely basic-science or analytical-validation or clinical-efficacy studies with no delivery dimension, ineligible publication types without chartable implementation content, non-retrievable full texts, non-English records, non-health-system contexts, and records with insufficient implementation content to chart.

B.5 Limitations of the AI-assisted approach

Screening, full-text assessment, and charting were performed by a single reviewer supported by AI-assisted prioritization rather than by two or more independent reviewers, so no inter-rater reliability statistic was computed and reviewer subjectivity or error cannot be excluded (Section 9.6). The AI tools were used for prioritization and extraction support only; their outputs were not treated as reliable eligibility judgments, and their role does not extend to any inclusion or exclusion decision.

Appendix C. Complete Included-Study Bibliographic List and Evidence-Charting Dataset

This appendix lists all 332 studies included in the review, with charted metadata drawn from the final charting register. Because the in-text citations in the main text are representative rather than exhaustive, this list constitutes the complete included-study evidence base. For each study the following are given as available: citation (first authors, year, title, journal), PubMed identifier (PMID), country or health-system setting, study design, precision-medicine modality, readiness domains addressed, and key implementation findings. Excluded records are not listed here; they are summarized by exclusion code in Table 2 and the PRISMA-ScR flow (Figure 1).

[1] Abbas Maram O, Rahma Azhar T, Elbarazi Iffat et al. (2026). Cardiologists' perspectives on pharmacogenomics implementation in a hybrid health system: A qualitative study from the United Arab Emirates.. PloS one. PMID: 42284323.

Setting: United Arab Emirates - hybrid public-private cardiology settings.. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics - cardiovascular prescribing, including clopidogrel, warfarin, and statins.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: Fifteen cardiologists from UAE public and private institutions participated in semi-structured interviews analysed using an abductive CFIR-informed approach (Abstract; Methods, pp. 3-6). The study identified cost/reimbursement, laboratory/EHR capacity, workflow and role clarity, policy, and ...

[2] Abdel-Latif Rania, Al Muftah Wadha, Mohammed Shaban et al. (2026). Implementing CYP2C19 Pharmacogenetic Testing for Personalized Antiplatelet Therapy: Findings From the QPGx-CARES Initiative.. Clinical therapeutics. PMID: 41455673.

Setting: Qatar – Hamad Medical Corporation Heart Hospital, within the largest community healthcare provider in Qatar.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – point-of-care CYP2C19 testing to guide P2Y12 inhibitor selection for PCI patients.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Of 376 patients tested, 283 received PGx-guided antiplatelet recommendations (Abstract). Actionable CYP2C19 alleles were detected in 22% of patients receiving recommendations; recommendations were adopted in 80% of cases (Abstract). The cost sub-analysis estimated a reduction of approximately 300 ...

[3] Abou Diwan Elizabeth, Zeitoun Ralph I, Abou Haidar Lea et al. (2020). Implementation and obstacles of pharmacogenetics in clinical practice: An international survey.. British journal of clinical pharmacology. PMID: 31141189.

Setting: International – online survey respondents from 43 countries, predominantly academic institutions.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability. Key findings: The survey received 204 responses from 43 countries (Abstract; p. 4). Respondents described common barriers across settings: evidence and interpretation, education, reimbursement, and EMR/CDS capability (Table 3, p. 8). Barrier patterns differed across Human Development Index groups, particularly ...

[4] Abushanab Dina, Mohammed Shaban, Abdel-Latif Rania et al. (2024). Cost-effectiveness analysis of genotype-guided optimization of major depression treatment in Qatar.. Journal of pharmaceutical policy and practice. PMID: 39469318.

Setting: Qatar – public-hospital perspective, with Qatar Genome Programme/QPGx-CARES context.. Design: Economic evaluation. Modality: Pharmacogenomics/pharmacogenetics – multi-gene CYP2D6/CYP2C19-guided pharmacotherapy for major depression.. Domains: Finance and Sustainability. Key findings: The 6-week decision-tree model estimated a mean health-system saving of QAR 2,289 per patient for genotype-guided care versus standard care (Results, PDF p. 23). The lifetime Markov model estimated a mean saving of QAR 46,215 and a gain of 0.06 QALYs per patient (Results, PDF p. 23). A real-world ...

[5] Adnan Hassan Sami, Shidani Amitis, Clifton Lei et al. (2025). Implementation framework for AI deployment at scale in healthcare systems.. iScience. PMID: 40384926.

Setting: Not reported - health-system AI deployment framework designed for multi-site healthcare settings.. Design: Framework / perspective. Modality: Clinical AI / machine learning - large-scale healthcare-system deployment.. Domains: Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The review presents a modular Health xAI Framework for privacy, model

selection, explainability, validation, deployment, and maintenance (Figures 1-8, pp. 2-10). It explicitly identifies governance, interoperability, training, funding, and sustainability as prerequisites for scale-up (pp. 9-10). AI ...

[6] Agarwal Arushi, Pritchard Daryl, Gullett Laura et al. (2021). A Quantitative Framework for Measuring Personalized Medicine Integration into US Healthcare Delivery Organizations.. Journal of personalized medicine. PMID: 33809012.

Setting: United States - healthcare delivery organizations.. Design: Survey / cross-sectional. Modality: General/multiple - personalized medicine across clinical areas and data types.. Domains: Strategic Leadership and Readiness; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The framework assessed PM integration in 153 US organizations through a stakeholder survey (PDF pp. 1, 5). Eight criteria covered testing/data access, leadership, internal funding, data use/sharing, and breadth/consistency of genomic, omics, and non-laboratory data collection (PDF p. 4, Table 1)

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[7] Aguilera-Cobos Lorena, García-Sanz Patricia, Rosario-Lozano María Piedad et al. (2023). An innovative framework to determine the implementation level of personalized medicine: A systematic review.. Frontiers in public health. PMID: 36817923.

Setting: International - national personalised-medicine implementation framework; no single evaluated health system.. Design: Systematic / scoping review. Modality: General/multiple - national personalised-medicine implementation and health-system readiness.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The review identified 19 eligible documents from 1,432 screened records to inform a framework for assessing personalised-medicine implementation (Results, pp. 3-4). The resulting framework contains ten domains and 35 assessable elements for determining implementation level (Results/Table 1, pp ...

[8] Al-Kubaisi Khalid Awad, Abdel-Qader Derar H, Al Mazrouei Nadia et al. (2026). Pharmacogenomics knowledge and implementation readiness among community pharmacists in Jordan: A national cross-sectional study.. PloS one. PMID: 42154777.

Setting: Jordan, community-pharmacy sector across all three administrative regions. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: Organizational commitment and capability, mean 3.39 ("Organizational Readiness"; Table 3) Positive association between attitudes and readiness, $r=0.42$ (" $r=0.42$, $p<0.001$ "; Table 5) Proportionate stratified national sampling and high response rate, 66.7% ("overall response rate of 66.7%"; Results) ...

[9] Al-Mahayri Zeina N, Khasawneh Lubna Q, Alqasrawi Mais N et al. (2022). Pharmacogenomics implementation in cardiovascular disease in a highly diverse population: initial findings and lessons learned from a pilot study in United Arab Emirates.. Human genomics. PMID: 36154845.

Setting: United Arab Emirates – cardiovascular pharmacogenomics pilot conducted at two recruitment sites in the same region.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – cardiovascular prescribing for clopidogrel, warfarin and statins. Domains: Clinical Workflow and Service Integration. Key findings: The pilot recruited 160 patients receiving one or more relevant cardiovascular drugs (pp. 1–2). CYP2C19 phenotypes indicated 46.9% of participants could warrant avoidance of clopidogrel or consideration of an alternative drug (p. 1). The report concludes that the pilot verified feasibility and ...

[10] Alessandrini Marco, Chaudhry Mamoonah, Dodgen Tyren M et al. (2017). Pharmacogenomics and Global Precision Medicine in the Context of Adverse Drug Reactions: Top 10 Opportunities and Challenges for the Next Decade.. Omics : a journal of integrative biology. PMID: 27643672.

Setting: Not reported. Global precision-medicine and adverse-drug-reaction implementation context.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability. Key findings: The paper synthesizes ten interlinked opportunities and challenges for PGx and global precision medicine in relation to adverse-drug-reaction prevention (Abstract; pp. 6–10). Infrastructure, expertise, policy, evidence generation, and sustainable funding are presented as core cross-cutting ...

[11] Algahtani Mohammed (2022). Knowledge, Perception, and Application of Pharmacogenomics Among Hospital Pharmacists in Saudi Arabia.. Risk management and healthcare policy. PMID: 32904476.

Setting: Saudi Arabia - hospital-pharmacist practice across Ministry of Health, military, university, and private hospitals.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics - hospital-pharmacist readiness for PGx testing and clinical application.. Domains: Strategic Leadership and Readiness;

Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The cross-sectional survey included 206 hospital pharmacists in Saudi Arabia (Methods/Results, PDF pp. 3-4). Formal PGx training and recent test-ordering experience were uncommon, despite broadly positive perceptions of pharmacists' clinical role (Results, PDF pp. 4-7). Knowledge, local service ...

[12] Alghamdi Bader M, Rogers Sara, Roberman Susan et al. (2025). Implementation and integration of a multidisciplinary pharmacogenomics service in an underserved integrated behavioral health clinic.. Frontiers in pharmacology. PMID: 40487400.

Setting: United States, Texas A&M Family Care Clinic in Bryan, Texas. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: A pharmacist-led multidisciplinary PGx workflow was developed for an underserved behavioral-health clinic ("workflow map integrating PGx"; Figure 1). The service used patient identification, consent, testing, pharmacist review, provider discussion, and follow-up ("test is ordered"; Results). Team ...

[13] Alhaddad Zahra Abdulathim, AlMousa Hissah Abdullatif, Younis Nancy S (2022). Pharmacists' Knowledge, and Insights in Implementing Pharmacogenomics in Saudi Arabia.. International journal of environmental research and public health. PMID: 36011723.

Setting: Saudi Arabia - pharmacists across all five national regions.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics.. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: The national web survey included 671 pharmacists (PDF pp. 1, 3). Only 22.6% had applied PGx testing to drug therapy selection/dosing/monitoring and 21.6% had counselled a patient on PGx results (PDF p. 4). Completed training was associated with higher knowledge (40.3%, $p=0.001$) and self-confidence ...

[14] Alharthi Mohammed S (2025). How equipped are pharmacists for pharmacogenomics?: A cross-sectional study on knowledge, attitudes, and implementation practices in Saudi Arabia.. Medicine. PMID: 40295244.

Setting: Saudi Arabia, pharmacists across multiple practice settings. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The survey included 426 licensed pharmacists across Saudi practice settings ("n = 426"; Abstract). Only 52.3% had formal PGx education, while 40.6% had never consulted PGx resources in practice ("52.3%"; "40.6%"; Abstract). Access to testing and reimbursement were the most common reported ...

[15] Alimohamed Mohamed Zahir, Obeng George Dennis, Csanadi Marcell et al. (2025). Implementing health economics for pharmacogenomics research translation in Africa.. Communications medicine. PMID: 40542221.

Setting: Africa – continent-wide implementation perspective; no single national health system was studied. Design: Framework / perspective. Modality: Pharmacogenomics / pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The article identifies pricing, evaluation, infrastructure, education, regulation, and socio-economic factors as implementation challenges in Africa (p. 3). The article cites substantial variation in African readiness, noting HTA institutionalization in Ghana and South Africa but not most African ...

[16] Alnaimi Shaikha Jabor, Ajaj Fatima, Awaisu Ahmed et al. (2024). Assessment of knowledge, perceptions, and readiness of healthcare professionals towards clinical pharmacogenomics implementation in Qatar: a mixed-method study.. Journal of pharmaceutical policy and practice. PMID: 39605985.

Setting: Qatar – Hamad Medical Corporation, a public secondary and tertiary health system with 12 hospitals.. Design: Mixed-methods. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Finance and Sustainability. Key findings: The quantitative survey included 802 HMC healthcare professionals, a 20% response rate (Results, pp. 6–7). Six focus groups involved 31 participants (Results, p. 12). Only 15.4% reported prior PGx-related education or training (Results, p. 6). Barriers ranked highest were specialized ...

[17] Alqahtani Saud, Alqahtani Taha, Venkatesan Krishnaraju et al. (2026). Pharmacogenomics knowledge, attitudes, and perceptions among pharmacists in the Asir Region, Saudi Arabia: a cross-

sectional analysis.. Saudi pharmaceutical journal : SPJ : the official publication of the Saudi Pharmaceutical PMID: 41661499.

Setting: Saudi Arabia – pharmacists in the Asir Region.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics – pharmacist readiness for clinical implementation.. Domains: Workforce Capability and Change Management. Key findings: The cross-sectional survey included 209 pharmacists in Asir (Abstract; Results, pp. 3–4). Seventy-one percent had poor PGx knowledge, despite predominantly positive attitudes and perceptions (Abstract; Results, pp. 3–7). Prior training and experience with genetic conditions were associated with ...

[18] Alsina M, Huerta A E, Lordick F et al. (2026). Current practices and challenges in implementing precision medicine for upper gastrointestinal cancers in European academic centers: an EORTC survey.. ESMO gastrointestinal oncology. PMID: 41647591.

Setting: Europe – 41 EORTC-affiliated academic cancer institutions represented by 45 oncology specialists.. Design: Survey / cross-sectional. Modality: Genomic cancer-risk/hereditary and biomarker-guided precision oncology for upper gastrointestinal cancers. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Forty-five oncology specialists from 41 European institutions completed the survey (Abstract, p. 1). Routine biomarker testing rates were 100% for HER2, 89% for PD-L1, and 91% for MMR (Abstract, p. 1). Comprehensive tissue sequencing was available in 84% of centres; regular MTBs in 75% (Results, p ...

[19] Alyabsi Mesnad, Alhumaid Abdulrahman, Allah-Bakhsh Haafiz et al. (2021). Colorectal cancer in Saudi Arabia as the proof-of-principle model for implementing strategies of predictive, preventive, and personalized medicine in healthcare.. The EPMA journal. PMID: 32140189.

Setting: Saudi Arabia - national colorectal-cancer prevention and healthcare-policy context.. Design: Policy analysis. Modality: Precision oncology / stratified prevention - colorectal-cancer screening, risk assessment, molecular profiling, and Domains: Strategic Leadership and Readiness; Governance and Policy; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The review documents rising CRC burden in Saudi Arabia, frequent late-stage diagnosis, and a young population relevant to future screening policy (Abstract; pp. 1-3). It identifies a gap in predictive diagnostics and targeted prevention within the national CRC response (Abstract; p. 1). Saudi ...

[20] Amer Khaled, Soliman Neveen A, Soror Sameh et al. (2025). Egypt Genome: Towards an African new genomic era.. Journal of advanced research. PMID: 38844121.

Setting: Egypt – Egypt Genome Project, a national population-genomics and precision-medicine initiative.. Design: Framework / perspective. Modality: General/multiple – national reference genome, disease genomics, population pharmacogenomics and clinical data Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Patient Access, Equity and Ethics. Key findings: The project uses a national structure with central coordination and geographically distributed recruitment to improve population representation (Figure 1; Project structure, pp. 4–5). Planned tracks include healthy-population reference data, rare disease, cancer, infectious disease and population ...

[21] Apellaniz-Ruiz Maria, Barrachina Jordi, Castro-Sanchez Paula et al. (2025). Status of the implementation of pharmacogenetics in clinical practice in Spain: from regional to national initiatives.. Drug metabolism and personalized therapy. PMID: 39523122.

Setting: Spain – Spanish National Health System (NHS), with regional implementation across the Autonomous Communities.. Design: Policy analysis. Modality: Pharmacogenomics/pharmacogenetics – regional and national clinical PGx service implementation.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The review documents substantial variation in PGx maturity across Spanish regions, from isolated hospital services to coordinated regional initiatives (pp. 184–193). A national PGx catalogue was approved through the NHS common genetics portfolio in 2023 and presented in 2024 (p. 193). The catalogue ...

[22] Aquilante Christina L, Kao David P, Trinkley Katy E et al. (2021). Clinical implementation of pharmacogenomics via a health system-wide research biobank: the University of Colorado experience.. Pharmacogenomics. PMID: 32077359.

Setting: United States, University of Colorado/UCHealth system spanning Colorado and parts of Wyoming and Nebraska. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: UCHealth implemented a pre-emptive PGx return model through a health-system research biobank,

using clinical consent, structured EHR results, and CDS tools (“preemptively return”; pages 1–4). The first implementation use case was CYP2C19-guided clopidogrel prescribing for ACS/PCI patients (“first ...

[23] Aquilante Christina L, Trinkley Katy E, Lee Yee Ming et al. (2024). Implementation of clopidogrel pharmacogenetic clinical decision support for a preemptive return of results program.. American journal of health-system pharmacy : AJHP : official journal of the American PMID: 38253063.

Setting: United States – UCHealth system serving Colorado, Wyoming, and Nebraska; University of Colorado Anschutz Medical Campus/Colorado Center for Design: Institutional case study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: UCHealth implemented and iteratively expanded CYP2C19-guided clopidogrel CDS from a focused 2018 cardiology use case to system-wide use (Table 1, pp. 4–5). Results were stored as structured data and used to drive drug–gene-specific CDS (p. 3). As of July 2023, PGx CDS tools were live for 30 ...

[24] Arango Celso, Vieta Eduard, Fañanás Lourdes et al. (2026). Precision medicine in mental health: applications, challenges, and recommendations.. European psychiatry : the journal of the Association of European Psychiatrists. PMID: 42037368.

Setting: Europe – European Psychiatric Association guidance; no single evaluated health system.. Design: Framework / perspective. Modality: General/multiple precision mental health – genomic, digital, biomarker, and AI-enabled approaches. Domains: Governance and Policy; Workforce Capability and Change Management; Patient Access, Equity and Ethics. Key findings: The guidance identifies implementation barriers spanning evidence, regulation, workforce capacity, infrastructure, and equity (pp. 7–8). The authors emphasize that most precision-mental-health tools remain insufficiently validated for routine broad deployment (pp. 6–8). European systems should ...

[25] Aref Heba A T, Makowsky Mark J, Kung Janice Y et al. (2023). Mapping the implementation of pharmacogenomic testing in community pharmacies 2003-2021 using the Theoretical Domains Framework: A scoping review.. Journal of the American Pharmacists Association : JAPhA. PMID: 36371398.

Setting: International – community-pharmacy implementation literature; no single health system.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics – community-pharmacy testing services.. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Of 1,176 documents screened, 39 empirical community-pharmacy studies were included (Abstract/Results, PDF pp. 1, 3). Pre-implementation surveys/interviews/focus groups comprised 56% of studies; 38% were single-cohort feasibility studies (Abstract, PDF p. 1). TDF mapping identified capability ...

[26] Arwood Meghan J, Dietrich Eric A, Duong Benjamin Q et al. (2024). Design and Early Implementation Successes and Challenges of a Pharmacogenetics Consult Clinic.. Journal of clinical medicine. PMID: 32708920.

Setting: United States – University of Florida Health general internal medicine clinic, Gainesville, Florida.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – pharmacist-led outpatient CYP2C19/CYP2D6 consult clinic for antidepressants Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Ninety-one referred patients were seen during the first two years of implementation (Abstract; Results, pp. 7–8). Of patients tested, 77% had at least one CYP2C19 or CYP2D6 phenotype making conventional prescribing unfavorable (Abstract). A medication or dose change was recommended for 59% of ...

[27] Ayati Nayyereh, Afzali Monireh, Hasanzad Mandana et al. (2022). Pharmacogenomics Implementation and Hurdles to Overcome; In the Context of a Developing Country.. Iranian journal of pharmaceutical research : IJPR. PMID: 35194431.

Setting: Iran – national pharmacogenomics and companion-diagnostics implementation context.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics and companion diagnostics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The study combined a scoping review with expert contextualization and cognitive mapping to identify Iran-specific barriers to PGx implementation (pp. 3–5). The identified barriers span rational medicine use, ethical/legal/social issues, guideline development, digital decision support, regulatory ...

[28] B Tata Emiliene, A Ambele Melvin, S Pepper Michael (2020). Barriers to Implementing Clinical Pharmacogenetics Testing in Sub-Saharan Africa. A Critical Review.. Pharmaceutics. PMID: 32858798.

Setting: Sub-Saharan Africa, regional health-system context rather than one evaluated country or programme. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review identifies system-resource limitations, weak PGx evidence generation, technical genotyping issues, and socio-cultural and ethical barriers as major constraints in SSA (“under-resourced clinical care logistics”; Abstract). Digital readiness is a major problem: the paper states EHR ...

[29] Bagher Amina M, Neamatallah Thikryat, Balto Ghadeer et al. (2022). Knowledge, perception, and confidence of hospital pharmacists toward pharmacogenetics in Jeddah, Kingdom of Saudi Arabia.. Saudi pharmaceutical journal : SPJ : the official publication of the Saudi Pharmaceutical PMID: 33603539.

Setting: Saudi Arabia – pharmacists in five randomly selected governmental hospitals in Jeddah.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics – hospital pharmacist readiness for clinical testing implementation.. Domains: Workforce Capability and Change Management. Key findings: The survey included 119 governmental-hospital pharmacists in Jeddah (Abstract; Results, p. 3). Thirty-six pharmacists (30.3%) had PGx-related education/training and 34 (28.6%) had applied PGx testing in practice (Results, p. 3). Lack of proper education/training was the leading stated ...

[30] Balaban Ugur, Kocaaslan Tubanur, Demirkan Kutay (2026). Insights into pharmacogenetic testing in Türkiye: pharmacists' knowledge, attitudes, and perceived barriers to implementation.. Scientific reports. PMID: 42135435.

Setting: Türkiye, pharmacists across community, hospital, academic, and other pharmacy settings. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Finance and Sustainability. Key findings: The cross-sectional survey included 455 pharmacists (Methods/Results, pp. 2–4). Prior PGx education was uncommon (8.8%) and guideline familiarity was low (75.2% poor familiarity) (Results, p. 4). Knowledge gaps, cost, personnel availability, and absent guidelines were the principal reported ...

[31] Balicza Peter, Terebessy Andras, Grosz Zoltan et al. (2022). Implementation of personalized medicine in Central-Eastern Europe: pitfalls and potentials based on citizen's attitude.. The EPMA journal. PMID: 29515690.

Setting: Hungary – participants recruited through a neurogenetic outpatient clinic, public events, social media, and medical education settings.. Design: Survey / cross-sectional. Modality: Genomic genetic testing / NGS. Domains: Patient Access, Equity and Ethics. Key findings: A total of 657 respondents completed the survey (Results, p. 3). Access to physician consultation positively influenced attitudes toward testing (Abstract; Results, pp. 4–5). Genetic familiarity and perceived genetic influence were associated with testing willingness (Abstract; Results, pp. 3–5) ...

[32] Bangash Hana, Sutton Joseph, Gundelach Justin H et al. (2023). Deploying Clinical Decision Support for Familial Hypercholesterolemia.. ACI open. PMID: 36644330.

Setting: United States – Mayo Clinic, Rochester, Minnesota.. Design: Empirical implementation study. Modality: Genomic clinical decision support – familial hypercholesterolemia identification and cascade-care referral.. Domains: Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The algorithm correctly identified all 25 alert-triggering patients and correctly excluded all 25 non-triggering patients in the reported validation subset (Results, PDF p. 4). Provider feedback led to a linked FH Smart Set and iterative redesign of passive and asynchronous CDS formats (Results ...

[33] Bank Paul C D, Swen Jesse J, Guchelaar Henk-Jan (2019). Implementation of Pharmacogenomics in Everyday Clinical Settings.. Advances in pharmacology (San Diego, Calif.). PMID: 29801576.

Setting: Not reported - narrative implementation chapter drawing on international pharmacogenomics examples; authors based at Leiden University Medical Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - pre-emptive and reactive testing integrated into prescribing.. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The chapter organizes implementation challenges around gene/variant selection, diagnostic criteria, therapeutic guidance, clinical evidence, cost-effectiveness, and acceptance (PDF p. 5). Institutional or national electronic medication-surveillance/CDS systems integrating genotype data were already ...

[34] Barajas Megan R, Formea Christine M, McCormick Jennifer B et al. (2019). A patient-centered approach to the development and pilot of a warfarin pharmacogenomics patient education tool for health professionals.. Currents in pharmacy teaching & learning. PMID: 25729462.

Setting: United States - Mayo Clinic thrombophilia anticoagulation clinic.. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics - CYP2C9/VKORC1 warfarin pharmacogenomics patient education.. Domains: Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: Seventeen warfarin patients participated in three focus groups to assess a pharmacogenomics education tool (Methods/Results, pp. 3-4). Participants valued clear, plain-language explanation and reported that the resource was most useful near therapy initiation (Results, pp. 4-6). Feedback led to ...

[35] Basnayake Ralalage Prabhathi, Mitchell Tala, Zammit Claire et al. (2025). Equity in genomic health policies: a review of policies in the international arena.. Frontiers in public health. PMID: 39758206.

Setting: International – review of genomic-health policies across multiple jurisdictions.. Design: Policy analysis. Modality: General/multiple – genomic health policy, mainstream service integration and equitable access.. Domains: Governance and Policy; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review analyzed how equity concepts were represented in 17 genomic-health policies using the EquiFrame approach (Methods/Results, pp. 2–4). Access and participation were unevenly addressed; stronger policies linked equity to mainstream integration, remote access and vulnerable-population ...

[36] Beaudry Felix E G, Li Zhihao, Borgida Ayelet et al. (2025). Molecular Tumor Board-Guided Targeted Treatments for Biliary Tract Cancers in a Publicly Funded Healthcare System.. Current oncology (Toronto, Ont.). PMID: 39996880.

Setting: Canada - University Health Network / Princess Margaret Cancer Centre, Ontario publicly funded healthcare system.. Design: Empirical implementation study. Modality: Precision oncology - whole-genome and transcriptome sequencing with molecular-tumor-board-guided treatment for biliary Domains: Governance and Policy; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Of 55 sequenced patients, 28 (51%) had potentially targetable alterations and the tumor board made treatment recommendations for 43 (78%) (Abstract; Results, PDF pp. 6-7). Eight patients received nine targeted-treatment episodes; none were publicly funded and six used compassionate access (Results ...

[37] Beccia Flavia, Causio Francesco Andrea, Hoxhaj Ilda et al. (2023). Integrating China in the international consortium for personalised medicine. a position paper on healthcare professionals' education and citizens' empowerment in personalised medicine.. BMC medical education. PMID: 37316817.

Setting: China and European policy context – IC2PerMed policy mapping; not a single healthcare delivery system.. Design: Policy analysis. Modality: General/multiple – personalised medicine.. Domains: Governance and Policy; Workforce Capability and Change Management; Patient Access, Equity and Ethics. Key findings: Nine experts completed the Delphi survey and reached consensus on 17 priorities: seven for professional education/curricula and ten for citizen/patient awareness and empowerment (Abstract/Results). The priorities emphasised education, health literacy, collaboration, public trust, and ethical ...

[38] Beccia Flavia, Di Marcantonio Marzia, Causio Francesco Andrea et al. (2024). Integrating China in the International Consortium for Personalised Medicine: a position paper on innovation and digitalization in Personalized Medicine.. BMC public health. PMID: 38355452.

Setting: European Union and China - IC2PerMed policy and innovation context.. Design: Policy analysis. Modality: General/multiple - personalised medicine using ICT, Big Data, digital solutions, and personalised diagnostics.. Domains: Strategic Leadership and Readiness; Governance and Policy; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The project recruited 47 experts (37 EU; 10 China) and conducted a two-round Delphi survey between March and May 2021 (PDF p. 2). Seven priorities reached consensus for Big Data/ICT solutions and 12 for bringing innovation to market (PDF pp. 1, 3). Consensus priorities covered interoperability ...

[39] Berenbrok Lucas A, Hart Kristin M, McGrath Stephanie Harriman et al. (2020). Community pharmacists' educational needs for implementing clinical pharmacogenomic services.. Journal of the American Pharmacists Association : JAPhA. PMID: 31010787.

Setting: United States.. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: Eleven pharmacists from nine pharmacy locations identified five PGx educational-implementation needs (“Eleven pharmacists from 9 unique pharmacy locations”). The five themes were education, active learning, clinical resources, team-based implementation, and expert networks (“categorized into 5 key ...

[40] Bernsen Emma C, Hanff Lidwien M, Kouwenberg Theodorus W et al. (2026). Practical guide to implementing pre-emptive pharmacogenetic screening in routine pediatric oncology care.. Pharmacogenomics. PMID: 42265065.

Setting: Netherlands – Princess Máxima Center for Pediatric Oncology, Utrecht.. Design: Institutional case study. Modality: Pharmacogenomics/pharmacogenetics – preemptive WGS-based pharmacogenetic screening in routine pediatric oncology.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access Key findings: The team previously found that 16% of 1,151 pediatric oncology patients were eligible for genotype-guided dose or treatment modification (Abstract; Introduction, p. 1). The centre moved from limited TPMT/NUDT15/DPYD testing to a seven-gene preemptive panel integrated into routine pediatric oncology ...

[41] Bettio Cinzia, Salsi Valentina, Orsini Mirko et al. (2021). The Italian National Registry for FSHD: an enhanced data integration and an analytics framework towards Smart Health Care and Precision Medicine for a rare disease.. Orphanet journal of rare diseases. PMID: 34736505.

Setting: Italy – Italian Clinical Network for Facioscapulohumeral Dystrophy (FSHD), 14 neuromuscular clinics and the national FSHD Registry.. Design: Institutional case study. Modality: Genomic rare-disease registry and clinical-data integration. Domains: Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The registry integrated 7,197 molecular analyses and 3,577 clinical forms from the Italian FSHD network (p. 1). The platform combined clinical, molecular, and family-pedigree data into a unified virtual schema rather than replacing source databases (p. 2). The authors describe registry data as ...

[42] Blagec Kathrin, Swen Jesse J, Koopmann Rudolf et al. (2022). Pharmacogenomics decision support in the U-PGx project: Results and advice from clinical implementation across seven European countries.. PloS one. PMID: 35675343.

Setting: Europe – Ubiquitous Pharmacogenomics (U-PGx) implementation across seven countries.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – pre-emptive testing with clinical decision support.. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The study reports PGx CDS implementation, uptake/usability indicators, workflow feedback, and implementation experiences across seven European countries (Abstract/Methods). Perceived usefulness of the different CDS tools ranged from 63.6% to 85.2% (Results, p. 2). Institutional factors and ...

[43] Blazy Christopher, Ellingrod Vicki, Ward Kristen (2022). Variability Between Clinical Pharmacogenetics Implementation Consortium (CPIC. Frontiers in pharmacology. PMID: 35814245.

Setting: United States – Michigan Medicine academic health system, Ann Arbor.. Design: Cohort / clinical evaluation. Modality: Pharmacogenomics/pharmacogenetics – CYP2D6/CYP2C19-guided psychotropic prescribing. Domains: Governance and Policy. Key findings: A retrospective review identified 205 patients with commercial psychotropic PGx test results in the EHR (pp. 1–2). Phenotype discordance occurred in 59 patients (28.8%) for CYP2D6 and 66 patients (32.2%) for CYP2C19 (p. 3). Discordance could lead to different CPIC recommendations, particularly for ...

[44] Blout Zawatsky Carrie L, Leonhard Jennifer R, Bell Megan et al. (2024). Workforce Considerations When Building a Precision Medicine Program.. Journal of personalized medicine. PMID: 36422106.

Setting: United States - Sanford Health rural multi-state health system.. Design: Institutional case study. Modality: General/multiple - system-wide pre-emptive pharmacogenomics and medically actionable predisposition screening.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Genetic referrals rose from 1,438 in 2013 to 7,517 in 2020, while genetic-specialist staffing rose 190% from 10.1 to 29.3 FTEs (Abstract; Results, pp. 6-7). Among 11,771 screened patients, 95.0% had at least one atypical PGx finding and 1,764 required pharmacist review of a gene-drug interaction ...

[45] Borobia Alberto M, Dapia Irene, Tong Hoi Y et al. (2019). Clinical Implementation of Pharmacogenetic Testing in a Hospital of the Spanish National Health System: Strategy and Experience Over 3 Years.. Clinical and translational science. PMID: 29193749.

Setting: Spain – La Paz University Hospital, Madrid, within the Spanish National Health System.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: From January 2014 to December 2016, the unit received 2,539 requests; 1,939 were for actionable testing (Results, p. 4). A molecular profile related to the specific test request was observed in 32.1% of patients (Results, p. 4). The global three-year cost to the Spanish NHS was €202,140 (Results ...

[46] Bosic-Reiniger Jade, Martin James L, Brown Karen E et al. (2026). Barriers and facilitators of the use of clinical informatics resources to facilitate pharmacogenomic implementation in resource-limited settings.. JAMIA open. PMID: 39399271.

Setting: United States – rural and underserved health systems in Montana and Colorado.. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The study interviewed 24 clinical informaticists and executive leaders: 15 in Montana and nine in Colorado (Abstract; Methods, pp. 1–2). Three themes emerged: EHR infrastructure limitations, insufficient supporting resources, and unique contextual considerations (Results, p. 3). Key informatics ...

[47] Bottazzi Silvia, Chiloiro Giuditta, Russo Luca et al. (2025). Personalised medicine through AI-enhanced integration of diagnostic imaging and radiation therapy.. European radiology experimental. PMID: 41428013.

Setting: Not reported – narrative, cross-institutional precision-radiotherapy context.. Design: Framework / perspective. Modality: Multimodal precision oncology – AI-enhanced imaging, radiotherapy, clinical, genomic and pathology data. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The paper organizes its future implementation model into three steps: reorganization of the patient care journey, longitudinal imaging integrated with radiotherapy, and incorporation of biomarkers into clinical decision support (p. 1). AI is described as a means to integrate imaging, clinical ...

[48] Brandl Emily, Halford Zachery, Clark Matthew D et al. (2021). Pharmacogenomics in Pain Management: A Review of Relevant Gene-Drug Associations and Clinical Considerations.. The Annals of pharmacotherapy. PMID: 33771051.

Setting: United States - clinical pain-management context; no single evaluated health system.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - pain management and opioid-use-disorder pharmacotherapy.. Domains: Workforce Capability and Change Management; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review notes that few practices had integrated PGx testing into initial pain-management workups (Future directions, p. 1497). Evidence derived from selected trial populations may not directly generalize to complex pain-management patients (Relevance, p. 1497). Drug-gene decisions should use ...

[49] Bright David, Petry Natasha, Roath Eric et al. (2021). Barriers, solutions, and effect of using pharmacogenomics data to support opioid prescribing.. Journal of managed care & specialty pharmacy. PMID: 33252002.

Setting: United States - proposed state prescription-drug-monitoring programme (PDMP) and EHR integration context.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - CYP2D6-informed opioid prescribing through PDMP and EHR data sharing.. Domains: Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The paper documents PDMPs as established state-run controlled-substance databases with existing clinician/pharmacy access (PDF p. 2). A PDMP-linked PGx architecture should use standardized, actionable phenotype fields and clinical decision support (PDF pp. 2-4). Policymakers should address privacy ...

[50] Brown Jacob T, Ramsey Laura B, Van Driest Sara L et al. (2021). Characterizing Pharmacogenetic Testing Among Children's Hospitals.. Clinical and translational science. PMID: 33325650.

Setting: United States - Children's Hospital Association member hospitals.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics - pediatric hospital testing, reporting, and result integration.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Key findings: Detailed survey responses were obtained from 14 Children's Hospital Association institutions, with 11 complete and three partial responses (Abstract, PDF p. 1). Financial barriers were the most commonly cited, while low-use sites had higher perceived workforce and interpretation barriers (Abstract ...

[51] Brown-Johnson Cati G, Safaeinili Nadia, Baratta Juliana et al. (2021). Implementation outcomes of Humanwide: integrated precision health in team-based family practice primary care.. BMC family practice. PMID: 33530939.

Setting: United States. Design: Mixed-methods. Modality: General/multiple: pharmacogenomics/pharmacogenetics, genetic screening/testing, digital-health tools, and health Domains: Strategic Leadership and Readiness; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Only 21 of 50 patients received all four components, despite component uptake ranging from 64% to 94% (“Overall 42%”; Table 2).

Pharmacogenomic findings produced 18 medication-management changes among 11 patients (“7 dose changes, 4 medication changes”). Implementation feasibility depended on ...

[52] Bruno Debora S, Mirsky Matthew M, Donner Andrea L et al. (2026). Implementing a Precision Medicine Thoracic Service Using In-House Reflex Testing in a Large Academic-Community Practice.. Chest. PMID: 40912295.

Setting: United States – University Hospitals/Seidman Cancer Center academic-community practice, including 19 community cancer centres and an academic centre.. Design: Empirical implementation study. Modality: Biomarker-guided precision oncology – in-house reflex NGS and PD-L1 testing for stage IV non-small-cell lung cancer.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: NGS testing increased from 60.8% before implementation to 91.3% after PREDICT launch ($P < .0001$) (Abstract). Median biopsy-to-result turnaround decreased from 18 to 12 days for NGS and from 10 to 7 days for PD-L1 testing ($P < .0001$ for both) (Abstract). Actionable genomic alterations increased from ...

[53] Bupp Caleb P, Ames Elizabeth G, Arenchild Madison K et al. (2023). Breaking Barriers to Rapid Whole Genome Sequencing in Pediatrics: Michigan's Project Baby Deer.. Children (Basel, Switzerland). PMID: 36670656.

Setting: United States – Michigan statewide pediatric inpatient implementation across seven hospitals.. Design: Empirical implementation study. Modality: Genomic diagnosis – rapid whole genome sequencing (rWGS) for critically ill pediatric inpatients. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: Seven Michigan hospitals were onboarded by May 2022 (p. 6). After 18 months, 89 children had received rWGS; 64 clinical-impact surveys were returned, with a 39% diagnostic rate and 27% change-in-management rate (pp. 6–7). The economic analysis estimated a net saving of \$4,155.13 per patient under ...

[54] Calabrò Giovanna Elisa, Tognetto Alessia, Mazzaccara Alfonso et al. (2024). Capacity Building of Health Professionals on Genetics and Genomics Practice: Evaluation of the Effectiveness of a Distance Learning Training Course for Italian Physicians.. Frontiers in genetics. PMID: 33790945.

Setting: Italy – national Ministry of Health-supported distance-learning course for physicians.. Design: Empirical implementation study. Modality: General/multiple genomic medicine – genetic/genomic testing, pharmacogenetics, and oncogenomics.. Domains: Workforce Capability and Change Management. Key findings: 1,637 physicians completed the training course; primary-care physicians, public-health physicians, and pediatricians were prominent participant groups (Results, Table 2, PDF pp. 4–5). Mean knowledge increased from 59.46 before the course to 71.42 afterward ($p < 0.0001$) (Results, Table 4, PDF p. 6) ...

[55] Canedo Juan R, Wilkins Consuelo H, Senft Nicole et al. (2020). Barriers and facilitators to dissemination and adoption of precision medicine among Hispanics/Latinos.. BMC public health. PMID: 32357943.

Setting: United States – Hispanic/Latino communities in Nashville, Tennessee; community and healthcare-access context.. Design: Qualitative study. Modality: General/multiple precision medicine and genomic medicine. Domains: Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Six focus groups with 41 Hispanic/Latino adults identified financial, language, trust, immigration, and privacy concerns as major barriers to adoption. Participants preferred culturally and linguistically tailored education and trusted-community engagement. Precision-medicine dissemination should ...

[56] Caraballo Pedro J, Hodge Lucy S, Bielinski Suzette J et al. (2018). Multidisciplinary model to implement pharmacogenomics at the point of care.. Genetics in medicine : official journal of the American College of Medical Genetics. PMID: 27657685.

Setting: United States – Mayo Clinic, Rochester, Minnesota.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Between August 2012 and June 2015, the governance team reviewed 21 drug–gene interactions and implemented 18 as EHR CDS interventions (Abstract; Results, p. 6). CDS production time ranged from 98 to 392 days, with implementation delay of 0 to 148 days (Abstract, p. 2). CDS interventions reached ...

[57] Caraballo Pedro J, Sutton Joseph A, Giri Jyothsna et al. (2021). Integrating pharmacogenomics into the electronic health record by implementing genomic indicators.. Journal of the American Medical Informatics Association : JAMIA. PMID: 31591640.

Setting: United States, Mayo Clinic in Rochester, Minnesota. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy;

Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The program implemented 190,433 genomic indicators for 20,816 patients (Results, p. 4). Three EHRs and three laboratory interfaces contributed data to the implementation process (Results, p. 4). Technical data-quality remediation was substantial: 15,504 retransmissions and 4,681 manual corrections ...

[58] Carstens Nadia, Mudau Maria, Essop Fahmida et al. (2026). Implementation of an Inherited Diseases Gene Panel to Accelerate Precision Medicine in the South African Public Healthcare System.. Molecular genetics & genomic medicine. PMID: 41952431.

Setting: South Africa – state/public healthcare system, including National Health Laboratory Service-linked genetics services.. Design: Empirical implementation study. Modality: Genomic diagnosis / hereditary disease gene-panel testing. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: A 500-gene inherited-disease panel was developed, validated and implemented within the South African state healthcare system (p. 1). Among 276 patients tested in the validation phase, 127 (46%) received a molecular diagnosis (p. 1). High coverage reduced the need for additional validation testing ...

[59] Caudle Kelly E, Dunnenberger Henry M, Freimuth Robert R et al. (2017). Standardizing terms for clinical pharmacogenetic test results: consensus terms from the Clinical Pharmacogenetics Implementation Consortium (CPIC).. Genetics in medicine : official journal of the American College of Medical Genetics. PMID: 27441996.

Setting: Not reported - international CPIC/clinical-laboratory consensus; no single evaluated health system.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - standardized laboratory result terminology for EHR decision support.. Domains: Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Consensus was reached on all allele-function terms and on 91.7% of proposed phenotype terms (Results, PDF pp. 4-6). The terminology was registered as LOINC answer lists to support structured reporting (Discussion, PDF p. 7). Laboratories and health systems should use standardized result terminology ...

[60] Caudle Kelly E, Gammal Roseann S, Whirl-Carrillo Michelle et al. (2018). Evidence and resources to implement pharmacogenetic knowledge for precision medicine.. American journal of health-system pharmacy : AJHP : official journal of the American PMID: 27864205.

Setting: International pharmacogenetic implementation resource context. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: The paper describes CPIC and PharmGKB resources developed to support implementation of pharmacogenetic knowledge in practice (Review). It identifies evidence appraisal, guideline development and clinician-facing resources as critical translation mechanisms (Review). Health systems should use ...

[61] Caudle Kelly E, Keeling Nicholas J, Klein Teri E et al. (2019). Standardization can accelerate the adoption of pharmacogenomics: current status and the path forward.. Pharmacogenomics. PMID: 29914287.

Setting: Not reported. International pharmacogenomics implementation context.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The paper identifies laboratory, ordering, reporting, EHR, workflow, and reimbursement standardization as linked prerequisites for wider PGx adoption (Abstract; Tables 1–2). Table 1 details laboratory-standardization elements, while Table 2 outlines clinical-ordering and reimbursement ...

[62] Causio Francesco Andrea, Farina Sara, Maio Alessandra et al. (2025). The italian national genomic strategy: current status, challenges, and future perspectives in clinical practice and public health.. Journal of community genetics. PMID: 41082076.

Setting: Italy – national genomic strategy and Italian National Health Service/public-health context.. Design: Policy analysis. Modality: General/multiple – national genomic medicine, clinical testing, data infrastructure and public-health genomics.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: Italy's policy trajectory includes public-health genomics guidelines, an omics-healthcare innovation plan and the National Genomics Plan (Introduction, pp. 1–2). The national initiative organized genomic strategy into domains including governance, clinical practice, centres, data infrastructure ...

[63] Cavallari Larisa H, Lee Craig R, Duarte Julio D et al. (2018). Implementation of inpatient models of pharmacogenetics programs.. American journal of health-system pharmacy : AJHP : official journal of the American PMID: 27864202.

Setting: United States - review of inpatient pharmacogenetics programmes. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - inpatient services. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The paper describes three inpatient pharmacogenetics programme models in the United States (Review). Common implementation components were pharmacy leadership, institutional approval, evidence review, education, EHR/CDS and consultation services (Review). Inpatient programmes should select a ...

[64] Cavallari Larisa H, Hicks J Kevin, Patel Jai N et al. (2024). The Pharmacogenomics Global Research Network Implementation Working Group: global collaboration to advance pharmacogenetic implementation.. Pharmacogenetics and genomics. PMID: 39485373.

Setting: Global – 39 PGRN Implementation Working Group institutions responding from 54 contacted institutions; 31 US and eight non-US sites. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics – multi- and single-gene implementation across clinical settings. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: Thirty-nine of 54 institutions returned the survey (72%); 35 of 39 had clinically implemented PGx testing (pp. 5–6). Of 35 implementing sites, 46% used both single- and multigene testing, 40% multigene only, and 14% single-gene only (p. 5). CYP2C19–clopidogrel was implemented by 83% of sites; 92% ...

[65] Chahal C Anwar A, Alahdab Fares, Asatryan Babken et al. (2025). Data Interoperability and Harmonization in Cardiovascular Genomic and Precision Medicine.. Circulation. Genomic and precision medicine. PMID: 40340425.

Setting: International - cardiovascular genomic and precision-medicine data-infrastructure context; no single evaluated health system.. Design: Framework / perspective. Modality: Cardiovascular genomics / precision medicine - interoperable EHR, omics, and AI data systems.. Domains: Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The review identifies data fragmentation, weak interoperability, governance, and inequitable representation as linked barriers to cardiovascular precision medicine (Abstract; PDF pp. 15-16). FAIR-aligned standards, ontologies, and common data models are presented as core components of harmonized ...

[66] Chan Christopher Yi Wen, Chua Boon Yiang, Subramaniam Mythily et al. (2017). Clinicians' perceptions of pharmacogenomics use in psychiatry.. Pharmacogenomics. PMID: 28290747.

Setting: Singapore - Institute of Mental Health and national psychiatry clinical workforce.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics - psychiatric prescribing.. Domains: Governance and Policy; Workforce Capability and Change Management; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: One hundred ninety-four clinicians responded (50.5%): 167 doctors and 27 pharmacists (Results, p. 532). 94.3% named cost and 84.5% lack of clear guidelines as risks; only 49.3-59.3% felt competent across testing tasks (pp. 532-533). 98.5% wanted further education, with lectures the most preferred ...

[67] Chan Mei-Yoke (2026). Ethical Issues in Pediatric Precision Oncology in Singapore.. Asian bioethics review. PMID: 40225799.

Setting: Singapore – pediatric precision-oncology clinical-care and national policy context.. Design: Framework / perspective. Modality: Precision oncology – pediatric tumor/germline sequencing and genomically guided targeted therapies.. Domains: Governance and Policy; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The perspective identifies consent, the clinical–research boundary, resource utility and justice as central implementation issues in pediatric precision oncology (Abstract, pp. 1, 3–10). Novel therapies may be accessed on compassionate/expanded-access bases in Singapore, with cost and eligibility ...

[68] Chanfreau-Coffinier Catherine, Peredo Jane, Russell Marcia M et al. (2020). A logic model for precision medicine implementation informed by stakeholder views and implementation science.. Genetics in medicine : official journal of the American College of Medical Genetics. PMID: 30353149.

Setting: United States – Veterans Health Administration context, intended for VHA and other healthcare organizations. Design: Framework / perspective. Modality: General/multiple precision medicine – genomic and other precision-medicine applications. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: Eighty stakeholders contributed qualitative conference data to a context-specific logic model for precision-medicine implementation (Abstract; Methods). The logic

model includes clinical/research/IT infrastructure, data analytics, workforce and funding inputs; research, practice, and education ...

[69] Chang Wan-Chun, Tanoshima Reo, Ross Colin J D et al. (2021). Challenges and Opportunities in Implementing Pharmacogenetic Testing in Clinical Settings.. Annual review of pharmacology and toxicology. PMID: 33006916.

Setting: International clinical pharmacogenetics implementation context. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: The review describes expanding implementation of pharmacogenetic biomarkers alongside persistent evidence, education, informatics and reimbursement barriers (Abstract/Review). Services should align testing strategy, evidence review, result communication, EHR/CDS and education before scaling ...

[70] Chase Dian A, Baron Sherry, Ash Joan S (2018). Clinical Decision Support and Primary Care Acceptance of Genomic Medicine.. Studies in health technology and informatics. PMID: 29295188.

Setting: United States - five primary-care sites across community, regional, and academic organizations using different EHR vendors.. Design: Qualitative study. Modality: General/multiple - genomic/pharmacogenomic clinical decision support in primary care.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The qualitative study purposively sampled five US primary-care sites with varied sizes, patients, and EHR vendors, interviewing an average of seven clinicians per site (Abstract/Methods, PDF p. 1). Clinicians assigned low priority to incorporating pharmacogenomics and reported unfamiliarity ...

[71] Chen Yi-Ming, Hsiao Tzu-Hung, Lin Ching-Heng et al. (2025). Unlocking precision medicine: clinical applications of integrating health records, genetics, and immunology through artificial intelligence.. Journal of biomedical science. PMID: 39915780.

Setting: This is not a primary implementation study and does not evaluate a deployed PGx service. It is eligible only because its explicit purpose is to Design: Framework / perspective. Modality: Multimodal (genomic+imaging+clinical), integrating EHRs, genetics, immunology, and AI/ML. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: The proposed architecture links EHRs, genetic analysis, and immunological profiles to an AI-processing layer, producing disease-risk prediction, treatment optimisation, and patient monitoring outputs (Figure 1, page 3). The paper defines four operational data-preparation stages: collection ...

[72] Chenchula Santenna, Atal Shubham, Jhaj Ratinder et al. (2024). Implementing pharmacogenetic testing to optimize proton-pump inhibitors use among Indian population based on CPIC-CYP2C19-PPI dosing guidelines: The need of the hour.. Indian journal of pharmacology. PMID: 39250625.

Setting: India, national implementation context for CYP2C19-guided. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The paper states that India lacks definitive country-specific PGx policies and regulatory guidelines, leaving clinicians to rely on CPIC guidance and drug labels (“rely on PGx guidelines”; page 3). It identifies infrastructure, affordability, access, workforce, data systems, and population genetic ...

[73] Cho Ha Na, Shin Soo Yong, Hwangbo Bin et al. (2020). Views on Precision Medicine among Health Professionals in Korea: A Mixed Methods Study.. Yonsei medical journal. PMID: 31997629.

Setting: South Korea - National Cancer Center and Korean health-professional survey context.. Design: Mixed-methods. Modality: General/multiple - precision medicine, predominantly precision oncology and genetic-data-enabled care.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Six experts participated in a focus group and 526 health professionals completed the survey (Methods/Results, pp. 2-4). About 96% expected precision medicine to improve treatment and 94.9% expected more precise diagnosis (Table 3, pp. 3-4). Qualitative participants identified cost, access inequity ...

[74] Chong Huey Yi, Allotey Pascale A, Chaiyakunapruk Nathorn (2019). Current landscape of personalized medicine adoption and implementation in Southeast Asia.. BMC medical genomics. PMID: 30367635.

Setting: Indonesia, Malaysia, Singapore, and Thailand – Southeast Asian healthcare-system contexts.. Design: Mixed-methods. Modality: General/multiple – personalised medicine programmes including pharmacogenomics, companion diagnostics, genomic Domains: Strategic Leadership and Readiness; Governance and Policy;

Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The study combined a scoping review with stakeholder interviews in four Southeast Asian countries and evaluated six programmes for financing and implementation mechanisms (Abstract/Methods). Singapore and Thailand had progressed further in adoption, but policies, funding, and programme arrangements ...

[75] Cicali Emily J, Weitzel Kristin Wiisanen, Elsey Amanda R et al. (2020). Challenges and lessons learned from clinical pharmacogenetic implementation of multiple gene-drug pairs across ambulatory care settings.. Genetics in medicine : official journal of the American College of Medical Genetics. PMID: 30926959.

Setting: United States – University of Florida Health ambulatory care settings and collaborating clinics.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – CYP2D6-opioids, CYP2D6/CYP2C19-SSRIs, and CYP2C19-proton-pump inhibitors.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: UF Health had clinically implemented six gene–drug pairs; this paper reports challenges and lessons from implementation of three pairs across ambulatory settings (Abstract). The six pragmatic trials had enrollment periods of 5–28 months and compared genotype-guided with usual care in opioid, SSRI ...

[76] Cicali Emily J, Lemke Lauren, Al Alshaykh Hana et al. (2023). How to Implement a Pharmacogenetics Service at your Institution.. Journal of the American College of Clinical Pharmacy : JACCP. PMID: 36589694.

Setting: United States – institution-level implementation guide drawing on University of Florida Health and other early-adopter pharmacogenetics programs.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics – institution-wide pharmacogenetic service implementation.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The paper synthesizes early-adopter lessons into seven decision domains for implementation (Guiding principles, p. 2). Most established implementation programs used pharmacist leadership or participation within multidisciplinary teams (Abstract; pp. 1–2). A scoping review cited in the paper found ...

[77] Cicali Emily J, Eddy Elizabeth, Gong Yan et al. (2024). Implementation of a pharmacogenetic panel-based test for pharmacotherapy-based supportive care in an adult oncology clinic.. Clinical and translational science. PMID: 39046302.

Setting: United States – adult oncology clinic at the University of Florida Health Cancer Center.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics for supportive-care pharmacotherapy in adult oncology. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Of 1,734 screened patients, 150 were randomized and 127 of 144 eligible patients completed PGx testing. Cost exposure materially influenced testing uptake: insurance-billed testing had substantially higher refusal than study-funded testing. Twenty alerts were generated for five patients, and three ...

[78] Cinti Caterina, Trivella Maria Giovanna, Joulie Michael et al. (2024). The Roadmap toward Personalized Medicine: Challenges and Opportunities.. Journal of personalized medicine. PMID: 38929767.

Setting: International/European personalized-medicine policy and healthcare-system context. Design: Framework / perspective. Modality: General/multiple personalized medicine. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The ICPeMed working group identified eight major facilitators for personalized-medicine implementation (Fig. 1, pp. 3–4). The framework maps access risks linked to digital divide, cultural differences, urban–rural density, workforce retention, care continuity, and interdisciplinary integration ...

[79] Claw Katrina G, Dorr Casey R, Woodahl Erica L (2024). Implementing community-engaged pharmacogenomics in Indigenous communities.. Nature communications. PMID: 38296967.

Setting: United States – American Indian and Alaska Native community and tribal-health-system implementation context; implications may extend to other Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics – community-engaged testing and population-specific medication guidance.. Domains: Governance and Policy; Workforce Capability and Change Management; Patient Access, Equity and Ethics. Key findings: The commentary describes shared Indigenous concerns around research oversight, tribal sovereignty, data/biospecimen storage and culturally appropriate research (p. 1). It highlights examples in which population-specific PGx variation has implications for drug selection and dosing (pp. 2–4). PGx ...

[80] Cohen-Kfir Nehama, Bentwich Miriam Ethel, Kent Andrew et al. (2021). Challenges to effective and autonomous genetic testing and counseling for ethno-cultural minorities: a qualitative study.. BMC medical ethics. PMID: 33059675.

Setting: Israel - prenatal genetic-testing and counseling services for Arab Muslim, Christian, and Druze minority communities in the Acre district.. Design: Qualitative study. Modality: Genetic testing and counseling - prenatal genetic services.. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The study interviewed 18 women from three Arab religious subgroups and held focus groups with 16 local healthcare providers (Abstract; Methods, pp. 1-4). Lack of understanding of counseling goals was associated with negative views of testing and counseling across groups (Abstract; Results, pp ...

[81] Cohn Iris, Manshaei Roozbeh, Liston Eriskay et al. (2022). Assessment of the Implementation of Pharmacogenomic Testing in a Pediatric Tertiary Care Setting.. JAMA network open. PMID: 34037732.

Setting: Canada – The Hospital for Sick Children, Toronto, a pediatric tertiary-care hospital.. Design: Cohort / clinical evaluation. Modality: Pharmacogenomics/pharmacogenetics – point-of-care targeted testing and whole-genome-sequencing-guided pre-emptive Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: 172 children were enrolled: 57 in the point-of-care cohort and 115 in the whole-genome-sequencing-guided pre-emptive cohort (Abstract). Standard therapy was genetically incompatible for 21 of 57 point-of-care patients (36.8%) and 92 of 115 pre-emptive patients (80.0%) (Abstract). The authors ...

[82] Coumau Aude, Coumau Claire, Csajka Chantal (2025). Implementing pharmacogenetic testing in community pharmacy practice: a scoping review.. Frontiers in pharmacology. PMID: 41059196.

Setting: Multiple countries - community pharmacy studies, including Netherlands, Canada, United States, Switzerland, and others.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics - community pharmacy-based testing and counselling.. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review identified 935 records, reviewed 20 full texts, and included 17 community-pharmacy implementation studies (PDF p. 4). The review synthesized feasibility, appropriateness, adoption, acceptability, cost, penetration, and sustainability using Proctor implementation outcomes (PDF pp. 3, 7) ...

[83] Crimini Edoardo, Repetto Matteo, Tarantino Paolo et al. (2023). Challenges and Obstacles in Applying Therapeutical Indications Formulated in Molecular Tumor Boards.. Cancers. PMID: 35804968.

Setting: International molecular-tumor-board literature; no single evaluated health system.. Design: Framework / perspective. Modality: Precision oncology – molecular tumor boards using NGS-informed matched therapy.. Domains: Governance and Policy; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review reports a mean MTB turnaround time of 38.4 days in the cited systematic review, compared with a proposed 28-day target (PDF p. 3). Seventy-four percent of recommendations in one cited Freiburg MTB experience were off-label (PDF p. 3). The review identifies drug access as the most ...

[84] Crown Natalie, Sproule Beth A, Luke Miles J et al. (2020). A Continuing Professional Development Program for Pharmacists Implementing Pharmacogenomics into Practice.. Pharmacy (Basel, Switzerland). PMID: 32231164.

Setting: Canada – Ontario community pharmacies and interprofessional primary-care clinics.. Design: Mixed-methods. Modality: Pharmacogenomics/pharmacogenetics – pharmacist-led primary-care testing service. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: Twenty-one of 26 pharmacists completed the programme and most achieved at least 80% on the post-training knowledge assessment (Abstract; Results, pp. 6–7). Pre/post surveys showed increased perceived knowledge, competence, readiness, and comfort using PGx in practice (pp. 7–8). Fifteen pharmacists ...

[85] Dalton W Brian, Forde Patrick M, Kang Hyunseok et al. (2022). Personalized Medicine in the Oncology Clinic: Implementation and Outcomes of the Johns Hopkins Molecular Tumor Board.. JCO precision oncology. PMID: 30003184.

Setting: United States – Sidney Kimmel Comprehensive Cancer Center at Johns Hopkins, Baltimore, Maryland.. Design: Institutional case study. Modality: Biomarker-guided precision oncology – multidisciplinary molecular tumour board for interpretation of tumour genomic Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The tumour board reviewed 155 consecutive referrals and identified actionable genomic alterations in 132 patients (85%) (Abstract). Off-label targeted therapy was recommended for 37 patients; 11 patients received off-label treatment and 13 enrolled on matched targeted-therapy trials (Abstract) ...

[86] Darabi Sourat, Braxton David, Homer Jeanne et al. (2022). Programmatic Efforts Increase Adoption of Genomic Precision Medicine in Cancer Care in a Community Cancer Center.. JCO precision oncology. PMID: 35731999.

Setting: United States - tertiary-referral community cancer center.. Design: Empirical implementation study. Modality: Precision oncology - somatic and germline NGS supported by a multidisciplinary precision-medicine programme.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: The programme reviewed 3,131 tumor samples; annual reviewed cases rose from 661 to 1,532 (Results, pp. 3-4). The team made recommendations beyond commercial laboratory reports in 42.9% of cases (Results, p. 3). Process improvements reduced insufficient-DNA samples to 3.3% and mean order-to-report ...

[87] David Sean P, Dunnenberger Henry M, Choi Sarah et al. (2024). Personalized medicine in a community health system: the NorthShore experience.. Frontiers in genetics. PMID: 38090148.

Setting: United States, NorthShore University HealthSystem / NorthShore Connect integrated community health system in the Chicago area. Design: Institutional case study. Modality: General/multiple – genomic screening, pharmacogenomics, hereditary risk assessment, and biobank-supported precision Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The health system screened more than 225,000 patients and conducted clinical testing in more than 35,000 people (Abstract, p. 1). More than 33,000 patients had pharmacogenomic data available in the EHR and more than 390 PGx CDS rules had been developed as of August 2023 (EHR integration, p. 4) ...

[88] de Belvis Antonio Giulio, Pellegrino Rossella, Castagna Carolina et al. (2023). Success Factors and Barriers in Combining Personalized Medicine and Patient Centered Care in Breast Cancer. Results from a Systematic Review and Proposal of Conceptual Framework.. Journal of personalized medicine. PMID: 34357121.

Setting: Not reported – systematic review of 25 breast-cancer publications from varied countries and settings.. Design: Systematic / scoping review. Modality: Genomic cancer-risk/hereditary and precision oncology (breast cancer). Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review screened 1,885 records and included 25 publications (Results, p. 3). Eleven of 25 articles reported personalized-medicine treatment dimensions; five of 25 addressed patient-centered-care dimensions (Results, pp. 5–6). Seven articles highlighted multidisciplinary approaches, including ...

[89] De Brabander Emma Y, Leibold Nicole K, van Amelsvoort Therese et al. (2026). Knowledge and Attitudes Regarding Pharmacogenetics of Pharmacists in the Netherlands: A National Online Survey Study.. Journal of evaluation in clinical practice. PMID: 41764771.

Setting: Netherlands - nationally recruited pharmacists and pharmacy students across Dutch practice settings.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics.. Domains: Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The national online survey analysed 281 respondents; 44.4% had requested a pharmacogenetic test and 88.6% had interpreted results (Abstract, PDF p. 1). Cost, insurance reimbursement, and guideline availability were identified as key barriers (Abstract/Results, PDF pp. 1, 4-7). Knowledge and ...

[90] de Oliveira Thais C, Lopes-Cendes Iscia (2025). Population molecular genetics in Brazil: From genomic databases and research to the implementation of precision medicine.. Journal of community genetics. PMID: 39557816.

Setting: Brazil - Unified Health System (SUS) and national genomic/precision-medicine initiatives.. Design: Framework / perspective. Modality: General/multiple - population genomics and genetic/genomic testing in SUS.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review identifies national data representation, infrastructure, workforce, financing, and equitable access as interrelated barriers (pp. 412-416). Policy developments included rare-disease referral-center accreditation, WES coverage for unexplained intellectual disability, and BRCA/tumor-test ...

[91] de Vries Jeroen K, Levin Adeera, Loud Fiona et al. (2019). Implementing personalized medicine in diabetic kidney disease: Stakeholders' perspectives.. Diabetes, obesity & metabolism. PMID: 30294955.

Setting: International stakeholder perspective - diabetic kidney disease implementation context. Design: Framework / perspective. Modality: General/multiple - risk stratification and personalized treatment in diabetic kidney disease. Domains: Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The paper identifies guideline integration, economic evaluation, patient context and global access as core

conditions for applying personalized medicine in diabetic kidney disease (Abstract). New diagnostic and treatment options should be assessed together with downstream complications and resource ...

[92] De Wachter Matthias, Schoonjans An-Sofie, Weckhuysen Sarah et al. (2024). From diagnosis to treatment in genetic epilepsies: Implementation of precision medicine in real-world clinical practice.. European journal of paediatric neurology : EJPN : official journal of the European PMID: 38039826.

Setting: Belgium – Antwerp University Hospital and affiliated Centre of Medical Genetics.. Design: Cohort / clinical evaluation. Modality: Rare-disease genomic diagnostics and precision medicine – whole-exome sequencing in genetic epilepsies. Domains: Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Of 247 patients undergoing whole-exome sequencing, 34 received a molecular diagnosis (14%) (Results, p. 3). Precision-medicine options were identified for 20 of 34 diagnosed patients, but were implemented for only 11 patients (Abstract; Results, pp. 3–4). Reimbursement and access were major reasons ...

[93] Delgado-Coka Lyanne A, Roa-Peña Lucia, Flescher Andrew et al. (2025). Advancing Precision Medicine in PDAC: An Ethical Scoping Review and Call to Action for IHC Implementation.. Cancers. PMID: 40563550.

Setting: Not reported – global pancreatic-cancer precision-oncology context.. Design: Systematic / scoping review. Modality: Biomarker-guided precision oncology – immunohistochemistry (IHC) molecular subtyping in pancreatic ductal adenocarcinoma. Domains: Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The scoping review screened 130 references, reviewed 79 full texts and included 9 studies in its final analysis (p. 1). The authors position IHC as a lower-resource companion-diagnostic option relative to costly, specialized molecular subtyping technologies (pp. 1, 13). The review identifies ...

[94] Doll Bruce, De Castro Mauricio J, Fries Melissa H et al. (2022). Precision Medicine-A Demand Signal for Genomics Education.. Military medicine. PMID: 34967402.

Setting: United States – Department of Defense/Military Health System genomics and precision-medicine education context.. Design: Framework / perspective. Modality: General/multiple precision medicine and genomics education. Domains: Workforce Capability and Change Management. Key findings: The paper identifies a growing demand signal for genomics education as precision medicine expands within the Military Health System. Health-system education should integrate genomics competencies into undergraduate, graduate, and continuing professional development. Training should be role-specific ...

[95] Dong Olivia M, Wiltshire Tim (2018). Advancing precision medicine in healthcare: addressing implementation challenges to increase pharmacogenetic testing in the clinical setting.. Physiological genomics. PMID: 28550089.

Setting: United States - clinical pharmacogenetic testing implementation context. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The paper identifies evidence, reimbursement, education, informatics and workflow as recurring barriers to clinical pharmacogenetic testing (Review). Health systems should pair testing with guideline-based recommendations, education and CDS rather than treat testing as a stand-alone intervention ...

[96] Dopazo Joaquín, Maya-Miles Douglas, García Federico et al. (2023). Implementing Personalized Medicine in COVID-19 in Andalusia: An Opportunity to Transform the Healthcare System.. Journal of personalized medicine. PMID: 34073493.

Setting: Spain – Andalusia, within the public Andalusian Health System and regional government infrastructure.. Design: Framework / perspective. Modality: General/multiple (human genomics, viral genomics, clinical data, surveillance, and AI-enabled precision medicine). Domains: Strategic Leadership and Readiness; Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The Andalusian SARS-CoV-2 genomic surveillance project engaged 16 tertiary hospitals and three sequencing research centers (p. 11). More than 2,000 whole viral genomes had been sequenced since February 2021 (p. 12). The BPS linked clinical data and viral genomes to support secondary studies and ...

[97] Dreikorn Erika N, Sacchi Seth, Riden Katherine et al. (2025). Understanding clinician support preferences related to the use of pharmacogenomic results in electronic health records: A qualitative study in an academic health system.. Journal of the American Pharmacists Association : JAPhA. PMID: 40865680.

Setting: United States – large academic health system in Western Pennsylvania.. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics – clinician support preferences for integrating PGx results into the EHR.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability;

Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: Sixteen clinician interviews generated seven themes: contextualized utility, confidence, consults, resulting/alerting, communication, decelerators, and education preferences (Abstract; Results, pp. 2–3). Participants consistently requested simplified workflows, specialty-specific training, embedded ...

[98] Duarte Flavia A, Ferreira Carlos Gil, Dienstmann Rodrigo et al. (2022). Barriers in precision medicine implementation among Advanced Nonsquamous Cell Lung Cancer-patients: A Real-World Evidence Scenario.. Journal of market access & health policy. PMID: 36353186.

Setting: Brazil – private referral oncology center within the Oncoclínicas group.. Design: Cohort / clinical evaluation. Modality: Precision oncology – molecular testing for advanced nonsquamous NSCLC (EGFR, ALK, ROS1, BRAF, KRAS, and PD-L1).. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: In 78 patients, median time from advanced diagnosis to molecular-profile characterization was 40.5 days; diagnosis to request was 29 days versus 12 days from request to result (Results, PDF p. 1). Of 71 patients receiving systemic therapy, 36 (51%) started treatment before driver-panel results; 15 ...

[99] Duarte Julio D, Dalton Rachel, Elchynski Amanda L et al. (2022). Multisite investigation of strategies for the clinical implementation of pre-emptive pharmacogenetic testing.. Genetics in medicine : official journal of the American College of Medical Genetics. PMID: 34282303.

Setting: United States – 15 early-adopter institutions affiliated with the IGNITE Pharmacogenetics Working Group; “institutions across the United States” Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: Fifteen institutions completed the survey, representing more than 60% of affiliated IGNITE PGx Working Group institutions (Results, p. 5). Table 1 identifies eight institutions using a fully preemptive strategy, five using partially preemptive testing, and two using reactive testing with planned ...

[100] Dunnenberger Henry M, Crews Kristine R, Hoffman James M et al. (2015). Preemptive clinical pharmacogenetics implementation: current programs in five US medical centers.. Annual review of pharmacology and toxicology. PMID: 25292429.

Setting: United States - five medical centers and additional early-adopter health-system programmes.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - pre-emptive multi-gene clinical testing.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The review describes current pre-emptive PGx programmes at five US medical centers and their implementation components (PDF pp. 7-11). St Jude and Vanderbilt examples reported high exposure to pharmacogenetically high-risk drugs, supporting a pre-emptive model (PDF p. 3). Vanderbilt reported ...

[101] Duong Benjamin Q, Arwood Meghan J, Hicks J Kevin et al. (2022). Development of Customizable Implementation Guides to Support Clinical Adoption of Pharmacogenomics: Experiences of the Implementing GeNomics In pracTice (IGNITE) Network.. Pharmacogenomics and personalized medicine. PMID: 32765043.

Setting: United States - IGNITE Network implementation-resource initiative spanning participating clinical institutions.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics - CYP2C19-guided clopidogrel testing implementation.. Domains: Strategic Leadership and Readiness; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The resource repository contained 65 implementation resources contributed by 12 institutions (Results, pp. 3-4). During pilot testing, 96 CYP2C19-clopidogrel guides were created from 249 unique page views, with a mean of 19 resources per guide (Results, p. 5). Reimbursement, evidence, workflow, and ...

[102] El Shamieh Said, Saleem Rimah Abdullah, Hammoudi Halat Dalal et al. (2025). Integrating pharmacogenomics in three Middle Eastern countries' healthcare (Lebanon, Qatar, and Saudi Arabia): Current insights, challenges, and strategic directions.. PloS one. PMID: 40215419.

Setting: Lebanon, Qatar, and Saudi Arabia - cross-country healthcare-professional and academic context.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics.. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: The online survey collected 337 responses: 145 from Lebanon, 137 from Qatar, and 55 from Saudi Arabia (PDF pp. 4-5). Familiarity with PGx was reported by 83% of Qatar participants, 75% of Saudi participants, and 67% of Lebanon participants (PDF p. 1). Key reported barriers included education gaps ...

[103] Ewasiuk Emma, Emery Jon, Reid Gabrielle et al. (2024). Implementing pharmacogenomic testing in Australian general practice: an exploratory qualitative study.. Pharmacogenomics. PMID: 39109497.

Setting: Australia – general practice; nine GPs recruited through primary-care networks.. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics.. Domains: Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The study used semi-structured interviews with nine Australian GPs and mapped themes to CFIR domains (Abstract/Methods). Barriers included knowledge/education gaps, limited guidance and standardised reporting, and financial inaccessibility (Abstract/Results). Facilitators included positive ...

[104] Fishe Jennifer N, Higley Rebecca K, Casey Deirdre et al. (2021). Methods and implementation of a pediatric asthma pharmacogenomic study in the emergency department setting.. Pharmacogenetics and genomics. PMID: 33017130.

Setting: United States – UF Health Jacksonville pediatric emergency department.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – pediatric asthma bronchodilator-response study in emergency care.. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: Fifty-nine of 90 eligible children (65%) were enrolled over five months, reaching the 12-month recruitment target early (Abstract/Results, PDF pp. 1, 5). Buccal-swab DNA was successfully obtained from all enrolled children (Results, PDF p. 5). Most responding physicians, nurses, and respiratory ...

[105] Floris Matteo, Moschella Antonino, Capasso Mario et al. (2026). Position statement from the Italian Society of Human Genetics (SIGU) on the implementation of germline pharmacogenetic testing.. European journal of human genetics : EJHG. PMID: 41927801.

Setting: Italy, Italian National Health Service, SSN. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics, germline pharmacogenetic testing. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: Italy's national framework reimbursed only three germline PGx tests as of January 2025 ("includes only three"; page 2). Regional implementation varies and may leave tests privately funded or omitted ("performed privately or omitted"; page 2). The position statement sets eight implementation ...

[106] Formea Christine M, Nicholson Wayne T, Vitek Carolyn Rohrer (2023). An inter-professional approach to personalized medicine education: one institution's experience.. Personalized medicine. PMID: 28413426.

Setting: United States - Mayo Clinic, a large multi-campus academic health system.. Design: Institutional case study. Modality: Pharmacogenomics/pharmacogenetics - multidisciplinary education and EHR-linked resources for implementation.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Mayo implemented a staged, interprofessional pharmacogenomics education model within a large academic health system (PDF pp. 5-7). The first online competency modules were directed to approximately 500 pharmacists and early course evaluations were positive (PDF p. 6). The programme combined ...

[107] Francisco Kishi Kobe Yee, Apuhin Andrane Estelle Carnicer, Maravilla Nicholle Mae Amor Tan et al. (2026). Personalized medicine and health equity: overcoming cost barriers and ethical challenges.. International journal for equity in health. PMID: 41354810.

Setting: Not reported - global narrative focus with particular attention to low- and middle-income countries.. Design: Framework / perspective. Modality: General/multiple - personalized medicine, genomic diagnostics, and AI-enabled care.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review synthesizes cost, infrastructure, workforce, regulatory, and ethical determinants of equitable PM, particularly for LMICs (pp. 2-17). It describes how unequal data, infrastructure, and skilled-workforce distribution can concentrate PM benefits in wealthier settings (pp. 5-7). PM planning ...

[108] Friedman Paula N, Shaazuddin Mohammed, Gong Li et al. (2020). The ACCOuNT Consortium: A Model for the Discovery, Translation, and Implementation of Precision Medicine in African Americans.. Clinical and translational science. PMID: 30592548.

Setting: United States - ACCOuNT Consortium across University of Chicago, Northwestern, University of Illinois Chicago, and community partners.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - genotype-guided anticoagulant and antiplatelet therapy with a Genomic Prescribing Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access Key findings: ACCOuNT created a multi-institutional model focused on discovering,

translating, and implementing precision medicine relevant to African American populations (Abstract; pp. 3-5). The Genomic Prescribing System was being used with an inpatient hospitalist service at the University of Chicago, with ...

[109] Furukawa Yoichi (2023). Implementation of genomic medicine for gastrointestinal tumors.. Annals of gastroenterological surgery. PMID: 30003187.

Setting: Japan and international gastrointestinal-oncology implementation context; no single evaluated health system.. Design: Framework / perspective. Modality: Tumour genomics / molecular diagnostics - next-generation sequencing and biomarker-guided treatment for Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The paper presents an end-to-end implementation workflow for genomic medicine in gastrointestinal tumours, including consent, sequencing, interpretation, tumour-board review, reporting, counselling, and follow-up (Fig. 1, p. 2). Cited precision-oncology experience shows that genomic actionability ...

[110] Gallipani Alyssa, Cope Rebecca, Fischetti Briann et al. (2022). Prescriber Attitudes Toward Implementation of Pharmacogenomic Testing in a Family Medicine Residency Program.. PRiMER (Leawood, Kan.). PMID: 32818194.

Setting: United States – Brooklyn Hospital Center family-medicine residency clinic, Brooklyn, New York. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics – family-medicine prescriber education and prospective PGx testing. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Fifteen of 28 eligible family-medicine residents and attendings were interviewed (53% response) (Abstract/Methods). Four central implementation concerns emerged: benefits/risks, feasibility, accessibility, and modification of residency curricula (Abstract). Participants had favourable attitudes but ...

[111] García-González Xandra, Cabaleiro Teresa, Herrero María José et al. (2016). Clinical implementation of pharmacogenetics.. Drug metabolism and personalized therapy. PMID: 26751902.

Setting: United States – small metropolitan, rural, and tribal health-practice settings in western Montana. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Seventeen clinicians and allied professionals in western Montana were interviewed, including 10 physicians, one pharmacist, two nurse practitioners, three nurses, and one physician assistant (Table 1, p. 3). Only three participants had ordered a PGx test; participants nevertheless generally ...

[112] Ghanbarian Shahzad, Wong Gavin W K, Bunka Mary et al. (2023). Cost-effectiveness of pharmacogenomic-guided treatment for major depression.. CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne. PMID: 37963621.

Setting: Canada – British Columbia public-payer health-system perspective.. Design: Economic evaluation. Modality: Pharmacogenomics/pharmacogenetics – CYP2D6/CYP2C19-guided antidepressant treatment for major depressive disorder.. Domains: Finance and Sustainability. Key findings: Microsimulation predicted \$956 million in total 20-year health-system savings (\$4,926 per patient) with pharmacogenomic-guided care (Results, Table 2, PDF p. 5). The model predicted 0.381 QALYs per patient and 37% fewer patients with refractory depression over 20 years (Abstract/Results, PDF pp. 1 ...

[113] Giannopoulou Efstathia, Katsila Theodora, Mitropoulou Christina et al. (2020). Integrating Next-Generation Sequencing in the Clinical Pharmacogenomics Workflow.. Frontiers in pharmacology. PMID: 31024324.

Setting: International clinical pharmacogenomics implementation context. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - next-generation sequencing-based workflow. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: The review describes NGS as a potential route to more comprehensive pharmacogenomic testing but emphasizes validation, interpretation and implementation challenges (Abstract/Review). Clinical NGS-PGx workflows should incorporate quality assurance, evidence review, standardized reporting ...

[114] Gill Pritmohinder S, Elchynski Amanda L, Porter-Gill Patricia A et al. (2022). Multidisciplinary Consulting Team for Complicated Cases of Neurodevelopmental and Neurobehavioral Disorders: Assessing the Opportunities and Challenges of Integrating Pharmacogenomics into a Team Setting.. Journal of personalized medicine. PMID: 35455715.

Setting: United States – Arkansas Children's Hospital Northwest multidisciplinary pediatric precision-care service.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics –

CYP2D6/CYP2C19-guided psychotropic treatment in neurodevelopmental and Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: Twenty-seven patients were assessed; 70.4% had at least one clinically actionable phenotype (Results, PDF pp. 5–6). The team used pharmacogenomic information to guide or confirm medication therapy in 66.7% of patients (Results, Table 6, PDF pp. 7–8). The clinic adopted pharmacogenomics in direct ...

[115] Ginsburg Geoffrey S, Cavallari Larisa H, Chakraborty Hrishikesh et al. (2021). Establishing the value of genomics in medicine: the IGNITE Pragmatic Trials Network.. Genetics in medicine : official journal of the American College of Medical Genetics. PMID: 33782552.

Setting: United States - five IGNITE Pragmatic Trials Network clinical groups across academic, community, rural, pediatric, and safety-net settings.. Design: Framework / perspective. Modality: General/multiple - APOL1 risk testing and pharmacogenomics integrated through pragmatic trials.. Domains: Strategic Leadership and Readiness; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: IGNITE PTN comprised five clinical groups and a coordinating center; two pragmatic trials had been initiated (Abstract; pp. 2, 7-8). Trials were designed for usual-care sites with EHR-resident genomic results and CDS recommendations (pp. 6-7). Pragmatic genomic trials should use diverse real-world ...

[116] Giri Jyothsna, Moyer Ann M, Bielinski Suzette J et al. (2024). Concepts Driving Pharmacogenomics Implementation Into Everyday Healthcare.. Pharmacogenomics and personalized medicine. PMID: 31802928.

Setting: Not reported. International implementation review with examples from multiple health systems.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The review organizes implementation around evidence generation, EHR/CDS integration, testing and reporting standardization, reimbursement, and education (Abstract; pp. 1–12). Inconsistent laboratory result representations and panel content are major obstacles to portability and scalable CDS (pp ...

[117] Gong Li, Klein Clarissa J, Caudle Kelly E et al. (2025). Integrating Pharmacogenomics into the Broader Construct of Genomic Medicine: Efforts by the ClinGen Pharmacogenomics Working Group (PGxWG).. Clinical chemistry. PMID: 39749515.

Setting: Not reported - ClinGen/ClinPGx international genomic-medicine resource context; no single evaluated health system.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - gene-drug validity/actionability and variant-classification standards.. Domains: Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The paper describes PGxWG work to develop standard frameworks for gene-drug validity, actionability, and pharmacogenetic variant curation (PDF pp. 4-7). The authors document action discordance across current pharmacogenomics guidance resources (PDF p. 5). In the PGxWG user assessment, 97% supported ...

[118] González Ana Rita, Merchán Lizbeth Alexandra Acuña, Alexander Jorge A Alatorre et al. (2025). Precision Medicine for Cancer and Health Equity in Latin America: Generating Understanding for Policy and Health System Shaping.. International journal of environmental research and public health. PMID: 40869806.

Setting: Latin America – regional cancer-policy and health-system analysis, drawing on country-level evidence including Argentina, Brazil, Colombia, and Design: Policy analysis. Modality: Precision oncology – cancer biomarker testing and targeted therapies.. Domains: Governance and Policy; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review identifies inequitable access to biomarker testing, therapies, workforce, and cancer infrastructure across Latin American health systems (Discussion, PDF p. 34). Recent national cancer plans in the focus countries had no biomarker or genetic-marker content, according to the policy-gap ...

[119] Goodspeed Andrew, Kostman Nicolas, Kriete Trenton E et al. (2022). Leveraging the utility of pharmacogenomics in psychiatry through clinical decision support: a focus group study.. Annals of general psychiatry. PMID: 31413721.

Setting: United States – Mental Health Center of Denver, an urban specialty mental-healthcare setting.. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics – psychiatric prescribing supported by an EHR-embedded clinical decision-support Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Sixteen mental-health clinicians participated in three focus groups; all practised in urban settings and saw 25–50 patients weekly (Results, p. 4). The final feature set prioritised prior medication history, coverage/cost, longitudinal labs/vitals, PGx summaries linked to full reports, and use ...

[120] Guchelaar Henk-Jan, van der Wouden Cathelijne H, Manson Lisanne E N et al. (2025). Pharmacogenetic Implementation Studies-Lessons Learned From the PREPARE Study.. Clinical pharmacology and therapeutics. PMID: 40552566.

Setting: Europe – PREPARE implementation study across seven countries, including hospitals, community health centres, and community pharmacies.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics – pre-emptive 12-gene panel for 39 medicines.. Domains: Strategic Leadership and Readiness; Governance and Policy; Clinical Workflow and Service Integration. Key findings: PREPARE implemented panel-based pharmacogenetic testing across seven European countries and 55 participating care sites (Study setting, PDF pp. 2–3). The tutorial identifies reimbursement, data exchange, evidence consensus, ethics, and real-world case-mix variation as implementation-study issues ...

[121] Haga Susanne B (2020). Pharmacogenomic Testing In Pediatrics: Navigating The Ethical, Social, And Legal Challenges.. Pharmacogenomics and personalized medicine. PMID: 31686893.

Setting: Not reported. Review of pediatric pharmacogenomics across clinical settings; no single evaluated health system.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics – pediatric, prenatal, and newborn applications. Domains: Governance and Policy; Workforce Capability and Change Management; Patient Access, Equity and Ethics. Key findings: The review distinguishes immediate therapeutic testing from pre-emptive testing in healthy children because benefits and ethical trade-offs differ (pp. 2, 4–6). The authors identify pediatric evidence gaps, developmental pharmacology, consent, family implications, and inequitable evidence bases as ...

[122] Haga Susanne B (2022). Integrating pharmacogenetic testing into primary care.. Expert review of precision medicine and drug development. PMID: 31853504.

Setting: United States – primary-care implementation context and published US practice examples.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics – primary-care delivery of reactive and pre-emptive PGx testing.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The review identifies provider preparedness, reimbursement, and availability of clinical decision support as key barriers to primary-care PGx uptake (Introduction, p. 2). The paper synthesises education, CDS, consultation services, and team-based care as recurrent implementation strategies (Expert ...

[123] Hall Bradley T, Eken Eda, Cavallari Larisa H et al. (2025). Implementing Pharmacogenomics Clinical Decision Support: A Comprehensive Tutorial on how to Integrate the Epic Genomics Module.. Clinical pharmacology and therapeutics. PMID: 39960348.

Setting: United States – University of Florida Health Precision Medicine Program.. Design: Institutional case study. Modality: Pharmacogenomics/pharmacogenetics – Epic Genomics Module and EHR clinical decision support. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: UF Health deployed Epic's Genomics Module in early 2022 to replace unreliable laboratory-result workflows for PGx information (pp. 1–2). The implementation focused on converting legacy PGx results to structured indicators that can drive CDS (pp. 3–5, 12–13). Data standardization, external-report ...

[124] Hamdi Yosr, Trabelsi Mediha, Ghedira Kais et al. (2024). Genome Tunisia Project: paving the way for precision medicine in North Africa.. Genome medicine. PMID: 39187811.

Setting: Tunisia – national Genome Tunisia Project spanning research institutions, laboratories, hospitals and public-health stakeholders.. Design: Framework / perspective. Modality: General/multiple – national genomics infrastructure, sequencing, biobanking, pharmacogenomics and oncogenetics for Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Patient Access, Equity and Ethics. Key findings: Genome Tunisia is a two-phase 2022–2035 initiative intended to create a Tunisian reference genome and support personalized-medicine implementation (Abstract, p. 1; Figures 1–2, pp. 4–5). The reported implementation architecture includes task forces covering scientific strategy, data infrastructure ...

[125] Hamdi Yosr, Boujemaa Maroua, Ben Aissa-Haj Jihenne et al. (2026). A regionally based precision medicine implementation initiative in North Africa:The PerMediNA consortium.. Translational oncology. PMID: 38537326.

Setting: North Africa – Tunisia, Algeria and Morocco through the PerMediNA consortium.. Design: Institutional case study. Modality: General/multiple – precision oncology, multi-omics and genomic medicine capacity building. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: PerMediNA was launched across Tunisia, Algeria and Morocco to assess readiness,

strengthen infrastructure, train workforce, generate North-African genomic data and inform policy (p. 1). The precision-oncology pilot plans genomic/transcriptomic analysis for 450 NSCLC cases, 150 from each ...

[126] Hansen Johanne Mølby, Nørgaard Josefine D S V, Källemark Sporrøng Sofia (2022). A systematic review of pharmacogenetic testing in primary care: Attitudes of patients, general practitioners, and pharmacists.. Research in social & administrative pharmacy : RSAP. PMID: 34996718.

Setting: International primary-care settings represented in the included literature; no single evaluated health system.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics – testing and use in primary care.. Domains: Workforce Capability and Change Management; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The PRISMA-based review included 15 studies of patient, general-practitioner, and pharmacist attitudes or knowledge (Methods/Results, PDF pp. 2–4). Lack of PGx knowledge was a recurring theme in 11 of the 15 included studies (Discussion, PDF p. 8). Cost coverage was emphasized in 7 of 15 included ...

[127] Harada S, Zhou Y, Duncan S et al. (2017). Precision Medicine at the University of Alabama at Birmingham: Laying the Foundational Processes Through Implementation of Genotype-Guided Antiplatelet Therapy.. Clinical pharmacology and therapeutics. PMID: 28124392.

Setting: United States - University of Alabama at Birmingham Health System.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics - CYP2C19 genotype-guided antiplatelet therapy after percutaneous coronary Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The UAB Pharmacy and Therapeutics Committee approved selective CYP2C19 testing for high-risk patients after stakeholder consensus (Implementation consensus, p. 4). The laboratory achieved approximately 70-minute turnaround for CYP2C19 testing within the implementation pathway (Laboratory ...

[128] Harada Shuko, Arend Rebecca, Dai Qian et al. (2017). Implementation and utilization of the molecular tumor board to guide precision medicine.. Oncotarget. PMID: 28915716.

Setting: United States - University of Alabama at Birmingham academic health system.. Design: Empirical implementation study. Modality: Precision oncology - next-generation sequencing gene-panel testing governed by a molecular tumor board.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The molecular tumor board discussed 191 cases and approved 132 for gene-panel testing over three years (Results, PDF pp. 1, 3). Forty-six of 132 approved patients (34.8%) had predictive or prognostic findings; 13 of 15 considered ultimately received targeted therapy (Abstract; Results, PDF pp ...

[129] Hatem Najmaddin A H, Badullah Wafa, Yousuf Seena A et al. (2025). Pharmacists' perspectives on integrating pharmacogenetics in clinical practice.. Human genomics. PMID: 40563094.

Setting: Yemen - pharmacist practice setting.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics.. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The online cross-sectional survey included 211 Yemeni pharmacists (PDF p. 1). 74.4% achieved a high knowledge score, but only 14.7% answered all six knowledge items correctly (PDF p. 4). Only 45.5% reported high overall perceived ability to practise PGx, and 29.9% agreed they could perform all four ...

[130] Hayward Judith, McDermott John, Qureshi Nadeem et al. (2022). Pharmacogenomic testing to support prescribing in primary care: a structured review of implementation models.. Pharmacogenomics. PMID: 34467776.

Setting: United Kingdom – NHS primary-care implementation framing, with reviewed panel-testing models from multiple countries.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics – multigene panel testing to support prescribing in primary care and community Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The structured review identified 13 studies describing eight multigene-panel PGx implementation models in primary-care or community settings (Abstract; Results). Models were small feasibility studies (n < 200) and consistently highlighted pre-test counselling, pharmacists, EMR data integration, and ...

[131] Heffernan Emory W, Hearld Kristine R, Moss Irene P et al. (2026). Implementing Genomic Medicine in Primary Care: A Convergent Mixed Method Case Study.. Journal of evaluation in clinical practice. PMID: 41773642.

Setting: United States, Alabama Genomic Health Initiative across three UAB family medicine clinics, two urban and one rural. Design: Mixed-methods. Modality: General/multiple, genomic screening plus pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Workforce Capability and

Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Genomic medicine was viewed as moderately acceptable, appropriate, and feasible, with means of 3.77, 3.73, and 3.66 (“Implementation outcome descriptives”; Table 4). Clinic leadership and learning climate were more favorable than genomic-specific implementation climate (“3.85”; “3.61”; “3.02” ...

[132] Heffernan Emory William, Das Paramita, Hearld Larry et al. (2026). Implementing Genomic Medicine in a Federally Qualified Health Center: Assessing Readiness through a Mixed-Methods Approach.. Public health genomics. PMID: 41802142.

Setting: United States, Alabama Regional Medical Services, a Federally Qualified Health Center in Birmingham, Alabama. Design: Mixed-methods. Modality: General/multiple, population genomic screening plus pharmacogenomic testing. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Thirteen clinic members participated; 12 completed the survey, 10 interviews, 11 concept mapping, and 10 nominal-group ranking sessions (“12 participants completed surveys”; page 5). The three dominant barriers were staffing shortages, financial constraints, and language obstacles (“three dominant ...

[133] Hernandez Marta, Culell Natalia, Cendros Marc et al. (2024). Clinical Utility and Implementation of Pharmacogenomics for the Personalisation of Antipsychotic Treatments.. Pharmaceuticals. PMID: 38399298.

Setting: Not reported - international literature review; no single evaluated health system.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics - CYP-guided antipsychotic selection and dosing.. Domains: Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The review identifies cost, delayed results, incomplete antipsychotic guidance, and education as recurring barriers to pharmacogenetics use in psychiatric practice (Abstract/Discussion, PDF pp. 1, 8-10). Existing clinical guidance covers only a subset of antipsychotic medicines and gene-drug ...

[134] Hernandez Wendy, Danahey Keith, Pei Xun et al. (2021). Pharmacogenomic genotypes define genetic ancestry in patients and enable population-specific genomic implementation.. The pharmacogenomics journal. PMID: 31506565.

Setting: United States – University of Chicago tertiary academic medical centre and institutional pre-emptive pharmacogenomics programme.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – population-specific warfarin decision support using individual genetic ancestry.. Domains: Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The study analyzed 1,572 1000 Genomes participants, external cohorts and 330 real-world patients from an institutional pre-emptive PGx programme (Abstract, pp. 1–2; Methods, p. 3). Focused PGx panels estimated ancestry with high performance and supported identification of patients eligible for ...

[135] Hicks J Kevin, Dunnenberger Henry M, Gumpfer Karl F et al. (2018). Integrating pharmacogenomics into electronic health records with clinical decision support.. American journal of health-system pharmacy : AJHP : official journal of the American PMID: 27864204.

Setting: Not reported. Multi-institutional clinical informatics framework using international PGx implementation examples.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics – EHR-integrated clinical decision support. Domains: Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The paper outlines major design components for EHR-integrated PGx: data representation, result display, triggering logic, and CDS delivery (pp. 2–8). Passive and interruptive CDS have different workflow and monitoring implications (pp. 5–7). Institutions should use structured, standards-aligned ...

[136] Hicks J Kevin, Shealy Amy, Schreiber Allison et al. (2019). Patient Decisions to Receive Secondary Pharmacogenomic Findings and Development of a Multidisciplinary Practice Model to Integrate Results Into Patient Care.. Clinical and translational science. PMID: 28749586.

Setting: United States – Cleveland Clinic Genomic Medicine Institute / Center for Personalized Genetic Healthcare.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – return and clinical integration of secondary pharmacogenomic findings from clinical Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: Of 106 patients with returned clinical exome results, 99 (93.4%) elected to receive secondary PGx findings (Results, p. 73). Eighty-four patients (84.8%) had at least one actionable phenotype under the selected CPIC gene-drug pairs (Results; Table 1, pp. 73–74). The paper developed a prospective ...

[137] Hicks J Kevin, Aquilante Christina L, Dunnenberger Henry M et al. (2022). Precision Pharmacotherapy: Integrating Pharmacogenomics into Clinical Pharmacy Practice.. Journal of the American College of Clinical Pharmacy : JACCP. PMID: 32984775.

Setting: United States context – clinical pharmacy practice framework drawing on published institutional pharmacogenomics programmes.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The paper identifies common implementation components: institutional buy-in, oversight, laboratory testing, EHR/CDS infrastructure, education, and maintenance (pp. 4–7). Clinical pharmacists are positioned to lead implementation, interpretation, education, and practice support (Abstract ...

[138] Hinderer Marc, Boerries Melanie, Boeker Martin et al. (2018). Implementing Pharmacogenomic Clinical Decision Support into German Hospitals.. Studies in health technology and informatics. PMID: 29678085.

Setting: Germany, German university hospitals. Design: Mixed-methods. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Three principal barriers were legal uncertainty, missing machine-readable data, and physician knowledge gaps (“three major barriers”). Genetic information was generally available but remained in diagnostic-department file systems (“generally available in filesystems”). All five hospitals used ...

[139] Hinderer Marc, Boeker Martin, Wagner Sebastian A et al. (2018). Integrating clinical decision support systems for pharmacogenomic testing into clinical routine - a scoping review of designs of user-system interactions in recent system development.. BMC medical informatics and decision making. PMID: 28587608.

Setting: Not reported – scoping review of 20 pharmacogenomic CDSS across multiple institutions and countries.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics. Domains: Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The review identified 20 PGx CDSS described in publications from 2012–2016 (Abstract; Results, pp. 4–5). Alerts were the most widespread interaction design, but both pre-test and post-test approaches were used (Abstract; Results, pp. 5–7). Thirteen CDSS used post-test alerts with a problem ...

[140] Hippman Catriona, Nislow Corey (2020). Pharmacogenomic Testing: Clinical Evidence and Implementation Challenges.. Journal of personalized medicine. PMID: 31394823.

Setting: Not reported – international/general clinical implementation context. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: The review reports 132 pharmacogenomic dosing guidelines covering 99 drugs and 309 drug labels containing pharmacogenomic information at the time of its evidence summary (Abstract/Introduction). Implementation challenges span clinical evidence, laboratory/analytic validity, clinical integration ...

[141] Hjemås Bodil Jahren, Bøvre Katrine, Bjerknes Kathrin et al. (2023). Implementation of pharmacogenetic testing in medication reviews in a hospital setting.. British journal of clinical pharmacology. PMID: 37277227.

Setting: Norway – Akershus University Hospital geriatric and cardiology wards, with pharmacogenetic analysis by Diakonhjemmet Hospital.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – reactive testing integrated into pharmacist-led medication review for multimorbid Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Pharmacogenetic results were available for medication review in 18 of 46 enrolled patients (39.1%) (Abstract). The pharmacist recommended changes for 21 of 49 detected gene–drug interactions (42.9%); physicians accepted 19 of 21 recommendations (90.5%) (Abstract). The most commonly detected ...

[142] Hoffman James M, Dunnenberger Henry M, Kevin Hicks J et al. (2017). Developing knowledge resources to support precision medicine: principles from the Clinical Pharmacogenetics Implementation Consortium (CPIC).. Journal of the American Medical Informatics Association : JAMIA. PMID: 27026620.

Setting: Not reported - international CPIC implementation-resource context; EHR-agnostic approach.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - machine-readable PGx knowledge for EHR clinical decision support.. Domains: Governance and Policy; Digital Infrastructure and Interoperability;

Clinical Workflow and Service Integration. Key findings: The paper states that routine PGx adoption requires a curated, machine-readable knowledge base for EHR use with CDS (PDF p. 1). It outlines five design principles for PGx knowledge resources, including structured interpretation, evidence rating, transparent representation of test limitations, and ...

[143] Houwink Elisa J F, Meagher Karen M, Thorsteinsdottir Bjoerg Bjorg et al. (2026). Ethically Integrating Genomics in Primary Care: An Invitation to Share Implementation Best Practices.. Mayo Clinic proceedings. PMID: 41369639.

Setting: United States – Mayo Clinic primary-care genomics implementation context and task-force recommendations.. Design: Framework / perspective. Modality: General/multiple clinical genomics in primary care. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: A Mayo Clinic task force convened across 2023 to identify practical approaches for ethical integration of genomics in primary care. The paper identifies interconnected gaps in training, pathways, infrastructure, reimbursement, governance, privacy, and equity. Primary-care genomics should be ...

[144] Huang Zhong, O'Leary Kevin J, Nutescu Edith A et al. (2025). Results of the ACCOuNT Trial: A Multi-Institutional Prospective Pharmacogenomics Implementation Trial for African American Inpatients.. Clinical pharmacology and therapeutics. PMID: 40847467.

Setting: United States – University of Chicago Medicine, Northwestern Medicine, and University of Illinois Chicago hospitals.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – pre-emptive multi-gene EHR/CDS guidance for self-identified African American Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The trial recruited 531 patients; 187 were subsequently readmitted, yielding 518 evaluable inpatient admissions (Results, pp. 4–5). Care teams used PGx CDS in 50% of evaluable admissions, and 12% of inpatient prescriptions were PGx-annotated (Abstract; Results). Genomically discordant discharge ...

[145] Ibrahim Asmaa, Alenany Reem, Bader Loulia et al. (2025). Pharmacogenomics Education and Knowledge Assessment in Healthcare Curricula: A Scoping Review of the Middle East and North Africa Region.. Pharmacology research & perspectives. PMID: 40641329.

Setting: Middle East and North Africa region – included studies from Jordan, Kuwait, United Arab Emirates, Saudi Arabia, and Palestine; none from North Africa.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics – workforce education, curriculum delivery, and knowledge readiness among healthcare Domains: Workforce Capability and Change Management. Key findings: Seven cross-sectional studies published from 2014–2023 met inclusion criteria (Results, pp. 3–4). Seventy-one percent reported integrated undergraduate PGx delivery, all used didactic lectures, and 29% reported standalone PGx courses (Abstract; Results, p. 4). Knowledge was classified as low in 43% ...

[146] Jameson Adam, Fylan Beth, Bristow Greg C et al. (2021). What Are the Barriers and Enablers to the Implementation of Pharmacogenetic Testing in Mental Health Care Settings?. Frontiers in genetics. PMID: 34630531.

Setting: United Kingdom National Health Service mental-health care context. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - mental-health care. Domains: Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review identified recurrent cost, knowledge, workflow, ethical and evidence barriers to pharmacogenetic testing in mental-health care (Results). The evidence base included 11 studies addressing implementation conditions in mental-health settings (Methods/Results). Future implementation should ...

[147] Jameson Adam, Tomlinson Justine, Medlinskiene Kristina et al. (2024). Normalising the Implementation of Pharmacogenomic (PGx) Testing in Adult Mental Health Settings: A Theory-Based Systematic Review.. Journal of personalized medicine. PMID: 39452539.

Setting: International adult mental-health settings – systematic review of 29 records.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics – psychiatric prescribing.. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: The review followed PRISMA guidance, used QuADS appraisal, and included 29 records in the synthesis (Abstract/Methods). Barriers clustered around knowledge, policy/guidance, uncertainty, and the work needed to normalise testing in practice (Abstract/Results). Facilitators included perceived value ...

[148] Jiang Shangqing, Mathias Patrick C, Hendrix Nathaniel et al. (2022). Implementation of pharmacogenomic clinical decision support for health systems: a cost-utility analysis.. The pharmacogenomics journal. PMID: 35365779.

Setting: United States – hypothetical 500,000-patient integrated health-system model.. Design: Economic evaluation. Modality: Pharmacogenomics/pharmacogenetics clinical decision support. Domains: Finance and Sustainability. Key findings: In a modeled 500,000-patient health system over 20 years, the intervention generated an estimated 3,169 actionable alerts. The model estimated an ICER of approximately US\$39,477 per QALY. Health systems should assess local costs, event rates, uptake, and infrastructure before relying on modeled ...

[149] Jongeneel C Victor, Kotze Maritha J, Bhaw-Luximon Archana et al. (2025). A View on Genomic Medicine Activities in Africa: Implications for Policy.. Frontiers in genetics. PMID: 35571023.

Setting: Africa - multi-country genomic medicine policy and institutional readiness survey. Design: Survey / cross-sectional. Modality: General/multiple - genomic medicine and precision medicine. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The survey assessed African scientists' and stakeholders' views on genomic medicine knowledge, infrastructure, awareness and implementation barriers (Abstract/Methods). The paper identifies infrastructure, translational research, training, information dissemination and stakeholder engagement as ...

[150] Jordan Elizabeth, Ni Hanyu, Parker Patricia et al. (2025). Implementing Precision Medicine for Dilated Cardiomyopathy: Insights From the DCM Consortium.. Circulation. Genomic and precision medicine. PMID: 40528765.

Setting: United States – DCM Consortium advanced heart-failure/transplant programmes.. Design: Mixed-methods. Modality: Genomic cardiology – genetic evaluation for dilated cardiomyopathy. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Twenty-five cardiologists completed the survey and 15 participated in the in-person discussion (Abstract, p. 2). All institutions offered genetic evaluation or testing, but estimated annual testing uptake ranged from 5% to 70% (mean 26%) (Results, p. 4). Six themes emerged: access to genetics ...

[151] Just Katja Susanne, Steffens Michael, Swen Jesse Joachim et al. (2018). 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).. European journal of clinical pharmacology. PMID: 28669097.

Setting: Europe, U-PGx implementation sites in Austria, Greece, Italy, Netherlands, Slovenia, Spain, and Great Britain. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics. Domains: Workforce Capability and Change Management. Key findings: Future PGx adopters had positive attitudes but limited experience using PGx tests (“general positive attitude”; Conclusion). Knowledge gaps were strongest around clinical application, result interpretation, and therapy adjustment (“application and interpretation”; Discussion). Education needs ...

[152] Kabbani Danya, Akika Reem, Wahid Ahmed et al. (2023). Pharmacogenomics in practice: a review and implementation guide.. Frontiers in pharmacology. PMID: 37274118.

Setting: Not reported. General hospital-setting implementation guide drawing on international PGx resources, regulators, and implementation examples. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics, hospital implementation of reactive or pre-emptive PGx testing. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The paper presents a hospital PGx implementation model involving regulators, leadership, P&T committees, laboratories, IT, providers, patients, and payers (“eight main stakeholders”; page 2). The proposed design sequence is: select evidence-supported drug-gene pairs, determine variants, choose ...

[153] Kamath Ashwin, Shenoy Preethi J, Ullal Sheetal D et al. (2023). Clinical pharmacology and pharmacogenomics for implementation of personalized medicine.. Pharmacogenomics. PMID: 38009368.

Setting: India and global implementation examples; the conference report includes accounts from Egypt and United States programmes.. Design: Framework / perspective. Modality: General/multiple - clinical pharmacology, pharmacogenomics, therapeutic drug monitoring, and pharmacogenetic Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: The conference report synthesizes operational lessons from clinical-pharmacology and pharmacogenomics programmes, including examples from Egypt and St Jude Children's Research Hospital (pp. 4-8). It identifies point-of-care data access, interpretation capacity, cost-effectiveness evidence, and ...

[154] Kayani Maryam, Sangeetha Gadde Krishna, Sarangi Swapna et al. (2025). Pharmacogenomics and its Role in Cardiovascular Diseases: A Narrative Literature Review.. Current cardiology reviews. PMID: 39901689.

Setting: Not reported - international cardiovascular pharmacogenomics context.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - cardiovascular medicines.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review identifies evidence uncertainty, cost-effectiveness, data/ELSI, regulation, population diversity, and clinician familiarity as barriers to cardiovascular PGx implementation (pp. 29-32). It describes real-time EHR genetic data and continuing clinician education as implementation needs ...

[155] Keane Madeline, Wojciechowska Natalia, Zumwalt Lindsay et al. (2025). Implementation of a Pediatric Oncology Precision Medicine Clinic to Personalize Approaches for Diagnosing and Treating Solid Tumors.. Oncology research. PMID: 40746881.

Setting: United States - Cook Children's Medical Center, Fort Worth, Texas.. Design: Institutional case study. Modality: Precision oncology - paediatric solid-tumour next-generation sequencing, molecular tumour board, and precision medicine Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The clinic evolved from a molecular tumour board established in 2019 into a dedicated precision medicine clinic in 2021 (Methods, pp. 1896-1897). Sixty-nine patients were reviewed during 2022-2023; 133 variants in 101 genes were identified, and four patients initiated a molecularly recommended ...

[156] Kehl Kenneth L, Lathan Christopher S, Johnson Bruce E et al. (2020). Race, Poverty, and Initial Implementation of Precision Medicine for Lung Cancer.. Journal of the National Cancer Institute. PMID: 30576459.

Setting: United States - SEER-Medicare stage-IV lung-adenocarcinoma care.. Design: Cohort / clinical evaluation. Modality: Precision oncology - molecular testing and biomarker-directed lung-cancer treatment.. Domains: Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: Of 5,556 Medicare patients with stage-IV lung adenocarcinoma, 25.9% had molecular testing within 60 days (Abstract; Table 1, pp. 1-2). Testing rates were 14.1% for Black patients versus 26.2% for White patients; Medicaid-eligible patients had lower adjusted odds of testing (Abstract; Table 1, p ...

[157] Keogh Murray, Fragala Maren S, Peter Arul Prakasam et al. (2022). Early Insights From a Pharmacogenomic-Enriched Comprehensive Medication Management Program Implementation in an Adult Employee Population.. Journal of occupational and environmental medicine. PMID: 36155954.

Setting: United States - self-insured employer-sponsored health plan / adult employee population.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics - PGx-enriched comprehensive medication management with pharmacist consultation.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Of 7,500 invited high-risk employees, 802 (10.7%) enrolled and 469 (61% of enrollees) completed a pharmacist consultation by 180 days (Fig. 1, PDF p. 3). Among 437 consenting participants, 375 (85.8%) received actionable pharmacist recommendations, averaging 5.2 recommendations each (Results, PDF ...

[158] Kerr Katie, McKenna Caoimhe, Heggarty Shirley et al. (2022). A Formative Study of the Implementation of Whole Genome Sequencing in Northern Ireland.. Genes. PMID: 35885887.

Setting: United Kingdom - Northern Ireland Genomic Medicine Centre and Belfast Health and Social Care Trust, within the NHS/100,000 Genomes Project.. Design: Mixed-methods. Modality: Whole-genome sequencing for rare-disease diagnosis and molecular diagnostic service integration.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The programme delivered WGS to 1,073 participants, including 442 probands, across eight specialty clinics (Results, p. 5). Detailed reflections were obtained from 74 participants: 42 survey respondents, 19 healthcare-staff interviewees, and 13 workshop participants (Abstract; Methods). Participants ...

[159] Khalil Amal I, Khan Muhammad Anwar, Alzahrani Ghada (2026). Healthcare providers' proficiency, challenges, and attitudes toward genetic testing integration in psychiatric practices: The influence of an educational initiative.. Wiadomosci lekarskie (Warsaw, Poland : 1960). PMID: 41759017.

Setting: Saudi Arabia, Erada Complex for Mental Health and Addiction, Jeddah. Design: Empirical implementation study. Modality: General/multiple – genetic testing integration in psychiatric practice. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and

Sustainability. Key findings: The quasi-experimental single-group pre/post study enrolled 227 healthcare providers (Methods, p. 3). Mean proficiency increased from 71.3 to 76.6, attitudes from 37.3 to 40.8, and barrier-management scores from 18.4 to 19.6 after the initiative (Results, pp. 5–6). Reimbursement, uncertain ...

[160] Khelifi Maher, Tarczy-Hornoch Peter, Devine Emily B et al. (2022). Design Recommendations for Pharmacogenomics Clinical Decision Support Systems.. AMIA Joint Summits on Translational Science proceedings. AMIA Joint Summits on PMID: 28815136.

Setting: United States - University of Washington prototype clinical-decision-support design setting; no deployed health system evaluated.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - user-centered EHR clinical decision support for prescribing.. Domains: Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The prototype used a contextual display to support medication search, selection, and personalized prescribing (PDF pp. 5-6). Sixteen evaluators identified the need for concise results summaries, clear interpretation, dosing guidance, and links to full reports (Methods/Results, PDF pp. 3, 6-7). PGx ...

[161] Khoury Muin J, Bowen Scott, Dotson W David et al. (2022). Health equity in the implementation of genomics and precision medicine: A public health imperative.. Genetics in medicine : official journal of the American College of Medical Genetics. PMID: 35482015.

Setting: United States, public-health implementation context. Design: Framework / perspective. Modality: General/multiple – genomics and precision medicine. Domains: Strategic Leadership and Readiness; Governance and Policy; Patient Access, Equity and Ethics. Key findings: The paper frames genomic and precision-medicine implementation as a public-health equity imperative because access and benefits are unevenly distributed (Abstract; pp. 1–3). The authors apply assessment, policy development, and assurance functions to genomic medicine implementation (pp. 3–5) ...

[162] Khyatti Meriem, Radouani Fouzia, Benamri Ichrak et al. (2025). Precision medicine in Morocco: State of art and challenges for implementation.. Journal of cancer policy. PMID: 40419188.

Setting: Morocco, national healthcare and oncology context. Design: Mixed-methods. Modality: General/multiple, with oncology focus and whole-genome/exome sequencing capability. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The assessment identified 204 stakeholders, then selected 30 for interviews and 40 for focus groups (“204 stakeholders”; “30 key stakeholders”; “40 people”). Twenty-five percent of surveyed respondents had never used NGS because of cost, lack of equipment, or lack of qualified personnel (“25 %... ...

[163] Kichko Kateryna, Marschall Paul, Flessa Steffen (2016). Personalized Medicine in the U.S. and Germany: Awareness, Acceptance, Use and Preconditions for the Wide Implementation into the Medical Standard.. Journal of personalized medicine. PMID: 27144585.

Setting: United States (Pennsylvania) and Germany (Bavaria) - public and physician survey settings.. Design: Survey / cross-sectional. Modality: General/multiple - personalized medicine, pharmacogenomic tests, and personalized drugs.. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The study surveyed public and physician samples in Pennsylvania and Bavaria using parallel questionnaires (Methods/Results, pp. 3-4, 14-18). Participants regarded privacy, reimbursement, patient involvement, and data management as preconditions for wider implementation (Discussion, pp. 17-18) ...

[164] Kim Woo-Young, Kim Ho-Sook, Oh Minkyung et al. (2020). Survey of physicians' views on the clinical implementation of pharmacogenomics-based personalized therapy.. Translational and clinical pharmacology. PMID: 32274379.

Setting: South Korea - physicians involved in pharmacogenomics-based personalized therapy. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: Fifty-three physicians completed the survey on clinical implementation of pharmacogenomics-based personalized therapy in Korea (Methods/Results). Lack of knowledge, test cost, need for training/experts and lack of actionable guidance were prominent reported barriers (Results). The authors call for ...

[165] King Richard I (2025). Implementing genomic medicine in New Zealand.. Journal of the Royal Society of New Zealand. PMID: 40756825.

Setting: New Zealand health system.. Design: Framework / perspective. Modality: General/multiple - genomic medicine across rare disease, reproductive health, cancer, pharmacogenetics, and infectious Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key

findings: The viewpoint identifies systemwide change as necessary for effective and efficient adoption of genomic tests (PDF p. 1). It identifies workforce training, data governance, laboratory coordination, funding, infrastructure, and equity as linked implementation conditions (PDF pp. 4-5). New Zealand's ...

[166] Klein Clarissa J, Gong Li, Caudle Kelly E et al. (2025). Toward an integrated resource for pharmacogenomics (PGx): Survey findings from the genomic medicine communities.. Genetics in medicine : official journal of the American College of Medical Genetics. PMID: 40662343.

Setting: International PGx and genomic-medicine communities; respondents were predominantly US-based and English-speaking.. Design: Mixed-methods. Modality: Pharmacogenomics/pharmacogenetics - standards, terminology, and resources supporting clinical implementation.. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability. Key findings: Two PGx/genomic-medicine community surveys analyzed responses from 508 participants, primarily with qualitative content analysis (Abstract; Methods, pp. 5-6). Respondents described terminology confusion and endorsed standardization and centralized resources (Abstract; Results/Discussion, pp. 7-10) ...

[167] Klein Michelle E, Parvez Md Masud, Shin Jae-Gook (2018). Clinical Implementation of Pharmacogenomics for Personalized Precision Medicine: Barriers and Solutions.. Journal of pharmaceutical sciences. PMID: 28619604.

Setting: Not reported. International implementation literature; no single evaluated health system.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The article groups barriers into evidence, education, ethical/legal/social, information technology, and reimbursement domains (Abstract; pp. 1-2). IT systems must support result storage, interpretation, and clinical decision support rather than merely document test reports (pp. 5-6). Implementation ...

[168] Knezevic Claire E, Stevenson James M, Merran Jonathan et al. (2025). Implementation of Integrated Clinical Pharmacogenomics Testing at an Academic Medical Center.. The journal of applied laboratory medicine. PMID: 39657156.

Setting: United States – Johns Hopkins quaternary academic medical centre.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – in-house 11-gene actionable panel with direct EHR reporting, CDS, and eConsult Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The actionable panel covered 39 alleles across 11 genes and was used across eight clinical areas after implementation (Abstract; Results). Fifty-six percent of orders occurred in the outpatient setting, 22.1% of assays identified at least one actionable pharmacogene, and 67% of orders involved a ...

[169] Knott Tanya, Creeden James, Horbach Benjamin et al. (2024). Stakeholders' expectations of precision medicine: A qualitative study to identify areas of (mis)alignment.. Health science reports. PMID: 37599652.

Setting: International – stakeholders mainly from the United States, Western Europe, Canada, and global organizations; no single health system.. Design: Qualitative study. Modality: General/multiple precision medicine – molecular/genomic testing and targeted treatments, predominantly oncology.. Domains: Governance and Policy; Digital Infrastructure and Interoperability; Patient Access, Equity and Ethics. Key findings: Thirty stakeholder interviews identified both alignment on collaboration and misalignment around industry, guidelines, and leadership responsibility (Results, PDF pp. 4-6). Policymakers and payers were perceived as key drivers of access, while reimbursement/value frameworks were a central ...

[170] Knowles Lori, Luth Westerly, Bubela Tania (2020). Paving the road to personalized medicine: recommendations on regulatory, intellectual property and reimbursement challenges.. Journal of law and the biosciences. PMID: 29868182.

Setting: Policy and regulatory contexts of the European Union, United States, Canada, Japan, Singapore, and China.. Design: Systematic / scoping review. Modality: General/multiple – targeted diagnostics, therapies, and other omics-based personalised-medicine products.. Domains: Governance and Policy; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The scoping review identified regulatory barriers and recommendations in 344 academic papers across the EU, USA, Canada, Japan, Singapore, and China (Abstract/Methods). Regulatory uncertainty was a central barrier, with intellectual-property and reimbursement challenges also constraining ...

[171] Koleva-Kolarova Rositsa, Szilberhorn László, Zelei Tamás et al. (2023). Financial incentives to promote personalized medicine in Europe: an overview and guidance for implementation.. Personalized medicine. PMID: 37623911.

Setting: Europe - multi-country personalized-medicine financing context. Design: Policy analysis. Modality: General/multiple - personalized medicine financing and incentives. Domains: Governance and Policy; Digital

Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The paper synthesizes European evidence and expert input on financial incentives and implementation barriers for personalized medicine (Abstract/Methods). Financing was linked to evidence uncertainty, data requirements, health-technology assessment and cross-border variation in reimbursement ...

[172] Korngiebel Diane M, Thummel Kenneth E, Burke Wylie (2017). Implementing Precision Medicine: The Ethical Challenges.. Trends in pharmacological sciences. PMID: 27939182.

Setting: United States - ethics and health-system implementation perspective with US EHR/PGx programme examples.. Design: Framework / perspective. Modality: General/multiple - precision-medicine testing and pharmacogenomic clinical decision support.. Domains: Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The paper identifies evidence appraisal, clinical decision support, patient education, and family communication as ethical implementation requirements (pp. 3-5). It uses Vanderbilt PREDICT and DIGITizE as examples of EHR-linked precision-medicine decision support (p. 4). New tests introduced with ...

[173] Koutsilieri Stefania, Tzioufa Foteini, Sismanoglou Despoina-Christina et al. (2021). Unveiling the guidance heterogeneity for genome-informed drug treatment interventions among regulatory bodies and research consortia.. Pharmacological research. PMID: 31830522.

Setting: United States and European Union regulatory setting; CPIC international consortium context. No single evaluated health system.. Design: Policy analysis. Modality: Pharmacogenomics/pharmacogenetics – genome-informed drug-treatment guidance.. Domains: Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: Data mining identified 404 drug–gene correlations, including 300 germline correlations (Results, PDF p. 4). The analysis found discordance among regulatory labels and CPIC guidance for some overlapping drug–gene pairs (Results, PDF pp. 7–10). Harmonized, regularly updated guidance should be ...

[174] Kreeftenberg Loes Lindiwe, Henneman Lidewij, Rigter Tessel et al. (2026). From evidence to implementation: key priorities for pharmacogenomics-guided treatment and prevention from a European expert workshop.. European journal of human genetics : EJHG. PMID: 42209751.

Setting: Europe, multi-country expert workshop involving 10 European countries. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The workshop identified five priorities: evidence, education and awareness, IT infrastructure, policy harmonization, and equity (“five key priorities”; Abstract). Fifty-five participants from 10 countries contributed across policy, healthcare, academia, patient organizations, and industry (“55 ...

[175] Lajmi Nesrine, Alves-Vasconcelos Sofia, Tsiachristas Apostolos et al. (2024). Challenges and solutions to system-wide use of precision oncology as the standard of care paradigm.. Cambridge prisms. Precision medicine. PMID: 38699518.

Setting: United Kingdom/Europe-led precision-oncology systems context with international examples; no single evaluated programme.. Design: Framework / perspective. Modality: Precision oncology - genomics-guided molecular testing, molecular tumour boards, data integration, and therapy/trial Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The review identifies system-wide technical, governance, resource, leadership, workflow, and financing barriers to precision-oncology scale-up (PDF pp. 1-7). It describes molecular tumour boards, standardization, data-sharing frameworks, and workforce education as existing solution approaches (PDF ...

[176] Landstrom Andrew P, Ferguson Jane F, James Cynthia A et al. (2025). Genetic and Genomic Testing in Cardiovascular Disease: A Policy Statement From the American Heart Association.. Circulation. PMID: 41230602.

Setting: United States - cardiovascular genomic medicine policy context.. Design: Framework / perspective. Modality: General/multiple - genetic/genomic testing, pharmacogenomics, polygenic risk, and genomic therapies in cardiovascular Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The AHA policy statement addresses equitable access, regulatory oversight, data stewardship, reimbursement for genetic counselling, and emerging technology integration (PDF p. 1). It recommends investment in research/health-care infrastructure and diverse data generation to support equitable ...

[177] Lee Yee Ming, McKillip Ryan P, Borden Brittany A et al. (2017). Assessment of patient perceptions of genomic testing to inform pharmacogenomic implementation.. Pharmacogenetics and genomics. PMID: 28267054.

Setting: United States – University of Chicago institutional pharmacogenomic implementation setting (1200 Patients Project).. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Two focus groups compared individuals exposed to pharmacogenomic-guided care with traditional-care participants (pp. 1–4). Participants with PGx-care exposure showed better understanding and greater receptivity; traditional-care participants expressed more skepticism (p. 9). Privacy, result access ...

[178] Leitch Tianna M, Killam Shayna R, Brown Karen E et al. (2024). Ensuring equity: Pharmacogenetic implementation in rural and tribal communities.. Frontiers in pharmacology. PMID: 36176435.

Setting: United States, Montana rural and tribal communities: University of Montana, Confederated Salish and Kootenai Tribes Tribal Health, Partnership Health Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Forty-five stakeholders participated in interviews across four Montana organizations serving rural and tribal communities (Methods/Results, pp. 3–5). Stakeholders identified infrastructure, personnel, funding, cultural context, ethics, and result-return processes as central determinants of ...

[179] Lemke Amy A, Thompson Jennifer, Hulick Peter J et al. (2021). Primary care physician experiences utilizing a family health history tool with electronic health record-integrated clinical decision support: an implementation process assessment.. Journal of community genetics. PMID: 32020508.

Setting: United States – NorthShore University HealthSystem community-based primary-care network in the Chicago area (27 sites).. Design: Qualitative study. Modality: General/multiple – family health-history risk stratification with EHR-integrated genomic clinical decision support Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: Of 118,062 patients offered the tool, 86,444 (73.2%) completed screening and 55,601 personalized-medicine CDS alerts were triggered (p. 341). PCPs acted on 12,105 (21.8%) CDS recommendations, placed 3,753 referrals, and ordered 1,590 genetic tests during early implementation (pp. 341–342) ...

[180] Lemke Amy A, Choi Sarah H, Dang Vinh et al. (2022). Assessing Vietnamese American patient perspectives on population genetic testing in primary care: A community-engaged approach.. HGG advances. PMID: 36039118.

Setting: United States – primary-care population genetic-testing pilot serving Vietnamese American patients.. Design: Qualitative study. Modality: Population genetic testing / clinical genomics – primary-care implementation with community engagement.. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The study used a community-engaged qualitative approach to assess Vietnamese American patient perspectives on primary-care population genetic testing (Abstract/Methods, pp. 1–3). Participants expressed interest in testing but wanted clear explanations, confidentiality protections and meaningful ...

[181] Lemke Amy A, Amendola Laura M, Kuchta Kristine et al. (2024). Primary Care Physician Experiences with Integrated Population-Scale Genetic Testing: A Mixed-Methods Assessment.. Journal of personalized medicine. PMID: 33066060.

Setting: United States – NorthShore University HealthSystem DNA-10K population genetic-testing program, Illinois.. Design: Mixed-methods. Modality: General/multiple – population-scale genomic screening for cancer/cardiac risk and pharmacogenomics. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: Mixed interviews and a PCP survey examined experiences with a pilot population-scale genetic-testing program (pp. 2–4). Most PCPs were satisfied with offering (61.4%) and ordering (70.0%) testing, but satisfaction was lower for patient (29.8%) and provider (42.0%) result return (p. 7). PCPs ...

[182] Lenin Chaitanyasre, Chan Frederick H F, Lim Phoebe X H et al. (2026). FH Genetic Testing in Preventive Cardiology: Unpacking Challenges and Enablers Beyond Cost.. BMC health services research. PMID: 41736064.

Setting: Singapore – preventive cardiology and familial-hypercholesterolaemia (FH) genetic-testing pathway.. Design: Qualitative study. Modality: Genomic hereditary-risk testing – familial hypercholesterolaemia. Domains: Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service

Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Twenty-four individuals with or without FH genetic testing participated in interviews about testing experiences and decisions. Barriers extended beyond price: perceived utility, privacy/insurance concerns, logistics, communication, and counselling access affected uptake. FH programmes should pair ...

[183] Levit Laura A, Kim Edward S, McAneny Barbara L et al. (2020). Implementing Precision Medicine in Community-Based Oncology Programs: Three Models.. Journal of oncology practice. PMID: 30802151.

Setting: United States - Intermountain Healthcare, Levine Cancer Institute/Atrium Health, and National Cancer Care Alliance community-oncology networks.. Design: Institutional case study. Modality: Precision oncology - somatic genomic profiling/NGS and targeted therapies.. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The article presents three large community-oncology implementation models: Intermountain, LCI/Atrium, and NCCA (Abstract; pp. 1-2). Molecular tumor boards, clinical pathways, and administrative services for prior authorization and trial matching were shared supports (pp. 2-5). Barriers included ...

[184] Li Ling Jing, Legeay Samuel, Gagnon Ann-Lorie et al. (2024). Moving towards the implementation of pharmacogenetic testing in Quebec.. Frontiers in genetics. PMID: 38234998.

Setting: Canada – Quebec provincial pharmacogenetic-testing implementation context.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The paper proposes a Quebec implementation framework that addresses financing, governance, roles, data systems, clinical workflows, education, and equity. Begin with prioritized gene-drug pairs and pilots, then scale through provincial coordination, shared infrastructure, workforce education, and ...

[185] Liang Shuang, Kennedy Elizabeth, Gale Nyree et al. (2025). Implementation of precision medicine in treating non-communicable diseases: a systematic review.. Journal of translational medicine. PMID: 41146138.

Setting: Not reported – systematic review of 68 precision-medicine interventions, services, or programmes for non-communicable diseases across varied settings.. Design: Systematic / scoping review. Modality: General/multiple (genomics, digital/AI, lifestyle, environmental, behavioural, and other omics approaches). Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Sixty-eight studies were included; 64 described determinants, 61 barriers, and 40 facilitators (Abstract; Results, pp. 5–6). Genomics was the most common intervention category (n=50); digital/AI technology was reported in 12 studies (Results, p. 5). Forty-two studies reported strategies, but many ...

[186] Liu Michelle, Vnencak-Jones Cindy L, Roland Bartholomew P et al. (2021). A Tutorial for Pharmacogenomics Implementation Through End-to-End Clinical Decision Support Based on Ten Years of Experience from PREDICT.. Clinical pharmacology and therapeutics. PMID: 33048353.

Setting: United States – Vanderbilt University Medical Center PREDICT program, Nashville, Tennessee.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics – panel-based PGx testing with end-to-end EHR clinical decision support.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: PREDICT began at Vanderbilt in 2010 with CYP2C19-guided clopidogrel prescribing and expanded to 16 drug-gene interactions (Introduction, p. 2). The programme transitioned from institutionally supported preemptive testing to concurrent clinician ordering with panel-based future-use results (p. 2) ...

[187] Livingood William C, Bautista Maria A B, Smotherman Carmen et al. (2022). Comparative study of different SES neighborhood clinics for health literacy and internet access.. Digital health. PMID: 36081750.

Setting: United States - Northeast Florida primary-care clinics affiliated with a safety-net hospital.. Design: Survey / cross-sectional. Modality: General/multiple - patient-engaged digital tools supporting primary-care precision medicine.. Domains: Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The analysis included 791 primary-care patients across lower-SES, higher-SES, and technology-mitigated clinics (Results, pp. 5-6). Health literacy was lower in the lower-SES clinic than in the higher-SES and technology-mitigated clinics (Table 3, pp. 6-7). The technology-mitigated clinic achieved ...

[188] Lorente Reyes, Antonanzas Fernando, Rodriguez-Ibeas Roberto (2024). Implementation of risk-sharing contracts as perceived by Spanish hospital pharmacists.. Health economics review. PMID: 31317339.

Setting: Spain - hospital pharmacy and national/regional public health-system context.. Design: Survey / cross-sectional. Modality: Biomarker-guided/personalized medicine - risk-sharing contracts for high-cost treatments.. Domains: Governance and Policy; Digital Infrastructure and Interoperability; Finance and Sustainability. Key findings: Eighty hospital-pharmacy responses were analyzed and 90% reported risk-sharing contracts (Results/Conclusions, pp. 4-7). Pay-for-performance was viewed as more specific for personalized medicine, and 85% said it promotes genetic testing (Results, pp. 4-6). Insufficient monitoring-data ...

[189] Loudon Elizabeth, Scott Stuart A, Rigobello Robert et al. (2021). Pharmacogenomic education among genetic counseling training programs in North America.. Journal of genetic counseling. PMID: 33882174.

Setting: United States and Canada - accredited genetic-counseling training programs.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics - genetic counseling and PGx service delivery.. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: Thirty-one programme leaders responded; 96.3% reported PGx didactics, generally fewer than seven hours (Results, pp. 1502-1504). 85.2% agreed programmes should provide PGx education, while curricular time and local expertise were key barriers (Results, pp. 1503-1505). Counselor-pharmacist ...

[190] Lucas Beckett Isabelle A, Emery Kate R, Wagner Josiah T et al. (2025). Geno4ME Study: implementation of whole genome sequencing for population screening in a large healthcare system.. NPJ genomic medicine. PMID: 40593689.

Setting: United States – Providence Health system across seven states.. Design: Empirical implementation study. Modality: General/multiple – whole-genome population screening for inherited disease and pharmacogenomics.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: Providence contacted more than 30,800 potential participants; 2,716 consented and 2,017 had results returned, with 47.5% identifying as racial or ethnic minority individuals (Abstract, p. 1). 432 of 2,017 participants (21.4%) had one or more hereditary-disease and/or pharmacogenomic management ...

[191] Luke Miles J, Krupetsky Nina, Liu Helen et al. (2021). Pharmacists as Personalized Medicine Experts (PRIME): Experiences Implementing Pharmacist-Led Pharmacogenomic Testing in Primary Care Practices.. Pharmacy (Basel, Switzerland). PMID: 34941633.

Setting: Canada – Ontario primary care settings, including community pharmacies, family health teams, and nurse-practitioner-led clinics.. Design: Qualitative study. Modality: Pharmacogenomics / pharmacogenetics. Domains: Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Ten of 21 pharmacists who completed PRIME training participated in interviews: five in community pharmacy, four in interprofessional primary care, and one in both settings (Results: Participants, p. 4). Seven key TDF domains were identified: memory/attention/decision processes; behavioural ...

[192] Lunenburg Carin A T C, Gasse Christiane (2021). Pharmacogenetics in psychiatric care, a call for uptake of available applications.. Psychiatry research. PMID: 32739644.

Setting: Denmark / international psychiatric-care implementation context; no single evaluated health system.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - psychiatric medication prescribing.. Domains: Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The review identifies psychiatric pharmacogenetics as less routinely implemented than PGx in several other clinical areas despite available guidelines (Introduction; pp. 3-7). The paper synthesizes barriers around clinical indication, laboratory interpretation, complex drug metabolism, and limited ...

[193] Luzum J A, Pakyz R E, Elsey A R et al. (2017). The Pharmacogenomics Research Network Translational Pharmacogenetics Program: Outcomes and Metrics of Pharmacogenetic Implementations Across Diverse Healthcare Systems.. Clinical pharmacology and therapeutics. PMID: 28090649.

Setting: United States – Pharmacogenomics Research Network Translational Pharmacogenetics Program across seven reporting healthcare systems.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The NIH Pharmacogenomics Research Network established TPP in 2011 to catalogue and advance implementation across eight US health systems; seven sites contributed normalised metrics through June 2015 (Abstract/Methods). Collected data included implemented gene–drug pairs, allele/diplotype ...

[194] Magavern Emma F, Durrani Faiza, Raza Mehru et al. (2023). British South Asian ancestry participants views of pharmacogenomics clinical implementation and research: a thematic analysis.. The pharmacogenomics journal. PMID: 37907686.

Setting: United Kingdom – four focus groups with British South Asian ancestry participants in East London.. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: Four focus groups included 42 British South Asian ancestry participants (Table 1, p. 2). Themes covered clinical implementation, communication, timing, data custodianship, cost, trust, education, and safeguards (Table 2, p. 3). Participants saw the greatest clinical benefit where PGx data could ...

[195] Mai Chun-Wai, Sridhar Sathvik B, Karattuthodi Mohammed Salim et al. (2024). Scoping review of enablers and challenges of implementing pharmacogenomics testing in the primary care settings.. BMJ open. PMID: 39500605.

Setting: Multiple countries, primary-care settings; included studies were predominantly from the global north, including USA, Canada, European Union, and Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The review included 78 studies on PGx implementation in primary care (“78 studies were included”). Main implementation enablers were clinical benefit, cost reduction, and professional empowerment (“three main factors, broadly”). Core challenges were evidence gaps, training deficits, patient ...

[196] Mangalagiu Andrei Gabriel, Petrescu Bogdan Mircea, Riga Sorin et al. (2026). Psychiatric pharmacogenomics: from genetic evidence to clinical integration - structural, educational, and ethical challenges.. Frontiers in pharmacology. PMID: 42022561.

Setting: Not reported. International psychiatric-pharmacogenomics implementation context.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics – psychiatric pharmacotherapy. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: The review identifies structural, educational, economic, governance, and ethical barriers as jointly limiting psychiatric PGx integration (Abstract; pp. 28–31). The paper reports that only a minority of hospitals currently meet the combined infrastructure, governance, education, and workflow ...

[197] Manolio Teri A (2017). Implementing genomics and pharmacogenomics in the clinic: The National Human Genome Research Institute's genomic medicine portfolio.. Atherosclerosis. PMID: 27612677.

Setting: United States – NHGRI genomic-medicine portfolio, including national multi-institutional implementation networks and early-adopter health systems.. Design: Framework / perspective. Modality: General/multiple – clinical genomics, pharmacogenomics, disease-risk assessment, sequencing and clinical decision Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The paper describes six NHGRI research and dissemination initiatives spanning individual care, multicentre networks and knowledge infrastructure (pp. 7–12). eMERGE implementation work addressed consent, clinical workflow, approvals and tools for genomic integration across ten institutions (pp ...

[198] Manzi Shannon F, Fusaro Vincent A, Chadwick Laura et al. (2017). Creating a scalable clinical pharmacogenomics service with automated interpretation and medical record result integration - experience from a pediatric tertiary care facility.. Journal of the American Medical Informatics Association : JAMIA. PMID: 27301749.

Setting: United States – Boston Children’s Hospital pediatric tertiary-care teaching hospital.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – clinical PGx service with automated interpretation and EHR-based Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: Clinical decision-support rules supplied guidance for all 31 initial patients with actionable variants who were prescribed interacting medications (Abstract). Ninety percent of 394 TPMT genotyping orders were placed preemptively (Abstract). The service used clinical testing for TPMT and ...

[199] Marcu Loredana G, Marcu David C (2024). Pharmacogenomics and Big Data in medical oncology: developments and challenges.. Therapeutic advances in medical oncology. PMID: 39483136.

Setting: Not reported – international medical-oncology context; implementation examples are drawn from multiple US and European programs.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics with Big Data-enabled precision oncology. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service

Integration; Finance and Sustainability. Key findings: The review describes a shift from reactive, gene-by-gene testing to pre-emptive testing with EHR-held genomic data available for future prescribing decisions (p. 6). The Mayo RIGHT protocol is presented as using biobank data and EHR infrastructure to provide point-of-care clinical decision support ...

[200] Martin-Sanchez Fernando, Lázaro Martín, López-Otín Carlos et al. (2023). Personalized Precision Medicine for Health Care Professionals: Development of a Competency Framework.. JMIR medical education. PMID: 36749626.

Setting: Spain – national health-professional precision-medicine competency-development context.. Design: Framework / perspective. Modality: General/multiple precision medicine workforce competencies. Domains: Workforce Capability and Change Management. Key findings: The authors identified 58 competencies in five domains and six professional profiles for personalized precision medicine. The framework was benchmarked against 22 documents and refined with 11 experts. Health systems and education providers should use role-specific competency frameworks to prepare ...

[201] Maruf Abdullah Al, Bousman Chad A (2025). Approaches and hurdles of implementing pharmacogenetic testing in the psychiatric clinic.. PCN reports : psychiatry and clinical neurosciences. PMID: 38868642.

Setting: Canada / international psychiatric-care implementation context; no single evaluated health system.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - pharmacogenetic testing for psychiatric prescribing.. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: The review synthesizes psychiatric PGx implementation hurdles in workflow, EHR integration, reimbursement, regulation, clinical generalizability, and education (pp. 3-10). It identifies static reports and nonstandard laboratory formats as barriers to durable clinical use (EHR integration, p. 6) ...

[202] Mason Thuy, Ní Dheasmhúnaigh Éirne, Ghazal Heba (2024). Exploring the preparedness of hospital pharmacists practising in Southwest London for implementing pharmacogenomics testing.. Journal of pharmaceutical policy and practice. PMID: 39640415.

Setting: United Kingdom – NHS hospitals in Southwest London.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics – hospital-pharmacist preparedness for testing services.. Domains: Workforce Capability and Change Management; Finance and Sustainability. Key findings: Forty-six hospital pharmacists responded (33.6% response rate); 28.3% reported undergraduate and 26.1% postgraduate pharmacogenomics training (Results, PDF pp. 5–6). Confidence was low: only 2/46 felt confident providing testing and recommendations (Results, PDF pp. 6–7). Funding/training and staff ...

[203] McDermott John H, Tsakiroglou Maria, Newman William G et al. (2025). Pharmacogenomics in the UK National Health Service: Progress towards implementation.. British journal of clinical pharmacology. PMID: 40460990.

Setting: United Kingdom – National Health Service pharmacogenomics implementation context.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The paper synthesizes implementation issues, recommendations, and progress across NHS PGx testing, evidence, data, workforce, and service-delivery areas (Table 1, p. 2). PGx-NoE was launched in 2024 to coordinate national stakeholders and implementation activity (p. 1). The authors identify ...

[204] McDermott John Henry, Sharma Videha, Keen Jessica et al. (2025). Embedding Pharmacogenetics Into Clinical Practice to Improve Patient Outcomes.. Annals of human genetics. PMID: 40358420.

Setting: Not reported – review is grounded largely in United Kingdom/NHS pharmacogenetics examples but discusses wider international implementation.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: The authors identify three principal transition challenges: the testing approach, digital/data integration and service-delivery model (p. 4). Broad adoption requires EHR-visible, actionable prescribing guidance and standardized data storage/messaging rather than detailed laboratory reports alone ...

[205] McKay Skye, Elias Joseph, Mazariego Carolyn et al. (2026). A single logic model capturing clinical, service, and implementation interventions using a practical example in pediatric precision medicine.. JBI evidence implementation. PMID: 42129957.

Setting: Australia - Sydney Children's Hospital/UNSW pediatric precision-medicine context.. Design: Framework / perspective. Modality: Pediatric precision oncology - ProCure off-label-therapy application support database.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The CSII-RLM was developed from qualitative data from 17 pediatric healthcare-professional interviews (Methods, pp. 3-4). The model separates clinical, service, and implementation interventions and maps determinants, strategies, mechanisms, and outcomes (Results, pp. 5-12). Centralized ProCure ...

[206] McKillip R P, Borden B A, Galecki P et al. (2019). Patient Perceptions of Care as Influenced by a Large Institutional Pharmacogenomic Implementation Program.. Clinical pharmacology and therapeutics. PMID: 27981566.

Setting: United States – University of Chicago institutional pharmacogenomic implementation programme.. Design: Cohort / clinical evaluation. Modality: Pharmacogenomics/pharmacogenetics – patient perceptions within an institutional implementation programme. Domains: Patient Access, Equity and Ethics. Key findings: The study analysed patient perceptions after encounters within a large institutional PGx programme (Methods/Results, pp. 3–6). Patients whose visit involved PGx-guided prescribing reported higher perceived personalized care than comparison encounters (Results, pp. 5–6). The programme demonstrates ...

[207] McMichael Alan J, Kane Joseph P M, Rolison Jonathan J et al. (2022). Implementation of personalised medicine policies in mental healthcare: results from a stated preference study in the UK.. BJPsych open. PMID: 35109949.

Setting: United Kingdom – UK public preferences regarding hypothetical national implementation of personalised medicine policies funded through annual taxation. Design: Survey / cross-sectional. Modality: General/multiple – biomarker-stratified treatment policies for depression and cystic fibrosis.. Domains: Governance and Policy; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The discrete-choice experiment included 2,804 UK respondents: 1,360 received depression vignettes and 1,444 cystic-fibrosis vignettes (Methods, p. 3). Reducing taxpayer cost from £90 to £10 accounted for more than half of total achievable utility change: CRAI 56.11% for cystic fibrosis and 55.86% ...

[208] Menendez-Gonzalez Manuel (2025). Implementing a tridimensional diagnostic framework for personalized medicine in neurodegenerative diseases.. Alzheimer's & dementia : the journal of the Alzheimer's Association. PMID: 39976261.

Setting: Not reported – proposed international diagnostic framework for neurodegenerative diseases. Design: Framework / perspective. Modality: General/multiple – genomic, molecular biomarker, imaging, and AI-supported precision diagnostics for neurodegenerative Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The paper proposes a three-dimensional framework for integrating clinical, biomarker, imaging, and genetic information in neurodegenerative-disease diagnosis. Case examples are illustrative rather than evidence of implementation in a health system. Prospective validation across diverse populations ...

[209] Minari Jusaku, Brothers Kyle B, Morrison Michael (2019). Tensions in ethics and policy created by National Precision Medicine Programs.. Human genomics. PMID: 29665847.

Setting: United States, United Kingdom, and Japan - national precision-medicine programme policy contexts.. Design: Policy analysis. Modality: General/multiple - national precision-medicine programmes and genome-wide sequencing governance.. Domains: Governance and Policy; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The analysis compares policy and ethical tensions across United States, United Kingdom, and Japanese national precision-medicine initiatives (PDF pp. 3-4). Consent, return of uncertain findings, data governance, insurance, commercialization, and sustainability are interdependent implementation ...

[210] Mir Joan Francesc, Rodríguez-Caba Cristina, Estrada-Campmany Maria et al. (2023). An Integrated Multidisciplinary Circuit Led by Hospital and Community Pharmacists to Implement Clopidogrel Pharmacogenetics in Clinical Practice.. Pharmacy (Basel, Switzerland). PMID: 37104082.

Setting: Spain – Barcelona hospital and community-pharmacy circuit for clopidogrel pharmacogenetics.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – CYP2C19-guided clopidogrel prescribing. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Of 120 patients assessed, 16 were recruited and genotyped in the pilot circuit. Six participants (37.5%) had an intermediate

metabolizer phenotype; no prescriptions were changed during follow-up. Mean result turnaround was 13.8 ± 5.4 days. Wider deployment requires stronger logistics, sustainable ...

[211] Mitchell Sharon, Jaccard Evrim, Schmitz Felix Michael et al. (2022). Investigating acceptability of a training programme in precision medicine for frontline healthcare professionals: a mixed methods study.. BMC medical education. PMID: 35850770.

Setting: Switzerland - frontline primary-care professional context.. Design: Mixed-methods. Modality: General/multiple - precision medicine training for pharmacists, advanced-practice nurses, and general practitioners.. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: Two focus groups included 12 Swiss frontline professionals: four general practitioners, four advanced-practice nurses, and four pharmacists (PDF pp. 3, 7). Participants rated proposed learning objectives highly, with mean importance ratings from 6.25 to 9.75 (PDF p. 8). Implementation feasibility ...

[212] Mizuno Tomoyuki, Dong Min, Taylor Zachary L et al. (2022). Clinical implementation of pharmacogenetics and model-informed precision dosing to improve patient care.. British journal of clinical pharmacology. PMID: 32529759.

Setting: United States – Cincinnati Children’s Hospital Medical Center; institutional examples of pharmacogenetics and model-informed precision dosing (MIPD).. Design: Framework / perspective. Modality: General/multiple – pharmacogenetics-guided therapy and pharmacokinetic/pharmacodynamic model-informed precision dosing.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The Cincinnati Children’s GPS began in 2004 and initially focused on CYP2D6, CYP2C19, CYP2C9, and TPMT (p. 1419). The service later expanded to warfarin, pain-management, and transplantation-related PGx applications (p. 1419). In a cited pediatric sirolimus MIPD implementation, 94% of patients ...

[213] Moffitt Laura R, Karimnia Nazanin, Wilson Amy L et al. (2024). Challenges in Implementing Comprehensive Precision Medicine Screening for Ovarian Cancer.. Current oncology (Toronto, Ont.). PMID: 39727715.

Setting: Australia-focused contextual discussion, with broader international evidence. Design: Framework / perspective. Modality: Multimodal (genomic+imaging+clinical), combining genomic profiling, functional drug screening, multi-omics, AI/ML, and Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The review identifies a connected implementation cycle spanning tumour heterogeneity, sample quality, screening constraints, data infrastructure, complex resources, patient access, ethics, and clinical integration (Figure 1, page 11). Comprehensive tumour profiling, testing, and reporting were ...

[214] Mogaka John J O, James San E, Chimbari Moses J (2020). Leveraging implementation science to improve implementation outcomes in precision medicine.. American journal of translational research. PMID: 33042394.

Setting: Not reported - framework based on international implementation-science literature; no single evaluated health system.. Design: Framework / perspective. Modality: General/multiple - omics-based biomarkers for stratified diagnosis, treatment selection, and dosing.. Domains: Strategic Leadership and Readiness; Governance and Policy; Digital Infrastructure and Interoperability; Patient Access, Equity and Ethics. Key findings: The authors identified 15 implementation theories, models, and frameworks relevant to precision medicine (PDF pp. 5-10). The most frequently cited frameworks were RE-AIM, CFIR, PRISM, and PARIHS (PDF pp. 6-10). Precision-medicine implementation should explicitly address evidence, stakeholder ...

[215] Mogaka John Jules O, Chimbari Moses J (2020). The mediating effects of public genomic knowledge in precision medicine implementation: A structural equation model approach.. PloS one. PMID: 33052984.

Setting: Pan-African - survey of participants affiliated with African organisations and institutions involved in molecular/genetic testing; no single health Design: Survey / cross-sectional. Modality: General/multiple - omics-based biomarkers, public genomic knowledge, and precision-medicine implementation readiness.. Domains: Patient Access, Equity and Ethics. Key findings: The online survey included 270 participants involved with omics-based molecular testing across Africa (Abstract; Methods/Results, pp. 3-9). The SEM reported a partial indirect effect of public genomic awareness on the relationship between biomarker characteristics and the study's ...

[216] Moore Claire, Lazarakis Smaro, Stenta Tayla et al. (2023). A systematic review of knowledge, attitude and practice of pharmacogenomics in pediatric oncology patients.. Pharmacology research & perspectives. PMID: 38013228.

Setting: Australia, United States, and Egypt - studies included in a pediatric-oncology implementation literature review; no single health system.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics - pediatric oncology.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Of 146 records identified, three studies met the review's eligibility criteria (Abstract; Results, p. 4). Across the included studies, education was the only enabler reported by both healthcare-professional and consumer groups (Results, pp. 5-7). Consumer concerns centred on cost, insurance ...

[217] Morales Ana, Goehringer Jessica, McDonald Paige L et al. (2025). Implementation of genetic testing for heritable cardiac conditions: A scoping review.. Genetics in medicine open. PMID: 40756326.

Setting: International, predominantly United States - scoping review of genetic-testing implementation for heritable cardiac conditions.. Design: Systematic / scoping review. Modality: Genetic testing for heritable cardiac conditions, including familial hypercholesterolaemia, inherited Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The scoping review included 32 studies on implementation of genetic testing for heritable cardiac conditions (Results, pp. 4-5). Studies most commonly concerned familial hypercholesterolaemia, cardiovascular pharmacogenomics, and inherited cardiomyopathies/arrhythmias, with most conducted in the ...

[218] Morris Sarah A, Alsaidi Ashraf T, Verbyla Allison et al. (2022). Cost Effectiveness of Pharmacogenetic Testing for Drugs with Clinical Pharmacogenetics Implementation Consortium (CPIC) Guidelines: A Systematic Review.. Clinical pharmacology and therapeutics. PMID: 36149409.

Setting: Multiple countries - 108 published pharmacoeconomic evaluations; most studies were from North America.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics - CPIC Level A/B gene-drug pairs.. Domains: Finance and Sustainability. Key findings: The systematic review screened 2,819 unique articles, assessed 139 full texts, and included 108 economic evaluations (PDF p. 3, Figure 1). About three-quarters of included articles concluded PGx testing was cost-effective or cost-saving (PDF p. 5). Most analyses examined single-gene testing; only a ...

[219] Mroz Pawel, Michel Stephen, Allen Josiah D et al. (2021). Development and Implementation of In-House Pharmacogenomic Testing Program at a Major Academic Health System.. Frontiers in genetics. PMID: 34745204.

Setting: United States, M Health Fairview / University of Minnesota academic health-system setting. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The programme developed an in-house PGx assay covering 20 genes, 48 SNPs, and CYP2D6 copy-number variation (Methods, pp. 3–5). Four pilot programmes were implemented across the health system (Pilot implementation, pp. 5–8). Sixteen live and 23 virtual provider-training sessions were delivered ...

[220] Mukabyiringiro Esther, Kinyanjui Andrew Wainaina, Nthenya Gachie Ruth et al. (2026). Strengthening Pharmacogenomics Implementation in Africa: Challenges and Opportunities - A Narrative Review.. Health science reports. PMID: 41948624.

Setting: Africa – narrative synthesis of continent-wide pharmacogenomics research, policy, and health-system implementation conditions.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The narrative review screened 91 records and included 39 articles and policy reports relevant to Africa (Methods, p. 1). Major barriers span technical infrastructure, policy, workforce education, affordability, research representation, and ethics (Abstract; pp. 3–6). The paper maps current African ...

[221] Méndez-Vidal Cristina, Bravo-Gil Nereida, Pérez-Florido Javier et al. (2025). A genomic strategy for precision medicine in rare diseases: integrating customized algorithms into clinical practice.. Journal of translational medicine. PMID: 39833864.

Setting: Spain – Andalusia public healthcare system; rare-disease NGS pilot at a public reference hospital serving all eight Andalusian provinces.. Design: Empirical implementation study. Modality: Genomic rare-disease diagnosis (NGS-based). Domains: Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The five-year pilot retrospectively reviewed 6,500 NGS tests: 6,267 diagnostic assays

and 233 carrier studies (Abstract; Methods, p. 3). Causative variants were identified in 2,061 index patients, a 32.9% average diagnostic yield (Abstract; Results, p. 8). Results generated more than 5,000 ...

[222] Najafzadeh Mehdi, Garces Jorge A, Maciel Alejandra (2018). Economic Evaluation of Implementing a Novel Pharmacogenomic Test (IDgenetix. PharmacoEconomics. PMID: 29110140.

Setting: United States - societal perspective; simulated implementation of IDgenetix-guided treatment for depression/anxiety. Design: Economic evaluation. Modality: Pharmacogenomics/pharmacogenetics - IDgenetix-guided antidepressant/anxiolytic treatment. Domains: Finance and Sustainability. Key findings: The model predicted 3-year cumulative remission of 78% with IDgenetix-guided care versus 66% with treatment as usual (Abstract/Results). Predicted 3-year total costs, including the test, were US\$14,124 versus US\$14,659 per patient, respectively (Abstract/Results). The model predicted 2.09 versus ...

[223] Nasir Bushra Farah, Vinayagam Ritwika, Massi Luciana et al. (2024). A Systematic Review Exploring Empirical Pharmacogenomics Research Within Global Indigenous Populations.. Molecular genetics & genomic medicine. PMID: 39435544.

Setting: Global – systematic review of pharmacogenomics research involving Indigenous populations; most included studies were from the United States.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics – Indigenous-population research and pathways to equitable clinical translation.. Domains: Governance and Policy; Workforce Capability and Change Management; Patient Access, Equity and Ethics. Key findings: Of 427 identified articles, 30 empirical studies were included: 16 quantitative and 14 qualitative or mixed-methods studies (Abstract, p. 1). Most included studies were from the United States (36%), indicating limited global coverage (Abstract, p. 1). Reviewed work repeatedly identified governance ...

[224] Nembaware Victoria, Mulder Nicola (2026). The African Genomic Medicine Training Initiative (AGMT): Showcasing a Community and Framework Driven Genomic Medicine Training for Nurses in Africa.. Frontiers in genetics. PMID: 31921282.

Setting: Africa – pan-African nursing education and genomic-medicine capacity-building initiative across participating countries.. Design: Empirical implementation study. Modality: General/multiple genomic medicine workforce training. Domains: Workforce Capability and Change Management. Key findings: The initiative surveyed needs across 19 countries and delivered 19 classes in 11 countries. A total of 225 participants enrolled, with reported completion of approximately 35%. Local adaptation, facilitator development, and blended-delivery approaches were central to extending genomics education ...

[225] Ng Fiona Fj, Verma Rashmi, Sani Levana et al. (2025). A feasibility study on implementing pre-emptive pharmacogenomics testing in outpatient clinics in Singapore (IMPT study).. The pharmacogenomics journal. PMID: 40074758.

Setting: Singapore – five outpatient clinics within the private Raffles Medical Group: three general-practitioner clinics and two specialist outpatient Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The intervention was implemented across five private outpatient clinics, using a five-pharmacogene, 21-variant qPCR panel linked to CPIC/DPWG and regulatory recommendations (Methods, pp. 2–3). Of 222 analysed patients, 95% had at least one clinically actionable variant; 71.2% had at least two ...

[226] Obeng Aniwaa Owusu, Scott Stuart A, Kaszemacher Tom et al. (2023). Prescriber Adoption of SLCO1B1 Genotype-Guided Simvastatin Clinical Decision Support in a Clinical Pharmacogenetics Program.. Clinical pharmacology and therapeutics. PMID: 36372942.

Setting: United States – Mount Sinai Health System primary-care clinical pharmacogenetics programme, New York.. Design: Cohort / clinical evaluation. Modality: Pharmacogenomics/pharmacogenetics – SLCO1B1-guided simvastatin prescribing.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Among 1,639 preemptively genotyped primary-care patients, 298 (18.2%) had intermediate-function and 25 (1.53%) poor-function OATP1B1 phenotypes (Abstract). CDS was deployed 134 times for 40 high-risk patients between January 2015 and April 2020 (Results, p. 6). 64.2% of point-of-care CDS ...

[227] Olander Megan, Waring Stephen, Stenehjem David D et al. (2023). Primary Care Clinicians Attitudes and Knowledge of Pharmacogenetics in a Large, Multi-state, Healthcare System.. Innovations in pharmacy. PMID: 34007697.

Setting: United States, Essentia Health multi-state healthcare system. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The survey invited 520 clinicians and received 90 responses (17% response rate) (Methods/Results, pp.

2–4). Thirty-five percent believed PGx should be used currently, while 63% believed it would have value soon (Results, p. 4). Ordering and result-application confidence were low: 82% and 71% ...

[228] Omer Mohamed S (2020). Literature Review Concerning the Challenges of Implementing Pharmacogenetics in Primary Care Practice.. Cureus. PMID: 32923217.

Setting: United States context,. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Finance and Sustainability. Key findings: The review identifies three main challenges: test evaluation, cost-effectiveness, and regulatory burden (“three main challenges are facing this integration”). Reported economic findings varied across cited studies, including no significant QALY difference with an added cost of US \$47,705 for one ...

[229] Omran Safa, Leong Siew Lian, Blebil Ali et al. (2024). The needs and gaps in pharmacogenomics knowledge and education among healthcare professionals in Malaysia: A multisite Delphi study.. Clinical and translational science. PMID: 39523855.

Setting: Malaysia – multisite healthcare-professional Delphi panel across public/governmental and teaching hospitals and universities.. Design: Other [check]. Modality: Pharmacogenomics/pharmacogenetics – workforce competence and education for clinical integration.. Domains: Governance and Policy; Workforce Capability and Change Management. Key findings: The study included 38 multidisciplinary experts in round one across 14 sites (Results, p. 4). Consensus identified gaps in healthcare professionals’ PGx knowledge and practice and specified education components (Results, pp. 4–8). Malaysia should develop tailored competency-based education to ...

[230] Omran Safa, Gan Siew Hua, Teoh Siew Li (2026). Pharmacogenomics in drug therapy: global regulatory guidelines for managing high-risk drug reactions.. European journal of human genetics : EJHG. PMID: 40993225.

Setting: Global multi-country policy context; carbamazepine pharmacogenomics used as the comparative implementation example.. Design: Policy analysis. Modality: Pharmacogenomics/pharmacogenetics - high-risk drug reactions, particularly HLA-guided carbamazepine prescribing.. Domains: Governance and Policy; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review compared global PGx policy status across regulatory authority, implementation settings, labeling, laboratory testing, reimbursement, discrimination protections, and patient-data considerations (PDF p. 3, Table 1). Singapore and Thailand were identified as Southeast Asian countries with ...

[231] Owusu Obeng Aniwa, Fei Kezhen, Levy Kenneth D et al. (2020). Physician-Reported Benefits and Barriers to Clinical Implementation of Genomic Medicine: A Multi-Site IGNITE-Network Survey.. Journal of personalized medicine. PMID: 30042363.

Setting: United States, five Implementing GeNomics In pracTicE (IGNITE) institutions in academic and community outpatient settings. Design: Survey / cross-sectional. Modality: General/multiple, comparing pharmacogenomics/pharmacogenetics with disease-risk or diagnostic genetics. Domains: Workforce Capability and Change Management. Key findings: Two-thirds of physicians considered genetic or PGx testing relevant to practice (“67”; Table 3). Only 15% felt confident using genetic-test results (“15”; Table 3). Physicians at PGx sites were more likely to report preparedness, 58% versus 22% (“58% vs. 22%”; Table 3). Clinical tools, decision ...

[232] Paolinelli Pablo S, Saavedra Azcona Tomas, Casto Florencia B et al. (2026). Accessibility to molecular studies in gliomas: a challenge for precision medicine in low-resource countries.. Frontiers in oncology. PMID: 42088211.

Setting: Argentina – high-volume tertiary neurosurgical centre in Buenos Aires; interpreted in the context of low-resource-country molecular-diagnostic access.. Design: Cohort / clinical evaluation. Modality: Precision oncology / molecular diagnostics – glioma molecular classification and testing access.. Domains: Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The retrospective cohort included patients undergoing elective glioma surgery from 2010 through 2024 (Abstract/Methods, pp. 1–3). Molecular testing increased after WHO 2016 implementation but remained incomplete for key markers (Results, pp. 4–6). The study documents the mismatch between evolving ...

[233] Pasternak Amy L, Ward Kristen, Irwin Madison et al. (2023). Identifying the prevalence of clinically actionable drug-gene interactions in a health system biorepository to guide pharmacogenetics implementation services.. Clinical and translational science. PMID: 36510710.

Setting: United States - Michigan Medicine / Michigan Genomics Initiative biorepository. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics - clinically actionable drug-gene interactions. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Among 75,337 biorepository participants with Michigan Medicine encounters, 57,058 (75.8%) had been prescribed at least one medication

with a pharmacogenetic guideline (Results). The study evaluated 151,325 prescriptions over 6.5 years to characterize drug-gene interaction opportunities in the ...

[234] Pastorino Roberta, Loreti Claudia, Giovannini Silvia et al. (2021). Challenges of Prevention for a Sustainable Personalized Medicine.. Journal of personalized medicine. PMID: 33923579.

Setting: Europe/general health-system and prevention context.. Design: Framework / perspective. Modality: General/multiple - personalised medicine for primary, secondary, and tertiary prevention.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The paper frames PM prevention across primary, secondary, and tertiary prevention and notes that implementation remains in its infancy (PDF pp. 1-2). It identifies policy-relevant conditions: pathway-specific evidence, cost-effectiveness, data/privacy safeguards, equity, stakeholder engagement, and ...

[235] Patel Jai N, Chaihorsky Lena, Dong Olivia M et al. (2025). Medical policy determinations for pharmacogenetic tests among US health plans.. The American journal of managed care. PMID: 39977287.

Setting: United States - national health-insurer, laboratory-benefit-manager, and Medicare MolDX policy environment.. Design: Policy analysis. Modality: Pharmacogenomics/pharmacogenetics - coverage determinations for clinically relevant drug-gene tests.. Domains: Governance and Policy; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Policies from eight insurers, three laboratory benefit managers, and MolDX were evaluated for 65 drug-gene pairs (Abstract; Methods, pp. 1-3). MolDX covered all 65 pairs, whereas eight policies covered 10 or fewer; coverage was more common when CPIC or FDA Section 1 guidance existed (Abstract ...

[236] Patel Tark J, Wehbe Eman, Hughes Stephen et al. (2025). Implementing CYP2C19-guided clopidogrel therapy: a scoping review of pharmacogenomic testing services.. The pharmacogenomics journal. PMID: 40280918.

Setting: International – 37 published CYP2C19-clopidogrel pharmacogenomic service descriptions; 28 were from the United States. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics – CYP2C19-guided clopidogrel therapy. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The review included 37 services: 22 hospital-based, 14 community-based, and one serving both settings; 28 were US-based (Results, p. 3). Twenty-three services used multigene panels and 14 used single-gene testing (Results, p. 3). Turnaround ranged from 1–14 days for external laboratories ...

[237] Pearce Angela, Terrill Bronwyn, Alffenaar Jan-Willem et al. (2022). Pharmacogenomic testing: perception of clinical utility, enablers and barriers to adoption in Australian hospitals.. Internal medicine journal. PMID: 35191159.

Setting: Australia, three tertiary hospitals in Sydney, New South Wales. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: PGx testing was considered relevant by 79/100 HCP, but only 23/100 reported past use (“considered... relevant”; Abstract). The major barriers were lack of guidelines and knowledge, reported by 62/79 and 54/77 (“lack of clinical practice guidelines”; Abstract). Most HCP saw PGx value for identifying ...

[238] Perezcano Carlos (2026). The critical need to implement pharmacogenomics in public health services: Mexico in the global picture.. Frontiers in public health. PMID: 41869608.

Setting: Mexico, public health institutions and public-sector implementation context. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The article proposes five interdependent building blocks: pilots, capacity, regulation and ethics, real-world evaluation, and partnerships (“interdependent building blocks”; Section 6). The proposed model prioritizes scalability, regulatory oversight, ethics, and equity (“scalability, regulatory ...

[239] Peruzzi Elena, Roncato Rossana, De Mattia Elena et al. (2025). Implementation of pre-emptive testing of a pharmacogenomic panel in clinical practice: Where do we stand?. British journal of clinical pharmacology. PMID: 37926674.

Setting: International – implementation review drawing on pre-emptive pharmacogenomic panel initiatives, including European health systems and North American Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The review describes implementation programmes using pre-emptive panel testing,

including PG4KDS, PREDICT, RIGHT, U-PGx, and PREPARE (Table 1, pp. 4–5). PREPARE is cited as showing a 30% reduction in clinically relevant toxicities with pre-emptive PGx-guided therapy (Abstract; p. 6). The review ...

[240] Peterson J F, Field J R, Shi Y et al. (2017). Attitudes of clinicians following large-scale pharmacogenomics implementation.. The pharmacogenomics journal. PMID: 26261062.

Setting: United States - Vanderbilt University Medical Center PREDICT programme. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics - preemptive multiplex testing with EHR decision support. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The survey analyzed 99 clinician responses after a large-scale PREDICT implementation at an academic medical centre (Results). Most clinicians agreed that pharmacogenetic variants could guide tailoring of prescriptions, although there was no consensus on responsibility for action or disclosure ...

[241] Pinzón-Espinosa Justo, van der Horst Marte, Zinkstok Janneke et al. (2022). Barriers to genetic testing in clinical psychiatry and ways to overcome them: from clinicians' attitudes to sociocultural differences between patients across the globe.. Translational psychiatry. PMID: 36220808.

Setting: International - clinical psychiatry genetic-testing implementation context; no single evaluated health system.. Design: Framework / perspective. Modality: General/multiple - psychiatric genetic testing, including pharmacogenomics, polygenic risk scores, and sequencing.. Domains: Governance and Policy; Workforce Capability and Change Management; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review organizes barriers into methodological, implementation, clinician-skill, and ethical/sociocultural categories (Figure 1, pp. 4-7). Cost, reimbursement, facilities, clinician knowledge, counseling access, and stigma were identified as recurring obstacles (Figure 1, pp. 4-7). Psychiatric ...

[242] Pritchard Daryl E, Moeckel Franziska, Villa Mary Susan et al. (2018). Strategies for integrating personalized medicine into healthcare practice.. Personalized medicine. PMID: 29754553.

Setting: United States healthcare delivery organizations. Design: Framework / perspective. Modality: General/multiple (“personalized medicine”; “often genetic”; “molecular diagnostics and targeted therapies”). Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The authors grouped implementation challenges into five areas: education, empowerment, value, infrastructure, and access (“five general areas of challenges”). The identified barriers span workforce, governance, information systems, financing, access, and equity (“Box 2. Common challenges”) ...

[243] Qoronfleh M Walid, Chouchane Lotfi, Mifsud Borbala et al. (2021). THE FUTURE OF MEDICINE, healthcare innovation through precision medicine: policy case study of Qatar.. Life sciences, society and policy. PMID: 33129349.

Setting: Qatar - national precision-medicine policy and healthcare-system context. Design: Policy analysis. Modality: General/multiple - genomic and precision medicine. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The paper presents Qatar as a national policy case for translating precision medicine across research, healthcare, regulation, education and public engagement (Abstract/Discussion). Implementation should use a national strategy with coordinated governance, sustainable financing, interoperable data ...

[244] Rahma Azhar T, Elsheik Mahanna, Ali Bassam R et al. (2020). Knowledge, Attitudes, and Perceived Barriers toward Genetic Testing and Pharmacogenomics among Healthcare Workers in the United Arab Emirates: A Cross-Sectional Study.. Journal of personalized medicine. PMID: 33182317.

Setting: United Arab Emirates, healthcare workers in public and private hospitals or clinics. Design: Survey / cross-sectional. Modality: General/multiple, genetic testing and pharmacogenomics. Domains: Workforce Capability and Change Management; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The mean genomic and PGX knowledge score was 5.2 out of 9, classified as fair (“5.2 ± 2.3”; Abstract). Cost, training, and insurance coverage were the three leading reported implementation barriers (“62%”; “57.8%”; “57.2%”; Section 3.2.5). Healthcare workers had positive attitudes toward ...

[245] Rahma Azhar T, Elbarazi Iffat, Ali Bassam R et al. (2020). Genomics and Pharmacogenomics Knowledge, Attitude and Practice of Pharmacists Working in United Arab Emirates: Findings from Focus Group Discussions-A Qualitative Study.. Journal of personalized medicine. PMID: 32962013.

Setting: United Arab Emirates - pharmacists from public and private hospitals, clinics, and community pharmacies in Abu Dhabi Emirate.. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Four focus groups with pharmacists working across UAE

healthcare settings reached thematic saturation (Methods, pp. 2-3). Most participants reported no formal genomic/PGx education and uncertainty about test services and EHR results (Results, pp. 3-4). Participants described leadership, role ...

[246] Rahma Azhar T, Elsheik Mahanna, Elbarazi Iffat et al. (2020). Knowledge and Attitudes of Medical and Health Science Students in the United Arab Emirates toward Genomic Medicine and Pharmacogenomics: A Cross-Sectional Study.. Journal of personalized medicine. PMID: 33114420.

Setting: United Arab Emirates - medical and health-science student education setting.. Design: Survey / cross-sectional. Modality: General/multiple - genomic medicine and pharmacogenomics workforce preparation.. Domains: Workforce Capability and Change Management; Governance and Policy; Patient Access, Equity and Ethics. Key findings: Five hundred ten UAE medical and health-science students completed the survey (Results, p. 3). Mean knowledge score was 5.4/9; training, degree stage, and internship/study-abroad exposure were associated with knowledge differences (Abstract; Results, pp. 4-6). Lack of training and lack of clinical ...

[247] Rahma Azhar T, Ali Bassam R, Patrinos George P et al. (2023). Knowledge, attitudes, and perceptions of the multi-ethnic population of the United Arab Emirates on genomic medicine and genetic testing.. Human genomics. PMID: 37454085.

Setting: United Arab Emirates – multi-ethnic community survey.. Design: Survey / cross-sectional. Modality: General/multiple genomic medicine – genetic/genomic testing and pharmacogenomics.. Domains: Patient Access, Equity and Ethics. Key findings: 757 individuals completed the survey; 76.9% would take a genetic test for familial disease despite low measured knowledge (Abstract/Results, PDF pp. 1, 3–4). Cost, turnaround time, privacy, and research participation concerns were documented as access constraints (Results, PDF p. 5). Respondents ...

[248] Ramsey Laura B, Prows Cynthia A, Chidambaran Vidya et al. (2023). Implementation of CYP2D6-guided opioid therapy at Cincinnati Children's Hospital Medical Center.. American journal of health-system pharmacy : AJHP : official journal of the American PMID: 36715063.

Setting: United States - Cincinnati Children's Hospital Medical Center, Ohio.. Design: Institutional case study. Modality: Pharmacogenomics/pharmacogenetics - CYP2D6-guided paediatric opioid prescribing.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Cincinnati Children's implemented CYP2D6 testing to inform codeine prescribing in 2004 and subsequently updated the programme in response to evidence, platform, EHR, and FDA changes (Summary; pp. 852-858). The service retained an in-house turnaround time of two business days after later assay ...

[249] Relling Mary V, Klein Teri E, Gammal Roseann S et al. (2020). The Clinical Pharmacogenetics Implementation Consortium: 10 Years Later.. Clinical pharmacology and therapeutics. PMID: 31562822.

Setting: Not reported – international CPIC implementation-resource context spanning 33 countries and 245 institutions.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: By 2019 CPIC had published 23 guidelines, including 11 updates, covering 19 genes and 46 drugs (p. 1). CPIC had grown to over 350 members from 245 institutions in 33 countries, with FDA and NIH observers (p. 2). The consortium supports implementation through EHR/clinical-decision-support resources ...

[250] Rigter Tessel, Jansen Marleen E, de Groot Jordy M et al. (2022). Implementation of Pharmacogenetics in Primary Care: A Multi-Stakeholder Perspective.. Frontiers in genetics. PMID: 32076434.

Setting: Netherlands – primary-care pharmacogenetics implementation context, incorporating pharmacists, physicians, patients, and national stakeholders.. Design: Mixed-methods. Modality: Pharmacogenomics/pharmacogenetics in primary care. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The study combined focus groups with 24 pharmacists, eight physicians, and 21 patients; an expert meeting; and a Delphi process involving 27 stakeholders. Sixteen potential actions were identified, with nine retained as priority actions after the Delphi process. Primary-care PGx implementation ...

[251] Roberts Megan C, Kennedy Amy E, Chambers David A et al. (2018). The current state of implementation science in genomic medicine: opportunities for improvement.. Genetics in medicine : official journal of the American College of Medical Genetics. PMID: 28079898.

Setting: United States – CDC Public Health Genomics Knowledge Base review of international 2014 literature; no single evaluated health system.. Design: Systematic / scoping review. Modality: General/multiple genomic medicine – genomic testing, genetic counselling, and family-history collection.. Domains: Strategic Leadership

and Readiness; Workforce Capability and Change Management; Patient Access, Equity and Ethics. Key findings: The review included 283 articles; uptake (35.7%) and preferences (36.4%) were the most frequently reported implementation outcomes (Abstract/Results, PDF pp. 1, 3). 91.5% of studies addressed T3 translation, while sustainability and capacity-building outcomes were uncommon (Results, PDF pp. 3–5) ...

[252] Roden Dan M, Van Driest Sara L, Wells Quinn S et al. (2019). Opportunities and Challenges in Cardiovascular Pharmacogenomics: From Discovery to Implementation.. Circulation research. PMID: 29700066.

Setting: United States - early-adopter institutions and NIH IGNITE Network; broader international guideline context.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics - cardiovascular therapeutics, especially clopidogrel and warfarin.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The review contrasts rapid point-of-care genotyping with pre-emptive multi-gene EHR/CDS models, which have different turnaround and maintenance requirements (pp. 10-11). The described IGNITE CYP2C19 implementation involved 1,815 PCI patients across seven medical centers (p. 10). Pre-emptive PGx ...

[253] Rodrigues-Soares Fernanda, Suarez-Kurtz Guilherme (2019). Pharmacogenomics research and clinical implementation in Brazil.. Basic & clinical pharmacology & toxicology. PMID: 30589990.

Setting: Brazil - national pharmacogenomics implementation and Unified Health System (SUS) policy context.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics - PGx-guided prescribing in the Brazilian health-system context.. Domains: Governance and Policy; Workforce Capability and Change Management; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The structured PubMed and Lattes search selected 72 Brazilian PGx articles published between 2011 and 2018 (Methods/Results, PDF p. 2). No prospective clinical-outcome or cost-effectiveness analyses of PGx-guided therapy in Brazil were identified (Abstract, PDF p. 1). Population admixture affected ...

[254] Roelofsen Anja H A, Kreeftenberg Loes Lindiwe, van El Carla G et al. (2025). Barriers and facilitators for implementing a pharmacogenetic passport: lessons learned from reusing sequencing data.. Pharmacogenomics. PMID: 40396487.

Setting: The Netherlands, Amsterdam University Medical Center. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access Key findings: Twenty-one stakeholders identified six implementation barriers and three key facilitators (“N = 21”; Methods; Figure 3). Broader rollout was constrained mainly by infrastructure, education, visibility of guidance, roles, and institutional priorities (“inadequate data infrastructure”; Abstract). Two ...

[255] Rohrer Vitek Carolyn R, Abul-Husn Noura S, Connolly John J et al. (2018). Healthcare provider education to support integration of pharmacogenomics in practice: the eMERGE Network experience.. Pharmacogenomics. PMID: 28639489.

Setting: United States – 10 organizations in the eMERGE Network, including large health systems, pediatric centres, and academic medical centres.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Ten eMERGE organizations developed PGx sequencing and clinical-decision-support programmes (Abstract; Organizational context, p. 2). Educational strategies varied by site and targeted prescribers, pharmacists, and other clinical staff (Tables 1–3, pp. 3, 5–6). Only three sites developed formal ...

[256] Roncato Rossana, Perfler Samantha, Gambrun Martina et al. (2026). Pharmacogenetic testing in Italy: results of a nationwide survey by the Joint Working Group for the pharmacogenetics implementation in Italy.. European journal of human genetics : EJHG. PMID: 41927802.

Setting: Italy – Italian National Health System; nationwide laboratory-level survey conducted January–October 2025.. Design: Survey / cross-sectional. Modality: Pharmacogenomics / pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The survey captured 49 of 75 identified laboratories, a 65% response rate; 82% were public institutions (Results, p. 2). Italian pharmacogenetic implementation was concentrated in oncology: DPYD and UGT1A1 constituted 59% of diagnostic services offered (Results: Laboratory characteristics, p. 2) ...

[257] Ronquillo Jay G, Weng Chunhua, Lester William T (2018). Assessing the readiness of precision medicine interoperability: An exploratory study of the National Institutes of Health genetic testing registry.. Journal of innovation in health informatics. PMID: 29334348.

Setting: United States – National Institutes of Health Genetic Testing Registry (GTR) data environment.. Design: Other [check]. Modality: Genomic-test registry interoperability and semantic standardization. Domains: Digital Infrastructure and Interoperability. Key findings: The study assessed readiness for genomic-test interoperability using thousands of tests and laboratory entries in the NIH GTR (Methods/Results, pp. 2–5). Many registry elements could be linked to standard identifiers, but important condition and test-description mappings remained incomplete ...

[258] Rose Christian, Shearer Emily, Woller Isabela et al. (2025). Identifying High-Priority Ethical Challenges for Precision Emergency Medicine: Nominal Group Study.. JMIR formative research. PMID: 39916376.

Setting: United States - emergency medicine participants from county, community, academic, and integrated managed-care settings.. Design: Qualitative study. Modality: General/multiple - precision medicine in emergency care.. Domains: Patient Access, Equity and Ethics. Key findings: Twelve emergency physicians generated 82 initial ethical challenges, consolidated to 48 unique challenges (PDF pp. 1, 4). Challenges were organized into values, privacy, and justice across three time points: data acquisition, actualization in practice, and aftereffects (PDF pp. 4-5). Accessibility ...

[259] Rosenman Marc B, Decker Brian, Levy Kenneth D et al. (2017). Lessons Learned When Introducing Pharmacogenomic Panel Testing into Clinical Practice.. Value in health : the journal of the International Society for Pharmacoeconomics and PMID: 28212969.

Setting: United States - Eskenazi Health, a large urban safety-net hospital and outpatient clinics in Indiana.. Design: Institutional case study. Modality: Pharmacogenomics/pharmacogenetics - 14-gene, 43-variant, 28-medication panel with EHR/CDS support.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: INGenious was a 14-gene, 43-variant, 28-medication programme implemented at a safety-net hospital and outpatient clinics (PDF p. 3). The programme identified operational challenges across eligibility algorithms, EHR location naming, report storage, CDS, consult service, alerts, regulation, and ...

[260] Rothman Russell L, Peterson Josh, Kripalani Sunil et al. (2026). Leveraging PCORnet® to Advance Clinical Genetics and the Genomic Learning Health System.. Medical care. PMID: 41505169.

Setting: United States - PCORnet network of health systems and a genomic learning-health-system infrastructure.. Design: Framework / perspective. Modality: General/multiple - clinical genetics, genomics, pharmacogenomics, and genomic learning-health-system infrastructure.. Domains: Strategic Leadership and Readiness; Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: PCORnet included 78 health-system partners and more than 47 million unique patients in fiscal year 2023 (PCORnet infrastructure, pp. 2-3). The paper identifies EHR/registry heterogeneity, governance barriers, and vendor-data linkage as key obstacles to genomic-data integration (Clinical Genetics ...

[261] Russell Callan, Champion MaryAnn, Grove Megan E et al. (2024). Knowledge and attitudes on implementing cardiovascular pharmacogenomic testing.. Clinical and translational science. PMID: 38421234.

Setting: United States – cardiology providers in California; survey linked to Stanford-affiliated settings rather than one evaluated health system.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics – cardiovascular drug response.. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: Sixty-one cardiology providers completed the survey (Abstract). Only 15% reported prior PGx-test ordering, whereas roughly 90% were interested in including cardiovascular PGx content with inherited-cardiovascular-disease diagnostic panels (Discussion). Major implementation constraints were ...

[262] Russmann Stefan, Rahmany Ali, Niedrig David et al. (2021). Implementation and management outcomes of pharmacogenetic CYP2C19 testing for clopidogrel therapy in clinical practice.. European journal of clinical pharmacology. PMID: 33242107.

Setting: Switzerland – Hirslanden Hospitals in Aarau and Zurich; drugsafety.ch clinical pharmacology service. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – CYP2C19-guided clopidogrel therapy. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Among 56 referred patients, 18 (32.1%) carried a CYP2C19 loss-of-function phenotype; 17 medication switches were

recommended and 12 were implemented (Results, p. 4). The programme identified a CYP2C19-inhibiting co-medication in five patients (8.9%), producing additional recommendations (Results ...

[263] Sackey Godsway, Owoyele Babajide, Baiden Frank E et al. (2026). Digital Health as an Enabler of Personalized Medicine in Ghana: Gaps, Opportunities, and Future Directions.. Journal of medical Internet research. PMID: 42061847.

Setting: Ghana – national digital-health and health-system context. Design: Framework / perspective. Modality: General/multiple – digital-health-enabled personalized medicine and proposed N-of-1/adaptive care. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The protocol-guided literature examination identified 40 relevant studies from 2000–2024; approximately 60% involved mobile health, about one-quarter involved EHR/eHealth systems, and fewer than 10% explicitly addressed personalized medicine (p. 2). No empirical Ghanaian N-of-1 trials were ...

[264] Sadik Helen, Pritchard Daryl, Keeling Derry-Mae et al. (2022). Impact of Clinical Practice Gaps on the Implementation of Personalized Medicine in Advanced Non-Small-Cell Lung Cancer.. JCO precision oncology. PMID: 36315914.

Setting: United States, commercial and Medicare claims plus laboratory-data context. Design: Cohort / clinical evaluation. Modality: Genomic cancer-risk/hereditary, biomarker-guided precision oncology for advanced non-small-cell lung cancer. Domains: Strategic Leadership and Readiness; Governance and Policy; Digital Infrastructure and Interoperability; Finance and Sustainability. Key findings: For every 1,000 potentially eligible patients, 497 were lost before receiving usable biomarker-test results (“497... lost to precision oncology”; Abstract). Of 503 patients with biomarker results, 147, or 29.2%, did not receive appropriate targeted treatment (“147 (29.2%)”; Abstract). Overall, 644 of ...

[265] Salas-Hernández Aimeé, Galleguillos Macarena, Carrasco Matías et al. (2023). An updated examination of the perception of barriers for pharmacogenomics implementation and the usefulness of drug/gene pairs in Latin America and the Caribbean.. Frontiers in pharmacology. PMID: 37251329.

Setting: Latin America and the Caribbean – regional survey of professionals from 17 countries.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics.. Domains: Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Latin American and Caribbean countries accounted for 3.44% of global PGx publications and 2.45% of PGx-related clinical trials identified by the study (Results). A total of 106 professionals from 17 countries completed the survey, and six major barrier groups were identified (Abstract/Results) ...

[266] Salloum Ramzi G, Bishop Jeffrey R, Elchynski Amanda L et al. (2022). Best-worst scaling methodology to evaluate constructs of the Consolidated Framework for Implementation Research: application to the implementation of pharmacogenetic testing for antidepressant therapy.. Implementation science communications. PMID: 35568931.

Setting: United States – 17 IGNITE-network healthcare organizations implementing or planning pharmacogenetic testing for antidepressant therapy.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Finance and Sustainability. Key findings: All 17 invited IGNITE organizations completed the best–worst scaling survey (Results, p. 4). Patient needs/resources, leadership engagement, knowledge/beliefs, evidence quality, and champions ranked as the most important constructs (Abstract; Results, pp. 4–5). In one latent class, external ...

[267] Sanabria-Salas Maria Carolina, Anggala Nina C, Gillies Brittany et al. (2025). Clinical integration of germline findings from a tumor testing precision medicine program.. BMC cancer. PMID: 39885482.

Setting: Canada - University Health Network / Princess Margaret Cancer Centre, Toronto. Design: Empirical implementation study. Modality: Genomic cancer-risk/hereditary - tumour sequencing with germline follow-up. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: Of 243 tumour profiles reviewed, 83 (34.2%) were flagged as potentially relevant for germline assessment (Results). The review group assessed 127 variants; 44 were considered germline relevant and 27 patients proceeded to germline testing (Results). Nine pathogenic or likely pathogenic germline ...

[268] Sanghvi Sonali, Ferner Robin E, Scourfield Andrew et al. (2023). How to assess pharmacogenomic tests for implementation in the NHS in England.. British journal of clinical pharmacology. PMID: 37313748.

Setting: England, National Health Service (NHS). Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow

and Service Integration; Finance and Key findings: The authors developed a 10-question checklist to assess proposed pharmacogenomic tests (“distilled as 10 questions”; Results). The checklist covers evidence, clinical outcomes, guidance, target patients, alternatives, pathway fit, cost, operations, and impact evaluation (“Checklist for assessing” ...

[269] Sbitan Lana, Alzraikat Noor, Tanous Haneen et al. (2025). From one size fits all to a tailored approach: integrating precision medicine into medical education.. BMC medical education. PMID: 39827113.

Setting: Jordan – survey of 312 medical students and 295 physicians across public and private practice settings.. Design: Survey / cross-sectional. Modality: General/multiple precision medicine. Domains: Governance and Policy; Workforce Capability and Change Management; Finance and Sustainability. Key findings: The study included 607 respondents: 312 medical students and 295 physicians (Table 1, p. 5). Knowledge was low in 29.6%, moderate in 53.4%, and high in 17.0% of respondents (Table 3, p. 6). Physicians most often cited limited accessibility (92.9%), while students most often cited cost (80.2%) ...

[270] Schaibley Valerie M, Ramos Irma N, Woosley Raymond L et al. (2022). Limited Genomics Training Among Physicians Remains a Barrier to Genomics-Based Implementation of Precision Medicine.. Frontiers in medicine. PMID: 35372454.

Setting: United States – Banner–University Medical Center Phoenix, Arizona academic medical centre.. Design: Survey / cross-sectional. Modality: General/multiple – genomic medicine and clinical genetic testing. Domains: Workforce Capability and Change Management. Key findings: A 12-question survey of 64 providers at a large academic medical centre assessed use of genetic testing, confidence and implementation barriers (p. 2). About half of respondents had previously ordered a genetic test for diagnosis (p. 2). Limited genomics education was the principal reported barrier ...

[271] Schmitt Tugce, Delnord Marie, Cauët Emilie et al. (2024). Contextual factors influencing the equitable implementation of precision medicine in routine cancer care in Belgium.. European journal of public health. PMID: 38547501.

Setting: Belgium, routine cancer care within the Belgian health system. Design: Mixed-methods. Modality: Genomic cancer-risk/hereditary and Multimodal (genomic+imaging+clinical). Domains: Strategic Leadership and Readiness; Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Experts identified eight top contextual factors out of 46, concentrated in economic and technological domains (“eight... out of 46”; Results). Dedicated reimbursement budgets had an importance median of 5 and mean of 4.63 (“Allocated budget for reimbursement”; Table 2). Quality of data had an ...

[272] Schneider Thomas M, Eadon Michael T, Cooper-DeHoff Rhonda M et al. (2022). Multi-Institutional Implementation of Clinical Decision Support for. Journal of personalized medicine. PMID: 34071920.

Setting: United States – 10 recruiting sites in five clinical groups participating in the GUARDD-US pragmatic trial.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics – APOL1, NAT2, and YEATS4 EHR clinical decision support for antihypertensive Domains: Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Five clinical groups comprising 10 recruiting sites implemented CDS in preparation for the multi-centre GUARDD-US trial (Methods, PDF p. 2). The CDS was built around eight implementation principles and included action-oriented alerts with relevant results, vitals, handouts, and order sets ...

[273] Schroll Monica M, Agarwal Arushi, Foroughi Olivia et al. (2022). Stakeholders Perceptions of Barriers to Precision Medicine Adoption in the United States.. Journal of personalized medicine. PMID: 35887521.

Setting: United States – precision-oncology and biomarker-testing ecosystem across clinicians, laboratory directors, payers, and patients. Design: Survey / cross-sectional. Modality: Biomarker-guided precision oncology – single-gene, multigene-panel, and comprehensive genomic profiling. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The survey included 653 respondents: 194 oncologists, 98 surgeons, 69 laboratory directors, 40 payers, and 252 patients (Table 1; Fig. 2). Payers rated overutilization as their largest biomarker-testing challenge, whereas clinicians emphasized payer coverage; the study documents this stakeholder ...

[274] Shaheen Safa, Ghaly Mohammed (2026). Geneticization outside genetics' birthplace: ethical, legal and social implications in the Gulf Cooperation Council region.. Frontiers in genetics. PMID: 41788410.

Setting: Gulf Cooperation Council – Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.. Design: Policy analysis. Modality: General/multiple – premarital, prenatal/newborn and genomic screening programmes; ELSI and clinical implementation.. Domains: Governance and Policy; Workforce Capability and

Change Management; Patient Access, Equity and Ethics. Key findings: GCC countries use differing legal approaches, target populations and conditions within premarital screening programmes (Table 1, pp. 7–8). The analysis identifies consent, privacy, discrimination, stigma, public knowledge and counselling capacity as central ELSI implementation determinants ...

[275] Sharma Neha, Oteiza Jokin Zubizarreta, Seiler Daniel et al. (2026). Clinical implementation of an EU MDR-compliant point-of-care manufacturing framework for patient-specific 3D-printed PEEK implants in craniomaxillofacial reconstruction.. 3D printing in medicine. PMID: 42014629.

Setting: Switzerland – University Hospital Basel; framework subsequently adopted at multiple European centres.. Design: Institutional case study. Modality: Other [check] – patient-specific precision-care manufacturing: point-of-care 3D-printed PEEK implants for Domains: Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The framework supported more than 40 point-of-care PEEK implants at the index institution and adoption at multiple European centres (Abstract, PDF p. 1). In two reported anatomical applications, image-to-sterile-delivery turnaround was 3–5 days, with accurate fit and no major device-related ...

[276] Sharma Videha, McDermott John, Keen Jessica et al. (2024). Pharmacogenetics Clinical Decision Support Systems for Primary Care in England: Co-Design Study.. Journal of medical Internet research. PMID: 39042886.

Setting: England, National Health Service North West Genomic Medicine Service Alliance primary-care context. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics – primary-care clinical decision support. Domains: Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The study used five ethnographic observations, three co-design workshops, and prototype development with primary-care stakeholders (Methods, pp. 4–7). Eighty-eight people registered interest in participation, with GPs and pharmacists among the key stakeholder groups (Methods, pp. 5–6). The dominant ...

[277] Sharma Videha, McDermott John, Keen Jessica et al. (2025). Designing an interoperable solution to support pharmacogenomic-guided prescribing in primary care: an implementer report.. BMJ health & care informatics. PMID: 40216452.

Setting: England – National Health Service primary care; proof-of-concept across two general-practice sites using EMIS.. Design: Institutional case study. Modality: Pharmacogenomics/pharmacogenetics – primary-care prescribing decision support. Domains: Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: A proof-of-concept interoperable architecture was designed and tested across two NHS primary-care practices. The system transformed external laboratory outputs into coded, reusable data and integrated PGx guidance into routine prescribing. Scalable implementation requires standard data models ...

[278] Sharma Videha, McDermott John H, Keen Jessica et al. (2026). Development and validation of an open data model for pharmacogenetics to enable semantic interoperability in clinical practice.. The pharmacogenomics journal. PMID: 42285967.

Setting: United Kingdom - Manchester/NHS-oriented development with international expert validation.. Design: Other [check]. Modality: Pharmacogenomics/pharmacogenetics - openEHR and HL7 FHIR data model for structured results, exchange, and clinical Domains: Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The study developed and expert-validated an open data model for pharmacogenetic testing and therapeutic implications (Methods/Results, pp. 2-6). The model was mapped to HL7 FHIR using FHIR-Connect, supporting exchange with FHIR-based systems (Results, pp. 5-6). PGx data should be stored as ...

[279] Shaunak Nisha, Keen Jessica, Kim Anna et al. (2025). Implementation of mass pharmacogenetic testing: Dihydropyrimidine dehydrogenase testing prior to fluoropyrimidine treatment for patients.. British journal of clinical pharmacology. PMID: 40289265.

Setting: United Kingdom – NHS England and the devolved nations (Scotland, Wales, Northern Ireland); hospitals delivering fluoropyrimidine systemic anticancer Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics – DPYD testing before fluoropyrimidine treatment.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: 131 of 138 eligible provider organizations (94.9%) reported testing all patients planned for fluoropyrimidines (Results, p. 2537). 220 of 221 English organizations responded; 115 delivered fluoropyrimidine systemic anticancer therapy and were included with 23 providers from devolved nations ...

[280] Shih Ya-Chen Tina, Pan I-Wen, Teich Nelson (2022). Global Challenges in Access to and Implementation of Precision Oncology: The Health Care Manager and Health Economist Perspective..

American Society of Clinical Oncology educational book. American Society of Clinical PMID: 35829692.

Setting: Global – precision-oncology implementation, contrasting high-income and low-/middle-income health-system contexts.. Design: Framework / perspective. Modality: Precision oncology – tumor molecular profiling and biomarker-guided targeted therapies.. Domains: Strategic Leadership and Readiness; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The paper distinguishes access and implementation constraints in high-income versus low- and middle-income settings (Abstract, p. 1). Accessibility, affordability and system readiness are presented as linked determinants of precision-oncology uptake (Abstract, p. 1; Figure 1, pp. 3–4). Health ...

[281] Shugg Tyler, Tillman Emma M, Breman Amy M et al. (2024). Development of a Multifaceted Program for Pharmacogenetics Adoption at an Academic Medical Center: Practical Considerations and Lessons Learned.. Clinical pharmacology and therapeutics. PMID: 39169556.

Setting: United States – Indiana University and Indiana University Health academic health-system programme.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – health-system programme with EHR-based decision support and pharmacist-led services. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The programme describes development of an academic health-system PGx service spanning testing, interpretation, consultation, EHR integration, education, and evaluation (pp. 3–18). The authors report operational service activity including clinic and consultation volumes, alongside learning from ...

[282] Silva Abigail, Voora Deepak, Wu Rebekah RYanne et al. (2025). Trends in and predictors of patient pharmacogenomic test uptake in a national health care system.. Genetics in medicine : official journal of the American College of Medical Genetics. PMID: 39484796.

Setting: United States - Veterans Health Administration national PHASER pharmacogenomics programme.. Design: Cohort / clinical evaluation. Modality: Pharmacogenomics/pharmacogenetics - panel-based testing in Veterans Health Administration routine care.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The matched cohort comprised 48,146 veterans, including 24,073 with a PGx test order and 24,073 matched controls (Table 1, PDF p. 6). Non-Hispanic Black and Hispanic veterans had higher adjusted odds of an order than non-Hispanic White veterans (OR 1.46 and 1.52; Table 3, PDF p. 8). Education ...

[283] Sissung Tristan M, McKeeby Jon W, Patel Jharana et al. (2018). Pharmacogenomics Implementation at the National Institutes of Health Clinical Center.. Journal of clinical pharmacology. PMID: 28921647.

Setting: United States - National Institutes of Health Clinical Center, Bethesda, Maryland.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics - phased HLA and multi-gene ADME testing integrated with EHR medication-order Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The NIH Clinical Center implemented pharmacogenetic testing in two phases: HLA testing with clinical decision support, then selected ADME genes and drugs (Abstract/Methods, PDF pp. 1, 6-8). The Pharmacy and Therapeutics governance structure formally selected actionable drug-gene pairs and clinical ...

[284] Smith D Max, Douglas Michael P, Aquilante Christina L et al. (2025). Progress in Pharmacogenomics Implementation in the United States: Barrier Erosion and Remaining Challenges.. Clinical pharmacology and therapeutics. PMID: 40468601.

Setting: United States – national pharmacogenomics implementation context. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: The review organizes US implementation into seven domains: equity/inclusion; evidence/guidelines; regulatory oversight; payer coverage; test availability/quality; EHR; and provider/patient education (Conclusion, p. 10). The paper reports progress in Medicare coverage and ...

[285] Sperber Nina R, Carpenter Janet S, Cavallari Larisa H et al. (2018). Challenges and strategies for implementing genomic services in diverse settings: experiences from the Implementing GeNomics In pracTice (IGNITE) network.. BMC medical genomics. PMID: 28532511.

Setting: United States – six Implementing GeNomics In pracTice (IGNITE) Network genomic-service implementation projects in diverse clinical settings.. Design: Mixed-methods. Modality: General/multiple genomic medicine, including disease-risk testing and pharmacogenomics. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical

Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: Six IGNITE projects described common implementation challenges across EHR integration, provider readiness, and patient engagement. Education, structured data approaches, and tailored patient-engagement strategies were repeatedly used to address those challenges. Genomic service implementation ...

[286] Sperber Nina R, Roberts Megan C, Gonzales Sarah et al. (2024). Pharmacogenetic testing in primary care could bolster depression treatment: A value proposition.. Clinical and translational science. PMID: 38898561.

Setting: United States - four health systems at differing pharmacogenetic-testing implementation stages.. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics - depression and mental-health medication selection in primary care.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Key findings: Interviews included 37 participants - eight administrators and 29 prescribers - from four health systems across implementation stages (Methods/Results, PDF pp. 3-4). Participants framed value through care quality, population health/access, and cost, but did not agree on clinical value or ...

[287] Sperber Nina R, Dong Olivia M, Roberts Megan C et al. (2026). Strategies to Integrate Genomic Medicine into Clinical Care: Evidence from the IGNITE Network.. Journal of personalized medicine. PMID: 34357114.

Setting: United States – six NIH IGNITE genomic-medicine implementation projects across academic, community, and diverse-care settings. Design: Mixed-methods. Modality: General/multiple genomic medicine – pharmacogenomics, disease genetics, and family-history risk tools delivered with Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Key findings: Six IGNITE projects used an average of 32 ERIC strategies, ranging from 11 to 47; all three PGx projects used more than 40 strategies (Results, p. 4). Four strategies appeared across all projects: stakeholder feedback, early adopters, educational meetings, and expert clinician education (Results ...

[288] Spiech Katherine M, Tripathy Purnima R, Woodcock Alex M et al. (2022). Implementation of a Renal Precision Medicine Program: Clinician Attitudes and Acceptance.. Life (Basel, Switzerland). PMID: 32224869.

Setting: United States – multi-hospital system comprising a university hospital and county safety-net hospital in Indiana. Design: Survey / cross-sectional. Modality: General/multiple genomic medicine – CKD-risk genetics and pharmacogenomic predictors of antihypertensive response. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: A 26-gene/72-variant panel was implemented in a multi-hospital nephrology system; 76 of 94 clinicians completed or partially completed the baseline survey (81% response) (pp. 2–3, 10). Respondents rated PGx-guided antihypertensive prescribing as valuable (mean 4.0/5) and stated willingness to ...

[289] St Sauver Jennifer L, Bielinski Suzette J, Olson Janet E et al. (2017). Integrating Pharmacogenomics into Clinical Practice: Promise vs Reality.. The American journal of medicine. PMID: 27155109.

Setting: United States, Mayo Clinic primary care practice in Rochester, Minnesota. Design: Mixed-methods. Modality: Pharmacogenomics / pharmacogenetics. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability. Key findings: Of 90 survey respondents, 52% did not expect to use or did not know whether they would use PGx information in future prescribing (“52%”; page 2). Of clinicians recalling an alert, 53% reported only negative usability responses, while 33% reported only positive responses (“53%”; “33%”; page 5) ...

[290] Stefanicka-Wojtas Dorota, Kurpas Donata (2022). eHealth and mHealth in Chronic Diseases-Identification of Barriers, Existing Solutions, and Promoters Based on a Survey of EU Stakeholders Involved in Regions4PerMed (H2020).. Journal of personalized medicine. PMID: 35330466.

Setting: European Union – 69 survey respondents from 19 countries participating in Regions4PerMed (H2020); no single health system.. Design: Mixed-methods. Modality: General/multiple – eHealth and mHealth tools supporting personalised medicine in chronic-disease care.. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The study drew on 69 online surveys from stakeholders in 19 countries, plus a Regions4PerMed conference with 86 registered participants (Methods, pp. 3–4). Major reported barriers were skills of seniors, poor usability, data security/access concerns, limited digitisation, and legal fragmentation ...

[291] Stefanicka-Wojtas Dorota, Kurpas Donata (2023). Barriers and Facilitators to the Implementation of Personalised Medicine across Europe.. Journal of personalized medicine. PMID: 36836438.

Setting: Europe – Regions4PerMed semi-structured stakeholder survey; 85 respondents from 20 countries, predominantly European but also including Canada and Design: Qualitative study. Modality: General/multiple precision medicine. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The semi-structured survey collected 85 responses from stakeholders in 20 countries (Methods, pp. 3–4). The study mapped barriers and facilitators across government, health systems, providers, patients, industry, technology, finance, and media (Abstract; Table 2, pp. 9–10). Data protection/IT/data ...

[292] Stefanicka-Wojtas Dorota, Kurpas Donata (2023). Personalised Medicine-Implementation to the Healthcare System in Europe (Focus Group Discussions).. Journal of personalized medicine. PMID: 36983562.

Setting: Europe – cross-country online focus groups with stakeholders including government-policy representatives, healthcare providers, insurance-policy Design: Qualitative study. Modality: General/multiple – personalised medicine across European healthcare systems. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: Three online focus groups, held in November–December 2022, explored implementation barriers and facilitators (pp. 2–3). Results are organized around data protection/data analysis, government systems, providers, finance, practitioners, health systems, patients and technology (pp. 4–6). Focus-group ...

[293] Strother Ashton, Park Jeong M, Pasternak Amy L (2025). Survey of the utilization of genotype-guided tacrolimus management in United States solid organ transplant centers.. Pharmacogenomics. PMID: 40205800.

Setting: United States - solid-organ transplant centers.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics - CYP3A5 genotype-guided tacrolimus management.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Ninety organ programmes from 69 centers responded, representing 28.1% of active US transplant centers (Results, pp. 1-3). Only 14 programmes (15.6%) used tacrolimus PGx for patient care, with heterogeneous approaches (Abstract/Results, pp. 1-4). Cost/availability and unclear clinical utility were ...

[294] Sukasem Chonlaphat, Jantararoungtong Thawinee, Koomdee Napatrupron (2022). Pharmacogenomics research and its clinical implementation in Thailand: Lessons learned from the resource-limited settings.. Drug metabolism and pharmacokinetics. PMID: 34098253.

Setting: Thailand – national precision-medicine and pharmacogenomics implementation context, including university-hospital and private-hospital programmes.. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: Thailand had established national and institutional initiatives for genomic medicine, including Genomics Thailand and hospital-based pharmacogenomics programmes. Implementation examples described pre-emptive or reactive PGx testing supported by multidisciplinary interpretation and electronic ...

[295] Swen Jesse J, van der Wouden Cathelijne H, Manson Lisanne En et al. (2023). A 12-gene pharmacogenetic panel to prevent adverse drug reactions: an open-label, multicentre, controlled, cluster-randomised crossover implementation study.. Lancet (London, England). PMID: 36739136.

Setting: Europe – implementation sites in Austria, Greece, Italy, the Netherlands, Slovenia, Spain, and the United Kingdom.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – pre-emptive 12-gene panel testing across hospital, primary-care, and Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: 6,944 patients were enrolled across multiple European care settings (Abstract; Results). The intervention reduced clinically relevant adverse drug reactions from 27.7% under standard care to 21.0% with genotype-guided treatment (odds ratio 0.70; P = .0075) (Abstract). The authors concluded that a ...

[296] Tafazoli Alireza, Kitlas Golińska Agnieszka, Mnich Krzysztof et al. (2023). Toward Integration of Pharmacogenomic Tests into Daily Clinical Practice: A General Survey for Polish Healthcare Workers.. Medical science monitor : international medical journal of experimental and clinical PMID: 37303136.

Setting: Poland - national survey distributed through medical universities, clinical centres, and professional networks.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics - readiness for

pharmacogenomic testing in routine clinical practice.. Domains: Governance and Policy; Workforce Capability and Change Management; Finance and Sustainability. Key findings: The survey analysed 315 Polish respondents from healthcare and related settings (Results, pp. 2-3). Sixty-four point four percent had previously heard about pharmacogenomics and 93.3% considered it potentially beneficial (Results, pp. 3-4). Sixty-seven point six percent identified at least one ...

[297] Tamraz Bani, Shin Jaekyu, Khanna Raman et al. (2025). Clinical implementation of preemptive pharmacogenomics testing for personalized medicine at an academic medical center.. Journal of the American Medical Informatics Association : JAMIA. PMID: 39665424.

Setting: United States – UCSF Health academic medical center, San Francisco, California.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – preemptive multi-gene PGx testing linked to automated point-of-care CDS.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: Over 21 months UCSF developed a PGx programme covering 56 medications and 15 genes (Results, p. 567). The team built 232 post-test alerts and 15 pre-test testing prompts, reviewed and approved by clinicians across 16 specialties (p. 567). The selected assay had mean sensitivity of 99% and ...

[298] Taylor Casey Overby, Tarczy-Hornoch Peter (2019). Personalized Medicine Implementation with Non-traditional Data Sources: A Conceptual Framework and Survey of the Literature.. Yearbook of medical informatics. PMID: 31419830.

Setting: Not reported – literature survey of personalised-medicine applications using non-traditional data sources.. Design: Systematic / scoping review. Modality: General/multiple – personalised medicine combining genomic information with non-traditional data sources (e.g., mobile Domains: Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The review screened 702 records, assessed 272 full texts, and identified eight theory-driven articles relevant to non-traditional-data personalised-medicine tools (Results, p. 4). The included literature largely described tool characteristics rather than measured health-service adoption or ...

[299] Thornley Tracey, Esquivel Bernard, Wright David J et al. (2021). Implementation of a Pharmacogenomic Testing Service through Community Pharmacy in the Netherlands: Results from an Early Service Evaluation.. Pharmacy (Basel, Switzerland). PMID: 33673111.

Setting: Netherlands - 22 community pharmacies implementing a pharmacogenomic testing service with local physician engagement.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics - community-pharmacy testing service using a 27-gene/111-allele panel and medication Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: From September 2019 to June 2020, 611 tests were performed across 22 pharmacies: 207 clinical and 404 educational tests (Results, PDF p. 4). Prescribers actioned 28 of 34 medication recommendations (82.4%) (Results, PDF p. 4). Most pharmacists felt able to collect/send samples, but fewer felt able ...

[300] Tillman Emma, Nikirk Miley G, Chen Jeanne et al. (2023). Implementation of Clinical Cytochrome P450 3A Genotyping for Tacrolimus Dosing in a Large Kidney Transplant Program.. Journal of clinical pharmacology. PMID: 37042314.

Setting: United States – Indiana University Health kidney transplant programme.. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – CYP3A4/CYP3A5 genotyping for tacrolimus dosing in kidney transplantation.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: From September 2020 to December 2021, 560 candidates were genotyped and 103 subsequently underwent transplantation (Results, PDF p. 4). CDS alerts recommended a 1.5- to 2-fold starting-dose increase for CYP3A5 normal/intermediate metabolizers; alerts were then suppressed for two years after one ...

[301] Trabelsi Narjes, Othman Houcemeddine, Bedhioufi Hafsi et al. (2024). Is Tunisia ready for precision medicine? Challenges of medical genomics within a LMIC healthcare system.. Journal of community genetics. PMID: 39080231.

Setting: Tunisia – national low- and middle-income-country healthcare-system context.. Design: Framework / perspective. Modality: General/multiple – high-throughput genomic testing and precision medicine.. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The review groups implementation challenges into socioeconomic conditions, healthcare-system

readiness, and population/sociological attributes (Abstract). Mandatory health insurance and the medical-assistance scheme described in the paper did not reimburse the relevant genomic tests (Results, p ...

[302] Tremmel Roman, Schreeck Filippa, Jaeger Simon et al. (2025). Clinical Implementation of Pharmacogenomics and Drug-Drug Interaction Screening in a German Academic Teaching Hospital and Outpatient Follow-Up.. Clinical pharmacology and therapeutics. PMID: 41074844.

Setting: Germany – Robert Bosch Hospital, Stuttgart academic teaching hospital with outpatient general-practitioner follow-up. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – multigene pharmacogenomic panel plus drug–drug interaction screening. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Of 255 analysed patients, 94.9% had at least one actionable genotype and 52 patients (21.5%) generated 57 PGx recommendations (Results, pp. 4–6). Medication was guideline-concordant in 37 of 49 followed recommendations (75.5%); 12 therapies were modified after reactive testing (Results, p. 7) ...

[303] Tripura Utpal, Nagrale Ninad Vilas, Singh Oinam Gambhir et al. (2026). Ethical, Social, and Legal Issues Related to Precision Medicine in India: Challenges and Solutions.. Annals of African medicine. PMID: 40576405.

Setting: India, national healthcare and precision-medicine implementation context. Design: Framework / perspective. Modality: General/multiple, including pharmacogenomics and AI-enabled precision medicine. Domains: Governance and Policy; Workforce Capability and Change Management; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The article identifies consent, privacy, discrimination, cost, rural access, cultural concerns, regulation, data ownership, and patented-treatment costs as major implementation challenges (“ethical, social, and legal challenges”; Abstract). The article frames unequal access as a risk because ...

[304] Truong Tien M, Apfelbaum Jeffrey L, Schierer Emily et al. (2022). Anesthesia providers as stakeholders to adoption of pharmacogenomic information in perioperative care.. Pharmacogenetics and genomics. PMID: 34570085.

Setting: United States – University of Chicago tertiary academic medical center, Department of Anesthesia and Critical Care. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics – perioperative, anesthesia, critical-care, and pain-medicine prescribing. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: 149 of 153 anesthesia, critical-care, pain-medicine, nursing, mid-level, pharmacy, and trainee providers completed the baseline survey (97% response; Abstract/Methods). Ninety-two percent believed genetic results can influence drug therapy, but 49% were unsure whether sufficient evidence exists to ...

[305] Turongkaravee Saowalak, Jittikoon Jiraphun, Rochanathimoke Onwipa et al. (2021). Pharmacogenetic testing for adverse drug reaction prevention: systematic review of economic evaluations and the appraisal of quality matters for clinical practice and implementation.. BMC health services research. PMID: 34600523.

Setting: Multiple countries/health systems represented in published economic evaluations; no single implemented health system.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics for adverse-drug-reaction prevention. Domains: Finance and Sustainability. Key findings: Fifty-nine economic evaluations of pharmacogenetic testing for adverse-drug-reaction prevention were identified. Cost-effectiveness/utility findings varied across tests and settings, and quality shortcomings were common in model-based studies. Health systems should appraise methodological quality ...

[306] Tuteja Sony, Salloum Ramzi G, Elchynski Amanda L et al. (2022). Multisite evaluation of institutional processes and implementation determinants for pharmacogenetic testing to guide antidepressant therapy.. Clinical and translational science. PMID: 34562070.

Setting: United States – 17 IGNITE-network sites implementing or planning pharmacogenetic testing for antidepressant therapy.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: Seventeen sites participated; 13 had implemented testing and four were planning implementation (Table 1, p. 7). Most implemented programmes operated in outpatient settings (13/13), and nine also tested in inpatient settings (Results, p. 5). Electronic CDS was available at nine sites (53%), while ...

[307] Uddin Mohy, Deeb Ahmad, Ardah Husam et al. (2024). A nationwide cross-sectional study in Saudi Arabia for the assessment of understanding and practices of clinicians towards personalized genetic testing.. Scientific reports. PMID: 39738293.

Setting: Saudi Arabia - nationwide clinician survey, predominantly tertiary governmental/semi-governmental hospitals and medical cities.. Design: Survey / cross-sectional. Modality: General/multiple - personalized genetic testing in routine clinical practice.. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Two hundred eighteen practicing clinicians were analyzed in the nationwide online survey; 62.3% worked in tertiary governmental/semi-governmental hospitals or medical cities (Results, pp. 3-4). Thirty-nine percent directly ordered genetic tests, while 84.4% believed genetic profiles could influence ...

[308] van der Wouden Cathelijne H, Paasman Ellen, Teichert Martina et al. (2020). Assessing the Implementation of Pharmacogenomic Panel-Testing in Primary Care in the Netherlands Utilizing a Theoretical Framework.. Journal of clinical medicine. PMID: 32192029.

Setting: Netherlands – primary care/community pharmacy sites participating in the U-PGx PREPARE implementation.. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics – panel-based testing in primary care. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Fifteen primary-care professionals were interviewed to identify barriers and facilitators for panel-testing implementation (Methods/Results, pp. 2–3, 10). The analysis identified procedure, reimbursement, evidence, infrastructure, and healthcare-professional awareness as core barrier themes ...

[309] Vanneste Rachel, Bauer Sasha A, Borle Kennedy et al. (2025). Expanding the primary care workforce by integrating genetic counselors in multidisciplinary care teams.. Family practice. PMID: 39441176.

Setting: Canada, United States, and United Kingdom - literature-described primary-care genetic-counseling models.. Design: Framework / perspective. Modality: General/multiple - genomic medicine and genetic counseling integrated into primary care.. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The review identified nine articles describing two genetic-counseling service models in six primary-care clinics (Results, pp. 2-3). Hub-and-spoke and embedded models both used counselors for direct consultation and primary-care support (Results, pp. 2-3). Integrating genetic counselors can ...

[310] Vorderstrasse Allison, Katsanis Sara Huston, Minear Mollie A et al. (2020). Perceptions of Personalized Medicine in an Academic Health System: Educational Findings.. Journal of contemporary medical education. PMID: 26236542.

Setting: United States, Duke University Health System / Center for Applied Genomics and Precision Medicine. Design: Survey / cross-sectional. Modality: General/multiple – personalized medicine and clinical genomics. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability. Key findings: The academic health-system survey included 78 healthcare-provider respondents (Methods/Results, pp. 3–5). Only 18% considered the institution adequately prepared, while 42% considered it inadequately prepared for personalized medicine implementation (Results, p. 5). Education and protected time ...

[311] Wagner Ingrid M, Xuan Ziming, Lu Haibo et al. (2024). Racial Disparities in Accessing Care along the Continuum of Cancer Genetic Service Delivery.. Cancer epidemiology, biomarkers & prevention : a publication of the American Association PMID: 37819271.

Setting: United States - 15 clinical sites across six states delivering hereditary-cancer genetic services.. Design: Cohort / clinical evaluation. Modality: Cancer genetics - hereditary-cancer risk assessment, counseling, and genetic testing.. Domains: Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: The analysis included 14,527 individuals at risk for hereditary cancer across referral and POC workflows (Results, Table 1, p. 3). Testing uptake was 11.5% in referral sites and 33.5% in POC sites; POC testing had adjusted odds ratio 3.09 for testing (Tables 1-2, pp. 3-4). In referral sites ...

[312] Walker Evan J, Goldberg Dena, Gordon Kelly M et al. (2021). Implementation of an Embedded In-Clinic Genetic Testing Station to Optimize Germline Testing for Patients with Pancreatic Adenocarcinoma.. The oncologist. PMID: 34506673.

Setting: United States – University of California San Francisco GI Medical Oncology and Cancer Genetics/Prevention programme.. Design: Empirical implementation study. Modality: Genomic cancer-risk/hereditary – systematic germline multi-gene testing for patients with pancreatic adenocarcinoma.. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: Genetic counselling/testing was offered to 209 of 223 eligible patients (94%),

and 158 patients completed testing (71%) (Abstract). Confirmed testing increased from 19% under the referral model to 71% after implementation; referral-to-appointment attrition decreased from 36% to 3% (Abstract) ...

[313] Weiss Scott T (2016). Implementing Personalized Medicine in the Academic Health Center.. Journal of personalized medicine. PMID: 27657137.

Setting: United States – Partners HealthCare academic health system, including Massachusetts General Hospital and Brigham and Women's Hospital, Boston Design: Institutional case study. Modality: General/multiple – academic-health-system genomic personalized medicine.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Partners HealthCare was described as a 68,000-employee system including two academic medical centres (PDF p. 1). A common eCARE/Epic record was deployed across 12 Partners hospitals and practices (PDF p. 2). GeneInsight was used to deliver molecular-laboratory results through the EHR, while ...

[314] Weitzel Kristin Wiisanen, Alexander Madeline, Bernhardt Barbara A et al. (2016). The IGNITE network: a model for genomic medicine implementation and research.. BMC medical genomics. PMID: 26729011.

Setting: United States – NIH-funded IGNITE Network: six implementation projects and a coordinating center linked to academic medical centers and diverse Design: Framework / perspective. Modality: General/multiple – family health history, disease-risk assessment, diagnostic sequencing, and pharmacogenomics embedded Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: IGNITE initially comprised six projects and a coordinating center, established in 2013–2014 (Abstract; Methods, pp. 1–2). Projects addressed different clinical uses: family history, disease-risk prediction/prevention, pharmacogenomics, diagnostic mutation discovery, and education (Abstract, p. 1) ...

[315] Weitzel Kristin Wiisanen, Duong Benjamin Q, Arwood Meghan J et al. (2020). A stepwise approach to implementing pharmacogenetic testing in the primary care setting.. Pharmacogenomics. PMID: 31588877.

Setting: United States – primary-care implementation guidance derived from IGNITE Network experience. Design: Framework / perspective. Modality: Pharmacogenomics/pharmacogenetics – primary-care testing and genotype-guided drug selection/dosing. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The paper presents a practice-based four-step primary-care PGx approach grounded in IGNITE Network implementation experience (Abstract; Fig. 1, p. 4). It contrasts reactive single-gene testing with preemptive multigene-panel strategies and outlines their clinical, practical, and reimbursement ...

[316] Weymann Deirdre, Dragojlovic Nick, Pollard Samantha et al. (2022). Allocating healthcare resources to genomic testing in Canada: latest evidence and current challenges.. Journal of community genetics. PMID: 31273679.

Setting: Canada, provincial and national healthcare-resource allocation context. Design: Systematic / scoping review. Modality: General/multiple – genomic testing and precision medicine. Domains: Governance and Policy; Finance and Sustainability. Key findings: The review identified 25 relevant Canadian economic-evidence studies from 91 screened records (Results, pp. 3–4). Genomic-testing funding, reimbursement, and assessment processes were heterogeneous across Canada (Results/Discussion, pp. 4–8). Many genomic-testing applications were not routinely ...

[317] Whitcomb David C (2020). Barriers and Research Priorities for Implementing Precision Medicine.. Pancreas. PMID: 31688586.

Setting: United States - pancreatic-disease precision-medicine context; no evaluated health system.. Design: Framework / perspective. Modality: General/multiple - precision medicine for pancreatic diseases using clinical, biological, genetic, environmental, and Domains: Strategic Leadership and Readiness; Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The paper organizes pancreatic precision-medicine barriers into information, integration, translation, logistics, and acceptance domains (Abstract/Sections, PDF pp. 1-7). It identifies EHR data quality, cross-domain data integration, workflow disruption, and payer/institutional acceptance as ...

[318] White Stephanie, Jacobs Chris, Phillips Jane (2021). Mainstreaming genetics and genomics: a systematic review of the barriers and facilitators for nurses and physicians in secondary and tertiary care.. Genetics in medicine : official journal of the American College of Medical Genetics. PMID: 32313152.

Setting: Multiple countries - systematic review of secondary- and tertiary-care nursing and physician practice.. Design: Systematic / scoping review. Modality: General/multiple - mainstreaming genetics and genomics into

routine clinical care.. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: The systematic review searched 7,873 articles and included 48 studies (PDF pp. 1-2). Capability-related barriers were reported in 44 studies, opportunity-related barriers in 39, and motivation-related barriers in 38 (PDF p. 3). Knowledge was explored in 27 studies and skills in 41 studies (PDF p ...

[319] Wibowo Mochammad Fadjar, Pyle Alexandra, Lim Emma et al. (2025). Insights Into the Current and Future State of AI Adoption Within Health Systems in Southeast Asia: Cross-Sectional Qualitative Study.. Journal of medical Internet research. PMID: 40523280.

Setting: Southeast Asia – health-system AI adoption across Brunei Darussalam, Indonesia, Myanmar, Singapore, Thailand, Vietnam and the Philippines.. Design: Qualitative study. Modality: Clinical AI / machine learning – health-system adoption and integration, including personalized medicine applications.. Domains: Strategic Leadership and Readiness; Governance and Policy; Digital Infrastructure and Interoperability; Finance and Sustainability. Key findings: Thirty-one stakeholders involved in AI implementation across seven Southeast Asian countries were interviewed (Abstract, pp. 1–2). Five themes emerged: acceptance, digital-transformation disparities, technology governance, data governance and health-system transformation (Abstract, pp. 1–2) ...

[320] Williams Janet K, Feero W Gregory, Leonard Debra G B et al. (2017). Implementation science, genomic precision medicine, and improved health: A new path forward?. Nursing outlook. PMID: 27633263.

Setting: United States – national implementation-science workshop and genomic precision-health context.. Design: Framework / perspective. Modality: General/multiple – genomic precision medicine. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The National Academies Roundtable workshop examined genomic implementation from patient, institutional, state and national perspectives (p. 2). The paper identifies leadership, provider education, learning-health-system data capability, access, equity, regulation, privacy and cost as implementation ...

[321] Williams Marc S (2020). Early Lessons from the Implementation of Genomic Medicine Programs.. Annual review of genomics and human genetics. PMID: 30811224.

Setting: United States-led review of genomic medicine programmes with international implementation examples. Design: Framework / perspective. Modality: General/multiple - genomic medicine programmes. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: The review synthesizes early lessons from genomic medicine programmes and identifies recurring implementation needs across leadership, evidence, informatics, workflow, education and access (Review). Programmes should build implementation and evaluation infrastructure concurrently with genomic ...

[322] Wiss Florine M, Jakober Deborah, Lampert Markus L et al. (2024). Overcoming Barriers: Strategies for Implementing Pharmacist-Led Pharmacogenetic Services in Swiss Clinical Practice.. Genes. PMID: 39062642.

Setting: Switzerland, pharmacist-led pharmacogenetic services across community pharmacies, hospitals, psychiatry, and general practice. Design: Qualitative study. Modality: Pharmacogenomics/pharmacogenetics. Domains: Strategic Leadership and Readiness; Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Key findings: Interviews with nine pharmacists and nine physicians identified 12 barriers and seven facilitators (“12 as barriers”; Abstract). The strongest barriers included service design, communication, and IT infrastructure, each receiving strong negative CFIR ratings (Table 2, pages 5–6). Interviewees ...

[323] Woodbury R Brian, Beans Julie A, Wark Kyle A et al. (2022). Community Perspectives on Communicating About Precision Medicine in an Alaska Native Tribal Health Care System.. Frontiers in communication. PMID: 33511166.

Setting: United States – Alaska Native Tribal Health Care System / Southcentral Foundation, Alaska.. Design: Qualitative study. Modality: General/multiple – precision-medicine communication, genomic-data management and clinical/research integration.. Domains: Governance and Policy; Workforce Capability and Change Management; Patient Access, Equity and Ethics. Key findings: Interviews/focus groups with patients, providers and leaders identified informational needs about clinical/research uses, benefits/risks, costs and data management (Abstract, pp. 1–2; Results, pp. 8–15). In-person, relationship-based communication and group discussion were generally preferred ...

[324] Wu Fang, Lu Song, Zhang Dan et al. (2025). Clinical implementation and outcome evaluation of dihydropyrimidine dehydrogenase (DPYD) pharmacogenomic testing for fluoropyrimidine dosing in a Canadian Provincial Healthcare center.. Clinical biochemistry. PMID: 40912527.

Setting: Canada, Saskatchewan Health Authority and Saskatchewan Cancer Agency provincial cancer-care setting. Design: Empirical implementation study. Modality: Pharmacogenomics/pharmacogenetics – DPYD-guided fluoropyrimidine dosing. Domains: Workforce Capability and Change Management; Clinical Workflow and Service Integration. Key findings: Two hundred ninety-nine patients underwent DPYD testing from July to December 2024 (Results, p. 3). Twenty patients (6.7%) had a clinically significant DPYD result (Results, p. 3). The paper reports clinical review of fluoropyrimidine-treated patients and the implementation pathway from testing to ...

[325] Wu Wen-Wen, Guo Hong-Li, Li Yue et al. (2024). A national-wide survey on clinical implementation of PGx testing into precision therapeutics for Chinese children: a long way before standard clinical practice.. BMC health services research. PMID: 39294738.

Setting: China - 50 children's hospitals across 31 provinces, municipalities, and autonomous regions.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics - pediatric genotype testing for personalized medication.. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Thirty-eight of 50 hospitals responded; 15 active programmes were assessed, and only six tested at least five drug-related genes (Abstract/Results, pp. 1, 3-6). Twenty percent lacked internal quality control, 33.3% lacked external quality assessment, and nearly 63% of 81 practitioners had not ...

[326] Wästerlid Tove, Cavelier Lucia, Haferlach Claudia et al. (2022). Application of precision medicine in clinical routine in haematology-Challenges and opportunities.. Journal of internal medicine. PMID: 35599019.

Setting: International review with examples from European and United States haematology services. Design: Framework / perspective. Modality: Genomic cancer-risk/hereditary and multimodal precision oncology - haematological malignancies. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: The review describes molecular diagnostics as essential for diagnosis, prognosis and treatment choice in multiple haematological malignancies (Abstract). It identifies practical challenges in translating complex molecular data to real-world treatment selection (Abstract/Discussion). Services should ...

[327] Yang Ueng-Cheng, Hsiao Tzu-Hung, Lin Ching-Heng et al. (2023). Integrative LHS for precision medicine research: A shared NIH and Taiwan CIMS experience.. Learning health systems. PMID: 31245594.

Setting: Taiwan - Taichung Veterans General Hospital, modeled on a National Institutes of Health Clinical Informatics and Management System in the United Design: Institutional case study. Modality: General/multiple - learning-health-system architecture linking EHR, biobank, registry, and genomic data for dementia Domains: Governance and Policy; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Patient Access, Equity and Ethics. Key findings: TCVGH implemented a shared-design CIMS with hospital data marts to support a dementia precision-medicine registry (Abstract; PDF pp. 3-4). The implementation integrated governance, electronic research capture, specimen management, de-identification, and reuse of clinical data (PDF pp. 3-5). The ...

[328] Youssef Essra, Bhattacharya Debi, Sharma Ravi et al. (2023). A Theory-Informed Systematic Review of Barriers and Enablers to Implementing Multi-Drug Pharmacogenomic Testing.. Journal of personalized medicine. PMID: 36579514.

Setting: Not reported - systematic review of multi-drug pharmacogenomic implementation reports, mainly from the United States and other high-income settings.. Design: Systematic / scoping review. Modality: Pharmacogenomics/pharmacogenetics - multi-drug/multi-gene testing.. Domains: Governance and Policy; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Key findings: The review included 27 reports and mapped barriers/enablers across ordering, facilitating, interpreting, and applying multi-drug pharmacogenomic testing (Results, PDF pp. 4-5, 8-14). Four cross-cutting themes were identified: information technology, effort, rewards, and unknown territory (Results ...

[329] Zakinova Angela, Long-Boyle Janel R, French Deborah et al. (2022). A Practical First Step Using Needs Assessment and a Survey Approach to Implementing a Clinical Pharmacogenomics Consult Service.. Journal of the American College of Clinical Pharmacy : JACCP. PMID: 32391517.

Setting: United States – UCSF Health, a large tertiary academic medical centre.. Design: Survey / cross-sectional. Modality: Pharmacogenomics/pharmacogenetics – non-oncologic medication prescribing.. Domains: Workforce

Capability and Change Management; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: Of 396 clinicians surveyed, 76 physicians and 59 pharmacists participated; average response rates were 27% and 50%, respectively (Results, p. 2). Current PG use was reported by 29% of physicians and 32% of pharmacists, varying across clinical specialties (Results, p. 2). Guidelines/protocols ...

[330] Zhang Jingmin, Qi Guangzhao, Han Chao et al. (2022). The Landscape of Clinical Implementation of Pharmacogenetic Testing in Central China: A Single-Center Study.. Pharmacogenomics and personalized medicine. PMID: 34934339.

Setting: China – The First Affiliated Hospital of Zhengzhou University, a provincial tertiary hospital in central China. Design: Cohort / clinical evaluation. Modality: Pharmacogenomics/pharmacogenetics – hospital pharmacogenetic testing across CYP2C19, MTHFR, CYP2C9/VKORC1, and ALDH. Domains: Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration; Finance and Sustainability. Key findings: The hospital recorded 47,265 PGx test results from 2013–2018, rising from 991 to 11,393 annually, an average annual growth rate of 63.0% (Results, pp. 3–4). 95.3% of tests were inpatient; CYP2C19 testing represented 50.2% and MTHFR C677T testing 41.7% of all results (Table 1, p. 4). Cardiology ...

[331] Zubiaur Pablo, Mejía-Abril Gina, Navares-Gómez Marcos et al. (2021). PriME-PGx: La Princesa University Hospital Multidisciplinary Initiative for the Implementation of Pharmacogenetics.. Journal of clinical medicine. PMID: 34501219.

Setting: Spain – La Princesa University Hospital and Madrid Health Service.. Design: Institutional case study. Modality: Pharmacogenomics/pharmacogenetics.. Domains: Strategic Leadership and Readiness; Workforce Capability and Change Management; Digital Infrastructure and Interoperability; Clinical Workflow and Service Integration. Key findings: The paper describes the historical implementation of a pharmacogenetics unit established in 2006 and the subsequent PriME-PGx multidisciplinary initiative (Abstract/Introduction). The unit transitioned from paper-based requests to electronic pharmacogenetic test ordering and profile-based testing ...

[332] Čerina Dora, Krpina Kristina, Jakopović Marko et al. (2023). The Challenges and Opportunities of the Implementation of Comprehensive Genomic Profiling in Everyday Clinical Practice with Non-Small Cell Lung Cancer: National Results from Croatia.. Cancers. PMID: 37444505.

Setting: Croatia – national precision-oncology project across six Croatian institutions treating metastatic non-small-cell lung cancer.. Design: Cohort / clinical evaluation. Modality: Genomic cancer-risk/hereditary – comprehensive tumor genomic profiling (CGP) for precision oncology in metastatic Domains: Strategic Leadership and Readiness; Governance and Policy; Clinical Workflow and Service Integration; Finance and Sustainability; Patient Access, Equity and Ethics. Key findings: Forty-eight patients underwent CGP in six Croatian institutions during 2020–2021 (Methods; Results, pp. 4–5). Clinically relevant genomic alterations were identified in 38 of 48 patients (79%), and 29 patients (60%) had potentially targetable alterations outside the existing routine testing ...

Appendix D. PRISMA-ScR Checklist

Completed PRISMA Extension for Scoping Reviews (PRISMA-ScR) checklist (Tricco et al., 2018), mapping each item to where it is reported in this manuscript. Items 12 and 16 (critical appraisal) are optional and were not undertaken, consistent with scoping-review methodology.

#	PRISMA-ScR checklist item	Reported in
1	Title: identifies the report as a scoping review	Title page
2	Abstract: structured summary (objectives, methods, results, conclusions)	Abstract (English and Arabic)
3	Rationale for the review	Sec 1 Introduction; Sec 2 Research Problem
4	Objectives / review questions	Sec 4 Study Objectives
5	Protocol and registration	Sec 7.1 (not registered; conducted under an internal locked protocol)
6	Eligibility criteria	Sec 7.2
7	Information sources	Sec 7.3; Appendix A
8	Search (full electronic search strategy for at least one database)	Sec 7.3; Appendix A.1
9	Selection of sources of evidence	Sec 6.1, 7.4, 7.5; Figure 1
10	Data charting process	Sec 7.5, 7.6; Appendix B
11	Data items	Sec 7.5, 7.6; Appendix C
12	Critical appraisal of individual sources (optional)	Not performed (Sec 7.8, 9.6)
13	Synthesis of results (methods)	Sec 7.8
14	Selection of sources of evidence (results)	Sec 6.1; Figure 1; Table 2
15	Characteristics of sources of evidence	Sec 6.2, 6.3; Table 1; Figure 2
16	Critical appraisal within sources (optional)	Not performed (Sec 7.8, 9.6)
17	Results of individual sources of evidence	Sec 8; Appendix C
18	Synthesis of results	Sec 8.1–8.3; Table 3
19	Summary of evidence	Sec 9.1
20	Limitations	Sec 9.6
21	Conclusions	Sec 9.7
22	Funding	Sec 11 Declarations (None)