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Integrating pharmacogenomics into nursing practice implications for clinical decision-making

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***Abstract*---Background:** Integrating pharmacogenomics (PGx) into nursing practice has the potential to enhance personalized medicine and improve clinical decision-making. Despite its growing relevance, barriers such as insufficient training, limited knowledge, and unclear clinical guidelines hinder the adoption of PGx in nursing. **Methods:** This study employed a mixed-method systematic review using a convergent integrated approach to explore intrinsic and extrinsic

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factors influencing nurses' adherence to Clinical Practice Guidelines (CPGs) in PGx. A comprehensive literature search was conducted across multiple databases, synthesizing quantitative and qualitative findings to identify key determinants of adherence. **Results:** Key intrinsic factors identified include nurses' baseline knowledge, attitudes, and confidence in applying PGx-related CPGs. Extrinsic factors encompassed institutional support, access to training programs, integration of PGx into electronic health records, and interdisciplinary collaboration. Barriers such as a lack of standardized CPGs and resource limitations were also highlighted. The synthesis revealed that tailored educational interventions and robust support systems significantly improved adherence rates. Furthermore, a strong correlation between interdisciplinary teamwork and effective CPG implementation was noted. **Conclusion:** Successful integration of pharmacogenomics into nursing practice requires addressing both intrinsic and extrinsic barriers. Strategies such as enhanced education, clear guidelines, and systemic support are essential for fostering adherence to PGx CPGs. These findings underscore the importance of preparing nurses to play a pivotal role in the advancement of personalized medicine.

***Keywords*---**Pharmacogenomics, Nursing Practice, Clinical Practice Guidelines, Personalized Medicine, Review.

1. Introduction

Research in pharmacogenomics has uncovered more than 130 gene variants that can influence the safety and effectiveness of drug treatments [1]. Several hospitals have started utilizing genotype information to guide the selection of drugs and dosages for various medications, including warfarin and clopidogrel [2-5]. As genotyping becomes increasingly prevalent, pharmacists and physicians will come across more pharmacogenomic information. To utilize this information for minimizing the risks of adverse events and enhancing treatment effectiveness, clinicians will require insights that aid in interpreting the intricate interactions among patient genotypes, resulting phenotypes, and medications [6,7]. Although pharmacists are essential in the medication decision-making process, there has been a notable lack of focus on their information needs and preferences related to pharmacogenomics. This study explores the information needs and resource requirements of pharmacists about pharmacogenomics-based decision-making. This project aims to guide the creation of information resources that will assist pharmacists in addressing the information challenges posed by pharmacogenomics.

2. The Role of Pharmacists in Pharmacogenomics Information

Pharmacists, as skilled professionals, utilize their comprehensive training in drug therapy to offer medication guidance, playing an essential role in delivering pharmacogenomics information to prescribing clinicians [8-10]. There are various interdisciplinary clinical implementations led by model pharmacists. Pharmacists

recognize the clinical benefits of pharmacogenomics; however, they lack confidence in making recommendations without additional education. Nonetheless, there is limited understanding regarding the information requirements of pharmacists about pharmacogenomics. While several studies have explored pharmacists' overall drug information needs and their educational requirements concerning pharmacogenomics, there has yet to be a study that specifically addresses pharmacists' information needs about pharmacogenomics [11-16].

Physicians also have a deficiency in pharmacogenomics knowledge. They seek details regarding recommendations, interpretations of genetic test results, testing information, and insights into populations most at risk [6,17,18]. Additionally, they appreciate reliable, clinically relevant information concerning phenotypes and dosage recommendations [7,19,20]. Resources that focus on pharmacogenomics can assist pharmacists in delivering the essential guidance for the safe and effective prescribing of medications with pharmacogenomic considerations.

3. Challenges in Pharmacogenomics Information

Pharmacogenomics encompasses intricate relationships among genes, medication exposure, and patient characteristics that result in phenotypes [21]. Genetic variations can influence how individuals respond to medications, their effectiveness, and the likelihood of experiencing side effects [22]. Every combination offers a distinct array of factors to consider [23,24]. Interpreting this information involves several challenges, such as potentially unclear descriptions of gene variants, phenotypes, and the implications of their interactions. When evaluating a patient with a pharmacogenomic genotype pertinent to a medication being considered, the prescriber should combine this information with clinical variables such as age and weight to identify the most appropriate course of action.

4. Resources for Pharmacogenomics Information

In the United States, the Food and Drug Administration (FDA) mandates that manufacturers include pertinent pharmacogenomics information in the drug product labels of all medications with established pharmacogenomic effects. The information is dispersed across the label and found in various sections for different drugs. A range of commonly utilized electronic information resources encompasses pharmacogenomic information [25,26]. Nevertheless, the information frequently lacks completeness, with resources offering between 50% and 90% of the pharmacogenomics data found in FDA-approved product labels [26].

The Clinical Pharmacogenetics Implementation Consortium (CPIC), a collaborative effort between the Pharmacogenomics Research Network (PGRN) and the Pharmacogenomics Knowledgebase (PharmGKB), creates guidelines aimed at integrating pharmacogenomics knowledge into clinical practice [27-30]. The PharmGKB website offers CPIC and Dutch Pharmacogenetics Working Group (DPWG) guidelines, pertinent citations to primary literature, and certain product

label information. Although the research and guideline information are essential, PharmGKB offers only concise excerpts of pharmacogenomics information present in structured product labels, rather than the complete text of every pharmacogenomics-related statement or the specific section from which it came. [31-33] In line with previous studies showing that pharmacists depend significantly on the information from FDA-mandated labels, our informal observations indicate that detailed product label information is essential for pharmacists. This raises concerns about their trust in PharmGKB, as they may not view it as a source of authoritative information, even with the FDA statements provided on the platform [34,35].

5. Pharmacogenomics Information Requirements

The information needs of participating pharmacists, both in general and specifically regarding pharmacogenomics, can be categorized into four areas: background, medication, patient-specific, and guidance-related information. The needs outlined here closely resemble those of physicians, especially regarding the interpretation of test results, suggestions for alternatives, prevalence among different ethnic groups, and information on genotypic testing [6,7]. We discovered particular information needs that are both directly and indirectly associated with pharmacogenomics, which was not identified in similar studies regarding physicians' knowledge gaps in pharmacogenomics and the usability of pharmacogenomics decision support tools. This encompasses the monitoring of information, the severity of risk, and additional drugs influenced by a biomarker.

The views of pharmacists are probably shaped by the setting in which they operate. For example, although none of the pharmacists have interacted with patients who underwent pharmacogenomic testing, some had a greater familiarity with the concept than their peers. Nursing home consultant pharmacists had minimal exposure to pharmacogenomics, whereas hospital-based resident pharmacists possessed sufficient familiarity to understand recommendations for treating CYP2C19 poor metabolizers [36-38].

6. Requirements for Pharmacogenomics Information Resources

In this study, pharmacists express a preference for resources that are peer-reviewed, available online, full-text, well-referenced and include visualizations along with links to additional sources (Structure of the Resource). They view high-quality resources as familiar, trustworthy, current, and well-structured (Perceptions of the Resource). Ultimately, they view high-quality information as being swift, succinct yet comprehensive, pertinent, precise, and user-friendly (Perceptions of the Information). They are especially focused on the origin of the information: they seek references, access to complete studies, and favor data derived from FDA-mandated product labels. If there is uncertainty regarding the origin, they choose to depend exclusively on the information provided on the product label [39,40].

The involvement of pharmacists across various care settings enhances the applicability of our findings. The participants comprised pharmacists from various settings, including hospitals, nursing homes, ambulatory care, and retail

pharmacies, as well as pharmacy students and a resident. While these participants were not selected to represent a wider sample, the similarities in their responses indicate that concerns and information needs related to pharmacogenomics might be consistent across these work environments. Resource requirements are likely shaped by practice environments [41]. Pharmacists lacking access to high-speed Internet, particularly those relying on wireless connections, encountered slow resource speeds that hospital-based pharmacists with robust networks did not face. The selection and use of existing resources were influenced by varying work contexts, as pharmacists often noted their reliance on the resources funded and endorsed by their employers. Pharmacists working in the outpatient clinic expressed positive views about their chosen resource, noting that it presented information in unique ways that other resources did not replicate [42-46].

7. Pharmacogenomics in Qualitative Research

Although various studies have explored the pharmacogenomics education requirements of pharmacists, none have specifically focused on their information needs for clinical decision-making to effectively address those requirements. This study enhances the insights gained from other recent qualitative research that has concentrated on the pharmacogenomics information requirements of physicians, rather than those of pharmacists. A study conducted by Devine et al. in 2014 examined the usability of a computerized decision support alert that provided pharmacogenomics information [7]. The prototype was presented to cardiologists and oncologists to gather feedback on its usability. Nevertheless, qualitative inquiries were not conducted to identify information needs and resource requirements. Their analysis highlighted significant information needs, including the necessity for clinically relevant details regarding phenotypes and variants, yet it did not specify what constitutes clinical relevance in this context. A 2014 paper by Johansen Taber et al. evaluated physicians' understanding of pharmacogenomics, rather than emphasizing the information required for clinical decision-making.

8. Constraints

The analysis and interpretation of studies of this type can be limited by researcher bias. To tackle this bias, two researchers reviewed and coded the transcripts with a 50% overlap. The coders engaged in a discussion regarding the discrepancies in the agreement and reached a consensus. Furthermore, we confirmed the results through member checks with pharmacists. Although the study offers a comprehensive overview of pharmacists' information-seeking behavior and their information needs, the findings may not apply universally to all pharmacists or clinicians in different contexts.

9. Future Directions

We are in the process of integrating the findings of this study into the design and implementation of a clinically focused pharmacogenomics information resource that includes pharmacogenomics statements annotated from structured product labels. A laboratory-based task analysis will evaluate the effectiveness of the tool

in assisting pharmacists in finding and utilizing information for clinical decision-making.

10. Summary

Pharmacists, as medication specialists integral to decision-making, are well-positioned to spearhead the integration of pharmacogenomics information into clinical practice. The advantages of pharmacogenomics are evident for a limited number of drugs, and research in this area has progressed swiftly. Genotyping aims to empower clinicians to provide their patients with the most effective medication while minimizing the likelihood of adverse events. Merely understanding the patient's genotype is not enough for making treatment decisions; it is essential to know the appropriate steps to take based on that genotype. Our study highlights the pharmacogenomics information requirements of pharmacists and the necessary steps to fulfill those requirements. The design of a pharmacogenomics information resource is a high priority for future work, aimed at addressing information gaps as genotyping becomes increasingly standard practice. A resource that compiles pharmacogenomics information from reliable sources and presents it in a usable and actionable format enhances the practical application of pharmacogenomics in clinical care.

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دمج علم الصيدلة الجينية في ممارسات التمريض وتأثيراته على اتخاذ القرارات السريرية

الخلفية :إن دمج علم الجينوميات الدوائية (PGx) في ممارسة التمريض له القدرة على تعزيز الطب الشخصي وتحسين اتخاذ القرارات السريرية. على الرغم من الأهمية المتزايدة لهذا المجال، فإن الحواجز مثل التدريب غير الكافي، والمعرفة المحدودة، وعدم وضوح الإرشادات السريرية تعيق اعتماد PGx في مجال التمريض.

الأساليب :استندت هذه الدراسة إلى مراجعة منهجية مختلطة باستخدام نهج متكامل ومتقارب لاستكشاف العوامل الداخلية والخارجية التي تؤثر على التزام الممرضين بإرشادات الممارسة السريرية (CPGs) في علم الجينوميات الدوائية. تم إجراء بحث شامل في الأدبيات عبر قواعد بيانات متعددة، وتمت معالجة النتائج الكمية والنوعية لتحديد العوامل الرئيسية التي تؤثر على الالتزام.

النتائج :تتضمن العوامل الداخلية الرئيسية التي تم تحديدها معرفة الممرضين الأساسية، والمواقف، والثقة في تطبيق إرشادات الممارسة المتعلقة بـ .PGx تشمل العوامل الخارجية دعم المؤسسات، والوصول إلى برامج التدريب، ودمج PGx في السجلات الصحية الإلكترونية، والتعاون بين التخصصات. كما تم تسليط الضوء على الحواجز مثل نقص إرشادات الممارسة الموحدة وقيود الموارد. كشفت التركيبة عن أن التدخلات التعليمية المخصصة والأنظمة الداعمة القوية قد حسنت بشكل كبير من معدلات الالتزام. علاوة على ذلك، تم ملاحظة وجود ارتباط قوي بين العمل الجماعي بين التخصصات وتنفيذ الإرشادات السريرية بشكل فعال.

الاستنتاج :يتطلب الدمج الناجح للجينوميات الدوائية في ممارسة التمريض معالجة كل من الحواجز الداخلية والخارجية. تعتبر استراتيجيات مثل تعزيز التعليم، وإرشادات واضحة، ودعم نظامي ضرورية لتعزيز الالتزام بإرشادات الممارسة السريرية لـ .PGxتؤكد هذه النتائج على أهمية إعداد الممرضين للعب دور حيوي في تقدم الطب الشخصي.

الكلمات المفتاحية :علم الجينوميات الدوائية، ممارسة التمريض، إرشادات الممارسة السريرية، الطب الشخصي، مراجعة منهجية.