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ASSESSMENT OF KNOWLEDGE, ATTITUDE AND PERCEPTIONS TOWARD PHARMACOGENOMICS AMONG PHARMACY STUDENTS

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ABSTRACT

Background and Goals: Although pharmacogenomics has been widely used in clinical pharmacy practice, its application has not been as extensive as it might be. Pharmacists are among the best competent healthcare professionals for this work. In order to improve the way pharmacogenomics education programs are delivered in the future, the review attempts to methodically examine pharmacists' and pharmacy students' attitudes, beliefs, and knowledge about pharmacogenomics.

Methods: Searches were conducted until May 17, 2022, using PubMed, MEDLINE, Embase, Scopus, and the International Pharmaceutical Abstracts. Studies that provided information on the knowledge, attitudes, and perceptions of pharmacists or pharmacy students about pharmacogenomics that were published in an English-language, peer-reviewed journal with full-text accessibility were chosen. Published studies that weren't considered original research were not included. Using the critical evaluation instruments developed by the Center for Evidence-Based Management, every included study was evaluated critically. Based on the knowledge, awareness, and attitudes of pharmacists and pharmacy students toward pharmacogenomic (PGx), their comfort level with using and interpreting PGx test results, and their desire for additional PGx education or their preferred mode of further education, the data were descriptively analyzed and presented.

Findings: Across the 52 included studies, 12,430 pharmacists and pharmacy students from 26 different countries are represented. A general lack of confidence and expertise was discovered, despite the fact that pharmacists and pharmacy students had largely favorable views and opinions of pharmacogenomics. The analysis also revealed that pharmacy students and pharmacists have a high demand for further pharmacogenomics education.Conclusion: Despite their lack of understanding and confidence, pharmacists and pharmacy students have good opinions and attitudes on pharmacogenomics. Nevertheless, the low representativeness of the community or area under study, small sample sizes, and insufficient control for confounding reduce the review conclusions' generalizability. Through better pharmacogenomic course delivery within the pharmacy curriculum and continuing education programs, knowledge and confidence might be increased.

KEYWORDS: pharmacy student, pharmacogenomics, education, attitudes, knowledge, and perceptions.

I. INTRODUCTION

Interindividual variability is a major concern in optimal drug therapy. Although most licensed medications are effective and well-tolerated, up to 50% of individuals do not get any benefit from some medications, while other medications cause adverse drug reactions (ADRs). This leads to reduced adherence to treatment, increased morbidity and mortality, or requires further treatment that increases psychological distress and economic burden to the individual and the society.1,2 ADRs are estimated to be the fourth leading cause of death in the United States.3 In Canada, an estimated 200,000 severe ADRs are reported annually, leading to as many as 22,000 deaths, costing the Canadian healthcare system

between $13.7 and $17.7 billion.4 Similar figures have been reported in other countries rendering the issue a significant healthcare challenge worldwide, particularly with an increasingly aging population and rising multimorbidity.5,6 To partly counteract interindividual variation in drug response, the "precision medicine" concept has been developed that strives to achieve individualization of treatment plans and optimize patient outcomes. It has been estimated that up to 95% of variation in drug efficacy and tolerability can be attributed to genetic differences between individuals, and between 80% and 99.5% of the population carry an actionable genetic variant that could affect drug selection and/or dosing of at least one drug.5,7–9 Over the past two decades, pharmacogenomic (PGx) testing has emerged as one of the essential tools for precision medicine that can aid in determining how a person processes and reacts to drugs based on their genetic makeup.

PGx testing can potentially improve drug efficacy and safety, reduce time to therapeutic response, prevent ADRs, increase treatment compliance, and ultimately reduce morbidity and mortality risk. This testing aims to tailor pharmacotherapy based on interpretation of the patient's genetic sequences, which code for drug- metabolizing enzymes, functional proteins, transporters, receptors, and immune response molecules. This interpretation is accomplished by translating the genotype information from a genetic test into a phenotype of how a patient is likely to respond to therapy, such as whether they will be a poor versus ultrarapid metabolizer. When combined with other laboratory results, clinical symptoms, concomitant medications, and environmental factors, this information can allow healthcare professionals to practice precision medicine by providing an individualized therapeutic plan that takes into account the patient's genetic results in addition to other clinical factors.10,11 Currently, more than 200 licensed medications have therapeutic management (use of alternative drug or dose change) and/or warnings about potential ADRs on their labels12 or have prescribing guidelines based on genotype results recommended by several expert groups, for example, the Dutch Pharmacogenetics Working Group (DPWG),13 the Clinical Pharmacogenetics Implementation Consortium (CPIC),14 and the Canadian Pharmacogenomics Network for Drug Safety (CPNDS).15 These guidelines have been endorsed by the American Society of Health-System Pharmacists (ASHP),16 the American Society for Clinical Pharmacology and Therapeutics (ASCPT),17 Canadian Pediatric Society,18 the European Association for Clinical Pharmacology and Therapeutics (EACPT), the European Association of Hospital Pharmacists (EAHP), and Irish Pharmacy Union (IPU). More than 50 healthcare systems worldwide are already utilizing PGx testing, and commercial companies offer several options, including direct-to-consumer tests.19 Pharmacists, the medication experts, are leading the clinical implementation of PGx in various practice settings (e.g., hospitals, primary care, or community pharmacies).20–24

Pharmacists have been recognized as among the most qualified healthcare professionals due to their knowledge of pharmacokinetics and pharmacodynamics for interpreting PGx test results.25 They are also well positioned to lead interprofessional efforts to implement PGx testing due to their accessibility. In a recent position statement, the ASHP clearly outlined pharmacists' role in the clinical implementation of PGx.26 A recent scoping review reported the demonstrated feasibility of PGx testing and improved medication outcomes in pharmacy practice.27 Yet, some hesitate to share PGx information with other healthcare providers due to the lack of standardized PGx education

currently incorporated into pharmacy programs.28–31

Despite the advancement in high-quality PGx research, increased test and guideline availability, demonstrated feasibility and applicability of testing in pharmacy workflow, its widespread implementation in clinical pharmacy practice has remained limited.22,27,32 To inform the future delivery of PGx education and clinical implementation, we aim to provide an overview of what is currently known regarding the knowledge, attitudes, perceptions, and confidence of pharmacists and pharmacy students toward PGx. To accomplish this, we systematically reviewed and critically appraised available PGx literature on the knowledge, attitudes, perceptions, and confidence of pharmacists and future pharmacists (pharmacy students) toward PGx.

II. METHODS

This systematic review was registered with PROSPERO (CRD2022333026) and followed PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations.33 Two reviewers (A. W. and A. F.) independently searched PubMed, MEDLINE, Embase, Scopus, and International Pharmaceutical Abstracts (IPA) for English-language, original research. All database searches included studies published up to May 17, 2022. The search strategy was developed from keywords for the main concept of the review: “pharmacists,” “pharmacy students,” “pharmacogenetics,” “pharmacogenomics,” “precision medicine,” “individualized medicine,” “knowledge,” “awareness,” “understanding,”
“perception,”“view,”“opinion,”“perspective,”“attitude,”“interest,”“belief,”“confidence,”
“competence,” “qualified,” “capability,” and “experience.” Search strategies were refined through discussions with a librarian specializing in health sciences. Supporting Information S1: Table 1 details the search strategy. Both reviewers independently screened titles and abstracts of all articles identified during the systematic search and assessed full-text copies of the relevant articles. For articles where a consensus between the two reviewers was not achieved, a third reviewer (A. A. M.) assessed and resolved the conflict. The conflicts were mostly related to studies where separate data were not available for pharmacists or pharmacy students. The review was managed by Covidence systematic review software (Veritas Health Innovation). Studies were selected for data extraction if the following inclusion criteria were met: (1) included data about pharmacists' or pharmacy students' knowledge, perception, or attitude about PGx, and (2) published in a peer-reviewed, English-language journal and full-text was available. Review articles, case studies, posters/ abstracts, commentaries, perspectives, books, book chapters, editorial pieces, or any published material not deemed original research were excluded. Extracted information included authors, publication year and country, study title, participant characteristics, and main findings (knowledge or awareness of PGx, perceptions or attitudes toward PGx, confidence in using PGx in their practice, and desire for further education and/or the most desired format for further education). The level of knowledge (e.g., low/moderate/positive/ negative/poor) was designated as per the original study. No statistical comparisons were made between the studies. All included studies were critically appraised by two independent reviewers (A. W. and A. F.) using the Center for Evidence-Based Management (CEBMa)'s critical appraisal tools for surveys and qualitative studies.34

III. RESULTS

3.1 | Study selection

Figure 1 provides an overview of the article selection process. The literature search generated 1773 articles, duplicates were removed, and 865 articles underwent title and abstract screening. Eight hundred seven articles

were excluded as they did not meet the inclusion criteria. For the full-text screening, 58 articles were assessed, and six articles were excluded. A total of 52 articles underwent complete data extraction and critical appraisal.

3.2 | Study characteristics

Twenty-six countries were represented by the included studies (Figure 2). The studies were predominantly conducted in the United States (n = 12) and Canada (n = 4), followed by Jordan, Saudi Arabia, Malaysia, Australia, and United Arab Emirates, with three studies each. The included studies were conducted in different settings and used diverse methodologies for data collection (Table 1). Data were mainly gathered via convenience sampling from selected locations within the country or nationwide from pharmacists working in private and retail pharmacies, private and government hospitals, academic research institutes, or primary care facilities. Pharmacy students were recruited from educational institutes offering pharmacy programs. Most studies utilized cross-sectional surveys (n = 49) to gather data on knowledge, perception, attitudes, or confidence regarding PGx. Semistructured and focus group interviews were the primary methodologies of the three qualitative studies included. The findings for pharmacists and pharmacy students were presented separately to observe whether there was a difference in opinions about the clinical use of PGx and current PGx education delivery. A total of 8092 pharmacists (range 11–1313) and 4002 pharmacy students (range 62–637) were surveyed or interviewed among the 49 included studies. Three studies had combined data (pharmacists and pharmacy students) that included 336 participants. A total of 12,430 pharmacists and pharmacy students were represented among the 52 included studies.

3.3 | Synthesis of results

The data were descriptively analyzed and presented based on pharmacists' and pharmacy students' knowledge/awareness, perception/attitudes toward PGx, confidence in using or interpreting PGx testing results, and their desire to get further PGx education or their most preferred method of further education (Table 1).

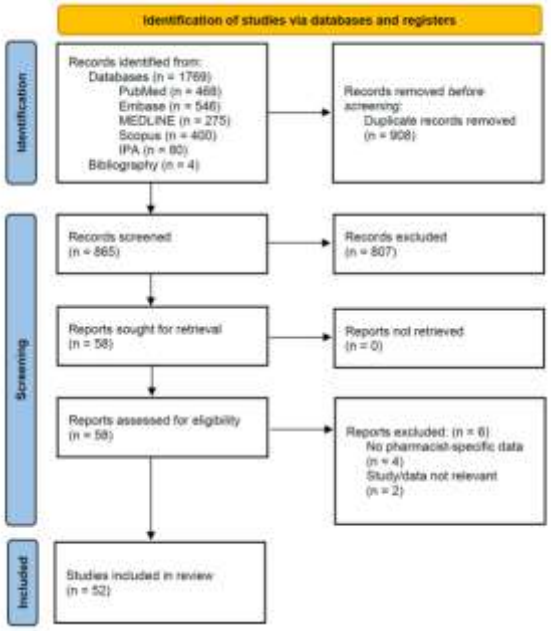

FIGURE 1 PRISMA flow diagram of the article selection process. IPA, International Pharmaceutical Abstracts; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

3.4 | Knowledge and awareness of PGx

There was an overall lack of PGx knowledge and awareness among pharmacists and pharmacy students. However, across studies, there was a consensus that PGx is relevant to pharmacy practice and pharmacists should be required to have adequate PGx knowledge (Table 1). Many respondents believed it was important for pharmacists to provide information on the appropriate use of PGx testing and know how to order/recommend and interpret the subsequent results.35,39,45,47,48,53,56,58,59,83,84 Out of the 34 studies that reported on PGx knowledge or awareness among pharmacists, 23 found that the majority of the respondents had a low or inadequate level of PGx knowledge or awareness.31,35–38,41,44,46,47,50–

52,54,55,57,59,60,66,67,76,82,83,85 None of the analyzed studies reported that most respondents had adequate PGx knowledge. In comparison, most studies with pharmacy students found a good or fair level of knowledge among most participants.69,73,74,76–81 Some studies only reported self-assessed (subjective) knowledge of PGx, which was generally reported as "low." However, self-assessed knowledge did not always correlate with actual expertise in studies that assessed both.37 While many studies did not report data on "biological sex," one study noted a difference in the knowledge level of pharmacy students between males and females. However, the reasons for this were not examined in detail.72

IV. DISCUSSION

One previous systematic review investigated the attitudes of patients, general practitioners, and pharmacists in primary care (included six studies with pharmacists),88 and a recent one investigated the knowledge and attitudes of medical and pharmacy students toward PGx (included 13 studies with pharmacy studies).29 The findings from this review and previous reviews reveal a global consensus among researchers and pharmacy professionals that PGx is gaining traction as a key avenue for applying precision medicine in healthcare. However, we have more work to do to prepare current and future pharmacists to take on the "PGx expert" role as a new standard of patient care.

Despite the general absence of PGx currently being incorporated into pharmacy practice, there is enough known about the benefits of PGx testing in precision medicine for pharmacists and pharmacy students to feel positive about using PGx in pharmacy practice.11,27,89 This perception seemed to be held globally, as there was no regional distinction between those studies that reported strong positive attitudes and those that revealed slightly more conservative views toward PGx by some pharmacists in Australia (2014 study)45 and Syria (2021 study).36 Furthermore, studies from more than 8 years ago may have been affected by the lack of robust clinical evidence and education at that time.45,65 The perceptions and attitudes toward PGx illustrated that pharmacists and pharmacy students agreed PGx testing would improve patient safety through individualization of treatment plans and avoidance of adverse effects linked to genetic differences in drug metabolism. Few studies reported that PGx is not applicable to their current practice,37,61,68 which may be a reflection of a lack of infrastructure for the incorporation of PGx testing into practice rather than a negative view of its applicability. Previous research revealed that other healthcare professionals also feel that pharmacists should take on a leadership role in providing PGx services and should be a resource that other healthcare providers can turn to for recommendations on the appropriate use of testing.35,48,88 The National Health Service Improvement and Genomics England announced plans in 2020 to implement PGx testing within the next 10 years. They also acknowledged the essential roles of pharmacists within the implementation model.90 With various pharmacy groups worldwide advocating that pharmacists be the face of these implementation efforts and the anticipated widespread availability of low-cost direct- to-consumer PGx tests, it is not now a question of "whether," but "when" and "how" pharmacists, the most accessible healthcare professionals, will be incorporating PGx testing into their day-to- day practice.91 Several barriers exist to the implementation of PGx testing into pharmacy practice. These include uncertainty about clinical efficacy, difficulty selecting who and when to test, lack of standardization and regulation, and difficulty coordinating with the prescribing physician. In addition, the lack of access to electronic medical records (EMR) to document PGx results, lack of automated EMR

infrastructure to flag potential PGx interactions, and pharmacists being at the point of dispensing rather than the point of prescribing causes inconvenience for patients. Moreover, the lack of reimbursement for pharmacists' time to educate patients, some jurisdiction's view of collecting samples is out of scope of pharmacy practice, religious or cultural values, and the cost burden for patients associated with the testing further contribute to the complexity of integration. This adds to an overall lack of knowledge about PGx and a low confidence level in applying knowledge into practice without proper training.27,32 It appears that pharmacy students were more likely to report a moderate to good level of knowledge (Table 1), which may be due to updates in pharmacy curriculums to include newer concepts of individualized healthcare. This theory is supported by Tuteja et al.,67 who reported that participants with Doctor of Pharmacy (PharmD) degrees (the most up-to-date pharmacy degree) had a higher level of knowledge, reflecting an increased prevalence of PGx education in current pharmacy programs. A 2019 global survey concluded that over 82% of pharmacy and medical programs worldwide contained PGx as a standalone subject or part of the "pharmacology" courses.92 Currently, the Accreditation Council for Pharmacy Education in the United States requires that all colleges/schools of pharmacy teach PGx in their curricula.93 A 2018 study in Kuwait found that pharmacists with 10 or more years of experience had significantly better knowledge than those less experienced.35 This contrasts with another study in Malaysia that found pharmacists with fewer years of experience had more PGx knowledge, likely highlighting differences in PGx education.78 The noted discrepancy in subjective (self- assessed) and objective knowledge about study participants is another key barrier to the implementation of PGx in pharmacy practice, reflecting a low level of confidence in their ability to identify medications that require PGx testing, and then accurately interpret, advise, and counsel on the results.27 Some researchers attributed this confidence deficit to a limited familiarity with PGx in general, which again describes a widespread lack of knowledge on the topic. The Kuwait study noted that most respondents identified a lack of education or training as their most significant barrier to implementing PGx testing in practice.35 The lack of standardized PGx guidelines and resources for pharmacy practice also contributes to pharmacists' hesitation to incorporate PGx testing into standard patient care, further illustrating the lack of awareness about available PGx resources. A low level of recognition of available PGx resources, including the US FDA labeling available on certain medications regarding PGx, also adds to the clinical implementation problem. These barriers are not solely isolated to the pharmacy profession, as several studies included in this review also surveyed physicians who identified a similar lack of knowledge and confidence toward PGx. This highlights the need for more comprehensive PGx education across healthcare professions, hopefully facilitating a collaborative multidisciplinary approach that we strive toward in the 21st century and improving trust and communication between healthcare professionals when providing individualized, patient-centered care. Improved education for pharmacists would facilitate their ability to educate other healthcare professionals and patients about the benefits of PGx testing and its application in optimized care.31 About half of the articles included in this review assessed participants' desire for further education on the topic of PGx, with a majority of these reporting a strong desire for future education in the form of CE (Table 1). Studies that reported a moderately positive response were from 2012 to 2014, once again reflecting an increased understanding of the need for PGx knowledge

and awareness in the profession in more recent years. Although there was not one specific format for CE delivery that was more highly requested, e-learning or web-based CE was mentioned in several articles and would likely be the most convenient format for the widespread delivery of PGx education for practicing pharmacists.41,42,44,56,58,64

V. CONCLUSION

This review found that, despite the inherent limitations of PGx testing and various implementation barriers, there is a limited application of PGx in pharmacy practice, and that pharmacists and pharmacy students worldwide strongly agree about the benefits of using PGx in routine pharmacy practice. Furthermore, more PGx training and education is required. The next generation of pharmacists would be prepared to accept PGx counseling as a regular part of their usual patient care responsibilities if PGx education were made an obligatory component in pharmacy curricula.

The development of training programs for practicing pharmacists should be a priority for academic pharmacy schools. These programs should be affordable, accessible (online or hybrid), engaging (hands-on clinical training, experiential education), and rewarding (CE credits, certifications).

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