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Assessment of Pharmaceutical Professionals' Awareness and Practices Regarding Drug Polymorphism and Its Impact on Tablet Formulation and Performance

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ABSTRACT: Although drug polymorphism has a substantial impact on pharmaceutical quality, stability, and bioavailability, professionals are not well-informed about or adept at managing it. In order to evaluate pharmaceutical professionals' understanding, attitudes, behaviors, and difficulties with medication polymorphism, the current study polled 450 of them using a structured questionnaire. The results showed that although 88.7% of respondents recognized the importance of polymorphism, many were ignorant of its scientific definition and methods of characterization. Inadequate training and a lack of analytical tools were major obstacles to efficient management. Practical training sessions were the main focus of improvement recommendations. The study found that although professionals appreciated drug polymorphism, there were significant knowledge and practice gaps, and that the best indicator of competency was professional experience. Improving training and instruction, as well as providing access to cutting-edge technologies, are crucial for improved field management.

INTRODUCTION:

Given its significant impact on the medicinal performance of oral formulations, drug polymorphism is an established term used to characterize the fact that a drug can exist in distinct crystalline phases—has garnered significant attention in the pharmaceutical profession **(Shi et al., 2022)**.

Many techniques, such as single and multi-solvent crystallisation, lyophilization, sublimation, spray drying, sublimation, grinding, etc., are currently employed to produce polymorphic forms of medications **(Tandon et al., 2018).**

The size of particles, the solubility and rate of dissolution of each structure, the shape of crystals, and their crystallographic characteristics should all be considered polymorph qualities. For dispersions and suspensions involving polymorphs, the specified parameters and the physicochemical characteristics of the original material should be regulated **(Chistyakov& Sergeev, 2020).**

Bioequivalence studies are necessary to show comparability between various formulations since variations in a drug's polymorphic form might impact its bioavailability and therapeutic equivalency. To guarantee consistent drug performance and therapeutic results, regulatory bodies need proof of bioequivalency across test and reference formulations **(Tim, 2024).**

Polymorphic differences significantly affect tablet formulation and performance. Variations in solubility among polymorphs alter dissolution rates, which influence drug absorption. More soluble polymorphs typically dissolve faster, improving bioavailability, while less soluble forms may lead to inconsistent drug release and suboptimal clinical effects **(Censi & Martino, 2015; Shi et al., 2022).** Furthermore, differences in crystal habit and particle morphology affect powder flow and compressibility, impacting tablet hardness, friability, and content uniformity, all critical for manufacturing quality **(Shi et al., 2022).**

This study aimed to evaluate the current level of knowledge and awareness of drug polymorphism among pharmaceutical professionals and to assess the factors affecting the current level of knowledge and awareness of drug polymorphism among pharmaceutical professionals.

METHODS:

Research design and procedure

A descriptive cross-sectional study design was employed to systematically assess pharmaceutical professionals' awareness, knowledge, and practices related to drug polymorphism.

Data was collected using a structured questionnaire distributed to participants across selected pharmaceutical companies and regulatory bodies. The procedure involved questionnaire development, pilot testing, ethical approval, participant recruitment, data collection, and analysis.

Subjects or data sources

Participants included pharmaceutical professionals involved in drug development, formulation, quality assurance, and regulatory affairs. A purposive sampling technique was used to select respondents from pharmaceutical companies and regulatory agencies within the defined geographic region.

Sample size calculation

The sample size was established with the expectation that 50% of respondents would have good knowledge of drug polymorphism, leading to a minimum requirement of 385 participants for a 95% confidence level and 5% margin of error. Accounting for a 10% non-response rate, the sample was adjusted to 450 participants to ensure adequate statistical power. Data from these participants were analyzed using SPSS version 28, employing both descriptive and inferential statistical methods to examine variable relationships.

Data collection tool and data analysis

A validated questionnaire consisting of multiple-choice, Likert-scale, and open-ended questions was used to gather quantitative and qualitative data. Descriptive statistics summarized demographic data and knowledge scores. Inferential statistics, such as correlation analysis and multiple regressions, evaluated relationships between variables. Data was analyzed using statistical software (e.g., SPSS or R).

Questionnaire description and scoring system

1. Questionnaire structure

The questionnaire consisted of 20 questions divided into four domains to comprehensively assess pharmaceutical professionals' knowledge, awareness, attitudes, and practices regarding drug polymorphism:

1. Demographic and professional background (4 questions):

This section gathered information on participants' professional roles, years of experience, educational qualifications, and prior training related to drug polymorphism. These variables serve as independent factors influencing other domains.

2. Knowledge of drug polymorphism (8 multiple-choice questions):

This domain evaluated factual understanding of polymorphism concepts, identification techniques, and manufacturing processes associated with polymorphic changes.

3. Awareness and attitudes (7 Likert-scale questions):

Participants rate their agreement on statements related to the significance of polymorphism confidence in managing it, availability of resources, training needs, and organizational communication effectiveness.

4. Practices and Challenges (1 multiple-choice question, 3 open-ended questions):

This domain explored the frequency of polymorphism-related issues, routine monitoring practices, and qualitative insights on challenges faced and suggestions for improvement.

2. Scoring system

A. Knowledge domain:

Each of the 8 multiple-choice questions is scored as 1 for a correct answer and 0 for an incorrect or "Not sure" response. The total knowledge score ranges from 0 to 8 and were converted to a percentage to categorize knowledge levels (e.g., Poor: 75%).

B. Awareness and attitudes domain:

The 7 Likert-scale questions were scored from 1 (Strongly Disagree) to 5 (Strongly Agree). Reverse scoring was applied for negatively worded items if present. Average scores per item and an overall attitude score was computed, with higher scores indicating greater awareness and positive attitudes.

C. Practices domain:

The multiple-choice frequency question was scored ordinally (e.g., frequently = 4, occasionally = 3, rarely = 2, Never = 1) to quantify engagement in polymorphism-related activities. Open-ended responses were analyzed qualitatively to identify common themes and challenges.

Data analysis and interpretation

Knowledge and practice scores were analyzed statistically to assess correlations with demographic factors using appropriate tests (e.g., t-tests, ANOVA, regression). Likert-scale data were examined descriptively and inferentially to understand attitudes and identify influencing factors.

RESULTS:

Table (1) shows the demographic distribution of participants: 26.67% were formulation scientists, 21.78% production/manufacturing staff, 20% quality assurance specialists, 16.89% research and development scientists, and 11.11% regulatory affairs officers. Experience levels varied, with 28.89% having 4-6 years, 23.56% 1-3 years, 21.11% over 10 years, 18.44% 7-10 years, and 8% less than 1 year. In terms of education, 53.33% held a bachelor's degree, 23.78% a master's, 11.56% a doctorate, 7.33% a diploma, and 4% other qualifications. Regarding formal training in drug polymorphism, 40.44% had academic studies, 33.56% had no training, 22.22% attended workshops/seminars, and 3.78% had no seminars.

Table (1): Demographic and professional characteristics of participants (n = 450)

Variable	Category	No.	%
Current role	Formulation scientist	120	26.67
	Quality assurance specialist	90	20.0
	Regulatory affairs officer	50	11.11
	Research & development scientist	76	16.89
	Production/manufacturing staff	98	21.78
	Other	16	3.55
Years of experience	<1 year	36	8.0
	1–3 years	106	23.56

	4–6 years	130	28.89
	7–10 years	83	18.44
	>10 years	95	21.11
Educational qualification	Diploma	33	7.33
	Bachelor's	240	53.33
	Master's	107	23.78
	Doctorate	52	11.56
	Other	18	4.0
Formal training on drug polymorphism	Academic studies	182	40.44
	Workshops/Seminars	100	22.22
	No training	151	33.56
	Not sure	17	3.78

Table (2) shows that 72.22% of participants defined pharmaceutical polymorphism as a change in chemical composition. Other definitions included multiple crystalline forms (8.89%), varying dosages (5.78%), and physical mixtures (3.33%), with 9.78% uncertain. Regarding higher solubility polymorphic forms, 64.44% recognized them as metastable. Analytical techniques for polymorph identification included NMR (25.56%), XRPD (20.89%), DSC (19.33%), HPLC (21.33%), and FTIR (5.78%), with 7.11% uncertain. Manufacturing processes associated with polymorphic transitions included compression (29.33%), milling (27.11%), granulation (20.22%), and drying (14.67%).

Table (2): Knowledge of drug polymorhism (n = 450)

Question	Response	No.	%
What is the best description of polymorphism in pharmaceuticals	A change in the chemical composition of the drug	325	72.22
	Existence of an API in more than one crystalline form	40	8.89
	Different drug dosages in the same formulation	26	5.78
	A physical mixture of drug and excipients	15	3.33
	Not sure	44	9.78
Which polymorphic form generally has higher solubility?	Metastable polymorph	290	64.44
	Stable polymorph	75	16.67
	Same solubility	30	6.67
	Not sure	55	12.22
	X-ray powder diffraction (XRPD)	94	20.89

Which of the following analytical techniques commonly used to identify polymorphs?	Differential scanning calorimetry (DSC)	87	19.33
	Nuclear magnetic resonance (NMR)	115	25.56
	High-performance liquid chromatography (HPLC)	96	21.33
	Fourier-transform infrared spectroscopy (FTIR)	26	5.78
	Not sure	32	7.11
Polymorphic transitions can occur during which of the following manufacturing processes?	Milling	122	27.11
	Granulation	91	20.22
	Drying	66	14.67
	Compression	132	29.33
	Packaging	15	3.33
	Not sure	24	5.33

According Table (3), the statement "Ongoing professional training is necessary" achieved the highest agreement with a mean score of 4.63 (± 0.60) and 93.8% agreement. The next highest was "Polymorphism significantly affects stability and bioavailability" with a mean of 4.48 (± 0.72) and 88.7% agreement. "Understanding polymorphism is critical for regulatory compliance" followed with 4.42 (± 0.75) and 86.7% agreement. In contrast, "I am confident in identifying polymorphic forms" scored 3.36 (± 0.98) with only 48.4% agreement, while "My workplace has adequate analytical instruments" had a mean of 3.29 (± 1.06) and 45.6% agreement. "Communication among departments is effective" received a score of 3.41 (± 0.97) with 53.6% agreement. Lastly, "Workload limits attention to polymorphism" had a median score of 4 and a mean of 3.82 (± 0.91), reflecting a 67.6% agreement.

Table (3): Awareness and attitudes toward drug polymorphism (Likert Scale, n = 450)

Statement	**Mean ± SD**	**Median**	**Agree/Strongly Agree n (%)**
Polymorphism significantly affects stability and bioavailability	4.48 ± 0.72	5	399 (88.7)
Understanding polymorphism is critical for regulatory compliance	4.42 ± 0.75	4	390 (86.7)
I am confident in identifying polymorphic forms	3.36 ± 0.98	3	218 (48.4)
My workplace has adequate analytical instruments	3.29 ± 1.06	3	205 (45.6)
Ongoing professional training is necessary	4.63 ± 0.60	5	422 (93.8)
Communication among departments is effective	3.41 ± 0.97	3	241 (53.6)
Workload limits attention to polymorphism	3.82 ± 0.91	4	304 (67.6)

According to Table (4); (45.56%) of the participants occasionally encountered polymorphism-related issues in their work; (24.44%) rarely; (18.57%) frequently; (8.22%) never and in (3.11%) of the participants not applicable. Regarding the routinely applied steps to monitor polymorphs during drug development or manufacturing; (48.89 %) of the participants said it is the stability testing under different conditions; (61.33%) said it is documentation in batch records; (49.77%) said it is routine XRPD/DSC screening; (15.33%) said it is consultation of regulatory guidelines and (12.22%) said it is none of the above.

Table (4): Practices regarding drug polymorphism (n = 450)

Question	Response	No.	%
How often do you encounter polymorphism-related issues in your work?	Frequently	84	18.67
	Occasionally	205	45.56
	Rarely	110	24.44
	Never	37	8.22
	Not applicable	14	3.11
Which of the following steps do you routinely take to monitor polymorphs during drug development or manufacturing?	Stability testing under different conditions	220	48.89
	Documentation in batch records	276	61.33
	Routine XRPD/DSC screening	224	49.77
	Consultation of regulatory guidelines	69	15.33
	None of the above	55	12.22

According to Table (5); participants identified various challenges in managing drug polymorphism: 28.22% cited insufficient analytical tools, 31.55% mentioned inadequate instruction, 27.33% referred to time and workload limitations, 21.33% pointed to difficult regulations, 18.22% highlighted financial constraints, 15.56% noted insufficient interdisciplinary interaction, and 14.0% faced challenges in analytical data interpretation.

Table (5): Major Challenges in managing drug polymorphism (Open-ended responses categorized (n = 450)

Challenge	No.	%
Insufficient analytical tools	127	28.22
Inadequate instruction	142	31.55
Limitations on time and workload	123	27.33
Difficulty of regulations	96	21.33
Financial constraints	82	18.22
Insufficient interaction between disciplines	70	15.56
Analytical data interpretation challenges	63	14.0

According to Table (6); (68.89%) of the participants said that the suggested resource needed is practical training sessions; (31.56%) said it is the revised regulations ; (29.11%) said it is programs for online continuous learning; (26.22%) said it is the basic methods of operation and (26.67%) said it is professional counsel.

Table (6): Suggested resources needed (n = 450)

Suggested resource	No.	%
Practical training sessions	310	68.89
Revised regulations	142	31.56
Programs for online continuous learning	131	29.11
Basic methods of operation	118	26.22
Professional counsel	120	26.67

According to Table (7); (62.44%) of the participants suggested Frequent interdisciplinary gatherings for improving interdisciplinary communication about polymorphism; (53.33%) suggested common electronic records platforms; (45.77%) suggested training across departments; (37.78%) suggested common methods for communicating and (24.22%) suggested committed polymorphism groups.

Table (7): Suggestion for improving interdisciplinary communication about polymorphism (n = 450)

Suggestion	No.	%
Frequent interdisciplinary gatherings	147	32.67
Common electronic records platforms	183	40.67
Training across departments	205	45.56
Common methods for communicating	136	30.22
Committed polymorphism groups	109	24.22

Table (8) indicates that years of professional experience significantly enhance participants' awareness, knowledge, and engagement with drug polymorphism (all $P < 0.05$), particularly in terms of awareness and solubility knowledge. While educational level showed correlations with knowledge outcomes, it did not influence practical engagement or communication preferences. Professional roles affected awareness and knowledge, but communication methods remained unchanged. Formal training bolstered theoretical understanding of drug polymorphism, whereas practical application and awareness were primarily driven by professional experience, with education largely addressing theoretical content.

Table (8): Chi-square testing for correlations between outcome categories and demographic traits

Outcome Domain	Demographic Variable	χ^2	df	P value	Interpretation
Polymorphism knowledge	Experience	28.74	12	<0.001	S
	Education	18.95	9	0.026	S
	Professional role	30.62	15	0.010	S
	Formal training	13.98	6	0.030	S

Outcome Domain	Demographic Variable	χ^2	df	P value	Interpretation
Solubility knowledge	Experience	34.81	12	<0.001	S
	Education	24.63	9	0.003	S
	Professional role	28.27	15	0.020	S
	Formal training	17.11	6	0.009	S
Analytical techniques knowledge	Experience	31.26	12	0.002	S
	Education	21.87	9	0.009	S
	Professional role	14.42	15	0.494	NS
	Formal training	15.68	6	0.016	S
Polymorphism transitions knowledge	Experience	37.94	12	<0.001	S
	Education	23.56	9	0.005	S
	Professional role	29.35	15	0.015	S
	Formal training	18.46	6	0.005	S
How frequently polymorphism is taken into account in practice	Experience	24.51	12	0.017	S
	Education	11.23	9	0.260	NS
	Professional role	17.58	15	0.286	NS
	Formal training	5.96	6	0.428	NS
Polymorphism managing obstacles	Experience	29.63	12	0.003	S
	Education	20.52	9	0.015	S
	Professional role	27.84	15	0.023	S
	Formal training	7.43	6	0.283	NS
Resources needed	Experience	32.75	12	0.001	S
	Education	22.91	9	0.006	S

Outcome Domain	Demographic Variable	χ^2	df	P value	Interpretation
	Professional role	31.48	15	0.008	S
	Formal training	8.16	6	0.227	NS
Choices for communication platforms	Experience	8.92	12	0.709	NS
	Education	6.87	9	0.650	NS
	Professional role	12.51	15	0.639	NS
	Formal training	4.82	6	0.567	NS

Table (9) shows that professional experience correlates with several outcome domains like awareness of polymorphism (V = 0.31), knowledge of solubility (V = 0.28), and polymorphic transitions (V = 0.37). Moderate correlations exist for perceived barriers (V = 0.38) and necessary resources (V = 0.30), while the practice of considering polymorphism has a weaker association (V = 0.17). Awareness and solubility knowledge are somewhat linked to educational level (V = 0.33). Formal training correlates with awareness (V = 0.30) and solubility knowledge (V = 0.29), while professional roles correlate with awareness (V = 0.27) and solubility knowledge (V = 0.26). Communication platform choices appear unaffected by demographic factors.

Table (9): Chi-square test and Cramer's V strength of association between outcome domains and demographic features (n = 450)

Outcome Variable	Demographic Variable	χ^2	df	P value	Cramer's V	Strength
Polymorphism knowledge	Experience	43.25	12	<0.001	0.31	Moderate
	Education	48.69	9	<0.001	0.33	Moderate
	Professional role	39.45	15	0.001	0.27	Moderate
	Formal training	40.52	6	<0.001	0.30	Moderate
Solubility knowledge	Experience	35.38	12	<0.001	0.28	Moderate
	Education	48.67	9	<0.001	0.33	Moderate
	Professional role	36.61	15	0.002	0.26	Moderate
	Formal training	37.88	6	<0.001	0.29	Moderate
Analytical techniques knowledge	Experience	37.96	12	<0.001	0.29	Moderate
	Education	21.64	9	0.010	0.22	Small

Outcome Variable	Demographic Variable	χ^2	df	P value	Cramer's V	Strength
	Professional role	13.82	15	0.537	NS	NS
	Formal training	14.52	6	0.024	0.18	Small
Polymorphic transitions knowledge	Experience	61.81	12	<0.001	0.37	Moderate–Strong
	Education	12.99	9	0.163	0.17	Small
	Professional role	45.87	15	<0.001	0.29	Moderate
	Formal training	20.08	6	0.003	0.21	Small
Regularity of consideration	Experience	15.72	12	0.047	0.17	Small
	Education	9.36	9	0.405	NS	NS
	Professional role	14.11	15	0.519	NS	NS
	Formal training	6.54	6	0.366	NS	NS
Apparent obstacles	Experience	65.89	12	<0.001	0.38	Moderate–Strong
	Education	24.13	9	0.004	0.23	Small
	Professional role	34.12	15	0.004	0.25	Moderate
	Formal training	7.48	6	0.278	NS	NS
Resources	Experience	40.48	12	<0.001	0.30	Moderate
	Education	20.18	9	0.017	0.21	Small
	Professional role	28.91	15	0.017	0.23	Small
	Formal training	5.76	6	0.451	NS	NS
Preferences for communication	Experience	8.91	12	0.709	NS	NS

Outcome Variable	Demographic Variable	χ^2	df	P value	Cramer's V	Strength
	Education	7.16	9	0.620	NS	NS
	Professional role	11.48	15	0.720	NS	NS
	Formal training	4.28	6	0.638	NS	NS

Note: Pearson's chi-square test was used. Cramer's V values were interpreted as: <0.10 negligible, 0.10–0.29 small, 0.30–0.49 moderate, ≥0.50 strong.

Table (10) shows that professional experience is the primary demographic factor influencing the understanding and application of pharmacological polymorphism (Cramer's V = 0.38). Educational level has a minor effect on practice but significantly influences theoretical understanding (Cramer's V = 0.33). Formal training enhances knowledge in specific areas (Cramer's V = 0.30) but does not impact practice-related outcomes. Professional roles moderately influence understanding across five domains (Cramer's V = 0.29). Effective application of drug polymorphism concepts requires a mix of experience, education, and ongoing workplace learning.

Table (10): Overall chi-square overview of demographic factors' predictive power in all outcome domains (n = 450)

Demographic Variable	Significant Domains	Overall χ^2	df	P value	Strongest Cramer's V	Interpretation
Experience	7 of 8	286.54	84	<0.001	0.38	Strongest overall predictor
Education	6 of 8	176.38	63	<0.001	0.33	Important predictor of knowledge and awareness
Professional role	5 of 8	191.72	105	0.002	0.29	Moderate predictor
Formal training	4 of 8	118.64	42	<0.001	0.30	Improved knowledge but limited effect on practice

Note: Overall χ^2 values represent the cumulative evidence of association across all tested outcome domains. Statistical significance was defined as **P < 0.05**. Cramer's V values represent the strongest observed effect size for each demographic variable

DISCUSSION:

Only 40.4% of participants had formal academic training in drug polymorphism. The majority were formulation scientists and manufacturing professionals, with over half holding bachelor's degrees. These findings align with global research indicating that while pharmaceutical professionals generally possess appropriate educational qualifications, they often lack formal training in pharmacogenomics or pharmacological polymorphism following graduation. A systematic analysis of 12,430 pharmacists and pharmacy students from 26 countries highlighted a significant interest in pharmacogenomics, despite the absence of formal education and ongoing training **(Wondrasek et al., 2024).** Pharmacogenomic testing is generally viewed positively by potential users, but confusion exists concerning its application and interpretation. A study by **Just et al., (2017)** suggests that educational programs for teaching and training could enhance the consistent use of pharmacogenomics across Europe.

The study highlights significant gaps in understanding drug polymorphism among individuals involved in pharmaceutical development. Many participants mistakenly defined polymorphism as a change in chemical composition, failing to recognize that active pharmaceutical ingredients (API) exist in different crystalline forms. Although most acknowledged that metastable polymorphs can enhance solubility, their knowledge of relevant analytical techniques and production processes was inconsistent. Overall, the findings suggest a weak theoretical foundation in solid-state pharmaceutics among various

pharmaceutical experts, corroborating earlier studies that indicate better grasp of practical implications than crystallographic and physicochemical principles. Understanding the structural basis of polymorphism is often misunderstood, leading to formulation errors and stability issues, as noted by **Cruz-Cabeza et al., (2015). Byrn et al., (2017)** further emphasized that a lack of knowledge in solid-state chemistry poses challenges to effective drug development and quality control.

In the current study, medication polymorphism is viewed positively by pharmaceutical specialists, with 88.7% acknowledging its importance for drug stability and bioavailability, and 86.7% stressing the need for compliance with regulations. A strong majority, 93.8%, emphasized the necessity of ongoing professional training. However, interdepartmental communication (53.6%), access to analytical tools (45.6%), and confidence in identifying polymorphic forms (48.4%) received only moderate ratings. Additionally, over two-thirds indicated that their workload hindered their focus on polymorphism.

Stonier et al., (2020) emphasized that competency-based education and lifelong professional development are crucial for maintaining expertise in pharmaceutical medicine, especially as analytical technologies and regulatory standards advance. They found strong consensus on the need for continuous education to improve proficiency in quality assurance and drug development.

In the present study, only 18.7% of participants reported regular polymorphism-related issues at work, significantly lower than the 45.6% who experienced such problems. Primary monitoring techniques included regular XRPD/DSC screening (49.8%), stability testing (48.9%), and batch record documentation (61.3%), while only 15.3% followed regulatory standards. This indicates a disparity in the application of comprehensive monitoring techniques despite recognition of polymorphism's significance. The findings align with **Shi et al., (2022)**, emphasizing the need for regular polymorph characterization to ensure drug quality during production and processing and advocating for the inclusion of these analytical methods in quality control during pharmaceutical development.

The current study identified inadequate training (31.55%), lack of analytical tools (28.22%), and time/workload constraints (27.33%) as the primary obstacles to effective management of pharmacological polymorphism. Additional barriers include regulatory complexity, budget limitations, poor interdisciplinary communication, and challenges in interpreting analytical data. The findings emphasize that the challenges faced by pharmaceutical experts are largely organizational and pedagogical rather than purely technical. **Nagy et al., (2020)** found that pharmacists often report insufficient confidence and inadequate educational preparation when using specialized pharmaceutical principles in practice, underscoring the necessity for ongoing professional education.

Participants raised concerns about regulatory complexities and challenges in interpreting analytical data, aligning with previous reviews on pharmacogenetics and precision medicine. Implementation hurdles are attributed to diverse foreign laws, rapidly changing norms, and technical data complexities. Regulatory uncertainty, insufficient institutional support, and the absence of standardized methods hinder the integration of advanced pharmaceutical research into routine practice, as corroborated by **Chang et al., (2021).**

In our study, practical training sessions were the most sought resource in the current survey (68.89%), followed by standard operating procedures (26.22%), online continuous learning programs (29.11%), professional counselling (26.67%), and amended rules (31.56%). These results showed that participants value competency-based, hands-on learning over theoretical training alone, indicating a perceived disconnect between academic knowledge and practical application in the workplace. The present results are also in line with pharmacogenomics surveys of chemists and medical professionals. According to **Benzeroual et al., (2012)** undergraduate education alone was insufficient to build confidence in implementing genetic information in practice; hence the majority of chemists expressed interest in continuing education and certificate-based programs.

The current study recommends enhancing interdisciplinary communication about drug polymorphism primarily through departmental training (45.56%), followed by shared electronic record platforms (40.67%), regular interdisciplinary meetings (32.67%), standardized communication techniques (30.22%), and specialized polymorphism working groups (24.22%). These findings highlight the importance of organized collaboration among formulation scientists, quality assurance staff, regulatory affairs experts, and manufacturing teams to address solid-state pharmaceutical issues. The universal definition of skills aids national surveys in identifying training and education gaps, allowing for comparisons across different labour markets and cultural backgrounds. To enhance competence levels for experts in pharmaceutical medicine and drug development, standardized assessments can provide opportunities for improvement **(Imamura et al., 2019).**

Jafari et al., (2024) emphasized reproducible documentation and information exchange while discussing the significance of standardised electronic systems and high-quality electronic health record data for clinical pharmacology and medication-related studies

The present study indicated that educational level strongly correlates with theoretical knowledge, while professional experience is linked to various knowledge and practice areas regarding drug polymorphism. Formal training tends to focus on theoretical aspects rather than practical application, while professional roles significantly influence several knowledge categories, excluding communication preferences. The findings suggest that combining academic education with real-world experience effectively enhances expertise in pharmacological polymorphism.

The study emphasizes the crucial role of professional experience in enhancing pharmaceutical proficiency, decision-making and scientific information usage. It supports earlier findings by **Stonier et al., (2020)**, indicating that competency in pharmaceutical medicine arises from a blend of structured education and practical experience in areas such as drug development and regulatory science, underscoring the necessity of workplace exposure to apply theoretical knowledge.

The current study's substantial correlation between educational attainment and knowledge outcomes is also in line with current educational studies. Higher educational attainment is linked to greater competency in research methodologies, statistics, and professional practice, according to a global assessment of pharmacoepidemiology training programs; however, there are still curriculum gaps in communication and practical skills **(Goodin et al., 2026)**.

Professional experience is the best predictor of knowledge and practice about drug polymorphism in this study, according to Cramer's V analysis (V = 0.37). Demographic characteristics did not link with communication options, however formal training had smaller effects on theoretical knowledge (V = 0.30) and professional role and educational level exhibited modest effects. In general, professional experience plays a major role in the practical use of drug polymorphism in pharmacology, whereas formal education helps to improve theoretical comprehension.

The study by **Sullivan et al., (2023)** highlights that networking, education, training, and professional development are key interests for pharmacy professionals. However, obstacles such as time and financial constraints, along with unclear benefits of organizational membership, hinder participation. To enhance job satisfaction, it is crucial to achieve professional recognition for pharmacists. Efforts to increase awareness of pharmacists' vital roles in healthcare, including public awareness campaigns **(Chereches et al., 2024)**, are recommended to ensure their contributions are acknowledged and rewarded.

CONCLUSION:

This study highlights inconsistencies in pharmaceutical professionals' knowledge and practices regarding drug polymorphism, despite recognizing the importance of continued education. Key knowledge gaps were identified, and practical monitoring of polymorphism was hindered by resource and expertise shortages. Professional experience emerged as the strongest predictor of engagement with polymorphism issues, indicating a need for enhanced theoretical knowledge and hands-on experience. To improve management of drug polymorphism, better training, laboratory resources, and specialized access are crucial.

Study limitations

The study's cross-sectional design limits the ability to determine causal links between pharmaceutical professionals' knowledge or behaviors and demographic factors. Self-reported questionnaires may introduce recall and social desirability biases, focusing on perceived rather than objective competency measures. The geographic specificity of participant selection restricts the generalizability of results to other healthcare systems. Despite finding statistically significant correlations, unmeasured variables, such as job responsibilities and institutional policies, could lead to residual confounding in knowledge and practice outcomes.

Study strengths

The investigation, with a robust sample size of 450, utilized participants from various pharmaceutical backgrounds, including formulation scientists and quality assurance specialists, to ensure statistical power. It employed chi-square analysis to assess knowledge, attitudes, and perceived barriers related to pharmacological polymorphism. Key findings indicated that professional experience, educational attainment, and formal training significantly influence these factors, providing valuable insights for workforce education and policy development.

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