

## Original Research Article

# Health Care Professionals' Knowledge of the Pharmacogenetics of Analgesics Used for Pain Management in Cameroon: A Cross-Sectional Knowledge, Attitudes, and Practices Study

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**Abstract: Background:** Pharmacogenetic variability in drug-metabolizing enzymes influences individual response to analgesics, affecting both efficacy and adverse-effect risk. Health care workers' knowledge of this variability is central to safe, individualized pain management. This study assessed their knowledge, attitudes, and practices regarding analgesic pharmacogenetics, with emphasis on knowledge relevant to individualized pain management. **Methods:** Descriptive cross-sectional study among 112 health care workers using a self-administered, bilingual (French/English) questionnaire. A nine-item objective knowledge score was built; attitudes and practices were rated on four-point scales. Associations were tested with the Kruskal-Wallis test, the Mann-Whitney U test, and Spearman correlation. **Results:** Mean knowledge score was  $5.0 \pm 1.2/9$ , moderate in 57.1% of participants and good in only 8.9%. While 93.8% recognized a link between pharmacogenetics and analgesic efficacy, only 8.9% identified the four metabolizer phenotypes and 27.7% understood that identical dosing may be inappropriate across patients. Knowledge score differed by qualification ( $p=0.027$ ) and was strongly associated with prior awareness ( $p<0.001$ ). Attitudes were favorable to neutral in 93.8% of respondents, while practice scores remained low in 60.7%. **Conclusion:** Health care workers understand the principle of pharmacogenetics but not its practical application (metabolizer phenotypes, dose adjustment), limiting the safety of pain management. Targeted training is needed.

**Keywords:** Pharmacogenetics, Analgesia, Knowledge, Attitudes and Practices, Personalized Medicine.

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## INTRODUCTION

Pain is one of the most common reasons for consultation, both in hospitals and in pharmacies, and prescribing analgesics is a daily task for many health care workers. The WHO analgesic ladder guides the escalation of therapy across three steps, from non-opioid analgesics to opioids, according to pain intensity [1]. This approach assumes a relatively uniform response to a given dose, an assumption increasingly challenged by pharmacogenetics, which studies the influence of inherited genetic variation — particularly in drug-metabolizing enzymes such as the cytochrome P450 (CYP) family — on individual response to medications

[2]. For analgesics, polymorphisms in genes such as CYP2D6, CYP3A4, OPRM1, and COMT can produce markedly different metabolic phenotypes — poor, intermediate, normal, or ultrarapid — with clinical consequences ranging from inadequate analgesia to drug accumulation, or even life-threatening toxicity, at standard doses [2,3]. A single fixed dose may therefore be appropriate for some patients, sub-therapeutic for others, and toxic for others still, depending on their metabolic phenotype [3].

Translating this evidence into practice assumes that health care workers understand not only that this

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variability exists, but above all how metabolizer phenotypes influence dosing. Several KAP surveys conducted in sub-Saharan Africa suggest that this operational understanding is often lacking, despite general awareness: in Zambia, objective knowledge of pharmacogenetics was low among 304 health care professionals (38%) [4]. In Zimbabwe, 56% of pharmacists and pharmacy students had fair-to-good knowledge, yet 88% scored at or below average on more practical, objective questions, even though they considered themselves competent in pharmacogenetics — reflecting a "knowledge-confidence paradox" [5]. In Nigeria, community pharmacists showed overall moderate knowledge (64%), with gaps regarding drugs requiring pharmacogenomic testing [6]. Furthermore, little data specifically address health care workers' knowledge of analgesic pharmacogenetics, even though this is precisely one of the contexts in which such knowledge most directly affects practice. To optimize pain management by health care providers, this study analyzed their knowledge, attitudes, and practices, with specific attention to the operational knowledge essential for personalizing treatment.

## MATERIALS AND METHODS

### Study Design and Population

This was a descriptive cross-sectional study conducted in pharmacies and general hospitals in Yaoundé and Douala. The study population comprised health care workers involved in prescribing or administering analgesics: interns, residents, general practitioners, specialists (predominantly in anesthesiology and intensive care), and pharmacists. A consecutive sampling method was used, including qualified professionals currently in post or in specialty training in medicine or pharmacy. A total of 112 valid questionnaires were analyzed.

### Data Collection Instrument

Data were collected using a structured, self-administered, bilingual (French/English) questionnaire, distributed via Google Forms. The questionnaire comprised 39 items across four sections: (i) sociodemographic and professional characteristics; (ii) knowledge of pharmacogenetics and its application to analgesics (9 items scored correct/incorrect); (iii) attitudes toward pharmacogenetic testing and individualized analgesic dosing (8 items on a four-point scale from "against" to "totally agree"); and (iv) self-reported practices related to analgesic use and the integration of genetic information (8 items on a four-point frequency scale from "never" to "always"), together with a free-text comment field.

### Scoring

#### Knowledge Score

Nine items were scored 1 point for a correct response and 0 for an incorrect or "don't know" response, for a maximum of 9 points: the definition of pharmacogenetics; the definition of an analgesic; the

number of steps in the WHO analgesic ladder (three) (1); recognition that identical dosing for the same diagnosis in the same patient group can be simultaneously toxic, beneficial, or non-beneficial depending on the individual; the number of metabolizer phenotypes (four: poor, intermediate, normal, and ultrarapid) (7); correct identification of all four metabolizer types; recognition of a link between pharmacogenetics and analgesic efficacy; the ability to name a gene involved in pharmacogenetics; and knowledge that pharmacogenetic testing is performed on genetic material. Scores were expressed as a percentage and categorized as poor (<50%), moderate (50-75%), and good (>75%) knowledge.

#### Attitude Score

Seven items rated on a four-point scale (against=1, indifferent=2, agree=3, totally agree=4) were summed (range 7-28) and categorized as unfavorable (<50%), neutral/moderate (50-75%), and favorable (>75%).

#### Practice Score

Six frequency items (never=1, once in the training program/semester=2, monthly=3, always=4) and two binary items (having personally undergone pharmacogenetic testing; habitually reading drug package inserts for pharmacogenetic information) were summed and categorized as poor (<50%), moderate (50-75%), and good (>75%).

### Statistical Analysis

Data were analyzed using Python (pandas, SciPy). Categorical variables were presented as frequencies and percentages, and continuous variables as means  $\pm$  standard deviation or medians. Associations between knowledge, attitude, and practice scores and professional characteristics were assessed using the Kruskal-Wallis test and the Mann-Whitney test. Associations with age and years of professional experience were assessed using Spearman's rank correlation. Correlations among the three KAP domains were also assessed using Spearman's correlation. A significance threshold of  $p < 0.05$  was used.

## RESULTS

### Sociodemographic and Professional Characteristics

Of the 112 participants, 66 (58.9%) were male, with a mean age of  $34.4 \pm 7.6$  years (range 24-73). Mean professional experience was  $6.0 \pm 5.6$  years (median 5 years). Participants were predominantly residents (49.1%), followed by specialists (27.7%), general practitioners (17.0%), and pharmacists (4.5%), among whom 55.4% practiced in anesthesiology and intensive care. Half of the participants were already aware of pharmacogenetics before completing the questionnaire, most often through scientific literature (44.6% of cases), postdoctoral training (28.6%), or predoctoral training (25.0%). These data are presented in Table I.

**Table I: Sociodemographic and professional characteristics of participants (n=112)**

| Characteristic                                          | n                      | %    |
|---------------------------------------------------------|------------------------|------|
| Sex — Male                                              | 66                     | 58.9 |
| Sex — Female                                            | 46                     | 41.1 |
| Age, years — mean $\pm$ SD (range)                      | 34.4 $\pm$ 7.6 (24-73) |      |
| Qualification — Resident                                | 55                     | 49.1 |
| Qualification — Specialist                              | 31                     | 27.7 |
| Qualification — General practitioner                    | 19                     | 17.0 |
| Qualification — Pharmacist                              | 5                      | 4.5  |
| Qualification — Intern in anesthesiology/intensive care | 2                      | 1.8  |
| Specialty in anesthesiology/intensive care              | 62                     | 55.4 |
| Years of practice — mean $\pm$ SD (median)              | 6.0 $\pm$ 5.6 (5)      |      |
| Prior awareness of pharmacogenetics                     | 56                     | 50.0 |

### Knowledge of Analgesic Pharmacogenetics

The mean knowledge score was  $5.0 \pm 1.2$  out of 9. Knowledge was moderate in 57.1% of participants, poor in 33.9%, and good in only 8.9%.

The item-by-item analysis in Table II showed a contrasting pattern: items of theoretical knowledge were well known by a majority of participants — a link between pharmacogenetics and analgesic efficacy was recognized by 93.8%, the correct definition of pharmacogenetics was given by 83.9%, the three-step WHO analgesic ladder was correctly identified by 89.3%, and 76.8% knew that pharmacogenetic testing is

performed on genetic material. By contrast, items of operational knowledge, directly useful for individualizing analgesia, were less well mastered. Indeed, only 27.7% knew that an identical analgesic dose could be simultaneously toxic, beneficial, or non-beneficial depending on the patient's metabolic profile. Furthermore, only 8.9% identified the exact number of metabolizer phenotypes, and only 8.0% could name all four phenotypes (poor, intermediate, normal, and ultrarapid metabolizers). Moreover, only 10.7% of participants could cite a specific gene involved in pharmacogenetics, of whom CYP2D6 was the most frequently cited (4/12 responses).

**Table II: Knowledge items regarding analgesic pharmacogenetics (n=112)**

| Knowledge item                                         | % Correct             | Domain      |
|--------------------------------------------------------|-----------------------|-------------|
| Definition of an analgesic                             | 100.0                 | Conceptual  |
| Link between pharmacogenetics and analgesic efficacy   | 93.8                  | Conceptual  |
| Number of steps in the WHO analgesic ladder (three)    | 89.3                  | Conceptual  |
| Definition of pharmacogenetics                         | 83.9                  | Conceptual  |
| Pharmacogenetic test performed on genetic material     | 76.8                  | Conceptual  |
| Recognition that identical dosing may be inappropriate | 27.7                  | Operational |
| Ability to name a gene involved in pharmacogenetics    | 10.7                  | Operational |
| Citing the exact number of metabolizer phenotypes      | 8.9                   | Operational |
| Correct identification of all four metabolizer types   | 8.0                   | Operational |
| Overall knowledge score (mean $\pm$ SD / 9)            | 5.0 $\pm$ 1.2 (55.5%) |             |

Knowledge level varied significantly by professional qualification (Kruskal-Wallis  $H=10.97$ ,  $p=0.027$ ): pharmacists (mean 5.4/9) and specialists (5.2/9) scored higher than general practitioners (4.3/9). Furthermore, prior awareness of pharmacogenetics was strongly associated with a higher score (mean 5.41 vs 4.57 among those unaware,  $p<0.001$ ). No significant difference was found by specialty in anesthesiology/intensive care ( $p=0.785$ ), age ( $p=0.057$ ), or years of professional experience ( $p=0.110$ ).

### Attitudes Toward Pharmacogenetic Testing and Individualized Dosing

The mean attitude score was  $22.7 \pm 3.4$  out of 28. Attitudes were favorable in 47.3% of participants and neutral-to-moderate in 46.4%; only 6.2% expressed an unfavorable attitude. A large majority of participants agreed that personalized medicine is achievable through

pharmacogenetics (95.5%), that it plays a key role in optimizing analgesic response (95.5%) and reducing adverse effects (93.8%), and that linking it with pharmacovigilance would benefit patients (94.6%). Placed in the position of patients, 81.2% would agree to undergo genetic testing to determine an appropriate initial analgesic dose, with a preference for saliva sampling (45.9%) or blood sampling (30.3%) — two matrices whose reliability for genotyping is well established (9). Nevertheless, 52.7% feared potential ethical or discriminatory drift. Among the minority opposed to personal testing ( $n=6$ ), the reasons cited included cost, the time needed to obtain results, the number of drugs concerned, and the multifactorial nature of pain. In contrast to professional profile and seniority ( $p=0.093$ ), only prior awareness of pharmacogenetics significantly increased the attitude score ( $p=0.022$ ).

### Practices Related to Analgesic use and Genetic Information

Practice related to pharmacogenetics remained limited: 60.7% of participants had a low score, 36.6% a moderate score, and 2.7% a good score. Despite very frequent use of analgesics (97.3%) and regular monitoring of adverse effects (91.1%), the integration of pharmacogenetics into daily practice remained low. Indeed, 51.8% of respondents never linked genetic variation to drug adverse effects, 85.7% had never attended a dedicated conference, and 54.5% never updated their knowledge of pharmacogenetics. Only two participants (1.8%) had ever personally undergone a pharmacogenetic test. Practice score differed significantly by professional profile ( $p=0.015$ ), being

significantly higher among specialists in anesthesiology/intensive care than among other professionals (15.2 vs 14.1,  $p=0.043$ ).

### Correlations Between Knowledge, Attitudes, and Practices

The analysis showed a strong correlation between knowledge, attitudes, and practices (knowledge-attitude:  $\rho=0.324$ ,  $p<0.001$ ; knowledge-practice:  $\rho=0.317$ ,  $p<0.001$ ; attitude-practice:  $\rho=0.237$ ,  $p=0.012$ ). This indicates that mastery of the operational concepts of analgesic pharmacogenetics is strongly linked to more favorable attitudes and to a more systematic integration of this discipline into daily clinical practice (Table III).

**Table III: Spearman correlations between knowledge, attitude, and practice scores**

| Domain pair          | $\rho$ (rho) | p-value |
|----------------------|--------------|---------|
| Knowledge – Attitude | 0.324        | <0.001* |
| Knowledge – Practice | 0.317        | <0.001* |
| Attitude – Practice  | 0.237        | 0.012*  |

## DISCUSSION

This study specifically addressed pharmacogenetics as applied to analgesia, from both a conceptual and an operational standpoint, among health care professionals involved in pain management. The central finding is a marked dissociation between the two: while the large majority of health care workers correctly recognized that pharmacogenetics influences analgesic efficacy (93.8%), fewer than one in ten could identify the metabolizer phenotypes that make this influence clinically actionable (8.9%), and only about a quarter (27.7%) challenged the assumption of a universal dosing regimen. This pattern, characterized by broad conceptual awareness without operational understanding, has direct implications for pain management. Indeed, it is precisely the recognition of metabolizer phenotypes that would allow a prescriber to anticipate under-dosing (in ultrarapid metabolizers, with a risk of inadequate analgesia) or overdosing (in poor metabolizers, with a risk of toxicity) [2,3], in accordance with the recommendations of the Clinical Pharmacogenetics Implementation Consortium (CPIC) [8].

The overall knowledge score obtained in our study (55.5%, corresponding to a moderate level in 57.1% of participants) is consistent with findings from several African studies: it is comparable to the low level of pharmacogenetics knowledge (38%) reported among 304 health care professionals in Zambia [4], and close to the moderate level reported among community pharmacists in northern Nigeria (64%) [6], as well as the fair-to-good level reported among pharmacists and pharmacy students in Zimbabwe (56%) [5]. As in the observations made in Zimbabwe, where a "knowledge-confidence paradox" was described [5], our participants combined largely favorable attitudes (93.8% favorable or neutral) with an objectively uneven operational

knowledge base. This discrepancy shows that an enthusiastic perception of pharmacogenetics does not guarantee the ability to apply it safely in analgesic prescribing. Accordingly, the development of locally adapted decision-support tools, reinforced by exposure to clinical scenarios — for example through simulation exercises — appears essential, in addition to theoretical teaching alone.

Consistent with prior KAP surveys conducted in the region [4-6], knowledge varied significantly by professional qualification, with pharmacists and specialists outperforming general practitioners, and was closely related to prior exposure to the subject. This finding reinforces the idea that targeted training is the main determinant of operational knowledge in this field. Although the cross-sectional design of the study does not allow a causal relationship to be established, the strong positive correlation between knowledge, attitude, and practice suggests that strengthening theoretical training could improve the operational implementation of pharmacogenetics.

Furthermore, the low practice scores reflect the near-absence of personal or institutional experience with pharmacogenetic testing (1.8% and 8.9%, respectively). This most likely reflects the limited availability of pharmacogenetic testing infrastructure in this setting [10], rather than reluctance on the part of health care providers. Indeed, 81.2% of participants indicated that they would personally accept genetic testing to guide their own analgesic dosing, using a saliva or blood sample — a proportion comparable to or higher than the willingness observed among Nigerian pharmacists after training [6-10]. Nevertheless, concerns about ethical issues or discrimination, expressed by just over half of participants (52.7%), echo the substantial concern about the misuse of genomic data reported among Zimbabwean

pharmacists [5]. These ethical considerations will need to be taken into account in any future training initiative.

Overall, these findings suggest that efforts to integrate pharmacogenetics into pain management in this setting should prioritize applied teaching focused directly on dose adjustment. Training should primarily target the characterization of metabolizer phenotypes and their implications for individualizing doses, rather than general awareness-raising, which already appears largely achieved [11]. This is also emphasized in the conclusion of a study conducted in Mali among pharmacists and pharmacy students, on the need to strengthen pharmacogenetics teaching in university training curricula [12].

### Limitations

This study has several methodological limitations. First, the consecutive sampling limited to Yaoundé and Douala does not allow the findings to be generalized nationwide. Second, self-reported knowledge and practices are subject to social desirability and recall bias. Third, some subgroups (interns, n=2; pharmacists, n=5) were of limited size, affecting the robustness of comparative analysis. Finally, the cross-sectional design does not allow causal or temporal inference between knowledge, attitudes, and practices.

Beyond these constraints, the strong engagement of health care providers and their receptiveness to personalized medicine constitute a major asset. By providing pioneering data in the Cameroonian context, this work offers a favorable outlook for the deployment of personalized pain management, provided it is supported by appropriate training.

### CONCLUSION

This study reveals broad conceptual endorsement, among health care providers, of the impact of pharmacogenetics in the use of certain analgesics, contrasting with a clear deficit in the operational competencies needed to deliver safer and more effective analgesic treatment. However, the strong personal and professional acceptability of testing shows that the lack of practice stems more from logistical constraints than from a lack of willingness. To close the gap between knowledge and practice in this setting, training centered on analgesic dosing and phenotypic response is recommended, within both initial and continuing education curricula.

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### Author Contributions

MMJA, KNYL, and SSS contributed to the study's conception, data collection, analysis, manuscript drafting, critical revision, and approval of the final version. KEJ and TR contributed to data collection. PS and MEB contributed to data analysis and manuscript

drafting. ZMJ contributed to critical revision and approval of the final version. All authors read and approved the final manuscript.

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