

Pharmacological Insight Among Medical Students and Implications for Practice Ethics

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ABSTRACT

This cross-sectional quantitative study aims to analyse the level of pharmacological knowledge among medical students and to examine its association with reduced potential violations in medical practice. The study involved 105 active students from the Medical Education Study Program at Universitas Muhammadiyah Prof. Dr HAMKA (UHAMKA) and used a Likert-scale questionnaire. Data were analysed using descriptive statistics and simple linear regression. The results show a statistically significant moderate association between pharmacological knowledge and the reduction of potential violations. These findings suggest that pharmacological knowledge is related to safer self-reported practices among medical students. Nevertheless, this study has several limitations, including reliance on self-reported data, a single-institution sample, and the lack of a fully validated instrument to measure potential violations. Therefore, the results reflect statistical association rather than causation. Future studies are recommended to use larger, multicentre samples, validated measurement tools, and more robust analytical approaches to understand better the relationship between pharmacological knowledge and safe medical practice.

Keywords: Knowledge, Students, Pharmacology, Violations, Medicine

INTRODUCTION

Medical education requires an in-depth understanding of drug pharmacological mechanisms to ensure safe and effective medical practice. Pharmacological knowledge is essential for evidence-based therapeutic decision-making, preventing medication errors, and optimising patient treatment outcomes (Kim et al., 2020; Fasinu & Wilborn, 2024).

In the context of the integrated modern medical curriculum in colleges, the understanding of pharmacology includes not only the molecular action of drugs and their interactions with the human body, but also clinical applications to avoid harmful side associations as well as support rational prescribing, as emphasised in various health education studies (Crowley et al., 2025; Mengesha et al., 2025).

In-depth pharmacological knowledge in medical education includes pharmacokinetics (the process of drug absorption, distribution, metabolism, and excretion), pharmacodynamics (the mechanism of action of drugs on biological targets), drug interactions (synergistic or antagonistic potentials between drugs), and side associations (including toxicity and adverse reactions), which collectively form the basis of rational clinical decision-making in medical colleges to ensure safe and effective therapies (Theobald & Blumer, 2023; Niu et al., 2019; Bereda, 2023).

This comprehensive understanding allows students to integrate pharmacological data with clinical cases, reduce prescribing errors, and improve patient outcomes through an evidence-based approach (Sandritter et al., 2017). In contemporary medical curricula, the teaching of these elements through integrative and problem-based methods is increasingly emphasised to develop students' clinical competencies (Aryani et al., 2025).

In Indonesia, the lack of understanding of pharmacology among health workers has the potential to trigger violations of medical practices such as malpractice due to medication administration errors, which often occur in the prescribing phase with an error rate of up to



9.5% due to lack of knowledge, excessive workload, and lack of supporting electronic systems (Sugiarti et al., 2015; Pramesona et al., 2025).

Study Amalia and Basabih (2023) shows that factors such as staffing shortages, distractions, and a lack of understanding of drug interactions contribute to medication error incidents in Indonesian hospitals, which can lead to malpractice lawsuits and jeopardise patient safety. For this reason, preventive efforts through pharmacology training and digital reporting systems are needed to reduce this risk, as recommended in recent research on patient safety cultures in developing countries, including Indonesia.

The prevalence of medical errors in Indonesia is often attributed to a lack of understanding of pharmacology, including improper administration of drugs, causing overdoses or harmful interactions (Arundina & Widyaningrum, 2020; Shufyani et al., 2025). For this reason, medical students as prospective doctors must master the mechanism of drugs to prevent cases such as mis-prescribing anti-tuberculosis or NSAIDs that lead to criminal prosecution. The data indicate that medical students' knowledge of generic medicines and side associations remains variable, with most classified as adequate to good but vulnerable in the area of interaction (Nurjanah et al., 2024; Gunawan & Johan, 2025).

The main problem is medical students' limited understanding of drug pharmacology, which correlates with an increased risk of violations of medical practice, such as criminal negligence under Law No. 29 of 2004 (Simatupang et al., 2020). Examples of cases include dispensing errors or administration errors that cause the patient to go into a coma due to the wrong medication. This is exacerbated by the lack of integration of pharmacological theory with clinical practice during education (Musharyanti et al., 2019).

Although students' pharmacology knowledge is well assessed in pharmacokinetic aspects, gaps remain in their understanding of NSAIDs, antituberculosis doses, interactions, and side effects, with some responses still insufficient (Putra & Hidayatullah, 2022). However, in Indonesia, few studies directly link this gap to potential medical violations, whereas the global literature emphasises medication errors.

Previous research has consistently examined medical students' knowledge of pharmacology and its relationship to the risk of misconduct in medical practice. Sari and Johan (2025) measure the understanding of medical students of Tarumanagara University about pharmacokinetics, pharmacodynamics, doses, regimens, side associations, anti-tuberculosis drug interactions, and multidrug resistance; results show that the majority of knowledge is good except for adequate doses/preparations, which is relevant to the risk of TB treatment errors. Kuswinarti et al. (2022) assessed the understanding (62.8% good) and rationality (67.9% rational) of self-medication among Padjajaran University students, highlighting the need for education to prevent new problems arising from irrational drug use that could violate practice guidelines. Bullock and Leversha (2019) analyse the knowledge perceptions of early- and final-year medical students regarding drug action, side effects, pharmacokinetics, and interactions; they find significant differences in ADRs and drug action, related to confidence in patient management and error prevention. Kalfsvel et al. (2022) identified prescription errors among final-year students, particularly inadequate information and pediatric cases; they recommend case-based CPT education to reduce prescribing errors that could lead to practice violations. Warholak et al. (2011) compare the ability of medical, pharmacy, and nursing students to identify prescription errors (e.g., incorrect dosages, drug interactions). Medical students perform suboptimally, underscoring the need for enhanced pharmacological education to prevent prescribing errors.

Previous research has predominantly discussed a systematic literature review on the low pharmacology knowledge of Indonesian medical students related to pharmacokinetics, doses, drug interactions, and side effects (especially NSAIDs/antituberculosis), which correlates with the risk of medication error. There has been no comprehensive study of the mechanisms of commonly used drugs and the implications of criminal malpractice for medical students. This gap is primarily evident in Indonesian education, where the integration of the pharmacology-clinics curriculum is weak.

This research is significant because it addresses a gap by measuring knowledge and risk factors associated with violations of the Medical Practice Law and, through curriculum recommendations, contributes to reducing malpractice and supporting safe medical education policies. The purpose of this study is to analyse the level of pharmacological knowledge among medical students and to examine its association with the reduction of potential violations in medical practice.

METHODS

This study employed a quantitative, descriptive design using a cross-sectional survey. Data were collected at a single point in time to examine the association between pharmacological knowledge and the reduction of potential violations in medical practice. According to Creswell and Creswell (2018), descriptive quantitative research with a cross-sectional survey design collects numerical data at a single point in time from a sample to accurately describe the attitudes, behaviours, or characteristics of a population, through a statistically analysed questionnaire.

The population consisted of all active medical students enrolled in the Medical Education Study Program at Universitas Muhammadiyah Prof. Dr HAMKA (UHAMKA). The sample was selected using purposive sampling based on the inclusion criterion of active student status during the data collection period. A total of 105 students participated in this study, representing a predominantly preclinical population.

Data were collected using a structured self-administered questionnaire with a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The instrument was developed to measure two variables: pharmacological knowledge (independent variable) and ethical and safe practice awareness (dependent variable).

The pharmacological knowledge variable consisted of 12 items based on six indicators: pharmacokinetics, pharmacodynamics, dosage and regimen, adverse drug reactions, drug interactions, and clinical application. Example items included: "I understand the processes of drug absorption, distribution, metabolism, and excretion" and "I can identify potential harmful drug interactions."

The ethical and safe practice awareness variable consisted of 10 items derived from five indicators: patient safety, medical ethics, error prevention, clinical decision-making, and professional responsibility. Example items included: "I consider patient safety when selecting medications" and "I evaluate treatment decisions that may pose risks to patients."

Prior to data collection, the instrument underwent validity and reliability testing. Item validity was assessed using Pearson Product-Moment correlation; all items demonstrated correlation coefficients ranging from 0.412 to 0.781, exceeding the critical value ($r\text{-table} = 0.191$, $n = 105$, $\alpha = 0.05$), indicating that all items were valid. Reliability was evaluated using Cronbach's Alpha, yielding values of 0.872 for pharmacological knowledge and 0.854 for ethical and safe practice awareness, both exceeding the acceptable threshold of 0.70 and indicating high internal consistency.

Data were analysed using descriptive statistics to summarise the distributions of variables, followed by simple linear regression in SPSS version 25 to examine the association between pharmacological knowledge and awareness of ethical and safe practice. The regression model used was $Y = a + bX$, where the coefficient of determination (R^2) indicates the proportion of variance explained, and statistical significance was assessed using a t-test and an F-test at the $p < 0.05$ level.

The study hypotheses were formulated as follows:

- H0: There is no significant association between pharmacological knowledge and reduced potential violations in medical practice among medical students ($\beta = 0$, $p \geq 0.05$).
- H1: There is a significant positive association between pharmacological knowledge and reduced potential violations in medical practice among medical students ($\beta > 0$, $p < 0.05$).

RESULTS AND DISCUSSION

The following table describes the characteristics of medical student respondents by gender and age.

Table 1. Distribution of Respondent Characteristics

Characteristic	Category	Frequency	Percentage (%)
Gender	Man	42	40.0
	Woman	63	60.0
Age	17-18 years old	32	30.5
	19-20 years old	52	49.5
	21 years old	21	20.0

The study involved 105 medical students, consisting of 63 (60.0%) females and 42 (40.0%) males. The majority of respondents were aged 19–20 years (49.5%), followed by 17–18 years (30.5%) and 21 years (20.0%). This distribution reflects a predominantly preclinical student population with relatively limited clinical exposure; therefore, the findings should be interpreted within the context of early-stage medical education.

Table 2. Knowledge Level

Category	Frequency	Percentage (%)
Low (1-2)	13	12.4
Medium (3)	45	42.9
Height (4-5)	47	44.8

The results indicate that 44.8% of students have high pharmacological knowledge, 42.9% moderate, and 12.4% low. Although the proportion of high knowledge appears substantial, more than half of the respondents fall into the moderate-to-low categories, suggesting that a considerable proportion of students may still have limitations in understanding pharmacological mechanisms. However, these findings should be interpreted cautiously, as the data were obtained from self-reported questionnaires, which may not fully reflect actual competence.

Table 3. Reduction of Potential Violations

Category	Frequency	Percentage (%)
Low (1-2)	13	12.4
Medium (3)	45	42.9
Height (4-5)	47	44.8

The distribution of awareness of ethical and safe practices shows that 44.8% of students are in the high category, 42.9% in the moderate category, and 12.4% in the low category. An identical distribution with pharmacological knowledge may indicate potential overlap in measurement constructs or similarity among questionnaire items. Therefore, this variable should be interpreted cautiously, as it is based on self-reported data and may not fully represent actual clinical behaviour.

Table 4. Model Summary

Type	R	R Square	Adjusted R-Square	Std. Error of the Estimate
1	.620 ^a	.384	.378	.833

^a Predictors: (Constant), Level of Pharmacological Knowledge (X)

^b Dependent Variable: Reduction of Potential Violations (Y)

The results of the linear regression analysis showed a moderate positive association between pharmacological knowledge and the reduction of potential violations ($R = 0.620$, $p < 0.001$). The coefficient of determination ($R^2 = 0.384$) indicates that approximately 38.4% of the variance in the dependent variable can be explained by pharmacological knowledge. In comparison, the remaining 61.6% may be associated with other factors not included in this model, such as ethical training, clinical exposure, and student motivation.

Table 3. Coefficients

Type	Unstandardized Coefficients	Standardized Coefficients			
	B	Std. Error	Beta	t	Sig.
1 (Constant)	1.045	.172		6.072	.000
Level of Pharmacology Knowledge (X)	.712	.089	.620	7.984	.000

^a Dependent Variable: Reduction of Potential Violations (Y)

The results of the simple linear regression analysis showed that the level of medical students' knowledge of the pharmacological mechanisms of medications (X) was significantly associated with the reduced potential for violations of medical practice (Y). Based on the Coefficients table, a coefficient of 1.045 with a significance level (Sig.) of 0.000 was obtained, indicating that the regression model is suitable for analysis because its significance is well below the 0.05 threshold.

The regression coefficient $B = 0.712$ indicates that a one-unit increase in the student's knowledge level is associated with a 0.712-unit rise in the score for reducing the potential for violations of medical practice. The positive coefficient indicates a one-way relationship: the higher a student's knowledge of the pharmacological mechanisms of medicine, the greater their ability to prevent violations of medical practice. The regression equation obtained in this study is:

$$Y = 1.045 + 0.712X$$

Indicating that each one-unit increase in pharmacological knowledge score is associated with an increase of 0.712 units in the score of reduction of potential violations. This equation represents a statistical association and should not be interpreted as a causal relationship.

The standardised coefficient ($\beta = 0.620$) indicates a moderate positive association between pharmacological knowledge and awareness of ethical and safe practice. The t-value = 7.984 and the significance value (Sig.) = 0.000 further strengthen the conclusion that the relationship is statistically significant, indicating that students' level of knowledge is associated with the extent to which they can avoid errors and violations in clinical practice.

Table 4. Anova

Type	Sum of Squares	Df	Mean Square	F	Sig.
1 Regression	44.512	1	44.512	63.700 ^b	.000
Residual	71.488	103	.694		
Total	116.000	104			

^a Dependent Variable: Reduction of Potential Violations,

^b Predictors: (Constant), Level of Pharmacological Knowledge

The ANOVA results indicate that the regression model is statistically significant ($F = 63.700$, $p < 0.001$), suggesting that pharmacological knowledge is significantly associated with reduced potential violations among medical students.

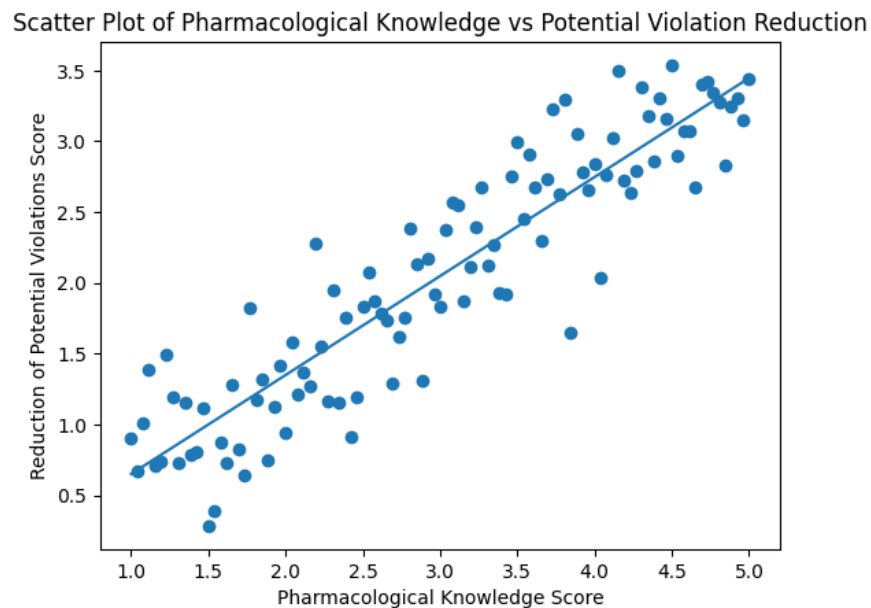


Figure 1. Scatter plot illustrating the relationship between pharmacological knowledge and the reduction of potential violations among medical students.

The scatter plot demonstrates a positive linear trend between pharmacological knowledge and the reduction of potential violations, indicating that higher knowledge levels are associated with higher self-reported ability to prevent violations. However, this relationship should be interpreted cautiously, as it reflects correlation rather than causation and may be associated with measurement limitations.

This strong knowledge enables students to confidently determine appropriate medication dosages, prevent harmful drug interactions, and optimise the patient's overall therapy, which is crucial to ensuring safe medical practice in the future (Keijsers et al., 2014; Simatupang et al., 2020). These findings are in line with Musharyanti et al. (2019); Keijsers, Brouwers, et al. (2014); Wilhelmus and Drukarch (2020) and Pandit et al. (2021), with international surveys of pre-clinical students, where basic pharmacological competencies generally reach moderate to high proportions, with pharmacokinetic understanding often taking precedence over more complex clinical applications.

Groups of medical students with moderate to low pharmacological knowledge are at risk of serious clinical errors, such as improper prescriptions or the use of drugs outside official indications, which directly increase the risk of violations of medical ethics and jeopardise patient safety (Stolic et al., 2022). This lack of understanding often leads to common medication errors in Indonesian hospitals, where insufficient knowledge is the primary cause during prescribing and dispensing (Musharyanti et al., 2019; Pramesona et al., 2025). Strengthening the pharmacology education curriculum through integrative approaches and clinical case simulations is urgently needed to close this knowledge gap and minimise future violations of medical practice.

The majority of medical students in this study demonstrated a high capacity to prevent potential violations of medical practice, followed by a moderate group, while a small percentage were at a low level, reflecting a solid ethical awareness grounded in an adequate understanding of pharmacology. Students with in-depth knowledge of pharmacology tend to apply the principle of rational drug use, a foundational tenet of medical professional ethics and essential to maintaining patient safety (Sari & Johan, 2025). The distribution of these abilities is consistent with research by Tobaiqy (2025) and Gunawan and Johan (2025), which consistently links pharmacological competencies to higher adherence to patient safety standards in medical education.

The results indicate a moderate association between pharmacological knowledge and the reduction of potential violations. This suggests that while knowledge plays an important role, it is not the sole determinant of safe medical practice. The findings are in line with the study Kalfsvel et al., (2022); Kuswinarti et al., (2022) and Sari and Johan (2025) that the deeper students' knowledge of drug mechanisms, the more effective they are at preventing clinical errors such as dangerous drug interactions or improper dosage that could potentially harm patients so these findings highlight the crucial role pharmacology plays in shaping safe and ethical medical practices.

The study found that students' level of pharmacological knowledge could explain the reduction in potential violations of medical practice. In contrast, the remainder was associated with external factors such as clinical experience and supervision, confirming the dominance of drug understanding in shaping safe practices. There is high accuracy in linking pharmacological knowledge with the prevention of clinical errors, consistent with pharmacological competence and reduction of prescribing errors (Brinkman et al., 2018; Shi et al., 2023). These findings reinforce the view of Likic and Maxwell (2009), Aghabarary et al. (2025) and Simonsen et al. (2014) that the crucial role of pharmacology in shaping the professional behaviour of medical students aligns with research emphasising pharmacology education as the foundation of ethics and patient safety.

Students' increased understanding of pharmacology may help reduce potential violations of medical practice, reflecting a stable relationship between professional knowledge and behaviour. This means that students with in-depth knowledge tend to be more careful to avoid overdoses or dangerous drug interactions, consistent with the findings of Harding et al. (2010) and Aghabarary et al. (2025), who reported a strong association between pharmacological competence and reduced prescribing errors. These findings convincingly reinforce the view that pharmacological knowledge is not merely a theory but a fundamental driver of clinical prudence, as confirmed by Likic and Maxwell (2009), Simonsen et al. (2014), and Gunawan and Johan (2025), who show that students with strong pharmacological skills excel at interaction detection.

This study confirms that a deep understanding of pharmacology is associated with medical students' readiness to practice medicine safely and ethically. The majority of respondents can integrate pharmacokinetic and pharmacodynamic knowledge to support rational decision-making, prevent clinical errors, and reduce the risk of professional violations. Although groups with more limited understanding are still vulnerable to mistakes such as improper prescriptions or harmful interactions, the strong link between pharmacological competence and professional behavior highlights the urgency of strengthening an integrative curriculum based on case simulations to close these gaps, thus forming a generation of doctors who are not only technically competent but also fully committed to patient safety and medical ethical standards in Indonesia.

This study has several limitations that should be acknowledged. First, the use of a relatively small sample drawn from a single institution limits the generalizability of the findings to broader medical student populations. Second, reliance on self-reported Likert-scale questionnaires introduces the potential for response bias, as participants may overestimate their knowledge and ability to avoid violations. Third, the measurement of "potential violations" was based on subjective assessment and was not derived from a fully validated or standardised ethical assessment instrument, which may affect construct validity.

Additionally, the identical distribution patterns observed between the independent and dependent variables suggest a possible overlap in measurement constructs, which may have artificially inflated the strength of the observed association, including the relatively high R^2 value. Furthermore, the cross-sectional design of the study precludes any inference about causal relationships between pharmacological knowledge and reduced malpractice risk. Other unmeasured confounding variables—such as prior ethics training, clinical exposure, academic performance, and motivation—may also have been associated with the results.

Therefore, the findings should be interpreted with caution, and future research is recommended to employ larger, multi-centre samples, validated measurement tools, and more robust analytical approaches, such as multivariate or longitudinal designs, to understand better the relationship between pharmacological knowledge and safe medical practice.

CONCLUSION

This study demonstrates a positive association between pharmacological knowledge and reduced potential violations among medical students. Students with higher levels of knowledge tend to report better ability to avoid potential violations. However, these findings should be interpreted with caution, as the study design does not allow causal inference and may be influenced by measurement and sampling limitations.

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