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Recognition of Substandard and Falsified Medicine Red Flags among Pharmacy Students

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ABSTRACT

Substandard and falsified medicines threaten treatment effectiveness, patient safety, antimicrobial stewardship, and public confidence in health systems. This study compared the recognition of substandard and falsified medicine red flags among pharmacy students with and without prior drug-quality-related exposure. An exploratory single-institution study involved 50 undergraduate pharmacy students, divided into an unexposed group (n = 25) and a prior-exposure group (n = 25). Prior exposure included community pharmacy training, pharmaceutical analysis or drug-quality coursework, or formal teaching on substandard and falsified medicines. A 34-point questionnaire assessed knowledge, scenario recognition, and counseling readiness. Group differences were analyzed using the Mann-Whitney U and Fisher's exact tests, with rank-biserial effect sizes and odds ratios reported. The groups were similar in age and sex but differed in academic year, with more senior students in the prior-exposure group. Content-validity indices were at least 0.938, and Cronbach's alpha ranged from 0.721 to 0.907. Median knowledge, scenario-recognition, counseling-readiness, and total scores were 8 versus 5, 11 versus 8, 7 versus 5, and 26 versus 18, respectively (all $p < 0.001$). Rank-biserial effect sizes ranged from 0.806 to 0.976. Prior exposure was associated with higher recognition and counseling-readiness scores. However, the findings do not establish causality because of the small convenience sample, single-institution design, academic-year imbalance, absence of multivariable adjustment, unavailable item-level data, and lack of external instrument validation. Larger prospective multicenter studies with academic-year matching or adjustment and external validation are needed.

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ABSTRAK

Obat substandar dan palsu dapat mengancam efektivitas pengobatan, keselamatan pasien, pengendalian antimikroba, dan kepercayaan masyarakat terhadap sistem kesehatan. Penelitian ini membandingkan kemampuan mahasiswa farmasi dalam mengenali tanda bahaya obat substandar dan palsu berdasarkan ada atau tidaknya paparan sebelumnya terkait mutu obat. Penelitian eksploratif pada satu institusi ini melibatkan 50 mahasiswa sarjana farmasi yang dibagi menjadi kelompok tanpa paparan (n = 25) dan kelompok dengan paparan sebelumnya (n = 25). Paparan sebelumnya mencakup pelatihan farmasi komunitas, mata kuliah analisis farmasi atau mutu obat, atau pembelajaran formal mengenai obat substandar dan palsu. Kuesioner 34 poin digunakan untuk menilai pengetahuan, pengenalan skenario, dan kesiapan konseling. Perbedaan antar kelompok dianalisis menggunakan uji Mann-Whitney U dan Fisher exact, serta dilengkapi dengan rank-biserial effect size dan odds ratio. Kedua kelompok memiliki usia dan jenis kelamin yang relatif serupa, tetapi berbeda dalam tingkat tahun akademik, dengan lebih banyak mahasiswa tingkat akhir pada kelompok dengan paparan sebelumnya. Indeks validitas isi mencapai sedikitnya 0,938 dan nilai Cronbach's alpha berkisar antara 0,721 hingga 0,907. Median skor pengetahuan, pengenalan skenario, kesiapan konseling, dan skor total masing-masing adalah 8 dibandingkan 5, 11 dibandingkan 8, 7 dibandingkan 5, serta 26 dibandingkan 18 (seluruh $p < 0,001$). Nilai rank-biserial effect size berkisar antara 0,806 hingga 0,976. Paparan sebelumnya berhubungan dengan skor pengenalan dan kesiapan konseling yang lebih tinggi. Namun, hasil ini tidak dapat menunjukkan hubungan sebab-akibat karena keterbatasan berupa sampel kecil, penggunaan sampel kenyamanan, penelitian satu institusi, ketidakseimbangan tahun akademik, tidak adanya penyesuaian multivariat, keterbatasan data tingkat butir, dan belum adanya validasi eksternal instrumen. Penelitian prospektif multisenter dengan pencocokan atau penyesuaian tahun akademik serta validasi eksternal masih diperlukan.

Kata Kunci: Obat substandar; Obat palsu; Pendidikan farmasi; Keselamatan obat; Apotek daring; konseling

1. Introduction

Substandard and falsified (SF) medicines remain a persistent medication-safety threat. They can cause treatment failure, toxicity, avoidable morbidity, antimicrobial resistance, and loss of confidence in medicines and health systems. Although the risk is global, it is intensified where regulatory surveillance, analytical capacity, supply-chain traceability, and access to licensed sources are constrained [1],[2].

Health-system pressures such as shortages, high out-of-pocket costs, and uneven access to licensed facilities can move patients toward informal or poorly regulated supply channels, and these vulnerabilities are particularly consequential in low- and middle-income settings where post-market surveillance capacity is limited [3],[4].

Online medicine sales add a distinct layer of risk. Anonymous websites, social-media pages, private messaging applications, and cross-border sellers may offer prescription-only medicines without a prescription, pharmacist oversight, verifiable registration, or reliable product provenance. Unusually low prices, exaggerated therapeutic claims, missing seller identity, and refusal to provide traceability information are therefore important frontline warning signs [5].

Recognition is not consistently strong among the public or health professionals. Evidence from Jordan documented deficits in awareness, identification, and reporting, while qualitative work shows that pharmacists see themselves as guardians of safe supply yet need practical knowledge, accessible reporting systems, and confidence in patient communication [6],[7]. Crises and medicine shortages may further normalize non-traditional sources, as reported among Lebanese community pharmacists [8].

Education is a modifiable component of preparedness. A dedicated course delivered to pharmacy students in three sub-Saharan African universities improved knowledge of SF medical products, supporting the inclusion of structured content rather than reliance on incidental exposure [9]. Contemporary educator guidance also

emphasizes online-seller verification, prescription requirements, reporting pathways, and safe counseling as core competencies [10],[11].

Definitive authentication may require chromatography, spectroscopy, or other analytical methods that are rarely available at the first point of patient contact. Initial recognition therefore depends on non-laboratory cues such as abnormal appearance or odor, visible degradation, inconsistent strength information, missing batch or expiry details, labeling errors, implausible storage or potency claims, and suspicious supply channels [12]. Early recognition supports isolation of a suspect product, referral, and regulatory reporting, although effective action also depends on functional legislation and supply-chain accountability [13].

Because the consequences of SF medicines extend beyond individual treatment failure to higher healthcare costs, antimicrobial resistance, and weakened public trust [14], educational assessment should measure more than factual definitions; it should examine whether future pharmacists can recognize risk in context and translate concern into safe counseling and reporting-oriented action. This is where the evidence remains thin. Most published work describes qualified pharmacists rather than students, and it is not known whether undergraduates who have already met drug-quality content or community-pharmacy practice differ from their peers in applied recognition and counseling readiness. That comparison is the gap addressed here.

The primary objective was therefore to compare total SF-medicine recognition scores between pharmacy students with and without prior drug-quality-related educational or practical exposure. Secondary objectives were to compare knowledge, scenario-recognition, and counseling-readiness scores, and to evaluate the preliminary content validity and internal consistency of the study-developed questionnaire.

2. Methods

Study Design and Setting

This was a comparative cross-sectional questionnaire study conducted among undergraduate pharmacy students at a single university faculty of pharmacy during one academic study period. The study compared students with and without prior drug-quality-related educational or practical exposure. No physical medicines were inspected, collected, or tested, and no laboratory authentication procedure was performed. Because the design is cross-sectional and observational, exposure and outcome were measured at the same point in time, and the design can identify variables that are associated with recognition scores but cannot establish cause and effect. Throughout this report, therefore, findings are described as "associated with" higher scores rather than as "improved by" or "caused by" any exposure.

Population, Sampling, and Sample Size

Undergraduate pharmacy students who could be reached through academic announcements, class groups, or institutional student communication channels were eligible for recruitment. Convenience sampling was used because group membership depended on pre-existing curricular or practical exposure. The feasible target was 50 complete responses, with 25 participants in each group. No a priori sample-size or power calculation was performed; the study was exploratory and the target was determined by the available study framework. The invitation denominator and the number of screened or excluded responses were not retained, so a response rate could not be calculated. This study is therefore explicitly exploratory and hypothesis-generating. The sample is small, was not randomly selected, and was drawn from a single faculty of pharmacy, so it cannot be assumed to represent the wider student body of that faculty, and its findings cannot be generalized to pharmacy students at other institutions or in other countries.

The results should be read as a preliminary signal that warrants testing in larger, prospectively designed, multicenter samples.

Eligibility Criteria

Eligible participants were pharmacy students aged 18 years or older, actively enrolled at the time of the survey, able to understand the English-language questionnaire, and willing to provide electronic informed consent. Responses were excluded if they were incomplete, duplicated, or ineligible, or if the respondent reported professional employment in medicine authentication, regulatory inspection, pharmaceutical quality-control laboratories, or anti-counterfeit programs. The retained analytic dataset contained 50 complete eligible responses.

Exposure-Group Definition

Participants were classified before analysis. The unexposed group included students reporting no community pharmacy training, no pharmaceutical analysis coursework, no drug-quality coursework, and no formal instruction on SF medicines. The prior-exposure group included students reporting at least one of the following: community pharmacy training, pharmaceutical analysis coursework, drug-quality coursework, or formal teaching on medicine quality, packaging evaluation, online-pharmacy risk, or SF-medicine recognition. Because the study was observational and exposure was not assigned, the groups are described as unexposed and prior-exposure rather than control and intervention groups. It should be emphasized that the prior-exposure group is deliberately heterogeneous. A student qualified through any one of four quite different experiences, and most qualifying students reported more than one of them, so these experiences overlap substantially within the same individuals. The design does not allow the effect of community pharmacy training, pharmaceutical analysis coursework, drug-quality coursework, and formal SF-medicine teaching to be separated from one another, and no attempt to do so was made. Every exposure-related result reported below therefore refers to the composite exposure as a whole, and no inference should be drawn about any single course, module, or placement.

Questionnaire Development and Structure

The Substandard and Falsified Medicines Recognition Questionnaire was developed for this study. Content was mapped to World Health Organization definitions and risk concepts, the International Pharmaceutical Federation educator handbook for SF products sold online, and pharmacist-focused evidence on recognition and e-commerce risk [1],[7],[8],[11]. The instrument was developed in English and was intended to assess applied recognition and professional response readiness rather than laboratory authentication.

The questionnaire contained four sections. Section I collected age, sex, academic year, community pharmacy training, pharmaceutical analysis coursework, drug-quality coursework, formal SF-medicine teaching, and previous encounter with a suspected SF medicine. Section II contained 10 single-best-answer knowledge items. Section III contained 16 text-based scenarios classified as low risk, moderate risk, high risk, or unsure. Section IV contained eight counseling-readiness items with agree, disagree, or unsure responses. Scenarios addressed product appearance and degradation, packaging and labeling inconsistencies, storage and potency claims, online-seller legitimacy, prescription requirements, and traceability. To make the content assessed concrete for the reader, representative items are described here. A knowledge item asked which single feature best distinguishes a substandard medicine from a falsified medicine, with distractors drawn from common misconceptions about price and packaging quality. A low-risk scenario described a medicine supplied by a licensed community pharmacy with intact packaging, a legible batch number, and an expiry date matching the outer carton. A high-risk scenario described a prescription-only antibiotic advertised by a

social-media seller at a small fraction of the usual price, with no pharmacist contact, no batch or expiry information, and refusal to supply the source on request. A counseling-readiness item asked whether the respondent would advise a patient who suspects a product to stop using it, retain the packaging, seek clinical assessment, and report the product, rather than simply replacing it from the same seller.

Scoring

The total score ranged from 0 to 34: knowledge, 0-10; scenario recognition, 0-16; and counseling readiness, 0-8. Correct knowledge responses, the predefined risk classification for each scenario, and safe professional counseling responses each received one point. Incorrect, unsafe, passive, or unsure responses received zero points. The scoring key was finalized before main data collection using the source frameworks and expert review. Higher scores indicated stronger recognition and counseling readiness.

Expert Review, Content Validity, and Pilot Testing

Five experts representing pharmaceutical chemistry, pharmaceutical analysis, and pharmacy practice reviewed all items. Each item was rated on a four-point scale for relevance, clarity, simplicity, and alignment with the intended construct. The item-level content validity index (I-CVI) was the proportion of experts assigning a rating of 3 or 4, and the scale-level average content validity index (S-CVI/Ave) was the mean I-CVI across retained items. Prespecified thresholds were I-CVI >= 0.78 and S-CVI/Ave >= 0.90. The revised questionnaire was then piloted with 10 pharmacy students who were not included in the analytic sample. The pilot participants were undergraduate pharmacy students at the same faculty and were drawn from a comparable range of academic years, so that the pilot group resembled the main participants in training stage and language of instruction. After the pilot, no items were added and none were removed; a small number of items were reworded where pilot respondents reported ambiguous phrasing, and the scoring key was left unchanged. Cronbach's alpha was calculated for each scored domain and the total score, with values of at least 0.70 treated as acceptable preliminary internal consistency. These procedures provide preliminary evidence of content validity and internal consistency only. The instrument is therefore described throughout as a study-developed questionnaire with preliminary measurement evidence, and it should not be described as a fully validated instrument: construct validity, criterion validity, test-retest reliability, item-level analysis, and external validation in an independent sample have not yet been performed.

Data Collection and Ethical Considerations

Data were collected through a structured electronic survey. The first page contained study information and electronic consent. No names, student identification numbers, telephone numbers, or email addresses were collected. Participants completed the questionnaire independently without model answers or immediate feedback. The study received institutional research ethics approval before recruitment; participation was voluntary and non-participation had no effect on academic status or assessment. Data were anonymous and stored in a password-protected file accessible to the research team. The study involved no patients, clinical intervention, biological samples, medicine handling, or laboratory testing.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 31.0 (IBM Corp., Armonk, NY, USA). Categorical variables were summarized as frequencies and percentages. Age, academic year, and score variables were summarized using medians and interquartile ranges. Mann-Whitney U tests compared age, academic year, domain scores, and total score; rank-biserial r quantified effect size, with positive values indicating higher values in the prior-exposure group. Fisher's exact test compared sex, exposure variables, and

previous encounter with a suspected SF medicine. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported; the Haldane-Anscombe correction was used only for tables containing a zero cell. All tests were two-sided and $p < 0.05$ was considered statistically significant. Every analysis reported in this paper is unadjusted. No multivariable model of any kind was fitted, no covariate adjustment for academic year or any other characteristic was applied, and no stratified or matched analysis was performed, because the sample was small, several exposure cells were structurally sparse, and academic year overlapped strongly with the exposure definition. All between-group comparisons presented below are therefore crude comparisons, and residual confounding cannot be excluded or quantified. Item-level responses were not retained in the anonymized analytic dataset, so no item-by-item analysis of individual red flags or counseling responses could be produced. Reporting was aligned with the Consensus-Based Checklist for Reporting of Survey Studies (CROSS) [15].

3. Results and Discussion

Fifty students were included: 25 in the unexposed group and 25 in the prior-exposure group. All reported analyses used the complete analytic sample.

Participant Characteristics

Median age did not differ significantly between groups, and the sex distribution was similar. Academic year differed substantially: the prior-exposure group contained more fourth-year, fifth-year, and internship-level students, whereas the unexposed group contained more second- and third-year students, as shown in **Table 1**. The imbalance is large. No second-year student appeared in the prior-exposure group at all, while 52.0% of that group were at fifth-year or internship level compared with 8.0% of the unexposed group ($U = 89.5$; $r = 0.714$; $p < 0.001$). The difference was expected, because several exposure components are acquired later in the curriculum, but it is the single most important methodological limitation of this study rather than an incidental imbalance. Because seniority and exposure move together, any between-group difference reported below may reflect academic year, cumulative curricular experience, or general professional maturity rather than the specific exposures used to define the groups. This caveat applies to every comparison in **Tables 2 and 4**, to both figures, and to the discussion and conclusion that follow.

Table 1. Participant demographic and academic characteristics by exposure group

Characteristic	Unexposed (n=25)	Prior-exposure (n=25)	Test statistic / effect	p value
Age, years; median [IQR]	21.0 [20.0-22.0]	22.0 [21.0-22.0]	U = 235.0; r = 0.248	0.119
Sex, male; n (%)	10 (40.0)	9 (36.0)	OR = 0.85 (0.28-2.60)	1.000
Academic year (ordinal)			U = 89.5; r = 0.714	<0.001
Second year; n (%)	8 (32.0)	0 (0.0)		
Third year; n (%)	10 (40.0)	3 (12.0)		
Fourth year; n (%)	5 (20.0)	9 (36.0)		
Fifth/internship; n (%)	2 (8.0)	13 (52.0)		

Source: Author's analysis. Age and academic year were compared using the Mann-Whitney U test; sex using Fisher's exact test. IQR, interquartile range; OR, odds ratio.

Exposure Profile

The four variables used to define prior exposure were all substantially more common in the prior-exposure group, as shown in **Table 2**. The very large corrected ORs for these variables primarily confirm the predefined group classification and should not be interpreted as independent etiologic effects. A previous encounter with a suspected

SF medicine was more frequent in the prior-exposure group (32.0% vs 8.0%), but the difference did not meet the conventional significance threshold (OR 5.41, 95% CI 1.02-28.79; Fisher exact p = 0.074). This row deserves careful reading, because the confidence interval and the p value appear to disagree. They come from two different procedures. The odds ratio and its interval are derived from the large-sample (Wald) approximation on the log-odds scale, whereas the p value comes from Fisher's exact test, which conditions on the observed margins and makes no large-sample assumption. With only 2 and 8 events in cells of this size the two procedures need not agree, and a confidence interval whose lower bound falls only marginally above 1.00 can legitimately accompany a non-significant exact p value. The exact test is the more appropriate inference at this sample size. This comparison is therefore reported as not statistically significant, and the apparently large odds ratio should be read as a very imprecise estimate rather than as evidence of a real difference in previous encounters between the groups.

Table 2. Exposure components used to define group membership

Exposure variable, yes; n (%)	Unexposed (n=25)	Prior-exposure (n=25)	Effect estimate	p value
Community pharmacy training	0 (0.0)	20 (80.0)	Corr. OR = 190.09 (9.92-3642.48)	<0.001
Pharmaceutical analysis coursework	0 (0.0)	22 (88.0)	Corr. OR = 327.86 (16.05-6697.98)	<0.001
Drug-quality coursework	0 (0.0)	18 (72.0)	Corr. OR = 125.80 (6.75-2343.42)	<0.001
Formal SF-medicine teaching	0 (0.0)	16 (64.0)	Corr. OR = 88.58 (4.82-1626.85)	<0.001
Previously encountered suspected SF medicine	2 (8.0)	8 (32.0)	OR = 5.41 (1.02-28.79)	0.074

Source: Author's analysis. Fisher's exact test was used; the Haldane-Anscombe correction was applied only to rows containing a zero cell. SF, substandard and falsified; OR, odds ratio.

Preliminary Measurement Properties

All domains met the prespecified content-validity thresholds, as shown in **Table 3**. S-CVI/Ave values ranged from 0.938 to 0.975, and the total questionnaire S-CVI/Ave was 0.953. Pilot Cronbach's alpha values were 0.730 for knowledge, 0.841 for scenario recognition, 0.721 for counseling readiness, and 0.907 for the total score. These findings provide preliminary evidence of content validity and internal consistency, while the small pilot sample and absence of external validation require cautious interpretation.

Table 3. Preliminary content validity and pilot internal consistency of the questionnaire

Component	Items	I-CVI median [range]	S-CVI/Ave	Cronbach's alpha	Interpretation
Knowledge	10	1.00 [0.80-1.00]	0.960	0.730	Acceptable
Scenario recognition	16	1.00 [0.80-1.00]	0.938	0.841	Acceptable
Counseling readiness	8	1.00 [0.80-1.00]	0.975	0.721	Acceptable
Total scored questionnaire	34	1.00 [0.80-1.00]	0.953	0.907	Acceptable

Source: Author's analysis. Five experts rated item relevance on a four-point scale. Thresholds: I-CVI >= 0.78, S-CVI/Ave >= 0.90, Cronbach's alpha >= 0.70. "Acceptable" denotes that the prespecified preliminary thresholds were met; it does not indicate a fully validated instrument, since construct validity, test-retest reliability, item analysis, and external validation were not performed.

Recognition and Counseling-Readiness Scores

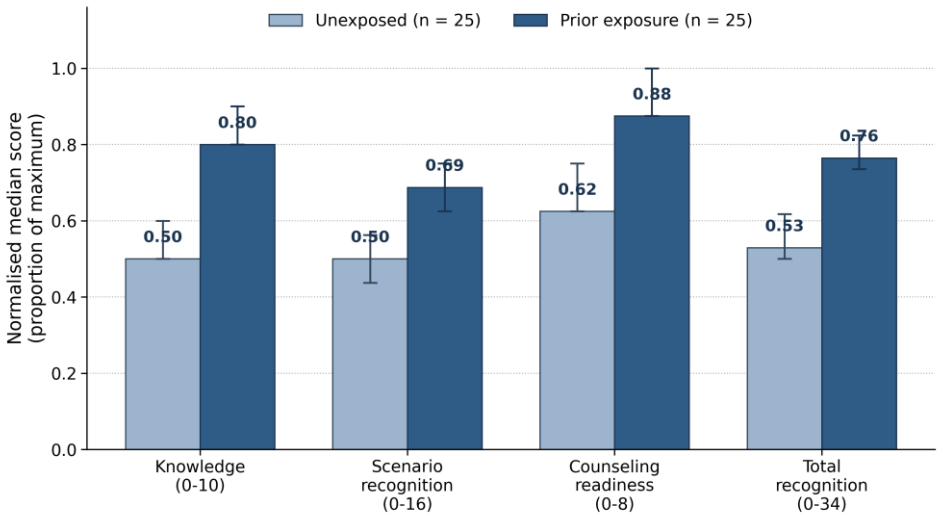
All four score outcomes were higher in the prior-exposure group, as shown in **Table 4**. Median knowledge scores were 8.0 versus 5.0, scenario-recognition scores were

11.0 versus 8.0, counseling-readiness scores were 7.0 versus 5.0, and total recognition scores were 26.0 versus 18.0 (all $p < 0.001$). Effect sizes were large across outcomes, ranging from $r = 0.806$ for counseling readiness to $r = 0.976$ for knowledge. These values are very large by conventional benchmarks and should not be taken at face value. They are unadjusted, and the prior-exposure group was also substantially more senior, so part of the separation they express almost certainly reflects academic year and cumulative curricular experience rather than the defining exposures alone. Rank-biserial correlations computed in small samples with near-complete group separation on a correlated covariate also tend to overstate the magnitude of any true difference. The effect sizes should therefore be read as descriptive indicators of separation between two groups that differ in more than one respect, not as estimates of the size of an educational effect.

Table 4. Recognition and counseling-readiness scores by exposure group

Score	Unexposed median [IQR]	Prior-exposure median [IQR]	U	r	p value
Knowledge (0-10)	5.0 [5.0-6.0]	8.0 [8.0-9.0]	7.5	0.976	<0.001
Scenario recognition (0-16)	8.0 [7.0-9.0]	11.0 [10.0-12.0]	60.0	0.808	<0.001
Counseling readiness (0-8)	5.0 [5.0-6.0]	7.0 [7.0-8.0]	60.5	0.806	<0.001
Total recognition (0-34)	18.0 [17.0-21.0]	26.0 [25.0-28.0]	18.5	0.941	<0.001

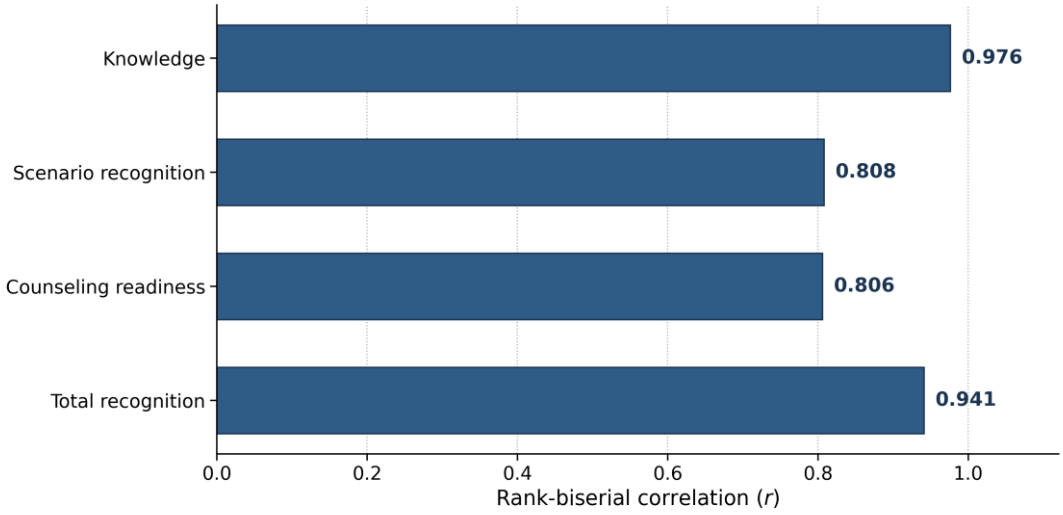
Source: Author's analysis. Mann-Whitney U test; positive rank-biserial r indicates higher scores in the prior-exposure group. IQR, interquartile range.



Note: Error bars show the interquartile range

Figure 1. Median domain scores normalized to the maximum possible score

When medians and interquartile ranges were normalized to each domain's maximum possible score, the prior-exposure group remained higher across all domains, as shown in **Figure 1**. The greatest normalized median difference was observed for knowledge, followed by total recognition. **Figure 2** illustrates the corresponding rank-biserial effect sizes and demonstrates consistently strong separation between the groups.



Note: Positive values indicate higher scores in the prior-exposure group

Figure 2. Rank-biserial effect sizes for score comparisons

This exploratory study found a consistent association between prior drug-quality-related exposure and higher SF-medicine recognition performance. Students in the prior-exposure group scored higher in factual knowledge, applied scenario classification, counseling readiness, and the total score. The pattern is educationally coherent: exposure was associated not only with knowing definitions but also with interpreting written risk cues and selecting protective professional responses.

The knowledge difference is consistent with evidence that dedicated SF-medicine teaching can improve pharmacy students' knowledge. Kusynova et al. reported measurable gains after a structured course across three sub-Saharan African universities [9]. Student-focused work on online pharmacy use similarly indicates that awareness of digital purchasing does not necessarily translate into curricular preparedness without focused instruction [16].

The findings also fit evidence from practicing pharmacists. Surveys in the United States and Sweden identified uncertainty about recognizing illegal online pharmacies, verifying legitimate websites, and identifying authorized online-pharmacy symbols [17], [18]. In Saudi Arabia, community pharmacists reported limited knowledge and recognition experience related to SF medicines [19]. These studies support the premise that practical recognition should be taught explicitly rather than assumed to emerge automatically from general pharmacy training.

Scenario recognition showed a slightly smaller effect than factual knowledge, although the difference remained large. Applied classification requires integration of seller legitimacy, prescription status, packaging consistency, product appearance, and clinical context. This is more cognitively demanding than recalling definitions and may better approximate the uncertainty encountered at community-pharmacy contact points. The distinction is important because awareness without operational judgment may not prevent unsafe purchase or continued use.

Counseling readiness was also higher in the prior-exposure group. Pharmacists' protective role depends on converting suspicion into clear advice: avoiding unauthorized sellers, withholding use pending assessment, preserving packaging, seeking care when symptoms occur, and reporting through official channels. Qualitative pharmacy research describes this guardian role, while system-level research shows that its effectiveness depends on accessible reporting pathways, organizational support, and

regulatory feedback [7], [20]. Education is therefore necessary but not sufficient for real-world protection.

The preliminary measurement findings are encouraging but should not be overstated. Content validity was strong and internal consistency met the prespecified threshold, yet content validity and Cronbach's alpha do not establish construct validity, criterion validity, test-retest reliability, or cross-cultural performance. Recent scoping evidence continues to identify variability in how knowledge, attitudes, identification, and reporting are measured in SF-medicine research [21]. External validation and item-level psychometric analysis are required before the questionnaire can be treated as a broadly validated instrument.

The educational implications are practical. Curricula can integrate SF-medicine content across pharmaceutical analysis, quality assurance, community pharmacy, medication safety, and digital-health teaching. Scenario-based learning should include suspicious prices and claims, missing batch or expiry information, abnormal appearance, conflicting strength information, sale of prescription-only medicines without a prescription, and absent seller registration. Educator guidance on online SF products provides a useful framework for this integration [10], [11].

Evidence from healthcare providers and pharmacy professionals in Ethiopia, Uganda, and Iraq shows that awareness, recognition confidence, and reporting practice remain uneven and are influenced by training, professional context, and access to formal alerts [22]-[26]. Public studies in Lebanon and pharmacy research in Egypt and Nigeria further indicate that pharmacists remain strategically positioned to compensate for patient knowledge gaps, but require stronger training and professional engagement [27]-[29]. The present findings add preliminary student-level evidence to this broader literature.

Two alternative explanations are strong enough that they must be weighed before any educational reading of these results. The first, and the more serious, is academic seniority. Academic year was markedly imbalanced and closely linked to the exposure definition: no second-year student fell into the prior-exposure group, and more than half of that group were at fifth-year or internship level. Senior students may have broader pharmacotherapy knowledge, greater familiarity with medicine packaging and labeling conventions, more patient-facing experience, and more practice at the kind of structured professional reasoning that the scenario and counseling items reward, all independently of the specific exposures measured here. Because the sample was small and cells were sparse, neither stable multivariable adjustment nor within-year stratification was possible, so this explanation cannot be ruled out and its contribution cannot be quantified. A design in which students at the same academic year differ in exposure would be required to separate the two. The second alternative explanation concerns the composition of the exposure itself. The prior-exposure group was defined by any of four heterogeneous experiences that differ in duration, delivery, and assessment: a community pharmacy placement is experiential and patient-facing, pharmaceutical analysis coursework is laboratory-oriented, drug-quality coursework is regulatory and conceptual, and formal SF-medicine teaching is the only one directly targeted at the construct measured. Most exposed students reported more than one, so these experiences are confounded with one another as well as with seniority. The composite may therefore be acting largely as a proxy for cumulative curricular contact rather than as a marker of any specific instruction, and the observed differences cannot be attributed to formal SF-medicine teaching in particular. A further and smaller consideration is that exposure was self-reported and students with more interest in medicine quality may both recall exposure more readily and engage more carefully with a questionnaire on the topic. Accordingly, the results of this study demonstrate association and educational

separation between two groups that differ in several respects at once; they do not demonstrate a causal effect of any single course, placement, or training experience.

Limitations

This study has several limitations that should be acknowledged. First, it used a small convenience sample from one institution, and no a priori sample-size calculation was performed, so the study is exploratory and its findings cannot be generalized to pharmacy students elsewhere. Second, the recruitment denominator and screening log were not retained, preventing calculation of a response rate and full assessment of non-response bias. Third, academic year was a major uncontrolled confounder that overlapped with the exposure definition; all analyses were unadjusted and no multivariable, adjusted, matched, or stratified analysis was feasible, so residual confounding can be neither excluded nor quantified. Fourth, the prior-exposure group combined several different educational and practical experiences, so the contribution of any single exposure cannot be isolated. Fifth, exposure was self-reported and may be affected by recall or classification error. Sixth, item-level responses were not retained in the anonymized dataset, so it was not possible to report which individual red flags or counseling responses were most often answered correctly or incorrectly; such item-level results would be informative for curriculum design and should be collected and reported as supplementary material in future work. Finally, outcomes were based on an English-language, text-only questionnaire rather than direct observation of physical-product inspection, reporting behavior, or patient counseling, and the instrument has not undergone external validation, factor analysis, or test-retest assessment, so its measurement properties remain preliminary.

Future studies are recommended to address these limitations by involving larger and more diverse multicenter populations, matching or adjusting for academic year, isolating individual exposure components, and incorporating observed counseling and reporting outcomes. Such improvements would provide more comprehensive insights and enhance the external validity of the findings.

4. Conclusion

In this exploratory single-institution study, prior drug-quality-related educational or practical exposure was associated with higher knowledge, scenario-recognition, counseling-readiness, and total SF-medicine recognition scores. The study-developed questionnaire showed strong expert content-validity indices and acceptable preliminary internal consistency, although it has not been externally validated. This association must not be read as a causal finding. The prior-exposure group was substantially more senior than the unexposed group, the exposure definition combined four different experiences whose individual contributions could not be separated, the sample was small and selected by convenience from one faculty, all analyses were unadjusted, and item-level data were unavailable. The study therefore cannot demonstrate that any specific course, placement, or training experience caused the higher scores observed, and its findings should be treated as a preliminary association requiring confirmation. Beyond its immediate educational application, the findings open avenues for further scientific exploration. Future research could evaluate structured, scenario-based SF-medicine education in prospective multicenter designs with academic-year matching or adjustment, assess observed counseling and reporting behavior rather than self-reported readiness, and pursue external validation of the instrument. These directions will be crucial to strengthen the translational value of SF-medicine education within pharmacy curricula.

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Conflict of Interest:

The author declares no conflict of interest, and no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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