

Knowledge, attitudes, and awareness of drug-drug interactions among pharmacy students in Palestine: a cross-sectional study

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Abstract

Background: Drug-drug interactions (DDIs) are crucial clinical challenges that lead to decrease effectiveness, unexpected side effects, or toxicity. According to the World Health Organization (WHO) briefing note, a significant proportion of adverse drug reactions related to drug-drug interactions are preventable. In Palestine, the healthcare system faces unique challenges; including limited resources, restricted access to advanced clinical decision support systems, and evolving pharmaceutical education standards. No empirical research has evaluated DDI competencies among pharmacy students in West bank, Palestine. This study evaluated the knowledge, attitudes, and awareness of drug-drug interactions among pharmacy students in West bank, Palestine; assessed differences across academic years; and identified probable factors associated with increased DDI knowledge.

Methods: A cross-sectional study with quantitative, descriptive, and correlational design. A total of 801 participants of Pharmacy students from Palestinian universities in the West Bank, Palestine. Self-administered and structured questionnaires were distributed which include: sociodemographic information, DDI knowledge, attitudes toward management, awareness of clinical significance, self-perceived confidence, and perceived barriers. Data analysis were carried out using SPSS version 27.0.

Results: Participants demonstrated a moderate level of knowledge regarding drug–drug interactions, with 62.2% positive responses and 37.8% negative responses. The largest proportion of participants demonstrated a high level of knowledge (40.7%). The mean attitude score toward DDI management was 3.22, indicating generally positive attitudes. The study showed a great majority of the participants (72.3%) were aware of the drug–drug interactions.

Age group was significantly associated with all the outcomes, including knowledge, attitudes, awareness, confidence, and barriers ($P < 0.01$), the academic year was found significantly different across all the outcomes ($P < 0.001$).

Conclusions: The findings of this study provides a baseline data on student's knowledge, attitudes, and awareness toward DDI competencies among pharmacy students at Palestinian Universities. It is crucial to revise assessment standards, and teaching methodologies to boost Pharmacy graduates with knowledge crucial for preparedness for clinical responsibilities which reflects positively on community health in the country. To achieve this goal, strengthening DDI competencies during training courses is especially urgent and critical.

Background

Drug-drug interactions (DDIs) have long been recognized as crucial clinical challenges in healthcare, when drugs react with each other, this will lead to decrease effectiveness, develop unexpected and sometimes life threatening side effects. On the other hand, increasing the activity of one drug may lead to toxicity; which could be harmful or even fatal to patient if not controlled.

According to the World Health Organization (WHO) briefing note; many adverse drug reactions related to DDI, including interactions with herbal medicines and certain food products, could be prevented and managed [1]. As medication regimens become increasingly complex, particularly in patients with multiple comorbidities and polypharmacy, the risk of clinically significant DDIs continues to rise. this challenge triggered the need for increased awareness and knowledge of DDI among health care professionals.

In Palestine, the healthcare system faces unique challenges, including limited resources, restricted access to advanced clinical decision support systems, and evolving pharmaceutical education standards. Recent studies have shown that community pharmacy professionals in Palestine demonstrate acceptable knowledge of drug interactions, with higher scores in drug-food/herb interactions than in DDIs [2, 3]. However, their actual practice related to drug interactions was less positive; only approximately one-third of them were regularly checked DDIs. A striking disconnect for professionals whose training explicitly covers this domain. Therefore, it is crucial to examine students' competencies during the educational phase at the universities since attitudes and professional behaviors are developing.

Regional studies from surrounding countries revealed gaps in DDI knowledge among healthcare professionals. In Jordan, only 7% of pharmacists have reached excellent knowledge levels about food-drug interactions [4]. Practicing pharmacists in Egypt, Saudi Arabia, Ethiopia, and Indonesia scored between 38% and 60%, which is considerably low to moderate [5–9]. Clinical pharmacists consistently outscored their community-pharmacy peers on the knowledge assessment.

This pattern implicates clinical exposure, rather than formal training alone, as the stronger determinant of DDI competency. The Pharmacy curriculum structure and the environment in which it is delivered to the students determine whether students are prepared and ready for clinical practice. Pharmacy education in Palestine has developed in recent years; increased attention and focus to clinical pharmacy

practices and giving priority for pharmaceutical care. Still, there is limited empirical evidence regarding the effectiveness of current educational approaches in developing students' DDI competencies [10].

Demographic and educational factors may equally shape students' DDI skills. Gender, practical training time and experiences, access to resources, and practice settings have all been linked to DDI knowledge among practicing pharmacists [2, 7].

The primary aim of this cross-sectional study was to evaluate the knowledge, attitudes, and awareness of DDIs among pharmacy students in Palestine. Examining these competencies across academic years and identifying the factors that drive or suppress that may contribute to pharmacy education reform in Palestine and lay down the groundwork for targeted interventions that strengthen DDI competencies among all future pharmacy graduates.

Methods

This study used a cross-sectional quantitative descriptive correlational design. The study was conducted in the academic year 2025–2026, several Palestinian universities in the West Bank have been participated in the study with Al-Quds University as the coordinating institution.

Study Design

A cross-sectional quantitative descriptive correlational design was employed. Pharmacy students' knowledge, attitudes, awareness, confidence, and perceived barriers to DDI and institutional environments, without any manipulation of variables have been assessed. This simultaneity is precisely what made this design appropriate.

Study Setting

The participants of the study were Pharmacy students enrolled in several Palestinian universities in the West Bank who had completed at least one pharmacology course and participated in pharmacy training. These requirements confined eligibility to third-, fourth-, fifth-, and sixth-year students (Pharm.D.). The pharmacy department at Al-Quds University formed the primary setting, although restricting recruitment to a single institution would have narrowed the findings considerably. The scope was therefore extended to Al-Najah National University, Birzeit University, Arab American University, and Hebron University. Students participated were came from six districts across the West Bank: Jerusalem, Nablus, Ramallah, Hebron, Jenin, and Bethlehem (Fig. 1).

The map illustrates the regional representation of the study cohort recruited during the 2025–2026 academic year from five Palestinian universities. The data reveal a significant concentration of participants within the Jerusalem district (n = 614; 76.7%), which served as the primary hub for the research. Regional representation also included clusters from Nablus (n = 61; 7.6%), Hebron (n = 61; 7.6%), and Ramallah (n = 40; 5.0%). Smaller participant groups were identified in Jenin (n = 16; 2.0%) and Bethlehem (n = 9; 1.1%), ensuring a broad cross-sectional reach across the West Bank and Jerusalem areas. This distribution reflects the multi-institutional nature of the study while acknowledging the heavy representation from the coordinating institution.

Inclusion and Exclusion Criteria

The inclusion criteria; Third-, fourth-, fifth-, and sixth-year pharmacy students (including Pharm.D. students) who had completed at least one pharmacology course and attended pharmacy training, while the exclusion criteria; first- and second-year pharmacy students, sincethe pharmacology coursework and hands-on training that provide DDI assessment of its clinical grounding were not conducted.

Sample size and sampling method

A convenience sampling approach was used, in which participants were recruited from students who were readily accessible to the research team, due to logistical and time constraints. A total of 1000 students were targeted; 801 entered the final analysis. Among the total participants; 81.5% were females. Bachelor's degree students made up of 87.4% of the participants, and Pharm.D. students were 12.6%. For institutional contribution, Al-Quds University was the primary contributor of 80.8%, followed by Birzeit University (7.2%), Al-Najah National University (6.9%), Hebron University (2.7%), and Arab American University of (1.4%).

Data collection

Data were collected via a self-administered structured questionnaire that participants completed remotely and independently. Participation was entirely voluntary; and anonymously to ensure full participant privacy and confidentiality.

Instrument and scoring

The structure and scoring of the study questionnaire (Table 1).

Table 1
Structure and scoring of the study questionnaire sections.

Section	Content	Items	Scoring	Levels / Range
Demographics	Age, gender, education level, academic year, university, and prior training.	13	—	—
DDI Knowledge	Identification of interaction severity for specific drug pairs (12 items) and pharmacokinetic/pharmacodynamic mechanisms (11 True/False items).	23	Correct = 1; Incorrect or "Don't know" = 0	Low (0–9), Moderate (10–16), High (17–23)
Attitudes	Perspectives on professional responsibility and the importance of DDI checking; 5-point Likert scale.	12	Strongly Agree = 5 to Strongly Disagree = 1	Negative (12–27), Neutral (28–44), Positive (45–60)
Awareness	Clinical consequences of DDIs, adverse drug event prevalence, and vulnerable populations; True/False format.	5	1 point per correct answer	Score range: 0–5
Confidence	Self-perceived ability to identify interactions, recommend alternatives, and counsel patients; 5-point Likert scale.	5	Very Confident = 5 to Not at All Confident = 1	Low (5–11), Moderate (12–18), High (19–25)
Barriers	Perceived challenges including workload, lack of resources, and insufficient training; 5-point Likert scale.	11	Major Barrier = 5 to Not at All a Barrier = 1	Low (11–25), Moderate (26–40), High (41–55)

The questionnaire was developed by the study team specifically for this study and is provided in full as a supplementary file (Additional File 1). The structured questionnaire comprises approximately 69 items organized into six sections. The Demographics section includes 13 items covering age, gender, education level, academic year, university, and prior training, with no scoring applied. The DDI Knowledge section consists of 23 items: 12 items assess identification of interaction severity for specific drug pairs, and 11 True/False items evaluate understanding of pharmacokinetic/pharmacodynamic mechanisms. Correct answers are scored as 1, while incorrect or "Don't know" responses are scored as 0, with total scores categorized as low (0–9), moderate (10–16), or high (17–23). The Attitudes section includes 12 items measured on a 5-point Likert scale (Strongly Agree = 5 to Strongly Disagree = 1), with total scores ranging from 12 to 60, categorized as negative (12–27), neutral (28–44), or positive (45–60). The Awareness section consists of 5 True/False items covering clinical consequences of DDIs, adverse drug event prevalence, and vulnerable populations, with 1 point per correct answer, yielding a score range of 0–5. The Confidence section includes 5 items measured on a 5-point Likert scale (Very Confident = 5 to Not at All Confident = 1), with total scores ranging from 5 to 25, categorized as low (5–11), moderate (12–18), or high (19–25). The Barriers section consists of 11 items measured on a 5-point Likert scale (Major Barrier = 5 to Not at All a Barrier = 1), with total scores ranging from 11 to 55, categorized as low (11–25), moderate (26–40), or high (41–55).

Statistical analysis

SPSS software version 27.0 have been used for data analysis [11]. First, descriptive statistics were applied to calculate frequencies, percentages, means, and standard deviations to summarize participants' demographic information and the core variables of the study. Inferential statistics were then used for further analysis: independent samples t-tests were employed to compare variables between two groups, one-way analysis of variance (ANOVA) was used to analyze differences across multicategory groups, including age and academic year, and Pearson correlation analysis was adopted to test the associations between core variables. The normality of the data was confirmed via the Shapiro-Wilk test ($P < 0.05$), and the Cronbach's alpha values measuring the reliability of the study's subscales ranged from 0.72 to 0.95.

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee at Al-Quds University (Approval No. 665/REC/2026, approved 28 January 2026). Prior to participation, all students received

information about the research purpose. Participation was entirely voluntary; withdrawal at any time had no consequences for academic standing.

No names or identifying information were collected; all the data were stored under restricted access, solely for research purposes.

Validity and Reliability

The questionnaire was reviewed by a panel of experts for face validity. The internal consistency of the study instruments was assessed via Cronbach’s alpha, which is a measurement used to evaluate how multiple items measuring the same content are related. The results demonstrated excellent reliability for most scales, including barriers ($\alpha = 0.95$), attitudes ($\alpha = 0.94$), and confidence ($\alpha = 0.93$), indicating a very high level of internal consistency. The knowledge scale also showed good reliability ($\alpha = 0.87$), confirming its suitability for measuring the construct.

The awareness scale exhibited acceptable reliability ($\alpha = 0.72$), which is still considered adequate for research purposes, especially given the smaller number of items. Overall, these findings indicate that all the study scales are reliable and appropriate for further statistical analysis.

Results

The demographic characteristics of the participants (Table 2).

Table 2
Demographic variables of the participants.

Variable		No.	%
Age group (years)	20–21	315	39.4%
	22–23	392	48.9%
	24–25	63	7.9%
	> 25	31	3.8%
Gender	Male	148	18.5%
	Female	653	81.5%
Education level	Bachelor's Degree in Pharmacy	700	87.4%
	Pharm D	101	12.6%
Academic year	3rd	252	31.4%
	4th	258	32.2%
	5th	264	33.0%
	6th (Pharm D)	27	3.4%
University name	Al-Najah National University	55	6.9%
	Al-Quds University	647	80.8%
	Birzeit University	58	7.2%
	Arab American University	11	1.4%
	Hebron University	22	2.7%
	Other	8	1.0%
University location	Jerusalem district	614	76.7%
	Nablus	61	7.6%
	Ramallah	40	5.0%
	Hebron	61	7.6%
	Jenin	16	2.0%
	Bethlehem	9	1.1%

Most of the participants were middle aged of 22–23 years (48.9%), followed by the age group of 20–21 years (39.4%), and there are fewer age groups of 24–25 (7.9%) and > 25 years (3.8%). The sample was predominantly female students (81.5%). On average, most participants (87.4%) had a bachelor's degree in pharmacy, whereas (12.6%) were Pharm.D.. Participants were relatively evenly distributed across academic years, with the highest proportion in the fifth year (33.0%), followed by the fourth (32.2%) and third year (31.4%), and only 3.4% were in the sixth year (Pharm.D.). The majority of the participants were from Al-Quds University (80.8%). Most participants were from Jerusalem district (76.7%). The remaining participants were distributed to other districts.

Work-related information for the participants (Table 3).

Table 3
Work-related information of the participants.

Variable		No.	%
Previous pharmacy training	No	194	24.2%
	Yes, community pharmacy	543	67.8%
	Yes, hospital pharmacy	12	1.5%
	Yes, both	52	6.5%
Employment status	Yes, part-time	318	39.7%
	Yes, full-time	59	7.4%
	No	424	52.9%
Role (if working)	Main pharmacist	109	13.6%
	Assistant pharmacist	140	17.5%
	Intern	128	16.0%
Primary practice setting	Community pharmacy	358	44.7%
	Hospital pharmacy	19	2.4%
Medications per prescription	1–2	375	46.8%
	3–5	298	37.2%
	6–8	67	8.4%
	More than 8	61	7.6%
Access to DDI resources	Yes	615	76.8%
	No	186	23.2%
Most sources of DDI information*	University lectures/course materials	471	58.8%
	Textbooks (Pharmacology/Therapeutics)	246	30.7%
	Scientific journals	78	9.7%
	Online databases (Lexicomp, Micromedex, UpToDate, Medscape)	56	7.0%
	Internet websites	44	5.5%
	AI tools (ChatGPT, Gemini)	36	4.5%

* Possible more than one answer.

Most participants had prior training in pharmacies, which were mostly in community pharmacies (67.8%), whereas 24.2% of the participants had no prior training. More than half of the participants are unemployed (52.9%), on the other hand, those who have working positions; a 39.7% were part-timers, and 7.4% were full-timers. Most of the participants were employed in the following roles: assistant pharmacists (17.5%), interns (16.0%), and main pharmacists (13.6%). The primary practice setting was community pharmacies (44.7%), with a limited proportion in hospitals (2.4%).

Regarding clinical exposure, nearly half of the participants (46.8%) encountered prescriptions containing 1–2 medications, while 37.2% managed cases involving 3–5 medications. Furthermore, a significant majority of the students (76.8%) confirmed they had consistent access to drug-drug interaction (DDI) reference resources.

The most common sources of DDI information were university lectures (58.8%) and textbooks (30.7%), followed by scientific journals (9.7%), online databases (7.0%), internet websites (5.5%), and AI tools (4.5%).

Overall knowledge levels toward DDIs (Fig. 2).

Distribution of pharmacy students fall in three knowledge categories based on the scores from the 23 DDI knowledge scale. Just over 40% of the participants scored in the high range (40.7%), whereas roughly one in five fell into the low category (20.7%), leaving the remainder (38.6%), the largest single group when combined with moderate scorers, somewhere in between. The distribution of correct and incorrect answers for each DDI knowledge item is shown in Table 4.

Table 4
Distribution of correct and incorrect answers toward DDI.

Knowledge item	Incorrect No. (%)	Correct No.(%)
1. Simvastatin + Clarithromycin. (Major)	289 (36.1%)	512 (63.9%)
2. Allopurinol + Warfarin. (Major)	402 (50.2%)	399 (49.8%)
3. Carbamazepine + Macrolides. (Major)	445 (55.6%)	356 (44.4%)
4. Warfarin + Trimethoprim–Sulfamethoxazole. (Major)	324 (40.4%)	477 (59.6%)
5. Digoxin + Amiodarone. (Major)	271 (33.8%)	530 (66.2%)
6. Metformin + Erythromycin. (Minor)	552 (68.9%)	249 (31.1%)
7. Sildenafil + Isosorbide mononitrate. (Major)	317 (39.6%)	484 (60.4%)
8. NSAIDs + Antihypertensives. (Minor)	508 (63.4%)	293 (36.6%)
9. SSRIs + MAO inhibitors. (Major)	322 (40.2%)	479 (59.8%)
10. Phenytoin + Cimetidine. (Major)	406 (50.7%)	395 (49.3%)
11. Clopidogrel + Omeprazole. (Minor)	652 (81.4%)	149 (18.6%)
12. Ciprofloxacin + Theophylline. (Major)	386 (48.2%)	415 (51.8%)
13. DDIs may involve CYP450 enzymes. (True)	95 (11.9%)	706 (88.1%)
14. All DDIs present obvious symptoms. (False)	250 (31.2%)	551 (68.8%)
15. Pharmacokinetic interactions involve ADME. (True)	138 (17.2%)	663 (82.8%)
16. OTC drugs do not interact with prescriptions. (False)	204 (25.5%)	597 (74.5%)
17. Mechanism understanding guides clinical action. (True)	126 (15.7%)	675 (84.3%)
18. Systems detect all DDIs without error. (False)	284 (35.5%)	517 (64.5%)
19. DDIs increase risk of adverse reactions. (True)	156 (19.5%)	645 (80.5%)
20. Polypharmacy does not influence DDIs. (False)	231 (28.8%)	570 (71.2%)
21. P-glycoprotein affects DDIs. (True)	161 (20.1%)	640 (79.9%)
22. Severity based only on presence. (False)	279 (34.8%)	522 (65.2%)
23. Polypharmacy is a major risk factor. (True)	161 (20.1%)	640 (79.9%)
Average of correct and incorrect answers (23 items)	37.8%	62.2%

The participants had a moderate level of knowledge of DDIs with an average of 62.2% Positive responses and 37.8% negative responses for the 23 items. Higher correct response rates were noted with general knowledge statements such as CYP450 involvement (88.1%), pharmacokinetic interactions (82.8%), and the role of polypharmacy (79.9%). The number of correct answers for individual drug pairs varied widely. A high frequency of interactions was detected; such as digoxin with amiodarone (66.2%) and simvastatin with clarithromycin (63.9%), However, lower accuracy was reported for minor interactions such as metformin with erythromycin (31.1%), clopidogrel with omeprazole (18.6%), and NSAIDs with antihypertensives (36.6%).

Overall attitudes toward DDI management (Fig. 3).

The majority of participants that showed a positive attitude toward DDI management (41.1%), followed by a neutral attitude (35.8%), and a smaller proportion for a negative attitude (23.1%). Mean scores for each item related to attitudes toward DDI management are presented

in Table 5.

Table 5
Mean score for each item related to attitudes.

Item	Mean	SD
1. Checking for DDIs is an essential part of pharmaceutical care.	3.31	1.53
2. Pharmacists have a professional responsibility to prevent DDIs.	3.24	1.37
3. Identifying and preventing DDIs can significantly improve patient safety.	3.37	1.42
4. I feel confident in my ability to identify clinically significant DDIs.	3.02	1.10
5. DDI checking should be routine for every prescription.	3.29	1.37
6. Pharmacists are more responsible for DDI detection than physicians.	3.07	1.21
7. Limited time makes it difficult to check for DDIs thoroughly*.	2.89	1.18
8. I believe pharmacists need more training related to DDIs.	3.29	1.29
9. I intend to regularly check for DDIs in my future practice.	3.24	1.34
10. Ignoring potential DDIs can result in serious harm to patients.	3.33	1.39
11. Monitoring high-risk patients (e.g., polypharmacy, elderly) for potential DDIs is essential.	3.32	1.38
12. Education about DDIs should include practical topics (e.g., identifying high-risk patients, using drug interaction databases, monitoring for adverse effects).	3.36	1.36
Total Mean Score (12 items)	3.22	1.022
<i>Note. A higher mean score indicates a positive attitude.</i>		

*Reversed coded.

The mean total attitude score for DDI management was 3.22 (SD = 1.02), indicating that the attitudes were generally positive. The highest mean scores for the items related to patient safety improvement (M = 3.37, SD = 1.42), practical DDI education (M = 3.36, SD = 1.36), and the importance of DDI checking in pharmaceutical care (M = 3.31, SD = 1.53).

Confidence in identifying clinically significant DDIs (M = 3.02, SD = 1.10) and the perception that limited time is a barrier to DDI checking (M = 2.89, SD = 1.18) had lower mean scores. Overall, the participants had favorable attitudes toward DDI management but some concerns regarding confidence and time constraint.

Overall awareness of DDIs among participants (Fig. 4).

Proportion of participants who answered awareness items correctly versus incorrectly, covering clinical consequences, prevalence of adverse drug events linked to DDIs, and high-risk patient groups. The participants were strongly aware of DDIs, with an overall positive response rate of 579 (72.3%), versus 222 (27.7%) for negative responses. The distribution of participants' awareness of DDIs is presented in Table 6.

Table 6
Distribution of awareness of DDI.

Item	Not aware No. (%)	Aware No. (%)
1. Approximately 5–10% of adverse drug events are due to DDIs. (True)	145 (18.1%)	656 (81.9%)
2. Undetected DDIs are usually harmless. (False)	326 (40.7%)	475 (59.3%)
3. Elderly and polypharmacy patients are high-risk. (True)	164 (20.5%)	637 (79.5%)
4. DDI severity classified as major, moderate, minor. (True)	179 (22.3%)	622 (77.7%)
5. Pharmacogenomics has no effect on DDIs. (False)	296 (37.0%)	505 (63.0%)
Average of awareness (5 items)	27.7%	72.3%

The highest level of awareness (81.9%), was found for the role of DDIs in adverse drug events and the highest level of risk (79.5%) was reported among elderly and polypharmacy patients. Moderate awareness (77.7%) was obtained for DDI categorization and pharmacogenomics (63.0%), but less awareness (59.3%) was observed for misperception that undetected DDIs are harmless.

Self-perceived confidence and practice intentions (Fig. 5).

Distribution of participants across confidence levels regarding their ability to identify interactions, suggest alternatives, and counsel patients. Confidence clustered heavily in the low-to-moderate range; high confidence was rare, reported by only approximately one in twenty participants (5.1%). Nearly half of the participants had a moderate level of self-confidence and practice intention (49.7%), meanwhile, a low level (45.2%) of self-confidence and self-intention has been recorded. Mean scores for each item related to self-perceived confidence are presented in Table 7.

Table 7
Mean score for each item toward self-perceived confidence.

Item	Mean	SD
1. Confidence in identifying clinically significant DDIs.	2.79	1.26
2. Confidence in understanding DDI mechanisms.	2.95	1.13
3. Confidence in recommending alternative medications to avoid DDIs.	2.82	1.09
4. Confidence in counseling patients about DDIs.	2.92	1.19
5. Confidence in communicating DDI concerns to physicians.	2.94	1.20
Total Mean Score (5 items)	2.86	1.04

The overall mean score for self-perceived confidence in managing DDIs was 2.86 (SD = 1.04), suggesting moderate confidence. The highest confidence scores were observed for knowing the mechanisms of DDIs (M = 2.95, SD = 1.13), and communicating any issues to physicians (M = 2.94, SD = 1.20). However, the participants generally showed lower confidence in the identification of the DDIs, which are clinically significant (M = 2.79, SD = 1.26), and in the provision of alternative treatment (M = 2.82, SD = 1.09).

Perceived barriers to effective DDI management (Fig. 6).

Categorization of participants by the extent to which they perceived barriers, workload, limited resources, and insufficient training as obstacles to manage interactions in practice. Together, moderate and high barrier perceptions accounted for roughly four out of the five participants. There is a greatest percentage; 40.1% of the responders indicated a high level of barriers to effective DDI management, followed by moderate level (39.6%), and a low level (20.3%). Mean scores for each item related to barriers to effective DDI management are presented in Table 8.

Table 8
Mean score for each item toward the barriers to effective DDI management.

Item	Mean	SD
1. Difficulty contacting prescribers when needed.	3.01	1.28
2. Difficulty understanding complex DDI mechanisms.	3.08	1.12
3. Lack of private counseling space.	3.07	1.15
4. Limited training opportunities on DDIs.	3.36	1.20
5. Lack of updated reference resources.	3.22	1.19
6. High workload and insufficient time.	3.32	1.24
7. Difficulty accessing reliable online resources.	3.02	1.15
8. Insufficient clinical training.	3.27	1.18
9. Lack of support or collaboration from physicians.	3.20	1.14
10. Limited access to patients' complete medication profiles.	3.20	1.24
11. Lack of DDI courses limits effective management of interactions.	3.32	1.19
Total Mean Score (11 items)	3.18	.975

The overall mean (3.18, SD = 0.98) indicated a moderate barrier level to the effective management of DDIs.

The highest mean (M = 3.36, SD = 1.20) were prominent among the participants that have no DDIs training opportunities; high workload and insufficient time (M = 3.32, SD = 1.24); and insufficient DDI courses (M = 3.32, SD = 1.19).

Lack of clinical training (M = 3.27, SD = 1.18) and lack of up-to-date reference resources (M = 3.22, SD = 1.19) found to have moderate barrier levels. On the other hand, Lower barrier levels were associated with difficulty in contacting prescribers (M = 3.01, SD = 1.28) and finding reliable online sources (M = 3.02, SD = 1.15). Overall, the participants perceived multiple system, and training, related challenges affecting effective DDI management.

Knowledge, attitudes, and awareness scores by demographic variables (Table 9).

Table 9
Knowledge, attitudes, and awareness by demographic variables.

Variable	Response	No.	Knowledge		Attitude		Awareness		Confidence		Barriers	
			Mean (SD)	P-value	Mean (SD)	P-value	Mean (SD)	P-value	Mean (SD)	P-value	Mean (SD)	P-value
Age group (years)	20–21	315	12.71 (5.29)	< 0.001*	37.21 (11.83)	< 0.001*	3.43 (1.26)	< 0.001*	10.89 (4.12)	< 0.001*	33.84 (10.99)	0.005*
	22–23	392	14.95 (5.16)		38.80 (12.41)		3.65 (1.27)		11.67 (3.96)		35.41 (10.39)	
	24–25	63	16.75 (4.33)		41.16 (12.75)		4.05 (1.14)		11.95 (4.12)		36.67 (11.37)	
	> 25	31	17.52 (3.87)		48.39 (8.67)		4.23 (1.33)		15.35 (3.36)		40.19 (9.24)	
Gender	Male	148	13.55 (5.08)	0.046*	38.57 (12.18)	0.855	3.56 (1.21)	0.573	11.95 (4.49)	0.203	35.49 (10.66)	0.601
	Female	653	14.49 (5.34)		38.77 (12.30)		3.63 (1.29)		11.43 (4.01)		34.98 (10.76)	
Education level	Bachelor's Degree in Pharmacy	700	14.31 (5.39)	0.928	38.17 (12.29)	0.001*	3.62 (1.27)	0.557	11.31 (3.99)	< 0.001*	34.61 (10.73)	0.001*
	Pharm D	101	14.36 (4.67)		42.66 (11.43)		3.54 (1.32)		13.07 (4.53)		38.34 (10.25)	
Academic year	3rd	252	11.32 (5.33)	< 0.001*	36.14 (11.22)	< 0.001*	3.18 (1.29)	< 0.001*	10.63 (4.20)	< 0.001*	32.63 (11.02)	< 0.001*
	4th	258	16.05 (4.17)		39.81 (12.64)		3.93 (1.14)		11.97 (3.98)		36.62 (10.43)	
	5th	264	15.15 (5.21)		39.26 (12.38)		3.63 (1.30)		11.68 (3.94)		35.42 (10.48)	
	6th (Pharm D)	27	17.41 (3.00)		47.48 (11.38)		4.48 (0.75)		14.30 (4.03)		39.81 (8.93)	
University name	Al-Najah National University	55	14.40 (4.75)	0.023*	39.98 (13.09)	< 0.001*	3.84 (1.33)	0.025*	12.35 (4.63)	< 0.001*	37.56 (9.77)	< 0.001*
	Al-Quds University	647	14.15 (5.50)		37.89 (12.05)		3.55 (1.27)		11.05 (3.82)		34.21 (10.73)	
	Birzeit University	58	14.16 (3.87)		46.14 (9.95)		3.74 (1.26)		15.60 (3.55)		42.00 (8.90)	
	Arab American University	11	17.91 (3.21)		34.18 (16.47)		3.91 (1.38)		10.45 (5.16)		31.00 (11.46)	
	Hebron University	22	15.77 (4.10)		38.59 (13.30)		4.00 (1.27)		12.00 (5.01)		36.86 (10.35)	
	Other	8	18.75 (1.16)		51.50 (2.73)		4.75 (0.71)		14.88 (3.91)		38.25 (9.57)	
University location	Jerusalem district	614	14.52 (5.28)	< 0.001*	38.60 (12.34)	0.741	3.67 (1.26)	0.001*	11.28 (4.01)	0.016*	34.68 (10.98)	0.053
	Nablus	61	14.48 (4.77)		39.85 (13.19)		3.74 (1.30)		12.59 (4.56)		38.26 (9.99)	
	Ramallah	40	14.83 (3.82)		41.10 (13.07)		3.70 (1.32)		12.75 (4.62)		37.25 (11.46)	
* $p < 0.05$												

Variable	Response	No.	Knowledge		Attitude		Awareness		Confidence		Barriers	
			Mean (SD)	P-value	Mean (SD)	P-value	Mean (SD)	P-value	Mean (SD)	P-value	Mean (SD)	P-value
	Hebron	61	11.23 (5.99)		37.92 (8.89)		2.95 (1.22)		12.26 (3.39)		35.33 (7.67)	
	Jenin	16	16.13 (4.13)		38.19 (15.23)		3.75 (1.34)		12.25 (5.60)		35.38 (10.59)	
	Bethlehem	9	14.44 (6.65)		36.22 (13.09)		3.11 (1.27)		9.89 (4.08)		28.89 (9.16)	
* $p < 0.05$												

There were several significant differences between the demographic variables. Age group was significantly ($P < 0.01$) related to every outcome measured. Similarly, academic year was significantly related to all the outcomes.

The relationship with gender was significant for knowledge only ($P = 0.046$). However, there was no relationship between gender and the other outcomes. There were significant differences with respect to educational level for attitude ($P = 0.001$), confidence ($P < 0.001$), and barriers ($P = 0.001$), but there were no significant differences with respect to knowledge and awareness. The name of the University was significantly associated with every outcome measured; for knowledge ($P = 0.023$), attitudes ($P < 0.001$), awareness ($P = 0.025$), confidence ($P < 0.001$), and barriers ($P < 0.001$). There were significant differences between university locations in terms of knowledge ($P < 0.001$), awareness ($P = 0.001$), and confidence ($P = 0.016$), but not for attitudes and barriers.

Knowledge, attitudes, and awareness scores by work-related variables (Table 10).

Table 10
Knowledge, attitudes, and awareness by work-related variables.

Variable		No.	Knowledge		Attitude		Awareness		Confidence		Barriers	
			Mean (SD)	P-value	Mean (SD)	P-value	Mean (SD)	P-value	Mean (SD)	P-value	Mean (SD)	P-value
Previous training	No	315	12.71 (5.29)	< 0.001*	37.21 (11.83)	< 0.001*	3.43 (1.26)	< 0.001*	10.89 (4.12)	< 0.001*	33.84 (10.99)	0.005*
	Yes, community pharmacy	392	14.95 (5.16)		38.80 (12.41)		3.65 (1.27)		11.67 (3.96)		35.41 (10.39)	
	Yes, hospital pharmacy	63	16.75 (4.33)		41.16 (12.75)		4.05 (1.14)		11.95 (4.12)		36.67 (11.37)	
	Yes, both	31	17.52 (3.87)		48.39 (8.67)		4.23 (1.33)		15.35 (3.36)		40.19 (9.24)	
Employment status	Yes, part-time	148	13.55 (5.08)	0.046*	38.57 (12.18)	0.855	3.56 (1.21)	0.573	11.95 (4.49)	0.203	35.49 (10.66)	0.601
	Yes, full-time	653	14.49 (5.34)		38.77 (12.30)		3.63 (1.29)		11.43 (4.01)		34.98 (10.76)	
	No	700	14.31 (5.39)	0.928	38.17 (12.29)	0.001	3.62 (1.27)	0.557	11.31 (3.99)	< 0.001*	34.61 (10.73)	0.001*
Role (if working)	Main pharmacist	101	14.36 (4.67)		42.66 (11.43)		3.54 (1.32)		13.07 (4.53)		38.34 (10.25)	
	Assistant pharmacist	252	11.32 (5.33)	< 0.001*	36.14 (11.22)	< 0.001*	3.18 (1.29)	< 0.001*	10.63 (4.20)	< 0.001*	32.63 (11.02)	< 0.001*
	Intern	258	16.05 (4.17)		39.81 (12.64)		3.93 (1.14)		11.97 (3.98)		36.62 (10.43)	
Primary practice setting	Community pharmacy	264	15.15 (5.21)		39.26 (12.38)		3.63 (1.30)		11.68 (3.94)		35.42 (10.48)	
	Hospital pharmacy	27	17.41 (3.00)		47.48 (11.38)		4.48 (0.75)		14.30 (4.03)		39.81 (8.93)	
Medications per prescription	1–2	55	14.40 (4.75)	0.023*	39.98 (13.09)	< 0.001*	3.84 (1.33)	0.025*	12.35 (4.63)	< 0.001*	37.56 (9.77)	< 0.001*
	3–5	647	14.15 (5.50)		37.89 (12.05)		3.55 (1.27)		11.05 (3.82)		34.21 (10.73)	
	6–8	58	14.16 (3.87)		46.14 (9.95)		3.74 (1.26)		15.60 (3.55)		42.00 (8.90)	
	More than 8	11	17.91 (3.21)		34.18 (16.47)		3.91 (1.38)		10.45 (5.16)		31.00 (11.46)	
Access to DDI resources	Yes	22	15.77 (4.10)		38.59 (13.30)		4.00 (1.27)		12.00 (5.01)		36.86 (10.35)	
	No	8	18.75 (1.16)		51.50 (2.73)		4.75 (0.71)		14.88 (3.91)		38.25 (9.57)	
		614	14.52 (5.28)	< 0.001*	38.60 (12.34)	0.741	3.67 (1.26)	0.001*	11.28 (4.01)	0.016*	34.68 (10.98)	0.053
		61	14.48 (4.77)		39.85 (13.19)		3.74 (1.30)		12.59 (4.56)		38.26 (9.99)	
		40	14.83 (3.82)		41.10 (13.07)		3.70 (1.32)		12.75 (4.62)		37.25 (11.46)	

* $P < 0.05$

Variable	No.	Knowledge		Attitude		Awareness		Confidence		Barriers	
		Mean (SD)	P-value	Mean (SD)	P-value	Mean (SD)	P-value	Mean (SD)	P-value	Mean (SD)	P-value
	61	11.23 (5.99)		37.92 (8.89)		2.95 (1.22)		12.26 (3.39)		35.33 (7.67)	
	16	16.13 (4.13)		38.19 (15.23)		3.75 (1.34)		12.25 (5.60)		35.38 (10.59)	
	9	14.44 (6.65)		36.22 (13.09)		3.11 (1.27)		9.89 (4.08)		28.89 (9.16)	
	358	15.68 (4.43)	< 0.001*	38.65 (12.67)	0.466	3.77 (1.25)	0.012*	11.81 (4.38)	0.324	35.02 (11.04)	0.639
	19	11.68 (4.62)		36.47 (13.00)		3.21 (0.85)		10.79 (4.38)		33.79 (12.64)	
	375	13.18 (5.69)	< 0.001*	38.27 (12.02)	0.437	3.51 (1.28)	0.081	11.10 (3.88)	0.008*	34.82 (10.22)	0.406
	298	15.14 (4.69)		39.01 (12.53)		3.68 (1.30)		11.93 (4.28)		35.50 (10.88)	
* $P < 0.05$											

Significant differences were obtained for work-related factors for some variables. Training on DDIs in the past was significantly related to all outcomes, including knowledge, attitudes, awareness, confidence, and barriers ($P \leq 0.005$).

Employment status had a significant effect only on knowledge ($P = 0.046$) but was not significant for the other outcomes.

Role had a significant effect on all outcomes ($P < 0.001$). The number of medications in a prescription was significantly related to all outcomes, including knowledge ($P = 0.023$), attitude ($P < 0.001$), awareness ($P = 0.025$), confidence ($P < 0.001$), and barriers ($P < 0.001$).

The availability of DDI information sources was significantly correlated with knowledge ($P < 0.001$), awareness ($P = 0.001$), and confidence ($P = 0.016$), but not for attitudes and barriers.

The number of drugs in a prescription was also found to be significant for knowledge ($P < 0.001$) and confidence ($P = 0.008$), whereas the practice setting had a significant difference for knowledge ($P < 0.001$) and awareness ($P = 0.012$).

Discussion

Knowledge of drug-drug interactions

The findings of the current study indicated that the knowledge of the Palestinian pharmacy students toward DDIs was moderate. These findings concur with several studies conducted in the region, such as in Jordan [12], Egypt [9]; where study participants exhibited basic (not advanced) skills toward DDIs [13], and Saudi Arabia [7], where students had theoretical knowledge toward DDIs but failed to identify specific drug pairs involved in drug–drug interactions, seems likely, they had insufficient clinical exposure during their undergraduate training [14]. The results revealed that there is still a gap between knowledge and practice. While Palestinian pharmacy students have a medium level of knowledge, there have been similar reports in the region; for example, Jordanian pharmacists had “poorly satisfied” food–drug interaction skills (median score approximately 60%), and the mean DDI knowledge score among Saudi community pharmacists was 38.22%.

Interestingly, the participants in this study scored higher than those in the study in Ethiopia [6], potentially because of differences in curriculum or exposure to specific training. However, the low accuracy rate of 18.6% in identifying the interaction between clopidogrel and omeprazole indicates limitations in practice, which was similarly noted to be the case with some of the other minor DDIs as well.

Although students generally understand the concept, they sometimes have trouble applying it in real clinical situations similar to those observed in Indonesia[5]. These gaps may directly impact patient safety. Poor identification of these DDIs results in adverse drug reactions [15].

Attitudes and Self-Confidence

The data indicate that the majority of pharmacy students (41.1%) have highly positive attitudes concerning the necessity of DDI management. It appears that the participants view the ability to determine and prevent interactions as an integral part of their professional commitments to the patient safety. The high reliability of the attitude scale ($\alpha = 0.94$) further amplifies the inner consistency and sincerity of these positive views of the participants. This alignment is consistent with other studies on Palestinian community pharmacists [2].

However, even though they have positive attitudes, they are not very self-confident in regard to providing clinical recommendations or suggesting alternative medications. This could be attributed to limited hands-on experience and insufficient clinical training. This gap in confidence was also depicted in Ethiopian studies [6] and in Saudi Arabia [8].

Collectively, these findings indicate that students might experience difficulties in dealing with real-life clinical management, even though they may have strong theoretical knowledge.

Impact of Academic Level and Practical Training

The validity of the comparative analysis was ensured by the normal distribution of the data according to the Shapiro-Wilk test ($P < 0.05$).

Normal distribution is a premise for using inferential statistics, including independent-samples t-tests and ANOVA. Our results showed students in higher academic years, especially Pharm.D. had better results than did students with lower academic years.

This can be explained by increased exposure to clinical courses and hospital-based training. The Pharm.D. program in Palestine focuses on clinical, patient-oriented studies, more heavily than the traditional B.Sc. Pharmacy program. Besides that, Pharm. D. students have good practice in community pharmacies which has positive effect on students' confidence as well as practice scores [12]. This highlights the importance of practical clinical training knowledge development and gain confidence by students, which is in agreement with previous research that documented the need for practical experience in understanding complex clinical cases [2].

Barriers to Effective DDI Management

Throughout the study, several barriers were recognized that can affect students' ability to identify and manage DDIs; the lack of training opportunities ($M = 3.36$), a high workload and insufficient time ($M = 3.32$), and a lack of DDI-related courses ($M = 3.32$). Such barriers are likely to limit students' ability to put the knowledge they learn into practice. Multiple barriers at the systemic level and related to training were mentioned by the participants, with a lack of opportunities for training and a heavy workload being the most important.

Similar barriers were reported in literature from different countries in Indonesia [5] and Egypt [9].

Strengths and Limitations

This study has several strengths, including the use of a large sample consisting of 801 pharmacy students representative of multiple universities in Palestine, thus improving the validity and reliability of the results. Nevertheless, there are limitations that should be mentioned; owing to the use of a self-administered structured questionnaire, some participants may have provided socially acceptable answers rather than how they actually practice in real life (social desirability bias), which can influence the accuracy of the results. Additionally, the fact that only pharmacy students were chosen to participate in the study might reduce its generalizability to practicing pharmacists. Furthermore, this study employed convenience sampling, which may limit the generalizability of the findings to the broader student population and introduces the potential for selection bias. Finally, the nature of cross-sectional studies also means that the evolution of the competency of the participants cannot be tracked, and as a result, definitive cause-effect relationships cannot be clearly established.

Conclusion

Summary of Findings

The study revealed that pharmacy students in Palestine have a moderate degree of knowledge of DDIs, with an average percentage of correct answers of 62.2%. This knowledge exists together with relatively high levels of awareness (72.3%) and positive attitudes about the importance of DDIs in a clinical setting. However, there is a noticeable gap between theory and practice, particularly in the recognition of specific drug interactions, such as clopidogrel-omeprazole pair (18.6%). Moreover, a moderate level of confidence was detected ($M = 2.86$), indicating the need to improve clinical decision-making and clinical application skills.

Additionally, academic year and previous training positively affected knowledge, awareness, and confidence ($P < 0.001$). There are several barriers to effective DDI management, including a lack of training opportunities and time due to workload.

Implications and Recommendations

Overall, the results highlight the need for improvements in practice and clinical skills training in the pharmacy curriculum, which will not only help to improve the preparedness of students in professional practice but also improve the safety of patients from preventable adverse drug interactions. This study fills a regional evidence gap as it provides one of the first studies assessing the competencies of DDI among pharmacy students in Palestine. The results provide baseline information about students' knowledge, attitudes, and awareness, which will be useful in changing the curriculum and evaluation criteria.

Improving DDI competencies during training and producing well-trained graduates is essential to improve population health outcomes.

Abbreviations

- ADME: Absorption, distribution, metabolism, and excretion (factors involved in pharmacokinetic interactions).
- AI: Artificial intelligence (which specifically refers to tools such as ChatGPT and Gemini).
- ANOVA: One-way analysis of variance (a statistical method used to compare means across multiple groups).
- B.Sc. Pharmacy: Bachelor of science in pharmacy.
- CYP450: Cytochrome P450 (enzymes involved in drug metabolism).
- DDIs: Drug-drug interactions.
- M: Mean (the average value in a dataset).
- MAO inhibitors: Monoamine oxidase inhibitors.
- NSAIDs: Nonsteroidal anti-inflammatory drugs.
- OTC: Over-the-counter (medications available without a prescription).
- Pharm.D.: Doctor of pharmacy.
- SD: Standard deviation (a measure of data variation).
- SPSS: Statistical Package for the Social Sciences (the software used for data analysis).
- SSRIs: Selective serotonin reuptake inhibitors.
- WHO: World Health Organization.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and the ethical standards of the Research Ethics Committee at Al-Quds University (Approval No. 665/REC/2026, approved 28 January 2026). All individuals signed informed consent before participating in the study. All participants were provided with information concerning the purpose of the study, assurance that participation was voluntary, and that they reserved the right to withdraw from the study at any time without any impact on their academic standing. No names or personal information was collected, ensuring the confidentiality and anonymity of all the participants.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and analyzed during the current study are available from the corresponding author, Huda Suleiman, on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

HKS, AHS, and YHK conceptualized the study design, developed the research instrument, and executed the data collection. They were also responsible for performing the statistical analysis. HKS critically revised the manuscript for important intellectual content. DIQ served as the primary supervisor. All the authors read and approved the final manuscript.

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Figures

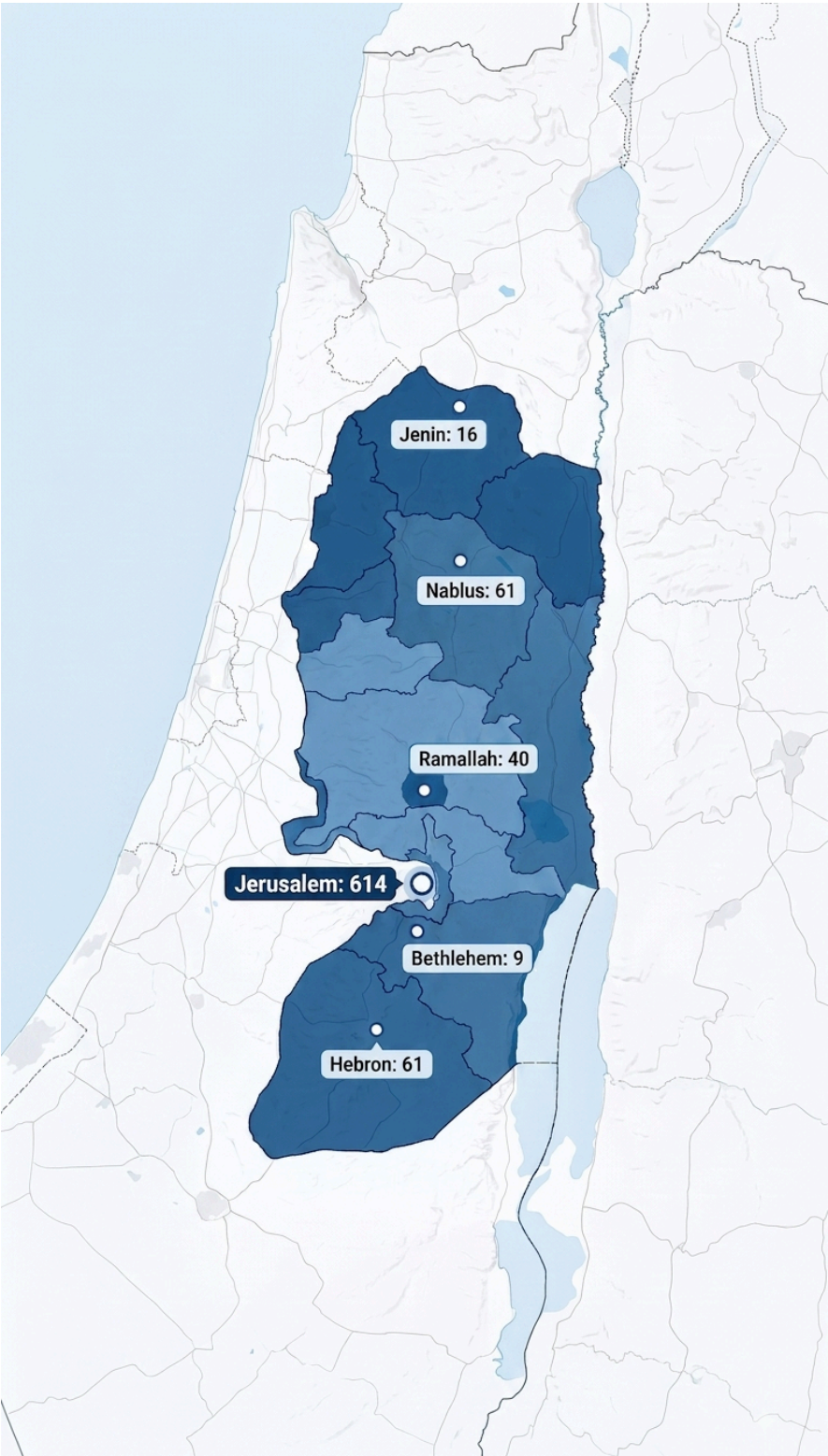


Figure 1
Geographic distribution of pharmacy student participants across Palestinian districts.

Knowledge Level Toward Drug–Drug Interaction

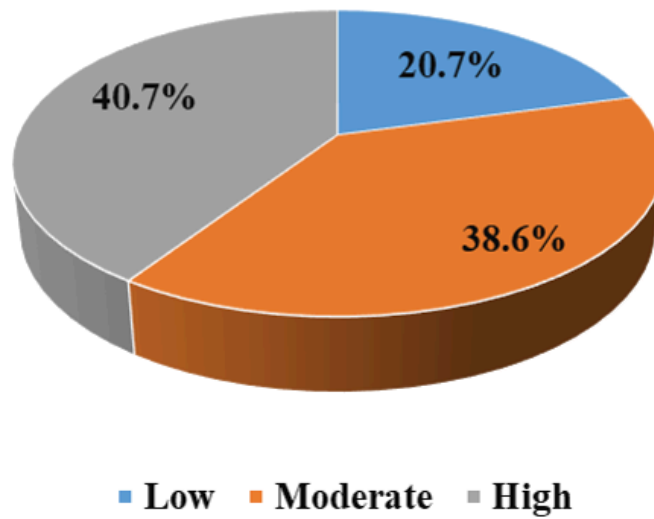


Figure 2

Knowledge levels toward DDIs.

Attitudes Level Toward DDI Management

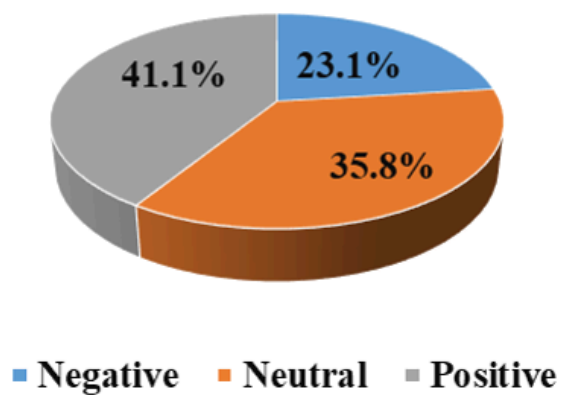


Figure 3

Attitudes toward DDI management.

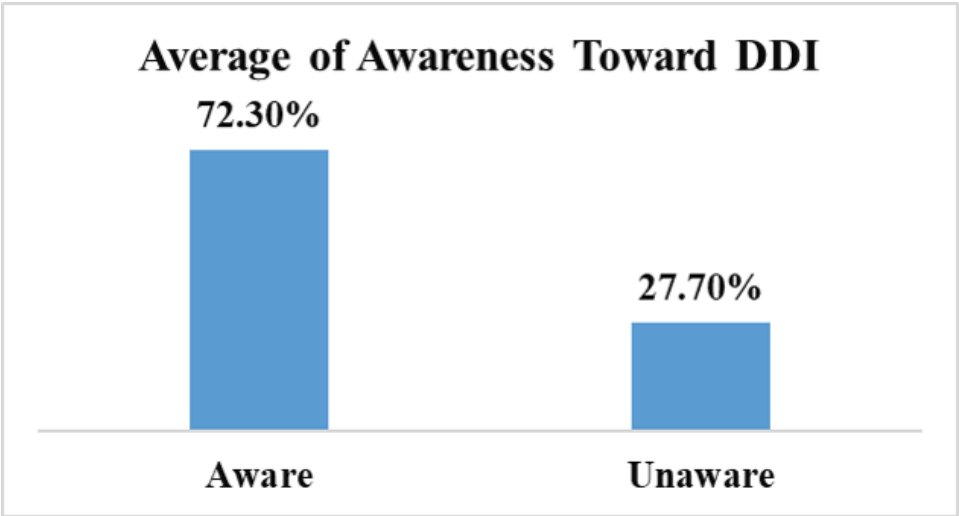


Figure 4

Average awareness of DDI.

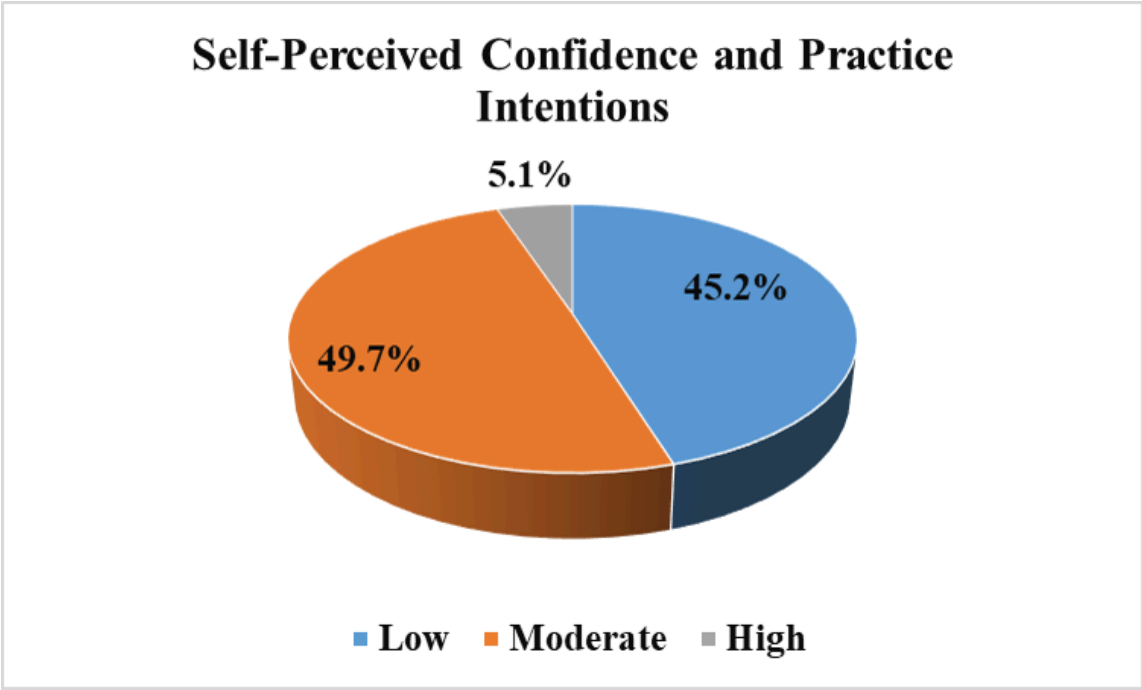


Figure 5

Self-perceived confidence and practice intentions.

Barriers level to effective DDI management

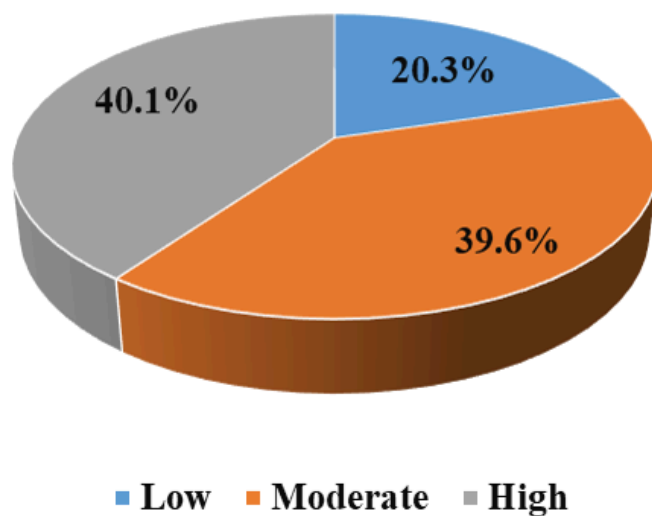


Figure 6

Barriers to effective DDI management.

Supplementary Files

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- [AdditionalFile1StudyQuestionnaire.docx](#)