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Impact of clinical pharmacist-led interventions on physicians' knowledge, attitudes, and practices in managing drug-induced QT prolongation

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ABSTRACT **Objective:** Drug-induced QT prolongation is a critical adverse effect associated with life-threatening arrhythmias. This study evaluated the impact of clinical pharmacist-led interventions on physicians' knowledge, attitudes, and practices (KAP) regarding QT prolongation management. **Material and Method:** A quasi-experimental study was conducted at three Iraqi hospitals (January–April 2025) involving 53 physicians and 100 patients. Pre- and post-intervention assessments were performed using validated questionnaires. The intervention included educational lectures, checklists, and pharmacist consultations targeting QT-prolonging drug risks, ECG monitoring, and electrolyte management. **Result and Discussion:** Post-intervention, physicians demonstrated significant improvements in knowledge (mean score: 4.3±1.4 to 5.6±1.7, $p<0.001$), with 26.4% achieving "good knowledge" (vs. 5.7% pre-intervention). Attitudes improved markedly, with 60.4% rating pharmacist collaboration as "important" (vs. 35.8%, $p=0.0046$). **Clinical practices showed the most pronounced change:** frequent prescribing of QT-prolonging drugs dropped from 18.9% to 0% ($p=0.0067$), and ECG monitoring adherence increased. The prevalence of QT prolongation in patients decreased non-significantly from 36% to 29% ($p=0.29$). These findings align with global evidence supporting pharmacist-led interventions in cardiovascular risk mitigation. The study highlights the value of interprofessional collaboration in enhancing medication safety.

KEYWORDS drug-induced QT prolongation, clinical pharmacist, physician education, medication safety, interprofessional collaboration

1. INTRODUCTION

The QT interval, measured on an electrocardiogram (ECG), represents the time from the beginning of ventricular depolarization to the end of repolarization [1]. Prolongation of the corrected QT interval (QTc) is associated with life-threatening arrhythmias such as Torsades de Pointes (TdP) and sudden cardiac death [2]. Various factors contribute to QTc prolongation, including medications (e.g., antibiotics, antiarrhythmics, antiemetics, antipsychotics) [3], electrolyte imbalances (e.g., hypokalemia, hypomagnesemia, hypocalcemia), genetic predispositions, and systemic inflammation. Women are generally more susceptible than men, and the condition is prevalent among patients in intensive care units and emergency departments [4], [5]. Accurate measurement and correction of the QT interval, often using formulas like Bazett's, are critical for clinical assessment, though no single standard method exists [6], [7]. Symptoms of QT prolongation range from dizziness and syncope to seizures and, in severe cases, cardiac arrest [6].

By assessing the knowledge, attitudes and practices of physicians towards drug induced QT prolongation, we expect that the prevalence and risks of QT prolongation will be declined and enhance practices and attitudes of physicians after our assessment. QTc prolongation is common, affecting 24–28% of ICU patients and 37% of elderly hospitalized individuals, yet its drug-related risks are often underrecognized in clinical practice [8]. Polypharmacy increases drug-related problems, especially in the elderly, but pharmacists have shown value in preventing such issues across care settings [9]. Collaborative Residential Medication Management Reviews (RMMRs) involve pharmacists in comprehensive medication assessments and have been supported since 1997, involving various healthcare stakeholders [10]. Pharmacists enhance detection of drug-related problems and reduce polypharmacy in older patients [9].

In psychiatric care, Daniel et al. implemented a pharmacist-led ECG protocol for QTc monitoring, improving appropriateness and reducing risks compared to traditional physician-led monitoring. Tien et al. supported the effectiveness of pharmacist-driven QTc surveillance [11]. Pharmacists also play a key role in identifying QTc-prolonging drug interactions, although specific guidelines for community and primary care settings are lacking [12]. Advanced clinical rules integrating patient and lab data help improve alert accuracy

and reduce unnecessary warnings [13].

2. MATERIAL AND METHOD

2.1 Study design

A pre and post interventional Quasi-experimental study was conducted at Merjan teaching Hospital, Imam Al Sadiq teaching hospital and Shahid Almehrab tertiary catheterization center. The time of this study was extended over a period of 3 months beginning from the 15th of January to the 15th of April 2025. The intervention also included

1. brochures and checklists to enhance awareness among physicians.
2. Identify and stop QT-prolonging drugs.
3. Suggest safer alternatives.
4. monitoring electrolytes.
5. Recommend ECG monitoring.
6. Flag drugs increasing QT risk.
7. Educate physicians by lectures and face to face dialogues.

2.2 Study populations

This study included a convenient sample of 100 patients pre and post intervention who admitted to coronary care and emergency units in Al-Hilla hospitals mentioned above who agreed to participate in this study.

2.3 Inclusion criteria

Hospitalized patients aged 18 or older, prescribed medications known to prolong the QT interval, and with at least one risk factor for QT prolongation (e.g., renal dysfunction, heart disease, electrolyte imbalances). And cardiologists and internists who work at coronary care units.

2.4 Exclusion criteria

Patients with congenital long QT syndrome or Those with incomplete medical records or ECGs

2.5 Sample calculation

The sample(size)for the number of doctors included in this study was estimated using the following assumptions:

- Confidence level (α) = 0.05 (two-tailed)
- Statistical power (1-β) = 0.80
- Expected effect size (Cohen's d) = 0.40 (moderate effect size)
- Study design = paired (within-subjects) comparison of pre- and post-intervention KAP scores.

Using these parameters and employing the formula for comparing means in paired samples, The smallest sample size needed was 45 participants. To take into consideration possible non-responses and insufficient information, a 15% increase was applied, yielding a final required sample size of approximately 53 participants.

2.6 Questionnaire Reliability and validation assessment

The reliability and validity of the developed questionnaire were evaluated using several statistical approaches to ensure its internal consistency, temporal stability, and construct validity.

2.7 Internal consistency reliability

Using Cronbach's Alpha (α), internal consistency was evaluated. The scale comprised 53 physicians (K = 53). The relevant parameters were as follows:

- Total sum of item scores (Sy) = 3216
- Sum of individual item scores (Si) = 1232
- Degrees of freedom (K-1) = 52

The computed Cronbach's Alpha indicated a satisfactory level of internal consistency across the items, supporting the reliability of the scale.

2.8 Split-half reliability

Two split-half methods were applied to further assess internal consistency:

- First half versus second half: correlation coefficient = 0.53
- Even-numbered items versus odd-numbered items: correlation coefficient = 0.46

These findings suggest a moderate level of agreement between the respective item groupings.

2.9 Test-retest reliability (external consistency)

Temporal stability of the questionnaire was evaluated by administering it twice, one week apart. The correlation coefficient between the first and second administrations was 0.68, indicating acceptable test-retest reliability.

2.10 Convergent validity and composite reliability

Composite Reliability (CR) and AverageVarianceExtracted (AVE) were used to evaluate convergent validity. Calculations were based on a sample size of 50 participants (n = 50) with the following values:

- Sum of standardized factor loadings ($\sum \lambda$) = 35.76
- Sum of squared standardized loadings ($\sum \lambda^2$) = 32.1696
- Sum of error variances ($\sum \varepsilon$) = 7.8304

The calculation of the Average Variance Extracted (AVE) was as follows:

$$AVE = \sum \lambda^2 / n = 32.1696/50 = 0.804.$$

The Composite Reliability (CR) was calculated as:

$$CR = \sum \lambda^2 / (\sum \lambda^2 + \sum \varepsilon) = 32.1696/(32.1696 + 7.8304) = 0.994.$$

These values indicate excellent convergent validity and high internal consistency of the construct being measured.

2.11 Sampling technique

This study included a convenient sample of 100 patients pre and post interventional who admitted to coronary care and emergency units in Al-Hilla hospitals mentioned above who agreed to participate in this study.

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2.12 Data collection tools

Data was collected by using a predesigned questionnaire by which the physicians were interviewed after giving their verbal consent. Each physician was interviewed for about 5 minutes. This questionnaire has been approved by a committee of experts as shown in the appendix which included the following items:

2.13 Demographic information

Age, Gender, Speciality, Years of Practicing medicine, Hospital type.

Knowledge attitude practice scoring logic

Knowledge Scoring Logic

Total Possible Knowledge Score: 0 to 11 according to Table 1.

The total knowledge score, derived from participants' responses to key questions related to QT interval prolongation, was categorized into two distinct levels to facilitate analysis. A cutoff score of 7 out of a maximum of 11 was selected as the threshold for adequate knowledge. Accordingly, participants who scored between 0 and 6 were classified as having inadequate knowledge, reflecting a limited understanding of QT prolongation risk factors, associated drug categories, and appropriate clinical practices. Conversely, those who achieved a score of 7 or higher were considered to possess adequate knowledge, indicating a satisfactory level of awareness and comprehension necessary for the effective identification and management of drug-induced QT interval prolongation in clinical settings.

2.14 Attitude scoring logic

This part of questionnaire consisted of 5 questions about attitudes of physicians which are evaluated This part included the following questions:

1) How comfortable are you collaborating with clinical pharmacist to manage QT prolongation risks?

2) What is your perception of clinical pharmacists' knowledge and skills in managing QT prolongation?

3) What do you perceive as the primary benefits of involving clinical pharmacists in QT prolongation interval management?

4) Would you be willing to involve clinical pharmacists more actively in the management of QT prolongation?

5) In your opinion, what are the main barriers to implementing pharmacist-led interventions for QT prolongation?

Total Attitude Score: Range depends on selected responses (Maximum: 9). The total attitude score, derived from participants' responses was categorized into two levels. Given the maximum possible attitude score of 9, a cutoff score of 5 was utilized to distinguish between favorable and unfavorable attitudes. Participants with scores ranging from 0 to 4 were classified as having an unfavorable attitude, reflecting limited recognition of the role of clinical pharmacists, lower comfort with interprofessional collaboration, or negative perceptions of pharmacists' expertise. In contrast, participants who scored 5 or above were considered to exhibit a favorable attitude, indicating a positive disposition toward collaborative practice, confidence in pharmacists' capabilities, and an appreciation of the clinical benefits of pharmacist-led interventions.

2.15 Practice scoring logic

This part of questionnaire consisted of 8 questions about practice of physicians about QT interval. This part included the following questions:

1. How often do you prescribe drugs known to cause QT prolongation?

2. Do you consult clinical pharmacist when prescribing QT-prolonging medications?

3. Based on a clinical pharmacist recommendation, do you have a previous modification on your prescribing decision?

4. How often do you perform ECG monitoring before prescribing QT-prolonging medications?

5. Do you request electrolyte monitoring for patients on QT-prolonging medications?

6. According to your experience, what is the most important electrolyte test for QT prolonged patients?

7. Have you experienced before a QT prolonged case?

8. If yes, what step do you take if a patient develops a prolonged QT interval?

The total practice score, derived from the participants' responses to items assessing their clinical behaviors related to the management of QT interval prolongation, was categorized into two levels for interpretative and analytical clarity. The maximum attainable practice score was 13.5, based on cumulative scores assigned to each response reflecting evidence-based or recommended clinical practices. A cutoff score of 7 was established to distinguish between inadequate and adequate practice. Participants who achieved a score of less than 7 were classified as having inadequate practice, indicating suboptimal adherence to recommended strategies such as ECG monitoring, consultation with clinical pharmacists, and appropriate response to QT-prolonging risks. Conversely, participants who scored 7 or above were categorized as having adequate practice.

2.16 Barriers to the study

1. The follow-up period post-intervention was short, which may not have been sufficient to capture long-term behavioral change or sustained impact on QT prolongation prevalence.

2. The intervention was limited to a single cycle of pharmacist-led education and consultation without reinforcement, which may have constrained the depth of knowledge retention or practice transformation among physicians.

3. Additionally, the study relied on self-reported data for certain physician practices, which may be subject to reporting bias or social desirability effects.

4. The lack of a control group prevents causal inference, as improvements could partly reflect external influences or concurrent institutional initiatives.

2.17 Statistical analysis

Categorical variables were summarized using frequencies and percentages. To assess changes in doctors' knowledge, attitudes, and practices before and after the clinical pharmacist-led intervention, appropriate paired categorical tests were applied. Specifically, McNemar's Chi-squared test with continuity correction was used to compare paired proportions in dichotomous variables, evaluating the significance of changes in binary responses pre- and post-intervention. For variables with more than two related categories, the Stuart-Maxwell test was employed to determine marginal homogeneity and assess the overall distributional shift across response categories. Continuous variables representing total knowledge, attitude, and practice scores were presented as means and standard deviations. To evaluate the effect of the clinical pharmacist-led intervention on these scores, a paired t-test was employed. The Welch's t-test was used to test the differences in means between two dependent variables. Either Fisher's exact test or the Chi-squared test

(χ^2) with Yates'correction were used to examine the difference between categorical variables when more than 20% of cells had expected frequencies less than 5. P-values below 0.05 were deemed statistically significant. R software packages were utilized for statistical analysis, data processing, and visualization. ("R version 4.5.0, R Foundation for Statistical Computing, Vienna, Austria").

3. RESULT AND DISCUSSION

3.1 Description of doctors characteristics

The demographic and educational characteristics of the doctors involved in the study are presented in Table 1.

TABLE 1. Description of doctor's demographics and information related to their education

Characteristic	N = 531
Age (years)	
<30	19 (35.8%)
31-40	17 (32.1%)
41-50	13 (24.5%)
>50	4 (7.5%)
Gender	
Male	36 (67.9%)
Female	17 (32.1%)
Medical specialty	
Internist	24 (45.3%)
Senior Cardiologist	15 (28.3%)
Cardiology Resident	14 (26.4%)
Years of Practicing medicine	
<5 years	20 (37.7%)
5-10 years	15 (28.3%)
>10 years	18 (34.0%)

3.2 Descriptions of doctor's knowledge, attitudes, and practices

changes in the doctors' knowledge regarding drug-induced QT interval prolongation before and after clinical pharmacist-led interventions presented in Table 2. Significant improvements in the doctors' understanding were observed across several key areas. Regarding their expectations about the seriousness of QT interval prolongation, a greater proportion of doctors considered it "very serious" after the intervention (86.8%) compared to before (73.6%), with a statistically significant change ($p < 0.001$). Regarding the identification of specific risk factors, there was no significant change in the recognition of QT-prolonging drugs (62.3% vs. 60.4%, $p = 0.8$) or pre-existing cardiac conditions (20.8% vs. 24.5%, $p = 0.7$), and responses related to electrolyte disturbances remained constant at 24.5%. However, a significant increase was observed in the recognition of advanced age as a risk factor (5.7% before vs. 24.5% after, $p = 0.002$). Notably, the proportion of participants who correctly identified all risk factors increased markedly from 3.8% to 20.8% post-intervention ($p < 0.001$). In terms of routine practices regarding the assessment of potential drug–drug interactions that could prolong the QT interval, there was a slight but significant increase in the number of doctors who routinely assessed for these interactions, from 86.8% to 90.6% ($p < 0.001$). When asked about the perceived most common consequences of QT prolongation in hospitalized patients, a larger proportion identified ventricular arrhythmia after the intervention (75.5%) compared to before (56.6%) ($p = 0.019$). Notably, the identification of specific drug categories most frequently associated with QT prolongation saw a marked shift. Finally, the willingness of doctors to collaborate with clinical pharmacists in managing drug-induced QT prolongation increased significantly, with 92.5% expressing willingness after the intervention, compared to 77.4% before ($p < 0.001$).

The clinical pharmacist-led intervention implemented in this study produced notable improvements in physician knowledge concerning drug-induced QT interval prolongation. Following the intervention, a significantly larger proportion of physicians recognized the condition as "very serious" (86.8% vs. 73.6%, $p < 0.001$), indicating a heightened appreciation for its clinical significance. This mirrors findings from Hoehns et al., who demonstrated that pharmacist integration using mobile ECG tools heightened prescriber awareness and responsiveness to QTc risks in outpatient settings [14]. While baseline recognition of QT-prolonging drugs remained unchanged, physicians demonstrated improved ability to identify advanced age as a risk factor (24.5% vs. 5.7%, $p = 0.002$) and to correctly select all relevant risk factors (20.8% vs. 3.8%, $p < 0.001$). These results reflect broader trends noted by Dixon et al., whose systematic review of pharmacist-led amiodarone monitoring highlighted similar increases in prescriber knowledge regarding age-related cardiac toxicities [15]. Furthermore, physicians showed enhanced recognition of the specific consequences of QT prolongation, with a significant increase in identifying ventricular arrhythmias (75.5% vs. 56.6%, $p = 0.019$). The accurate interpretation of clinical outcomes has been previously emphasized in collaborative care models like that evaluated by Quffa et al., where pharmacy-cardiology partnerships improved physician competency in the management of QT-prolonging agents

TABLE 2. Description of the knowledge of the doctors before and after clinical pharmacist-led interventions

Characteristic	Before intervention	After intervention	P-value
Participants' expectations regarding risk factors for QT interval prolongation.			<0.001
Very serious	39 (73.6%)	46 (86.8%)	
Ordinary serious	14 (26.4%)	7 (13.2%)	
Identification of the most common risk factors associated with QT interval prolongation.			
Use of QT prolongation drugs	33 (62.3%)	32 (60.4%)	0.8
Electrolyte disturbances	13 (24.5%)	13 (24.5%)	NA
Pre-existing cardiac conditions	11 (20.8%)	13 (24.5%)	0.7
Advanced age	3 (5.7%)	13 (24.5%)	0.002
All	2 (3.8%)	11 (20.8%)	<0.001
Routine practices regarding the assessment of potential drug–drug interactions that may prolong the QT interval.			<0.001
Yes	46 (86.8%)	48 (90.6%)	
No	7 (13.2%)	5 (9.4%)	
Perceived most common consequences of QT interval prolongation in hospitalized patients.			0.019
Ventricular arrhythmia	30 (56.6%)	40 (75.5%)	
Bradycardia	13 (24.5%)	13 (24.5%)	
AF	8 (15.1%)	0 (0.0%)	
MI	2 (3.8%)	0 (0.0%)	
Identification of the drug categories most frequently associated with QT interval prolongation in hospitalized patients.			
Certain antibiotic drugs	24 (45.3%)	38 (71.7%)	0.01
Antiarrhythmic drugs	18 (34.0%)	24 (45.3%)	0.02
Antiemetic drugs	5 (9.4%)	12 (22.6%)	<0.001
Antipsychotic drugs	1 (1.9%)	11 (20.8%)	<0.001
Willingness to collaborate with clinical pharmacists in the management of drug-induced QT interval prolongation.			<0.001
Yes	41 (77.4%)	49 (92.5%)	
No	12 (22.6%)	4 (7.5%)	
1 n (%)			
2 McNemar's Chi-squared test with continuity correction; Stuart-Maxwell test			

TABLE 3. Description of the attitudes of the doctors before and after clinical pharmacist-led intervention

Characteristic	Before intervention	After intervention	P-value
Level of comfort in collaborating with clinical pharmacists to manage QT prolongation risks.			0.0046
Very important	15 (28.3%)	15 (28.3%)	
Important	19 (35.8%)	32 (60.4%)	
Neutral	13 (24.5%)	0 (0.0%)	
Not Important	6 (11.3%)	6 (11.3%)	
Perceptions of clinical pharmacists' knowledge and skills in managing QT prolongation.			0.046
Excellent	3 (5.7%)	3 (5.7%)	
Good	22 (41.5%)	30 (56.6%)	
Average	20 (37.7%)	20 (37.7%)	
Poor	8 (15.1%)	0 (0.0%)	
Perceived primary benefits of involving clinical pharmacists in QT prolongation management.			
Reduction in medication errors	33 (62.3%)	36 (67.9%)	0.6
Improve patient compliance	10 (18.9%)	16 (30.2%)	0.1
Enhanced interprofessional collaboration	7 (13.2%)	4 (7.5%)	0.5
Reduce workload for physicians	4 (7.5%)	12 (22.6%)	0.01
Willingness to involve clinical pharmacists more actively in the management of QT prolongation.			<0.001
Yes	47 (88.7%)	53 (100.0%)	
No	6 (11.3%)	0 (0.0%)	
Perceived main barriers to implementing pharmacist-led interventions for QT prolongation.			
Limited access to clinical pharmacists	28 (52.8%)	35 (66.0%)	0.21
Lack of awareness about pharmacist roles	11 (20.8%)	24 (45.3%)	0.3
Time constraints	11 (20.8%)	13 (24.5%)	0.8
Resistance to collaborative practice	5 (9.4%)	17 (32.1%)	<0.001
1(n)(%)			
2 McNemar's Chi-squared test with continuity correction; Stuart-Maxwell test			

such as dofetilide [16]. Importantly, there was a marked improvement in identifying high-risk drug categories such as antibiotics (71.7%), antiarrhythmics (45.3%), antiemetics (22.6%), and antipsychotics (20.8%) post-intervention—all statistically significant changes. This broad-spectrum pharmacologic awareness is critical for proactive risk mitigation and supports evidence from Al Shakhori et al., who recently documented improved drug-related problem recognition in a telepsychiatric setting following pharmacist-led interventions [17]. Perhaps most notably, physician willingness to collaborate with pharmacists increased significantly (92.5% post-intervention vs. 77.4% pre-intervention, $p < 0.001$), underscoring a positive shift toward interprofessional trust and engagement. Similar findings were reported by Ritchie et

al., who highlighted that pharmacist-physician collaboration in atrial fibrillation care improved professional synergy and patient-centered communication [18].

Collectively, these findings reinforce the utility of pharmacist-led educational initiatives in closing physician knowledge gaps and fostering safer prescribing behaviors. Future interventions should focus on scalability, sustainability, and longitudinal impact evaluation in diverse clinical settings.

The changes in physicians' attitudes towards clinical pharmacist-led interventions for managing QT prolongation before and after the intervention illustrated in Table 3. A significant improvement was observed in the perceived importance of collaboration with clinical pharmacists, with the proportion of doctors rating this collaboration as "important" increasing from 35.8% to 60.4% (p = 0.0046), while the "neutral" category dropped from 24.5% to 0.0%. Regarding the perceived knowledge and skills of clinical pharmacists in this domain, a notable shift occurred, with the percentage of physicians rating them as "good" increasing from 41.5% to 56.6%, and those perceiving them as "poor" declining from 15.1% to 0.0% (p = 0.046). In terms of the perceived benefits of involving clinical pharmacists, although not all changes reached statistical significance, more physicians acknowledged benefits such as reducing medication errors (62.3% to 67.9%, p = 0.6), improving patient compliance (18.9% to 30.2%, p = 0.1), and reducing physician workload, which saw a significant increase from 7.5% to 22.6% (p = 0.01). Importantly, willingness to involve clinical pharmacists more actively increased significantly, with 100% of respondents endorsing this post-intervention compared to 88.7% pre-intervention (p < 0.001). As for perceived barriers, although increases in reported limited access to pharmacists (52.8% to 66.0%) and lack of awareness (20.8% to 45.3%) were not statistically significant, there was a significant rise in the proportion of physicians citing resistance to collaborative practice as a barrier (9.4% to 32.1% (p < 0.001).

The clinical pharmacist-led intervention significantly enhanced physicians' attitudes toward interdisciplinary collaboration for managing drug-induced QT prolongation. Most notably, the proportion of physicians who rated collaboration with clinical pharmacists as "important" rose significantly from 35.8% to 60.4% (p = 0.0046), accompanied by the complete elimination of the "neutral" category. These results suggest a meaningful shift in physician openness to pharmacist input, reflecting the growing acknowledgment of pharmacists as clinical partners. Similar attitudinal shifts have been documented by Ritchie et al., who found improved interprofessional respect and communication in atrial fibrillation management following pharmacist integration [18]. Perceptions of pharmacists' clinical competence also improved: the proportion of physicians who rated pharmacist knowledge and skills as "good" increased from 41.5% to 56.6%, while negative perceptions ("poor") dropped to zero (p = 0.046). This transformation echoes the findings of Cao et al., who emphasized that consistent pharmacist engagement in heart failure teams fosters greater clinical trust among physicians. Importantly, specific benefits attributed to pharmacist involvement—such as improved patient compliance (18.9% to 30.2%) and reduced physician workload (7.5% to 22.6%, p = 0.01)—gained greater recognition. Although not all of these changes were statistically significant, the overall trend supports a positive reappraisal of the pharmacist's role. Al Shakhori et al. reported similar perceptions in a telepsychiatric setting, where physicians acknowledged that pharmacist interventions reduced prescription burdens and medication errors [17].

The intervention also resulted in a unanimous willingness among physicians to involve pharmacists more actively in managing QT prolongation (100% post vs. 88.7% pre, p < 0.001), demonstrating the highest level of attitudinal transformation in the study. This mirrors findings by Dixon et al., who observed a similar uptick in physician-pharmacist collaboration during long-term amiodarone monitoring services [15]. However, not all indicators moved in a favorable direction. A statistically significant increase was observed in the number of physicians citing resistance to collaborative practice as a barrier (9.4% to 32.1%, p < 0.001), perhaps reflecting internal tensions or institutional inertia when shifting clinical responsibility. This paradox has also been noted by Hernández-Prats et al., who found that although pharmacist-led interventions were effective, their success depended heavily on preexisting interprofessional dynamics and organizational culture [19]. Table 4 provides a comparative overview of physicians' clinical practices related to QT prolongation before and after the implementation of clinical pharmacist-led interventions. A significant decrease was observed in the frequency of prescribing QT-prolonging drugs, with the proportion of physicians reporting frequent prescribing dropping from 18.9% to 0.0% (p = 0.0067), and a corresponding increase in those prescribing them only occasionally (from 52.8% to 71.7%). Consultation practices also improved, with a notable increase in physicians who "always" consulted clinical pharmacists when prescribing QT-prolonging medications (from 9.4% to 20.8%), and a reduction in those who did so "rarely" (from 24.5% to 5.7%) (p = 0.003). Additionally, the influence of pharmacists' recommendations on prescribing decisions significantly increased (77.4% to 88.7%, p < 0.001).

Although changes in the frequency of ECG monitoring prior to prescribing were not statistically significant (p = 0.17), a modest increase was observed in physicians who reported "always" performing ECGs (22.6% to 24.5%). Likewise, practices related to electrolyte monitoring showed improvement, with a rise in physicians who "always" requested such tests (30.2% to 39.6%, p = 0.093), although not reaching statistical significance. Regarding the perception of critical electrolytes, potassium remained the most frequently identified (64.2% before vs. 66.0% after, p = 0.8). All participants reported prior experience with QT prolongation cases, both before and after the intervention. Notably, there were marked improvements in management practices: discontinuation of the offending drug increased from 50.9% to 66.0% (p = 0.2),

TABLE 4. Description of the practices of the doctors before and after clinical pharmacist-led interventions

Characteristic	Before intervention	After intervention	P-value
Frequency of prescribing drugs known to cause QT prolongation.			0.0067
Frequently	10 (18.9%)	0 (0.0%)	
Occasionally	28 (52.8%)	38 (71.7%)	
Rarely	15 (28.3%)	15 (28.3%)	
Consultation practices with clinical pharmacists when prescribing QT-prolonging medications.			0.003
Always	5 (9.4%)	11 (20.8%)	
Sometimes	26 (49.1%)	34 (64.2%)	
Rarely	13 (24.5%)	3 (5.7%)	
Never	9 (17.0%)	5 (9.4%)	
Influence of clinical pharmacists' recommendations on prescribing decisions.			<0.001
Yes	41 (77.4%)	47 (88.7%)	
No	12 (22.6%)	6 (11.3%)	
Frequency of performing ECG monitoring prior to prescribing QT-prolonging medications.			0.17
Always	12 (22.6%)	13 (24.5%)	
Sometimes	19 (35.8%)	22 (41.5%)	
Rarely	17 (32.1%)	14 (26.4%)	
Never	5 (9.4%)	4 (7.5%)	
Practices regarding the request for electrolyte monitoring in patients receiving QT-prolonging medications.			0.093
Always	16 (30.2%)	21 (39.6%)	
Sometimes	27 (50.9%)	28 (52.8%)	
Rarely	6 (11.3%)	3 (5.7%)	
Never	4 (7.5%)	1 (1.9%)	
Perception of the most important electrolyte test for patients with QT prolongation.			0.8
Potassium	34 (64.2%)	35 (66.0%)	
Calcium	12 (22.6%)	12 (22.6%)	
Magnesium	6 (11.3%)	6 (11.3%)	
Sodium	1 (1.9%)	0 (0.0%)	
Previous experience with cases of QT interval prolongation.			NA
Yes	53 (100.0%)	53 (100.0%)	
No			
Management steps taken upon identification of a patient with a prolonged QT interval.			
Discontinue the offending drug	27 (50.9%)	35 (66.0%)	0.2
Correct electrolyte imbalance	15 (28.3%)	27 (50.9%)	0.02
Reduce medication dose	9 (17.0%)	16 (30.2%)	0.01
Consult a clinical pharmacist	2 (3.8%)	6 (11.3%)	<0.001
(1n)(%)			
2 McNemar's Chi-squared test with continuity correction; Stuart-Maxwell test			

correction of electrolyte imbalances rose significantly from 28.3% to 50.9% (p = 0.02), and dose reduction from 17.0% to 30.2% (p = 0.01). Importantly, consultation with clinical pharmacists increased significantly from 3.8% to 11.3% (p < 0.001). Collectively, these findings underscore the positive impact of pharmacist-led interventions on enhancing evidence-based prescribing and collaborative patient management practices among physicians.

The implementation of clinical pharmacist-led interventions significantly improved physician practices in the management of drug-induced QT interval prolongation. One of the most striking outcomes was the complete elimination of frequent prescribing of QT-prolonging medications (from 18.9% to 0.0%, p = 0.0067), with a concurrent rise in cautious prescribing behavior, reflected in increased reports of "occasional" prescribing (71.7%). This shift indicates heightened risk awareness and a shift toward more judicious medication use, a finding mirrored by Hoehns et al., who demonstrated that pharmacist-involved ECG monitoring led to more informed prescribing decisions in outpatient cardiovascular therapy [14]. Notably, the frequency of consultation with clinical pharmacists significantly improved (p = 0.003). The proportion of physicians who "always" consulted a pharmacist more than doubled, and those who "rarely" did so dropped from 24.5% to 5.7%. This reflects not only improved attitudes but also enhanced incorporation of pharmacists into routine clinical workflow—a cornerstone of effective team-based care. Such trends are supported by Dixon et al., who reported improved monitoring and clinical adherence when pharmacists provided ongoing consultative support in managing amiodarone-related QT risks [15].

The intervention also positively influenced physicians' responsiveness to pharmacist recommendations, with agreement rates rising from 77.4% to 88.7% (p < 0.001). This enhanced trust aligns with findings from Cao et al., whose systematic review noted that acceptance of pharmacist input is a key predictor of improved patient outcomes in heart failure and arrhythmia management programs [20]. Although not statistically significant, slight improvements in ECG monitoring and electrolyte testing (e.g., potassium and magnesium) were observed, suggesting increasing clinical diligence in cardiac risk screening. Ritchie et al. emphasized that these types of process-oriented changes may take longer to fully institutionalize, often requiring system-level reinforcement

through hospital protocols or decision-support tools [18]. Substantial improvement in the clinical management of QT prolongation was also reported. The proportion of physicians who corrected electrolyte disturbances increased significantly (from 28.3% to 50.9%, p = 0.02), and those who reduced drug doses rose from 17.0% to 30.2% (p = 0.01). These changes demonstrate greater clinical responsiveness and adherence to guideline-based management, further affirming the practical benefit of pharmacist-led education and collaboration. In parallel, more physicians began consulting pharmacists directly for QT prolongation cases (3.8% to 11.3%, p < 0.001), supporting the argument that active pharmacist presence catalyzes real-time intervention behavior. Taken together, these findings align with broader evidence that pharmacist involvement leads to more evidence-based, safety-conscious clinical practices. For example, Al Shakhori et al. recently reported improved management of drug-related problems in a telepsychiatric clinic, particularly in mitigating QTc-related psychotropic risks [17].

3.3 Summarization of KAP according to cutoff values

Brief summary of the variations in knowledge, attitudes, and practices (KAP) among physicians pre and post the implementation of clinical pharmacist-led interventions, using established cutoffs for interpretation presented in Table 5. The mean knowledge score increased significantly from 4.3 ± 1.4 to 5.6 ± 1.7 (p < 0.001), with the proportion of physicians categorized as having "good knowledge" increasing markedly from 5.7% to 26.4%, while those with "bad knowledge" decreased from 94.3% to 73.6%. Similarly, the mean attitude score showed a significant improvement from 3.4 ± 1.6 to 4.1 ± 1.2 (p < 0.001), with favorable attitudes increasing from 24.5% to 39.6% and unfavorable attitudes decreasing from 75.5% to 60.4%. The most pronounced improvement was observed in practice scores, which rose from a mean of 7.2 ± 1.8 to 8.9 ± 1.5 (p < 0.001). Correspondingly, the proportion of physicians demonstrating "adequate practice" increased substantially from 67.9% to 94.3%, while those with "inadequate practice" dropped from 32.1% to 5.7%. These results collectively highlight the significant positive impact of pharmacist-led interventions in enhancing physicians' competency in managing drug-induced QT prolongation through improved knowledge, attitudes, and clinical practices.

TABLE 5. Description of the level of knowledge, attitude and practice in doctors before and after pharmacist led intervention

Characteristic	Before intervention	After intervention	P-value
Knowledge score (cutoff is 7)	4.3 ± 1.4	5.6 ± 1.7	<0.001
	Good knowledge	3 (5.7%)	14 (26.4%)
	Bad knowledge	50 (94.3%)	39 (73.6%)
Attitude score (cutoff is 5)	3.4 ± 1.6	4.1 ± 1.2	<0.001
	Favorable attitudes	13 (24.5%)	21 (39.6%)
	Unfavorable attitudes	40 (75.5%)	32 (60.4%)
Practice score (cutoff is 7)	7.2 ± 1.8	8.9 ± 1.5	<0.001
	Adequate practice	36 (67.9%)	50 (94.3%)
	Inadequate practice	17 (32.1%)	3 (5.7%)
1Mean and SD; n (%)			
2Paired t-test; McNemar's Chi-squared test with continuity correction;			

How pharmacist led intervention affect QT interval prolongation among hospitalized patients involved in the study Incidence of drug-induced QT interval prolongation among hospitalized patients before and after the implementation of a clinical pharmacist-led intervention. A total of 100 patients were screened in each phase of the study. Prior to the intervention, 36 out of 100 patients (36%) were found to have QT prolongation. Following the intervention, the prevalence decreased to 29 out of 100 patients (29%). Although a reduction in prevalence was observed, the difference was not statistically significant, as indicated by a p-value of 0.29 based on the chi-squared test for equality of proportions. As shown in Table 6.

TABLE 6. Prevalence of QT-prolongation before and after pharmacist led intervention

Parameter	Number screened	Patients have QT prolongation
Prevalence of QT prolongation before intervention	100	36 (36%)
Prevalence of QT prolongation after intervention	100	29 (29%)
P-value1		0.29
1Chi-squared test for equality of proportions		

It was concluded that the clinical pharmacist-led interventions significantly improved physicians' knowledge, attitudes, and practices regarding the management of drug-induced QT prolongation in hospitalized patients. While the prevalence of QT prolongation showed a non-significant decline, there were notable post-intervention improvements in patient care behaviors, including ECG monitoring, cardiology follow-ups, and deprescribing. The intervention promoted greater interprofessional collaboration, with physicians showing increased willingness to consult pharmacists and act upon their recommendations. These findings support the integration of clinical pharmacists into multidisciplinary teams as a strategy to enhance medication safety and optimize cardiovascular risk management.

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AUTHOR CONTRIBUTIONS

Concept: H. A.; Design: A. A., H. A.; Control: H. A.; Sources: A. A.; Materials: A. A.; Data Collection and/or Processing: A. A., H. A.; Analysis and/or Interpretation: A. A., H. A.; Literature Review: A. A., H. A.; Manuscript Writing: A. A., H. A.; Critical Review: H. A.

CONFLICT OF INTEREST

The authors declare that there is no real, potential, or perceived conflict of interest for this article.

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ETHICS COMMITTEE APPROVAL

Study protocol was reviewed and granted permission by the medical ethical committee of University of Kufa (Reference No. MEC-111, Date: 12/02/2025). Verbal consent was obtained from the patients and physicians prior to interviewing. After explaining the purposes of this study to them. Official agreement was obtained from Babylon Health Directorate to carry out the study.

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