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Knowledge, Confidence, and Perception Toward Therapeutic Drug Monitoring Among Physicians and Pharmacists in Kuwait

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Background: Therapeutic drug monitoring (TDM) helps ensure an efficient and safe therapeutic outcome. This study assessed physicians' and pharmacists' knowledge, confidence, and perception regarding clinical pharmacokinetics and TDM.

Methods: A cross-sectional survey that used a self-administered questionnaire was used. A stratified random sample of 322 physicians and pharmacists across 3 Kuwait public hospitals was surveyed. Descriptive and comparative statistical analyses were performed during data analysis. A multivariate logistic regression model was used to identify factors associated with low levels of knowledge and confidence and negative perceptions among the subjects.

Results: The response rate was 88%. Overall, the respondents' mean total knowledge score percentage was low (50.3%), with no significant difference between the physicians' and pharmacists' scores ($P > 0.5$); 60.4% of the participants (95% confidence interval: 54.9–65.6) felt confident when using TDM in their practice. Most participants expressed positive perceptions (90.1%; 95% confidence interval: 86.3–92.9) toward TDM. There was high agreement internally that pharmacists require some knowledge of TDM, should be asked by physicians in general for recommendations on the appropriate use of TDM, and should be able to provide relevant information regarding the appropriate use of TDM.

Conclusions: Physicians and pharmacists in this study had high confidence in—and the positive perceptions of—TDM and its clinical implications. The present study's findings indicate an urgent need for professional education and training in clinical pharmacokinetics and TDM and its clinical implications through continuous professional development programs and its integration within the curricula of medical and pharmacy schools.

Key Words: therapeutic drug monitoring, clinical pharmacokinetics, perception, health care professionals, pharmacists

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Enhanced clinical outcomes are the ultimate goal for practitioners providing direct patient care. This is generally achieved by successful collaboration between pharmacists and physicians to ensure safe and effective pharmaceutical therapy. One approach for monitoring the treatment outcomes is therapeutic drug monitoring (TDM). The International Association of TDM and Clinical Toxicology views TDM as "a multi-disciplinary clinical specialty aimed at improving patient care by individually adjusting the dose of drugs, for which clinical experience or clinical trials have shown, that such adjustment improved outcomes in the general or special populations."[1] TDM can be useful when medications have a narrow therapeutic index or have unpredictable pharmacokinetic (PK) behavior, which may result in unpredictable pharmacological responses.[2] Suitable indications for TDM include the potential for avoiding adverse drug reactions and toxicities, as well as assessing adherence.[3]

Few studies to date have examined health care professionals' (HCPs) knowledge and/or perceptions regarding TDM. One study examined TDM knowledge in nurses and laboratory technicians.[4] This study reported that only 7% of the nurses and 18% of the laboratory technicians had good knowledge of TDM. Another study examined PK knowledge as part of a pharmacology course and provided a pharmacotherapeutic questionnaire to pharmacy and medical students.[5] The study found that pharmacy students had better knowledge

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of basic pharmacology than medical students, whereas medical students had better skills in writing prescriptions than pharmacy students. Another study examined physicians' attitudes toward and practice of PK/TDM in Saudi Arabia.[6] The study reported that physicians trained in Europe and North America were more experienced with PK/TDM. In addition, a majority of the participants indicated that they had used PK/TDM in their practice at least once, and that most of these participants were consultants. Another 4 studies examined the junior medical staff's or physicians' perceptions of TDM for specific medications, more specifically the aminoglycosides and anti–tumor necrosis factor drugs but not as a general service.[7–10] Studies from the United States, the United Kingdom, and India reported that the majority of physicians routinely use TDM reactively for secondary loss of therapeutic response and use TDM proactively to a lesser extent.[7–9] Some of the reported barriers to the use of TDM included the cost involved and the time lag from drug sample provision to the therapeutic result.[7–9] In addition, an Australian study reported that the majority of the medical officer participants had generally positive attitudes toward the TDM service.[10] Hence, more attention was devoted in these studies to assessing the perception of rather than to assessing the participants' knowledge and confidence of the clinical pharmacokinetic (CPK) services and TDM among those HCPs, namely, the pharmacist and physician participants, worldwide and in the Middle East and North African region. Another study was conducted to assess the physicians' and pharmacists' knowledge, confidence, and perceptions (KCPs) regarding pharmacogenetics in Kuwait.[11] This study's results showed low levels of knowledge and self-confidence about pharmacogenetics, which resulted in limited application of these principles among participants. However, most of the participants had positive perceptions toward pharmacogenetics and its clinical implications. This published study was adapted to assess CPK and TDM for the current research.[11]

The aim of the current study was to assess the physicians' and pharmacists' KCPs regarding CPK services and TDM in Kuwait. Findings from this study could potentially be used to motivate medical and pharmacy educators to design educational programs dedicated to improving the knowledge and implementation of TDM in general hospitals in Kuwait and abroad.

PARTICIPANTS AND METHODS

Study Design

From January to April 2019, a cross-sectional survey was conducted in Kuwait, a Middle Eastern country with a land area of 17,820 km^2 and an estimated population of 3,892,000 people (2015 estimate).[12] The study population included physicians and pharmacists working in 3 public hospitals in Kuwait. This study was approved by the Student Research Ethical Committee in the Health Science Centre at Kuwait University (Ref. No 8319/8320).

The sample size was calculated based on the assumption that the proportion of responses to most of the survey questions would be approximately 50% because there were no similar studies from Kuwait that could be used to predict the response rate. This was determined using the Raosoft sample size calculator (Raosoft, Seattle, WA) with an estimated margin of error of 5% and a confidence interval of 95%, which generated a target population size of 222 physicians and 228 pharmacists, who were currently practicing in the 3 hospitals.[13] The minimum acceptable sample size estimated for the study was 141 physicians and 144 pharmacists. Assuming a response rate of 80%, 177 physicians and 181 pharmacists were thus enrolled in the survey.

Participants

The physicians and pharmacists working in health care settings in Kuwait have diverse educational backgrounds. The Doctor of Medicine degree takes 7 years, and the Bachelor of Pharmacy (BPharm) degree takes 5 years. For the pharmacists, there is a 2-year add-on qualification of Doctor of Pharmacy (PharmD) program to provide advanced clinical skills and practical experiences. TDM is currently taught with moderate depth within a full course in the 2-year add-on PharmD program, whereas only basic PK knowledge is covered in the BPharm and Doctor of Medicine programs.

There are 6 ranks for pharmacists who work in public hospitals, which range from junior pharmacist up to consultant pharmacist. The rank upgrade for pharmacists is based solely on work experience. In contrast, the 6 ranks for physicians working in public hospitals range from resident to consultant. The rank upgrade for physicians is based on work experience and board certification. Therefore, the common denominator of years of experience was used for further analysis.

Questionnaire

The research team developed the survey questions based on published works on pharmacogenetics practice between pharmacists and physicians in hospital settings.[11] The questionnaire was validated by an expert panel of 2 faculty staff (PhD holders), one of whom is specialized in CPK and TDM. The survey was reviewed for face and content validity and underwent a pilot study by 5 pharmacists and 5 physicians. The validated survey comprised 4 sections. Section 1 covered participant demographic characteristics and included 7 items. Section 2 included 6 items to assess the level of the participants' knowledge on basic CPK and TDM. Section 3 included 4 items that assessed confidence. Section 4 included 5 items that assessed perception. All knowledge questions were in a multiple-choice format. Confidence and perception questions about the TDM service were tested using a Likert scale. The questionnaire is available as supplementary material.

Recruitment

Systematic random sampling, according to the methodology described by the World Health Organization, was used for participant sample selection.[14] The selected sample of participants in each hospital was proportionate to the number of pharmacists and physicians on staff. The selected phy-

sicians and pharmacists were approached for consent by the research team, and in compliance with guidelines for obtaining informed consent, the research aim or objectives were explained. Participation in the study was voluntary, and participants were free to decline to participate or withdraw at any time without any consequences. Those who agreed to participate were provided a written informed consent form and the survey form for self-administration (paper copy only). No monetary incentives were offered to the participants upon survey completion. Data were collected anonymously to ensure the participants' confidentiality. For the majority of participants, the survey was completed within 10–15 minutes, and in some cases, the survey was collected within 1–2 weeks.

Data Analysis

Each hospital in the sample was assigned a unique anonymous identification letter. Descriptive and comparative statistical analyses were performed using the Excel template and GraphPad Prism 8 software. Continuous data were presented with calculated mean and SD parameters or with calculated median and interquartile range parameters as appropriate. Categorical data were presented with calculated percentage and 95% confidence interval (CI) parameters, and the difference between proportions was analyzed via a χ^2 test (significance level = 0.05). For missing information, data were reported as missing.

Knowledge items were scored as 1 for the correct choice and as 0 for the incorrect answer or as "do not know." The knowledge score was then calculated as a categorical variable and summing the participant's number of correct answers for individual participants and dividing by 6 (the maximum score), and this was presented as the percentage knowledge score.[11] The percentage knowledge score was expressed as a median (25th and 75th percentile). Mann–Whitney test was used to assess the difference between physicians' and pharmacists' total percentage knowledge score. The percentage knowledge score was divided into low ($<$60%), moderate (60–79%), and high ($\geq$80%). The χ^2 and Fisher exact tests were used to compare frequencies for each item used for comparing the physician and pharmacist groups.

The confidence score was calculated as a continuous variable by summing the participant's number of appropriate responses to 4 items.[11] One point was awarded for each appropriate response (agree) and zero for each disagree or neutral response. The maximum obtainable score was 4. The confidence score was categorized into low ($\leq$2) and high ($\geq$3). The perception score was calculated similarly, with 5 being the maximum obtainable score.[11] The perceptions score was categorized into negative (0–2) and positive (3–5). The confidence and perceptions scores were reported as median (25th and 75th percentile). A multivariate logistic regression model was used to identify factors associated with the low levels of knowledge and confidence and negative perceptions. Confounding factors were initially assessed between independent variables using a χ^2 test for categorical variables and correlation analysis for continuous variables. Some of the included covariates were baseline demographics (age, sex, profession, years of experience, and country of qualification). Individuals were categorized into 2 groups based on age ($<$40 and $\geq$40 years), profession (physician or pharmacist), and years of experience ($<$10 and $\geq$10 years). Country of specialty education/qualification was divided into Kuwait or abroad (Middle East, United Kingdom, United States, and others). Variables with a significant association or correlation (level of P $<$0.05) were excluded from the multivariate model. The results for the logistic models were presented as odds ratios (ORs) (95% CI). Significance level was set at $\leq$0.05.

RESULTS

Of the 365 practitioners who were approached for enrollment, 322 agreed to participate (170 physicians and 152 pharmacists; response rate, 88%). Table 1 presents the participants' baseline characteristics and professional information. The participants' median age (25th and 75th percentile) was 36.0 (28.5–43.0) years; 47.3% (n = 133) obtained their degree from the Middle East, and 3.56% (n = 10) from the United States; 49.4% (n = 155) had less than 6 years of experience, 26.8% (n = 84) had between 6 and 14 years of experience, and 23.9% (n = 75) had more than 14 years of experience. More than half of the participating physicians were from a medical department (n = 96; 58.5%), 28% (n = 46) were from pediatrics, 9.8% (n = 16) were surgeons, and 3.7% (n = 6) were from the Intensive Care Unit, and none were from an infectious diseases specialty.

Respondents' Level of Knowledge About CPK and TDM

Overall, the respondents' median (25th and 75th percentile) percentage of knowledge score was low (50.0% (33–67), where 59.3% (n = 191; 95% CI: 53.9–64.5) answered 1 to 3 items correctly (low knowledge: $<$60%), 31.4% (n = 101; 95% CI: 26.5–36.6) answered 4 items correctly (moderate knowledge: 60–79%), and 9.32% (n = 30; 95% CI: 6.60–12.9) answered 5 to 6 items correctly (high knowledge: $\geq$80%). Only one pharmacist and none of the physicians answered all 6 items correctly. The overall median (25th and 75th percentile) percentage knowledge was low for physicians and pharmacists [50.0% (33–67) and 50.0% (33–67), with P = 0.108, respectively].

Table 2 presents the participants' responses to the 6 items used to assess knowledge on CPK and TDM; 70.2% (n = 226; 95% CI: 64.9–74.9) understood the term "bioavailability"; 7.76% (n = 25; 95% CI: 5.31–11.2) estimated the half-life correctly; 49.1% understood the term "TDM" (n = 158 (95% CI: 43.7–54.5); 87.9% disagreed that a similar amikacin dose can be administrated to all patients (due to nephrotoxicity) (n = 283, 95% CI: 83.9–91.0); 48.4% knew the correct recommended amikacin dose (n = 156, 95% CI: 43.0–53.9); and 38.2% knew the target therapeutic concentration range for vancomycin (n = 123, 95% CI: 33.1–43.6).

TABLE 1. Physicians' and Pharmacists' Characteristics

Variable	Physicians (n = 170)	Pharmacists (n = 152)	Total (N = 322)	*P*
Sex*				
Male (%)	113 (66.5%)	57 (38%)	170 (53.1%)	<0.0001
Female (%)	57 (33.5%)	93 (62%)	150 (46.9%)	
Age (yr)*				
<40	95 (56.5%)	94 (75.2%)	189 (64.5%)	0.0034
40–59.9	65 (38.7%)	26 (20.8%)	91 (31.1%)	
≥60	8 (4.76%)	5 (4.0)	13 (4.44%)	
Nationality*				
Kuwaiti (%)	69 (40.8%)	86 (58.1%)	155 (48.9%)	0.0024
Non-Kuwaiti (%)	100 (59.2%)	62 (41.9%)	162 (51.1%)	
Years of experience*				
≥6	89 (53.0%)	66 (45.2%)	155 (49.4%)	0.0001
>6–14	29 (17.3%)	55 (37.7%)	84 (26.8%)	
≤14	50 (29.8%)	25 (17.1%)	75 (23.9%)	
Country of qualification*				
Kuwait	45 (28.5%)	53 (43.1%)	98 (34.9%)	0.0165
Middle East	76 (48.1%)	57 (46.3%)	133 (47.3%)	
United Kingdom	28 (17.7%)	12 (9.76%)	40 (14.2%)	
North America	9 (5.70%)	1 (0.81%)	10 (3.56%)	
Others	12 (7.59%)	8 (6.50%)	20 (7.12%)	

*Includes missing data.
Sex = 2 missing, age = 27 missing, nationality = 4 missing, years of experience = 8 missing.
P value represents the comparison between 2 groups (physicians and pharmacists) with each variable using a χ^2 test.

Respondents' Confidence in Performing TDM in Their Practice

The overall median (25th and 75th percentile) confidence score was 3.00 (2.00–4.00; high confidence). Only 60.4% (n = 194; 95% CI: 54.9–65.6) of the respondents claimed overall high self-confidence scores of ≥3.0. Table 3 presents participants' responses to the 4 items used to assess their confidence with respect to performing TDM in their practice; 76.6% agreed that they could identify reliable sources of information regarding TDM for HCPs (n = 246; 95% CI: 71.7–80.9); 66.0% could accurately extrapolate the results of TDM services to drug therapy management and dosing (n = 212; 95% CI: 60.7–71.0); 73.5% could identify drugs that need TDM (n = 236; 95% CI: 68.4–78.0); and 55.1% (n = 177; 95% CI: 49.7–60.5) agreed that they could determine the available TDM services within their health care system. Pharmacists expressed significantly higher self-confidence than physicians with respect to identifying medications that require TDM, identifying reliable sources of information regarding TDM for HCPs, and determining the available TDM services within their health care system ($P < 0.05$).

Respondents' Perception Toward CPK and TDM

The overall median (25th and 75th percentile) perception score of the respondents was a positive perception [5 (4–5)]; 90.1% (n = 290; 95% CI: 86.3–92.9) expressed an overall positive perception of ≥3.0. Table 4 presents participants' responses to the 5 items used to assess perceptions toward TDM, that is, positive perceptions toward the relevance of TDM to their clinical practice (n = 247; 76.9%; 95% CI: 72.0–81.2), TDM should be used in their clinical practice (n = 277; 87.4%; 95% CI: 83.3–90.6), health care providers should ask pharmacists for recommendations regarding the appropriate use of TDM (n = 287; 89.4%; 95% CI: 85.6–92.3) and that they should be able to provide information on the appropriate use of TDM (n = 267; 83.2%; 95% CI: 78.7–86.9). In total, 90.9% (n = 291; 95% CI: 87.3–93.6) agreed that pharmacists should be required to have some knowledge of TDM. Physicians expressed a significantly greater positive perception than pharmacists toward the relevance of TDM and its application in their clinical practice, with pharmacists needing some knowledge of TDM and HCPs asking pharmacists for recommendations on the appropriate use of TDM ($P < 0.05$). In contrast, pharmacists expressed a significantly more positive perception than physicians toward the suggestion that they should be able to provide information on the appropriate use of TDM ($P < 0.05$).

Factors Influencing Knowledge, Confidence, and Perception Toward TDM Service

Table 5 presents the multivariate regression model and the factors associated with low knowledge and confidence and negative perceptions. The results of the association and correlation analysis between independent variables are presented in Supplemental Digital Content 1 (see Table 1S and Figure S1, http://links.lww.com/TDM/A546). Only the years

TABLE 2. Participants' Knowledge About CPK and TDM

Knowledge Item	Physicians (n = 170), Frequency (%)	Pharmacists (n = 152), Frequency (%)	Total (N = 322)	*P*
What does the extent to which a medication is absorbed partially determine?				
Correct answer	103 (60.6%)	123 (80.9%)	226 (70.2%)	<0.0001
Wrong answer	40 (23.5%)	25 (16.4%)	65 (20.2%)	
"Do not know"	27 (15.9%)	4 (2.63%)	31 (9.63%)	
For a medication that has an initial plasma concentration of 120 mg/L and a half-life of 3 hours, what would the plasma concentration be 12 hours after the initial concentration?				
Correct answer	14 (8.24%)	11 (7.24%)	25 (7.76%)	0.0009
Wrong answer	108 (63.5%)	123 (80.9%)	231 (71.7%)	
"Do not know"	48 (28.2%)	18 (11.8%)	66 (20.5%)	
What is therapeutic drug monitoring?				
Correct answer	78 (45.9%)	80 (52.6%)	158 (49.1%)	0.254
Wrong answer	70 (41.2%)	60 (39.5%)	130 (40.4%)	
"Do not know"	22 (12.9%)	12 (7.89%)	34 (10.6%)	
Can amikacin IV 500 mg every 12 hours be administrated to all patients?				
Correct answer	143 (84.1%)	140 (92.1%)	283 (87.9%)	0.0005
Wrong answer	2 (1.18%)	7 (4.61%)	9 (2.80%)	
"Do not know"	25 (14.7%)	5 (3.29%)	30 (9.32%)	
What is the recommended amikacin dose?				
Correct answer	85 (50.0%)	71 (46.7%)	156 (48.4%)	0.304
Wrong answer	41 (24.1%)	48 (31.6%)	89 (27.6%)	
"Do not know"	44 (25.9%)	33 (21.7%)	77 (23.9%)	
What is the target therapeutic concentration range for vancomycin?				
Correct answer	67 (39.4%)	56 (36.8%)	123 (38.2%)	0.856
Wrong answer	71 (41.8%)	68 (44.7%)	139 (43.2%)	
"Do not know"	32 (18.8%)	28 (18.4%)	60 (18.6%)	

of experience was positively associated with knowledge about CPK and TDM. Having 10 or more years of experience was significantly associated with a greater knowledge of CPK and TDM [OR = 0.39; 95% CI: (0.25–0.62); $P < 0.05$]. Further, some of the factors significantly associated with confidence to practice TDM were related to their specific profession and years of experience. Being a pharmacist and practicing for 10 or more years were associated with greater confidence [OR = 0.53; 95% CI: (0.33–0.85); $P < 0.05$; and OR = 0.37; 95% CI: (0.23–0.61); $P < 0.05$, respectively]. Profession was the only factor associated with perception, where the pharmacists [OR = 0.29; 95% CI: (0.11–0.68); $P < 0.05$] had better perceptions toward TDM service.

DISCUSSION

To the best of our knowledge, this is the first study to assess KCP toward CPK and TDM among HCPs worldwide. The present study shows that the HCPs had high confidence and positive perceptions toward TDM but had low levels of knowledge about the CPK and TDM concepts with an overall percentage of knowledge score of 50%. The current results highlight important concerns regarding the competence of HCPs to use CPK and TDM for the therapeutic benefit of their patients and reveal an important baseline quantitative dataset that will aid in the assessment of current TDM KCP which will help educators design better curricula for preparing physicians and pharmacists.

Results from the present study show that the levels of knowledge about CPK and TDM concepts were relatively low, with no significant difference between professions (physicians and pharmacists). Similar findings were reported by Albassam et al,[11] who reported a low knowledge score of 45% for pharmacogenetics testing and did not reveal a significant difference between HCPs. Results from the present study were further confirmed by multi-regression analysis, which showed that only those who had been practicing for 10 or more years had better knowledge of the profession. This study highlights the need to better educate junior HCPs earlier in their careers—and in particular pharmacists—about CPK and TDM to enable them to

TABLE 3. Participants' Confidence Toward Providing a TDM Service

Self-confidence Items	Physicians (n = 169), Frequency (%)	Pharmacists (n = 152), Frequency (%)	Total (N = 321), Frequency (%)	*P*
I can identify drugs that need a TDM service.				
Agree	106 (62.7%)	130 (85.5%)	236 (73.5%)	<0.0001
Neutral	49 (29.0%)	16 (10.5%)	65 (20.2%)	
Disagree	14 (8.28)	6 (3.95%)	20 (6.23%)	
I can identify reliable sources of information regarding TDM for health care professionals and patients.				
Agree	109 (64.5%)	137 (90.1%)	246 (76.6%)	<0.0001
Neutral	46 (27.2%)	11 (7.24%)	57 (17.8%)	
Disagree	14 (8.28%)	4 (2.63%)	18 (5.61%)	
I can readily determine the available TDM services within our health care system.				
Agree	80 (47.3%)	97 (63.8%)	177 (55.1%)	0.0013
Neutral	63 (37.3%)	29 (19.1%)	92 (28.1%)	
Disagree	26 (15.4%)	26 (17.1%)	52 (16.2%)	
I can accurately apply the results of TDM services to drug therapy management and dosing.				
Agree	103 (60.9%)	109 (71.7%)	212 (66.0%)	0.112
Neutral	46 (27.2%)	28 (18.4%)	74 (23.1%)	
Disagree	20 (11.8%)	15 (9.87%)	35 (10.9%)	

practice it for commonly prescribed medications like antibiotics for the benefit of their patients.

Education is vital in providing HCPs with modern therapeutic services, and furthermore, demonstrates the utility of TDM outside of the laboratory. Previously, practitioners were initially taught how to interpret the blood (plasma or serum) levels of medications, such as digoxin, phenytoin, lithium, theophylline, the aminoglycosides, and cyclosporine.[15] Later, the relevant list of medications requiring TDM was expanded to include more medications, such as antiepileptic, immunosuppressant, and anti-infective agents. The main reason for increasing the list of medications that require TDM is high interpatient variability (due in part to differences in pharmacogenomics), which indicate that one dose does not fit all. This concept remains underrecognized among HCPs, as shown in the present study. For example, in this study, 87.9% agreed that similar amikacin doses cannot be administered to all patients, 51.6% failed to correctly select the recommended amikacin dose in mg/kg, and 35% selected a fixed dose in mg regimen, thus indicating that further education is required regarding dose individualization for better clinical outcomes.

Although TDM is a well-established methodology for assessing the safety and efficacy of medications, which have a narrow therapeutic index and high between-patient variability, its definition and application is not well understood by many HCPs; only 49.1% of the participants in the present study understood the term "TDM," and only 40.3% referred to TDM as either plasma medication level or therapeutic range of safe and effective medication plasma concentration. This is not a surprising result because the clinical biochemistry departments that offer TDM services provide only the "measuring" (assay only) and not the "monitoring" (assay and clinical interpretation) service. The present results strongly suggest that services can be separated, that is, TDM would deal with measuring the plasma (or blood/serum) medication levels and another service would assess the target effect and target concentration levels for optimal patient outcomes to enable HCPs in making rational individual dose decisions. By having 2 such interrelated services, the value of TDM and interpretation of results in clinical practice will be increased to ultimately benefit the patients. This concept was first introduced in 2001 and was revisited in 2020.[16,17] It had been argued that the HCPs' perception of TDM is limited to the idea of a therapeutic range, with a low emphasis on the interpretation of measured drug concentrations, and thus reduces the anticipated benefit to patients because of its use as an oversimplified pharmacodynamic model. The term "target concentration intervention" was subsequently introduced as an added conceptual strategy to TDM.[16,17] It now includes PK and pharmacodynamic concepts and uses the idea of a target effect and associated target concentration to make rational individual dose decisions for the patient's benefit.

In the present study, 60.4% of the respondents claimed overall high self-confidence scores toward TDM. However, only 55.1% felt able to determine the available TDM services within their health care system, which indicates the need to

TABLE 4. Participants' Perception of TDM Service

Perception Items	Physicians (n = 169), Frequency (%)	Pharmacists (n = 152), Frequency (%)	Total (N = 321)	*P*
A TDM service is relevant to my clinical practice.				
Agree	125 (74.0%)	122 (80.3%)	247 (76.9%)	0.0157
Neutral	39 (23.1%)	19 (12.5%)	58 (18.1%)	
Disagree	5 (2.96%)	11 (7.24%)	16 (4.98%)	
Pharmacists should be required to have some knowledge of TDM.*				
Agree	146 (86.4%)	145 (96.0%)	291 (90.9%)	0.003
Neutral	22 (13.0%)	6 (3.97%)	28 (8.75%)	
Disagree	1 (0.59%)	0 (0.0%)	1 (0.31%)	
TDM services should be applied into my clinical practice.*				
Agree	139 (82.2%)	138 (93.2%)	277 (87.4%)	0.0037
Neutral	29 (17.2%)	10 (6.76%)	39 (12.3%)	
Disagree	1 (0.59%)	0 (0.0%)	1 (0.32%)	
Pharmacists should be asked by health care professionals for recommendations on appropriate use of a TDM service.				
Agree	145 (85.8%)	142 (93.4%)	287 (89.4%)	0.0297
Neutral	21 (12.4%)	7 (4.61%)	28 (8.72%)	
Disagree	3 (1.78%)	3 (1.97%)	6 (1.87%)	
I should be able to provide information on the appropriate use of a TDM service.				
Agree	125 (74.0%)	142 (93.4%)	267 (83.2%)	<0.0001
Neutral	40 (23.7%)	8 (5.26%)	48 (15.0%)	
Disagree	4 (2.37%)	2 (1.32%)	6 (1.87%)	

*Few missing responses.

increase health care awareness about the TDM services available within their institutions. Pharmacists had higher confidence scores than the physicians toward the TDM service based on the current findings. The pharmacists expressed significantly higher confidence in identifying medications that require TDM, identifying reliable sources of information regarding TDM for HCPs, and being able to determine the available TDM services within their health care system. A similar finding was also reported by Albassam et al.[11] This suggests that pharmacists have much interest in —and willingness to serve—many active roles in implementing TDM and pharmacogenetic testing in the health care setting. Moreover, these findings could reflect the fact that pharmacists might have greater exposure to CPK and TDM in their professional education. In the present study, a high correlation was found between age and years of experience, where Kuwaiti participants were 10 years younger than non-Kuwaiti participants who subsequently had more experience. Therefore, age and nationality were excluded from the regression analysis for being confounding factors and the results confirmed that having more experience and being pharmacists were associated with having high confidence. This might reflect the high level of knowledge accumulated over years of practicing TDM as shown previously from the knowledge results.

Over two-thirds of the participants in this study expressed an overall positive perception toward TDM. A similar finding was reported from 2 other studies, one examining nurses' perception of TDM and the other examining physicians' perception of TDM, where 79.3% of nurses and 90% of physicians had positive perceptions of TDM.[4,6] This can be attributed to the expected clinical benefits from TDM through ensuring both the effectiveness and the safety of medications, and it emphasizes the fact that TDM should be an integral part of the health care system. Despite the similar level of knowledge of CPK and TDM among physicians and pharmacists in the present study, pharmacists were found to be more positively perceptive toward the benefits of CPK and TDM than physicians. Interestingly, these findings were similar to the results of a survey by Albassam et al[11] covering pharmacogenetics testing in Kuwait. These results support the emerging and expanding role of pharmacists in delivering safe and effective therapeutic regimens for patients and their expected leadership role in TDM. Indeed, 86.4% of the physicians in this study agreed that pharmacists should

TABLE 5. Multivariate Logistic Regression Analysis for Factors Associated With Low Knowledge and Confidence and Negative Perception Toward a TDM Service

	Low Knowledge (n = 191)		Low Confidence (n = 127)		Negative Perception (n = 32)	
Variable	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***
Profession						
Physician	Reference					
Pharmacists	1.38 (0.87–2.21)	0.169	0.53 (0.33–0.85)	0.0095*	0.29 (0.11–0.68)	0.007*
Years of experience						
<10	Reference					
≥10	0.39 (0.25–0.62)	≤0.0001*	0.37 (0.23–0.61)	≤0.0001*	0.54 (0.23–1.19)	0.145

*Significant with $P \leq 0.05$.

have some knowledge of TDM, whereas 85.8% thought HCPs should ask pharmacists for recommendations on the appropriate use of TDM. These findings are in line with a published survey in Australia and New Zealand, where the profession most frequently involved in providing dosing and monitoring advice was the pharmacist followed by the clinical microbiologist and medical staff.[18] Similarly, in a survey conducted in Saudi Arabia, 82.3% of physicians reported consulting pharmacists given their expertise and knowledge in CPK.[6] In addition, the American Society of Health-System Pharmacists states that CPK and TDM services are a fundamental responsibility of all pharmacists in providing pharmaceutical care.[3] In the United States, 94.6% of surveyed hospitals had pharmacists who routinely monitor serum medication concentrations, where 82.3% of the hospitals gave pharmacists the authority by protocol to order the initial measurement of a serum medication concentration, and 81.7% of the hospitals allowed pharmacists to adjust the dosage of a medication being monitored.[19] In a meta-analysis of 27 clinical studies, the CPK services run by clinical pharmacists had a positive influence on the proportion of patients who demonstrated desirable serum drug concentrations and overall reduced proportion of inappropriately collected patient blood samples.[20] Such practice is widely used across the US, European, and Australian health care systems, although it is still in its infancy in Kuwait.[21]

The present study findings can be used as a tool by decision makers in designing professional education curricula and by policymakers in health care systems to better design future targeted multifaceted interventions that would improve TDM implementation. This study underscores an urgent need for effective educational programs on CPK and TDM at the undergraduate and postgraduate levels to improve the implementation of TDM in the Kuwait health care system. The faculties of medicine and pharmacy must prepare their physicians, and in particular pharmacists, to effectively use medication concentration data to deliver individualized doses for the patients' benefit and avoid learning by negative experience (trial and error). As a multidisciplinary service, implementation of CPK and TDM will benefit from interprofessional educational courses at the advanced training level. Pharmacists' high confidence in and positive perception toward the service and the expectation from the physicians that the service will be delivered by pharmacists strengthen or support the position of expanding the pharmacists' scope of practice in the country with appropriate education and training.

This study's strengths include the high response rate and the adequate sample size and sampling method to produce representative data regarding the study population; therefore, the present findings can be generalized to health care providers in secondary health care settings in Kuwait. This study also fills a gap in the existing literature worldwide and provides useful information for health care providers' KCP toward TDM and its implications in the Middle Eastern region. Use of the 3-option scale (agree, neutral, and disagree) minimizes central tendency bias. One of the study's limitations was the cross-sectional nature of the survey because it does not reflect any changes in respondents' KCP over time regarding TDM and its implications. Additionally, the findings may not be representative of all HCPs in Kuwait because the study sample was restricted to secondary care centers. Therefore, further studies are needed among those attending the private sector and tertiary care centers to explore how these findings may be relevant in those other clinical settings. This type of self-reported research depends on information provided by respondents and so is exposed to recall bias because there is a tendency for socially desirable behaviors to be overreported or socially undesirable behaviors to be underreported. Assessing the honesty of the answers or verifying respondents' claims is not objectively possible in this study. Furthermore, it was difficult to include specialization in the regression analysis for the current study because there is no specialization for pharmacists at this time in Kuwait; this might have influenced the results of the regression model. In addition, in the current study, none of the participants was an infectious diseases specialist or clinical microbiologist. Finally, other barriers to the use of TDM were not investigated, and so these can be explored in future studies.

CONCLUSION

The present findings show that the physicians and pharmacists have low levels of knowledge of CPK and TDM but high confidence and positive perceptions of TDM and its

clinical implications. Respondents' positive perceptions show that TDM should be an integral part of the health care system in Kuwait and that TDM practice is expected to be implemented by the respondents, particularly pharmacists. Therefore, there is an urgent need for education and training in the field of CPK and TDM and its clinical implications through continuous professional development programs and its integration into medical and pharmacy schools' curricula. Policymakers in the educational and health care systems should collaborate and focus on developing and improving TDM in Kuwait to improve its implementation in clinical practice.

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