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RESEARCH ARTICLE

# Clinical pharmacokinetics: perceptions of hospital pharmacists in Qatar about how it was taught and how it is applied

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**Abstract** *Background* The application of clinical pharmacokinetics (PK) is essential when providing pharmaceutical care. Appropriate application of PK monitoring results in improved patient outcomes including decreased mortality, length of treatment, length of hospital stay, and adverse effects of drug therapy. Despite the well-documented evidence of benefits of clinical PK services, many pharmacists find it challenging to apply PK in clinical practice. *Objective* To evaluate pharmacists' training backgrounds, attitude, practices, and perceived barriers pertaining to the application of PK in clinical practice in Qatar. *Setting* All hospitals under Hamad Medical Corporation, the main healthcare provider in Qatar. *Methodology* This was a cross-sectional, descriptive study that was conducted between October 2012 and January 2013, using a self-administered web-based survey. Pharmacists were eligible to participate if they: (1) were working as full-time hospital pharmacists and; (2) have been in practice for at least 1 year. *Main outcome measures* PK contents learned in undergraduate curriculum; perception towards the PK contents and instructions received in the undergraduate curriculum and; application of PK in current clinical practice. *Results* A total of 112 pharmacists responded to the questionnaire. The majority of the respondents (n = 91; 81.3 %) reported that they had received PK course(s) in their undergraduate curriculum. Similarly, the majority (70–80 %) of them agreed that the undergraduate PK courses or contents they received were important and relevant to their current practice. The pharmacists identified spending more time on dispensing and inventory issues rather than clinical practice, scarce resources, and manual rather than computerized PK calculations as some of the barriers they encountered in learning about PK and its application. The characteristics of the surveyed pharmacists such as gender, age, highest academic degree, and country of graduation did not influence the pharmacists' perception and attitudes towards PK teaching and application ($p > 0.05$). *Conclusion* PK course contents were perceived to lack depth and relevance to practice, and pharmacist had no experiential training that included aspects of PK. These, and other issues, result in poor application of PK in practice.

**Keywords** Clinical pharmacists · Clinical practice · Perceived barriers · Pharmacokinetics · Qatar

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## Impacts on Practice

- To improve the ability of pharmacists to use pharmacokinetics skills in clinical practice, there is a need for changes in the content and delivery of pharmacokinetics courses in undergraduate curricula.
- The main barriers that compromised the extent of pharmacists' preparedness to apply PK principles in practice are the lack of sufficient experiential exposure, and poor quality of instructions.

## Introduction

The American Society of Health-System Pharmacists [1] has defined clinical pharmacokinetics (PK) as "the process of applying PK principles to determine the dosage regimens of specific drug products for specific patients to maximize the therapeutic outcomes and minimize toxicity". It is believed that the application of clinical PK is an essential responsibility of all pharmacists providing pharmaceutical care [2]. The application of PK principles requires a thorough understanding of the absorption, distribution, metabolism, and excretion characteristics of specific drugs in specific diseases and patient populations. Appropriate application of clinical PK monitoring results in improved patient outcomes: decreased mortality, reduced length of treatment, reduced length of hospital stay (LOS), decreased morbidity, decreased adverse effects of drug therapy, and cost-savings [1–7].

It has been reported that pharmacist-led therapeutic drug monitoring (TDM) services for aminoglycosides increased the likelihood of obtaining adequate peak concentrations, increased the frequency of clinical improvements, decreased the number and mean total doses administered, and minimized changes in serum creatinine from baseline [4]. These services also led to a decrease in morbidity and mortality, length of drug therapy, LOS, and direct costs [2]. TDM of old and new generation antiepileptic drugs (AEDs) helped in assessing the therapeutic outcomes, dose adjustment, and improved adherence with uncontrolled or breakthrough seizures, and toxicity [8–11]. TDM and individualized dosing of theophylline have shown to achieve serum concentrations in the therapeutic range, rapid clinical improvements and fewer serious adverse events compared to conventional administration of theophylline [12, 13]. Similarly, pharmacist-led PK services on digoxin was associated with reduced LOS, morbidity, and associated cost [14, 15].

As part of the provision of pharmaceutical care services, pharmacists play an important role in ensuring appropriate and cost-effective TDM and clinical PK assessments [1, 3, 16]. Pharmacists can use their knowledge and skills to identify the actual and potential causes of abnormal TDM results which could be related to drug interactions, non-adherence to drug therapy or medication errors [5]. However, despite the well-documented evidence of the benefits of clinical PK services, many pharmacists find it challenging to apply their knowledge of PK in clinical practice settings [17]. A number of possible reasons for this missed opportunity had been proposed; including a lack of confidence; lack of sufficient training, related skills and knowledge during undergraduate pharmacy education; and being unsure about drugs that require TDM [17].

In recent years, pharmacy practice in Qatar has undergone a major transformation towards improvement of healthcare services and patient care outcomes. The most important drivers of these changes include the advancement of hospital pharmacy services, the evolution of pharmacy education, Qatar's strategic health care plans, and the strong pharmacy leadership in the country [18–20]. Clinical PK and TDM services provided by pharmacists have long been established in other developed counties, particularly in North America [3]. Despite the paucity of data on the extent to which pharmacists in Qatar are involved in the application of PK in clinical practice, anecdotal evidence and observations by practicing pharmacists suggest that these services are most commonly provided by personnel other than pharmacists in most hospitals. Therefore, it would appear that the assessment of the pharmacists' perception of their educational and training backgrounds pertaining to TDM and PK application is crucial. It is also important to investigate the barriers faced by the practicing pharmacists when applying PK and TDM services in this country. To our knowledge, no studies have been conducted to determine the hospital pharmacists' attitudes and practices in relation to PK in Qatar. Thus, an evaluation of the practitioners' attitude, practices and barriers, is needed in order to gain an insight into the current practice regarding PK application so that gaps in practice can be addressed to further advance pharmacy practice.

## Aim of the study

The present study aims to: (1) explore the training background and perceptions of pharmacists in Qatar on the PK course contents they received during their undergraduate pharmacy programs and the challenges they faced in learning PK principles; (2) determine the attitudes of, and the barriers experienced by, the pharmacists when applying PK principles in their current practice and; (3) explore the influence of the respondents' characteristics on their perception about clinical PK.

## Ethical approval

This study was approved by the Qatar University Institutional Review Board (QU IRB) and the Hamad Medical Corporation (HMC) Medical Research Committee.

## Methods

### Study design and participants

This was a cross-sectional, descriptive study that was conducted between October 2012 and January 2013, using

a self-administered online survey. The study targeted hospital pharmacists practicing in the state of Qatar.

## Study setting

All hospitals under the umbrella of Hamad Medical Corporation (HMC), the main healthcare provider in the state of Qatar. These hospitals were: Al-Rumailah Hospital, Hamad General Hospital, Women's Hospital, the Heart Hospital, Al-Khor Hospital, the National Center for Cancer Care and Research (NCCCR), and Al-Wakra Hospital.

## Eligibility criteria

Pharmacists were eligible to participate if they were: (1) working as full-time hospital pharmacist and; (2) in practice for at least 1 year. Hospital pharmacists who did not meet both criteria were excluded from the study.

## Survey instrument development and implementation

The questionnaire used in this study was developed after a thorough review of the available literature and through examination of other instruments evaluating attitudes and practices of pharmacists and other healthcare professionals regarding different aspects in clinical practice [1, 3, 5, 17, 21–25]. Besides items on demographic and professional characteristics, the questionnaire comprised of three main sections aimed to assess: (1) PK contents learned in undergraduate curriculum (four multiple choice items); (2) perception towards the PK contents and instructions received in the undergraduate curriculum (five items measured on a five-point Likert scale; strongly agree to strongly disagree); (3) application of PK in current clinical practice (six items assessing relevance of the PK courses received and the barriers faced towards application in practice). One open-ended question was included to assess perceived barriers in PK learning. Face and content validity of the questionnaire was conducted by three individuals identified as experts in the field and with sufficient expertise in questionnaire development. The resulting questionnaire was sent to five randomly selected hospital pharmacists for the assessment of readability, clarity, comprehension and burden (time taken to complete the questionnaire). Feedback from these processes were taken into account and a modified questionnaire was developed and piloted among four randomly selected hospital pharmacists who were excluded from the analysis. An invitation along with a consent form and a link to the questionnaire were sent to the seven pharmacy groups. Two follow-up e-mail messages were sent out to all participants at 4-weekly interval to maximize response rate.

## Data analyses

Data were analyzed using the IBM Statistical Package for Social Sciences (IBM SPSS Software) version 22. Both descriptive and inferential statistics were applied for the data analyses. All the categorical variables, including the respondents' socio-demographic and professional characteristics, items assessing the nature of PK courses taught at the undergraduate curriculum, perception towards these courses and PK applications were expressed as frequencies and percentages. The influence of respondents' professional and demographic factors on perception towards PK teaching and practice was tested using the Chi square and Fisher's Exact tests as appropriate. The level of significance was set a priori at $p \leq 0.05$.

The open-ended question about barriers was analyzed following qualitative data analysis technique. Basically, statements made by participants were retrieved from the web-based data collection software and common statements were used to generate categories that represented the perceptions of the group. The coded statements were clustered into thematic categories. These thematic categories are presented as part of the findings as frequencies (number of participants expressing similar ideas grouped under the same category). To support theme generation and an understanding of the participants' experiences and perceptions, textual data were included in the report to highlight key themes.

## Results

### Demographic and professional characteristics of the respondents

A total of 112 pharmacists completed and returned the questionnaire. More than half of the respondents were male (n = 63; 56.3 %), between the age of 31–40 years (n = 59; 52.7 %), with BSc (Pharm) degree or its equivalent (n = 75; 66.9 %), and had more than 5 years of experience as a hospital pharmacist (n = 65; 58.0 %). About 41 % of the respondents obtained their first degree in pharmacy from Egypt (n = 46). Table 1 provides more details on the characteristics of the respondents.

### Nature of the pharmacokinetic contents learned by the pharmacists in undergraduate curriculum

The majority of the respondents (n = 91; 81.3 %) reported that they had received PK course(s) in their undergraduate curriculum. Of this, 63 (69.2 %) of the respondents indicated that the PK courses studied were standalone courses. The remaining respondents indicated that PK was

integrated with other pharmacy courses such as pharmacotherapy, pharmaceutics, or pharmacology. Only 12 (10.7 %) of the respondents received more than two PK courses during their undergraduate studies compared to those who received only one PK course (n = 30; 26.8 %) or two PK courses (n = 31; 27.7 %). The remaining 39 respondents (34.8 %) did not receive any PK courses during their undergraduate studies. The majority of the respondents who received any PK courses described these courses as basic PK (n = 53; 47.3 %).

## Perception towards the pharmacokinetics courses and the applicability of pharmacokinetics skills in clinical practice

Table 2 illustrates the hospital pharmacists' perception towards PK courses they received during their undergraduate programs. The majority of the participants agreed or strongly agreed that the undergraduate PK courses or contents they received were important (80 %) and relevant (70 %) to their current practice. In addition, a large

**Table 1** Demographic and professional characteristics of hospital pharmacists in Qatar (n = 112)

| Characteristic | Frequency (%) |
| --- | --- |
| *Gender* | |
| Male | 63 (56.2) |
| Female | 49 (43.8) |
| *Age in years* | |
| 20–30 | 47(41.9) |
| 31–40 | 59 (52.7) |
| 41–50 | 4 (3.6) |
| >50 | 2 (1.8) |
| *Highest academic degree* | |
| BSc | 75 (66.9) |
| MSc | 13 (11.6) |
| PharmD | 7 (6.3) |
| PhD | 1 (0.9) |
| Other | 16 (14.3) |
| *Country of graduation* | |
| Egypt | 46 (41.1) |
| Jordan | 21 (18.7) |
| Syria | 3 (2.7) |
| Sudan | 6 (5.4) |
| India | 11 (9.8) |
| Other | 25 (22.3) |
| *Years of experience as a hospital pharmacist* | |
| <5 years | 47 (41.9) |
| 6–10 years | 48 (42.9) |
| 11–15 years | 13 (11.6) |
| >15 years | 4 (3.6) |

proportion of the pharmacists surveyed agreed or strongly agreed that the methods used to teach the PK courses in their undergraduate pharmacy studies were effective (55.2 %), but only 44.3 % were in agreement that the content was adequate. About 39 % of the respondents indicated that the depth of the PK courses received in the undergraduate pharmacy curriculum was appropriate to prepare them for relevant clinical roles in the future, while 30 (34.1 %) remained neutral about this point.

## Perceived barriers and practice

The barriers to provide PK services were generated in a qualitative manner, and responses were categorized into six themes: relevance to practice, experiential practice, application, facilities, quality of instruction, and other barriers. Table 3 provides examples and quotes from qualitative statements made. In summary, spending more time on dispensing and inventory issues rather than clinical practice, the need for practice, scarce resources, lack of facilities, manual rather than computerized PK calculations and lack of implementation of case studies were all perceived as barriers against applying PK principles by the hospital pharmacists in Qatar. Respondents thought that there were areas in PK that should be enhanced and topics that need be covered more deeply in PK teaching and learning. The barriers identified by the pharmacists while applying PK principles in their current practice were rated in order of importance in Table 4.

Hospital pharmacists described their utilization of the PK knowledge gained through undergraduate pharmacy degree programs in their current practice as: "used most of the times" (n = 21; 25.6 %); "Used fairly many times" (n = 23; 28.0 %); and "Used occasionally" (n = 25; 30.5 %). Only about 30 % of the respondents regarded their PK skills as "Just adequate" in allowing them to provide optimal care, while 40 (47.1 %) considered that it could be better. Furthermore, more than half of all respondents (57.6 %) admitted that it was reasonably feasible to utilize their PK knowledge and skills in clinical practice.

## Effect of pharmacists' characteristics on their perception and practices towards PK teaching and application

The influence of the respondents' demographic and professional characteristics on their perception of the relevance of PK contents learned and their application in practice was assessed. Years of experience had an effect on the pharmacists perception towards PK courses studied in the undergraduate program; where pharmacists with less years of experience tended to perceive that the PK courses

**Table 2** Hospital pharmacists' perception towards pharmacokinetics contents learned during undergraduate studies and their applicability to clinical practice (n = 112)

| Perception item[a] | Frequency (%) | | | | | Mean ± SD |
|---|---|---|---|---|---|---|
| | Strongly agree (5) | Agree (4) | Neutral (3) | Disagree (2) | Strongly disagree (1) | |
| 1. The undergraduate PK courses I received were important to my current practice | 22 (25) | 48 (54.5) | 16 (18.2) | 2 (2.3) | 0 (0) | 1.98 ± 0.73 |
| 2. The undergraduate PK courses I received were relevant to my current practice | 16 (18.2) | 45 (51.1) | 20 (22.7) | 5 (5.7) | 2 (2.3) | 2.23 ± 0.89 |
| 3. The method used to teach PK courses at my pharmacy undergraduate studies were effective | 10 (11.5) | 38 (43.7) | 27 (31.0) | 12 (13.8) | 0 (0) | 2.47 ± 0.88 |
| 4. The content of the PK courses I received at my pharmacy undergraduate studies was adequate | 2 (2.3) | 37 (42.0) | 30 (34.1) | 19 (21.6) | 0 (0) | 2.75 ± 0.82 |
| 5. The depth of the PK courses taught at the undergraduate pharmacy studies was appropriate to prepare me for my future clinical roles | 7 (8.0) | 26 (29.5) | 34 (38.6) | 20 (22.7) | 1 (1.1) | 2.80 ± 0.92 |

[a] There were some missing data across all the variables

and skills learnt during their undergraduate studies were more relevant to practice ($p \leq 0.05$). The remaining characteristics: gender, age, highest academic degree, and country of graduation did not seem to have an effect on the pharmacists' perception and attitudes towards PK teaching and application ($p > 0.05$).

## Discussion

Overall, most of the pharmacists surveyed indicated that they had received PK instructions during their undergraduate pharmacy study and that the PK courses or contents received were important and relevant to their current practice. On the other hand, the respondents identified several barriers they encountered in learning PK and the application of its principles in their current practice. Hospital pharmacists play a pivotal role in ensuring safe and effective selection and administration of medications. PK application and clinical PK consult service is one aspect of pharmacy practice that enables hospital pharmacists to deliver pharmaceutical care safely and effectively [1]. Having sufficient and sound foundational knowledge, positive attitudes towards PK application and practical experiences are crucial to the application of PK in practice. Exploring issues of concern to pharmacists with respect to the application of the science of PK in clinical practice is warranted at a time when voices are calling for a sobering look at how clinical pharmacokinetics fits into the pharmaceutical care process [3]. It was evident that the majority of the pharmacists in the current study were not completely confident with their PK knowledge and skills and this could be partly related to the barriers they

encountered in learning PK during their undergraduate pharmacy education. Lack of sufficient experiential exposure, inadequate application of knowledge, lack of facilities, and poor quality of instructions and teaching were identified in this study as the main obstacles that hindered the delivery of adequate PK contents. Respondents, however, indicated that the undergraduate PK contents they received were relevant and that they were appropriate to prepare them for their future clinical roles. On the other hand, many of them considered that their PK skills "could be better" in allowing them to provide optimal pharmaceutical care.

Our cohort of pharmacists thought that there were areas in PK teaching and learning that should be improved. Considering that these pharmacists graduated from different pharmacy schools from different countries and had been taught differently with diverse pharmacy curricula, this could be a reason to provide bridging training programs or continuing professional development to upscale and standardize the pharmacists' knowledge and skills in clinical PK.

Hospital pharmacists pointed at a focus on dispensing and inventory issues rather than clinical practice, scarce resources, manual PK calculations, and lack of incorporation of case studies in practice as barriers that they faced in their current practice. Since some of the surveyed pharmacists did not answer all questions, these might not be all the barriers that hospital pharmacists encounter in their practice. However, it is apparent that these barriers need to be tackled in order to provide optimal PK services that would ultimately impact patient outcomes. Previous studies have documented evidence of benefit of pharmacist provided clinical PK services on outcomes, reducing rates of

**Table 3** Barriers encountered by the hospital pharmacists in learning pharmacokinetics contents during their undergraduate studies

Barriers

*Category 1. Irrelevant practice (frequency: 5)*

1. I didn't encounter barriers while learning; I did encounter barriers while practicing and applying. For instance, TDM as we were taught is applied in different ways in hospitals. For instance they do not calculate the clearance of vancomycin, if the level is not optimal; they just decrease or increase the dose by 25 %

2. Difficulty in understanding the course and there are many factors affecting the PK of the medications and sometimes the student thinks that this course is completely not related to the future work

3. It was theoretical only. Clinical cases were rarely discussed

*Category 2. No experiential practice (frequency: 6)*

1. More practice and applicability to clinical situations to make calculations automatic and quick

2. Practical applications or practice

*Category 3. Poor application (frequency: 4)*

1. Practical application of all PK parameters during the course due to time limitation

2. Application of PK to our daily practice

*Category 4. Poor facilities (frequency: 2)*

1. There were no sufficient PK labs to help us in practicing PK in our work

2. We did not use computerized system; we were only doing the calculation manually

*Category 5. Quality of instruction (frequency: 7)*

1. It was one way learning, not interactive (teaching using one way as the student been receiving only)

2. Taught as academic material in a one way instruction… not interactive or practical

3. Many doctors teach the same subject, the content was not presented correctly for the student. The subject was given at the same period with other difficult subjects

4. Insufficient information. No practice. No good orientation about the importance of this branch

5. There was no specialized doctor in PK to teach us during my days. The amount of topics to be covered doesn't correlate with the amount of time/days we get PK—PK should be divided in two semester

6. No specialized instructors to teach the subject were available

7. Touching on the surface of various PK topics where some topics deserved more time to be invested in than others

*Category 6. Others (frequency: 6)*

1. I hate Maths

2. Application and trials

3. Introduced in early years of studies. Several instructors and different styles. One course rather than extended program

**Table 4** Barriers encountered by the hospital pharmacists in applying pharmacokinetics principles in their current practice (n = 112)

| Barrier[a] | Frequency (%) | | | | | Mean ± SD |
|---|---|---|---|---|---|---|
| | Extremely important barrier (1) | Important barrier (2) | Neutral (3) | Unimportant barrier (4) | Not a barrier at all (5) | |
| Lack of practical knowledge | 15 (17.6) | 36 (42.4) | 18 (21.2) | 4 (4.7) | 12 (14.1) | 3.54 ± 1.27 |
| Lack of PK-related continuing education topics | 19 (22.4) | 41 (48.2) | 17 (20.0) | 4 (4.7) | 4 (4.7) | 3.21 ± 1.00 |
| Lack of role model at work place who knows and applies PK skills | 21 (24.6) | 35 (41.2) | 17 (20.0) | 6 (7.1) | 6 (7.1) | 3.31 ± 1.13 |
| Poor understanding of PK by the health care professionals other than pharmacists | 11 (12.9) | 35 (41.2) | 32 (37.6) | 2 (2.4) | 5 (5.9) | 3.47 ± 0.96 |
| Poor understanding of PK by pharmacists | 9 (10.6) | 26 (30.6) | 34 (40.0) | 7 (8.2) | 9 (10.6) | 3.78 ± 1.10 |

[a] There were some missing data across all the variables

adverse drug events and costs-savings [1, 2, 4–8, 26, 27]. Hospital pharmacy departments need to address the issues raised by the pharmacists regarding the incorporation of case studies in practice through continuing professional development (CPD) programs in hospitals and elsewhere. As pharmacists are keen to learn and improve the current

practice, this should be a driver for the pharmacy departments to mandate these CPD sessions in order to maintain a life-long learning environment.

Pharmacists' attitude and practices towards PK learning and applications seemed to be influenced by the years of experience as a hospital pharmacist. Pharmacist who had less than 5 years of experience as hospital pharmacists had more positive attitudes towards the relevance of the PK curricula taught during their undergraduate pharmacy program to practice. Other characteristics that one would have imagined would affect the pharmacists' attitude towards PK practice such as highest academic degree and country of graduation did not show any influence.

To our knowledge, this is the first study to report pharmacists' attitudes and practices towards PK application in clinical practice in Qatar and the Middle East. The study was a nationwide study that included all pharmacists working under HMC; which is the main public healthcare provider in Qatar. The study has some important limitations that while inherent to most survey-type studies, warrant mentioning. There is a possibility of social desirability bias on the attitude domain, where respondents might tend to give more favorable responses toward PK practices. Although the cohort of pharmacists studied was young, there were potential for recall bias since respondents were asked about what they had learned during their undergraduate studies. Finally, a 'Dunning Krueger' effect might be involved, where individuals with poor competency will tend to overestimate their own level of skills [28]. This, we consider to be an issue with major implications but that was unavoidable in this sort of study.

## Conclusion

A large proportion of hospital pharmacists in Qatar had positive attitudes towards PK contents learned during their undergraduate studies; however, they admitted that their PK skills could be better in order to provide optimal PK service in their current practice. The findings of the current study should be taken into consideration to develop educational interventions to address pharmacists concerns with respect to the current clinical PK practice in Qatar. From a broader perspective, we believe that a fresh look at how the undergraduate PK curricula in schools and colleges of pharmacy are designed and delivered is imperative. A gap between what is taught and what needs to be applied in clinical practice needs bridging.

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