

1 **Clinical pharmacokinetics: perceptions of hospital pharmacists about how it was**
2 **taught and how it is applied**

3

4 **Introduction**

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

15

16 **It has been** reported that pharmacist-led therapeutic drug monitoring (TDM) services for
17 aminoglycosides increased the likelihood of obtaining adequate peak concentrations, increased
18 the frequency of clinical improvements, decreased the number and mean total doses
19 administered, and minimized changes in serum creatinine from baseline [4]. These services also
20 led to a decrease in morbidity and mortality, length of drug therapy, **LOS**, and direct costs [2].
21 TDM of old and new generation antiepileptic drugs (AEDs) helped in assessing the therapeutic
22 outcomes, dose adjustment, and improved adherence with uncontrolled or breakthrough seizures,
23 and toxicity [8-11]. TDM and individualized dosing of theophylline have shown to achieve

24 serum concentrations in the therapeutic range, rapid clinical improvements and fewer serious
25 adverse events compared to conventional administration of theophylline [12,13]. Similarly,
26 pharmacist-led PK services on digoxin was associated with reduced LOS, morbidity, and
27 associated cost [14,15].

28

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

38

39 In recent years, pharmacy practice in Qatar has undergone a major transformation towards
40 improvement of healthcare services and patient care outcomes. The most important drivers of
41 these changes include the advancement of hospital pharmacy services, the evolution of pharmacy
42 education, Qatar's strategic health care plans, and the strong pharmacy leadership in the country
43 [18-20]. Clinical PK and TDM services provided by pharmacists have long been established in
44 other developed countries, particularly in North America [3]. Despite the paucity of data on the
45 extent to which pharmacists in Qatar are involved in the application of PK in clinical practice,
46 anecdotal evidence and observations by practicing pharmacists suggest that these services are

47 most commonly provided by personnel other than pharmacists in most hospitals. Therefore, it
48 would appear that the assessment of the pharmacists' perception of their educational and training
49 backgrounds pertaining to TDM and PK application is crucial. It is also important to investigate
50 the barriers faced by the practicing pharmacists when applying PK and TDM services in this
51 country. To our knowledge, no studies have been conducted to determine the hospital
52 pharmacists' attitudes and practices in relation to PK in Qatar. Thus, an evaluation of the
53 practitioners' attitude, practices and barriers, is needed in order to gain an insight into the current
54 practice regarding PK application so that gaps in practice can be addressed to further advance
55 pharmacy practice.

56

57 **Aim of the study**

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

64

65 **Ethical approval**

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

68

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70

71 **Methods**

72 *Study design and participants*

73 This was a cross-sectional, descriptive study that was conducted between October 2012 and
74 January 2013, using a self-administered online survey. The study targeted hospital pharmacists
75 practicing in the state of Qatar.

76

77 *Study setting*

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

82

83 *Eligibility criteria*

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

87

88 *Survey instrument development and implementation*

89 The questionnaire used in this study was developed after a thorough review of the available
90 literature and through examination of other instruments evaluating attitudes and practices of
91 pharmacists and other healthcare professionals regarding different aspects in clinical practice
92 [1,3,5,17,21-25]. Besides items on demographic and professional characteristics, the questionnaire

93 comprised of three main sections aimed to assess: (1) PK contents learned in undergraduate
94 curriculum (four multiple choice items); (2) perception towards the PK contents and instructions
95 received in the undergraduate curriculum (five items measured on a five-point Likert scale;
96 strongly agree to strongly disagree); (3) application of PK in current clinical practice (six items
97 assessing relevance of the PK courses received and the barriers faced towards application in
98 practice). One open-ended question was included to assess perceived barriers in PK learning.
99 Face and content validity of the questionnaire was conducted by three individuals identified as
100 experts in the field and with sufficient expertise in questionnaire development. The resulting
101 questionnaire was sent to five randomly selected hospital pharmacists for the assessment of
102 readability, clarity, comprehension and burden (time taken to complete the questionnaire).
103 Feedback from these processes were taken into account and a modified questionnaire was
104 developed and piloted among four randomly selected hospital pharmacists who were excluded
105 from the analysis. An invitation along with a consent form and a link to the questionnaire were
106 sent to the 7 pharmacy groups. Two follow-up e-mail messages were sent out to all participants
107 at 4-weekly interval to maximize response rate.

108

109 *Data analyses*

110 Data were analyzed using the IBM Statistical Package for Social Sciences (IBM SPSS Software)
111 version 22. Both descriptive and inferential statistics were applied for the data analyses. All the
112 categorical variables, including the respondents' socio-demographic and professional
113 characteristics, items assessing the nature of PK courses taught at the undergraduate curriculum,
114 perception towards these courses and PK applications were expressed as frequencies and
115 percentages. The influence of respondents' professional and demographic factors on perception

116 towards PK teaching and practice was tested using the Chi-square and Fisher's Exact tests as
117 appropriate. The level of significance was set a priori at $p \leq 0.05$.

118
119 The open-ended question about barriers was analyzed following qualitative data analysis
120 technique. Basically, statements made by participants were retrieved from the web-based data
121 collection software and common statements were used to generate categories that represented the
122 perceptions of the group. The coded statements were clustered into thematic categories. These
123 thematic categories are presented as part of the findings as frequencies (number of participants
124 expressing similar ideas grouped under the same category). To support theme generation and an
125 understanding of the participants' experiences and perceptions, textual data were included in the
126 report to highlight key themes.

127

128 **Results**

129 *Demographic and professional characteristics of the respondents*

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

136

137

138 *Nature of the pharmacokinetic contents learned by the pharmacists in undergraduate*
139 *curriculum*

140 The majority of the respondents (n=91; 81.3%) reported that they had received PK course(s) in
141 their undergraduate curriculum. Of this, 63 (69.2%) of the respondents indicated that the PK
142 courses studied were standalone courses. The remaining respondents indicated that PK was
143 integrated with other pharmacy courses such as pharmacotherapy, pharmaceutics, or
144 pharmacology. Only 12 (10.7%) of the respondents received more than two PK courses during
145 their undergraduate studies compared to those who received only one PK course (n=30; 26.8%)
146 or two PK courses (n=31; 27.7%). The remaining 39 respondents (34.8%) did not receive any PK
147 courses during their undergraduate studies. The majority of the respondents who received any
148 PK courses described these courses as basic PK (n=53; 47.3%).

149
150 *Perception towards the pharmacokinetics courses and the applicability of pharmacokinetics*
151 *skills in clinical practice*

152 Table 2 illustrates the hospital pharmacists' perception towards PK courses they received during
153 their undergraduate programs. The majority of the participants agreed or strongly agreed that the
154 undergraduate PK courses or contents they received were important (80%) and relevant (70%) to
155 their current practice. In addition, a large proportion of the pharmacists surveyed agreed or
156 strongly agreed that the methods used to teach the PK courses in their undergraduate pharmacy
157 studies were effective (55.2%), but only 44.3% were in agreement that the content was
158 adequate. About 39% of the respondents indicated that the depth of the PK courses received in
159 the undergraduate pharmacy curriculum was appropriate to prepare them for relevant clinical
160 roles in the future, while 30 (34.1%) remained neutral about this point.

161 *Perceived barriers and practice*

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

172 Hospital pharmacists described their utilization of the PK knowledge gained through
173 undergraduate pharmacy degree programs in their current practice as: “used most of the times”
174 (n=21; 25.6%); “Used fairly many times” (n=23; 28.0%); and “Used occasionally” (n=25;
175 30.5%). Only about 30% of the respondents regarded their PK skills as “Just adequate” in
176 allowing them to provide optimal care, while 40 (47.1%) considered that it could be better.
177 Furthermore, more than half of all respondents (57.6%) admitted that it was reasonably feasible
178 to utilize their PK knowledge and skills in clinical practice.

179

180 *Effect of pharmacists’ characteristics on their perception and practices towards PK teaching*
181 *and application*

182 The influence of the respondents’ demographic and professional characteristics on their
183 perception of the relevance of PK contents learned and their application in practice was assessed.

184 Years of experience had an effect on the pharmacists perception towards PK courses studied in
185 the undergraduate program; where pharmacists with less years of experience tended to perceive
186 that the PK courses and skills learnt during their undergraduate studies were more relevant to
187 practice ($p \leq 0.05$). The remaining characteristics: gender, age, highest academic degree, and
188 country of graduation did not seem to have an effect on the pharmacists' perception and attitudes
189 towards PK teaching and application ($p > 0.05$).

190

191 **Discussion**

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

207 inadequate application of knowledge, lack of facilities, and poor quality of instructions and
208 teaching were identified in this study as the main obstacles that hindered the delivery of adequate
209 PK contents. Respondents, however, indicated that the undergraduate PK contents they received
210 were relevant and that they were appropriate to prepare them for their future clinical roles. On
211 the other hand, many of them considered that their PK skills “could be better” in allowing them
212 to provide optimal pharmaceutical care.

213
214 Our cohort of pharmacists thought that there were areas in PK teaching and learning that should
215 be improved. Considering that these pharmacists graduated from different pharmacy schools
216 from different countries and had been taught differently with diverse pharmacy curricula, this
217 could be a reason to provide bridging training programs or continuing professional development
218 to upscale and standardize the pharmacists’ knowledge and skills in clinical PK.

219
220 Hospital pharmacists pointed at a focus on dispensing and inventory issues rather than clinical
221 practice, scarce resources, manual PK calculations, and lack of incorporation of case studies in
222 practice as barriers that they faced in their current practice. Since some of the surveyed
223 pharmacists did not answer all questions, these might not be all the barriers that hospital
224 pharmacists encounter in their practice. However, it is apparent that these barriers need to be
225 tackled in order to provide optimal PK services that would ultimately impact patient outcomes.
226 Previous studies have documented evidence of benefit of pharmacist provided clinical PK
227 services on outcomes, reducing rates of adverse drug events and costs-savings [1,2,4-8,26,27].
228 Hospital pharmacy departments need to address the issues raised by the pharmacists regarding
229 the incorporation of case studies in practice through continuing professional development (CPD)

230 programs in hospitals and elsewhere. As pharmacists are keen to learn and improve the current
231 practice, this should be a driver for the pharmacy departments to mandate these CPD sessions in
232 order to maintain a life-long learning environment.

233
234 Pharmacists' attitude and practices towards PK learning and applications seemed to be
235 influenced by the years of experience as a hospital pharmacist. Pharmacist who had more than 5
236 years of experience as hospital pharmacist had more positive attitudes towards PK learning and
237 applications compared to those who had less than five years of experience in hospital pharmacy.
238 Other characteristics that one would have imagined would affect the pharmacists' attitude
239 towards PK practice such as highest academic degree and country of graduation did not show
240 any influence.

241
242 To our knowledge, this is the first study to report pharmacists' attitudes and practices towards
243 PK application in clinical practice in Qatar and the Middle East. The study was a nationwide
244 study that included all pharmacists working under HMC; which is the main public healthcare
245 provider in Qatar. The study has some important limitations that while inherent to most survey-
246 type studies, warrant mentioning. There is a possibility of social desirability bias on the attitude
247 domain, where respondents might tend to give more favorable responses toward PK practices.
248 Although the cohort of pharmacists studied was young, there were potential for recall bias since
249 respondents were asked about what they had learned during their undergraduate studies. Finally,
250 a 'Dunning Krueger' effect might be involved, where individuals with poor competency will
251 tend to overestimate their own level of skills [28]. This, we consider to be an issue with major
252 implications but that was unavoidable in this sort of study.

253

254 **Conclusion**

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

263

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274

275 **Conflicts of interest**

276 The authors have no competing interests to declare.

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