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RESEARCH ARTICLE

A cross-sectional study of the current situation with therapeutic drug monitoring in Thailand: Requirements, challenges and the role of educational institutions

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Abstract

Background: Therapeutic drug monitoring (TDM) is a drug dose determination tool for individualised therapy. **Objective:** This study examined the TDM services provided by hospitals and topics taught in pharmacy schools in Thailand. **Methods:** TDM service and curriculum questionnaires were sent to 179 hospitals and all 19 pharmacy schools in Thailand. Correlations were tested using Fisher's exact test. **Results:** Completed questionnaires were returned by 116 hospitals (64.8%). Forty-three hospitals (37.1%) conducted TDM and most were large hospitals (>500 beds, n=27, 62.8%). Higher numbers of beds and pharmacists positively correlated with conducting TDM ($p < 0.001$ and $p = 0.003$, respectively). Phenytoin was the most frequently monitored drug (n=39, 90.7%). All pharmacy schools taught TDM for phenytoin, valproic acid, vancomycin, carbamazepine, and digoxin. The most frequently cited benefit of TDM was to prevent adverse drug reactions (n = 108, 93.1%). The primary reason cited for not conducting TDM was a lack of in-house laboratories (n=78, 67.2%). **Conclusion:** Despite a positive attitude among respondents and that TDM subjects were being taught in all pharmacy schools in Thailand, less than half of the surveyed hospitals reported conducting TDM. Providing smaller hospitals with access to the TDM laboratories and expertise at large hospitals could increase this proportion.

Introduction

Therapeutic drug monitoring (TDM) involves determining the appropriate drug dose for individual patients based on the measured drug concentration in blood, biological fluid, or tissue samples. The primary goal of TDM is to ensure optimal treatment outcomes while minimising drug toxicity (Kang *et al.*, 2009). In certain situations, TDM can be utilised as a means to delay drug resistance, prevent uncontrolled symptoms or mitigate severe drug toxicity. It can be performed independently or integrated into both acute care and ambulatory care settings. While some regions in South America and Europe (Antunes *et al.*, 2021; Zhang *et al.*, 2021; Green *et al.*, 2022) have incorporated pharmacogenetics into TDM service at the research level and Australia (Firman *et al.*, 2022) and the USA (Pedersen *et al.*, 2016) have initiated programmes where pharmacists can order and interpret laboratory tests for TDM and adjust the drug dose without consulting with doctors, another country has reported a lack of trained pharmacists or clinical pharmacologists to interpret and provide clinical recommendations in TDM (Yin *et al.*, 2023). Previous research exploring TDM practices in various countries has identified several challenges to establishing and advancing TDM services(Antunes *et al.*, 2021; Albassam *et al.*, 2022; Al Mutarid *et al.*, 2022). These obstacles include a lack of suitable TDM laboratories within hospitals, insufficient space for conducting TDM tests or storing biological specimens, inadequate funding for the measurement of drug levels, staff shortages, inaccessibility to the relevant training and limited awareness regarding the importance of TDM.

A six-year programme of pharmacy study was implemented in all universities in Thailand in 2014 (Chaiyakunapruk *et al*., 2016) with three areas of specialisation: pharmaceutical care, industrial pharmacy and consumer protection in drug and health (Ploylearmsang *et al*., 2019). TDM is included in the pharmacy curriculum as an elective placement in pharmaceutical care. Additionally, university-affiliated hospitals that are accredited by the Pharmacy Council of Thailand offer short-course training in TDM for pharmacists. It is worth noting that TDM has been established in Thailand since the late 1990s when four regional universities provided five-day workshops for pharmacy preceptor development (Chaiyakunapruk *et al*., 2016). However, these workshops are no longer regularly conducted with the incorporation of TDM into the pharmacy curriculum and the increase in the number of TDM-trained pharmacists through short-course training.

Despite the long-standing recognition of TDM as an integral part of pharmacy practice in Thailand, there is a lack of information regarding the number of hospitals conducting this activity, the TDM implementation process, and the challenges associated with its execution. It is important to note that the pharmacy curriculum in Thai universities is closely aligned with the policies and strategies of the Pharmacy Council of Thailand, which are based on the pharmacy practices provided in hospitals and community settings. Therefore, any data obtained about current TDM practices would also inform pharmacy education. Ultimately, this information could facilitate the adaption of the pharmacy curriculum to better align with the demands of healthcare settings in Thailand, specifically regarding TDM. Therefore, this study was conducted to explore the nature of TDM services provided at hospitals in Thailand as well as to examine how TDM is incorporated into the pharmacy curriculum at universities.

Methods

Participants and setting

This cross-sectional study was conducted to survey the patterns of TDM service in hospitals and the relevant topics taught in pharmacy schools in Thailand.

Data collection

Questionnaire development

A questionnaire was developed for hospital staff with four sections: general data of hospitals (Three multiple choice questions; MCQ), pattern of TDM service provided in the hospitals (twelve MCQ), list of drugs monitored (one MCQ), and staff opinion regarding TDM service (three MCQ and one open-ended question). The first three sections were designed to ascertain the status of TDM in the country and explore factors associated with the establishment of this service. The staff opinion section was designed to collect ideas or suggestions for enhancing the service. The questionnaire was validated by three experts before it was modified according to their suggestions and sent to the recipients. Three experts (two pharmacy lecturers and one hospital pharmacist) were provided with the aims and methodology along with the questionnaire and were required to score each question according to its alignment with the study objectives. Questions were scored "*+1*" if they aligned with the study objectives,"*-1*" if they did not and "*0*" if they were not certain. The index of item-objective congruence (IOC) was then determined for each question from the average of the three expert's scores. Questions with IOC values greater than or equal to 0.5 were included in the final version of the questionnaire.

The questionnaire developed for the schools of pharmacy requested the titles of subjects related to TDM and a list of drugs included in the teaching topics. This questionnaire was also validated by three experts and modified according to their suggestions before being sent out. This questionnaire was not validated for alignment with the study objectives using IOC values, as the data was only required to be collated from curricula. Thailand Qualification Framework 3 (TQF 3) documentation for each of the relevant subjects was requested to be sent back along with the filled questionnaire. The TQF 3 documentation contains the number of credits for a subject, the number of lecture hours and practice hours, the list of teaching topics, the teaching schedule and the assessment methods.

TDM service in hospitals

The validated TDM service questionnaire was sent to 179 public hospitals across Thailand. These included 140 hospitals under the management of The Ministry of Public Health of Thailand (MoPH), 24 university hospitals, ten military hospitals and five hospitals under the management of other organisations. All university hospitals were recruited into the study, but only non-university hospitals with at least 200 serviced beds were invited to participate. This selection criterion was based on the hospital's ability to conduct TDM, which depends on the number of patients (indicated by bed size) and the number of hospital pharmacists. A letter with a hard copy of the questionnaire and a QR code linked to the online version of the questionnaire was sent directly to hospital directors. The directors were instructed to pass the questionnaire on to the manager of the pharmacy

department, who could answer the questions themselves or pass it to the TDM pharmacist. The data collection period was from January to July 2020. The first round of letters was sent in January 2020, and the second round was sent four weeks later. Recipients were instructed to complete only one of the hard copies or the online form and not to answer the questionnaire again. Data collection was ended in July 2020.

TDM subjects in pharmacy curricula in universities

Letters containing the validated pharmacy curriculum questionnaire in hard copy and QR code format were sent to the deans of all 19 pharmacy schools accredited to produce pharmacy graduates by the Pharmacy Council of Thailand and the Office of the Higher Education Commission of Thailand (OHEC) in two rounds, four weeks apart. Recipients were instructed to forward the questionnaire to the head of the pharmacy programme or the TDM subject coordinator.

Data analysis

The number of hospital beds and the number of pharmacists in hospitals with and without TDM were compared using Fisher's exact test (IBM SPSS statistics version 28.0.0.0) with a significance level of $p \leq 0.05$. All other data were analysed using descriptive statistics.

Ethical statement

This study was approved by the Institutional Review Board on 18th December 2019 (Approval reference number: HE 622257) and was conducted by following the Declaration of Helsinki and the ICH Good Clinical Practice guidelines determined by The Khon Kaen University Ethics Committee for Human Research.

Results

Response from hospitals

Table I shows the demographic characteristics of the responding hospitals. Responses were obtained from 131 hospitals (73.2%), but 15 of these responses contained incomplete data and were excluded. The analysis was conducted using the data from 116 hospitals (64.8%). Most of the responses were received from hospitals under the management of the MoPH (n=86, 74.1%) and were 201-500 bed-size centres (n=53, 45.7%). TDM was conducted in 43 responding hospitals (37.1%), most of which were 501-bed-size centres or greater (n=27, 62.8%). Within hospital types, the proportion of hospitals conducting TDM increased with the number of beds and pharmacists. The number of hospital beds and the number of hospital pharmacists were significantly correlated with the provision of TDM services ($p < 0.001$ and $p = 003$, respectively). Subgroup analysis reveals that 100% of responding hospitals with more than 1000 beds (n=10) and 100% of hospitals with more than 100 pharmacists (n=3) conducted TDM. Surprisingly, only 52.6% of the 19 university hospitals surveyed conducted TDM, which was higher than the rate in MoPH-managed hospitals (29.1%) but lower than the rate in other hospitals (72.7%).

Table I: Demographic characteristics of the responding hospitals

Characteristics	All hospitals n = 116 (64.8%)	Hospitals conducting TDM n = 43 (37.1%)
Type of hospital		
Ministry of Public Health	86 (74.1)	25 (58.1)
University Hospital	19 (16.4)	10 (23.3)
Other	11 (9.5)*	8 (18.6)
Number of beds† ($p < 0.001$)		
≤ 200	18 (15.5)	3 (7.0)
201-500	53 (45.7)	13 (30.2)
≥501 ‡	45 (38.8)	27 (62.8)
Number of hospital pharmacists† ($p = 0.003$)		
25 or less	57 (49.1)	15 (34.9)
26-50	45 (38.8)	17 (39.5)
51-75	7 (6.0)	5 (11.6)
≥76 ¶	7 (6.0)	6 (13.9)

* Military hospitals, psychiatric hospitals, rehabilitation centres, Bangkok metropolitan hospitals; † Fisher's exact test; ‡ Hospitals with > 1000 beds conduct TDM (n =10); ¶All hospitals with more than 100 pharmacists conduct TDM (n =3)

Table II contains detailed information from the 43 responding hospitals that provided TDM services. The number of pharmacists taking responsibility for TDM service in each of these hospitals ranged from one or two in 22 hospitals (51.2%) to more than four in 11 hospitals (25.6%). Twenty-six of the respondents (60.5%) reported that they had completed a TDM training course. All hospitals reported interpreting drug levels from blood samples, with one hospital (2.3%) reporting that they also interpreted drug levels from tissue samples. Two hospitals (4.6%) reported using pharmacokinetic software to assist in TDM service, with one using PrecisePK and one using ClinCal. TDM was conducted in adult and pediatric patients in about half of hospitals (n=21, 48.8%) and for outpatients and inpatients in about two-thirds of hospitals (n=29, 67.4%). Most hospitals conducted less than 40 TDM services a month (n=28, 65.1%), and the average time spent on TDM service per case was greater than 60 minutes (n=29, 67.4%). TDM drug levels were determined solely in-house at the hospital laboratory in 21 hospitals (48.8%), solely at external outsourced laboratories in 12 hospitals (27.9%), with ten hospitals (23.3%) reporting that they used both in-house and external laboratories, depending on the drug being analysed.

Table II: **Pattern of therapeutic drug monitoring service in hospitals** (**n**= **43**)

Service	Number of hospitals (%)
Patient group	
Pediatric only	2 (4.7)
Adult only	20 (46.5)
Pediatric and adult	21 (48.8)
Setting	
Inpatient units only	14 (32.6)
Outpatient and inpatient units	29 (67.4)
Number of TDM* pharmacists	
1	12 (27.9)
2	10 (23.3)
3	6 (14)
4	4 (9.3)
> 4	11 (25.6)
Number of cases per month	
≤ 20	17 (39.5)
21-40	11 (25.6)
41-60	2 (4.7)
61-80	3 (7)
81-100	4 (9.3)
> 100	6 (14)
Time spent for each case (minutes)	
< 30	1 (2.3)
31-60	13 (30.2)
61-90	13 (30.2)
> 90	16 (37.2)
Setting for drug concentration determination	
Hospital laboratory	21 (48.8)
Outsourced	12 (27.9)
Hospital laboratory and outsourced	10 (23.3)

*TDM = therapeutic drug monitoring

A total of 22 drugs were reported to be monitored in TDM service at the hospital (Table III). Most drugs being monitored at hospitals were antiepileptic, antibiotic or antifungal agents. The antiepileptic drugs phenytoin (n=39, 90.7%) and valproic acid (n=33, 76.7%) were the most frequently monitored agents followed by the antibiotic vancomycin (n=31, 72.1%), the antiepileptic phenobarbital (n=25, 58.1%), the cardiovascular drug digoxin (n=24, 55.8%), the antiepileptic carbamazepine (n=17, 39.5%) and the immunosuppressant cyclosporine (n=13, 30.2%). Voriconazole (n=9, 20.9%) was the most frequently monitored antifungal agent.

Responses from pharmacy schools

Questionnaires were returned from all 19 pharmacy schools in Thailand (100%). The schools reported that TDM topics were included in their curriculum in specialised therapeutic drug monitoring subjects or clinical pharmacokinetics subjects. All schools reported that they taught the TDM of phenytoin, valproic acid, carbamazepine, vancomycin, and digoxin (Table III). The next most frequently included drugs were the aminoglycoside antibiotics amikacin (n=18, 94.7%) and gentamicin (n=17, 89.5%) followed by the bronchodilator theophylline/aminophylline (n=15, 78.9%), the immunosuppressant cyclosporine (n=13, 68.4%), the antiepileptic phenobarbital (n=12, 63.2%), and the psychiatric agent lithium and immunosuppressant tacrolimus (both n=10, 52.6%).

Table III: **Drugs monitored in hospitals and taught in pharmacy schools**

Drug groups	Hospitals conducting TDM† (n = 43) (%)	Pharmacy schools teaching TDM (n = 19) (%)
Antibiotics		
Vancomycin	31 (72.1)	19 (100.0)
Gentamicin	6 (14)	17 (89.5)
Amikacin	4 (9.3)	18 (94.7)
Tobramycin	2 (4.7)	8 (42.1)
Netilmicin	0	1 (5.3)
Antifungal agents		
Voriconazole	9 (20.9)	8 (42.1)
Itraconazole	2 (4.7)	3 (15.8)
Posaconazole	2 (4.7)	3 (15.8)
Flucytosine	1 (2.3)	1 (5.3)
Antiepileptic drugs		
Phenytoin	39 (90.7)	19 (100.0)
Valproic acid	33 (76.7)	19 (100.0)
Phenobarbital	25 (58.1)	12 (63.2)
Carbamazepine	17 (39.5)	19 (100.0)
Levetiracetam	1 (2.3)	1 (5.3)
Psychiatric agents		
Lithium	18 (41.9)	10 (52.6)
Imipramine	0	1 (5.3)
Clozapine	2 (4.7)	0
Cardiovascular drugs		
Digoxin	24 (55.8)	19 (100.0)
Propranolol	0	2 (10.5)
Warfarin	0	2 (10.5)
Amiodarone	0	1 (5.3)
Immunosuppressants		
Cyclosporine	13 (30.2)	13 (68.4)
Tacrolimus	12 (27.9)	10 (52.6)
Sirolimus	4 (9.3)	3 (15.8)
Everolimus	0	1 (5.3)
Mycophenolate mofetil	0	1 (5.3)
Miscellaneous		
Theophylline/aminophylline	10 (23.3)	15 (78.9)
Methotrexate	6 (14)	5 (26.3)
Busulfan	0	1 (5.3)
Paracetamol	1 (2.3)	0

†TDM = therapeutic drug monitoring

Hospital pharmacist's opinions regarding TDM service

Opinions reflecting the viewpoints of hospital pharmacists on TDM service were collected from 116 hospitals (Table IV). The most frequently reported benefits of conducting TDM in hospitals were to prevent adverse drug reactions (n=108, 93.1%), to ensure the effectiveness of drug use (n=104, 89.7%), and to prevent drug toxicity (n=93, 80.2%). The most frequently cited obstacles to conducting TDM in Thailand were the lack of a suitable TDM laboratory in the hospital (n=78, 67.2%), insufficient number of hospital pharmacists (n=71, 61.2%), and lack of trained TDM pharmacists (n=68, 58.6%). Respondents recommended a variety of drugs to be monitored in TDM, identifying them by their characteristics, name, or pharmacological group (Table IV). A narrow therapeutic index (n=28, 24.1%) was the most frequently recommended drug characteristic. A small number of respondents recommended conducting TDM by pharmacological group with immunosuppressants the most frequently recommended (n=12, 10.3%). Many individual drugs were recommended by name, including the antiepileptic drugs phenytoin (n=57, 49.1%) and valproic acid (n=43, 37.1%), and the antibiotic vancomycin (n=55, 47.4%).

Table IV: Hospital pharmacist's opinions regarding therapeutic drug monitoring service

Detail	Number of responses (n =116) (%)
Benefits of conducting TDM† in hospitals	
Prevent adverse drug reaction	108 (93.1)
Ensure the effectiveness of drug use	104 (89.7)
Prevent drug toxicity	93 (80.2)
Improve rational drug use	58 (50.0)
Reduce treatment cost	36 (31.0)
Ensure the drug level is in the therapeutic range	1(0.9)
Obstacles to conducting TDM in hospitals	
No TDM laboratory in hospital	78 (67.2)
Insufficient number of hospital pharmacists	71 (61.2)
Lack of trained TDM pharmacists	68 (58.6)
High cost of running TDM	54 (46.6)
Long time to obtain the result of drug level	40 (34.5)
Limited understanding of TDM from other HCPs ‡ (doctor, nurse)	6 (5.2)
Difficulty in running TDM outside normal working hours	3 (2.6)
Patients not permitting hospitals to monitor drug level	3 (2.6)
Limited TDM knowledge/skills among pharmacists	2 (1.7)
No support from the hospital board	2 (1.7)
The hospital too small to run TDM	1 (0.9)
No financial support for the establishment of TDM	1(0.9)
Recommendations for drugs to be monitored in TDM	
By characteristic	
Narrow therapeutic index	28 (24.1)
Severe drug toxicity	4 (3.6)
High alert drugs	2 (1.8)
Long half-life	1 (0.9)
By pharmacological group	
Immunosuppressants	12 (10.3)
Antifungal agents	6 (5.4)
Antiarrhythmic agents	5 (4.3)
Psychiatric agents	5 (4.3)
Antidepressants	2 (1.8)
Chemotherapeutic agents	1 (0.9)
By name/group name	
Phenytoin	57 (49.1)
Vancomycin	55 (47.4)
Valproic acid	43 (37.1)
Phenobarbital	37 (31.9)
Carbamazepine	35 (30.2)
Aminoglycosides	30 (25.9)
Digoxin	16 (13.8)
Lithium	8 (6.9)
Theophylline/aminophylline	7 (6.03)
Colistin	2 (1.8)
Non-vitamin K antagonist oral anticoagulants (NOACs)	1 (0.9)
Paracetamol	1 (0.9)

†TDM = therapeutic drug monitoring, ‡HCP = health care provider

Discussion

Barriers to TDM implementation

This study's results indicate a positive attitude among hospital staff towards TDM, with staff recognising its benefits in promoting drug effectiveness and minimising drug toxicity. However, the findings also revealed that TDM was implemented in less than half of the surveyed hospitals and mostly at large sites (> 500 beds). Several reasons for not conducting TDM were identified, including the lack of an in-house TDM laboratory, which has also been determined to be a primary obstacle in other studies (Al Mutarid et al., 2022; Antunes et al., 2021). In TDM, immunoassay techniques and liquid chromatography (LC) are widely employed as analytical methods (Salamone et al., 2023). Immunoassay methods are suitable for routine hospital work and do not require specialised staff training. However, many of the analytical reagents used in immunoassays have a limited shelf-life, which can lead to high per-case costs if the hospital has low numbers of TDM cases. While LC is more accurate, it is more complex and time-consuming compared to immunoassay techniques, and the per-case cost can be higher. Many respondents in this study mentioned the

expenses are a limitation to conducting TDM services, which appears to present the most significant obstacle to implementing TDM in hospitals.

More than half of the respondents in this study identified a lack of TDM-trained pharmacists as a significant barrier to implementing TDM services in their hospitals. This finding is inconsistent with Thai universities and hospitals' TDM education and training opportunities. In Thailand, all universities provide TDM subjects at the undergraduate level. These include dedicated coursework subjects and elective training subjects in the final years of study. Moreover, many institutes and hospitals under the management of the Pharmacy Council of Thailand offer four-month TDM training programmes for licensed pharmacists. A similar response was obtained in a recent study conducted in Palestinian hospitals (Shawahna *et al.*, 2022).

In this study, the major barriers reported to running TDM were a "*lack of continuing education in pharmacokinetics" (75%) and a "lack of confidence to apply knowledge in practice*" (71%) despite also reporting that pharmacy students undertake intensive pharmacokinetic course during their undergraduate study. Another study highlighted significantly higher levels of TDM knowledge and confidence in its implementation among pharmacists with ten or more years of working experience, with 96% of participating pharmacists believing that some knowledge of TDM should be a requirement for pharmacists (Albassam *et al.*, 2022). These studies emphasise the importance of ongoing pharmacist training together with the inclusion of TDM courses in pharmacy study programmes. It should be noted that pharmacist training incurs financial and time costs, and some respondents in this study identified a lack of support from their hospitals as a potential obstacle to implementing TDM services.

Roles of pharmacy education

All of the pharmacy schools in Thailand teach TDM for vancomycin, antiepileptic drugs and digoxin, and a high proportion teach TDM for aminoglycosides and theophylline. However, only vancomycin, phenytoin, valproic acid, phenobarbital, and digoxin were monitored by more than half of the hospitals in this study. This result was not surprising, considering the global issue of antibiotic resistance (De Oliveira *et al.*, 2020). TDM is one tool that can potentially delay the development of resistance (Al-Shaer *et al.*, 2020), and TDM for antibiotics is taught in most pharmacy schools, and the service is provided in most hospitals for vancomycin. However, very few hospitals practice TDM for the aminoglycosides gentamicin and amikacin, but nearly all schools still teach about these drugs in their TDM topics. The availability of safer alternatives, such as cephalosporins for the treatment of infections with Gram-negative bacteria, means that the overall use of aminoglycosides has decreased. However, the increase of multidrug-resistant tuberculosis (MDR-TB) in this region (Saikaew *et al.*, 2022) has led to an increase in amikacin use, and TDM of this drug may still be required, whereas that for gentamicin can be removed.

Antiepileptic drugs have complex pharmacokinetics that make it a challenge to achieve therapeutic ranges using standard doses, which require individualised dose determination based on measured drug levels. This explains and supports the high rates of antiepileptic drug TDM services seen in hospitals and the inclusion of these drugs in TDM subjects in all pharmacy schools.

Digoxin TDM is taught in all pharmacy schools in Thailand, but just over half of the surveyed hospitals conducted TDM for digoxin. The frequency of TDM services for digoxin in hospitals was found to be slightly higher (60-70%) in a study conducted in Europe (Green *et al.*, 2022) and slightly lower (50%) in a study conducted in China (Zhang *et al.*, 2021). Digoxin's slow onset of action and complicated pharmacokinetic characteristics (Scalese & Salvatore, 2017) combined with its significant association with mortality (Vamos *et al.*, 2015) has limited its use in practice but it is still recommended for treatment of atrial fibrillation in many countries (Ferrari *et al.*, 2020), which supports its inclusion as a TDM topic.

Theophylline TDM was only provided in one-quarter of surveyed hospitals but was taught in three-quarters of pharmacy schools. The most recent guidelines from The Global Initiative for Chronic Obstructive Lung Disease (GOLD) no longer recommend bronchodilators, including theophylline, as the first choice for COPD exacerbation (Augusti *et al.*, 2023), which has reduced its use in practice.

The topics taught at pharmacy schools should reflect the drugs monitored in practice because the time taken to teach an infrequently monitored drug, such as theophylline in pharmacy schools, is time that is unavailable to teach a more frequently monitored drug, such as lithium. Lithium was monitored in just under half of the surveyed hospitals, making it the sixth most frequently monitored drug in hospitals, but it was included in the TDM curricula at only half of the surveyed pharmacy schools. Other studies indicate high levels of lithium monitoring in practice, with rates ranging from 70-90% (Green *et al.*, 2022; Leung *et al.*, 2019) supporting its inclusion in Thai pharmacy school curricula.

Potential ways to circumvent barriers to TDM implementation

The obstacles identified in this study that could impede the implementation of TDM in hospitals include the limited availability of resources to conduct TDM (laboratories, hospital pharmacists and TDM-trained professionals), limited available funding due to insufficient support from hospitals, and some disparities between TDM practices in hospitals and TDM subjects in the pharmacy curriculum.

The establishment of centralised laboratories, based on facilities available at the large hospitals that already run TDM, could provide resources and guidance to pharmacists working in smaller hospitals and encourage the wider adoption of TDM services.

To encourage hospital pharmacists to engage in TDM activities, pathways for professional development and promotion based on TDM experience and financial support to attend relevant workshops, conferences, or training programmes can be provided. The Healthcare Accreditation Institute (HAI), which is responsible for the quality assurance of healthcare services in Thailand, recently designated the safe use of drugs with narrow therapeutic indices as one of its mandated Medication Management Systems tasks (HAI (Thailand), 2022). This policy change could provide hospitals with the legal framework to apply for financial support from health authorities to expand TDM services in Thailand. Once pharmacists trained in TDM are capable of independently conducting TDM procedures, they can become mentors for pharmacists in nearby hospitals. This creates a sustainable training model.

Ensuring that the pharmacy curriculum remains relevant to pharmacy practice in hospitals requires collaboration among educational institutions, hospitals and the Pharmacy Council of Thailand. The council defines the core competencies for practicing as a pharmacist and educational institutions develop curricula based on these requirements. The curriculum is revised every five years following review by a panel established by each Pharmacy school. The panel must also include at least one practising pharmacist from a hospital or community pharmacy. This approach appears to neglect the specialised experience of clinical pharmacists, which may contribute to a lack of detailed perspective on TDM. To address this, pharmacy schools should consider inviting clinical pharmacists to participate as additional reviewers in the curriculum review process.

TDM in special populations

Determining drug doses in pediatric patients is a complex process that involves developmental pharmacokinetics along with pharmacokinetic changes resulting from medical devices or procedures and challenges associated with invasive blood sampling (Leung *et al.*, 2019). Among the various pediatric age groups, neonates could be the most difficult group to manage due to the significant physiological changes that occur within the first four weeks of life (O'Hara *et al.*, 2015). Encouragingly, TDM was conducted for pediatric patients in many hospitals in this study, benefiting the young patients in those hospitals and providing a potential resource for other healthcare facilities.

Limitations

This survey predominantly took place in large public hospitals, necessitating caution when applying the study findings to smaller or private hospitals. The questionnaire was distributed to the heads of hospital pharmacy departments, who could either answer it themselves or delegate it to another pharmacist. This introduces unknown variations in the knowledge or experience of the respondents in TDM. The moderate response rate could produce an artificial positive view of TDM as individuals with neutral or negative opinions on the subject might opt not to return the questionnaire.

Conclusion

Despite TDM being practised in Thailand for over two decades, the number of hospitals that have implemented this service remains moderate. Policy developments, such as the mandated medication management systems standards set by the HAI, can encourage hospital boards to support the establishment and operation of TDM services through provisions for laboratory services, opportunities for TDM training for pharmacists, incentives for those working in the field, and the allocation of budget resources. Hospital pharmacists are encouraged to participate in continuing pharmacy education under accredited TDM pharmacists to enhance their expertise and enable them to provide training to other pharmacists within the same hospital. The TDM topics provided by pharmacy schools appear to be adequate for current practice, but the curriculum should be regularly reviewed and updated.

Conflict of interest

The authors declare no conflict of interest.

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