Clinical pharmacy services in the acute ward

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RESEARCH ARTICLE

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Abstract *Background* The majority of hospitalised patients have drug-related problems. Clinical pharmacist services including medication history, medication reconciliation and medication review may reduce the number of drug-related problems. Acute and emergency hospital services have changed considerably during the past decade in Denmark, and the new fast-paced workflows pose new challenges for the provision of clinical pharmacist service. *Objective* To describe and evaluate a method for a clinical pharmacist service that is relevant and fit the workflow of the medical care in the acute ward. *Setting* Acute wards at three Danish hospitals. *Methods* The clinical pharmacist intervention comprised medication history, medication reconciliation, medication review, medical record entries and entry of prescription templates into the electronic medication module. Drug-related problems were categorised using The PCNE Classification V6.2. Inter-rater agreement analysis was used to validate the tool. Acceptance rates were measured as the physicians' approval of prescription templates and according to outcome in the PCNE classification. *Main outcome measure* Acceptance rate of the clinical pharmacists' interventions through the described method and inter-rater agreement using the PCNE classification for drug-related problems. *Results* During 17 months, 188 patients were included in this study (average age 72 years and 55 % women). The clinical pharmacists found drug-related problems in 85 % of the patients. In the 1,724 prescriptions, 538 drug-related problems were identified. The overall acceptance rate by the physicians for the proposed interventions was 76 % (95 % CI 74–78 %). There was a substantial inter-rater agreement when using the PCNE classification system. *Conclusion* The methods for a clinical pharmacist service in the acute ward in this study have been demonstrated to be relevant and timely. The method received a high acceptance rate, regardless of no need for oral communication, and a substantial inter-rater agreement when classifying the drug-related problems.

Impacts on practice

- Clinical pharmacist services in the acute ward need to fit the high-paced workflow to benefit the health care professional teams and thereby the patients.
- The method for a clinical pharmacist service in the acute ward described here fits an intensive workflow, identifies multiple drug-related problems and yields a

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high acceptance rate of the interventions, regardless of no oral communication.

- Classifying drug-related problems in the acute wards can be done well with 'The PCNE Classification' system to categorise problems, interventions and outcomes.

Introduction

The majority of hospitalised patients have drug-related problems (DRPs) [1–11] which are events or circumstances involving drug therapy that actually or potentially can interfere with the desired health outcomes [12]. The total cost of drug-related morbidity and mortality exceeds the cost of the medications themselves [3]. Nevertheless, drug-related morbidity and mortality are often preventable, and pharmaceutical care services may reduce the number of DRPs, adverse drug events (ADEs), the length of hospital stays, and the cost of care [4, 13].

It has been described how clinical pharmacists (CPs) participate in various stages of the medication process such as compiling the medication history [14], medication reconciliation [15] and performing medication reviews [12, 16] and clinical pharmacy may benefit all stages of the medication process [4, 6, 17–23].

Acute and emergency hospital services have changed over the past decade in Denmark. One of the recent developments is the merging of all acute and emergency services and reception of patients into one ward [24]. The workflow, however, at these new acute wards, differ from the workflow at specialised wards. All patients are received in the acute ward, regardless of their medical problem. Within 6 h, the patients should be attended to by nurses, secretaries, laboratory technicians, and physicians and allocated to a dedicated specialised ward. Clinical pharmacist services must be relevant and timely to meet this workflow. Projects involving the implementation of clinical pharmacy services in various Danish hospitals have evolved around three main areas; medication history, medication reconciliation and medication review [23–26]. The learning and results from these projects can form the basis for what a clinical pharmacist service could comprise in the acute ward.

Most hospitals in Denmark use a form of electronic medical record and medication module, such as a computer physician order entry (CPOE). Electronic prescribing has proven to reduce drug prescription errors [27], and CPOE with clinical decision support (CDS) can improve patient safety [8, 28]. Still, occurrence of DRPs persists and pharmacists can enhance patient safety, despite CPOE [7, 8]. Electronic prescribing presents possibilities for standardisation of prescriptions using CDS such as prescription templates. This provides a tool for communicating pharmacists' interventions.

How interventions are communicated between pharmacists and physicians highly affect acceptance rates, and face-to-face communication has been recognised to be an important factor leading to the highest acceptance rate [29–31]. However, this form of communication can be difficult in acute wards with a high-paced workflow. The rate with which pharmacists' interventions are accepted and implemented by physicians in hospital settings varies considerably in the literature, though most acceptance rates reported are between 50 and 100 % [1, 21–23, 29, 31–39]. Again, this is highly dependent on the way the acceptance rate is defined within the study [29].

Throughout the literature, DRPs are classified into various systems, some validated, others invented to fit the purpose of the specific study [40]. On the European level, The Pharmaceutical Care Network Europe (PCNE) has developed 'The PCNE Classification for Drug Related Problems', which has proven to be a useful tool in documenting clinical pharmacist services in the hospital setting [9]. The PCNE system is continuously being developed [40] and might be a good option for a useful system for research and practise in the acute wards as well.

Aim of the study

The aim of this intervention study was to describe and evaluate a method for a clinical pharmacist service that is relevant and fits the workflow of the medical care in the acute ward.

Methods

Inclusion

Patients were included from the acute wards in three non-university hospitals in one of the five Danish regions. Patients were included 2–5 days a week between 08:00 and 17:00. Medical patients aged 18 years or older, taking four or more drugs a day (including over-the-counter (OTC) drugs and supplements) were eligible for inclusion. Patients in terminal or palliative care, patients too ill to wait for a physician before the CP interview, patients transferred directly from other hospitals in the region and patients unable to understand the consent form written in Danish, were not eligible for inclusion.

Intervention

Three CPs, all employed by the hospital pharmacy carried out the interventions. The pharmacist's intervention comprised a medication history, medication reconciliation, medication review, a written CP entry in the medical record, and entry of allergy information and prescriptions templates into the electronic medication module (EMM). Procedure for the pharmacist's intervention is described in details in "Appendix 1".

The purpose of the patient interviews was to obtain a secondary medication history [18] and to identify DRPs such as side-effects, lack of effect, or non-compliance. The interview revolved around the patient's own drugs (POD) if these were present [41–43] or previous medication lists. During the interviews, patients were asked specifically about their use of OTCs, herbal- or dietary supplements, and use of medications that were not taken orally (e.g. inhalers, eye-, nasal- or dermatological preparations) [18, 44].

Medication reconciliation was done by compiling all available information on the medication history and comparing this to the prescriptions in the EMM [45].

The medication review comprised an assessment of indications, contraindications, dosages, effects, interactions, availability, and costs of each prescription. National as well as local treatment guidelines were used in the assessment, along with summary of product characteristics (SPC) for the specific drug. The CPs documented the proposed changes in therapy in the medical record.

Finally, all prescriptions, including recommended changes, were entered into the EMM. Until approved electronically by a physician, the clinical pharmacist prescriptions were complete but inactive template prescriptions.

This approach was chosen to ensure that all details of the proposed interventions would be implemented in the prescriptions. If the physician agreed, an electronic approval was all that was needed to effectuate the proposed intervention. Otherwise, the template could be dismissed.

The CP interview was conducted before the physician saw the patients. After each interview, the CP performed the rest of the intervention while the physician examined the patient. The intention was that all CP electronic entries should be completed within 1 h.

The CP intervention was solely based on communication through medical record entries and prescription templates in EMM to fit the high-pace of workflow in the acute wards, where face-to-face communication is difficult and time-consuming. Additionally, prescription templates minimised the time required by the physician to approve and implement the interventions.

Data collection

The time spent on patient interviews and on the rest of the intervention, was recorded. All pharmacist interventions and their outcomes were recorded and categorised. Each outcome was collected from the patient's medical record and EMM a few days after the intervention. All pharmacists' allergy and prescription templates in EMM were recorded as well as the following physician-approved prescriptions.

Assessment of acceptance rates

The physicians' acceptance rates of the CP interventions were assessed as the proportion of prescription templates approved by the physicians, and as the proportion of intervention outcomes classified as 'problem totally' or 'partially solved' or 'no need to solve', according to the PCNE classification.

Classification of drug-related problems

The PCNE classification V6.2 [12] was used to classify identified problems, causes and interventions by each CP finding the DRP. The same system was used to classify the outcome of the interventions by one evaluating pharmacist.

The PCNE classification V6.2 was translated into Danish and adapted slightly for the purpose of the CP report form. The adaptation consisted of an extra level of detail (subdomain) to the intervention-codes (I-codes) I3.1, I3.2, I3.3 and I3.4. The translated and adapted version is available in "Appendix 2". The DRPs are reported in the original level of detail.

To validate the usability of The PCNE Classification V6.2 as a tool for the CP intervention in acute wards, an inter-rater reliability study was made using Cohen's Kappa statistics [46]. The two pharmacists who had performed the majority of all interventions, each rated a random sample (generated by Research Randomizer [47]) of approximately one-fifth of the other pharmacist's medication reviews. The DRPs were rated using a copy of the CP's entry in the medication record and EMM, but blinded to the first pharmacist's ratings. Only the PCNE-codes 'P', 'C' and 'I' were compaired since the 'O'-codes were rated retrospectively by one rater only. Both the original I- PCNE classification and the adapted I -PCNE classification with an extra subdomain were analysed with Kappa statistics.

Statistics

Data were collected in standardised report forms by the CP and entered into Microsoft Access. IBM SPSS Statistics for

Windows, Version 20.0.0 (IBM Corp. Released 2011, Armonk, NY: IBM Corp) and Microsoft Excel were used for Kappa- and descriptive statistics.

Results

Demographics

From March 2010 to July 2011, three CPs screened 1,775 patients for eligibility in the acute wards in Naestved, Nykoebing F and Slagelse hospitals in Denmark. More than half of the patients did not meet the inclusion criteria, mostly by not taking four or more drugs, while some declined to participate or were already evaluated by a physician.

The 188 patients included were 26–97 years old and used 4–22 drugs per day, including OTCs and supplements (Table 1). Of the 168 patients who stated their height and weight, the average Body Mass Index was 26.6. After the acute ward, the patients were mainly transferred to a general internal medicine ward (39 %), a cardiac medicine ward (28 %) or respiratory medicine ward (14 %).

Intervention

In 181 (96 %) of the cases, the CPs obtained medication history by including patient interviews. One to five sources of information were used to compile the medication history. In 62 and 22 % of cases respectively, two or three sources of information were used. Most frequently, the source was

previous medical records or POD, besides the patient interview. The physicians documented their primary medication history in 78 % of the included patients' medical records. The median duration of a patient interview was 11 min, including time to obtain informed consent. Subsequently, the CP reconciled and reviewed the medications, entered the prescription templates and the notes in the medical records. Only 10 (5 %) cases lasted more than 60 min (65–95 min). As the CPs became familiar with the method (especially entering the prescription templates into the EMM), the time needed for the intervention decreased from average 39 min for the first half of patients to average 29 min for the second half. Table 2 shows the data from the interventions distributed at each centre.

The overall physician acceptance rate was 76 % (95 % CI 74–78 %) of the proposed prescriptions templates. The lowest acceptance rates were seen in patients who were discharged within 24 h (n = 36). The intervention also included the CPs entering allergy status into the EMM as a template. The overall acceptance rate of this was 46 % (95 % CI 37–55 %).

Drug-related problems

In total, 1724 prescriptions were assessed by the CPs, and DRPs were identified in one-third of the prescriptions as shown in Table 3.

The most frequent problem identified was 'Drug treatment more costly than necessary'. Another frequent problem was 'Effect of drug treatment not optimal', these two problems accounted for 51 % of all DRPs. Nearly half of

Table 1 Characteristics of the patients upon admission to the acute ward by centre

Characteristics of patients by centre	Naestved	Nykoebing	Slagelse	All
Patients, n	104	27	57	188
Age, mean (SD)	71.4 (±11.3)	72.4 (±12.9)	73.3 (±14.0)	72.1 (±12.4)
Gender female, %	59	52	51	55
Medications per pt., median (range)	7 (17)	11 (13)	8 (15)	8 (17)
Admission orders per pt., median (range)	9 (23)	9 (26)	12 (20)	10 (26)
Medical history (five main diagnose areas), %				
Heart diagnosis	62	63	42	56
Lung diagnosis	21	33	39	29
Muscoskeletal diagnosis	24	19	25	23
Endocrine diagnosis	18	26	18	19
Gastrointestinal diagnosis	7	15	23	13
Cause of admission, %				
Cardiovascular	38	22	9	27
Respiratory	22	37	30	27
Miscellaneous symptoms	18	22	12	17
Nervous system	4	4	14	7

Table 2 Clinical pharmacist interventions by centre

Interventions by centre	Naestved	Nykoebing	Slagelse	All
Clinical pharmacists (n)	1	1	1	3
Physicians involved (n)	93	6	21	116
Pharmacist prescription templates (n)	731	234	512	1,477
Approved pharmacist prescriptions (n)	557	153	411	1,121
Accept rate prescription entries, % (95 % CI)	76 (73–79)	65 (59–71)	80 (77–83)	76 (74–78)
Pharmacist time spent (min)				
Patient interview, median (range)	10 (36)	13 (41)	14 (19)	11 (42)
Pharmacist intervention, median (range)	25 (71)	36 (77)	40 (59)	30 (86)
Total time per patient, median (range)	35 (106)	65 (79)	51 (81)	44 (106)

Table 3 Clinical pharmacist interventions on drug-level

Interventions by drug-level	
Drugs, n	1,724
Patients with drug-related problem, n (%)	153 (85)
Drug-related problems found, n	538
Drug-related problems found, % (95 % CI)	31 (29–33)
Interventions, n (%)	537 (31)
Acceptance rate for Interventions	
Problem totally/partially solved/not needed to solve, % (95 % CI)	73 (69–77)
Problem not solved, % (95 % CI)	19 (16–22)
Outcome unknown, % (95 % CI)	8 (6–10)

causes for the DRPs were found to be 'More cost-effective drug available', 'Inappropriate drug' or 'Dose too low/high'. The drug specific interventions most proposed were 'Drug changed to equivalent drug' or 'Drug stopped', accounting for half of the interventions.

In two-thirds of cases, the outcomes were "Problem totally solved". When including 'Problem partially solved' and 'No need or possibility to solve problem' the acceptance rate was 73 % (95 % CI 69–77) of all interventions on drug-level.

Details of the distribution of all DRPs in the study using the PCNE classification are given in "Appendix 3".

The drugs most recurrently involved in DRPs were drugs for the cardiovascular system, alimentary tract and metabolism, and nervous system. Table 4 shows the distribution of the CPs' interventions by the anatomical therapeutic chemical (ATC) classification system [48].

From the centres Naestved and Slagelse, 36 randomly selected patients taking 353 drugs, were rated by two raters independently. Overall, there was a substantial inter-rater agreement, with Kappa >0.6 [46], as presented in Table 5.

The codes causing most disagreement were the P-codes; P3.1, P1.2 and P3.2, the C-codes; C1.7 and C3.1 and the I-codes; I3.1, I3.2 and I3.5. The most frequent disagreement factor was whether or not there actually was a problem, cause or intervention which was denominated P0, C0 and I0, respectively. These accounted for nearly half of the disagreements.

Discussion

Acceptance rates

The method described and evaluated in this study using electronic prescription templates to communicate the proposed interventions overall had a high acceptance rate. The acceptance of 76 % is similar to other studies where pharmacists reconciled and/or reviewed medications in hospital settings, with acceptance rates between 69 and 89 % [1, 22, 31, 49]. However, these studies all used oral communication when proposing interventions. Other Danish studies have used written communication in the form of paper notes or entries into the medical record. These studies in general have a lower acceptance rate of 39–70 % [23, 26, 39, 50]. In this perspective, the proposed method of prescription templates appears to be a good alternative to oral communication when the workflow or the time available limits the possibility of oral communication. Correspondingly, electronic prescribing in the hospital setting has been associated with an increased implementation of clinical pharmacologists' drug recommendations when compared with handwritten prescribing on paper [27].

The acceptance rate on the prescription template method includes templates suggesting generic substitution. This type of templates were not categorised as DRPs when evaluating the interventions on drug-level, thus this acceptance rate is slightly lower, at 73 %. Still, it is a high acceptance rate which indicates that the interventions have been timely and relevant for the physicians in the acute ward setting.

Timing

In many cases, a large part of the patients prescriptions cannot be optimised until the diagnosis is present. Thus, the

Table 4 Distribution of clinical pharmacist interventions by Anatomical Therapeutic Index (ATC)

Distribution of interventions by drug ATC-group 1. Level (%)		
A	Alimentary tract and metabolism	23
B	Blood and blood forming organs	9
C	Cardiovascular system	26
D	Dermatologicals	0
G	Genito-urinary system and sex hormones	1
H	Systemic hormonal preparations, excluding sex hormones and insulins	3
J	Antiinfectives for systemic use	1
L	Antineoplastic and immunomodulating agents	1
M	Musculo-skeletal system	5
N	Nervous system	17
P	Antiparasitic products, insecticides and repellents	1
R	Respiratory system	10
S	Sensory organs	1
V	Various	0
X	No ATC-code (supplements)	2

Table 5 Inter-rater agreement of the PCNE classification for DRPs analysed using Kappa statistics

Kappa inter-rater agreement	Kappa	CI 95 %	P
P-codes	0.614	(0.543–0.685)	<0.001
C-codes	0.601	(0.532–0.670)	<0.001
I-codes adapted	0.674	(0.605–0.743)	<0.001
I-codes original	0.700	(0.631–0.769)	<0.001
Kappa		Interpretation[a]	
<0		Poor agreement	
0.00–0.20		Slight agreement	
0.21–0.40		Fair agreement	
0.41–0.60		Moderate agreement	
0.61–0.80		Substantial agreement	
0.81–1.00		Almost perfect agreement	

[a] Landis and Koch [46]

medication review will be less time-consuming when the prescriptions is only checked for unusual dosages, costs, interactions, and contraindications. This makes it possible to perform the intervention in less than 1 h as the method suggests, and to deliver the interventions to the physician in a timely manner. In a time-study conducted at Naestved Hospital in the same period as the present study, the physicians' workflow in the acute ward was timed [51]. The study showed that physicians spend an average of 45 min on a patient in the acute ward. With a mean time of 30 min for the CP's intervention, the prescription templates will be complete when the physician is ready to make the admission orders. In the present study, the CPs spent a median of

11 min on the patient interviews (including informed consent). Other studies have found similar results from 10 to 20 min for pharmacists' medication history-taking [18, 52]. The medication history is thus relatively time-consuming, albeit it is the foundation for both a correct medication reconciliation and review that has proved to be clinically important [14, 18, 19, 44, 53].

Interventions

The most frequent types of interventions were 'changed drug', 'drug stopped', 'prescriber informed', 'changed dose' and 'drug started'. This reflects the typical focus areas of rational pharmacotherapy in the elderly and in polypharmacy patients [9, 54, 55] and is similar to other studies classifying DRPs with the PCNE classification [9, 56, 57].

The typical approach has to be changed in more than just the timing when performing medication review in the acute ward setting. At the time the CP performs the medication review, the new diagnosis has not been made, laboratory tests and blood work have not yet been done and only few vital parameters are measured. Thus, the medication review is based on optimisation of the pharmacotherapy that has no relation to the current symptoms only. This method classifies as 'The Intermediate medication review' in PCNE definitions [12]. What also deviates from medication reviews on non-acute patients is the focus on medication-related symptoms in the acute ward. The CP would record in the pharmacist's entry if any of the medications could be related to the admission cause symptoms.

Classification of DRPs

Overall, The PCNE Classification V6 was suitable for classifying the DRPs in the study. It was a great advantage to allocate the DRPs into problems, interventions and outcomes separately, which other classification systems lack [58]. The PCNE classification category 'Cause' was of less use in this study. The cause of the DRP was not always readily found in the acute ward setting, and it was usually not essential in order to solve the problem. Correspondingly, 'Cause' is the category scoring lowest kappa-value. Within the I-categories, the greatest disagreement was one rater choosing 'drug changed' or 'drug stopped' and the other rater choosing 'prescriber informed only' or 'no intervention', respectively. This disagreement originates from the method, rather than the classification system. If the CP proposed to stop a drug, the CP would simply omit making a prescription template of that drug and document this in the medical record. This could be rated either as 'drug stopped', 'prescriber informed only' or 'no intervention' since no template was made. In brief, The PCNE

Classification V6 performs as a usable system for the clinical pharmacist's intervention in the acute ward, however the 'Cause'-section may have too many and some irrelevant options for use in the acute ward, giving this a lower inter-rater agreement score.

Strengths and limitations

This study included a wide range of medical patients from three different acute wards, though the most critically ill patients were not included. The method has disadvantages regarding the limited clinical information available on the patient when performing medication review at the acute ward. Even with limited clinical information, DRPs were identified in 85 % of the patients, and the acceptance rate of proposed interventions was high. However, it has not been investigated whether this method caused a higher workload on the physicians or other health care personnel in the acute ward. Nor has the physicians' opinion of the CP's service been studied.

Clinical relevance

A large proportion of DRPs identified and a high acceptance rate of the interventions, does not guarantee a reduction of ADEs or a better clinical outcome for the patient. Only few randomised controlled studies have investigated the clinical effect of in-hospital clinical pharmacist services [21–23, 37, 56, 59]. Whether the clinical pharmacist service in the acute ward in this study will improve the clinical outcome for the patients is yet to be investigated.

Conclusion

The methods for a clinical pharmacist service in the acute ward described in this study are demonstrated to be relevant, timely and useful to the physicians. The CPs identified at least one DRP in 85 % of patients and intervened in every third prescription. The method presents with a good acceptance rate, regardless of no need for oral communication, and a substantial inter-rater agreement when classifying the DRPs.

Conflicts of interest None.

Appendix 1: Procedure for the clinical pharmacist service in the acute ward

Workflow acute ward	Clinical pharmacist task	Procedure
Patient is admitted to the acute ward	Screen	Inclusion criteria:
		Age ≥ 18
		Drugs ≥ 4 (incl. OTCs and supplements)
		Able to give consent in Danish
		Not in palliative or terminal care
Patient is evaluated by triage nurse	Assess patient	Proceed if patient can wait more than 15 min. for a physician
Patient is allocated a bed, changes clothes and is interviewed by nurse	Compile preliminary medication list	Check relevant sources for information on medications, if present:
		Previous medical records
		Referral papers
		Home care or nursing home notes, or personal medication lists
Patient has EKG taken and blood drawn	Patient interview	Medication history: (see details below)
Patient waits for physician (time dependent on triage)		Explain purpose of the interview
		Obtain POD if present
		Comprise medication history using the POD and/or preliminary medication list as interview guide
		Ask if the patient has drug-related questions for the clinical pharmacist.
Patient is interviewed by physician	Medication review	Medication reconciliation:
		Compare obtained medication list to the prescriptions in EMM
		Obtain further information from pharmacy dispensing records or GP if needed

Appendix 1 continued

Workflow acute ward	Clinical pharmacist task	Procedure
Patient is examined by physician		Medication review: (see details below)
		Verify if dosage, duration, indications, contraindications are within recommendations (SPC or treatment guidelines)
		Check for interactions (SPC or online interaction tool)
		Check for more cost-effective drug (hospitals formulary)
	Documentation	Enter clinical pharmacist's note in medical record with headings:
		Secondary medication history
		Summary of patient interview (compliance, ADR, DRP found)
		Proposed drug interventions
		Interactions and/or allergies
Physician dictates entry to medical record	Prescription templates	Enter allergy status templates and prescription templates for the patients medication including proposed interventions into the EMM
Physician writes admission orders and approves or dismisses prescription templates		
Patient is transferred to specialised ward		

OTC over-the-counter drugs, *POD* patient's own drugs, *EMM* electronic medication module, *GP* general practitioner, *SPC* summary of product characteristics, *ADR* adverse drug reaction, *DRP* drug related problem

Medication history

- Compile medication history using the PODs and/or preliminary medication list as interview guide
- Ask specifically for OTCs such as; pain-, allergy- or alimentary preparations.
- Ask specifically for herbal- and dietary supplements
- Ask specifically for non-oral medications, such as; inhalation-, ophthalmic-, dermatologic-, nasal-, sublingual-, or rectal preparations
- Ask for the patient's perceived effect of the medication
- Ask about compliance and adverse drug reactions
- Ask about known allergies or alerts, such as; antibiotics, opiates, NSAIDs, iodide, food dyes
- Also ask relatives or caregivers if they are present, especially if patient has aphasia, dyspnoea or otherwise cannot participate well in the interview

Medication review

- Check that medication prescribed is indicated and not contra-indicated (SPC)
- Check for untreated indications or missing prophylaxis medications (treatment guidelines)
- Check that the medication is effective for patient (interview)
- Check that dosing and dosing intervals are within recommendations (SPC)
- Check for cost-effectiveness (formulary and guidelines)
- Check for clinical relevant drug–drug interactions with good documentation (SPC or online interaction tool)
- Check for side effects, compliance or concordance problems (interview)
- Check that relevant monitoring is planned (e.g. blood work, blood pressure, blood glucose)
- Check for prescription errors especially in high alert medications such as; antibiotics, antidepressants, antipsychotics, antithrombotics and coagulation inhibitors, benzodiazepines, cytostatics, diuretics, insulin, NSAIDs, strong opioids (EMM)

(*Reference tools in brackets*)

Appendix 2

See Table 6.

Table 6 Adapted and translated version of the PCNE classification for drug-related problems

PCNE P-code	Original—English Problem	Translated—Danish Problem
P1.1	No effect of drug treatment/therapy failure	Ingen effekt af behandling/terapisvigt
P1.2	Effect of drug treatment not optimal	Effekt af lægemiddelbehandling ikke optimal
P1.3	Wrong effect of drug treatment	Forkert effekt af lægemiddelbehandling
P1.4	Untreated indication	Ubehandlet indikation
P2.1	Adverse drug event (non-allergic)	Lægemiddelrelateret utilsigtet hændelse/CAVE/Bivirkning (ikke-allergisk)
P2.2	Adverse drug event (allergic)	Lægemiddelrelateret utilsigtet hændelse/CAVE/Bivirkning (allergisk)
P2.3	Toxic adverse drug-event	Lægemiddelrelateret utilsigtet hændelse/CAVE/Bivirkning (toksisk)
P3.1	Drug treatment more costly than necessary	Lægemiddelbehandling dyrere end nødvendigt
P3.2	Unnecessary drug-treatment	Behandling uden indikation
P4.1	Patient dissatisfied with therapy despite optimal clinical and economic treatment outcomes	Patient utilfreds med behandling trods rationel farmakoterapeutisk behandling
P4.2	Unclear problem/complaint. Further clarification necessary (please use as escape only)	Uspecifikt/uklart problem/klage (hvis de øvrige koder udelukkes). Specificer i kommentarfelt

C-code	Cause	Årsag
C1.1	Inappropriate drug (incl. contra-indicated)	Uhensigtsmæssig/kontraindikeret lægemiddel
C1.2	No indication for drug	Ej indikation for lægemiddel
C1.3	Inappropriate combination of drugs, or drugs and food	Uhensigtsmæssig kombination af lægemidler, eller lægemidler og fødevarer
C1.4	Inappropriate duplication of therapeutic group or active ingredient	Uhensigtsmæssig dobbeltmedicinering inden for samme terapeutiske gruppe/generika
C1.5	Indication for drug-treatment not noticed	Indikation for lægemiddel mangler
C1.6	Too many drugs prescribed for indication	For mange lægemidler ordineret til samme indikation
C1.7	More cost-effective drug available	Billigere ækvieffektivt lægemiddel tilgængeligt
C1.8	Synergistic/preventive drug required and not given	Synergistisk/profylaktisk lægemiddel mangler
C1.9	New indication for drug treatment presented	Ny indikation for lægemiddelbehandling forelagt
C2.1	Inappropriate drug form	Uhensigtsmæssig lægemiddelform
C3.1	Drug dose too low	Lægemiddeldosis for lav
C3.2	Drug dose too high	Lægemiddeldosis for høj
C3.3	Dosage regimen not frequent enough	Doseringsinterval for langt
C3.4	Dosage regimen too frequent	Doseringsinterval for kort
C3.5	No therapeutic drug monitoring	Manglende lægemiddelmonitorering
C3.6	Pharmacokinetic problem requiring dose adjustment	Farmakokinetisk problem der kræver dosisjustering
C3.7	Deterioration/improvement of disease state requiring dose adjustment	Ændring i sygdom der kræver dosisjustering

Table 6 continued

C-code	Cause	Årsag
C4.1	Duration of treatment too short	Behandlingsvarighed for kort
C4.2	Duration of treatment too long	Behandlingsvarighed for lang
C5.1	Inappropriate timing of administration and/or dosing intervals	Uhensigtsmæssig doseringstidspunkt og/eller -interval
C5.2	Drug underused/under-administered (deliberately)	Dosis underadministreret (bevidst)
C5.3	Drug overused/over-administered (deliberately)	Dosis overadministreret (bevidst)
C5.4	Drug not taken/administered at all	Dosis ikke taget/administreret
C5.5	Wrong drug taken/administered	Forkert lægemiddel taget/administreret
C5.6	Drug abused (unregulated overuse)	Lægemiddel misbrugt (ureguleret overforbrug)
C5.7	Patient unable to use drug/form as directed	Patient ej i stand til at administrere lægemiddel/lægemiddelform som ordineret
C6.1	Prescribed drug not available	Ordineret lægemiddel ej tilgængeligt
C6.2	Prescribing error (necessary information missing)	Ordinationsfejl (nødvendige informationer mangler)
C6.3	Dispensing error (wrong drug or dose dispensed)	Dispenseringsfejl (forkert lægemiddel eller dosis dispenseret)
C7.1	Patient forgets to use/take drug	Patient glemmer at tage/bruge lægemiddel
C7.2	Patient uses unnecessary drug	Patient bruger unødvendigt lægemiddel
C7.3	Patient takes food that interacts	Patient spiser fødevarer der interagerer med lægemiddel
C7.4	Patient stored drug inappropriately	Patient opbevarer lægemiddel uhensigtsmæssigt
C8.1	Other cause; specify	Andet—specificer i kommentarfelt
C8.2	No obvious cause	Ingen specifik årsag

I-code	Intervention	Regulering
I0.0	No Intervention	Ingen regulering
I1.1	Prescriber informed only	Information givet til læge uden yderligere regulering
I1.2	Prescriber asked for information	Læge har bedt om information
I1.3	Intervention proposed, approved by Prescriber	Regulering foreslået og accepteret af læge
I1.4	Intervention proposed, not approved by Prescriber	Regulering foreslået, men ikke accepteret af læge
I1.5	Intervention proposed, outcome unknown	Regulering foreslået, accept uvist
I2.1	Patient (medication) counselling	Patient rådgivet (om medicinen)
I2.2	Written information provided only	Kun givet skriftlig information
I2.3	Patient referred to prescriber	Patient henvist til lægen
I2.4	Spoken to family member/caregiver	Talt med pårørende/værge/plejeperson
I3.1.1[a]	Drug changed to.... generic drug	Lægemiddel ændret til/synonymskift
I3.1.2[a]	Drug changed to.... equivalent drug	Lægemiddel ændret til/analogskift
I3.2.1[a]	Dosage changed to.... higher dose	Dosering ændret.... op
I3.2.2[a]	Dosage changed to.... lower dose	Dosering ændret.... ned

Table 6 continued

I-code	Intervention	Regulering
I3.3.1[a]	Formulation changed to.... other	Lægemiddelform ændret til andet
I3.3.2[a]	Formulation changed to.... injection	Lægemiddelform ændret til injektion
I3.3.3[a]	Formulation changed to.... oral	Lægemiddelform ændret til oral
I3.4.1[a]	Instructions for use changed.... according to electronic medication module	Instruktion/administrationsmåde/tidspunkt ændret af hensyn til medicineringsmodul
I3.4.2[a]	Instructions for use changed.... according to SPC	Instruktion/administrationsmåde/tidspunkt ændret af hensyn til SPC
I3.4.4[a]	Instructions for use changed to.... other	Instruktion/administationsmåde/tidspunkt ændret til andet
I3.5	Drug stopped	Lægemiddel seponeret
I3.6	New drug started	Nyt lægemiddel startet
I4.1	Other intervention (specify)	Anden regulering. Specificer i kommentarfelt
I4.2	Side effect reported to authorities	Bivirkning/Utilsigtet hændelse indberettet

O-code	Outcome	Resultat
O0.0	Outcome intervention not known	Resultat af regulering uvist
O1.0	Problem totally solved	Problem helt løst
O2.0	Problem partially solved	Problem delvist løst
O3.1	Problem not solved, lack of cooperation of patient	Problem ikke løst pga. patient
O3.2	Problem not solved, lack of cooperation of prescriber	Problem ikke løst pga. læge
O3.3	Problem not solved, intervention not effective	Problem ikke løst, regulering uden virkning
O3.4	No need or possibility to solve problem	Unødvendigt eller umuligt at løse problem

[a] Adapted with an extra level (subdomain)

Appendix 3

See Table 7.

Table 7 Distribution of the drug-related problems on PCNE Classification codes

P	Distribution of Drug Related Problems (DRP)	
P1.1	No effect of drug treatment/ therapy failure	4%
P1.2	Effect of drug treatment not optimal	24%
P1.3	Wrong effect of drug treatment	12%
P1.4	Untreated indication	7%
P2.1	Adverse drug event (non-allergic)	3%
P2.2	Adverse drug event (allergic)	0%
P2.3	Toxic adverse drug-event	0%
P3.1	Drug treatment more costly than necessary	27%
P3.2	Unnecessary drug-treatment	8%
P4.1	Patient dissatisfied with therapy despite optimal treatment	1%
P4.2	Unclear problem/complaint. Further clarification necessary	14%

C	Distribution of causes for DRP	
C1.1	Inappropriate drug (incl. contra-indicated)	12%
C1.2	No indication for drug	2%
C1.3	Inappropriate combination of drugs, or drugs and food	4%
C1.4	Inappropriate duplication of therapeutic group or ingredient	0%
C1.5	Indication for drug-treatment not noticed	2%
C1.6	Too many drugs prescribed for indication	4%
C1.7	More cost-effective drug available	18%
C1.8	Synergistic/preventive drug required and not given	4%
C1.9	New indication for drug treatment presented	5%
C2.1	Inappropriate drug form	0%
C3.1	Drug dose too low	9%
C3.2	Drug dose too high	9%
C3.3	Dosage regimen not frequent enough	0%
C3.4	Dosage regimen too frequent	1%
C3.5	No therapeutic drug monitoring	3%
C3.6	Pharmacokinetic problem requiring dose adjustment	1%
C3.7	Deterioration/improvement of disease state requiring adjustment	1%
C4.1	Duration of treatment too short	0%
C4.2	Duration of treatment too long	0%
C5.1	Inappropriate timing of administration and/or dosing intervals	3%
C5.2	Drug underused/ under-administered (deliberately)	1%
C5.3	Drug overused/ over-administered (deliberately)	1%
C5.4	Drug not taken/administered at all	0%
C5.5	Wrong drug taken/administered	0%
C5.6	Drug abused (unregulated overuse)	0%
C5.7	Patient unable to use drug/form as directed	1%
C6.1	Prescribed drug not available	7%
C6.2	Prescribing error (necessary information missing)	1%
C6.3	Dispensing error (wrong drug or dose dispensed)	0%
C7.1	Patient forgets to use/take drug	0%
C7.2	Patient uses unnecessary drug	8%
C7.3	Patient takes food that interacts	0%
C7.4	Patient stored drug inappropriately	0%
C8.1	Other cause	1%
C8.2	No obvious cause	3%

Table 7 continued

I	Distribution of Interventions		
I0.0	No Intervention	0%	
I1.1	Prescriber informed only	13%	
I1.2	Prescriber asked for information	0%	
I1.3	Intervention proposed, approved by Prescriber	0%	
I1.4	Intervention proposed, not approved by Prescriber	0%	
I1.5	Intervention proposed, outcome unknown	0%	
I2.1	Patient (medication) counselling	1%	
I2.2	Written information provided only	1%	
I2.3	Patient referred to prescriber	1%	
I2.4	Spoken to family member/caregiver	0%	
I3.1.1	Drug changed to synonym drug	1%	
I3.1.2	Drug changed to analog drug	29%	
I3.2.1	Dosage changed to higher dose	8%	
I3.2.2	Dosage changed to lower dose	10%	
I3.3.1	Formulation changed to other	1%	
I3.3.2	Formulation changed to injection	0%	
I3.3.3	Formulation changed to oral	0%	
I3.4.1	Instructions for use changed according to EMM	1%	
I3.4.2	Instructions for use changed to according to SPC	2%	
I3.4.3	Instructions for use changed according to treatment guidelines	0%	
I3.4.4	Instructions for use changed to other	2%	
I3.5	Drug stopped	20%	
I3.6	New drug started	10%	
I4.1	Other intervention	0%	
I4.2	Side effect reported to authorities	0%	

O	Distribution of Outcome		
O0.0	Outcome intervention not known	8%	
O1.0	Problem totally solved	67%	
O2.0	Problem partially solved	2%	
O3.1	Problem not solved, lack of cooperation of patient	1%	
O3.2	Problem not solved, lack of cooperation of prescriber	18%	
O3.3	Problem not solved, intervention not effective	0%	
O3.4	No need or possibility to solve problem	3%	

References

1. Bergkvist Christensen A, Holmbjer L, Midlöv P, Höglund P, Larsson L, Bondesson Å, et al. The process of identifying, solving and preventing drug related problems in the LIMM-study. Int J Clin Pharm. 2011;33(6):1010–8.
2. Lazarou J, Pomeranz BH, Corey PN. Incidence of adverse drug reactions in hospitalized patients: a meta-analysis of prospective studies. JAMA. 1998;279(15):1200–5.
3. Ernst FR, Grizzle AJ. Drug-related morbidity and mortality: updating the cost-of-illness model. J Am Pharm Assoc (Wash). 2001;41(2):192–9.
4. Viktil KK, Blix HS. The impact of clinical pharmacists on drug-related problems and clinical outcomes. Basic Clin Pharmacol Toxicol. 2008;102(3):275–80.
5. Viktil KK, Blix HS, Reikvam A, Moger TA, Hjemaas BJ, Walseth EK, et al. Comparison of drug-related problems in different patient groups. Ann Pharmacother. 2004;38(6):942–8.
6. Viktil KK, Blix HS, Moger TA, Reikvam A. Interview of patients by pharmacists contributes significantly to the identification of drug-related problems (DRPs). Pharmacoepidemiol Drug Saf. 2006;15(9):667–74.
7. Bedouch P, Allenet B, Grass A, Labarére J, Brudieu E, Bosson JL, et al. Drug-related problems in medical wards with a computerized physician order entry system. J Clin Pharm Ther. 2009;34(2):187–95.
8. Krähenbühl-Melcher A, Schlienger R, Lampert M, Haschke M, Drewe J, Krähenbühl S. Drug-related problems in hospitals: a review of the recent literature. Drug Saf. 2007;30(5):379–407.

9. Lampert M, Kraehenbuehl S, Hug B. Drug-related problems: evaluation of a classification system in the daily practice of a Swiss University Hospital. Pharm World Sci. 2008;30(6):768–76.
10. Blix HS, Viktil KK, Moger TA, Reikvam Å. Characteristics of drug-related problems discussed by hospital pharmacists in multidisciplinary teams. Pharm World Sci. 2006;28(3):152–8.
11. Blix HS, Viktil KK, Reikvam A, Moger TA, Hjemaas BJ, Pretsch P, et al. The majority of hospitalised patients have drug-related problems: results from a prospective study in general hospitals. Eur J Clin Pharmacol. 2004;60(9):651–8.
12. PCNE. Pharmaceutical Care Network Europe. www.pcne.org. 2013. Available from: URL: http://pcne.org/sig/MedRev/medication-review.php.
13. Hepler CD, Strand LM. Opportunities and responsibilities in pharmaceutical care. Am J Health Syst Pharm. 1990;47(3):533–43.
14. Tam VC, Knowles SR, Cornish PL, Fine N, Marchesano R, Etchells EE. Frequency, type and clinical importance of medication history errors at admission to hospital: a systematic review. CMAJ. 2005;173(5):510–5.
15. Manno MS, Hayes DD. Best-practice interventions: how medication reconciliation saves lives. Nursing. 2006;36(3):63–4.
16. European Society of Clinical Pharmacy. What is Clinical Pharmacy? http://www.escpweb.org/cms/Clinical_pharmacy. 2010 November 12 [cited 2013 Jan 3]. Available from: URL: http://www.escpweb.org/cms/Clinical_pharmacy.
17. Lau HS, Florax C, Porsius AJ, De BA. The completeness of medication histories in hospital medical records of patients admitted to general internal medicine wards. Br J Clin Pharmacol. 2000;49(6):597–603.
18. Andersen SE, Pedersen AB, Bach KF. Medication history on internal medicine wards: assessment of extra information collected from second drug interviews and GP lists. Pharmacoepidemiol Drug Saf. 2003;12(6):491–8.
19. Mueller SK, Sponsler KC, Kripalani S, Schnipper JL. Hospital-based medication reconciliation practices: a systematic review. Arch Intern Med. 2012;172(14):1057–69.
20. Hellstrom LM, Bondesson Å, Höglund P, Midlöv P, Holmdahl L, Rickhag E, et al. Impact of the Lund Integrated Medicines Management (LIMM) model on medication appropriateness and drug-related hospital revisits. Eur J Clin Pharmacol. 2011;67(7):741–52.
21. Scullin C, Scott MG, Hogg A, McElnay JC. An innovative approach to integrated medicines management. J Eval Clin Pract. 2007;13(5):781–8.
22. Gillespie U, Alassaad A, Henrohn D, Garmo H, Hammarlund-Udenaes M, Toss H, et al. A comprehensive pharmacist intervention to reduce morbidity in patients 80 years or older: a randomized controlled trial. Arch Intern Med. 2009;169(9):894–900.
23. Lisby M, Thomsen A, Nielsen LP, Lyhne NM, Breum-Leer C, Fredberg U, et al. The effect of systematic medication review in elderly patients admitted to an acute ward of internal medicine. Basic Clin Pharmacol Toxicol. 2010;106(5):422–7.
24. Kjeldsen LJ, Nielsen GS. Implementation of clinical pharmacy in Danish hospital-pharmacies: winning the championship or the wooden spoon? Eur J Hosp Pharm Sci Pract. 2012;19(6):539–40.
25. Olesen C. Ordination af vanlig medicin ved farmaceut. 2008 Oct.
26. Buck T, Brandstrup L, Brandslund I, Kampmann J. The effects of introducing a clinical pharmacist on orthopaedic wards in Denmark. Pharm World Sci. 2007;29(1):12–8.
27. Taegtmeyer AB, Curkovic I, Rufibach K, Corti N, Battegay E, Kullak-Ublick GA. Electronic prescribing increases uptake of clinical pharmacologists' recommendations in the hospital setting. Br J Clin Pharmacol. 2011;72(6):958–64.
28. Kuperman GJ, Bobb A, Payne TH, Avery AJ, Gandhi TK, Burns G, et al. Medication-related clinical decision support in computerized provider order entry systems: a review. J Am Med Inform Assoc. 2007;14(1):29–40.
29. Bondesson Å, Holmdahl L, Midlöv P, Höglund P, Andersson E, Eriksson T. Acceptance and importance of clinical pharmacists LIMM-based recommendations. Int J Clin Pharm. 2012;34(2):272–6.
30. Chen T, Almeida Neto A. Exploring elements of interprofessional collaboration between pharmacists and physicians in medication review. Pharm World Sci. 2007;29(6):574–6.
31. Spinewine A, Schmader KE, Barber N, Hughes C, Lapane KL, Swine C, et al. Appropriate prescribing in elderly people: how well can it be measured and optimised? Lancet. 2007;370(9582):173–84.
32. Bladh L, Ottosson E, Karlsson J, Klintberg L, Wallerstedt SM. Effects of a clinical pharmacist service on health-related quality of life and prescribing of drugs: a randomised controlled trial. BMJ Qual Saf. 2011;20(9):738–46.
33. Fertleman M, Barnett N, Patel T. Improving medication management for patients: the effect of a pharmacist on post-admission ward rounds. Qual Saf Health Care. 2005;14(3):207–11.
34. Mortimer C, Emmerton L, Lum E. The impact of an aged care pharmacist in a department of emergency medicine. J Eval Clin Pract. 2011;17(3):478–85.
35. Mutnick AH, Sterba KJ, Peroutka JA, Sloan NE, Beltz EA, Sorenson MK. Cost savings and avoidance from clinical interventions. Am J Health Syst Pharm. 1997;54(4):392–6.
36. Nesbit TW, Shermock KM, Bobek MB, Capozzi DL, Flores PA, Leonard MC, et al. Implementation and pharmacoeconomic analysis of a clinical staff pharmacist practice model. Am J Health Syst Pharm. 2001;58(9):784–90.
37. O'Dell KM, Kucukarslan SN. Impact of the clinical pharmacist on readmission in patients with acute coronary syndrome. Ann Pharmacother. 2005;39(9):1423–7.
38. Kjeldsen L, Olesen C, Truelshøj T, Nielsen L. Physicians' evaluation of clinical pharmacy revealed increased focus on quality improvement and cost savings. Eur J Hosp Pharm Sci Pract. 2011;17:31–4.
39. Vand S, Hermansen I. How can clinical pharmacy profession be used at the emergency wards? Scand J Trauma Resusc Emerg Med. 2012;20(2):1.
40. van Mil JW, Westerlund LO, Hersberger KE, Schaefer MA. Drug-related problem classification systems. Ann Pharmacother. 2004;38(5):859–67.
41. Nathan A, Goodyer L, Lovejoy A, Rashid A. "Brown bag" medication reviews as a means of optimizing patients' use of medication and of identifying potential clinical problems. Fam Pract. 1999;16(3):278–82.
42. Larrat EP, Taubman AH, Willey C. Compliance-related problems in the ambulatory population. Am Pharm. 1990;NS30(2):18–23.
43. Nielsen TRH, Kruse MG, Andersen SE, Rasmussen M, Honoré PH. The quality and quantity of patients' own drugs brought to hospital during admission. Eur J Hosp Pharm. doi:10.1136/ejhpharm-2013-000277.
44. Gracious B, Abe N, Sundberg J. The importance of taking a history of over-the-counter medication use: a brief review and case illustration of ''PRN'' antihistamine dependence in a hospitalized adolescent. J Child Adolesc Psychopharmacol. 2010;20(6):521–4.
45. Patientsikkert Sygehus. Medicinafstemningspakken version 1.0. http://www.patientsikkertsygehus.dk/media/27659/pss_pakke_medicinafstemning.pdf. 2010 April 1. Available from: URL: http://www.patientsikkertsygehus.dk/media/27659/pss_pakke_medicinafstemning.pdf.
46. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977;33(1):159–74.
47. Urbaniak GC, Plous S. Research randomizer (version 3.0) [computer software]. http://www.randomizer.org/. 2013 [cited 2011 Jul 14]. Available from: URL: http://www.randomizer.org/.

48. WHO Collaborating Centre for Drug Statistics Methodology. The Anatomical Therapeutic Chemical (ATC) classification system. http://www.whocc.no/atc/structure_and_principles/. 2012 May 4. Available from: URL: http://www.whocc.no/atc/structure_and_principles/.

49. Galindo C, Olive M, Lacasa C, Martinez J, Roure C, Llado M, et al. Pharmaceutical care: pharmacy involvement in prescribing in an acute − care hospital. Pharm World Sci. 2003;25(2): 56–64.

50. Munk CL, Bendixen HB, Kjeldsen LJ. Medication review with a focus on fracture prophylaxis among patients suffering collum femoris fractures. Eur J Hosp Pharm Sci Pract. 2011;2:26–30.

51. Ghazanfar M, Honoré PH, Nielsen TRH, Andersen SE, Rasmussen M. Hospital admission interviews are time-consuming with several interruptions. Dan Med J. 2012;59(12):A4534.

52. Lummis H, Sketris I, van Veldhuyzen ZS. Systematic review of the use of patients' own medications in acute care institutions. J Clin Pharm Ther. 2006;31(6):541–63.

53. Pippins JR, Gandhi TK, Hamann C, Ndumele CD, Labonville SA, Diedrichsen EK, et al. Classifying and predicting errors of inpatient medication reconciliation. J Gen Intern Med. 2008;23(9):1414–22.

54. Barry PJ, Gallagher P, Ryan C, O'mahony D. START (screening tool to alert doctors to the right treatment) an evidence-based screening tool to detect prescribing omissions in elderly patients. Age Ageing. 2007;36(6):632–8.

55. Gallagher P, Ryan C, Byrne S, Kennedy J, O'mahony D. STOPP (Screening Tool of Older Person's Prescriptions) and START (Screening Tool to Alert doctors to Right Treatment). Consensus validation. Int J Clin Pharmacol Ther. 2008;46(2):72–83.

56. Mannheimer B, Ulfvarson J, Eklöf S, Bergqvist M, Andersén-Karlsson E, Pettersson H, et al. Drug-related problems and pharmacotherapeutic advisory intervention at a medicine clinic. Eur J Clin Pharmacol. 2006;62(12):1075–81.

57. Chan DC, Chen JH, Kuo HK, We CJ, Lu IS, Chiu LS, et al. Drug-related problems (DRPs) identified from geriatric medication safety review clinics. Arch Gerontol Geriatr. 2012;54(1):168–74.

58. Strand LM, Morley PC, Cipolle RJ, Ramsey R, Lamsam GD. Drug-related problems: their structure and function. Ann Pharmacother. 1990;24(11):1093–7.

59. Spinewine A, Swine C, Dhillon S, Lambert P, Nachega JB, Wilmotte L, et al. Effect of a collaborative approach on the quality of prescribing for geriatric inpatients: a randomized, controlled trial. J Am Geriatr Soc. 2007;55(5):658–65.