

# Geriatric pharmacology and pharmacotherapy education for health professionals and students: a systematic review

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## WHAT IS ALREADY KNOWN ABOUT THIS SUBJECT

- The rate of medication errors is high, and these errors can cause adverse drug reactions. Elderly individuals are most vulnerable to adverse drug reactions.
- One cause of medication errors is the lack of drug knowledge on the part of different health professionals.
- Medical curricula have changed in recent years, resulting in less education in the basic sciences, such as pharmacology.

## WHAT THIS STUDY ADDS

- Our study shows that little curricular time is devoted to geriatric pharmacology and that educational programmes in geriatric pharmacology have not been thoroughly evaluated.
- While interest in pharmacology education has increased recently, this is not the case for geriatric pharmacology education.
- Education on geriatric pharmacology should have more attention in the curricula of health professionals, given the often complex pharmacotherapy in elderly patients.
- Educational topics should be related to the known risk factors of medication errors, such as polypharmacy, dose adjustments in organ dysfunction and psychopharmacotherapeutics.

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## Keywords

geriatrics, medical education, pharmacology, pharmacotherapy, postgraduate, undergraduate

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## AIMS

Given the reported high rates of medication errors, especially in elderly patients, we hypothesized that current curricula do not devote enough time to the teaching of geriatric pharmacology. This review explores the quantity and nature of geriatric pharmacology education in undergraduate and postgraduate curricula for health professionals.

## METHODS

Pubmed, Embase and PsycINFO databases were searched (from 1 January 2000 to 11 January 2011), using the terms 'pharmacology' and 'education' in combination. Articles describing content or evaluation of pharmacology education for health professionals were included. Education in general and geriatric pharmacology was compared.

## RESULTS

Articles on general pharmacology education (252) and geriatric pharmacology education (39) were included. The number of publications on education in general pharmacology, but not geriatric pharmacology, has increased over the last 10 years. Articles on undergraduate and postgraduate education for 12 different health disciplines were identified. A median of 24 h (from 15 min to 4956 h) devoted to pharmacology education and 2 h (1–935 h) devoted to geriatric pharmacology were reported. Of the articles on education in geriatric pharmacology, 61.5% evaluated the teaching provided, mostly student satisfaction with the course. The strength of findings was low. Similar educational interventions were not identified, and evaluation studies were not replicated.

## CONCLUSIONS

Recently, interest in pharmacology education has increased, possibly because of the high rate of medication errors and the recognized importance of evidence-based medical education. Nevertheless, courses on geriatric pharmacology have not been evaluated thoroughly and none can be recommended for use in training programmes. Suggestions for improvements in education in general and geriatric pharmacology are given.

## Introduction

Medication errors due to human mistakes have raised concerns about the pharmacological knowledge of different health professionals [1, 2]. Medication errors may lead to adverse drug reactions (ADRs) [3], which, in turn, are responsible for 3.0–6.5% of all hospital admissions [3–6]. The numbers are even higher for elderly individuals, ranging from 3.6 to 13.3% [4–6]. About 47–72% of ADRs are potentially preventable [3, 5]. The main cause of medication errors is insufficient knowledge of drug therapy on the part of doctors and other health professionals [1, 7]. Moreover, pharmacotherapy is becoming more complex, especially in older patients [7]. Worldwide, elderly people form the largest group of people admitted to hospital, and the elderly population is increasing rapidly [8, 9]. This means that most healthcare professionals will face the challenge of prescribing for elderly patients. In the last decade, medical and nursing curricula have changed, with less time being devoted to basic sciences, such as pharmacology [10, 11]. The focus of medical curricula has changed from basic science discipline-based to integrated organ- and disease-based approaches since the introduction of problem-based learning in the 1970–1980s in many places in the world [11–13], and in nursing curricula there has been a shift from a biomedical model focused on curing to a holistic model focused on caring [10]. This has frequently resulted in abandoning separate pharmacology courses and integrating pharmacology into problem-oriented courses. The lack of a thorough grounding in the medical sciences might contribute to insufficient knowledge of clinical pharmacology and drug therapy [14]. Moreover, there seem to be few effective programmes for teaching health professionals' prescribing skills. The systematic review of Ross *et al.* identified the 'World Health Organization guide to good prescribing' as the only effective programme for teaching medical students how to prescribe [15, 16]. Little is known about the education in pharmacol-

ogy given to health professionals other than medical students, and even less is known about their education in geriatric pharmacology.

Given the high rates of medication errors worldwide, we hypothesized that health professionals receive insufficient education in pharmacology, and especially in geriatric pharmacology, during their training. We performed a systematic review to gain insight into education in geriatric pharmacology in terms of its volume and content in curricula and to establish what constitutes effective education in geriatric pharmacology.

## Methods

The review was performed using the PRISMA guidelines for systematic reviews and meta-analysis and the Cochrane guidelines [17, 18].

### *Data sources and search strategy*

To put education in geriatric pharmacology in the context of education in general pharmacology, we searched the literature for studies on education in pharmacology, focusing on the literature after 2000. The reason for limiting the search to the period between 2000 and 2011 is to minimize results from curricula that no longer exist. Medical curricula change regularly, and many have changed to problem-based formats. An 11 year period provides a reasonable chance to report on current practices.

The databases PubMed, Embase and PsycINFO were searched from 1 January 2000 to 11 January 2011 using the terms 'pharmacology' (in title/abstract) combined with 'education' (in title), and synonyms. Articles on education in geriatric pharmacology were manually selected from this broader search, because adding the term 'geriatric' and synonyms resulted in an improbably low number of articles. Limits other than time limits were not used in the searches. The search syntax used in PubMed, Embase and PsycINFO is depicted in Figure 1.

Pubmed [title]	Education OR educating OR educate OR educated OR educators OR educator OR educative OR educates OR educations OR educationist OR educationally OR educational OR training OR teaching OR lessons OR train OR teach OR lesson OR learning OR learn OR learned OR taught OR trained OR skill OR skills OR curriculum OR curricula OR courses OR course
<b>AND</b>	
Pubmed [title/abstract]	Pharmacology OR pharmacy OR pharmacologic OR pharmaceutical OR pharmacotherapy OR medication OR prescribing OR prescription OR prescribe OR drug therapy

**Figure 1**

Search syntax in PubMed. Equal search strategy in Embase and PsycINFO (limit: 1 January 2000 to 11 January 2011)

All duplicate articles were excluded, and the remaining articles were screened on title, abstract and full text. If an abstract was not available, the full text of the article was screened. If the full-text article was not retrievable from the corresponding author or from national university libraries, the article was excluded. Articles cited by another article for the description of the education were included as related articles.

### Study selection

First, all titles were screened for relevance using the following exclusion criteria: (i) animal studies or nonhuman pharmacology education; (ii) content not (pharmacology) education; (iii) education for patients or informal caregivers; and (iv) educational terminology used with a non-educational meaning, e.g. teaching hospital. Second, the abstracts were screened for relevance using the same exclusion criteria as above with the additional exclusion criterion of language different from English, German or Dutch. Third, all relevant full-text articles were screened using the following exclusion criteria: (i) language different from English, German or Dutch; (ii) education for patients or informal caregivers (not health professionals); (iii) does not contain description of pharmacology education in terms of content or quantity; (iv) only congress abstract available without a description of education; and (v) full text not available.

### Study eligibility criteria

We considered all articles on education in geriatric pharmacology for health professionals. Education was defined as any structured educational activity. First, all articles describing pharmacology education for health professionals were selected. Articles were eligible if the education was described in terms of study load (study hours) or content; content was described in terms of educational topic and teaching method. Second, articles on education in geriatric pharmacology were selected from the articles on pharmacology education, namely, articles covering geriatrics, specific geriatric syndromes (e.g. Alzheimer's disease, delirium) or specific problems common in a geriatric population (e.g. polypharmacy, renal failure) as educational topic. There were no eligibility criteria for study design. All articles on education in geriatric pharmacology were independently assessed by three authors (C.J.P.W.K., L.v.H. and L.J.) in terms of the educational content, study load and evaluation. The reviewers reached full consensus on eligibility of the studies after discussion.

### Data extraction

To enable comparison of education in geriatric pharmacology and general pharmacology, we extracted information about the status of the education (mandatory or elective). If the education was given as part of a university or school curriculum, it was assumed to be mandatory if not mentioned otherwise. The study load was extracted and

described in terms of study hours devoted to pharmacology education, and in proportion to the total study load, if this information was provided. Credit hours (CHs) were transformed to 40 study hours, ECTS (European Credit Transfer System) to 28 study hours, and 1 day to 8 study hours if not described otherwise in the article. Education was classified by health profession and by undergraduate or postgraduate level.

### Qualitative grading

The methodology used to evaluate the education, summarized as strength of findings, and the impact of the studies were graded. The Best Evidence Medical Education (BEME) criteria were used to grade the methodology [19]. The BEME score is based on critical appraisal of the study and reflects the credibility of study results. Scores range from 1 to 5, as follows: level 1, no clear conclusions can be drawn, not significant; level 2, results ambiguous, but there appears to be a trend; level 3, conclusions can probably be based on the results; level 4, results are clear and very likely to be true; and level 5, results are unequivocal. The Kirkpatrick model of hierarchy of evaluation, modified by Freeth, was used to evaluate the impact of the education [20,21]. Scores range from 1 to 4, as follows: level 1, learners reaction such as learners' views on the learning experience; level 2a, modified attitude; level 2b, acquisition of knowledge or skills; level 3, behavioural changes; level 4a, change in organization practice; and level 4b, benefits to patients.

### Data synthesis

All descriptive analyses were performed in SPSS version 15.0 for Windows (SPSS Inc., Chicago, IL, USA). The proportion of articles published in different years, in different continents and with regard to different health professions were calculated. When ranges of study hours were given in an article, these were not used to calculate median values.

## Results

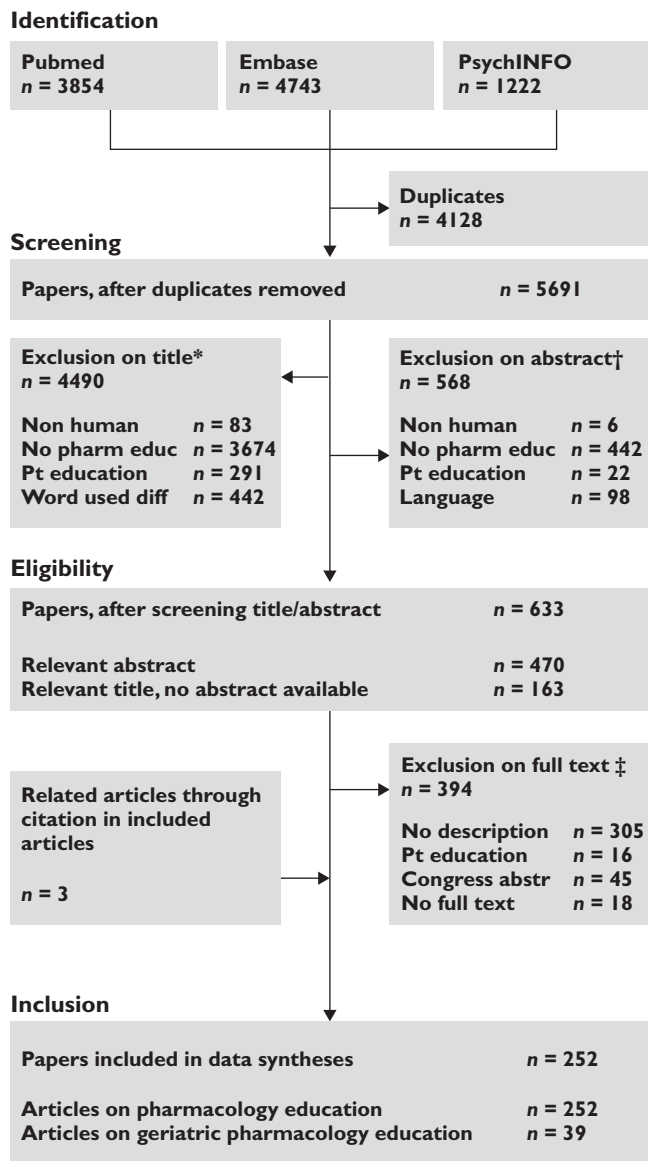
### Search results

Figure 2 shows the flowchart of the review. Of 9819 articles retrieved, 252 concerned pharmacology education and were included. Of these 252 articles, 39 reported on education in geriatric pharmacology as defined in the eligibility criteria.

### Study characteristics

The number of articles on pharmacology education appeared to have increased in the past decade, from six articles in 2000 to 45 articles in 2010. No such trend was seen for articles on education in geriatric pharmacology (Figure 3).

Most articles came from North America and Europe, 106 (42.6%) and 82 (32.9%) respectively, and mainly from the USA ( $n=90$ , 36.1%) and the UK ( $n=37$ , 14.9%). However, all continents were represented in the literature

**Figure 2**

Search results with reasons for exclusion. \*Exclusion criteria: Non human, animal studies or nonhuman pharmacology education; No pharm educ, content not (pharmacology) education; Pt educ, education for patients or informal caregivers (not health professionals); and Word used diff, the word education is used in a different way from education (e.g. teaching hospital, learning disabilities). † Exclusion criteria: Language, language other than English, German or Dutch. ‡ Exclusion criteria: No description, does not contain objective and quantitative description of pharmacology education; Congress abstr, only congress abstract available without a quantitative description of education; and No full text, not available in full text for screening, despite all efforts, and thus excluded

on pharmacology education. The topics described in most articles on pharmacology education were clinical pharmacology and therapeutics (28.5%), different medication groups (9.2%), geriatrics (6.4%) and basic knowledge of pharmacology (6.0%). For twelve different health professionals and students education was identified.

### Education in general and geriatric pharmacology

A median of 24 h (range 0.25–4965 h) was devoted to education in general pharmacology and a median of 2 h (range 1–935 h) to education in geriatric pharmacology (Table 1). The majority of studies did not provide information about the total study load; therefore, the proportion of the total study load could not be calculated for either general or geriatric pharmacology education.

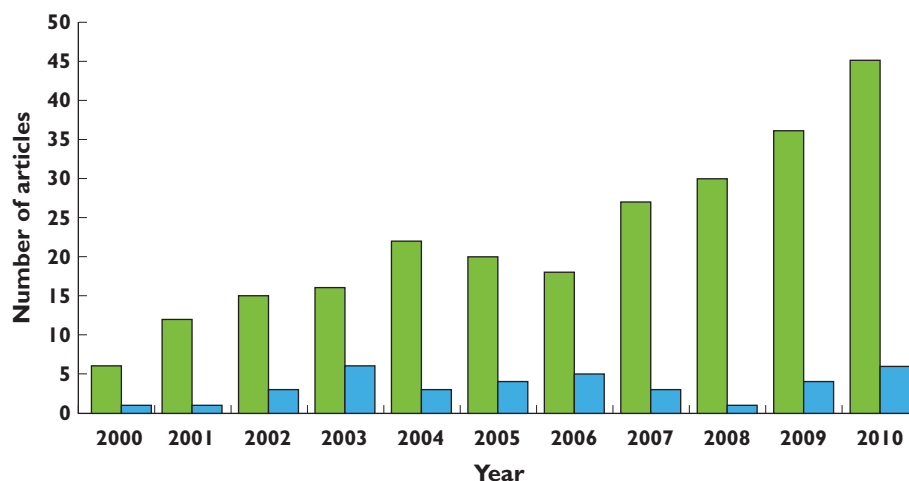
There were no studies reporting education in geriatric pharmacology for paramedical students, dental students, nurses, nurse practitioners, physician assistants and other paramedical health professionals. As shown in Table 1, the geriatric pharmacology study load was described for undergraduate and postgraduate medical and pharmacy courses only.

Table 2 describes the content, study load and evaluation of education in geriatric pharmacology in undergraduate ( $n = 18$ ) and postgraduate curricula ( $n = 14$ ). Twenty-four of the 32 articles (61.5%) presented data on the evaluation of education in geriatric pharmacology.

### Undergraduate education in geriatric pharmacology

As shown in Table 2, there was no uniform course on geriatric pharmacology for medical, pharmacy or nursing students, with courses differing in terms of topics covered and/or teaching method. There was little evidence that the education in geriatric pharmacology was effective; 67% (12 of 18) of the educational programmes had methodological problems and/or low levels of impact, such as students' satisfaction. No evaluation studies were replicated. Of articles reporting on courses for medical students, Franson *et al.* described an effective e-learning programme for pharmacology, in which geriatrics was one of the topics covered [22]. Dubois *et al.* reported that a therapeutic plan-writing course improved the therapeutic plan-writing skills of students who completed the course [23]. With regard to pharmacy students, Sauer showed that an ambulatory care service rotation improved students' attitudes towards the elderly [24].

Seven survey studies have described education in geriatric pharmacology for different health professionals in general without a description of the precise content of the education or an evaluation of the education. Therefore, these studies were not included in Table 2. [10, 25–30]. Of these studies, five concerned surveys with large methodological differences of the American and Canadian schools and universities for pharmacy, showing large differences in the provision of courses on geriatric pharmacology. Taken together, these studies describe that 53–100% of the schools and colleges provided some education on the topic within separate non-integrated courses, during integrated education or during geriatric clerkships [25–29]. One study showed that all UK colleges of nursing provided



**Figure 3**

Relevant articles on pharmacology education and geriatric pharmacology education per year. The three related articles in Figure 2 were from the period before 2000 and are not included. General pharmacology education (■); Geriatric pharmacology education (■)

**Table 1**

Time spent on education in general pharmacology and geriatric pharmacology for different health professionals and students

Health professional	Articles (n) General pharm educ	Geriatric pharm educ	General pharmacology education* Education time median h (range)	Geriatric pharmacology education* Education time median h (range)
<b>Undergraduate</b>				
Medical student	61	12	80 (1.5–4956)	1.5 (1–23)
Pharmacy student	85	13	20 (1–400)	10 (1–160)
Nursing student	16	2	13 (1.25–85)	NA
Paramedical student	2	NA	20	NA
Dental student	1	NA	20	NA
Nurse practitioner student	1	1	NA	NA
<b>Postgraduate</b>				
Physician	47	11	8 (0.5–160)	2 (1.25–23)
Pharmacist	21	2	20 (0.25–935)	471 (7–935)
Nurse	25	NA	15 (0.25–304)	NA
Physician assistant	1	NA	3	NA
Nurse practitioner	1	NA	3	NA
Other paramedical health professional	2	NA	38	NA
<b>Total†</b>	<b>263</b>	<b>41</b>	<b>24 (0.25–4965)</b>	<b>2 (1–935)</b>

\*Eighty-nine articles lacked a description of the education time and were left out of the calculations. †Eleven articles had descriptions of education for more than one health professional. NA, data not available. The proportion to the total study load could not be calculated due to a lack of data on total study load in the majority of studies.

some form of education in medicine and the elderly [10]. Another survey of the schools for nurse practitioners shows that 96% covered the topic ‘elderly individuals’ in the pharmacology and pharmacotherapy course [30].

Taken together, no single undergraduate course in geriatric pharmacology has been broadly implemented, i.e. no examples of geriatric pharmacology education were reported to be used inter-institutionally, and no studies evaluating educational interventions have been replicated.

### Postgraduate geriatric pharmacology education

Again, there were no uniform postgraduate courses on geriatric pharmacology for physicians or pharmacists, with courses differing in their content and/or teaching methods. Twelve of the 14 articles (86%) evaluated courses, but there were methodological problems in most studies. In contrast to the undergraduate courses, the postgraduate courses were mostly evaluated in terms of improving patient care. Again, no educational programme was

**Table 2**  
Pre- and postgraduate geriatric pharmacology education, sorted by health professional

Study	Country	Health professional	Course description	Quantitative description	Type of teaching	In curriculum	Evaluation	Level of evaluation*	Strength of finding†
Undergraduate Estus <i>et al.</i> (2010) [52, 53]	USA	Pharm students (pharmD)	Geriatric pharmacotherapy	120 h (3 CH)	Facebook, 'adopt a patient', patient cases, book and film clubs, lectures, scientific and reflective writing	Yes	Students' (n = 28) satisfaction on Facebook use: 93% valuable. Students' (n = 92) satisfaction on other teaching methods: 3.8–4.7 out of maximum 5 points	1	1
Jaedhe (2009) [54]	Germany	Pharm students	Individual pharmacotherapy, 1/6 topics geriatric patients	5 h for 6 topics	Lectures	Yes	?	?	?
Divine & Cain (2009) [55]	USA	Pharm students	Polypharmacy adherence as part of geriatric course	Total course 120 h (3 CH)	Polypharmacy medication simulation project, reflective assignment	Yes	Qualitative research on students' satisfaction (n = 173, response rate 100%); 83% positive comments on education on open-ended questions	1	1
Ross <i>et al.</i> (2006) [56]	USA	Pharm students	Vertical integrated course. 68 topics of which Alzheimer's and Parkinson's disease	80 h for 68 topics	Small groups	Yes	Mandatory ?	?	?
Sauer (2006) [24]	USA	Pharm students	Pharmacy practice experience in ambulatory care, topic geriatrics	6 weeks, half time	Rotations	Yes	Mandatory	Qualitative research using portfolio essays: 107 of 117 portfolios studied, essay pre-experience and postexperience. Students' attitudes towards elderly improved	2a
Lam (2005) [57]	USA	Pharm students	Geriatric clerkship	160 h	Clerkship	Yes	Elective	Students n = 24. 65% of written advices to prescribers was adopted by prescriber	4b
Bratt (2003) [58]	UK	Pharm students	CNS pharmacology, 1 topic: Alzheimer's disease	10 h	Integrated, hybrid lecture and PBL containing lectures, seminars and self study	Yes	Mandatory	Of 104 students, 51.4% preferred traditional lectures to the PBL; 54.2% PBL did aid knowledge retention. Mature students (44%) vs. younger students (25.8%) preferred PBL over traditional lectures (P < 0.01, Mann-Whitney U rank sum test)	1
Strohkirch & Jaehde (2003) [59]	Germany	Pharm students	clinical pharmacology. Topics: geriatrics, renal failure, medication review	?	Lectures, workshops, bedside teaching, practice simulation	Yes	Elective ?	?	?
George & Jacobs (2011) [60]	USA	Medical students, residents and fellows	Geriatric pharmacotherapy review	23 times, 1 h sessions	Seminars using the Medication Screening Questionnaire	Yes ?	?	Qualitative evaluation of education. 163 of 241 participants. 99% (strongly) agreed that overall quality of the sessions was excellent. All (strongly) agreed on meeting learning goals	1
Naritoku & Faingold (2009) [61]	USA	Medical students	Pharmacotherapeutics, 1 topic, Alzheimer's disease	1 h	(Interactive) lectures	Yes	Mandatory	n = 39, response rate 64%. Students' satisfaction on Alzheimer's topic: 4.7 ± 0.61 (out of 5)	1
Franson <i>et al.</i> (2008) [22]	Netherlands	Medical students	Pharmacology, 1 topic geriatrics	Average time 1–2 h	e-Learning	Yes	Mandatory	1100 students, >175 000 hits. Time spent on the program was associated with grades on topic: regression equation grade = 5.02 + 0.034 × time spent on program	2b
Dubois <i>et al.</i> (2007) [23]	Netherlands	Medical students	Geriatric pharmacotherapy	?	Therapeutic plan writing and self-study computer materials	Yes	Both	Cohort 1999 vs. cohort 2000 with intervention: percentage of students with sufficient result on therapeutic plan writing in intervention cohort improved compared with pre-intervention cohort (31% vs 69% two-sample t-test, P < 0.05)	4
Smith <i>et al.</i> (2006) [62]	Australia	Medical students	Polypharmacy as part of rational prescribing course	12 modules	e-Learning	Yes ?	?	In total, 363 students on online survey (response rate 6–13% in different years): 91–92% content module appropriate, 78–86% felt equipped to prescribe	1
Eroglu & Uresin (2003) [63]	Turkey	Medical students	Pharmacology education, geriatrics 1 of 17 subjects	24 h for all 17 subjects	PBL	Yes	Mandatory ?	?	?
Herzig <i>et al.</i> (2003) [64]; Antepohl & Herzig (1999) [65]	Canada	Medical students	Pharmacology course, 1 topic Parkinson's disease	3 h per topic	Problem based learning vs Lecture based learning	No		Pretest, post-test, post-test after 18 months showed no differences in the PBL group (n = 17/55, mean score on final test 20.1 ± 5.0) vs. the lecture-based learning group (n = 15/57, mean score on final test 19.0 ± 4.7) on pharmacology knowledge. 80 students were lost to follow-up for the final post-test	2b
Faingold & Dunaway (2002) [66]	USA	Medical students	CNS: Topics: Parkinson's disease, dementia	1.5 h for both topics together	Integrated lectures, small groups	Yes	Mandatory ?	?	?
Lathers & Smith (2002) [67]	USA	Medical students, residents	Geriatric clinical pharmacology	2 h	'Clinical pharmacology problem-solving unit'. Case-based learning	Yes ?	?	Of 455 students and residents, 40% (range in different years 25–65%) found it useful for learning	1
Lim & Honey (2006) [68]	New Zealand	Nursing students	Elderly pharmacokinetics	?	Integrated, PBL	Yes	Mandatory ?	?	?

**Table 2**  
Continued

Study	Country	Health professional	Course description	Quantitative description	Type of teaching	In curriculum	Evaluation	Level of evaluation*	Strength of findingst
<b>Postgraduate</b> <b>Leikola et al. (2009) [69]</b>	Finland	Pharmacists	Comprehensive medication review, rational prescribing, clinical pharmacology	935 h (35 ECTS)	Seminars, e-learning, learning in practice	Yes	Online evaluation (n = 38, response rate 90%): 92% met educational needs, 95% would recommend training to peers	1	1
<b>Demirkan et al. (2004) [35]</b>	Turkey	Pharmacists	Good practice pharmacists, 1 topic, group at risk (geriatric, renal and liver failure)	7 h	Lectures, workshops	Yes	95 pharmacists participated: score on pretest vs. post-test on all topics: 36.1 ± 7.9 vs. 56.6 ± 10.3	2b	3
<b>Strohkirch &amp; Jaehde (2003) [59]</b>	Germany	Pharmacists	Clinical pharmacology	1 year, 4 modules at university	Practice in own work environment, online support	Yes	?	?	?
<b>Warshaw et al. (2010) [70]</b>	USA	GP	Medication management as part of geriatric education	1.25 h	Presentations	Yes	?	?	?
<b>Midlöv et al. (2006) [31]</b>	Sweden	GP	Psychoactive drugs	2 visits	Outreach visits	No	60 GPs: response rate 80–93% (over different years). Score 3.8 out of 4 on presentation content, quality and meeting educational needs	1	1
<b>Straand et al. (2006) [71]</b>	Norway	GP	Pharmacotherapeutics	2 visits, 8 h workshop	Outreach visits, workshops, feedback reports	No	?	?	?
<b>Pimlott et al. (2003) [32]</b>	Canada	GP	Benzodiazepine use in elderly	3 times in 6 months	Educational bulletins, feedback on prescriptions	No	Randomisation of physicians. Intervention (n = 168) vs. control group (n = 206): 0.7% decrease vs. 1.1% increase in long-acting benzodiazepine (P = 0.036, not clinically relevant), no other significant differences	4b	3
<b>Lutters et al. (2004) [72]</b>	Switzerland	Hospital physicians	Antibiotics prescriptions in elderly	Weekly ward rounds	Ward rounds with infectious disease specialist, lectures, individual counselling, pocket cards	Yes	Mandatory intervention: 680 patients receiving antibiotics included: 15% reduction in proportion of patients receiving antibiotics (P = 0.08), 26% reduction in number of antibiotics administered (P < 0.001). In 83 of 110 patients, guidelines correctly implemented	4b	2
<b>George &amp; Jacobs (2011) [60]</b>	USA	Residents and fellows, medical students	Geriatric pharmacotherapy	23 times, 1 h sessions	Seminars using the Medication Screening Questionnaire	Yes	?	?	?
<b>Naughton et al. (2010) [33]</b>	USA	Internal medicine residents	Polypharmacy training as part of NSAID prescribing training	7 monthly modules	Patient chart review, lectures	Yes	Mandatory 35 postgraduate internal medicine residents. Pre-intervention vs. postintervention: reduction in NSAID prescribing after 1 year: 29 vs. 16% (P = 0.002) reduction in NSAID and 14 vs. 7% reduction in NSAID in conjunction with a diuretic (P = 0.024)	4b	3
<b>Baum &amp; Harder (2010) [34]</b>	Germany	Residents, senior physicians	Renal failure adjustments	2 h	Lecture	Yes	?	?	?
<b>Montagnini et al. (2004) [73]</b>	USA	Internal medicine residents	Geriatric and palliation rotation	One month rotation. Amount of hours on pharmacology education unclear.	Lectures, bedside teaching, conferences, practice-based learning	Yes	Mandatory 28 residents completed the evaluation forms (peroration and postrotation). On palliation topics (including delirium), residents self-assessments increased from 2.89–3.71 to 4.10–4.67 (out of 5). P < 0.00001	2b	2
<b>Lathers &amp; Smith (2002) [67]</b>	USA	Residents (medical, psychiatry), medical students	Geriatric clinical psychopharmacology	2 h	Clinical pharmacology problem-solving unit. Case-based learning	Yes	?	?	?
<b>Meagher (2010) [74]</b>	UK	Healthcare workers	Pharmacotherapy in delirium	2 h	Workshop	No	Congress workshop. n = 66 (response rate unknown). Pre-education vs. posteducation on rating adverse events: concerns regarding extrapyramidal side effects reduced (52 vs. 21%, P < 0.001). Posteducation survey on future pharmacotherapy: positive attitude regarding prophylaxis in high-risk patients: 56% respondents.	2a	1

Abbreviations: CH, credit hour; CNS, central nervous system; ECTS, European Credit Transfer System; NSAID, nonsteroidal anti-inflammatory drug; GP, General Practitioner; PBL, problem-based learning; and Pharm students, pharmacy students. \*Modified level of evaluation of Kirkpatrick. †Strength of findings after critical appraisal.

evaluated more than once. For general practitioners, Midlöv *et al.* showed that outreach visits could decrease benzodiazepine use in elderly patients [31]. Pimlot *et al.* showed that educational bulletins and feedback on prescriptions for general practitioners could cause a small, probably not relevant, decrease in the use of long-acting benzodiazepines [32]. For residents, Naughton *et al.* found a reduction in inappropriate nonsteroidal anti-inflammatory drug use after polypharmacy medication review and lectures [33]. Baum and Harder showed that a lecture for senior physicians and residents on renal failure adjustments led to a decrease in medication misdosing [34]. Demirkan *et al.* evaluated a course for pharmacists containing lectures and workshops about drug therapy for groups at risk [35].

Taken together, there was no broadly implemented course on geriatric pharmacology in postgraduate curricula for physicians or pharmacists, i.e. no examples of geriatric pharmacology education were reported to be used inter-institutionally, and no studies evaluating educational interventions have been replicated.

## Discussion

The increasingly complex pharmacotherapy, especially in elderly patients, and medication errors due to health professionals' lack of knowledge of drug therapy, leads to an urgent need to improve health professionals' knowledge of geriatric pharmacology. This review shows that interest in education in general pharmacology is increasing, with undergraduate and postgraduate courses providing a median of 24 h of teaching in general pharmacology. In contrast, interest in education in geriatric pharmacology has not increased in the last decade, with undergraduate/postgraduate courses providing a median of 2 h of teaching in geriatric pharmacology per course. Taken together, we found that undergraduate and postgraduate curricula for different health professionals devote relatively little study time to general and geriatric pharmacology. We could not retrieve reliable information on the proportion of time spent on geriatric pharmacology education relative to general pharmacology or to the total study load in the described curricula. In addition, we could not find any information on the optimal or desirable study load on and content of geriatric pharmacology education. Educational programmes in geriatric pharmacology have not been broadly implemented in curricula and have hardly been proved to be effective in evaluation studies. We conclude that there is no inter-institutional consensus about a best approach to geriatric pharmacology education.

While one would expect more time to be devoted to geriatric pharmacology education research, given the increasing interest in evidence-based medical education [36] and the high rate of medication errors in the vulnerable elderly [1, 37], this would not appear to be the case,

even though databases such as PubMed showed increased numbers of publications searching for geriatrics, pharmacology and education separately. This review shows that the interest in research in general pharmacology education has increased, in contrast to research in geriatric pharmacology education. In addition, the need for improvement in geriatric education seems to be a worldwide issue for different health professionals [38, 39]. Taken together, it remains unexpected and unclear why there is not an increasing interest specifically in education in geriatric pharmacology, as there seems to be in pharmacology and geriatric education. This may underline the need for improvement in geriatric pharmacology education and research on this topic.

In contrast to ideas about the content and study load of a core curriculum for medical students, no mention is made of how many hours should be devoted to teaching geriatric pharmacology [11]. Although a clear norm on study load is not available, given the problems of complex pharmacotherapy in elderly patients, the present study load is probably insufficient [1].

None of the courses in geriatric pharmacology has been thoroughly researched and been proved to be effective, and no studies reporting education in geriatric pharmacology for paramedical students, dental students, nurses, nurse practitioners, physician assistants and other health professionals were found. We did not find clear best practices, but many interventions concerned polypharmacy, dose adjustments in elderly patients and in renal failure, and psychopharmacotherapeutics. This seems to be a logical choice for the content of the education, because these are all known risk factors for medication errors [3, 40, 41]. Odegard *et al.* suggested teaching geriatric pharmacology to pharmacy students in terms of values, attitudes, knowledge and skills [42]. In contrast to education in geriatric pharmacology, there is an effective educational programme for general pharmacotherapy. Medical students and junior doctors can be taught how to prescribe with the World Health Organization 'Guide to Good Prescribing', or six-step method, a broadly evaluated educational intervention on prescribing [15, 16].

The need to improve the pharmacological training of different health professionals is clear because it may decrease harmful medication errors [1]. In general, training is most effective if it fulfils three criteria: it is offered throughout the study; it is integrated in the curriculum; and it is placed in the context of clinical cases. Studies have shown that knowledge is best acquired and retained if it is imparted regularly in small portions [43], and that integration in the curriculum can lead to a more contextualized approach to learning [44]. Integration can be horizontal, with a more-or-less interdisciplinary approach within study years, or vertical, with integration between theoretical knowledge and clinical practice throughout the study years [44, 45]. Moreover, education with a focus on contextualization of pharmacology problems has



been shown to improve pharmacotherapeutics [46]. A longitudinal course on clinical pharmacology and pharmacotherapy, although not specifically on geriatric pharmacology education, is described by Richir *et al.* and fulfils these criteria [47].

This study had several limitations. It was based on the literature, and the literature might not accurately reflect the amount of teaching devoted to specific topics in existing curricula. A large publication bias is likely. Therefore, it is difficult to draw conclusions about how many hours are actually spent on the topic. In this review, we primarily focused on evidence-based education with proof of efficacy of the education. However, in medical education research this proof is difficult to acquire because it is methodologically difficult to tie curricular interventions to relevant long-term outcomes effectively. This is due to the large and partly unclear set of variables of the contextually rich environment of medical education. One way to improve education might be to focus on understanding collective theoretical problems in this contextually rich environment, e.g. students' motivation, instead of looking for proof of the efficacy of a specific intervention [48]. Related to this problem, it must be noted that the evidence for an improvement in pharmacotherapy education leading to a reduction in medication errors in clinical practice is still weak. However, it is a generally accepted focus for preventing medication errors [1, 49]. As mainly junior doctors are involved in medication errors, it can be assumed that considerable knowledge acquisition occurs, often implicitly, through experience in the workplace [50, 51]. Explicit learning, such as courses, might make this implicit learning more explicit. In this review, we only addressed explicit learning. Finally, as we concentrated on studies published after the major curricular innovations of the late 1990s and the shift to problem-based learning, we do not know how effective the 'traditional' curricula were in teaching general pharmacology and, in particular, geriatric pharmacology.

This review shows that there is a considerable need to improve education in geriatric pharmacology for health professionals at both undergraduate and postgraduate levels, and that in general the current curricula do not devote enough time to the teaching of pharmacology. Moreover, the best way to provide this education needs to be investigated. The content of geriatric pharmacology education should be related to known risk factors of medication errors in elderly patients and should focus especially on the appropriate prescribing in the case of polypharmacy and renal failure and on the prevention of inappropriate prescribing of psychotropic drugs. The literature suggests that training in pharmacology might be most effective if it is offered throughout the medical curriculum, is integrated in the different disciplines and is given clinical relevance in the form of case studies. More research in the field of geriatric pharmacology education may contribute to improving the care for older people.

## Competing Interests

There are no competing interests to declare.

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## REFERENCES

- 1 Likic R, Maxwell SR. Prevention of medication errors: teaching and training. *Br J Clin Pharmacol* 2009; 67: 656–61.
- 2 Leape LL, Bates DW, Cullen DJ, Cooper J, Demonaco HJ, Gollivan T, Hallisey R, Ives J, Laird N, Laffel G. Systems analysis of adverse drug events. ADE Prevention Study Group. *JAMA* 1995; 274: 35–43.
- 3 Krahenbuhl-Melcher A, Schlienger R, Lampert M, Haschke M, Drewe J, Krahenbuhl S. Drug-related problems in hospitals: a review of the recent literature. *Drug Saf* 2007; 30: 379–407.
- 4 Kongkaew C, Noyce PR, Ashcroft DM. Hospital admissions associated with adverse drug reactions: a systematic review of prospective observational studies. *Ann Pharmacother* 2008; 42: 1017–25.
- 5 Pirmohamed M, James S, Meakin S, Green C, Scott AK, Walley TJ, Farrar K, Park BK, Breckenridge AM. Adverse drug reactions as cause of admission to hospital: prospective analysis of 18 820 patients. *BMJ* 2004; 329: 15–9.
- 6 Leendertse AJ, Visser D, Egberts AC, van den Bemt PM. The relationship between study characteristics and the prevalence of medication-related hospitalizations: a literature review and novel analysis. *Drug Saf* 2010; 33: 233–44.
- 7 Aronson JK, Henderson G, Webb DJ, Rawlins MD. A prescription for better prescribing. *BMJ* 2006; 333: 459–60.
- 8 Agency for Healthcare Research and Quality, Agency for Healthcare Research and Quality, U.S. Department of Health & Human Services. Available at <http://www.ahrq.gov/data/hcup/factbk6/fbk6fig3.htm> (last accessed 26 July 2011).
- 9 Hospital Episode Statistics HES (admitted patient care) England 2009/10, The Health and Social Care Information Centre. Available at <http://www.ic.nhs.uk/news-and-events/news/elderly-people-account-for-bigger-proportion-of-nhs-hospital-activity-every-year-report-shows> (last accessed 28 March 2012).
- 10 Morrison-Griffiths S, Snowden MA, Pirmohamed M. Pre-registration nurse education in pharmacology: is it adequate for the roles that nurses are expected to fulfil? *Nurse Educ Today* 2002; 22: 447–56.
- 11 Maxwell S, Walley T, BPS Clinical Section Committee. Teaching safe and effective prescribing in UK medical schools: a core curriculum for tomorrow's doctors. *Br J Clin Pharmacol* 2003; 55: 496–503.

- 12 Harden RM, Sowden S, Dunn WR. Educational strategies in curriculum development: the SPICES model. *Med Educ* 1984; 18: 284–97.
- 13 Wood DF. Problem based learning. *BMJ* 2008; 336: 971.
- 14 Boreham NC, Mawer GE, Foster RW. Medical students' errors in pharmacotherapeutics. *Med Educ* 2000; 34: 188–93.
- 15 Ross S, Loke YK. Do educational interventions improve prescribing by medical students and junior doctors? A systematic review. *Br J Clin Pharmacol* 2009; 67: 662–70.
- 16 de Vries TPGM, Henning RH, Hogerzeil HV, Fresle DA. Guide to Good Prescribing, a practical manual. World Health Organization. Available at <http://apps.who.int/medicinedocs/pdf/whozip23e/whozip23e.pdf> (last accessed 1 December 2011).
- 17 Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ* 2009; 339: b2535.
- 18 Cochrane Handbook for Systematic Reviews of Interventions, Cochrane Collaboration. Available at <http://www.cochrane-handbook.org/> (last accessed 26 July 2011).
- 19 BEME Collaboration. Best Evidence Medical Education, BEME Collaboration. Available at <http://www2.warwick.ac.uk/fac/med/beme/writing/startingreview/> (last accessed 26 July 2011).
- 20 Steinert Y, Mann K, Centeno A, Dolmans D, Spencer J, Gelula M, Prideaux D. A systematic review of faculty development initiatives designed to improve teaching effectiveness in medical education: BEME Guide No. 8. *Med Teach* 2006; 28: 497–526.
- 21 Freeth D, Hammick M, Koppel I, Reeves S, Barr H. A Critical Review of Evaluations of Interprofessional Education. Higher Education Academy Learning and Teaching Support Network. Available at <http://repos.hsap.kcl.ac.uk/content/m10123/latest/occp2.pdf> (last accessed 28 March 2012).
- 22 Franson KL, Dubois EA, de Kam ML, Cohen AF. Measuring learning from the TRC pharmacology E-Learning program. *Br J Clin Pharmacol* 2008; 66: 135–41.
- 23 Dubois E, Franson K, Bolk J, Cohen A. The impact of pre-clinical pharmacology and pharmacotherapy training on students' abilities and perceptions during clinical rotations. *Med Teach* 2007; 29: 981–3.
- 24 Sauer BL. Student-directed learning in a community geriatrics advanced pharmacy practice experience. *Am J Pharm Educ* 2006; 70: 54.
- 25 Linnebur SA, O'Connell MB, Wessell AM, McCord AD, Kennedy DH, DeMaagd G, Dent LA, Splinter MY, Biery JC Jr, Chang F, Jackson RC, Miller SL, Sterling T, ACCP Task Force. Pharmacy practice, research, education, and advocacy for older adults. *Pharmacotherapy* 2005; 25: 1396–430.
- 26 Herndon CM, Jackson K II, Fike DS, Woods T. End-of-life care education in United States pharmacy schools. *Am J Hosp Palliat Care* 2003; 20: 340–4.
- 27 Dutta AP, Daftary MN, Oke F, Mims B, Hailemeskel B, Sansgiry SS. Geriatric education in US schools of pharmacy: a snapshot. *Consult Pharm* 2005; 20: 45–52.
- 28 Bloom MZ. How teaching students about geriatric pharmacy can help patients – and you. *Consult Pharm* 2005; 20: 16–21, 25–8.
- 29 Dawson GD. Geriatric-care education and training: pharmacy education and state home care association surveys. *Gerontol Geriatr Educ* 2000; 20: 51–71.
- 30 Morris NS, Possidente CJ, Muskus C. Implementation of curriculum guidelines for pharmacology and pharmacotherapeutics in FNP graduate programs: a national survey. *Clin Excell Nurse Pract* 2001; 5: 37–43.
- 31 Midlöv P, Bondesson A, Eriksson T, Nerbrand C, Höglund P. Effects of educational outreach visits on prescribing of benzodiazepines and antipsychotic drugs to elderly patients in primary health care in southern Sweden. *Fam Pract* 2006; 23: 60–4.
- 32 Pimlott NJ, Hux JE, Wilson LM, Kahan M, Li C, Rosser WW. Educating physicians to reduce benzodiazepine use by elderly patients: a randomized controlled trial. *CMAJ* 2003; 168: 835–9.
- 33 Naughton BJ, Singh R, Wisniewski AM, Singh G, Anderson DR. Improving quality of NSAID prescribing by internal medicine trainees with an educational intervention. *Teach Learn Med* 2010; 22: 287–92.
- 34 Baum S, Harder S. Appropriate dosing in patients with impaired renal function on medical wards before and after an educational intervention. *Int J Clin Pharmacol Ther* 2010; 48: 29–35.
- 35 Demirkan K, Celiker A, Yilmaz D, Sancar M, Apikoglu Rabus S, Izzettin FV, Sahin F. Improvement in pharmacists' knowledge through professional inservice education programs. *Fabard J Pharm Sci* 2004; 29: 117–20.
- 36 Harden RM, Grant J, Buckley G, Hart IR. Best Evidence Medical Education. *Adv Health Sci Educ Theory Pract* 2000; 5: 71–90.
- 37 Ballentine NH. Polypharmacy in the elderly: maximizing benefit, minimizing harm. *Crit Care Nurs Q* 2008; 31: 40–5.
- 38 Bednash G, Mezey M, Tagliareni E. The Hartford Geriatric Nursing Initiative experience in geriatric nursing education: looking back, looking forward. *Nurs Outlook* 2011; 59: 228–35.
- 39 Keller I, Makipaa A, Kalenscher T, Kalache A. Global Survey on Geriatrics in the Medical Curriculum. World Health Organization. Available at [http://www.who.int/ageing/publications/alc\\_tegeme\\_survey.pdf](http://www.who.int/ageing/publications/alc_tegeme_survey.pdf) (last accessed 1 December 2011).
- 40 Zaal RJ, van Doormaal JE, Lenderink AW, Mol PG, Kosterink JG, Egberts TC, Haaijer-Ruskamp FM, van den Bemt PM. Comparison of potential risk factors for medication errors with and without patient harm. *Pharmacoepidemiol Drug Saf* 2010; 19: 825–33.
- 41 van den Bemt PM, Egberts TC, de Jong-van den Berg LT, Brouwers JR. Drug-related problems in hospitalised patients. *Drug Saf* 2000; 22: 321–33.

- 42** Odegard PS, Breslow RM, Koronkowski MJ, Williams BR, Hudgins GA. Geriatric pharmacy education: a strategic plan for the future. *Am J Pharm Educ* 2007; 71: 47.
- 43** Raman M, McLaughlin K, Violato C, Rostom A, Allard JP, Coderre S. Teaching in small portions dispersed over time enhances long-term knowledge retention. *Med Teach* 2010; 32: 250–5.
- 44** Wijnen-Meijer M, ten Cate OT, van der Schaaf M, Borleffs JC. Vertical integration in medical school: effect on the transition to postgraduate training. *Med Educ* 2010; 44: 272–9.
- 45** Harden RM, Davis MH, Crosby JR. The new Dundee medical curriculum: a whole that is greater than the sum of the parts. *Med Educ* 1997; 31: 264–71.
- 46** Schwartz A, Weiner SJ, Harris IB, Binns-Calvey A. An educational intervention for contextualizing patient care and medical students' abilities to probe for contextual issues in simulated patients. *JAMA* 2010; 304: 1191–7.
- 47** Richir MC, Tichelaar J, Geijteman EC, de Vries TP. Teaching clinical pharmacology and therapeutics with an emphasis on the therapeutic reasoning of undergraduate medical students. *Eur J Clin Pharmacol* 2008; 64: 217–24.
- 48** Regehr G. It's NOT rocket science: rethinking our metaphors for research in health professions education. *Med Educ* 2010; 44: 31–9.
- 49** De Vries TP. Presenting clinical pharmacology and therapeutics: general introduction. *Br J Clin Pharmacol* 1993; 35: 577–9.
- 50** Tichelaar J, Richir MC, Avis HJ, Scholten HJ, Antonini NF, De Vries TP. Do medical students copy the drug treatment choices of their teachers or do they think for themselves? *Eur J Clin Pharmacol* 2010; 66: 407–12.
- 51** Dean B, Schachter M, Vincent C, Barber N. Prescribing errors in hospital inpatients: their incidence and clinical significance. *Qual Saf Health Care* 2002; 11: 340–4.
- 52** Estus EL, Hume AL, Owens NJ. An active-learning course model to teach pharmacotherapy in geriatrics. *Am J Pharm Educ* 2010; 74: 38.
- 53** Estus EL. Using facebook within a geriatric pharmacotherapy course. *Am J Pharm Educ* 2010; 74: 145.
- 54** Jaehde U. Training in clinical pharmacy at the University of Bonn – the first steps towards the patient. *Krankenhauspharmazie* 2009; 30: 205–8.
- 55** Divine HS, Cain J. Assessing the effect of a polypharmacy medication adherence simulation project in a geriatrics course in a college of pharmacy. *J Am Geriatr Soc* 2009; 57: 1487–91.
- 56** Ross LA, Crabtree BL, Theilman GD, Ross BS, Cleary JD, Byrd HJ. Implementation and refinement of a problem-based learning model: a ten-year experience. *Am J Pharm Educ* 2007; 71: 17.
- 57** Lam A. Senior care clerkship: an innovative collaboration of pharmaceutical care and learning. *Consult Pharm* 2005; 20: 55–60.
- 58** Bratt AM. A large group hybrid lecture and problem-based learning approach to teach Central Nervous System Pharmacology within the third year of an integrated masters level pharmacy degree course. *Pharm Educ* 2003; 3: 35–52.
- 59** Strohkirch AM, Jaehde U. The role of the teacher-practitioner in integrating pharmacy education and practice: a pilot project in Germany. *Pharm Educ* 2003; 3: 67–71.
- 60** George CJ, Jacobs LG. Geriatrics medication management rounds: a novel approach to teaching rational prescribing with the use of the medication screening questionnaire. *J Am Geriatr Soc* 2011; 59: 138–42.
- 61** Naritoku DK, Faingold CL. Development of a therapeutics curriculum to enhance knowledge of fourth-year medical students about clinical uses and adverse effects of drugs. *Teach Learn Med* 2009; 21: 148–52.
- 62** Smith A, Tasioulas T, Cockayne N, Misan G, Walker G, Quick G. Construction and evaluation of a web-based interactive prescribing curriculum for senior medical students. *Br J Clin Pharmacol* 2006; 62: 653–9.
- 63** Eroglu L, Uresin Y. A model of pharmacology education: the experience of Istanbul Medical Faculty. *J Clin Pharmacol* 2003; 43: 237–42.
- 64** Herzig S, Linke RM, Marxen B, Borner U, Antepohl W. Long-term follow up of factual knowledge after a single, randomised problem-based learning course. *BMC Med Educ* 2003; 3: 3.
- 65** Antepohl W, Herzig S. Problem-based learning versus lecture-based learning in a course of basic pharmacology: a controlled, randomized study. *Med Educ* 1999; 33: 106–13.
- 66** Faingold CL, Dunaway GA. Teaching pharmacology within a multidisciplinary organ system-based medical curriculum. *Naunyn Schmiedebergs Arch Pharmacol* 2002; 366: 18–25.
- 67** Lathers CM, Smith CM. Development of innovative teaching materials: clinical pharmacology problem-solving (CPPS) units: comparison with patient-oriented problem-solving units and problem-based learning – a 10-year review. *J Clin Pharmacol* 2002; 42: 477–91.
- 68** Lim AG, Honey M. Integrated undergraduate nursing curriculum for pharmacology. *Nurse Educ Pract* 2006; 6: 163–8.
- 69** Leikola SN, Tuomainen L, Ovaskainen H, Peura S, Sevón-Vilkman N, Tanskanen P, Airaksinen MS. Continuing education course to attain collaborative comprehensive medication review competencies. *Am J Pharm Educ* 2009; 73: 108.
- 70** Warshaw GA, Modawal A, Kues J, Moore I, Margolin G, Sehgal M, Mueller S, Cluxton R. Community physician education in geriatrics: applying the assessing care of vulnerable elders model with a multisite primary care group. *J Am Geriatr Soc* 2010; 58: 1780–5.
- 71** Straand J, Fetveit A, Rognstad S, Gjelstad S, Brekke M, Dalen I. A cluster-randomized educational intervention to reduce inappropriate prescription patterns for elderly patients in general practice – the Prescription Peer Academic Detailing (Rx-PAD) study [NCT00281450]. *BMC Health Serv Res* 2006; 6: 72.

- 72** Lutters M, Harbarth S, Janssens JP, Freudiger H, Herrmann F, Michel JP, Vogt N. Effect of a comprehensive, multidisciplinary, educational program on the use of antibiotics in a geriatric university hospital. *J Am Geriatr Soc* 2004; 52: 112–6.
- 73** Montagnini M, Varkey B, Duthie E Jr. Palliative care education integrated into a geriatrics rotation for resident physicians. *J Palliat Med* 2004; 7: 652–9.
- 74** Meagher DJ. Impact of an educational workshop upon attitudes towards pharmacotherapy for delirium. *Int Psychogeriatr* 2010; 22: 938–46.