

# Educational interventions to improve prescribing competency: a systematic review

Gritta Kamarudin, Jonathan Penm, Betty Chaar, Rebekah Moles

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GK and JP contributed equally to this paper.

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Faculty of Pharmacy, World Hospital Pharmacy Research Consortium, The University of Sydney, New South Wales, Australia

## Correspondence to

Dr Rebekah Moles;  
rebekah.moles@sydney.edu.au

## ABSTRACT

**Objective:** To review the literature on educational interventions to improve prescribing and identify educational methods that improve prescribing competency in both medical and non-medical prescribers.

**Design:** A systematic review was conducted. The databases Medline, International Pharmaceutical Abstracts (IPA), EMBASE and CINAHL were searched for articles in English published between January 1990 and July 2013.

**Setting:** Primary and secondary care.

**Participants:** Medical and non-medical prescribers.

**Intervention:** Education-based interventions to aid improvement in prescribing competency.

**Primary outcome:** Improvements in prescribing competency (knows how) or performance (shows how) as defined by Miller's competency model. This was primarily demonstrated through prescribing examinations, changes in prescribing habits or adherence to guidelines.

**Results:** A total of 47 studies met the inclusion criteria and were included in the systematic review. Studies were categorised by their method of assessment, with 20 studies assessing prescribing competence and 27 assessing prescribing performance. A wide variety of educational interventions were employed, with different outcome measures and methods of assessments. In particular, six studies demonstrated that specific prescribing training using the WHO *Guide to Good Prescribing* increased prescribing competency in a wide variety of settings. Continuing medical education in the form of academic detailing and personalised prescriber feedback also yielded positive results. Only four studies evaluated educational interventions targeted at non-medical prescribers, highlighting that further research is needed in this area.

**Conclusions:** A broad range of educational interventions have been conducted to improve prescribing competency. The WHO *Guide to Good Prescribing* has the largest body of evidence to support its use and is a promising model for the design of targeted prescribing courses. There is a need for further development and evaluation of educational methods for non-medical prescribers.

## ARTICLE SUMMARY

### Article focus

- Prescribing competencies that cover both medical and non-medical prescribers have been developed internationally.
- A review of the educational interventions designed to improve prescribing competencies will help to ensure evidence-based interventions are used to develop competent medical and non-medical prescribers.

### Key messages

- The WHO *Guide to Good Prescribing* has the largest body of evidence supporting its use to improve prescribing competencies internationally.
- Few studies have focused on educational interventions for non-medical prescribers.
- There is a need for further development and evaluation of educational methods for non-medical prescribers.

### Strengths and limitations of this study

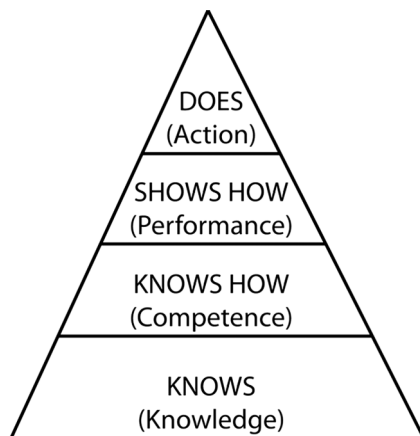
- Timely systematic review considering international developments regarding non-medical prescribers.
- Difficult to generalise findings considering different methods of assessments used.
- Limited to publications in English only.

## INTRODUCTION

Prescribing, a complex process involving the initiation, monitoring, continuation and modification of medication therapy,<sup>1</sup> demands a thorough understanding of clinical pharmacology as well as the judgement and ability to prescribe rationally for the benefit of patients.<sup>2</sup> The rational prescribing of medicines as defined by the WHO is “the situation in which patients receive medications appropriate to their clinical needs, in doses that meet their own individual requirements for a sufficient length of time, with the lowest cost to them and their community.”<sup>3</sup> Equipping prescribers with skills for rational prescribing is essential.

The diversity of skills required for good prescribing present a major challenge for the development of educational programmes. Adding to this complexity is the extension of prescribing rights to non-medical healthcare professionals such as optometrists, nurses and pharmacists. Potential benefits of non-medical prescribing have been argued to include improved continuity of care and access to medicines, better allocation of human resources, increased patient convenience and less fragmentation of care<sup>1</sup>; however, the process of prescribing is considered high-risk and error-prone.<sup>2</sup> Hence competent prescribing is paramount to patient safety. Poor prescribing can be illustrated by prescription errors, under or overprescribing or inappropriate and irrational prescribing.<sup>2-4</sup> Junior prescribers appear most prone to prescribing errors, yet are expected to perform a significant prescribing role.<sup>5-8</sup> Although many prescribing errors are unintentional, studies have shown that the prescribing performance of interns and medical students is poor, partly because of inadequate training.<sup>9-10</sup> Little is known however about non-medical prescribing practices and rates of prescription errors. Research into non-medical prescribing has mainly been confined to self-report measures such as questionnaire and interview surveys.<sup>11</sup> Although one UK study indicated that nurses' prescribing decisions were generally clinically appropriate, a large proportion did not display some prescribing competencies, for example, taking patients' medicines history and allergy status.<sup>12</sup>

Traditionally assessment of education was based on knowledge tests; however, it is recognised today that knowledge alone is insufficient to predict performance in practice.<sup>13</sup> This has led to the introduction of competency-based education, focusing on developing knowledge, judgement and skills.<sup>13-14</sup> Miller<sup>13</sup> proposed a four-staged competency assessment model beginning with assimilation of pure knowledge, progressing to development of real performance in practice (figure 1). Mucklow *et al*<sup>15</sup> provides further examples of assessing prescribing competence based on Miller's model and its importance for the healthcare profession. Such



**Figure 1** Miller's framework for clinical assessment.<sup>13</sup>

developments have led the National Prescribing Centre in the UK and the NPS MedicineWise (Quality Use of Medicines service agency for Australia's National Medicines Policy) to produce a core competency framework for all prescribing, both medical and non-medical.<sup>16-17</sup> Although a number of recommendations for prescribing education to ensure competency have been introduced,<sup>15</sup> there is little evidence and detail as to how these competencies could actually be achieved.<sup>18</sup>

Three systematic reviews of interventions to improve prescribing were published since 2009.<sup>19-21</sup> One focused on medical students and junior doctors,<sup>20</sup> while another was an update of two previous reviews investigating the effectiveness of different types of interventions on improving prescribing.<sup>19</sup> The most recent review focuses on the hospital setting with an emphasis on new prescribers who were less than 2 years postgraduation.<sup>21</sup> Although all new prescribers were included in this review, little was discussed regarding non-medical prescribers. The Cochrane collaboration has also comprehensively evaluated the use of audit and feedback to improve prescribing.<sup>22-23</sup> The focus of this review is on prescribing competencies and its assessment, based on the higher stages of Miller's model (competency and performance). This comprises practical aspects of prescription-writing as well as therapeutic decision-making, ensuring that rational, evidence-based therapy-selection is made based on patients' requirements and evaluation of their capacity to comply with a prescribed medicine).

This review aimed to examine the literature on educational interventions designed to develop and improve patient-focused prescribing competency in both medical and non-medical prescribers.

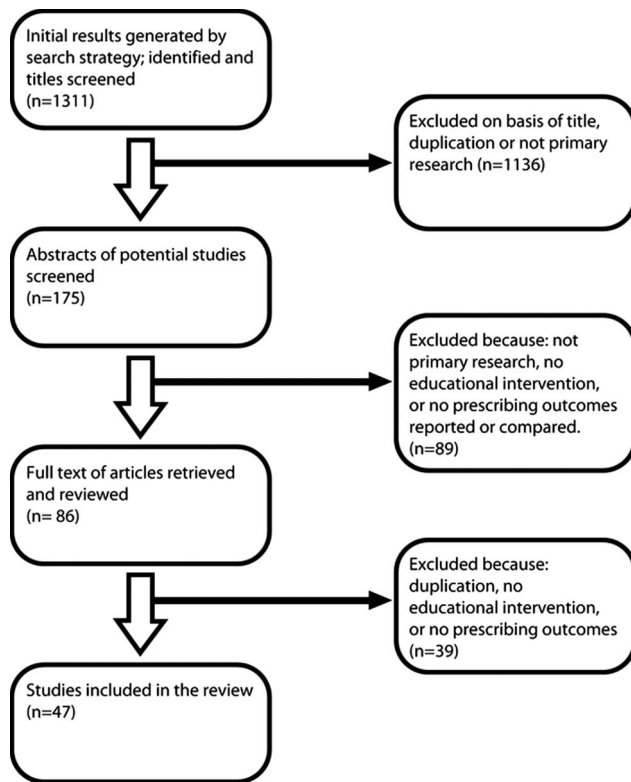
## METHOD

### Search strategy

MEDLINE, International Pharmaceutical Abstracts (IPA), EMBASE and CINAHL were searched using the key words: ('prescription\$' OR 'prescriber\$' OR 'prescribing') AND ('education' OR 'curriculum' OR 'course\$' OR 'training' OR 'intervention\$') AND ('drug \$' OR 'medication\$' or 'medication therapy management') AND ('clinical competence' OR 'competency' OR 'competency assessment'). The search terms were mapped onto Medical Subject Headings (MeSH) in Medline and EMBASE and carried through other database as key search terms. The search was limited to articles published in English from January 1990 to July 2013 (see online supplementary appendices 1-4).

### Study selection

Citations generated by the search strategy were screened by all authors for relevance and eligibility. The full texts of potentially relevant articles were reviewed to determine satisfaction of inclusion criteria. The screening process was conducted according to PRISMA guidelines<sup>24</sup> (figure 2).



**Figure 2** Flow chart of search strategy and study selection based on PRISMA guidelines.<sup>24</sup>

The target population was medical or non-medical prescribers. All study designs were considered for this review. Studies were included if they were original research articles, had an educational intervention, and at least one outcome measure of prescribing competency demonstrated through prescribing examinations which evaluated the application of knowledge to patient cases or scenarios, changes in prescribing habits or adherence to guidelines. Studies were excluded if they only measured theoretical knowledge of pharmacology and therapeutics or studied an intervention involving drug utilisation evaluation primarily using audit and feedback without a focus on the educational intervention, as these were often targeted towards cost-effectiveness and contains a large body of literature that has been previously reviewed by the Cochrane collaboration.<sup>22 23</sup> Systematic reviews, letters, meeting reports and opinion pieces were also excluded. The review was not restricted to any country.

Two authors (GK and JP) reviewed the titles and abstracts of the articles retrieved in the search to assess relevance. Discussions were conducted between the four authors to exclude studies which did not meet the inclusion criteria, and this continued until consensus was achieved regarding study selection.

### Data extraction and analysis

Study location, design, characteristics of the study population, description of the education intervention,

outcomes measured and results were extracted by GK and JP.

## RESULTS

### Number of studies

The search strategy generated 796 articles in MEDLINE, 300 in EMBASE, 20 in IPA and 195 in CINAHL. Further refinement using the exclusion and inclusion criteria and duplicate exclusion resulted in 47 studies identified and reviewed (table 1).

### Study designs

Of the 47 reviewed studies, there were 20 randomised controlled trials (RCTs),<sup>18 25–43</sup> 15 non-randomised comparative trials<sup>44–58</sup> and 12 before-after studies.<sup>59–68</sup>

### Setting and participant characterisation

Ten educational interventions were targeted at general practitioners (GPs),<sup>25 29 30 32–34 40 44 46 63</sup> 10 were conducted in hospitals,<sup>41 45 52 59 61 62 65–67 69</sup> six were implemented at primary healthcare clinics/facilities,<sup>36–38 43 60 70</sup> 20 interventions were incorporated within the curriculum at universities<sup>18 26–28 31 39 42 47–51 53–58 64 68</sup> and one intervention was carried out in pharmacies.<sup>35</sup> These studies were conducted in numerous countries around the world (table 1).

### Types of educational interventions and prescribing outcomes

A wide variety of educational methods and outcome measures were used. Interventions were summarised into two categories using Miller's competency model:

1. Prescribing competence ('knows how')—assessing prescriptions written for theoretical cases;
2. Prescribing performance ('shows how')—assessing prescriptions written for real patients.

### Prescribing competence

Twenty studies included interventions targeting particular tasks involved in prescribing, from taking accurate medication history, in choosing a rational treatment and writing the prescription.<sup>18 25–29 31 39 42 47–51 54 56–58 64 68</sup>

Eight of these studies used a method of rational pharmacotherapy education based on the WHO *Guide to Good Prescribing*.<sup>25 27 31 47 54 56 64 68</sup> De Vries *et al*<sup>27</sup> conducted a multicentre RCT with 583 medical students from eight countries. The trial reported a significant increase in mean scores of the intervention group following the WHO *Guide to Good Prescribing* intervention.

Other studies found evidence of a retention effect, where improvement in rational prescribing was maintained several months after the intervention<sup>25 42</sup> and a transfer effect, where students were able to apply acquired rational prescribing skills in new situations.<sup>25 54</sup>

The main limitation of the trials was that assessments were based primarily on written scenarios with a limited number of disease topics.

**Table 1** Summary of educational intervention studies for prescribing

Authors	Setting	Study design	Number of participants	Intervention	Prescribing outcome measures	Results	Potential for bias
Akici <i>et al</i> <sup>25</sup>	Turkey	Randomised controlled trial	12 GPs in intervention group; 13 GPs in control group	Short rational pharmacotherapy course based on the 'problem-based Groningen/WHO model'	Written examination with open and structured questions based on hypertensive cases as well as a question on osteoarthritis (unexposed indication)	Significant improvement in the mean test scores post-training of the intervention group ( $p<0.05$ ) for both questions, showing a transfer effect. The improvement was maintained for at least 4 months after training	None declared
Butler <i>et al</i> <sup>43</sup>	UK	Randomised controlled trial	34 medical practices with 139 GPs were in the intervention group; 34 medical practices with 124 GPs in the control group	The intervention contained 7 parts. Six of these were online and included a reflection on their own practice, evidence and guidelines, novel communication skills and sharing experiences. Last, a face-to-face presentation of resistance trends throughout Wales and actual practices	Total numbers of oral antibiotic items dispensed for all causes per 1000 practice patients adjusted for the previous year's dispensing	A significant reduction of total oral antibiotic dispensing for the intervention group was observed compared with the control group (664 vs 681.1, $p=0.02$ )	None declared
Celebi <i>et al</i> <sup>26</sup>	Germany	Randomised controlled trial	36 medical students in early intervention group; 38 medical students in late intervention group	A 1-week prescribing training module which comprised a seminar on common prescription errors, a prescribing exercise with a standardised paper case patient, drafting of inoperative prescription charts for real patients and discussions with a lecturer	Students were asked to make prescriptions for two virtual cases on a standard patient chart. These prescription charts were subsequently analysed by two independent raters using a checklist for common prescription errors	Prior to training, students committed a mean of $69\pm 12\%$ of the potential prescription errors. This decreased to $29\pm 15\%$ after prescribing training ( $p<0.001$ )	None declared
De Vries <i>et al</i> <sup>27</sup>	Eight countries in Asia and Europe	Randomised controlled trial	194 medical students in personal formulary (PF) group; 198 in existing formulary (EF) group; 191 in control group	The PF and EF groups were given teaching sessions based on the WHO Guide to Good Prescribing model (PF group=whole manual; EF group>manual minus p-drugs), with and without use of PF	Written examination using 16 patient cases based on four topics: hypertension, osteoarthritis, acute bronchitis, gastroenteritis	A significant increase in mean scores of the intervention group compared with the control group ( $p<0.05$ ). The increase in the PF group was significantly higher than in the EF group. However, this effect was only visible in the universities in Yemen, the Russian Federation, and Indonesia.	Funded by the VU University Medical Center and by the Department of Essential Drugs and Medicines Policy of the WHO

Continued

Table 1 Continued

Authors	Setting	Study design	Number of participants	Intervention	Prescribing outcome measures	Results	Potential for bias
Degnan <i>et al</i> <sup>28</sup>	UK	Randomised controlled trial	9 medical students in intervention group; 35 in the control group	An online teaching module consisting of an interactive tutorial of 12 multiple-choice questions and three case studies covering pharmacokinetics, adverse drug reactions and drug doses calculations	OSCE station requiring administration of lidocaine and adrenaline for a patient with laceration and anaphylaxis	No significant differences between PF and EF scores were found in the universities in the Netherlands, Slovakia, Spain, India or South Africa The teaching module significantly improved the students' ability to calculate the correct volume of lidocaine (p=0.005) and adrenaline (O=0.0002)	Funded by the Association of Anaesthetists of Great Britain and Ireland
Esmaily <i>et al</i> <sup>29</sup>	Iran	Randomised controlled trial	58 GPs in intervention group; 54 GPs in control group	Education with an outcome-based approach utilising active-learning principles	Multiple choice and short answer questions, with two case scenarios and three 'irrational' prescriptions	There was an overall improvement of 26 percentage units in the prescribing knowledge and skills of GPs in the intervention group. No such improvements were seen in the control group	Additional funding from the National Public Health Management Centre in Tabriz and the Ministry of Health and Medical Education of Iran
Fender <i>et al</i> <sup>30</sup>	UK	Randomised controlled trial	54 GPs in intervention group; 46 GPs in control group	An educational package based on principles of 'academic detailing'	The appropriate prescribing of tranexamic acid, nonsteroidal antiinflammatory drugs and norethisterone	A proportionately higher level of appropriate prescribing was found in the intervention group. An increase of 63% in the prescription of tranexamic acid, the most effective first line treatment for menorrhagia, was observed in the intervention group	None declared
Gordon <i>et al</i> <sup>42</sup>	UK	Randomised controlled trial	76 junior doctors in intervention group; 86 in control group	A 1–2 h e-learning course on paediatric prescribing	Total correct responses on each prescribing assessment. Drug selection, prescribing calculations for children, discussing therapies and sources of errors were assessed	A significant increase in correct responses by the intervention group compared with the control group at both 4 and 12 weeks after the intervention. At 4 weeks: 79% vs 63% (p<0.0001)	None declared

Continued



Table 1 Continued

Authors	Setting	Study design	Number of participants	Intervention	Prescribing outcome measures	Results	Potential for bias
Hassan <i>et al</i> <sup>31</sup>	Yemen	Randomised controlled trial	56 medical students in intervention group; 44 students in control group	A prescribing course based on WHO's Guide to Good Prescribing, the Yemen Essential Drug List and Yemen Standard Treatment Guidelines	Written examination based on eight patient problems where a complete treatment plan form must be completed	At 12 weeks: 79% vs 69% (p<0.0001) Students from the study group performed significantly better than those from control in all problems presented and also when compared with the results of the pretest (p<0.05)	None declared
Hux <i>et al</i> <sup>32</sup>	Canada	Randomised controlled trial	135 GPs in intervention group; 116 GPs in control group	Mailed packages of prescribing feedback and guidelines-based educational materials	Median antibiotic cost and proportion of episodes of care in which a prespecified first-line antibiotic was used first	The median prescription cost remained constant in the feedback group but rose in the control group (p<0.002). First-line drug use increased in the feedback group but decreased in the control group (p<0.01)	Author receives salary support from the Institute for Clinical Evaluative Sciences in Ontario
Kahan <i>et al</i> <sup>33</sup>	Israel	Randomised controlled trial	32 physicians exposed to both interventions; 130 physicians who only received personalised letter; 29 physicians who only attended the lecture; 107 in the control group	Interventions were in the form of a lecture at a conference and a letter with personalised feedback to improve physicians' rates of prescribing in the treatment of acute uncomplicated cystitis in adult women	Outcome was the rate of adherence to the guidelines for appropriate treatment using nitrofurantoin or second-line therapy of ofloxacin for 3 days	The letter intervention significantly influenced physicians' prescribing patterns. The lecture intervention was only effective in the short run, indicating that the effect of this technique does not last unless reinforced	Partially funded through a research grant from The Israel National Institute for Health Policy and Health Services Research and through an educational grant from Schering Plough Israel
Midlöv <i>et al</i> <sup>34</sup>	Sweden	Randomised controlled trial	23 GPs in the intervention group; 31 GPs in the control group	Educational outreach visits	Number of prescriptions of benzodiazepines (BDP) and antipsychotics to the elderly	One year after the educational outreach visits there was a significant decrease in prescribing of medium-acting and long-acting BDP and total BDP in the active group compared with the control group (p<0.05). For antipsychotics there were no significant differences between active and control group	Funded by the Department of Primary Care Research and Development in the county of Skåne, Apoteket AB and the Faculty of Medicine, Lund University

Continued

Table 1 Continued

Authors	Setting	Study design	Number of participants	Intervention	Prescribing outcome measures	Results	Potential for bias
Nsimba <sup>35</sup>	Tanzania	Randomised controlled trial	20 pharmacists in intervention facilities; 20 in control facilities	Posters, individual information and one-to-one training sessions	Simulated clients assessed the drug seller/pharmacist's knowledge and prescribing choices. A short examination was also conducted to assess participants' knowledge of appropriate treatments for common childhood conditions	85% of simulated clients who went to the intervention facilities were sold the first line drug sulfadoxine/pyrimethamine (SP) compared with 55% at control facilities (p<0.01). The intervention group also performed significantly better on the knowledge examination (p<0.01)	Funded by COSTECH-Tanzania
Ochoa <i>et al</i> <sup>86</sup>	Cuba	Randomised controlled trial	4 groups of 10 physicians (A, B, C, D) with A receiving community education programme and refresher training, B receiving refresher training, C receiving community education, D was the control group	Refresher training based on teaching sessions and periodic advisory visits. Community education involved group discussions and distribution of educational materials	Rate of overprescription of antibiotics for mild-acute respiratory infection (ARI) cases	Following the interventions, antibiotic overprescription rates declined by 26% and 63% in groups A and B, while increasing by 2% and 48% in groups C and D	None declared
Odusanya and Oyediran <sup>37</sup>	Lagos state, Nigeria	Randomised controlled trial	Number of participants not specified. Primary healthcare workers (no doctors) in Mushin were in the intervention group; health workers in Ikeja were in the control group	4-week training programme on rational drug use	Prescriptions were evaluated according to compliance to 'standing orders', which are a set of treatment modules. Drug use indicators were also compared	At the 2-week evaluation, the intervention group achieved a significant reduction in the average number of medicines prescribed compared with the control group. There was also a significant increase in the percentage of patients rationally managed from 18% to 30% (p=0.0005) in the intervention group. Improvements were not sustained at the 3-month evaluation	None declared
Rothmann <i>et al</i> <sup>38</sup>	South Africa	Randomised controlled trial	35 primary healthcare nurses in the intervention group; 31 in the control group	A competency-based primary care drug therapy training programme in the treatment of acute minor ailments	Written examination with 8 case studies including scenarios on acute gout, congestive heart failure, acute tonsillitis and infectious arthritis	Post-test results of the intervention group indicated significant improvement towards correct diagnosis and management of the conditions (p<0.05)	Funded by Boehringer Ingelheim (Pty) Ltd
Sandilands <i>et al</i> <sup>18</sup>	UK	(Self-Medication Division) Randomised controlled trial	50 medical students in the intervention group;		Written prescribing examination consisting of	Teaching improved the assessment score of the	None declared

Continued

Table 1 Continued

Authors	Setting	Study design	Number of participants	Intervention	Prescribing outcome measures	Results	Potential for bias
			28 students in control group	Focused doctor-led and pharmacist-led practical prescribing teaching	six scenario-based questions	intervention group: mean assessment 2 vs 1, 70% vs 62%, p=0.007; allergy documentation: 98% vs 74%, p=0.0001 and confidence. However, 30% of prescriptions continued to include prescribing errors	
Scobie <i>et al</i> <sup>39</sup>	UK	Randomised controlled trial	16 medical students in intervention group; 16 students in control group	Practical structured teaching sessions led by a pharmacist	Nine station OSCE examination covering topics such as anticoagulation, intravenous administration, discharge prescription and medication history	The intervention group achieved higher scores in 8 OSCE stations. Four of these were statistically significant (p<=0.005)	None declared
Smeele <i>et al</i> <sup>40</sup>	The Netherlands	Randomised controlled trial	17 GPs in the intervention group; 17 GPs in control group	Four sessions (lasting 2 h each) of interactive group education and peer-review programme aimed at implementing national guidelines	Data on prescription of inhaled and anti-inflammatory medications were collected through self-recording by GPs and recording of repeat prescriptions for patients	No significant difference was found in the pharmacological treatment between intervention and control groups (p>0.05)	None declared
Webbe <i>et al</i> <sup>41</sup>	UK	Randomised controlled trial	13 preregistration house officers	A clinical teaching pharmacist programme to improve prescribing skills	Number of prescribing errors	A 37.5% reduction (p=0.14) in prescribing errors after pharmacist intervention	None declared
Akici <i>et al</i> <sup>47</sup>	Turkey	Non-randomised comparative control	50 medical students (interns) in intervention group; 54 interns in control group; 53 GPs	Problem-based rational pharmacotherapy education via the WHO/Groningen model	A written examination with open and structured questions based on case scenarios of tonsillitis and mild-to-moderate essential hypertension patients	Mean scores of the interns in the intervention group were higher than GPs, which were in turn higher than those of interns in the control group for all cases	Funded by a grant from Marmara University Scientific Research Projects Commission
Akram <i>et al</i> <sup>66</sup>	Malaysia	Non-randomised comparative control	18 final year dental students in the intervention group; 19 in the control group	Didactic lecture on how to write a complete prescription	Three case studies including irreversible pulpitis associated with a child, a pregnant woman and periapical pulpitis for an adult man. Assessed according to WHO's	Significant improvement in the intervention group occurred compared with the control group in the following areas; date of issue, Rx symbol present, medicine legible, direction to use medicines, refill instructions, prescriber's	Funded by the faculty of medicine, Universiti Kebangsaan Malaysia

Continued



Table 1 Continued

Authors	Setting	Study design	Number of participants	Intervention	Prescribing outcome measures	Results	Potential for bias
Al Khaja <i>et al</i> <sup>67</sup>	Bahrain	Non-randomised comparative control	460 medical students over different stages of the degree were in the intervention group; 450 in the control group	A 2 h interactive session on prescription writing skills is presented followed by 5–6 case scenarios given as homework. Formative feedback on these cases was given to the students	Guide to good prescribing A written examination. Physician-related components of the prescription assessed legality of prescription writing while drug-related components relate to the rational and appropriate use of medicines	signature, prescriber's date and prescriber's registration Significantly higher scores were achieved by those that attended the interactive sessions compared with those that did not. 73.5% vs 59.5% (p<0.0001)	No funding received
Al Khaja <i>et al</i> <sup>48</sup>	Bahrain	Non-randomised comparative cohort	539 medical students	Problem-based learning curriculum incorporating a prescribing programme	A written examination. Physician-related components of the prescription assessed legality of prescription writing while drug-related components relate to the rational and appropriate use of medicines	Rate of physician-related components by students (years 2–4) was 96.1 (CI 94.1 to 97.5). However, the rate of various drug-related components was 50.2 (CI 46.0 to 54.4). No significant difference in overall performance of years 4 and 2 students (p=0.237). However appropriateness of drug-related components was significantly higher in year 4 than 2 (p<0.05)	None declared
Celebi <i>et al</i> <sup>49</sup>	Germany	Non-randomised comparative control	18 medical students who had never completed an internal-medicine clerkship; 38 students who had completed 1–4 weeks of clerkship; 18 students who had completed >5 weeks of clerkship	Internal medicine clerkship based on one general learning objective of 'students are to be familiarised with caring for patients in an outpatient and inpatient setting'	A written test comprising of the completion of prescription charts for two standardised patient paper cases. These were marked using a checklist for common prescription errors	Students committed 69%±12% of all possible prescription mistakes. There was no significant difference between the group without clerkships in internal medicine (G1) (71±9%), the group with 1–4 weeks (G2) (67±15%), and the group with more than 5 weeks of clerkships (G3) (71±10%), p=.76	None declared
Coombes <i>et al</i> <sup>60</sup>	Australia	Non-randomised comparative control	99 medical students in intervention group; 134 in control group	Eight interactive problem-based tutorials covering topics such as antibiotics, anticoagulants, intravenous fluids, analgesics, oral hypoglycaemics and insulin	A written examination consisting of short answer questions on ADR identification, anticoagulants and analgesics	A significantly higher score was found in intervention students compared with controls; mean score in intervention group 29.46; control group 26.35 (p<0.05)	None declared

Continued

Table 1 Continued

Authors	Setting	Study design	Number of participants	Intervention	Prescribing outcome measures	Results	Potential for bias
Franson <i>et al</i> <sup>61</sup>	The Netherlands	Non-randomised comparative cohort	181 medical students in baseline 2003 cohort, 285 students in 2004, 275 students in 2005, 264 students in 2006	Students were taught to use a structured format called the Individualised Therapy Evaluation and Plan (ITEP) to communicate a therapeutic plan including the writing of a prescription	Written examination involving two different therapeutic cases; a simple paediatric case and a complex geriatric case	Students' scores improved significantly in the 3 years after the introduction of the ITEP in the curriculum. The average score of the 2006 cohort was 6.76 compared with 3.83 for the 2003 group ( $p < 0.0001$ )	None declared
Kozer <i>et al</i> <sup>62</sup>	Canada	Non-randomised comparative control	13 trainees in intervention; 9 trainees in control	30 min tutorial focusing on appropriate methods for prescribing medications followed by a written test	Main outcome measure was the number of prescribing errors on medication charts completed after the tutorial	No significant difference in errors was found between the intervention group (12.4%) and the control group (12.7%)	Funded by the Trainee's Start-up Fund, The Research Institution, The Hospital for Sick Children, Toronto Canada
McCall <i>et al</i> <sup>44</sup>	Australia	Non-randomised comparative control	14 GPs in intervention group; 14 in control group	Completion of a Graduate Certificate in General Practice Psychiatry conducted primarily via distance education programme	A clinical audit assessed GPs' recognition, drug management, non-drug management of patients with depression and anxiety	No effect on the intervention GPs prescribing habits ( $p > 0.05$ )	None declared
Pandjpong <i>et al</i> <sup>63</sup>	Thailand	Non-randomised comparative control	38 continuity of care (CCC) participants; 52 non-CCC participants	CCC curriculum	Medical chart audits were performed and scored with a 12-task checklist of cardiovascular risk management including appropriate prescribing	There was a significant increase in ability to properly adjust antihypertensive medication and in the prescribing of aspirin as primary prevention for cardiovascular disease in the CCC group ( $p < 0.05$ )	Funded by a Faculty of Medicines Siriraj Hospital Medical Education Research Grant, Mahidol University
Richir <i>et al</i> <sup>64</sup>	The Netherlands	Non-randomised comparative control	197 medical students in the intervention group; 33 students in control	A context-learning pharmacotherapy programme with role-play sessions and OSCE	A written examination involving the formulation of a treatment plan for two patients using the WHO six-step guide of rational prescribing	The mean score on the six steps of the WHO six-step plan for prescribing increased significantly for students who have received the pharmacotherapy study ( $p < 0.001$ )	None declared
Shaw <i>et al</i> <sup>45</sup>	Australia	Non-randomised comparative control	The number of junior doctors in intervention	Academic detailing including the provision of a bookmark containing	Prescription error rates of addictive medicines were assessed. Errors were	At the intervention hospital, there was a significant decrease in error rate (from	Partially funded by the Postgraduate

Continued

Table 1 Continued

Authors	Setting	Study design	Number of participants	Intervention	Prescribing outcome measures	Results	Potential for bias
Tamblyn <i>et al</i> <sup>65</sup>	Canada	Non-randomised comparative cohort	751 doctors from four graduation cohorts; 600 from before the intervention and 151 after the intervention	A community-oriented problem-based learning curriculum	Annual performance in diagnosis (difference in prescribing rates for specific diseases and relief of symptoms), and management (prescribing rate for contraindicated medicines) assessed using provincial health databases for the first 4–7 years of practice	41% to 24%, p<0.0001). The control hospital did not show a significant change in error rate over the same study period (p=0.66) After the intervention, graduates showed a significant fourfold increase in disease specific prescribing rates compared with prescribing for symptom relief. No difference in rate of prescribing for contraindicated medicines was observed	Medical Council of NSW  Funded by the Canadian Institutes of Health Research and Fonds de Recherche en Sante du Quebec
Volovitz <i>et al</i> <sup>46</sup>	Israel	Non-randomised comparative control	83 physicians attended the education programme. Four groups of patients were included. The study group had patients whose physicians were also asked to invite patients for three visits to reinforce the principles highlighted in the education programme	Asthma education programme involving lectures on pathophysiology, asthma management and prevention. Physicians were also asked to invite patients for three visits to reinforce the principles highlighted in the education programme	Changes in asthma medicine use were analysed before and after the intervention. Data were derived from the central database of Maccabi, Israel	In all four patient groups, a smaller proportion of reliever medicines (SABA) and a greater proportion of controller medicines (ICS and LABA) were used in the follow-up period compared with before the intervention. Patients in the study group were twice more likely to decrease their use of SABA than patients from the control group (p=0.042)	None declared
Wallace <i>et al</i> <sup>68</sup>	UK	Non-randomised comparative control	20 final year medical students in the intervention group; 11 in the control group	8 tutorials on prescribing in acute clinical scenarios using peer assisted learning	Accurate completion of a prescription chart	The intervention group significantly improved after the intervention; median score was 47 before; 66 after (p<0.01). No significant change occurred in the control group (p=0.17)	None declared
Aghamirsalim <i>et al</i> <sup>69</sup>	Iran	Before and after study	72 orthopaedic surgeons	Formal 2 h lectures once a week for 4 weeks and a 30 min refresher course was offered at the 4th month. Also, simplified osteoporosis guidelines were distributed	Proportion of patients with fragility fractures who received appropriate treatment for osteoporosis	Significantly more patients were appropriately prescribed calcium and vitamin D supplements on discharge. 10% vs 91% (p<0.05). Significantly more patients were appropriately prescribed a	None declared

Continued

Table 1 Continued

Authors	Setting	Study design	Number of participants	Intervention	Prescribing outcome measures	Results	Potential for bias
Bojalil <i>et al</i> <sup>69</sup>	Tlaxcala, Mexico	Before and after	72 private GPs; 44 public GPs	A training course based on in-service practice. Other materials included the official training manuals for the control of diarrhoea and ARI, training videos and wall charts	Aspects of diarrhoea and ARI treatment which were evaluated and scored using a checklist	bisphosphonate on discharge. 0.1% vs 73% (p<0.05) Private practitioners showed significant improvements in prescribing practices for children with diarrhoea. For ARI management, decisions on antimicrobial therapy and symptomatic drug use improved for both groups but only reached statistical significance for public physicians	Funded by the Mexican Social Security Institute
Chopra <i>et al</i> <sup>60</sup>	Cape Town, South Africa	Before and after	21 nurse prescribers	WHO and UNICEF's Integrated Management of Childhood Illness implementation. Training used the WHO/UNICEF teaching and assessment modules	A structured observation checklist of the case management of sick children including rational prescribing	There were significant improvements in the appropriate prescribing of antibiotics, with a significant reduction of inappropriate antibiotic use (62% vs 84%). However, there was no change in the treatment of anaemia or the prescribing of vitamin A to sick children	None declared
Davey <i>et al</i> <sup>61</sup>	UK	Before and after	The number of junior doctors included in the study was not specified	A paediatric junior doctor prescribing tutorial conducted by a pharmacist and a bedside prescribing guideline to encompass the most frequently prescribed medications utilised on the children's unit	Prescribing errors and preventable adverse drug events	The introduction of the prescribing tutorial decreased prescribing errors by 46% (p=0.023). The introduction of a bedside prescribing guideline did not decrease prescribing errors	Author's research position was funded by Airedale NHS Trust
Elkharrat <i>et al</i> <sup>62</sup>	France	Before and after	27 doctors	Doctors were informed of the Drug Regulatory Agency prescribing guidelines of NSAIDs. Group sessions were held, posters were displayed and pocket sized, 10-page manuals were distributed	The rate of NSAID prescribing errors was analysed	Prescribing errors declined from 20% to 14% and when prescriptions were stratified by cause, the quality of prescribing increased significantly	None declared
Guney <i>et al</i> <sup>64</sup>	Turkey	Before and after study	101 medical students	Rational pharmacotherapy training	Prescription audit and OSCE examination	A significant improvement in prescription audit scores was	None declared

Continued

Table 1 Continued

Authors	Setting	Study design	Number of participants	Intervention	Prescribing outcome measures	Results	Potential for bias
Gall <i>et al</i> <sup>63</sup>	UK	Before and after study	212 GPs; 139 community nurses	based on the Groningen/WHO model  Training on the use of guidelines on prescribing supplements	based on a simulated patient case with uncomplicated essential hypertension  Changes in prescribing practice of supplements	observed after the training (p: 0.022)  Education significantly reduced total prescribing by 15% and reduced the levels of inappropriate prescribing from 77% to 59% due to an improvement in monitoring of patients prescribed supplements	Funded by South Thames Health Authorities Clinical Audit Programme
Leonard <i>et al</i> <sup>65</sup>	USA	Before and after study	The number of clinical staff (physicians, nurses, pharmacists) included in the study was not specified	Educational patient safety initiatives using multiple interrelated educational and behavioural modification strategies	Assessment of medication orders which were then used to calculate the absolute risk reduction from prescribing errors	The absolute risk reduction achieved after the interventions was 38/100 orders written (t=25.735; p=0.001). This yielded an overall relative risk reduction from prescribing errors of 49% (p<0.001)	Funded by the New York State Department of Health 2003 Patient Safety Award and by a donation from Lexi-Comp of Pediatric Lexi-Drugs limited licenses  None declared
Minas <i>et al</i> <sup>70</sup>	Australia	Before and after study	GPs and healthcare prescribers in Emergency Departments and Sexual Health Clinics. Number included not specified	Treatment guidelines were distributed and informed through professional development sessions, letters and newsletters	Proportion of patients receiving non-occupational postexposure prophylaxis (nPEP) according to the relevant treatment guidelines	Significantly more patients that received nPEP met the eligibility criteria as stated in the relevant treatment guidelines after the educational intervention. 61.2% vs 90% (p<0.001)	None declared
Otero <sup>66</sup>	Argentina	Before and after study	Number of participants not specified. Prescriptions for 95 patients were analysed in 2002 and for 92 patients in 2004	Educational programme developed by the Patient Safety Committee of the Department of Pediatrics including the implementation of the '10 steps to reduce medication errors' checklist	Prevalence of medication errors detected in written prescription orders during June 2002 (before intervention) and May 2004 (after intervention)	Prevalence of prescription errors was significantly lower in 2004 compared with 2002; 11.4% vs 7.3% (p<0.05)	None declared
Taylor <i>et al</i> <sup>67</sup>	UK	Before and after study	242 junior doctors	1 h interactive, case-based educational programme regarding inpatient diabetes care	Number of insulin prescribing errors on medication charts observed after the tutorial	Insulin prescription errors were significantly lower after the intervention; 15.4% vs 7.8% (p<0.05)	None declared

Continued

Table 1 Continued

Authors	Setting	Study design	Number of participants	Intervention	Prescribing outcome measures	Results	Potential for bias
Zgheib <i>et al</i> <sup>68</sup>	Lebanon	Before and after study	127 final year medical students divided into 18 groups of 6–7 students	5 team-based learning (TBL) based on WHO's Guide to Good Prescribing. A lecture on the role of the pharmacist, Pharmacy and Therapeutics committees, formularies and hospital policies were also presented	Group formulary and prescription writing exercises occurred after each TBL session. Rationale for the selection of a drug and the format of the prescription was included in these assessments	Significant improvement in mean group scores for both formulary and prescription-writing exercises occurred over the 5 TBL sessions (p=0.002)	None declared

GP, general practitioner.

Four studies examined the effect of structured prescribing tutorials and programmes on prescribing skills of medical students and GPs.<sup>29 39 42 50</sup> Three, specifically covered high-risk medicines and reported significant improvements in prescribing skills.<sup>29 39 50</sup> Prescribing outcomes were assessed using written case scenarios<sup>29 50</sup> and a nine-station OSCE.<sup>39</sup>

Five studies assessed prescription writing skills of medical students following a prescribing programme at university.<sup>48 51 57 58 68</sup> Al Khaja *et al*<sup>48</sup> evaluated a prescribing programme incorporated into a problem-based learning (PBL) curriculum. Students acquired limited prescribing competency during the PBL programme. Only 50.2% correctly selected appropriate medicine(s), strength and dosage-form in the written examination.<sup>48</sup> Al Khaja *et al*<sup>57</sup> later used a 2 h interactive session on prescription writing skills with formative feedback. This programme increased appropriate medicine(s) selection to 83.9%, appropriate strength to 68% and appropriate dosage form to 59.6%.<sup>57</sup> The other three studies used peer-assisted learning,<sup>58</sup> team-based learning (TBL) based on WHO's *Guide to Good Prescribing*<sup>68</sup> and Individualised Therapy Evaluation and Plan (ITEP) in the curriculum.<sup>51</sup> The TBL and ITEP format allowed students to provide a rationale-based treatment plan for an individual patient. Both TBL and ITEP improved students' ability to solve therapeutic problems and select appropriate medications.<sup>51 68</sup> However, all of these studies were non-randomised making it difficult to attribute their findings to the impact of interventions alone.

Three studies measured the incidence of prescribing errors in written scenario-based examinations.<sup>18 26 49</sup> Specific prescribing tutorials/teaching modules significantly reduced prescription errors.<sup>18 26</sup> However obligatory medical clerkships, where students are assumed to acquire prescribing skills by spending up to 16 weeks with a GP or in a hospital setting, did not have a significant effect on the rate of prescription errors.<sup>49</sup>

One study examining an online interactive teaching module found a significant improvement in students' ability to calculate correct volumes of lignocaine and adrenaline in an OSCE setting.<sup>28</sup>

### Prescribing performance

Twenty-seven studies used educational interventions which aimed to improve management of particular conditions and increase the appropriateness of prescribing.<sup>30 32–38 40 41 43–46 52 53 55 59–63 65–67 69 70</sup>

In 11 of these studies, interventions were implemented to specifically promote prescribing first-line therapy or reduce inappropriate prescribing.<sup>30 32–36 43 62 63 69 70</sup> Academic detailing approaches<sup>30</sup> and educational outreach visits,<sup>34–36 63</sup> were found to show positive results in improving prescribing adherence to guidelines. Mailed personalised prescribing feedback<sup>32 33</sup> was also found to be effective. An intervention in the form of a lecture was found to be ineffective unless reinforced with another intervention, for example, individual feedback.<sup>33</sup> An



in-house training programme was found to reduce the inappropriate prescribing of non-steroidal anti-inflammatory drugs but results were not statistically significant.<sup>62</sup>

Nine studies used educational interventions to improve overall treatment practices of various conditions, with appropriate and rational pharmacological therapy assessed.<sup>37 38 40 44 46 53 55 59 60</sup> The methods which reported improvements included educational outreach visits,<sup>37 38</sup> in-service training<sup>59</sup> and a multipronged approach involving training sessions and some reorganisation of management systems.<sup>60</sup> Two studies assessed the effectiveness of curriculum changes at university on medical graduates' patient-care performance.<sup>53 55</sup> Both a PBL curriculum<sup>55</sup> and a continuity of care clinic curriculum<sup>53</sup> increased prescribing performance indicators. However, outcome measures differed, with one study assessing prescribing rates in ambulatory patients aged >65 years<sup>55</sup> and the other focusing specifically on cardiovascular risk management.<sup>53</sup>

Mixed results were found in two studies which evaluated asthma management following an educational intervention.<sup>40 46</sup> An intensive small-group education session and peer-review programme did not show a significant influence on adherence to guidelines for general pharmacological treatment and management of exacerbations.<sup>40</sup> Another study found a positive change in medication prescribing following an asthma education programme; however, the intervention and control groups showed this change in practice.<sup>46</sup>

McCall *et al*<sup>44</sup> examined the impact of a distance-learning graduate course in general practice psychiatry on managing mental illness. Although the intervention had a positive impact on GP's knowledge, there was no significant effect on overall prescribing habits.

Seven studies evaluated the impact of educational interventions on the rate of prescribing errors using an audit of medication charts before and after the intervention.<sup>41 45 52 61 65-67</sup> Multidisciplinary interventions using interrelated educational and behavioural modification strategies significantly reduced prescribing errors.<sup>65 66</sup> Academic detailing reduced the number of incorrect prescriptions written for addictive medicines,<sup>45</sup> however prescription errors were defined only on the basis of local state laws in Australia and no assessment of the appropriateness of the choice of medicines was made. Webbe *et al*<sup>41</sup> reported a reduction in prescribing errors following pharmacist accompaniment on prescribing rounds and a clinical teaching pharmacist programme. However, the small sample meant that statistical significance was not reached. Two studies assessed the effect of a prescribing tutorial on the incidence of paediatric prescribing errors.<sup>52 61</sup> Both tutorials focused on prescribing in the paediatric population; however, the studies reported mixed results. Kozer *et al*<sup>52</sup> found no difference in prescribing errors whereas Davey *et al*<sup>61</sup> reported significant differences.

## DISCUSSION

Although a considerable amount of research has been conducted in improving prescribing competency through educational interventions, the range of heterogeneous study designs and outcome measures limits the validity and the ability to generalise their conclusions.

According to Miller's framework of competency assessment, tests of knowledge alone are insufficient to properly assess educational interventions. Hence, the assessment of prescribing skills included in these studies mainly focused on Miller's pyramid base 'knows how' and 'shows how'. The translation of knowledge and skills into a rational diagnostic or management plan is defined as competency (knowing how), which was measured using written examinations, patient management or OSCEs. This in turn predicts performance (showing how) and action (does) which was evaluated in daily life circumstances through audits to detect prescription errors or direct observations of prescribers' performance using standardised checklists. However, prescribing performance is difficult to measure as it can be influenced by many factors such as physicians' clinical experience, sociocultural factors, histopathology of disease, pharmaceutical industry representatives and the ever-increasing pressure from patients.<sup>25</sup>

Although studies differed considerably in their methods and assessment procedures, a number of key findings were highlighted. First, specific prescribing teaching can lead to improvements in prescribing competency. This was reported in studies that used tutorials and educational programmes to guide participants in the process of rational prescribing.<sup>25 27 29 31 39 47 48 50 51 54 64</sup>

Of these studies, only the WHO *Guide to Good Prescribing* has been evaluated for both medical students and GPs across a range of countries.<sup>25 27 31 47 54 64 68</sup> The WHO model provides a six-step guide to choose, prescribe and monitor a suitable medicine for an individual patient and presents a good foundation for the development of therapeutic reasoning in a prescribing curriculum. This model is in line with the prescribing competency framework developed by the National Prescribing Centre<sup>16</sup> and NPS MedicineWise.<sup>17</sup> It also provides important guidance in the development of educational interventions for medical and non-medical prescribers. The WHO method also encourages prescribers to verify standard treatment for each patient (recognising issues such as aging or cognition impairment) and to alter treatment if necessary,<sup>25</sup> which is an essential skill to acquire, particularly with the aging community.

Incorporating a prescribing component into a structured, problem-based curriculum also improved students' ability to prescribe correctly.<sup>26 27 31 39 48 54</sup> Although targeted prescribing-teaching is mainly implemented at the undergraduate level, studies have found that GPs and non-medical prescribers often do not apply rational prescribing principles in daily practice and would benefit from these interventions.<sup>25 35 37 38</sup>

Many studies attempted to influence prescribing behaviour through the promotion of rational medication use based on published practice guidelines. These guidelines have been promoted in face-to-face interactions and training through educational outreach visits, academic detailing and through institutional audits and feedback. All of these methods have positively affected health professionals' behaviour.<sup>30 34 63</sup> Although effective, these methods could be labour intensive and may be prohibitively expensive. Findings suggest that personalised feedback letters could be just as effective while blunting costs.<sup>32 33</sup> There is scope to explore why these interventions work and determine which interventions are suitable for different types of prescribers and settings.

Prescribing practices can also be improved through enhanced communication between doctors, pharmacists, nurses, other health professionals as well as patients and carers. Several studies highlight the interactive role of medical, pharmacy and nursing staff in ensuring safe and effective use of medicines.<sup>18 35 39 41 50 59 61</sup> This is not surprising, as many prescribing errors cannot be attributed to knowledge deficits alone.<sup>18</sup> Hence improving prescribing practices may require interventions aimed at multiple operant factors, such as developing a safety-oriented attitude through improving environment conditions, direct staff supervision and adopting a zero-tolerance policy for incomplete or incorrect prescriptions.<sup>66</sup> Indeed positive results were reported following multifaceted interventions where education was incorporated into a system-based approach to influence prescribing behaviour.<sup>65 66</sup>

Finally, this review has highlighted a lack of educational interventions targeted at non-medical prescribers. Four studies assessed the effectiveness of training programmes: two were for nurses,<sup>38 60</sup> one for pharmacists<sup>35</sup> and one for primary healthcare workers (community health officers, nurses and community health extension workers).<sup>37</sup> All four studies had relatively small sample sizes and differed greatly in prescribing outcome measures. This suggests that further description and evaluation of educational methods is needed for non-medical prescribers.

Overall the conclusions that can be drawn are limited by the quality of the studies reviewed. The number of participants included ranged from 13 in an RCT<sup>41</sup> to 751 in a cohort study.<sup>55</sup> RCTs are considered the gold standard; however, the smaller studies may have been underpowered and hence could not produce statistically significant results. Nevertheless large-sample randomisation and effective blinding are often not appropriate or possible in prescribing intervention studies. The current literature also does not show if the improvements in prescribing persists after the intervention occurs as many studies only assess up to a few months after the intervention. Higher quality studies looking at long-term changes in prescribing habits is required to assess the effectiveness of educational interventions on prescribing.

Lastly, the different methods of assessments were often used with no discussion about their validity and reliability, and marking schemes were inconsistent across the different studies. For example, the definitions of 'prescription error' differed slightly between studies and one study defined errors based on local state laws instead of on appropriateness of medication choices.<sup>45</sup> The correlation between the duration of interventions and the impact on prescribing was also difficult to determine as the interventions ranged from a 30 min tutorial<sup>52</sup> to a prescribing programme implemented for up to 3 years.<sup>51 53 55</sup> This made assessing the quality of the studies difficult and no criteria appeared appropriate for this purpose.

As our search strategy excluded studies that were not in English, we were unable to report important educational strategies that may exist in this area. However, these interventions have already been shown to decrease costs and may subsequently improve prescribing appropriateness.<sup>22 23</sup> Furthermore, the comprehensiveness of our review may have been limited by only including databases that we perceived would contain the bulk of the prescribing competency literature, using the key word 'competency' and following PRISMA guidelines<sup>24</sup> which do not stipulate hand searches. Overall the studies retrieved provided a broad overview of a range of prescribing interventions and may be useful in identifying strategies that can be explored further in more robust, longer term trials in the future.

## CONCLUSION

A wide range of educational interventions has been conducted to develop and maintain prescribing competency. However few studies have sought to evaluate the educational models used to develop non-medical prescribers' prescribing competency and there is a need for further development in the assessment of teaching for non-medical prescribers as expansions of prescribing powers continue to be implemented. The development of competency frameworks for prescribing has highlighted the need to design interventions which target each prescribing competency domain. In particular, the WHO *Guide to Good Prescribing* is a promising model for the design of targeted prescribing programmes and has been shown to be effective in a wide variety of settings. The corresponding author has the right to grant on behalf of all authors and does grant on behalf of all authors, a worldwide license to the Publishers and its licensees in perpetuity, in all forms, formats and media (whether known now or created in the future) to: (1) publish, reproduce, distribute, display and store the Contribution; (2) translate the Contribution into other languages, create adaptations, reprints, include within collections and create summaries, extracts and/or, abstracts of the Contribution; (3) create any other derivative work(s) based on the Contribution; (4) to exploit all subsidiary rights in the Contribution; (5) the inclusion of electronic links from the Contribution to

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