



IUPHAR International geriatric clinical pharmacology curriculum for medical students



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Future physicians will need better knowledge, skills and attitudes to prescribe well for the growing numbers of older patients world-wide. The world's population is ageing, with the population aged 80 years or over growing fastest of all [1], and ageing is associated with multi-morbidity and polypharmacy. Education of medical students can give future physicians a better and more positive approach towards provision of health care to complex older people [2], and improve their ability to manage patients with multi-morbidity [3]. Internationally, there are concerns about and strategies to address overall clinical pharmacology education and prescribing competence in medical graduates [4]. Recent review of the literature suggested that there is inadequate education on geriatric pharmacology in medical schools internationally, with a median (range) of 1.5 (1–23) hours spent on geriatric education [5]. There are similar issues in education of other healthcare professionals, with opportunities for interprofessional learning [6]. The lack of knowledge and skills amongst graduates may translate into sub-optimal prescribing for older people, increasing the risk of adverse drug events in this vulnerable population.

While the WHO Guide to Good Prescribing [7] describes the six steps necessary for prescribing for all patients, it does not specifically address the complexity of prescribing for older adults beyond mentioning challenges with adherence, an increased risk of adverse effects and providing an example of dose reduction. Similarly, the WHO study on teaching geriatrics in medical education [8] found very little evidence of geriatric pharmacology teaching. There is currently no published comprehensive geriatric clinical pharmacology curriculum for medical graduates detailing necessary learning objectives, skills and attitudes. Therefore, we developed a comprehensive medical school curriculum in geriatric clinical pharmacology that can be applied internationally.

1. Strategy to define the international geriatric pharmacology curriculum

A modified Delphi technique was used (details in Supplementary Data Methods). A literature review informed a draft curriculum, which was initially revised by an international panel of experts from the

geriatric pharmacology subcommittee of the Clinical Division of IUPHAR (DA, DLC, PT, SH). The model curriculum was emailed with a questionnaire, to experts in geriatric clinical pharmacology, geriatric medicine and clinical pharmacology, from developed and developing countries, to further refine and reach consensus on the curriculum and to highlight key issues for implementation.

The draft curriculum contained eight key learning topics, with each aligned to a learning objective and learning outcomes in terms of knowledge, skills and attitudes (Supplementary Table 2). In summary, the proposed learning topics were (1) biology, physiology and pathophysiology; (2) principles of geriatric clinical pharmacology; (3) communication; (4) quality use of medicines; (5) individualization of therapy and pharmacogenomics; (6) polypharmacy; (7) adverse drug events, adverse drug reactions, medication errors and drug interactions; and (8) drug development, evaluation and regulation.

2. International opinions on the need for, content of and implementation of the curriculum

Of the 110 participants invited to participate in the survey, 35 (32%) responded. There was excellent international representation (Supplementary Table 3), with 20 respondents from developed countries and 15 from developing countries. The professional backgrounds of participants included medical practitioner, geriatrician, pharmacologist, clinical pharmacologist, pharmacist and researcher. All respondents were actively involved in health care of older patients and directly involved in teaching medical students as a staff member or affiliate of a university. None of the respondents was aware of a comprehensive geriatric pharmacology curriculum in their school or country. Presence of some geriatric pharmacology topics in the medical student curriculum was reported by 13/20 respondents from developed countries and 2/15 from developing countries.

Participants' assessments of the importance and applicability of the model geriatric pharmacology curriculum are shown in Supplementary Figure 1. Ninety-four percent of respondents agreed or strongly agreed that it was important to include a comprehensive geriatric clinical pharmacology curriculum in the medical program. There was excellent

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Table 1
Revised IUPHAR International Geriatric Clinical Pharmacology Curriculum for Medical Students.

#	Learning topic	Learning objectives	Learning Outcomes		
			Knowledge	Skills	Attitudes
1	Biology, Physiology, Pathophysiology	Outline the impact of altered physiology and pathophysiology in ageing on pharmacokinetics and pharmacodynamics.	<ul style="list-style-type: none"> ● Explain the impact of physiological changes with ageing on pharmacology ● Explain the impact of age associated disease processes on pharmacology ● Describe how changes in pharmacokinetics and pharmacodynamics in old age affect the selection, dosing, and the therapeutic and adverse effects of drugs. 	<ul style="list-style-type: none"> ● Consider knowledge of ageing in clinical assessment and pharmacotherapeutic management of older patients ● Consider age and disease related changes in pharmacokinetics and pharmacodynamics to optimise drug choice and drug dose for older patients ● Recognise when therapeutic failure, adverse effects or drug interactions are due to age related changes in pharmacokinetic and pharmacodynamics ● Take an accurate medication history from older patients and confirm with a second source where necessary ● Provide accurate and appropriate information about drugs to older patients and their carers ● Collaborate with patients, carers and other health care practitioners involved to determine a medication list that helps each older patient achieve their goals. 	<ul style="list-style-type: none"> ● Accept that age is one of many factors to consider when individualising prescribing ● Willingness to regularly review older patients' medications with consideration of changed pharmacokinetics and pharmacodynamics
2	Pharmacokinetic and pharmacodynamic principles of geriatric clinical pharmacology	Apply age-related changes in pharmacokinetics and pharmacodynamics to prescribing for older patients	<ul style="list-style-type: none"> ● Describe the challenges of and strategies for obtaining an accurate medication history (including adherence) from older patients ● Explain the importance of communication with patients, carers and other health care practitioners (including medical, pharmacy, nursing and allied health) involved in the older person's care ● Explain the importance of providing medicines information that the patient and/or caregiver can understand and use 	<ul style="list-style-type: none"> ● Critically review all of a patients medicines when prescribing ● Adjust therapeutic regimens appropriately to maximise benefit and minimise risk in older patients ● Apply or extrapolate the available evidence to inform prescribing decisions for older patients ● Consider guidelines and reliable resources for appropriate and inappropriate prescribing in older patients ● Assess the short and long term therapeutic effects of drugs in older patients appropriately ● Consider adherence challenges ● Consider the effectiveness and safety of non-pharmacological and pharmacological therapies ● Consider the economic impact of prescribing on the individual patient and society ● Consider, investigate and manage variability including individualising drug and dose selection for older patients ● Identify common ways in which genomic variation influences the handling of and response to drugs in older patients ● Monitor drug therapy in older patients through drug levels and/or response 	<ul style="list-style-type: none"> ● Respect roles and opinions of patients, carers, other health care team members and collaborate with them to review prescribing ● Appreciate the importance of communicating an accurate medication list and reasons for any changes ● Willingness to work with patients, carers and other health care practitioners to optimise prescribing ● Willingness to tackle the challenge of managing multiple acute and chronic diseases in older patients ● Appreciation of the risk-benefit analysis of all of the drugs taken by older patients ● Acceptance that prescribing includes initiation, monitoring, modification and discontinuation of therapy ● Willingness to implement strategies to reduce inappropriate drug use ● Empathy towards older patients and willingness to consider their goals, priorities and concerns ● Sensitivity to the economic impact of prescribing on the individual patient and society
3	Communication in prescribing for older patients	Outline considerations for effective communication when prescribing for older people	<ul style="list-style-type: none"> ● Explain the principles of appropriate prescribing for robust and frail older patients. ● Outline the application of guidelines to the care of robust and frail old patients, considering multi-morbidity, polypharmacy and time to benefit. ● Describe inappropriate drug use in older patients, including examples of drugs to be avoided in older patients ● Describe pharmacological and non-pharmacological treatment options in older patients ● List the most reliable sources of information available to guide rational drug use in older patients ● Describe factors that contribute to adherence with drug therapy in older patients ● Explain ethical and legal aspects of prescribing in older patients and in people with cognitive impairment ● Understand the economic impact of prescribed drugs on the individual patient and society 	<ul style="list-style-type: none"> ● Critically review all of a patients medicines when prescribing ● Adjust therapeutic regimens appropriately to maximise benefit and minimise risk in older patients ● Apply or extrapolate the available evidence to inform prescribing decisions for older patients ● Consider guidelines and reliable resources for appropriate and inappropriate prescribing in older patients ● Assess the short and long term therapeutic effects of drugs in older patients appropriately ● Consider adherence challenges ● Consider the effectiveness and safety of non-pharmacological and pharmacological therapies ● Consider the economic impact of prescribing on the individual patient and society ● Consider, investigate and manage variability including individualising drug and dose selection for older patients ● Identify common ways in which genomic variation influences the handling of and response to drugs in older patients ● Monitor drug therapy in older patients through drug levels and/or response 	<ul style="list-style-type: none"> ● Willingness to individualise and monitor therapy in older patients
4	Quality use of medicines in older patients	Describe appropriate prescribing for older patients	<ul style="list-style-type: none"> ● Describe inter- and intra-individual variability with ageing and frailty, and impact on goals of care, adherence, pharmacokinetics and pharmacodynamics ● Describe the role of genetic polymorphisms in determining variability in pharmacokinetics and pharmacodynamics in older patients ● Describe the importance of and methods for monitoring effects of drug therapy in older patients 	<ul style="list-style-type: none"> ● Consider the economic impact of prescribing on the individual patient and society ● Consider, investigate and manage variability including individualising drug and dose selection for older patients ● Identify common ways in which genomic variation influences the handling of and response to drugs in older patients ● Monitor drug therapy in older patients through drug levels and/or response 	<ul style="list-style-type: none"> ● Willingness to individualise and monitor therapy in older patients
5	Individualising therapy	Inter- and intra-individual variation and drug response in older patients	<ul style="list-style-type: none"> ● Describe inter- and intra-individual variability with ageing and frailty, and impact on goals of care, adherence, pharmacokinetics and pharmacodynamics ● Describe the role of genetic polymorphisms in determining variability in pharmacokinetics and pharmacodynamics in older patients ● Describe the importance of and methods for monitoring effects of drug therapy in older patients 	<ul style="list-style-type: none"> ● Consider the economic impact of prescribing on the individual patient and society ● Consider, investigate and manage variability including individualising drug and dose selection for older patients ● Identify common ways in which genomic variation influences the handling of and response to drugs in older patients ● Monitor drug therapy in older patients through drug levels and/or response 	<ul style="list-style-type: none"> ● Willingness to individualise and monitor therapy in older patients

(continued on next page)

Table 1 (continued)

#	Learning topic	Learning objectives	Learning Outcomes	Knowledge	Skills	Attitudes
6	Polypharmacy and deprescribing	Understand and manage polypharmacy	<ul style="list-style-type: none"> Describe the prevalence and risk factors for polypharmacy Describe the effects of polypharmacy on older patients, including non-adherence, medication errors, drug interactions and adverse drug reactions. Describe strategies to minimise polypharmacy Outline the evidence on the effects of deprescribing (supervised medication withdrawal) in older patients Describe how to deprescribe medicines in older patients Describe the impact of polypharmacy on the individual older patient and on society 	<ul style="list-style-type: none"> Recognise polypharmacy Identify medicines to deprescribe and apply deprescribing processes in older patients 	<ul style="list-style-type: none"> Willingness to identify and minimise polypharmacy, with the goal of improving outcomes for older patients 	
7	Adverse drug events (harm from adverse drug reactions and medication errors) and drug interactions in older patients	Outline the prevalence, aetiology, diagnosis, management and implications of adverse drug events and drug interactions in older patients	<ul style="list-style-type: none"> Describe the prevalence and aetiology of adverse drug events (adverse drug reactions and medication errors) and drug interactions in older patients Describe clinical presentations of adverse drug reactions in older patients, including non-specific atypical presentations, e.g. falls, confusion, functional impairment, incontinence. Define the prescribing cascade (treating unrecognised adverse drug events with another drug) and strategies to recognise and avoid it Outline the prevention and management of adverse drug events in older patients Understand identification and management of drug-drug, drug-food and drug-disease interactions in older patients Understand investigation and management of common forms of suspected drug poisoning in older patients Explain the role of pharmacovigilance in evaluating drug effects in older patients 	<ul style="list-style-type: none"> Be vigilant for adverse drug events, adverse drug reactions, medication errors and drug interactions in older patients, particularly those with polypharmacy Avoid the 'prescribing cascade' Recognise factors causing adverse drug events and minimise the risk Investigate and manage suspected adverse drug events in older patients Recognise, assess and manage poisoning in older patients appropriately Report suspected adverse drug reactions appropriately 	<ul style="list-style-type: none"> Accept that older patients are at increased risk of adverse drug reactions, medication errors and drug interactions Demonstrate a positive attitude toward identifying, treating and reducing risk of adverse drug events in older patients Understand the importance of achieving competence in the management of adverse drug events in older patients Display sensitivity to the risks of drugs in older patients 	
8	Drug development, evaluation and regulation	Outline the principles of drug development and evaluation for older patients	<ul style="list-style-type: none"> Discuss limitations of evidence on drug use in older patients. Describe different trial designs and considerations in trial design to evaluate drugs in older patients Describe the requirements for evidence in the geriatric 'special population' by major regulatory authorities 	<ul style="list-style-type: none"> Evaluate scientific papers to find or extrapolate evidence-based information on drugs for older patients 	<ul style="list-style-type: none"> Accept the need for more evidence to guide treatment of older patients Be cautious with use of new drugs that have not been evaluated in older patients 	

agreement (97%) on appropriateness of inclusion of the learning outcomes in the draft geriatric clinical pharmacology curriculum in their medical curricula. Over 70% of respondents found this curriculum suitable for their country/school.

Supplementary Table 4 shows participants' views and comments about the proposed model geriatric pharmacology curriculum. Participants acknowledged the importance of the project and encouraged international implementation of such a curriculum. Almost all participants commented that the model curriculum is applicable and ready for use. Participants from developed countries expressed that the curriculum is organised, thorough, insightful, complete, focused, comprehensive, logical, with broad coverage of all related topics of geriatric pharmacology. Participants from developing countries expressed that the curriculum is thorough, comprehensive and complete. A small proportion of participants from both developed and developing countries raised concerns that the curriculum was long and exhaustive. A few participants from developed countries suggested that the curriculum would benefit from case-based teaching.

The main barriers identified to implementation of the model curriculum, in both developed and developing countries, were limited emphasis on geriatrics in the current curriculum, lack of trained staff to teach this course, lack of time in the medical course, overcrowded curriculum of medical schools, competition with other courses, presence of this course as an elective, and obtaining approval from management. Participants recognised extra time, additional trained faculty, approval from higher authorities, additional books, numbers of lectures, tutorials, case studies, online resources, web-based learning, translation to other languages (especially by European countries) and financial support as some additional resources required for the implementation of curriculum.

3. The international geriatric pharmacology curriculum

This feedback was considered by the authors and used to revise the curriculum (Table 1). Suggestions to make the curriculum shorter were carefully considered. We slightly abbreviated the final version by tightening the language of the curriculum, but have not removed any learning topics. While acknowledging the challenges of a long document, we elected to keep the curriculum comprehensive providing detail that is not readily available elsewhere because geriatric clinical pharmacology is a new area for medical school curricula.

There were some suggestions for inclusion of additional learning topics, which were already in the proposed curriculum. The abbreviated and clearer language of the final version of the curriculum may help users identify these topics more easily.

The final learning topics were (1) impact of altered physiology and pathophysiology in old age on pharmacokinetics and pharmacodynamics; (2) application of changes in pharmacokinetics and pharmacodynamics to therapeutics; (3) communication in prescribing for older people; (4) quality use of medicines (including appropriate and inappropriate prescribing, drug information and evidence based medicine, consideration of frailty and dementia, adherence, ethics and economics); (5) individualising therapy; (6) polypharmacy and deprescribing; (7) adverse drug events and drug interactions; and (8) drug development, evaluation and regulation.

4. Concluding remarks

This comprehensive geriatric clinical pharmacology curriculum for medical students has international applicability for educating doctors to prescribe for the ageing population. It reflects the important

components required for student learning, with agreement on the need for a geriatric clinical pharmacology curriculum and on the proposed topics by experts from both developed and developing countries.

Respondents were concerned about implementation of the curriculum, teaching resources and assessment of student competency. A survey by the World Health Organisation found that the most common reason for lack of progress in improving medical student geriatrics teaching was either lack of specific direction to teach the specialty in the country's national curriculum or the absence of a national curriculum altogether [9]. Development of a comprehensive international curriculum in this study is the first of many steps in implementation. Our findings highlight the need for, and can inform, future implementation studies. The current WHO third global patient safety challenge: medication without harm, in which polypharmacy is one of three priority areas that governments are asked to address [10], may provide momentum for implementation.

A major strength of development of this curriculum is the feedback from experts from a wide range of regions to ensure that the curriculum would be applicable internationally. We acknowledge the limitation of responder bias, which is inherent in survey research. The 32% response rate is comparable to the mean response rate of 39.6% for electronic surveys [11]. The respondents may have had different interest in geriatric clinical pharmacology and in medical school curricula than the non-responders. Furthermore, our survey was limited to experts in geriatric clinical pharmacology. Another approach used in studies of prescribing in general, which may have given different perspectives, is to survey first year doctors about whether they thought they had adequate training in geriatric clinical pharmacology to do their jobs, and whether they thought teaching based on our proposed curriculum would have helped them prescribe for older patients.

International experts agree on the need for and content of the IUPHAR international geriatric clinical pharmacology curriculum for medical students. This curriculum can help to develop the teaching of geriatric clinical pharmacology in medical schools across the world. Implementation will require major efforts to overcome barriers, which are likely to differ between medical schools within and between countries.

Conflicts of interest

There are no conflicting interests to declare.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.phrs.2019.01.032>.

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