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RESEARCH

A comparison of the clinical pharmacotherapy knowledge of medical and surgical residents and consultants

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Abstract

Purpose Knowledge of clinical pharmacotherapy is essential for all who prescribe medication. The aims of this study were to investigate differences in the pharmacotherapy and polypharmacy knowledge of medical and surgical residents and consultants and whether this knowledge can be improved by following an online course.

Methods Design: A before-and-after-measurement.

Setting: An online course available for Dutch residents and consultants working in hospitals.

Study population: Dutch residents and consultants from different disciplines who voluntarily followed an online course on geriatric care.

Intervention An online 6-week course on geriatric care, with 1 week dedicated to clinical pharmacotherapy and polypharmacy. Variables, such as medical vs surgical specialty, consultant vs resident, age, and sex, that could predict the level of knowledge. The effects of the online course were studied using repeated measures ANOVA. The study was approved by the National Ethics Review Board of Medical Education (NERB dossier number 996).

Results A total of 394 residents and 270 consultants, 220 from surgical and 444 from medical specialties, completed the online course in 2016 and 2017. Residents had higher test scores than consultants for pharmacotherapy (73% vs 70%, $p<0.02$) and polypharmacy (75% vs 72%, $p<0.02$). The learning effect did not differ. Medical residents/consultants had a better knowledge of pharmacotherapy (74% vs 68%, $p<0.001$) and polypharmacy (77% vs 66%, $p<0.001$) than surgical residents/consultants, but the learning effect was the same.

Conclusions Residents and consultants had a similar learning curve for acquiring knowledge, but residents outperformed consultants on all measures. In addition, surgical and medical residents/consultants had similar learning curves, but medical residents/consultants had higher test scores on all measures.

Keywords Polypharmacy · Education · Online course · Older patients · Residents · Consultants · Pharmacotherapy

Introduction

Many prescribers find prescribing for patients aged 65 plus challenging, in part because of age-related changes in drug indications and pharmacokinetics and pharmacodynamics. These patients often use several medications, which increases the likelihood of drug–drug interactions. The use of multiple medications is a recognised

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risk factor for inappropriate prescribing, and more than 40% of adults aged 65 years plus take five or more medications [1, 2]. Earlier studies have shown that 6% of all acute hospital admissions of older patients are medication related, with half being potentially avoidable with optimal prescribing [3, 4]. The estimated number of unreported cases is thought to be much higher, up to 20% [5]. Poor pharmacotherapy and/or polypharmacy knowledge will lead to prescribing errors in this vulnerable group of patients [6–9].

An obvious solution is to improve the prescribing knowledge of doctors, by improving education on clinical pharmacotherapy during undergraduate training [10, 11] and by providing postgraduate training, for example with an online course [12, 13]. It is unclear what the level of pharmacotherapy knowledge of doctors is and if and how this improves after graduation. Besides workplace learning, with its inherent risk for patients, there is no evidence-based education tool to improve pharmacotherapy knowledge and skills [14, 15].

The first step is to identify which doctors require more training. One study found that the pharmacotherapy knowledge of primary care residents could be improved [16] and another that pharmacotherapy knowledge and pharmacotherapy skills may be lost over time, meaning that senior doctors would need more training than junior doctors [17].

The aim of this study was to investigate differences in the pharmacotherapy and polypharmacy knowledge of residents and consultants, and between medical and surgical residents/consultants, and whether this knowledge can be improved by following an online course.

Methods

Study design

The knowledge of pharmacotherapy and polypharmacy of residents and consultants from medical and surgical specialties and possible explanatory variables, such as specialty, sex, and age, were studied. The effect of a free, interactive, online educational intervention was studied using a before and after measurement [18].

Study population

The participants were not approached particularly for this study. Dutch residents and consultants from different disciplines who voluntarily followed an online course on geriatric care were included from May 2016 to September 2017. Other health professionals, such as physician assistants and pharmacists, were excluded. Geriatricians were also excluded because we expected them to have a high level of appropriate pharmacological knowledge. Dropouts were those who signed on for the course, but who did not start it.

The participants were grouped as residents or consultants by medical specialty (e.g. internal medicine, neurology, cardiology, referred to hereafter as medical doctors) or surgical specialty (e.g. general surgery, orthopaedic surgery, anaesthesiology, referred to hereafter as surgical doctors).

Educational intervention: online course

In 2016, the professional association of medical consultants in the Netherlands (Federation of Medical Specialist, FMS) launched an online course on geriatric care [18]. It was especially promoted for residents' training and was open for consultants and other interested participants. Promotion was done by, e.g. symposia and newsletters. The online course was a 6-week interactive course covering various aspects of geriatric care in Dutch hospitals. One of the main learning goals was pharmacotherapy and polypharmacy on which 1 week was dedicated. All data from this week were obtained and used for our study. The course was run several times.

The design of the course put emphasis on the interaction between participants by means of discussion fora and media. Different teaching styles were used, incorporating different case vignettes, videos, discussions with ethical questions, and reading material. Moderators (geriatricians, surgeons, and an education expert) moderated discussions and acted as 'experts' in geriatric care. Each week started with a pre-test (baseline) and ended (post-intervention) with a post-test, using formative multiple-choice tests, to assess what had been learned.

A baseline questionnaire was used to identify risk factors that could influence assessment scores, such as age, sex, and work experience. If information was missing, the researchers used information on the open source Linked-in accounts of the participants. If the participants did not have a Linked-in account, age and work experience were reported missing.

Test and setting

The pre- and post-tests were performed in a test modality within the online course. All participants had their own login code. Due to the personal login codes, the pre- and post-tests could be matched to the participants. All tests were made by one person alone, due to the individual character of the online course; however, there was no supervision on that. The condition of the pre- and post-test was similar. It was a formative test, so there were no consequences for the participants. We computed the learning effect as the difference between pre- and post-test results.

The pre and post-tests were based on what students are expected to learn during their medical training, as defined by the educational committee of the Dutch Society of Clinical Pharmacology and Biopharmacy (NVKF&B) [19, 20]. Both baseline and post-intervention tests contained 23 multiple-choice questions: 11 concerning general pharmacotherapy and 12 concerning polypharmacy; answers were either right or wrong. For example, in patients with long-term use of prednisone 10-mg daily, which drug should be prescribed additionally: omeprazole, folic acid, alendronic acid. The tests were matched for difficulty and topic. The assessment is added as supplement 1.

We used the same questions mentioned in the self-assessment study of van der Steen et al. [21]. In this study more details are given on the validity and reliability. The content validity of the assessment was secured by the use of experts in the field of clinical pharmacology in the design of the assessment, e.g. clinical pharmacologists. For the reliability, we performed additional analyses on the reliability in our cohort, with comparable good results as the study of van der Steen et al. All analyses showed the assessment have a good reliability: all but 2 questions had a fair to good item-rest correlation score (Rir score > 1). Two out of forty-six questions had negative Rir scores, but none had an influence of > 0.05 on the internal consistency scores, estimated with Guttman λ. Thus, all the questions could be used; none had to be deleted. There was a spread of question difficulty, with probability values of 29–100% (percentages of participants with the correct answer). The overall reliability of our assessment measured with Guttman $\lambda 2$ (0.730) was good [22].

Power calculation

An expected 20% increase in score before and after the intervention was expected, based on results from a comparable study [12]. To detect differences with small effect sizes (Cohen's $D > 0.2$), an estimated 884 ($n1 = 591$ residents, $n2 = 295$ consultants) participants would be needed (double-sided, allocation ratio 2:1, $\alpha = 0.05$ and $\beta = 0.20$).

Data analysis

Descriptive statistics were used for participant characteristics. *T*-tests and chi-square tests were used to compare groups, where appropriate. The main analysis was performed with repeated measures ANOVA: the baseline and post-intervention test scores were analysed to identify whether a learning effect occurred in and between groups. Next, linear regression was used to identify variables that affected the level of knowledge before the start of the online course. *P* values of < 0.05 were considered significant. SPPS 22.0 was used for the analyses.

Ethical considerations

The study was approved by the National Ethics Review Board of Medical Education (NERB dossier number 996).

Results

Baseline

A total of 989 participants took the baseline test, and the data of 664 participants were analysed after the exclusion of geriatricians, participants other than residents and consultants, and participants who did not complete the second test (Fig. 1). The baseline characteristics of the included participants are shown in Table 1. There were more women than men and more female than male residents. Participant sex was not used as a covariate in further analyses because sex-related differences in knowledge of pharmacotherapy have not been reported in the literature.

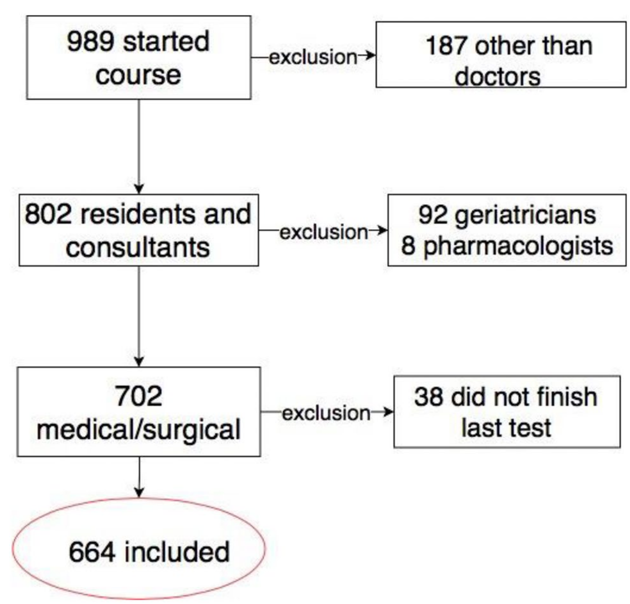

Fig. 1 Flowchart of participants with reasons for exclusion

Table 1 Characteristics of participants in different groups. Significant when $p < 0.05$

	Medical ($n = 445$)	**Surgical ($n = 219$)**	**Statistics**
Mean age (SD)	36.2 (9.7)	35.7 (8.8)	$p = 0.528$[a]
Sex, female, n (%)	182 (66)	108 (56)	$p = 0.034$[b]
	Residents ($n = 394$)	**Consultants ($n = 270$)**	**Statistics**
Mean age (SD)	30 (3.7)	45 (7.6)	$p < 0.001$[a]
Sex, female, n (%)	186 (69%)	89 (48%)	$p < 0.001$[b]

[a]Unpaired t-test

[b]Chi square, missing data sex $n = 223$

Test scores and group differences in training effect

Tables 2 and 3 shows the main results. The pre-test scores differed between groups. In general, residents had higher baseline scores for both general pharmacotherapy and polypharmacy than consultants, and medical doctors had higher baseline scores than surgical doctors (t (662) = 9.549; $p < 0.001$ and t (662) = 4.762; $p < 0.001$ for general pharmacotherapy and polypharmacy, respectively).

Overall, test scores increased after the course with medium to large effect sizes (72.0% SD 14.5 vs 89.0% SD 10.8, (t (663) = − 29,656; $p < 0.001$, Cohen's D 1.15 for pharmacotherapy and 73.6%, SD 15.2 versus 79.9% SD 12.85,(t (662) = − 11.762; $p < 0.001$, Cohen's D 0.46 for polypharmacy).

Medical doctors had higher test scores than surgical doctors for pharmacotherapy (74% vs 68%, $p < 0.001$) and polypharmacy (77% vs 66%, $p < 0.001$). However, the absolute increase in knowledge did not differ for both pharmacotherapy (within groups, $p = 0.201$) and polypharmacy (within groups, $p = 0.440$). This means that surgical doctors acquired this knowledge equally well as medical doctors, even though medical doctors had higher test scores overall.

Residents had higher test scores than consultants in the pretests on pharmacotherapy (residents 73% vs consultants 70%, p 0.015) and polypharmacy (residents 75% vs consultants 72%, p 0.015). The learning effect was similar ($p = 0.120$ and $p = 0.513$) for pharmacotherapy and polypharmacy, respectively, in both groups. This means that residents acquired this knowledge equally well as consultants, even though medical doctors had higher test scores overall.

Secondary outcomes

Too few data on work experience were collected to determine the effect of this variable on test scores. Age (F (1, 425) = 2.34, p 0.127) and sex (F (1, 456) = 0.557, p 0.451) did not predict test scores.

Discussion

This large intervention study investigated the geriatric pharmacotherapy and polypharmacy knowledge of 664 residents and consultants. This is the first study comparing the pharmacological knowledge of residents with consultants. The residents had higher scores for all outcomes investigated than the consultants, but both groups showed a similar increase in knowledge after following a relevant online course. The scores of medical doctors were higher than those of surgical doctors, although their learning curves were similar. Age and sex did not affect findings.

The online course proved to be an effective educational tool—it improved knowledge and could be used by large groups of doctors of varying clinical experience. Similar positive results of e-learning have been reported earlier. For example, Cullinan et al. reported promising results but limited their study to non-consultants [12]. Although knowledge improves, there are doubts whether this knowledge is used in daily clinical practice. Franchi et al. failed to demonstrate better clinical outcomes in older patients on geriatric or internal medicine wards after doctors followed an e-learning educational programme [23]. However, this

Table 2 Pre- and post-scores in surgical versus medical groups

	Surgical		Medical		Statistics	
	Pre-test (%, SD)	Post-test (%, SD)	Pre-test (%, SD)	Post-test (%, SD)	Pre-test vs pre-test[a]	Learning effect[b]
Pharmacotherapy	68 (15)	84 (11)	74 (14)	92 (10)	$p < 0.001$	$p = 0.201$
Polypharmacy	66 (15)	72 (12)	77 (14)	84 (12)	$p < 0.001$	$p = 0.440$

Statistics: p value: significant when < 0.05

[a]Difference between groups surgical and medical by repeated measure ANOVA, pre-test vs pre-test

[b]Learning effect between groups surgical and medical by repeated measure ANOVA, within-subjects contrast on posttest-pretest scores

Table 3 Pre- and post-scores in residents versus consultants

	Residents		Consultants		Statistics	
	Pre-test (%, SD)	Post-test (%, SD)	Pre-test (%, SD)	Post-test (%, SD)	Pre-test vs pre-test[a]	Learning effect[b]
Pharmacotherapy	73 (14)	89 (10)	70 (15)	89 (11)	$p=0.015$	$p=0.120$
Polypharmacy	75 (14)	83 (12)	72 (16)	88 (12)	$p=0.015$	$p=0.513$

Statistics: p value: significant when <0.05

[a]Difference between groups residents and consultants by repeated measure ANOVA, pre-test vs pre-test

[b]Learning effect between groups residents and consultants by repeated measure ANOVA, within-subjects contrast on posttest-pretest scores

programme was more of a refresher course and did not focus on changes in knowledge per se, so it was difficult to establish whether e-learning had a direct effect. As a possible explanation for this, the authors commented that there was a lack of interaction [23]. For this reason, we specifically tried to stimulate discussion and integration of this knowledge in the work situation.

The high baseline levels of knowledge of the medical doctors could be the result of "learning by doing", because medical doctors are expected to prescribe more often than surgical doctors. However, in the surgical group, comparable pharmaceutical experience with polypharmacy should be expected as the incidence of polypharmacy does not differ from other specialties. Yet Ryan et al. reported that prescribing errors made by junior doctors were more often seen on surgical wards than on medical wards, but no explanation was given for this difference [24]. We found a gap in the pharmacotherapy and polypharmacy knowledge of the surgical doctors compared with the medical doctors. With the exception of a study showing a lack of opioid prescription education, no other studies have investigated the prescribing abilities and errors of surgical health professionals [25]. Although the medical doctors had a better prescribing knowledge at baseline, the improvement in knowledge after the course was similar in the medical and surgical doctors. This shows that, regardless of entry level, a single educational intervention can improve prescribing and pharmacotherapy knowledge in different groups of health professionals. It would be interesting to know whether additional education could further bridge the knowledge gap between medical and surgical doctors.

Surprisingly, the residents had a better knowledge of prescribing and pharmacotherapy than the consultants at baseline. In the Netherlands, clinical pharmacotherapy education has been integrated into medical curricula, which might explain the higher scores of the residents [11]. Another explanation could be the shorter time since they had followed pharmacotherapy education [26]. We think that there is a gap between knowledge and its application, which may be why previous studies found a lack of safe prescribing competence in final-year medical students [9, 27], despite the students having received relevant education. Unfortunately, we were unable to trace the years of work experience and couple scores for pharmacotherapy knowledge with those measured here in the residents.

Overall, the level of knowledge at baseline was relatively high but increased after an online intervention. Although the questions met the standards of the national examination for medical students, they might have been too easy for residents and consultants [20], such that the moderate increase in polypharmacy scores was because of a ceiling effect. Furthermore, the multiple-choice format of the questions may have facilitated educated guessing.

Limitations

Although this is the first study to show that an interactive educational course improved the prescribing/pharmacotherapeutic knowledge of medical and surgical doctors, the study had some limitations.

First, there could have been bias in the selection of participants. The course was available nationwide and voluntary, except for some surgical residents. Some teaching hospitals made the course compulsory, but we do not know for which doctors this was the case. The voluntary nature of the study may have led to the recruitment of participants with a special interest in clinical pharmacotherapy or geriatric care and thereby more eager to learn. Secondly, we studied age, sex, and work experience as potential explanatory variables, whereas other factors, such as where doctors trained and previous geriatric education, may have been relevant. Although we did not recruit the number of participants indicated by the power calculation, the effect size was larger than expected (0.45 (medium) instead of the estimated 0.2 (small)). Thus, we found several significant differences in test scores despite the dataset being rather small.

Conclusion

While the educational effect of an online course was similar in residents and consultants, residents outperformed their consultants on all measures investigated. Likewise, although the educational effect of the course was similar in medical and surgical doctors, medical doctors outperformed surgical doctors. The question remains whether improved knowledge acquired via interactive learning actually reduces prescribing errors and improves patient outcomes. Further research is needed.

Author contribution All authors have a substantial contribution to the concept of the study. The conception or design of the work: FvdH, EO, CK, HvG. The acquisition: FvdH, EO, CK, HvG. Analysis: FvdH, EO, CH, MvH. Interpretation of data: FvdH, EO, CK, MvH. The creation of new software used in de the work (elearning): HvG, CK, FvH, EO. Drafted the work: FvdH, EO, MvH, CK. Revised it critically for important intellectual conent: MvA, JT, HvG. Approval of latest version and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved: all.

Availability of data and materials The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval The study was approved by the National Ethics Review Board of Medical Education (NERB dossier number 996).

Consent to participate The ethical board approved the study design in which data could be used without the informed consent of participants. Due to the retrospective design, in which already collected data were analysed, obtaining informed consent was not reasonably feasible.

Consent for publication All authors approved the final version and agree on publication.

Competing interests The authors declare no competing interests.

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