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A comparison of medical and pharmacy students' knowledge and skills of pharmacology and pharmacotherapy

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WHAT IS ALREADY KNOWN ON THIS SUBJECT?

- Pharmacists and physicians need to work together to provide pharmaceutical care, but differences in the 'language' of the two disciplines often impair this collaboration.
- Interdisciplinary education, both undergraduate and postgraduate, is suggested as a way to improve pharmaceutical care. The design of interdisciplinary education programmes should take into account the knowledge and skills acquired during undergraduate education.
- It is not known to what extent both health professionals' knowledge and skills overlap or differ.

WHAT THIS STUDY ADDS?

- Pharmacy students have a better knowledge of basic pharmacology, but not of the application of pharmacology knowledge, than medical students, whereas medical students are better at writing prescriptions.
- These differences could be due to differences in the undergraduate curricula of the two courses.
- Knowledge of these differences could be harnessed to develop a joint interdisciplinary education for both students and professionals.

AIM

Pharmacotherapy might be improved if future pharmacists and physicians receive a joint educational programme in pharmacology and pharmacotherapeutics. This study investigated whether there are differences in the pharmacology and pharmacotherapy knowledge and skills of pharmacy and medical students after their undergraduate training. Differences could serve as a starting point from which to develop joint interdisciplinary educational programmes for better prescribing.

METHODS

In a cross-sectional design, the knowledge and skills of advanced pharmacy and medical students were assessed, using a standardized test with three domains (basic pharmacology knowledge, clinical or applied pharmacology knowledge and pharmacotherapy skills) and eight subdomains (pharmacodynamics, pharmacokinetics, interactions and side-effects, Anatomical Therapeutic Chemical Classification groups, prescribing, prescribing for special groups, drug information, regulations and laws, prescription writing).

RESULTS

Four hundred and fifty-one medical and 151 pharmacy students were included between August 2010 and July 2012. The response rate was 81%. Pharmacy students had better knowledge of basic pharmacology than medical students (77.0% *vs.* 68.2% correct answers; $P < 0.001$, $\delta = 0.88$), whereas medical students had better skills than pharmacy students in writing prescriptions (68.6% *vs.* 50.7%; $P < 0.001$, $\delta = 0.57$). The two groups of students had similar knowledge of applied pharmacology (73.8% *vs.* 72.2%, $P = 0.124$, $\delta = 0.15$).

CONCLUSIONS

Pharmacy students have better knowledge of basic pharmacology, but not of the application of pharmacology knowledge, than medical students, whereas medical students are better at writing prescriptions. Professional differences in knowledge and skills therefore might well stem from their undergraduate education. Knowledge of these differences could be harnessed to develop a joint interdisciplinary education for both students and professionals.

Introduction

The goals of pharmacists and physicians in patient management are optimization of the pharmaceutical care for, and outcomes of, their patients [1], and their collaboration can be a crucial factor in this process [2]. Effective collaboration between pharmacists and physicians can lead to improved clinical outcomes, such as fewer adverse drug events, less severe illness and greater patient satisfaction [3].

Historically, prescribing used to be done by a physician in the combined role of prescriber and dispenser, but the two roles have since diverged, and nowadays physicians and pharmacists have different duties and tasks, culture, undergraduate education, and knowledge and skills [4]. It is only in the last two decades that there has been interest in physician–pharmacist collaboration [1, 5]. Differences in professional culture and lack of awareness of each other's knowledge and skills can cause interdisciplinary barriers [2], although the same differences could be regarded as complementary, and when combined potentially lead to improved patient care [2, 4].

Differences in the knowledge and skills of physicians and pharmacists may be the result of learning in practice or differences in their undergraduate training and education. For example, Harrington *et al*. found that pharmacy students outperformed medical students in their knowledge of drug–drug interactions [6], These differences increase after a 1 year follow-up, indicating a better knowledge retention for pharmacy students on drug–drug interactions [7]. Warholak *et al*. found pharmacy students to be significantly better at recognizing prescription errors [8]. No other studies were found in which pharmacy and medical students were compared on pharmacology or pharmacotherapy knowledge or skills. Joint training and education has been suggested as a way to improve interdisciplinary collaboration with a view to improving patient care [4, 9]. For instance, interdisciplinary education has been found to lead to a more uniform knowledge of drug–drug interactions [6]. However, it should be appreciated that there is a difference between basic pharmacology or factual knowledge, clinical pharmacology or the application of knowledge in relation to a patient and pharmacotherapy skills [10, 11]. The previous studies only addressed minor aspects of these different domains. It is essential to take earlier learning experiences and the knowledge acquired into consideration when developing a meaningful interdisciplinary curriculum [12]. For this reason, it would be useful to gain insight into the knowledge and skills that pharmacy and medical students have acquired with current curricula.

The goal of this study was to investigate differences in the pharmacology and pharmacotherapy knowledge and skills of pharmacy and medical students after their undergraduate training. Knowledge of potential differences can be used to develop joint educational programmes, both undergraduate and postgraduate, with a view to improving interdisciplinary collaboration and pharmaceutical care.

Methods

Study design

The study was designed as a cross-sectional comparison between pharmacy and medical students at the University of Utrecht, the Netherlands. A specially developed test was used to assess students' basic pharmacology knowledge, clinical pharmacology or applied knowledge and pharmacotherapy skills. Students were recruited during 2 academic years (August 2010–July 2012). Medical and pharmacy students who signed up to a specific 1 week course that was mandatory for both disciplines were asked to volunteer to take a formative written examination of their pharmacology and pharmacotherapy knowledge and skills.

Previous training of study population

Table 1 shows the hours of tuition scheduled according to the medical and pharmacy curricula. The medical curriculum offered optional courses but the uptake was very low, only two students. The pharmacy curriculum offered 120 h of optional courses and most students followed about 30 h of these courses (year 5).

The medical curriculum can be described as problem oriented, with an early focus on clinical skills, which are acquired during practical lessons from the first year onwards and during junior clerkships in the third year onwards. The pharmacy curriculum is also problem oriented, with students having rotation at a pharmacy in the first year. However, in general, the pharmacy curriculum has less emphasis on patient care and clinical subjects than the medical curriculum. In both curricula, most education is provided in the form of small group discussions and tutorials, lectures, and practical lessons, with the addition of rotations and clerkships in the last 2 years of the medical curriculum.

Table 1

Hours of scheduled classes on pharmacology and pharmacotherapy that are mandatory for pharmacy and medical students

Study year	Pharmacy (h)	Medical (h)
1	10	18
2	72	0
3	50	0
4	51	17
5	14	0
6	0	0
Sum	**197**	**35**

Table 2

Design of the assessment by use of test matrix for each parallel test

Question type: n	Domain and example of question	Subdomain (*n*)
Three options MCQ: *n* = 25	**Basic pharmacology knowledge** e.g. What is a 'first pass effect'?	- Pharmacodynamics (*n* = 7) - Pharmacokinetics (*n* = 7) - Interactions and side effects (*n* = 4) - ATC groups knowledge† (*n* = 7)
Three options MCQ: *n* = 24	**Clinical pharmacology or applied knowledge** e.g. an 80-year-old women with renal failure and a complicated urinary tract infection is presented to the GP. What is the best treatment for the UTI in this woman?	- Prescribing (*n* = 7) - Prescribing in special groups (*n* = 7) - Interactions and side effects (*n* = 3) - Drug information, regulations and laws (*n* = 7)
Open: *n* = 1	**Pharmacotherapy skill** e.g. Write the recipe for your ambulant patient for amoxicillin/clavulanic acid 625 mg 3 times a day for 7 days	- Recipe (*n* = 1)

†ATC groups: drug groups by the Anatomical Therapeutic Chemical Classification system. MCQ, multiple choice question.

Time spent in self-study was not considered when calculating the hours of tuition because self-study differs substantially per student. Since both curricula are problem oriented, and pharmacology and pharmacotherapy education is often integrated, only scheduled hours (e.g. seminars or lectures on a given topic) were considered as tuition time. This probably led to underestimation of the time devoted to basic pharmacology knowledge, clinical pharmacology or applied knowledge and pharmacotherapy skills, because these topics probably arose during other forms of tuition, such as tutorials and other small group discussions. Both curricula put emphasis on self-study and we did not expect there to be systematic differences in the time spent in self-study between medical and pharmacy students.

All participating medical and pharmacy students had completed at least the first 3.5 years of their 6 year course. At time of inclusion, medical students had completed 100% of their mandatory tuition on pharmacology and pharmacotherapy and pharmacy students 93–100%.

Sampling

All medical and pharmacy students actively studying during 2 academic years, 2010 and 2011, were asked to complete the test during an interdisciplinary scheduled lecture hour during a mandatory 1 week course. To gain access to courses, students normally have to enrol in an online registration system Osiris. As a result, the system registers the number of active students during a certain time frame. No information about the study was provided before students signed up for the course, in order to prevent selection bias. Both the lecture and test participation were voluntary. In addition, students were asked to fill in a short questionnaire about their age, gender, year they started their study, previous relevant study, such as other biomedical studies, etc. All data were collected anonymously and students were not asked to give their names.

Pharmacology and pharmacotherapy test: construction

The pharmacology and pharmacotherapy test covered the domains basic pharmacology knowledge, clinical pharmacology or applied knowledge and pharmacotherapy skills. The content of the test was derived from the available literature on core curricula [10, 13, 14].

A test matrix, as shown in Table 2, was developed to guide the selection of items for the assessment (basic pharmacology knowledge, clinical pharmacology or applied knowledge and pharmacotherapy skill) and the eight subdomains. All questions on basic pharmacology assessed the factual knowledge students are expected to acquire from study books (canonical knowledge). Questions that assessed clinical pharmacology knowledge contained a short case vignette that required students to apply their theoretical knowledge. Pharmacotherapy skills were assessed by asking students to write a prescription. Other pharmacotherapy skills, such as patient communication, cannot be tested in writing and were not assessed. Three similar parallel tests were developed, using a database of 170 questions prepared by experts in the field of pharmacotherapy and clinical pharmacology. These three parallel tests were used alternately.

Pharmacology and pharmacotherapy test: validity and reliability

The test matrix was used to ensure that the different question (sub)domains were equally distributed over the test (content validity). Ten clinical pharmacologists, with different backgrounds, but mostly in pharmacy and geriatric medicine, were asked to complete the test, to establish its construct validity. The scores of these experts were compared with those of the students, using a Student's *t*-test for independent samples. For the test to be a valid reflection of the knowledge students should possess, the experts should have a mean of >90% correct answers. The mean score of the expert group was 91.2% (SD 6.1) and that of the students was 71.4% (SD 8.4). On a *t*-test for independent groups, the expert group scored significantly higher ($t(611) = 7.351$, $P < 0.001$, 95% CI −0.25, −0.14) with a very large effect size (Cohen's $\delta = 2.68$), indicating that the test had good construct validity.

To study test reliability, the internal consistency of the parallel tests, the *P* values, and the item-rest correlation scores (r_{ir}) for the different questions were calculated. None of the questions from any of the parallel tests had a negative r_{ir}-value in either student group. Therefore none of the questions had to be excluded from the analyses. The Guttman lambda was used for internal consistency, because it gives a more reliable value than Cronbach's alpha [15]. All parallel tests had an internal consistency ranging between 0.5 and 0.7. Because the assessment was not used to determine individual scores but to compare groups, an internal consistency higher than 0.5 can be considered acceptable [16]. The *P* values (% of correctly answered questions) for the individual questions of the three different assessments ranged between 0.29 and 0.99, 0.15 and 1.00, and 0.16 and 0.99, respectively, indicating that the difficulty of the questions was variable, with some easy questions having high *P* values.

Data analysis

All assessment and questionnaire results were collected in Excel and SPSS version 20.0. Analyses were performed with SPSS version 20.0. Descriptive analyses of student characteristics were used. All previous biomedical studies were considered to be relevant previous studies. Response rates were determined by calculating the proportion of the students who volunteered relative to the number of students who enrolled for the course, as indicated by the online study administration system.

All multiple choice questions were scored as right or wrong (0–1). Each correct item included in the prescription (or skill) written by a student was awarded a score of 1 point (by researcher CK): (1) name patient and date of birth, (2) name physician and signature, (3) drug and dose, (4) number, (5) label instruction. Scores are expressed as a percentage of the maximum score for each domain and subdomain.

The mean domain and subdomain scores of the medical and pharmacy students were compared using a *t*-test for independent samples in the case of a normal distribution or a Mann–Whitney U-test in the case of a skewed distribution of data. Effect sizes were calculated to magnify the differences. Effect sizes <0.5 were considered small, 0.5–0.8 medium and >0.8 large [17]. Covariance analyses were performed to correct for possible confounders such as age, gender, previous relevant other study and study duration. In the pharmacy group, the effect of different study durations on test scores was compared with an ANOVA.

Ethical considerations

This study falls outside the scope of the Dutch Law on Medical Research (WMO), and when the study started the Dutch Ethics Review Board of Medical Education, which could provide study approval, was not yet operational. The students, all of whom were older than 18 years, were told about the study and gave their verbal consent to voluntary participation.

Results

Population characteristics

Table 3 shows the characteristics of the study population. Of the 602 students who participated, 451 were medical students. The overall response rate was 80.8% (602/745), 83.2% (450/541) for medical students and 74.5% (152/204) for pharmacy students compared with all students from

Table 3

Student characteristics

		Medical students (*n* = 451)	Pharmacy students (*n* = 151)	*P* value
Age	Median (range)	22 (19–45)	23 (20–40)	**<0.001†**
Gender	Female (%)	75,0	72,2	0.355‡
Year of inclusion	2010–2011 (*n*)	222	41	**<0.001‡**
	2011–2012 (*n*)	229	110	
Duration study (inclusion date-start study)	Median (range)	3 years 8 months (1 year 11 months– 6 years 9 months)	4 years 10 months (3 years 2 months– 12 years 7 months)	**<0.001†**
Previous study	Not or not relevant (*n*)	411	142	0.166‡
	Relevant (*n*)	40	8	

*Student's *t*-test. †Mann–Whitney. ‡Chi-square.

the academic years 2010 and 2011. All students present at the scheduled lecture participated (100%). Most of the students completed the assessment within 40 min.

Main results

Comparison of the basic pharmacology knowledge, applied pharmacology and pharmacotherapy skills of the pharmacy and medical students showed that, overall, the pharmacy students outperformed the medical students with regard to basic pharmacology knowledge (77.0% (SD 10.3) *vs*. 68.2% (SD 9.8) correct answers, $t(600) = -9.4$, $P < 0.001$, 95% CI –0.11, –0.07, $\delta = 0.88$), whereas the medical students outperformed the pharmacy students when it came to writing prescriptions (68.6% (SD 26.7) *vs*. 50.7% (SD 35.2), $t(600) = 6.5$, 95% CI 0.13, 0.23, $P < 0.001$, $\delta = 0.57$). The two groups of students had a similar knowledge of applied pharmacology (73.8% (SD 10.5) *vs*. 72.2% (SD 10.8), $t(600) = -1.5$, $P = 0.124$, 95% CI –0.04, 0.004, $\delta = 0.15$) (Table 4).

As the pharmacy students came from different years in their master's degree programme, we investigated whether the number of years of training and education influenced their pharmacological knowledge. There were no significant differences between the different study years in the three domains basic pharmacology knowledge, clinical or applied pharmacology and pharmacotherapy skills or in the eight subdomains.

Discussion

This study demonstrates that medical and pharmacy students differ in their pharmacology and pharmacotherapy knowledge and skills. Pharmacy students tended to have better basic pharmacology knowledge whereas medical students tended to have better skills in writing a prescription. There were only minor, borderline significant and not clinically relevant, differences in clinical pharmacology or applied knowledge. Given the differences in education, with pharmacy students having six times more mandatory classes, these results are surprising. Medical students, although their basic knowledge of pharmacy was less than that of pharmacy students, performed equally well in applying their knowledge in relation to a patient and had better prescribing skills. These findings suggest that the differences between pharmacists and physicians arise during their undergraduate training.

Both pharmacy and medical students should have appropriate pharmacology and pharmacotherapy knowledge at the end of their undergraduate training in order to provide safe medical care [18]. Although a gold standard of sufficient knowledge is not available, the test represents the learning goals of international core curricula and might be used as such a standard. Medication errors are a major problem in medical care [19], and one would hope that not only pharmacy students but also medical students would have an adequate basic knowledge of pharmacology to allow them to prescribe safely [9]. In our study, the medical students had an overall score of 68% for basic knowledge, not corrected for chance on multiple choice questions. This deficit relative to pharmacy students has been reported previously with regard to drug–drug interactions [6]. However, pharmacy students should know what information should be given in a prescription [8], yet many pharmacy students could not actively write out a prescription (overall score 51%), even though students had been taught, early in their study, what the core elements of a prescription are in order to be able to check whether a prescription is complete. Although prescribing is not a daily task for pharmacists, at least in the Netherlands, it would seem unlikely that pharmacists could recognize mistakes in a prescription if they are not able to

Table 4

Differences in knowledge and skills (main domains and per subdomain) between pharmacy and medical students

	Medical students (n = 451) Score in % (SD)	Pharmacy students (n = 151) Score in % (SD)	P value*	P value ANCOVA†	Effect sizes (Cohen's δ)
Basic pharmacology knowledge	68.2 (9.8)	77.0 (10.3)	<0.001	**<0.001**	0.88
- pharmacodynamics	69.1 (15.1)	74.4 (15.7)	<0.001	**<0.001**	0.34
- pharmacokinetics	69.6 (16.2)	78.6 (14.7)	<0.001	**<0.001**	0.58
- interactions and side effects	71.6 (17.0)	77.3 (16.7)	<0.001	**<0.001**	0.34
- ATC groups‡	63.8 (19.3)	77.6 (18.0)	<0.001	**<0.001**	0.74
Clinical pharmacology or applied knowledge	72.2 (10.8)	73.8 (10.5)	0.124	**0.007**	0.15
- prescribing	65.3 (16.0)	65.8 (15.5)	0.734	0.482	0.03
- prescribing in special groups	72.8 (18.8)	74.8 (16.6)	0.198	0.210	0.12
- drug information, regulation and laws	79.2 (18.3)	83.2 (18.1)	0.020	**0.009**	0.22
- interactions and side effects	71.6 (17.0)	77.3 (16.7)	<0.001	**<0.001**	0.34
Skills/recipe writing	68.6 (26.6)	50.7 (35.3)	<0.001	**<0.001**	0.57

*Student's *t*-test for independent samples. †Covariate analyses by ANCOVA, covariables: age, gender, previous study, study duration, inclusion year. ‡ATC groups: drug groups by the Anatomical Therapeutic Chemical Classification system.

actively reproduce the key elements of a prescription. However, another study suggests that pharmacy students do have relevant knowledge of a prescription [8].

Given that the aim of training is the safe delivery of pharmaceutical care, we did not find either student group to substantially outperform the other. While both groups had a similar performance on topics closely related to patients, namely, prescribing and prescribing for special groups, there were performance differences on other, less patient-related, topics, differences that could constitute a starting point for curriculum improvement. As the strengths and weaknesses of the two groups tended to complement each other, joint interdisciplinary education might be useful and effective, allowing both groups of students to profit from the knowledge and skills of the other profession. Pharmacy students would benefit from medical students' clinical experience and skills, and medical students would benefit from a further grounding in basic pharmacology knowledge. In addition, educational collaboration can improve interprofessional understanding and collaboration in patient care [4, 20, 21].

Despite the fact that this study clearly demonstrated differences in several knowledge and skills domains, measured with a formative test so that differences in study behaviour between the two groups of students would not have influenced the results [22], the results should be interpreted in the light of some limitations. The students' level of knowledge might not be representative of that of other students, nationally and internationally. Since this was a single centre study, the differences found might be due to the curricula of the university involved. The assessments had a rather low internal consistency, which could suggest that reliability was a problem. The internal consistency might have been negatively affected by the relatively short assessment and the relative homogeneity of the study population. However, because the study used a formative assessment, this level of internal consistency is considered acceptable [16]. Moreover, a low internal consistency primarily leads to underestimation of the relation between the studied variables, but since we found significant differences, the low consistency probably did not affect our findings [16]. As the pharmacy students were more advanced in their study than the medical students, we used study phase as a covariate in the ANCOVA but did not find it to affect the main results. In addition, most students had completed their mandatory courses: medical students 100% and pharmacy students 93–100%. Additional analyses using data for the pharmacy students showed that study duration at the time of the assessment did not influence the results, which suggests that the final 2 years of the study do not significantly increase the knowledge and skills of pharmacy students. Moreover, it is debatable whether a pharmacy student needs to be able to write a prescription, as this is not a skill they use in daily practice. The test investigated whether the core information of the prescription was present, and not whether it was present in the right order. All students had received training on the core information required for prescriptions, to enable them to check or write a prescription. Writing a prescription is just one pharmacology and pharmacotherapy skill, but it is one that can be tested in a written test. Other skills, such as patient communication, can only be tested in simulations [23]. There is no literature supporting the involvement of other potential differences between pharmacy and medical students, such as students' character, motivation and school results. In the Netherlands, pharmacy and medicine courses have a restricted number of places, and students with better grades are more likely to be admitted. As medicine is more popular than pharmacy as a study in the Netherlands, the medical students might have needed better school grades than the pharmacy students in order to gain admission to their study. Lastly, there is no clearly defined norm for what constitutes 'sufficient knowledge'. However, since it is essential to avoid medication errors, pharmacotherapy skills should be improved regardless of the norm.

In conclusion the differences between pharmacists and physicians appear to arise during their undergraduate training and education. Pharmacy students had better basic pharmacology knowledge and medical students had better prescribing skills, whereas applied knowledge was similar in the two groups of students. The findings suggest that joint interdisciplinary education would be a rational and useful way to improve curricula, whereby pharmacy students would gain knowledge of prescriptions and patient care and medical students would gain more knowledge of basic pharmacology. More research is needed to study whether these differences in knowledge and skills are still present in pharmacists and physicians after their first years of work experience.

Author contributions

All authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Keijsers, de Wildt, Brouwers, Jansen

Acquisition of data: Keijsers, Hazen

Analysis and interpretation of data: Keijsers, de Wildt, Brouwers, Jansen

Drafting of the manuscript: Keijsers

Critical revision of the manuscript for important intellectual content: de Wildt, Brouwers, Custers, ten Cate, Hazen, Jansen

Statistical analysis: Keijsers

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Administrative, technical, or material support: Jansen

Study supervision: De Wildt, Brouwers, Jansen

Competing Interests

All authors have completed the Unified Competing Interest form at http://www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author). Professor Dr Brouwers reports personal fees from Consultancy Europe-Expro Muenchen[Germ], personal fees from Consultancy Eijkman&Kuipers [NL], personal fees from Consultancy W-Pharma Wavre [B], personal fees from President Ethical Review Board, personal fees from Pharmaceutisch weekblad, personal fees from Tijdschr v Prakt.Farmacotherapie MFM, grants from St.Ondersteuningsfonds Ephor, all outside the submitted work. All other authors declare no support from any organization for the submitted work, no financial relationships with any organizations that might have an interest in the submitted work in the previous 3 years and no other relationships or activities that could appear to have influenced the submitted work.

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