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Presenting clinical pharmacology and therapeutics: evaluation of a problem based approach for choosing drug treatments

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Between 1983 and 1989 three studies were conducted to determine whether the ability of senior medical students to choose drug treatments rationally had improved. This period spanned the implementation of a course in pharmacotherapeutics which trained students to use a systematic problem-based approach to choosing and prescribing drugs. The results show that in the short-term students remembered how to choose drugs rationally for cases known to them (retention effect), but had difficulties in transferring what had been learned to similar but different problems (transfer effect). In the medium-term a retention effect was shown for all three aspects of choice (drug, dosage and duration), and a transfer effect for choosing a dosage and duration when solving almost all types of patient problems used in the study. Transfer of the ability to choose a drug was less easily demonstrable. Compared with control students rational choices of trained students increased significantly for all aspects of drug choice, and almost all patient problems used in the study, whether or not they had been discussed. Possible causes for not finding a full transfer effect are: the intervention (course) may have been too short; there was sufficient knowledge about drugs but a lack of understanding of basic pharmacological concepts; or there was no reinforcement of the problem-based approach during clinical clerkships.

Keywords clinical pharmacology drug choice assessment undergraduate problem solving transfer

Introduction

Choosing a drug is often regarded as a matter of knowing what drug to prescribe. However choice, as part of clinical reasoning, is a complex process (Elstein *et al.*, 1978; Feinstein, 1967; Sacket *et al.*, 1985; Weinstein & Fineberg, 1980; Wulff, 1976). The process can be conducted in various ways, for example intuitively, analytically, or by habit. Several factors determine which approach is used—the kind of decision, the time available, and the personal characteristics of the person making the decision. Normatively (ideally) a drug choice is made analytically or logically. Thus choosing a drug should be considered a skill in using facts about drugs, together with patient data, in a certain way to decide on the best possible treatment for the patient. Students and doctors should therefore be taught *how* to choose a drug rather than telling them *what* to choose.

Guidelines have been developed to aid the choice and prescribing of drugs. A problem-solving model of a stepwise approach to choosing and prescribing drugs was used to develop a course in pharmacotherapy for fifth year medical students (de Vries, 1993a,b). During this course students have to solve fifteen written patient problems, and to choose and prescribe one or more drugs (or no drug) for these patients using the stepwise approach. Because this approach is generally applicable, it was hoped that students would learn to choose drugs rationally not only for the patient problems that had been discussed but also for patient problems which had not been discussed. In other words, students trained in this way would hopefully be able to transfer what had been learned to similar but different situations. Between 1983 and 1989 we examined the first, and therefore key step in therapeutics: the ability of students to choose drug treatments rationally.

Methods

Fifth and sixth year medical students were tested during the clinical part of the curriculum after they had

completed four theoretical years, which included 84 pharmacology and clinical pharmacology lectures, and a short clinical introductory period. Three studies were performed. One control study was carried out before implementation of the course and two experimental studies were conducted to measure the transfer effects. In the control study students were tested who had not followed the course. In a short-term study students were tested before and immediately after the pharmacotherapy course. In a medium-term study students were tested immediately after the course and 15 months later at the end of their clinical clerkships.

Materials

Four types of materials were used: written patient problems and prescriptions written in daily practice to test the ability to choose drugs; a knowledge test and a questionnaire.

Five written patient problems were constructed as short cases by two clinical pharmacologists, several general practitioners and clinicians, and an educational specialist. Two similar patient problems concerned chronic obstructive airways disease (COAD), and three similar problems concerned urinary tract infections (UTI):

Patient problem	*Diagnosis*
1	acute asthma attack (COAD)
2	exacerbation asthma (COAD)
3	vaginal discharge (UTI)
4	cystitis (UTI)
5	acute prostatitis (UTI)

Patient problems were considered similar when the groups of drugs to choose from were more or less the same (bronchodilators/spasmolytics and antibiotics respectively), but the patients and indications were different. The patient problems were designed so that drug treatment was indicated or at least acceptable.

Prescriptions written during the clerkship in general practice for patients with COAD and UTI were used to test the ability to choose drugs rationally in daily practice.

In order to compare the groups all students participating in the three studies had to answer five 'true/false/don't know' questions at the level of the final qualifying exam. These questions were the same as those used in a so-called 'progress test' in which several questions had been supplied by all departments (Cohen-Schotanus, 1982). This type of knowledge test is regularly used to assess the progress of students.

Students participating in the short-term study completed anonymously a questionnaire at the end of the course on (1) the time spent on solving the problems at home, (2) their evaluation of the systematic problem-based approach for choosing and prescribing drugs, (3) their degree of self-confidence in choosing and prescribing drugs, and (4) any other therapeutic lectures attended following the pharmacotherapy course. The evaluation and self-confidence ratings were marked on a four-point scale.

Test procedure

When solving written patient problems students were allowed to use a pharmacology book, a therapeutic reference book, and their personal formulatory, but not to consult each other. Questions concerning the drug choices had to be answered within 15 min.

Scoring

All answers to the written patient problems were summarized on master sheets with no indication as to whether they were obtained before or after the course, or of the student's name. The answers and prescriptions were judged independently by two teachers, a clinical pharmacologist and a general practitioner. Three aspects of a drug treatment. i.e. the drug, dose regimen and duration, were judged as regards the criteria efficacy, safety, convenience and cost. Drug choices were scored 0–4 (no answer, poor, arguable, acceptable or good choice respectively). No answer was judged 0 because it was considered as 'not knowing' and 'not able to find in time'. The dose given and duration were scored 0–2 (no answer, too low/too high or acceptable) in relation to the drug prescribed. An acceptable score on these aspects could be awarded even if the drug which was prescribed was judged poor. There was little difference between scores of the two judges in all three studies, and consensus was easily achieved.

Statistical analysis

Data were analyzed using Student's *t*-test and for cross-over comparisons by analysis of variance (ANOVA nested design) (Keppel, 1973). $P < 0.05$ was taken as statistically significant.

Control study

Design

Two randomly chosen groups of students who had not followed the course were tested: group 1 ($n = 48$) students were about to start the clinical clerkships (control-test 1), and group 2 ($n = 56$) students had nearly finished their clerkships (control-test 2). These control students were tested at the same point in the curriculum as the trained students (see below). Group 1 had to solve one COAD (problem 1) and one UTI patient problem (problem 4). The same problems were presented to group 2. The knowledge tests were taken just before the control tests.

Results

There was no significant difference in the scores of the two tests (Table 1). At the beginning of the clerkships the average score in making a drug choice was 2.95, and at the end 2.83 (the maximum possible score being 4.00). For the choice of dosage schedule and duration the scores were 1.35 *vs* 1.37, and 1.28 *vs* 1.34 respectively (the maximum possible score being 2.00). There

Table 1 Results of the control study (group 1 and 2): the average scores (with standard deviations) of the control-tests 1 and 2, and the average percentages of the correct minus incorrect scores of the knowledge tests. There is no significant difference ($P < 0.05$) between the scores of the two control-tests

Group (test)	*Drug*	*Choice of Dosage*	*Duration*	*Knowledge (%)*
1 (control-test 1)	2.95 (0.72)	1.35 (0.41)	1.28 (0.46)	55.3
2 (control-test 2)	2.83 (0.79)	1.37 (0.38)	1.34 (0.41)	54.2

was no significant difference between the correct minus incorrect scores of the knowledge tests: 55.3 and 54.2% of maximum respectively.

Conclusions

When no specific training in pharmacotherapeutics had been given during the clerkships, the rationality of all three aspects of choice (drug, dosage schedule and duration), and the level of pharmacology knowledge did not alter.

Short-term study

Design

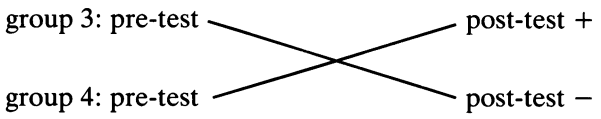
In this study two experimental groups of trained students were examined to determine the short-term effect of the course: group 3 ($n = 103$) and 4 ($n = 100$). Each student had to solve one patient problem just before entering the course (pre-test), and another at the end of the course (post-test). Four patient problems were used, two similar COAD problems (1 and 2) and two similar UTI problems (3 and 4). To measure transfer effects these four patient problems were changed for different groups of students by design, so that one of the two COAD, and one of the two UTI problems were discussed during the course, as follows:

Study group	*Pre-test*	*Course*	*Post-test*
1	2	2+4	1 (−)
2	4	2+4	3 (−)
3	1	2+4	2 (+)
4	3	2+4	4 (+)
5	2	1+3	1 (+)
6	4	1+3	3 (+)
7	1	1+3	2 (−)
8	3	1+3	4 (−)
9	2	2+3	1 (−)
10	4	2+3	3 (+)
11	1	2+3	2 (+)
12	3	2+3	4 (−)
13	2	1+4	1 (+)
14	4	1+4	3 (−)
15	1	1+4	2 (−)
16	3	1+4	4 (+)

((+) = discussed in the course; (−) = not discussed)

The other patient problems discussed during the course were the same for both groups. Students of group 3 had as a post-test the *same* problem discussed during the course (post-test +). Group 4 had as a post-test a problem which had *not* been discussed but was *similar* to the one discussed (post-test −).

To avoid a learning effect of the pre-test, the pre- and post-tests were different for each student. Because the same four patient problems were used in both pre- and post-tests, differences between scores of the same patient problems could be analyzed by cross-over comparisons between group 3 and 4:



The knowledge test was taken before, and the questionnaire after the post-test.

Results

In the short-term study the students' scores for choosing a drug, dosage schedule and duration increased significantly after the course for those problems which had been discussed during the course (Table 2). The average scores were 2.73 *vs* 3.70, 1.40 *vs* 1.79, and 1.34 *vs* 1.74 respectively. For problems which had *not* been discussed increases in scores were not significant (2.44 *vs* 2.98, 1.39 *vs* 1.64, and 1.31 *vs* 1.62 respectively). There was no significant difference between the pre-test scores of both groups: 2.73 and 2.44, 1.40 and 1.39, and 1.34 and 1.31. There was also no significant difference between the correct minus incorrect scores of the knowledge test of each group: 55.4 and 55.6% respectively.

The time spent at home preparing for each plenary session (MEQ) averaged 74 min. The students' evaluation of the merits of the systematic approach to choosing and prescribing drugs averaged 88% of maximum. The average score for self-confidence when choosing and prescribing drugs for patient problems that had been discussed was 85% of maximum. For patient problems not discussed the score for self-confidence was 60% of maximum. Students had not attended any other therapeutic lectures.

Conclusions

In the short term all three aspects of drug choice improved significantly when solving patient problems that had been discussed. However the increase was not

Table 2 Results of the short-term study (group 3 and 4): the average scores (with standard deviations) of the pre-tests, post-test(+) and post-test(−), and the average percentages of the correct minus incorrect scores of the knowledge tests. The differences between the pre- and post-tests of group 3 and 4 were analyzed by cross-over comparisons

Group (test)	*Drug*	*Choice of Dosage*	*Duration*	*Knowledge (%)*
4 (pre-test)	2.73 (1.42)	1.40 (0.68)	1.34 (0.81)	
3 (post-test+)	3.70 (0.74)*	1.79 (0.74)*	1.74 (0.55)*	55.4
3 (pre-test)	2.44 (1.39)	1.39 (0.71)	1.31 (0.79)	
4 (post-test)	2.98 (1.35)	1.64 (0.57)	1.62 (0.60)	55.6

* Significant difference with corresponding pre-test ($P < 0.05$).

significant for patient problems that had *not* been discussed.Thus in the short-term students remembered how to choose drugs rationally for cases known to them, the so-called 'retention effect', but had difficulties in transferring what had been learned to similar but different problems, the so-called 'transfer effect'.

Medium-term study

Design

For 2 years all students who had completed the course were randomly assigned to three groups (5, 6 and 7) to determine the medium-term effect of the course. These groups did not contain students who participated in the short-term study. All had to solve two patient problems presented immediately after the course (post-test). These problems had been discussed during the course —one COAD (problem 1), and one UTI (problem 4). At the beginning of the clerkship in general practice 15 months later group 5 ($n = 81$) had to solve the *same* two patient problems (15 month post-test +). Group 6 ($n = 69$) had to solve two problems *similar* to those presented 15 months earlier (15 month post-test −), but which had not been discussed during the course (problems 2 and 5). Group 7 made copies of any three prescriptions written during the clerkship in general practice which had not (yet) been supervised by the general practitioner. They also provided information about the patients concerned such as age, sex, complaint, diagnosis, use of other drugs, and other illnesses. During the testing period 76 students wrote 226 prescriptions. Forty-seven students ($n = 47$) presented a prescription for a patient with COAD or UTI that could be used for this study (prescription). Those patient problems had therefore presented in *real practice* and had not been discussed during the course.

For groups 5 and 6 the knowledge test was taken before making the 15 month post-test; for group 7 when entering the clerkship.

Results

The medium term effect on the achievement of students was determined in two ways: (1) comparison between the scores in the 15 month post-tests and those 15 months before; and (2) comparison between the scores of the 15 month post-tests in the experimental group, and those in control group 2.

After 15 months of clerkships the skill of group 5 in choosing a drug, dosage schedule and duration did not decrease or increase significantly when the same problems had to be solved as had been presented during the post-test: 3.91 *vs* 3.84, 1.79 *vs* 1.79 and 1.82 *vs* 1.85 (Table 3). When a different but similar problem had to be solved (group 6) the average scores for choice of drug and duration were significantly lower (3.91 *vs* 3.31, 184 *vs* 1.72 respectively), but scores for dosage schedule were the same (1.79 *vs* 1.80). When a related but real patient problem had to be solved (group 7) the scores for drug choice were significantly lower (3.98 *vs* 3.19). Scores for the other two aspects were similar (dose schedule 1.74 *vs* 1.49, duration 1.77 *vs* 1.72).

When compared with control students (group 2), the achievement of the experimental groups (5, 6, 7) in choosing drugs was significantly better. This was so not only for tests on a problem that had been discussed during the course, but also for different but similar problems, and for real patient problems. All 15 month scores in the experimental groups for all three aspects of drug choice were significantly higher than those of control students with one exception (Tables 1 and 3). The choice of dosage schedule for real patient problems showed no significant difference (1.49 *vs* 1.37). There was no significant difference between the knowledge tests of the trained and control students; the average correct minus incorrect scores were 55.3, 56.1, 55.7 and 54.2% respectively.

Conclusions

After 15 months of clerkships all three types of choice remained at the same relatively high level when solving patient problems which were discussed during the course. The ability to choose a drug and duration of treatment decreased when solving similar but different patient problems, and the ability to choose a drug decreased for a similar but different patient in real practice.

Comparison between the control students and the trained students showed that such training improved the ability to choose; all scores but one in the experi-

Table 3 Results of the medium-term study (group 5, 6 and 7): average scores (with s.d.) of the post-tests, 15 month post-test (+), 15 month post-test(−) and prescriptions, and the average percentages of the correct minus incorrect scores of the knowledge tests

Group (test)	*Drug*	*Choice of Dosage*	*Duration*	*Knowledge (%)*
5 (post-test 1)	3.91 (0.25)	1.79 (0.31)	1.82 (0.27)	
(15 month post-test+)	3.84 (0.28)†	1.79 (0.29)†	1.85 (0.25)†	55.3
6 (post-test)	3.91 (0.25)	1.79 (0.30)	1.84 (0.28)	
(15 month post-test−)	3.31 (0.68)*†	1.80 (0.32)†	1.72 (0.34)*†	56.1
7 (post-test)	3.98 (0.15)	1.74 (0.49)	1.77 (0.54)	
(prescription)	3.19 (0.82)*†	1.49 (0.69)	1.72 (0.54)†	55.7

*Significant difference with corresponding post-test ($P < 0.05$).
†Significant difference with control-test 2 of control students ($P < 0.05$); (see also Table 1).

mental groups at the end of the clerkships were significantly higher than those for control students.

Thus a medium term *retention* effect occurred for all three aspects of choice. Students could *transfer* what had been learned to nearly all similar but different patient problems when choosing a dosage and duration, but not when choosing a drug. Compared with control students rational choices increased significantly for all aspects of drug choice, and almost all types of patient problems used in the study.

Descriptive results

Further analysis revealed interesting descriptive results regarding the judgments (Figure 1). In the *control-study* drug choice was judged good or acceptable in 64 and 62% of both tests respectively. For choosing a dosage schedule and duration these figures were 44 *vs* 42%, and 45 *vs* 46% respectively. The data of the *short-term study* revealed that for problems discussed during the course (post-test +) good/acceptable judgments increased for all three aspects of drug choice. For choice of drug 57 *vs* 94%; for dose regimen 51 *vs* 81%; for duration 50 *vs* 81%. For problems not discussed (post-test −) the figures were 48 *vs* 74%, 54 *vs* 67%, and 54 *vs* 69% respectively. Further data analysis of the *medium-term study* revealed that for problems discussed (15 month post-test +) the good/acceptable choices in the experimental group for all three aspects of drug choice were: for choice of drug 98 *vs* 99%; for dose regimen 80 *vs* 79%; for duration 83 *vs* 85% (Figure 1). For problems not discussed (15 months post-test −) the figures were 99 *vs* 86%, 80 *vs* 81%, and 86 *vs* 73% respectively. For problems in real practice (prescriptions) the figures were 98 *vs* 85%, 77 *vs* 58%, and 79 *vs* 75% respectively. The good/acceptable choices in the experimental group for all three aspects of drug choice were higher than those in control students.

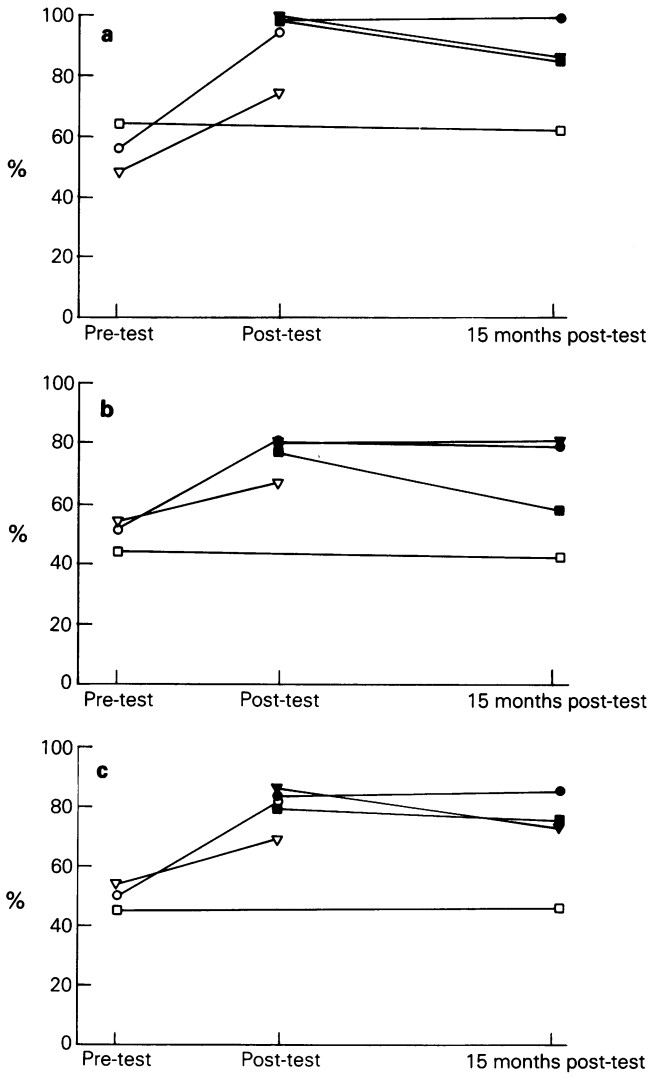


Figure 1 Percentages of the good/acceptable judgments in the control, short-term and medium-term studies for three aspects of drug choice (a drug, b dosage schedule and c duration). Control study: □; short-term study: ○ = post-test (+), ▽ = post-test (−); medium term study: ● = 15 months post-test (+), ▼ = 15 months post-test (−); ■ = prescriptions.

Discussion

The results show that in the short-term students remembered how to choose drugs rationally for cases known to them (retention effect), but had difficulties in transferring what had been learned to similar but different problems (no significant transfer effect). In the medium-term a retention effect was shown for all three aspects of choice (drug, dosage and duration), and a transfer effect for choosing a dosage and duration when solving almost all types of patient problems used in the study. Transfer of the ability to choose a drug was less easily demonstrable. Compared with control students rational choices of trained students were significantly better for all aspects of drug choice, and almost all types of patient problems used in the study.

The improvements can be ascribed to the training in pharmacotherapeutic skills as the groups were assigned randomly and did not differ in their level of pharmacology knowledge. Trained students were tested at the same points in the curriculum as the control students, there were no other major curriculum changes during the study period and there was no other specific training in therapeutics. The only difference between the control and trained students was the exposure of the latter to systematic training and assessment in choosing and prescribing drugs.

Why was a transfer effect not as fully demonstrable in trained students? The hope was that systematic training in choosing and prescribing drugs would induce transfer behaviour, because the approach would be generally applicable to any patient problem.

This may be explained by considering known general requirements for transfer (Gage, 1967; Schmidt, 1983; Simons & Vershaffel, 1992), and other findings in this study. The requirements to stimulate transfer behaviour, which were assumed to be present in the course, include:

(a) something has been retained initially,
(b) the initial learning is perceived as meaningful,
(c) the new situation is perceived as similar to the initial learning situation,
(d) general principles have been emphasized,
(e) sufficient opportunities have been provided to apply the methods, particularly for sequential and cumulative learning.

Considering these requirements, the choice of drug, of a dosage-schedule and of treatment duration will be discussed.

Concerning the *choice of drug* three reasons for the questionable transfer effect are suggested.

1. During the first sessions of the course students reported difficulties in choosing a drug, but also in perceiving as meaningful the general concept, the model for choosing a drug. They argued that formularies and textbooks already exist to provide the information they needed. This may be explained by a tendency to simplify 'complex' situations by using simple decision rules and standard procedures (Vlek, 1987), probably because of shortcomings in memory. However, the knowledge test results suggest that lack of factual knowledge about drugs was not a major reason for students tending to simplify the 'complex' choosing process. The average scores were not high but were acceptable. However the way that students justified their choices in the tests and in the plenary sessions suggested that a lack of understanding of basic pharmacological principles could be a major factor. They did not seem to know how to use facts about drugs when choosing a drug. Explaining these principles to them when discussing the drug treatments resulted in retention of what had been taught and acceptance of the general concept, but not to full transfer of the process to choosing a drug rationally when solving different patient problems.
2. There were possibly insufficient opportunities to apply what had been learned. The course may have been too short (10 plenary sessions, on average lasting one and a half hours). Most students mentioned this spontaneously in the questionnaire, and a second pointer is the relatively low self-confidence score for solving patient problems which had not been discussed.

   Few opportunities arise in the 15-month period of clerkships which follows. Enquiry among 40 randomly chosen students in Groningen just before graduation revealed that little time is spent on therapeutics during clinical clerkships, and that they had little opportunity to choose drugs themselves (de Vries, 1986). They estimated that the ratio of diagnostic to therapeutic instruction was 95 to 5%.
3. The same enquiry also revealed that advice on drug therapy received during clerkships was often of the 'cook book' kind, relying on empirical methods. The advice was rarely backed by reasons, but by statements such as 'because I have experience of this drug'. Enquiry among clinical teachers at all universities in The Netherlands between 1988–1990 provided further evidence of this problem (Metz *et al.*, 1990). Considering three teaching objectives, drawing up, executing and evaluating a drug treatment, 50% of clinical teachers thought that students had to learn these through 'direct training'. Others thought that 'discussing and watching' (20%), or 'practice makes perfect' (30%) were the methods of choice. This suggests that the general concept of choosing a drug was probably not reinforced during the clerkships at the time of this study.

Choosing a drug is obviously a difficult skill that needs systematic training. There are usually many drugs available, and it requires competence in weighing pharmacodynamic and kinetic properties of drugs in the framework of patient problems.

Choosing a *dosage schedule* needs different skills from choosing a drug. One can look up the standard dosage, but standard dosage schedules are often presented as a range (for example 20–80 mg 2–4 times daily). Therefore choosing the right dosage requires some understanding of pharmacokinetic principles and the use of these when choosing or adjusting a dosage schedule for a particular patient. Students seemed to learn this since there was a short- and long-term retention and transfer effect. The intervention was probably too short to produce a more rational approach to choosing

dosage schedule in daily practice because no difference was found if compared to the control group.

Choosing the *duration of treatment* appears to be difficult in another way. Often no information can be found in textbooks, compendia or formularies, and in many cases the duration cannot be deduced easily from pathophysiology or the mechanism of action of drugs. The initial training period was sufficient to effect short-term and medium-term retention. However experience during the clinical clerkships was insufficient to increase rational decision-making regarding this aspect. Nevertheless, a positive transfer effect occurred when students had to choose treatment duration themselves for real patients during general practice clerkships. Experience gained during this particular clerkship may be responsible for that.

In conclusion, training students in a stepwise approach to choosing drugs resulted in short- and medium-term retention, and a considerable medium-term transfer effect. Transfer behaviour was less than was hoped for, possibly because the intervention may have been too short, there was incomplete understanding of basic pharmacological concepts, and there was no reinforcement of the approach during clinical clerkships. The present study does not of course prove that this form of training is the only way to produce this outcome, and indeed there may be better methods. This study does however show that possession of sufficient factual knowledge about drugs does not guarantee rational use of the knowledge when choosing drug treatment. Students trained to use a stepwise approach were much better equipped to choose drug treatment rationally than were their colleagues who were not trained in this way.

More research is needed to find ways of enhancing transfer behaviour. Teaching students and doctors everything about the thousands of drugs available is quite impossible. Nor can they be taught to solve every patient problem which will confront them later in practice. Furthermore, new drugs with unpredictable properties and problems will continue to be introduced to medical practice. If future physicians are to be properly equipped to choose them and use them it is vital that they are trained in rational approaches to use basic pharmacological principles when treating patients.

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