04/14/2023

Student- run clinic

Effect of a medical masters' curriculum-embedded student-run clinic on prescribing skills of medical students at Erasmus MC, Rotterdam

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Leken samenvatting

Medicatie veiligheid is erg belangrijk. Het is aangetoond dat de meeste medicatie fouten worden gemaakt tijdens het voorschrijven van medicatie. Net pas afgestudeerde doktoren zijn verantwoordelijk voor het voorschrijven van ongeveer 70% van de medicatie. Terwijl, juist deze jonge doktoren de meeste voorschrijffouten maken. Master studenten krijgen tijdens hun master weinig de gelegenheid om hun voorschrijfvaardigheden te oefenen. Dit kan verbeterd worden door meer praktische oefensessies aan te bieden. Een Student-run-clinic maakt dit bijvoorbeeld mogelijk. Een student-run clinic is een polikliniek die voornamelijk wordt gerund door nog niet afgestudeerde medische studenten. In het Erasmus medisch centrum is de student-run clinic een verplicht onderdeel voor de studenten die het coschap interne geneeskunde lopen. Gedurende deze student run clinic zijn de studenten verantwoordelijk voor de consulten met de patiënten gericht op cardiovasculair risicomanagement. Indien noodzakelijk stellen de studenten een behandelplan op met bijhorende medicatie. De zaken worden eerst overlegd met een supervisor voordat de informatie wordt teruggekoppeld aan de patiënt. Ook zijn de studenten betrokken bij de nazorg van de patiënt: controle van de toestand van de patiënt, goed gebruik van medicijnen, en of aanpassingen in het behandelplan nodig zijn. De studenten presenteren hun bevindingen tijdens een overleg waarbij verschillende professional aanwezig zijn.

Deze studie onderzocht het effect van deelname aan SRC op de voorschrijfvaardigheden van master geneeskunde studenten in vergelijking met studenten die niet aan SRC deelnamen. Enerzijds gericht op de academische prestaties. Anderzijds op het zelfvertrouwen tegenover medicatie voorschrijven. Daarbij werden de resultaten van de formatieve vaardigheden toets, landelijke Nederlandse farmacotherapie toets en de antwoorden op vragenlijsten bekeken. Een formatieve toets is een toets die niet meetelt als cijfer, maar dient als leerproces door middel van feedback.

Er was geen verschil in resultaat te zien voor de formatieve toets. In de landelijke Nederlandse farmacotherapie toets scoorden de SRC studenten beter binnen de categorie pijn medicatie en voor benzodiazepines. De vragenlijsten waren vooral gericht op de gedachtes tegenover hun medicatie gerelateerde vaardigheden. De resultaten van de vragenlijst lieten zien dat de SRC groep zich gedurende het jaar positief ontwikkelende op het gebied van zelfvertrouwen tegenover hun medicatie gerelateerde vaardigheden.

SRC lijkt een mooie ervaring voor studenten om vroegtijdig in hun master op een veilige manier op een eigen polikliniek te leren voorschrijven onder supervisie. De vraag is alleen of de meerwaarde van SRC uit te drukken is in de prestaties van studenten.

Abstract

Aims: the prevalence of prescribing errors are common, especially among junior doctors. Undergraduate master students acquire few opportunities to prescribe medication during their studies. The implementation of an embedded Student-run-clinic (SRC) offers the opportunity for medical student to practice their prescribing skills in a safe environment. The aim of this study was to examine the impact of participation in SRC on medical students' attitudes towards and academic performance in pharmacotherapy.

Methods: this was a retrospective cohort study among first-year medical students at Erasmus Medical Centre, The Netherlands. The amount of errors, type of errors, and impact of these errors made in the skill-based formative assessment were analyzed. Secondly, the percentage scores within different subcategories (A-L) from the National Dutch Pharmacotherapy assessment (NDPA) were analyzed. Lastly, medical students were asked about their attitude towards and confidence in pharmacotherapy through online survey questionnaires.

Results: In the skill-based formative assessment no significant difference was observed in the amount of errors, type of errors and its consequence between the SRC and non-SRC group. The SCR group made less opium law errors (9.4%) and prescribed amount errors (20%) compared to the non-SRC group. 7.6% more SRC students passed the National Dutch pharmacotherapy assessment on their first attempt than non-SRC students and scored on average a higher percentage in the following 8/12 categories: pain medication (A), cardiovascular (C), antidepressants (E) , benzodiazepines (F), antibiotics (G), pharmacokinetic (H), drug allergy (I) and good use of medicines (K). This difference was significant for pain medication (A) and benzodiazepines (F) ($p = <0.05$). The survey questionnaires revealed that SRC students prescribed more often during internships in the beginning of their master year compared to non-SRC students. In addition, the SCR-group showed a consequent increase in scores over the duration of the year, but this is not the case for the non-SRC group.

Conclusion: In short, SRC offers an opportunity for medical students to learn how to prescribe medication safely at their 'own' outpatient policlinic. Although SRC is a great learning experience for students. The question is whether this learning experience can be quantitatively determined by means of assessments.

Key-words: medical education, medical student, pharmacotherapy, student-run clinic, prescribing

Introduction

Medical errors are unintended failures that can occur in any healthcare setting. The most common cause of these failures include incorrect medical treatments (1). In the Netherlands the HARM-study demonstrated that 2,4% of all hospital admissions and 5,6% of all acute admissions were related to a medication error (2). Additionally medication errors have been estimated as the primary cause of preventable harm to patients (3).

A medication error is defined as any preventable event in the medication treatment process that might cause less effect of the treatment or an adverse effects to the patient (4). In more detail, medication errors can occur at any step in the medication route. This route begins when a clinician prescribes the medication and ends after medication administration to the patient. Research confirms that most of the medication errors are related to the prescribing stage (5).

The World Health Organization (WHO) introduced a guide for good prescribing (GGP) that is based on a six-step model for therapeutic reasoning and prescribing (6). As defined by the WHO, rational prescribing includes making a diagnosis, determining the prognosis, establishing the goal of therapy, verifying treatment choices and monitoring of the treatment (7). Errors in therapeutic reasoning are frequently made during the prescription decision or technical prescribing process. Think of prescribing the wrong drug, drug dose, dose interval, dosage form, prescribed amount, providing of inadequate information, and administrative errors (8).

Junior doctors prescribe about 70% of the medication (8). It appears that especially these junior doctors are more likely to make prescribing errors (9). A large multi-center study (EQUIP study) showed that 9% of junior doctors' prescriptions contain an error. A vast proportion of these errors is due to the inadequate information type (8). This inadequate information type includes information provision to patients such as providing the appropriate usage instructions for medication. Although it is expected that young doctors perform an essential prescribing role.

The prescribing competence of junior doctors might be suboptimal because of inadequate clinical pharmacotherapy training (CPT) during their medical education that focused on the prescribing skills of the students. (10). Different skills are required to write accurate prescriptions. Such as adequate knowledge about the patients' health and that the medication serves the patient's needs (11), making this a challenge for developing the best educational program for medical students (11).

Most of the medical students do not feel adequately prepared for their future prescribing task and neither feel confident in their own prescribing competencies (12). Current medical curricula could be improved in preparing medical students on the principles of therapeutic reasoning for safe and effective prescribing (13).

Meanwhile, there is awareness about the fact that medical interns acquire few opportunities to prescribe medication during their training to become a doctor. This means that interns will mainly observe other doctors during the prescribing decision and technical prescribing process. Thus, it is believed that enrichment of pharmacotherapy training with real-world context will acquire junior doctors reliable prescribing skills. (14). Medical students should be more involved during daily clinical practice by treating real patients under the supervision of senior clinicians. Only an authorized person may prescribe medication , therefore supervision is required when students prescribe medication.

Interventions to improve prescribing practice for medical students are necessary. At this point, pharmacotherapy education in the European union is mainly focused on the theory instead of practice (15). However, education on clinical pharmacotherapy (CPT) is continually evolving. Think of introducing online programs such as e-learning models and the flipped-classroom model for interactive classes (8).

It is believed that contact with real patients will have beneficial effects on medical students performances. The transition from theory to practice can be improved by the implementation of practical prescribing training occasions (16). Previous studies demonstrated that learning by doing in practice turns out to be more effective than formal classroom-based instruction (11). Problem-based learning methods with patient simulation and real-life prescribing should be embedded in undergraduate CPT education (11). For instance, implementation of a Student-Run-Clinic (SRC) offers the opportunity for medical students to practice with real patients in a safe environment (17).

Student-run clinics (SRCs) are outpatient clinics mainly run by undergraduate medical students (17). At a student-run clinic, medical students see patients themselves, draw up a treatment plan and prescribe medication under the supervision of an internal medicine specialist (18). Prior studies demonstrated how SRCs improved patient care. However, few publications revealed SRCs educational value focused on both the skills and attitude towards prescribing medication (21).

Student-Run Clinics (SRCs) originally come from the United States of America. Since 1960 SRFCs have been an integral part of medical schools in the USA (19). These student-led clinics had the purpose of enhancing medical services at no cost to the uninsured and underserved populations (18). Nowadays, SRFCs also have been integrated in medical schools throughout Europe (20). In Europe, healthcare is organized differently than in the USA , most European countries have better access to healthcare (19). A study by R. Drexler *et al* demonstrated the usefulness of SRFC for a European city like Hamburg. The main objective of the implementation of SRFC was to provide healthcare services for everyone in this city. Besides, a SRFC provides teaching purposes for medical students who valued their experiences by volunteering in an SRFC with improved professional and personal qualities (19). These qualities consist of improved knowledge and skills in CPT, understanding of their role in an interprofessional team, and increased empathy toward patients (19).

In 2012, a SRC was set up in Amsterdam University Medical Centers (Vumc) to create clinical learning opportunities for medical students (21). In this concept medical students were responsible for outpatient consultations, including pharmacotherapy (22). Participating in the SRC was extracurricular, which means that medical students only participated on a voluntary basis. Medical students and supervisors valued the SRC and its educational value. (23). Based on these findings it is assumed that this context-based learning method with additional responsibilities, such as prescribing medication, improves medical education in pharmacotherapy.

Since 2020, Erasmus Medical Centre (MC), Rotterdam founded a student-run clinic (23). Erasmus MC is the first Dutch academic center with a learner-centered student-run clinic embedded in their medical curriculum that focuses primarily on pharmacotherapy. In more detail, all fourth-year medical students who follow their internship internal medicine at Erasmus MC take part in the SRC (24). The main purpose of this SRC is to learn medical students as early as possible reliable prescription skills according to the WHO-six-step model for rational pharmacotherapy.

All medical students at Erasmus MC start their medical master curriculum with ten weeks of education. Students are taught the basic skills of writing a prescription through informative theoretical and interactive classes. These ten weeks of education are followed by ten weeks of internal medicine clerkship. During the first week the students get information about SRC, and the SRC takes place in the third, fourth and eight week. During the third and fourth weeks of the internal medicine clerkship, students are teamed up in pairs and are responsible for consultations with patients with regular clinical care.

The outpatient contact consultations focuses on cardiovascular risk-management (e.g. for patients with hypercholesterolemia, hypertension, HIV or gastrointestinal ischemia). During these consultations, 45 minutes of time is reserved for the first conservation with the patient. The interns perform the patient consultation and the physical examination. If necessary the interns draw up a treatment plan including medication. Everything is discussed with the supervisor (clinical

pharmacologist) before the information is fed back to the patient. Upon agreement of the patient medication is prescribed by the interns according to the WHO-six step method for rational prescribing and the national guidelines (e.g. NHG. Lipid tools and LEEFH).

Also, students are involved in the follow-up of their own consultations, which promotes longitudinal learning. In the eighth week of the clerkship, the students are able to schedule a follow-up appointment with their patient through a phone conversation or physically in the outpatient clinic. This conservation verifies the patient's condition, right use of medication and whether adjustments are needed to be made to the treatment plan. Finally, students present their cases during a monthly multidisciplinary consultation (MDC) about the student-run clinic. All pharmacy interns from the hospital pharmacy, a clinical pharmacologist, a hospital pharmacist (in training) and a consultant in internal medicine join these MDC's. It is believed that participating in these MDC's will give students the opportunity to gain new insights from other professionals and to pronounce their own ideas.

In short, a SRC offers an opportunity for medical students to learn how to prescribe medication safely at their 'own' polyclinic. Erasmus MC is the only academic center in the Netherlands where the student-run clinic is an obligatory part of the internships that focuses on pharmacotherapy. It is believed that SRCs provide a vast educational value: it is an innovative opportunity, where early patient exposure and additional responsibilities such as prescribing medication themselves can improve student clinical competence. Furthermore it is hypothesized that participating in SRC will contribute to medical students' personal and professional growth.

The innovative aspect of this study is that these hypotheses will be examined by comparing the prescribing errors from assessments and the experiences towards prescribing medication between students who did and did not participate in a SRC. This study examines the following research question: What is the impact of participation in SRC on medical students' attitudes towards and skills in pharmacotherapy , related to fellow students who did not participate in SRC during their master curriculum in Erasmus MC?

Methods

This retrospective cohort study was conducted among medical master students at Erasmus MC, Rotterdam, the Netherlands. Since 2020, an embedded SRC was introduced at the department of internal medicine at Erasmus MC.

Data from 230 students' formative skill-base assessment, National Dutch pharmacotherapy assessment (NDPA) and survey questionnaires were available. 25 students were randomly selected from a group of 230 students and matched with another 25 students , which resulted in a group of 50 students. To make a reliable comparison between the students, these students were matched on the start date of their master curriculum (same cohort) , and opposite matched on SRC participation.

Inclusion

Approximately 70 students started every ten weeks with their clerkship internal medicine. These students were randomly assigned to regional hospitals for their clerkships. Of these, 12 students followed their internal medicine clerkship at Erasmus MC. The remaining students followed their clerkship internal medicine in other regional hospitals. All students who started their master curriculum from august 2020 , were requested to participate in this study. Students were informed written and orally about the study and had to sign an informed consent form for participation. Exclusion criteria were students who discontinued their masters' medical training.

Data collection

50 medical students were assessed on their skills through the results of the formative skill-based assessment and Dutch National Pharmacotherapy assessment (DNPA). Furthermore, students were asked about their attitude and confidence towards pharmacotherapy through online questionnaires.

Formative skill-based assessment

After the first clerkship internal medicine, students made a formative skill-based assessment as part of their regular curriculum, as presented in figure 1. This digital assessment was taken in the online program P-scribe (25). This assessment could be completed in their own time during two weeks.

The assessment consists of two case-based prescriptions with a predefined drug. The assignment is to write a complete prescription that meets the right criteria according to the national guidelines. Different questions were assigned to different groups based on the start date of medical students. The questions were developed by CPT teachers and consisted at least of one opioid or child receipt. Students were not graded on this assignment, but received personalized feedback from a CPT teacher. The prescriptions were graded as insufficient, sufficient, or good. Besides, a maximum of 9 points per prescription was assigned according to a standardized protocol.

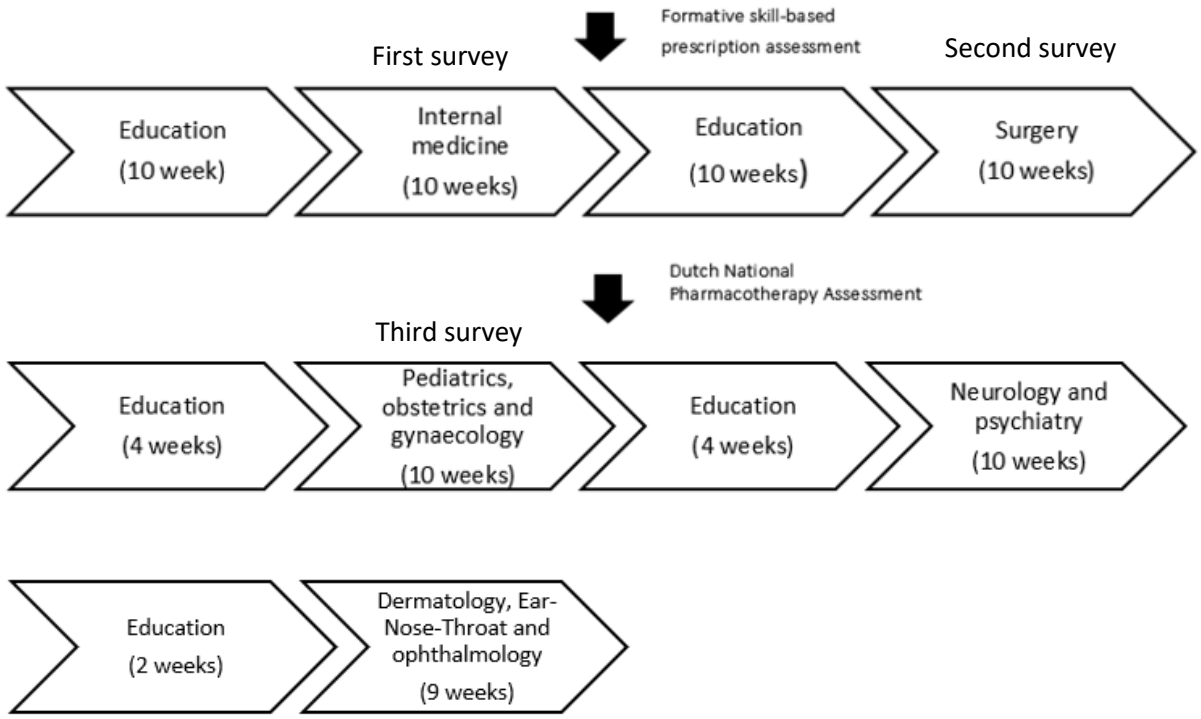


Figure 1. Master medical curriculum including skills and knowledge assignments at Erasmus Medical Centre.

The amount, type of error, and impact of errors made by students were extracted from P-scribe and processed using the database management system Castor ECD (26) . The categorization of the error types within each category is shown in table 1.

Table 1. error types within each category

Category	**Types of error**
Wrong drug dose	- Dose too low - Dose too high
Wrong dose interval	- Incorrect drug interval o e.g. immediate release instead of MGA release o e.g. if necessary instead of maintenance dose. o e.g. 2dd instead of 4dd
Wrong dosage form	- Incorrect or less desirable dosage form
Wrong prescribed amount	- Insufficient prescribed which makes the prescription unfriendly - Insufficient prescribed to finish treatment - Too much prescribed for newly started chronic drugs - Too much prescribed for necessary treatment
Inadequate information	- No weight of child - No indication stated when necessary

	- No concentration or dose stated - No dosage form stated - No amount to supply stated - Missing maximum use when necessary - Dose is not measurable (e.g. 3,47 ml) - Wrong usage instructions - Missing usage instructions - No “with controlled release product” stated with the drug name when prescribed as a “with controlled release” product - No duration of the treatment is stated - Confusing information
Administrative error	- Missing patient data - Non-existent preparation - Missing prescribed amount
Administrative error – opium	- Numbers and words are not completely written out - Initial instead of signature
Wrong Drug	

The categorization for the impact of the errors was derived from the classification of the National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) (27). The possible consequence of the error was assessed as if it would have occurred in a real prescription. The applied categories for this study according to the NCCMERP with some examples are represented in figure 2.

B- error occured but the error would not have reached the patient

- Administrative
- No weight of child

C - error would have reached the patient, but would not had the potential to cause patient harm

- Confusing information
  - Not relevant information stated on prescription
- Missing information
  - E.g. capsules only use for appropriate inhaler
  - Operating instructions for inhalation are missing – capture by pharmacy
- Compliance
  - Amount of ml intake for child not preferable
  - Half tablet instead of whole tablet in same dosage
- Too much prescribed for chronic drugs/ or necessary treatment
- Wrong drug interval
  - fentanyl patch 1dd instead of per 48/72 hours.

D - Error would have reached the patient and would have required additional monitoring to confirm that it resulted in no harm and/or would have required intervention to preclude harm

- Too much prescribed for necessary treatment
  - Herevaluation on response and tolerability after 1 week
  - There is no indication for longer use
- Insufficient prescribed to finish treatment/ which makes the prescription patient-friendly
- Missing usage instructions
  - Can lead to a sleep disorder
  - Intake without food increases the risk of gastrointestinal complaints
  - Maximum use per day is missing
  - Intake with dairy products can lead to be less effective
  - Chewing the ciprofloxacin tablet can lead to be less effective
  - To use 'If necessary "is missing
  - Applying fentanyl patch on the wrong area
- Drug interval between the doses is not mentioned
- Wrong drug dose
  - Dose child based on weight but within max tolerated dose
- Wrong dosage form
  - Tablets instead of suspension for young child
- Amount to supply is missing
- Missing duration of treatment / 'finish the prescription' text
- Compliance
  - Immediate release 4dd5 tablet instead of MGA

E - error occurred that would have contributed or resulted in temporary harm to patient and would have required intervention

- Missing usage instructions
  - MGA product is missing instruction “not chewing”
- Wrong dosage interval
  - Equivalent calculation from morphine 100 mg to oxycodone is 200 mg. 1 MGA tablet works for 12 hours. 2dd 80/120 mg instead of 5d1t 40 mg.
- Wrong drug dose
  - Dose way to low, no curative treatment goal
- Prescribed half tablets of Augmentin while breaking is not possible

G - error occurred that would have resulted in permanent harm

I - error occurred that would have resulted in death

- Lethal dose fentanyl
  - Fentanyl patch prescribed 100 mg instead of 100 ug

Figure 2. Impact of error according to the NCCMERP taxonomy

Dutch National Pharmacotherapy Assessment

During the 5th year medical students were tested on CPT knowledge through the Dutch National Pharmacotherapy Assessment, as shown in figure 1. This assessment consists of 60 multiple-choice questions divided in different subcategories (A – L) , taken in de online program TestVision (28) . For this assessment, the percentage scores on different subjects (A - L) were compared between the SRC and non-SRC group. An overview of these categories is represented in table 2.

Table 2. National final terms with regard to medication safety

Subject	
A	Pain medication
B	anticoagulants
C	Cardiovascular
D	Antidiabetics
E	Antidepressants
F	Benzodiazepines
G	Antibiotics
H	Pharmacokinetic
I	Drug allergy
J	Laws and Regulations
K	Good use of medicines
L	Pregnancy and lactation

Survey questionnaires

Lastly, students were asked about their attitude towards and confidence pharmacotherapy. Students were sent online questionnaires through LimeSurvey (29) during the completion of their curriculum. The first survey was sent after the internal medicine clerkship. The second survey was sent after the surgery clerkship and the third survey was sent after the pediatrics/gynecology clerkship (see figure 3).

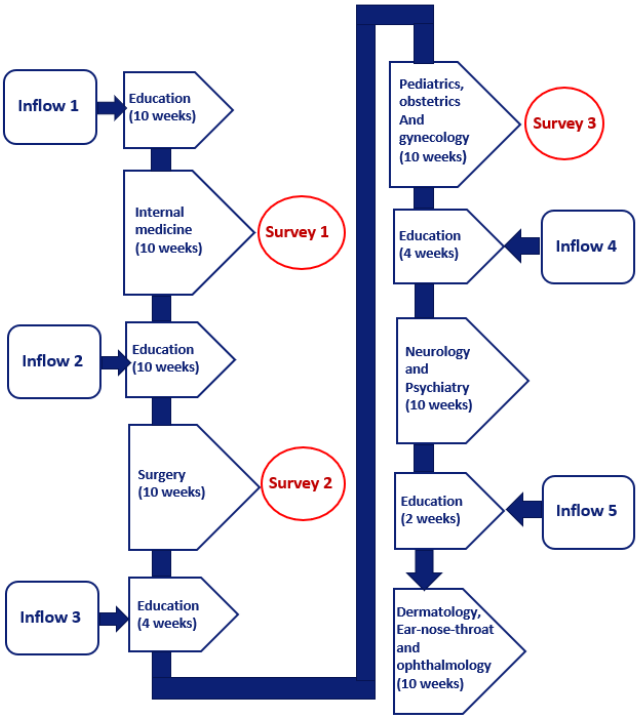


Figure 3. Step-Wedge design questionnaires

To minimize intervention bias, the surveys were sent using a step-wedge design. Every 10 weeks a new inflow has started with their master degree. During the whole curriculum, there were different starting points (inflow 1-5). Figure 3 shows which cohort groups were eligible to answer the survey questionnaires 1,2, and 3. Inflow 1 was able to answer the first, second and third survey. Inflow 2 was able to answer the second and third survey. Inflow 3 was able to answer the third survey. Both inflow 4 and 5 were not eligible to fill in the surveys. However, all these surveys were not mandatory.

The surveys consist of different statements about prescribing medication. The statement on the 5-point Likert scale were categorized with numbers 1-5: 1 = strongly disagree, 2 = disagree, 3 = neither agree or disagree, 4 = agree and 5 = strongly agree.

Statistical analysis

Statistical analyses was done through IBM SPSS statistics 28.0 (30). To compare the baseline characteristics of both groups descriptive statistics was used. Chi2 test was done for the comparison on the frequency of prescription errors made on the formative skill-based assessment between the SRC and non-SRC group. Mann-Whitney test was used to compare the results on different question categories in the Dutch National Pharmacotherapy Assessment between the SRC and non-SRC group. The data from the survey questionnaires consist of multiple-choice and qualitative data. Independent sample T-test was done for comparison the multiple choice data between the SRC and non-SRC group. The qualitative data was categorized, quoted and further explained in text. The graphs were designed using Graphpad prism 6 software (31).

Results

The population characteristics of the 50 students are represented in table 3. The gender and ages were equally distributed among both SRC and non-SRC group.

Table 3. Population characteristics

		SRC participation		
		Yes (n, and %)	No (n, and %)	Total (n, and %)
Number of students		25 (50%)	25 (50%)	50 (100%)
Gender	**Female**	18 (54.5%)	15 (45.5%)	33 (66%)
	Male	7 (41.2%)	10 (58.8%)	17 (34%)
		SRC participation		
		Yes (mean)	No (mean)	Total (mean)
Age (year)		24.3 [23.5 – 25.2]	24.7 [24.2 – 25.3]	24.5 [24.0 – 25.0]

Formative skill-based assessment

From 48 of the 50 students, information on the formative skill-based assessment was yet available. The other 2 students still have to make the assessment. 24 students participated in SRC and 24 did not participate in SRC. Each assessment included two case-based prescriptions, which results in 96 (see figure 4) prescriptions

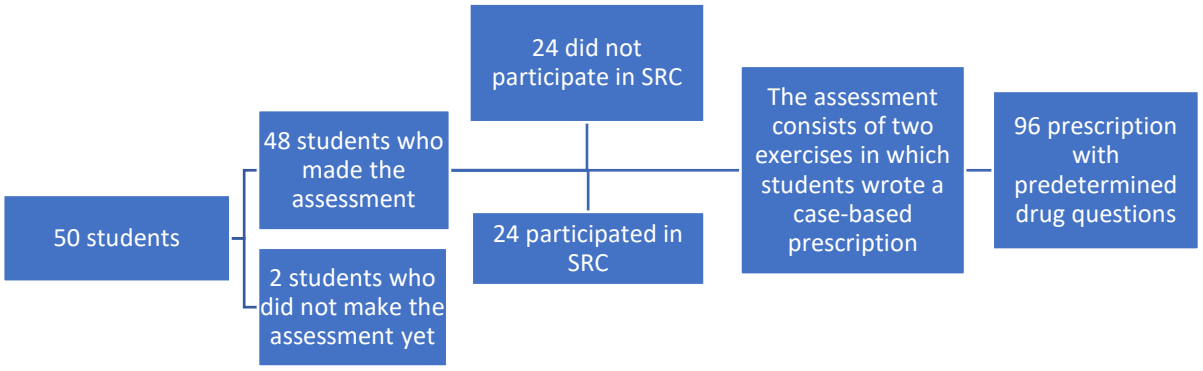


Figure 4. Number of students who made the formative skill-based assessment and available prescriptions

CPT teachers graded these 96 prescriptions with insufficient, sufficient or well done. These findings revealed that most of the prescriptions received a sufficient rating (41.7%) (see table 4). The percentage of prescriptions graded as insufficient were 15,4% higher in the SRC group compared to the non-SRC group, however this difference was not statistically significant (p = 0.0557).

The SRC-group made 2.67 errors on average per prescription. The non SRC-group made 2.63 errors on average per prescription. This difference was not statistically significant: (p = 0.909) .

Table 4. Grade and number of errors per prescription (Total 96)

	SRC participation			
Grade per prescription	Yes (n, %)	No (n, %)	Total (n, %)	Sign.
Insufficient (n = 26)	15 (57.7%)	11 (42.3%)	26 (27.1%)	0.557
Sufficient (n = 40)	19 (47.5%)	21 (52.5%)	40 (41.7%)	0.875
Well done (n = 30)	14 (46.7%)	16 (53.3%)	30 (31.2%)	0.856
	SRC participation			
Error per prescription	Yes (mean)	No (mean)	Total (mean)	Sign.
Number of errors	2.67 (2.15 – 3.19)	2.63 (2.11 – 3.14)	2.65 (2.29 – 3.01)	0.909 [-0.766 – 0.682]

The prescriptions were divided into the three following categories: opioids (n = 18 , 18,75%) , children (n = 41 , 42.7%) and residual (n = 37 , 37,75%). The mean number of errors per question category are represented in table 5. With an average of 3.59 errors, children prescriptions had the most errors, followed by opioid prescriptions with an average of 2.78 errors, and residual prescriptions with an average of 1.54 errors per prescription.

No statistical significant difference was observed between the SRC and non-SRC group on the question categories.

Table 5. Mean errors per question category (96 total)

	SRC participation			
Question category	Yes (mean)	No (mean)	Total (mean)	Sign.
Opioids (n = 18)	2.50	3.13	2.78	0.527 [-1.280 – 2.540]
Child (n = 41)	3.75	3.43	3.59	0.536 [-1.326 – 0.686]
Residual (n = 37)	1.56	1.53	1.54	0.935 [-0.705 – 0.685]

The errors made in the assessment were further categorized in different types of errors (see table 6). In total, 254 errors were made. In the SRC group, there were 128 errors and in the non-SRC group 126.

Firstly, most errors were classified as administrative errors: (n = 144, 44.88%). Examples of administrative errors were non-compliance with the opium laws and missing patient data. The amount of administrative errors in the SRC-group were 5.2% higher compared to the non-SRC group, but statistical significance was not demonstrated (p = 0.574). Opium law errors were made 9.4% less in the SRC group than the non-SRC group, however this difference was not statistically significant (p =0.492).

Secondly, (n = 82, 32.28%) errors were categorized as providing inadequate information. Both groups (SRC and non-SRC) made 41 errors within this error type. These kind of errors includes missing -and wrong usage instructions. There was no statistical significant difference when comparing the SRC group to the non-SRC group.

Thirdly, (n = 30 , 11.81%) errors were categorized as the wrong prescribed amount type. Compared to the non-SRC group, the SRC group made 20% less errors within this error type, but statistical significance was not demonstrated (p = 0.376). Some students prescribed insufficient medication which makes the prescription patient unfriendly. 33.4% less errors were made within this subcategory in the SRC group compared to the non-SRC group, however statistical significance was not proved (p = 0.302).

Oher types of errors include: wrong drug dose (n = 18 , 7.09%), wrong dose interval (n = 8, 3.15%) and wrong dosage form: (n = 2 , 0,79%). However statistical difference for the amount of these errors between the SRC-group and non-SRC group was not demonstrated.

Table 6. The type of errors.

		SRC participation			
Type of error		Yes (N, %)	No (N,%)	Total (N,%)	Sign.
	Wrong drug dose	10 (55.5%)	8 (44.4%)	18 (7.09%)	0.637
	Wrong dose interval	4 (50.0%)	4 (50.0%)	8 (3.15%)	1.000
	Wrong dosage form	1 (50.0%)	1 (50.0%)	2 (0.79%)	1.000
	Wrong prescribed amount	12 (40%)	18 (60%)	30 (11.81%)	0.376
	Insufficient prescribed which makes the prescription unfriendly	5 (33.3%)	10 (66.7%)		0.302
	Inadequate information	41 (50.0%)	41 (50.0%)	82 (32.28%)	1.000
	Missing usage instructions	19 (48.7%)	20 (51.3%)		0.873
	Wrong usage instructions	1 (25%)	3 (75%)		0.625
	Administrative error	60 (52.6%)	54 (47.4%)	114 (44.88%)	0.574
	Opium error	24 (45.3%)	29 (54.7%)		0.492
	Total errors	128 (100%)	126 (100%)	254 (100%)	

The consequences of the errors made by the students are shown in table 7. Most of these errors were classified as category B error (error occurred but the error would not have reached the patient) : (n = 137, 53.94%). No statistical significant difference between the SRC and non-SRC group were observed in the severity of the errors in all categories. The difference between the SRC and non-SRC group is that in category I (error would have resulted in patient death) one error was made in the non-SRC group (e.g. fentanyl 100 mg instead of μg) and the SCR group had zero errors.

Table 7. Consequence of error according to the NCCMERP taxonomy

	SRC participation			
NCCMERP Taxonomy	Yes (n, and %)	No (n, and %)	Total (n, and %)	Sign.
	B 72 (52.6%)	65 (47.4%)	137 (53.94%)	0.550
	C 11 (39.3%)	17 (60.7%)	28 (11.02%)	0.257
	D 41 (51.2%)	39 (48.8%)	80 (31.5 %)	0.823
	E 4 (50%)	4 (50%)	8 (3.15 %)	1.000
	I 0 (0%)	1 (100%)	1 (0.39 %)	-
Total	128 (100%)	126 (100%)	254 (100%)	

B taxonomy: error occurred but the error would not have reached the patient.
C taxonomy: error would have reached the patient but would not have had the potential to cause patient harm.
D taxonomy: error would have reached the patient and would have required additional monitoring to confirm that it resulted in no harm and/or would have required intervention to preclude harm.
E taxonomy: error would have contributed to or resulted in temporary harm to the patient and would have required intervention.
I taxonomy: error would have resulted in patient death.

National Dutch Pharmacotherapy assessment

From 47 of the 50 students, information on the National Dutch Pharmacotherapy assessment (NDPA) was yet available. The other 3 students still have to make the assessment. 23 students participated in SRC and 24 did not participate in SRC. The assessment included 60 multiple choice questions on the categories A - L (see figure 5).

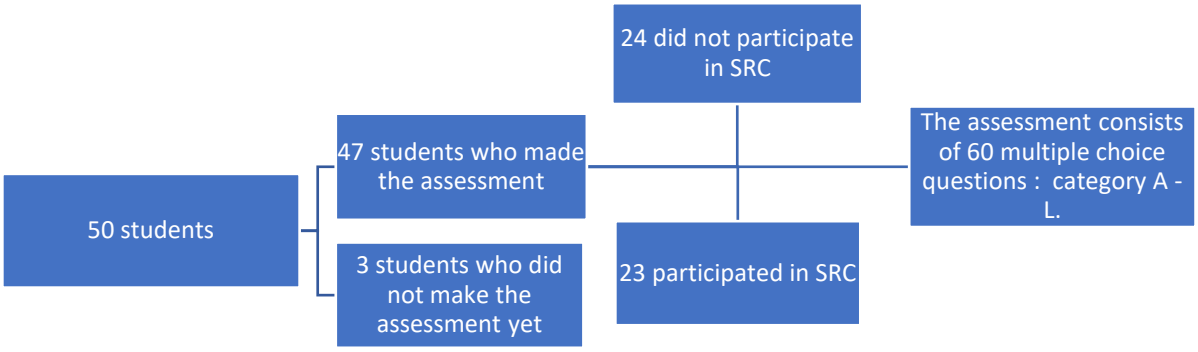


Figure 5. Number of students who made the National Dutch pharmacotherapy assessment
The assessment consist of the following categories:

A: Pain medication
B: Anticoagulants
C: Cardiovascular
D: Antidiabetics
E: Antidepressants
F: Benzodiazepines
G: Antibiotics
H: Pharmacokinetic
I: Drug allergy
J: Laws and regulation
K: good use of medicines
L: Pregnancy and lactation

The data from the NDPA is represented in table 7. The amount of students who passed the assessment on the first attempt was: n = 39 , 82.98%. In the SRC group this percentage was 7.6% higher compared to the non-SRC group, however this difference was not statistical significant (p = 0.631).

The assessment was divided into 12 different categories: A - L. The SRC group scored on average better within the categories A, C, E, F, G, H, I and K than the non-SRC group. Statistical significant difference was demonstrated for the categories A and F. The average score for category A (pain medication) was 6.9% higher compared to the non-SRC group (mean rank dif = + 8.6 | p = 0.021). For category F (benzodiazepines) the average score was 9.6 % higher compared to the non-SRC group with statistical significance (mean rank dif = + 6.77 | p = 0.021). For the remaining categories statistical significant difference was not demonstrated.

Table 8. National Dutch Pharmacotherapy assessment information

		SRC participation			
		Yes (n, and %)	No (n, and %)	Total (n, and %)	Sign.
After how many attempts did the student pass?	1	21 (53.8%)	18 (46.2%)	39 (82.98%)	0.631
	2	2 (25%)	6 (75 %)	8 (17.02%)	0.289

		SRC participation			
		Yes (%, mean rank)	No (%, mean rank)	Total (%)	Sign.
Total score 1st attempt		90.7 (25.28)	89.0 (22.77)	89.85	0.527

		SRC participation			
		Yes (%, mean rank)	No (%, mean rank)	Total (%)	Sign.
Question category	**A** (n=9)	**95.00 (28.39)**	**88.1 (19.79)**	**91.49**	**0.021**
	B (n=9)	87.1 (21.78)	89.5 (26.13)	88.32	0.260
	C (n=9)	89.7 (23.59)	88.0 (24.40)	87.94	0.832
	D (n=4)	85.9 (21.83)	92.7 (26.08)	89.36	0.208
	E (n=6)	95.7 (25.43)	93.1 (22.63)	94.33	0.396
	F (n=3)	**97.1 (27.46)**	**87.5 (20.69)**	**92.20**	**0.021**
	G (n=6)	91.5 (26.48)	89.4 (23.90)	89.36	0.953
	H (n=4)	91.5 (26.48)	85.6 (21.63)	88.51	0.165
	I (n=3)	91.3 (25.76)	83.3 (22.31)	87.24	0.292
	J (n=2)	94.2 (22.69)	97.9 (25.00)	96.10	0.291
	K (n=2)	87.7 (25.63)	80.6 (22.44)	84.04	0.332
	L (n=3)	88.4 (21.83)	94.4 (26.08)	91.94	0.159

Survey questionnaires

From 14 out of 50 students, information on the first question survey (after internal medicine internship) was available. From 15 out of 50 students, information on the second survey (after surgery internship) was available. From 20 out of 50 students, information on the third survey (after paediatrics/ gynaecology internship) was available. The distribution for SRC participation can been seen in figure 5.

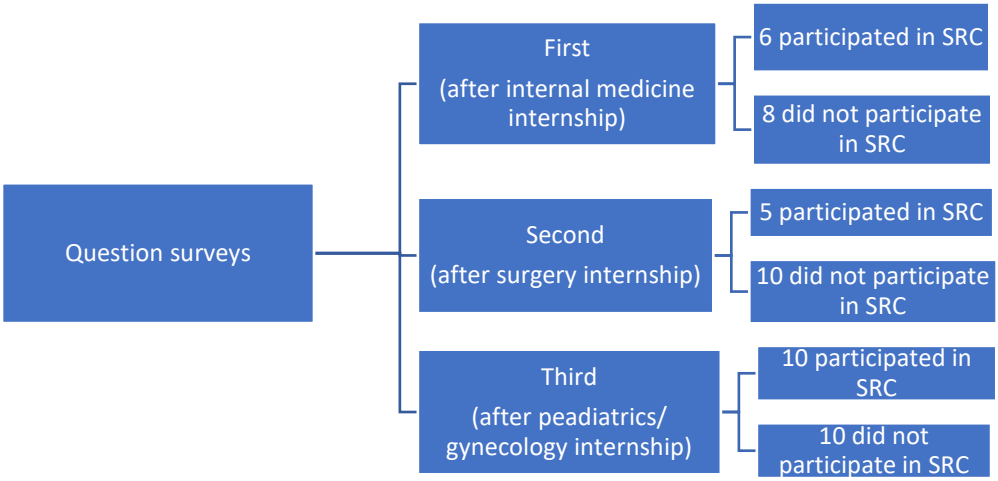


Figure 6. Number of students per question survey category.

One of the questions asked in the questionnaires was whether students had prescribed medication during their internships. An overview of the responses on this question within each survey category can been seen in table 9.

The results showed that first-year master's students prescribed medication more frequently throughout their first master year. The increase from the internal medicine internship to pediatrics/gynecology internship was 17.86%. In the SRC-group, the percentage of student who prescribed medication during their internship was higher compared to the non-SRC group. After the internal medicine internship this was 45.83% higher compared to the non-SRC group. After the surgery internship this was 24.44 % higher compared to the non-SRC group. However, after the pediatrics/gynecology internship a difference between both groups was not observed.

Table 9. Information about students who prescribed medication during their internships.

		SRC participation		
		Yes (n/total and %)	No (n/total , and %)	Total (n, and %)
Prescribed medication during internship (under supervision)	First survey (n =14)	5 / 6 (83.33%)	3 / 8 (37.5%)	8 (57.14%)
	Second survey (n = 15)	4 / 5 (80%)	5 / 10 (55.56%)	9 (60%)

Third survey (n = 20)	7/ 10 (70%)	8 / 10 (80%)	15 (75%)

Other statements that were asked in the questionnaires were:

1. If I had to prescribe medication to patients independently, I would feel confident about it
2. My medication knowledge is sufficient to start working as a doctor
3. My prescribing skills are sufficient to start working as a doctor
4. During my internships I was involved with prescribing medication
5. During my internship I thought about whether, or not to prescribe medication

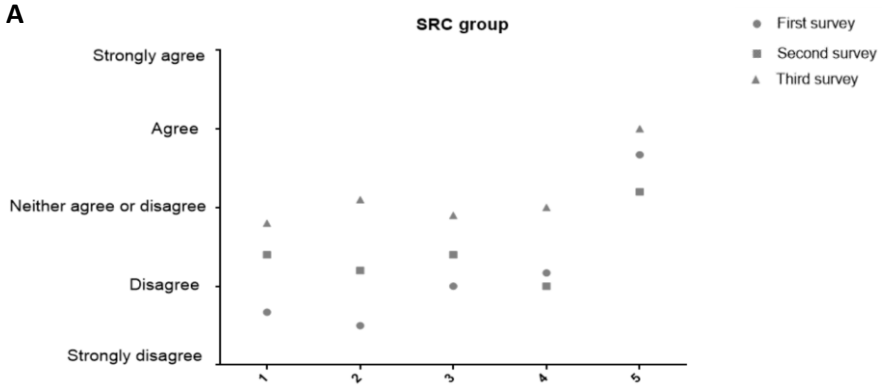
An overview of the responses on these statements within each survey category can been seen in appendix I. These statements were answered by using the 5-point Likert scale principle:

1. Strongly disagree
2. Disagree
3. Neither agree or disagree
4. Agree
5. Strongly agree

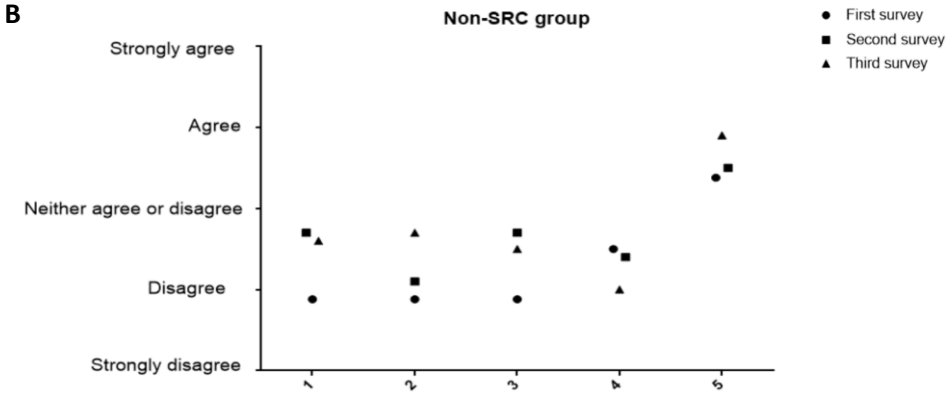
A visual overview of these data is represented in figure 7. The figure shows the average score according to the 5-point Likert scale among the students for the 5 statements. After the paediatrics/gynaecology internship the SRC group scored higher on all the 5 statements compared to the non-SRC group. Significance was only demonstrated for statement 4 (see appendix II). In the SRC group, the mean was 1.0 higher compared to the non-SRC group, with a statistical significance of p = 0.008.

Eventually, both groups scored higher on the Likert scale throughout their first master year, meaning that both groups become more in agreement with the statements. However the SRC-group ended higher on the Likert scale (see figure 4). When comparing the scores of these students during their first master year as a master student, the SCR-group shows a consequent increase in scores over the duration of the year, but this is not the case for the non-SRC group.

A



B



C

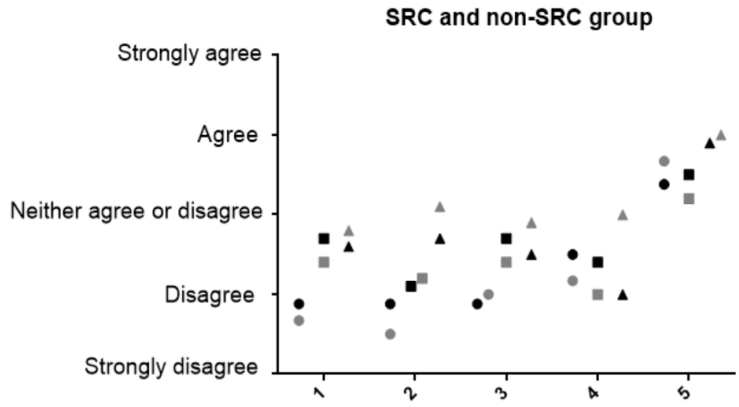


Figure 7. average score among students per statement

1: If I had to prescribe medication to patients independently, I would feel confident about it.

2: My medication knowledge is sufficient to start working as a doctor.

3: My prescribing skills are sufficient to start working as a doctor.

4: During my internships I was involved with prescribing medication.

5: During my internship I thought about whether, or not to prescribe medication

A) Data of the SRC group
B) Data of the non-SRC group
C) Data of both SRC and non-SRC group

Some students elaborate on their involvement with prescribing medication during their internship (see appendix III). The answers can be classified into the following categories:

1. Not involved with medication and prescribing of medication
2. Involved with medication, but not involved with prescribing medication
3. Self-prescribed medication

Suggestions about medication were often made by students during their internship, but prescribing medication under supervision was not obvious. If prescribing medication under supervision was possible, students did feel not enough competent with their prescribing skills. Some citations were:

''[I]was allowed to make suggestions regarding medication, but the doctor's prescribed the medication''

'' [I] feel confident about my knowledge in pharmacotherapy, but was not sufficiently involved with prescribing medication, and I do not feel competent enough with prescribing medication in the electronic prescribing system''

Furthermore, some students elaborate on whether they thought about prescribing, or not to prescribe medication during their internship (see appendix III). The answers can be classified into the following categories:

1. Thought about the considerations for prescribing medication, but felt there wasn't enough time
2. Proposed treatment plans including pharmacotherapy

The majority of the students said that they thought about pharmacotherapy. Some citations were:

"[I] thought about pharmacotherapy by gathering information about the indications and prescribing possibilities when encountering unfamiliar medication"

"[I]performed consultations with patients under supervision and thought about the considerations for prescribing medication"

Discussion and conclusion

The purpose of this research was to examine the impact of participation in SRC on medical students' attitude towards and skills in pharmacotherapy, related to fellow students who did not participate in SRC during their master curriculum at Erasmus MC. This SRC primarily focuses on pharmacotherapy and provides a vast value as an early prescribing training occasion for medical master students. More precisely SRC offers an opportunity for students to gain knowledge about pharmacotherapy and skills in prescribing medication for real patients in a safe environment. It is hypothesized that early exposure in training about pharmacotherapy and prescribing medication would have beneficial effect on students for the further duration of their master and career as a junior doctor. Because junior doctors, well-trained with reliable prescribing skills are essential for our society.

50 students were assessed through the results of the skill-based formative assessment and the National Dutch Pharmacotherapy assessment. In addition, information toward their attitude and skills in pharmacotherapy were available through three surveys taken after the internal medicine internship (first survey), after the surgery internship (second survey) and after the paediatrics/gynaecology internship (third survey).

The key result of the formative assessment is that no significant difference was observed in the amount of errors and its consequence between the SRC and non-SRC group. An explanation for this is that the skills that were tested in the assessment are not in line with the skills that are taught at SRC. The assignment is to write a prescription in handwritten format, while students prescribed electronically at the SRC. Computer generated prescriptions contain an algorithm that can directly detect an error (32). Errors will occur in any system, but it is essential to minimize risks. Therefore, electronically prescribing may reduce the occurrence of these prescribing errors (32) Besides, an electronically prescribed prescription will give a better representation of the day to day practice. The actual daily practice should be more assessed when comparing the e-prescribing skills between the SRC and non-SRC group.

On the other hand the formative aspect of this assignment could influence the teachers decisions and students performance (33). This assessment is meant to provide feedback to the students to improve their learning performances. The kind of feedback depends on the CPT teacher. This feedback can vary considerably and could affect the final grade given for the prescriptions. Besides, summative assessments often have high effort and priority by students over formative assessments (34). The formative aspect will probably lessen the learning effect. However, other personal factors may influence the students learning performance (34).

In this study we found that the main source of errors in prescriptions were from the administrative error type. Within this error type less opium law errors (9.4%) were made in the SRC group compared to the non-SRC group. Also, the SRC-group made less wrong prescribed amount errors (20%) compared to the non-SRC group. This is an important finding, suggesting that SRC participation can lead to less prescribing errors within these categories. It is possible that SRC students developed more feeling for the opium laws and prescribed amounts due to SRC participation, because internal medicine covers a wide range of patient who use different medications.

One key result of the National Dutch Pharmacotherapy assessment is that 7.6% more students passed the assessment on the first attempt a compared to the non-SRC group. Also, the SRC group scored on average higher within subcategories: pain medication (A), cardiovascular (C), antidepressants (E), benzodiazepines (F), antibiotics (G), pharmacokinetic (H), drug allergy (I) and good use of medicines

(K). This difference was significant for pain medication (A) and benzodiazepines (F). The assessment was taken after the paediatrics/gynaecology internship, which revealed that SRC students in terms of knowledge scored higher across the majority of the categories after this internship. All prescribers should have insight into the most important medication categories. Besides , they have to consider other factors that might alter the benefits or harms of the treatment such as individual patient characteristics (e.g. CYP enzymes, allergies, kidney function, weight and liver function) (35). Furthermore, it is essential to provide the right usage instructions for medication (35). The SRC group scored higher within category allergy (8%), pharmacokinetics (5.9%) and good use of medicines (7.7%). This results assumes that SRC may contribute to better prescribing competencies.

One key result from the surveys questions is that the percentage of first-year master's students who prescribed medication during internships increases throughout their first master year. In the SRC-group, this percentages was higher compared to the non-SRC group for survey 1 and 2. However survey 3 showed more balance for prescribing medication during internships. This can be explained by the increased number of completed internships and thus there were more prescribing opportunities for both groups. Among the other statements statistical difference was demonstrated for statement 4 (involvement with prescribing medication during internships) in survey 3. In the SRC group, a trend seems to be reflected on the data points. The data points of each upcoming survey are higher represented on the scale, which means that the students become more in agreement with the statement about prescribing during the duration of their first master year, while this was not the case for the non-SRC group

Previous studies with findings about how participation in SRC affects student's educational value are rare. If research has been done, this was about a SRC with a completely different set-up and participation was on a volunteer basis. However, some studies have been conducted that studied the effect of participating in SRC on the learning performance of the students (36). The endpoints included for instance clinical grades, shelf exam scores and students confidence feeling in general(36) . Conflicting results has been documented; in one case SRC students scored higher grades than the non-SRC students (37), and in another study no difference in grades was observed between both groups (38). However, the effects of participation in SRC on students' attitude are mainly positive (39). Students valued their experiences with skills and knowledge they were unlikely to achieve other where in the curriculum. In our study question about SRC were not an integral part of the survey, so we don't have this kind of additional information.

The results revealed that participating in SRC seems to have a positive effect on the skills and attitude of students towards prescribing medication. David A. Newby *et all* described that practicing with prescribing medication improves the confidence level across all areas of generic prescribing. Such as selecting appropriate medications for a condition, identifying potential drug interactions, identifying adverse drug reactions, monitoring the effectiveness of a medication and planning of discharge medication (40) . The questions asked in the SRC surveys were more general about prescribing. The confidence level was not increased immediately after participation, but increased throughout the first master year. Suggesting that more practicing with prescribing, improved the confidence level toward prescribing medication among students.

Strengths and limitations

SRC provides a vast value as an early prescribing training occasion for medical students. It's clinically relevant, because less prescribing errors may result in less harm to patients. Another strength is that the data was collected during 1 year follow-up.

A limitation is that there is limited data available due to the retrospective nature of this study. The population group consisted of 50 students (25 SRC and 25 non-SRC). A larger size-group (n = 230) will have a higher probability to show robust results.

Another limitation was the impossibility to match the students with the same start date and opposite match the students on SRC participation. This was the case for participant: 32 and 48. In this case a student from the successive cohort was selected.

The national Dutch pharmacotherapy assessment was made by the students on different dates. The questions form the assessment were different, but were comparable in terms of difficulty.

Furthermore, it was optional for the students to complete the survey questionnaires, as a result not much data was available. In addition, the surveys were sent using a step-wedge design, so not all the data of the 3 surveys was available for everyone. No firm statement can be made if the results from these questionnaires are not representable for the selected cohort.

Future recommendations

This SRC is conducted during the internal medicine internship and is mainly focused on the cardiovascular risk management. It would be a vast value to introduce SRC's during other internships, so that students become familiar with prescribing medication among other important medication categories. SRC's provide a multifunctional context-based learning environment, from which students gain realistic communication and prescribing skills. The team could be expanded with someone with a pharmaceutical background (e.g. master student pharmacy), to share their knowledge about medication during the outpatient consultations. It is also recommended to implement education lessons which are more specified on the technical prescribing process of medication.

In particular focused on the prescribing errors that are often made among young doctors. Also, education and training should rely on the e-prescribing systems (41) . This can be achieved due the creation of scenario-based exercises with fictive patients. In this manner undergraduates are prepared for the real-world scenarios. It would be recommended to create realistic scenarios with polypharmacy patients which also occur during SRC.

A follow-up study could be examined from the results of these scenario-based exercises. The skills that are tested in this assignment are in line with the skills that are taught during SRC, which makes this a better way to assess the effect of SRC on student's prescribing skills.

Furthermore, interviews with students who participated in SRC could give more information about SRC and its value when prescribing medication. During the monthly multidisciplinary consultation, students get the opportunity to gain new medication related insights. A qualitative study about the effects of these MDC's would be recommended.

Conclusion

Participating in SRC seems to have a positive effect on the skills and attitude of students towards prescribing medication. However, this cannot be a hard statement because of the small group size. A larger group-size is needed to exclude these observations as mere by chance. The effects especially seems to occur later in the first year of the master. The SRC group scored better within certain categories in the NDPA and the students were more in agreement with the statements about prescribing medication during internships. The best method to enhance patient safety as early as possible is to develop a strategy for education. An embedded SRC is a beginning, but further research

is necessary. Although SRC seems to be a great learning experience for students. The question is whether this learning experience can be quantitatively determined by means of assessments.

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Appendix I– Questionnaire survey statements about prescribing medication

		SRC participation		
Statements		Yes (mean)	No (mean)	Sign. [95% interval]
If I had to prescribe medication to patients independently, I would feel confident about it.	**Surgery**	1.67 [0.81 – 2.52]	1.88 [1.18 – 2.57]	0.647 [-1.806 – 0.666]
	Kindgyn	2.40 [1.72 – 3.08]	2.70 [2.11 – 3.29]	0.478 [-1.104 – 0.504]
	Neuropsych	2.80 [2.50 – 3.10]	2.60 [2.00 – 3.20]	0.511 [-0.384 – 0.784]
My medication knowledge is sufficient to start working as a doctor.	**Surgery**	1.50 [0.93 – 2.07]	1.88 [1.34– 2.14]	0.267 [-1.019 – 0.259]
	Kindgyn	2.20 [1.16 – 3.24]	2.10 [1.69 – 2.51]	0.787 [-0.611 – 0.811]
	Neuropsych	3.10 [2.47 – 3.73]	2.70 [2.02 – 3.38]	0.340 [-0.400 -1.200]
My prescribing skills are sufficient to start working as a doctor.	**Surgery**	2.00 [1.34 – 2.66]	1.88 [1.18 – 2.57]	0.774 [-0.681 – 0.921]
	Kindgyn	2.40 [1.72 – 3.08]	2.70 [2.35 – 3.05]	0.297 [-0.841 – 0.241]
	Neuropsych	2.90 [2.37 – 3.43]	2.50 [2.12 – 2.88]	0.180 [- 0.162 – 0.962]
During my internships I was involved with prescribing medication.	**Surgery**	2.17 [1.38 – 2.96]	2.50 [1.73 – 3.27]	0.490 [-1.238 – 0.578]
	Kindgyn	2.00 [1.12 – 2.88]	2.40 [1.80 - 3.00]	0.380 [-1.263 – 0.463]
	Neuropsych	**3.00 [2.42 – 3.58]**	**2.00 [1.52- 2.48]**	**0.008 [0.347 – 1.653]**
During my internship I thought about whether, or not to prescribe medication.	**Surgery**	3.67 [3.12 – 4.12]	3.38 [2.49 – 4.26]	0.551 [-0.637 – 1.217]
	Kindgyn	3.20 [2.16 – 4.24]	3.50 [2.89 – 4.11]	0.529 [-1.208 – 0.608]
	Neuropsych	4.00 [3.66 – 4.34]	3.90 [3.37 – 4.43]	0.722 [-0.443 – 0.643]

1-1,8 = strongly disagree, 1,81 – 2,6 = disagree. 2,61 -3,4 = neither agree or disagree. 3,41- 4,2 = agree. 4,2 -5 = strongly agree.

Appendix II– explanation statement 4 and 5

During my internships I am involved with prescribing medication.

- Involvement with prescribing medication depends on the accompanying specialist
- It's difficult to be involved in the thinking process of the doctors when they are prescribing medication
- Involved with medication due to doctor's visits, but not particularly involved with prescribing medication
- Doctors prescribed medication themselves without actively involving the student
- Doctors occasionally gave an explanation about their prescribed medication
- Self-prescribed medication, but still insecure about prescribing skills
- Allowed to make suggestions regarding medication, but doctor's prescribed the medication
- Involved with prescribing medication, but experienced that most doctors prescribed the medication.
- Involvement with prescribing medication differs per internship
- Was motivated to think about the considerations for prescribing medication, but in almost all cases doctors prescribed the medication
- Was not sufficiently involved with prescribing medication, making it difficult to understand the principles of prescribing
- Confident about knowledge in pharmacotherapy, but was not sufficiently involved with prescribing medication, and feels not competent enough with prescribing in the EPS

During my internship I thought about whether, or not to prescribe medication.

- Thought about prescribing medication, but felt there wasn't enough time
- Proposed treatment plans including pharmacotherapy, but did not self-prescribe the medication
- Thought about pharmacotherapy by gather information about the indications and prescribe possibilities when encountering an unfamiliar medication.
- Performed consultations with patients under supervision and thought about the considerations for prescribing medication
- Proposed treatment plans including pharmacotherapy but did not self-prescribe the medication.
- Formulated treatment plans including medication with doctors, but an explanation about prescribing medication itself was often not given
- Thought about the considerations for prescribing medication and is knowledgeable with dosage calculations