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ORIGINAL ARTICLE

Differences in prescribing errors between electronic prescribing and traditional prescribing among medical students: A randomized pilot study

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Aims: This randomized controlled pilot study aimed to assess the differences in the frequency, type and severity of prescribing errors made by medical students when assessed in an electronic (e-)prescribing system compared to a traditional prescribing method (e.g., typing out a prescription).

Methods: Fourth year medical students in the period of 1 November to 31 July 2023, were asked to participate in this single-centre prospective, randomized, controlled intervention study. Participants performed a prescribing assessment in either an e-prescribing system (intervention group) or in a more traditional prescribing platform (control group). The prescriptions were checked for errors, graded and categorized. Differences in prescribing errors, error categories and severity were analysed.

Results: Out of 334 students, 84 participated in the study. Nearly all participants (98.8%) made 1 or more prescribing errors, primarily involving inadequate information errors. In the intervention group, more participants made prescribing errors involving the prescribed amount (71.4 *vs*. 19.0%; $P < .01$), but fewer involving administrative errors (2.4 *vs*. 19.0%; $P = .03$). Prescribing-method-specific errors were identified in 4.8 and 40.5% of the intervention and control group, respectively, with significant differences in overlapping errors as well.

Conclusion: This pilot study shows the importance of training e-prescribing competencies in medical curricula, in addition to traditional prescribing methods. It identifies prescribing-method-specific prescribing errors and emphasizes the need for further research to define e-prescribing competencies. Additionally, the need for an accessible real-life-like e-prescribing environment tailored to educators and students is essential for effective learning and incorporation of e-prescribing into medical curricula.

KEYWORDS
e-prescribing, medical education, prescribing, prescribing errors

F. van Rosse

1 | INTRODUCTION

Prescribing errors are a known cause of negative patient health outcomes, including decreased health-related quality of life, drug-related hospital admissions and death.[1–7] For this reason, it is important to reduce the number of prescribing errors. Junior doctors are more likely to make prescribing errors[8,9] and for a large part feel to have been inadequately prepared by their medical curriculum.[10–14] This incentivizes improvement of the prescribing curriculum.

One way of achieving this, is through practicing and assessing in electronic (e-)learning environments. Earlier studies have shown the benefit of practicing and assessing in e-learning environments.[15–17] For example, Kalfsvel *et al*. have shown that students who practice longer and more frequently in the web-based learning environment Pscribe are more likely to pass their clinical pharmacotherapy (CPT) assessments at the first attempt.[15]

When addressing the characteristics of safe and rational prescribing, the concept of competencies frequently arises. While some categorize knowledge, skill and attitude as individual *prescribing competencies*, and others prescribing itself as a competency, it is evident that all these elements are fundamental in achieving actual prescribing competence.[10,11,18] In this context, we adopt the former definition with knowledge, skill and attitude being individual prescribing competencies necessary for achieving prescribing competence (Figure 1).

Despite substantial research identifying essential prescribing competencies and medical students' competency levels,[10,11,15,18–21] e-prescribing and its distinct competencies have evaded scholarly attention. In their study, Bakkum *et al*. provided an overview of the digital education resources used in European CPT education in 2019.[16] Despite its widespread use, only a few pertained to the training or assessment of e-prescribing, through the use of (copies) of the electronic prescribing system (EPS)[21] or a prescribing simulator. This oversight is concerning, given that—as in many other countries—e-prescribing has been the standard of practice in the Netherlands for close to a decade.[22,23]

We hypothesize that distinct competencies may be required for e-prescribing (e.g., navigating the EPS and patient and drug selection) and *traditional* prescribing (e.g., adhering to the correct format), resulting in prescribing method-specific errors. The latter being supported by studies performed on e-prescribing errors in (clinical) practice, which have shown the existence of various types of e-prescribing specific errors.[24–27]

In light of this, our study aims to assess the differences in the frequency, type and severity of prescribing errors made by medical students in an EPS compared to a more traditional prescribing method. Our objective is addressing the gap regarding the distinctions between e-prescribing and traditional prescribing and offer recommendations for improving the prescribing education curriculum through harmonizing it with the contemporary practices.

What is already known about this subject

- Little is known about e-prescribing competencies.
- Prescribing education may not sufficiently prepare medical students for the future responsibilities.

What this study adds

- On top of differences in frequency in overlapping prescribing error types, medical students make distinct prescribing method-specific errors.
- Both e-prescribing and traditional prescribing competencies should be addressed in medical curricula.
- A more integrated approach to prescribing education in medical curricula, encompassing both prescribing method-specific and non-prescribing method-specific competencies.

2 | METHODS

2.1 | Setting

In the Netherlands, medical education is organized through a 6-year curriculum consisting of a 3-year bachelor and 3-year master's phase. During the bachelor in the Erasmus MC University Medical Center, (clinical) pharmacotherapy education is focused mostly on knowledge, whereas in the master's phase students it is focused on applying this knowledge. Specifically, prescribing education is taught in this phase. This education is interlaced in the curriculum and is primarily organized by the hospital pharmacy, and classes are generally taught by pharmacists and clinical pharmacologists (in-training). On top of the classes, students have access to various (non)mandatory educational materials, including e-learning modules and podcasts on pharmacology and pharmacotherapy.

In the first year of the master's phase, students are taught how to write a paper prescription, how to use the World Health Organization (WHO) 6-step model for rational prescribing[28] and perform a formative skill-based prescribing assessment. The latter consists of 6 knowledge-based questions and 2 cases for which they prescribe a predefined drug. This formative assessment is performed in Pscribe,[29] an online e-learning platform (see Section 2.4). Here, students are presented with a case description, after which they prescribe according to the WHO 6-step model (see Figure S1). In the second year, students are required to perform the Dutch National Pharmacotherapy assessment,[30] a knowledge-based summative assessment. This is also the year in which students receive a 1-h practical class in which they

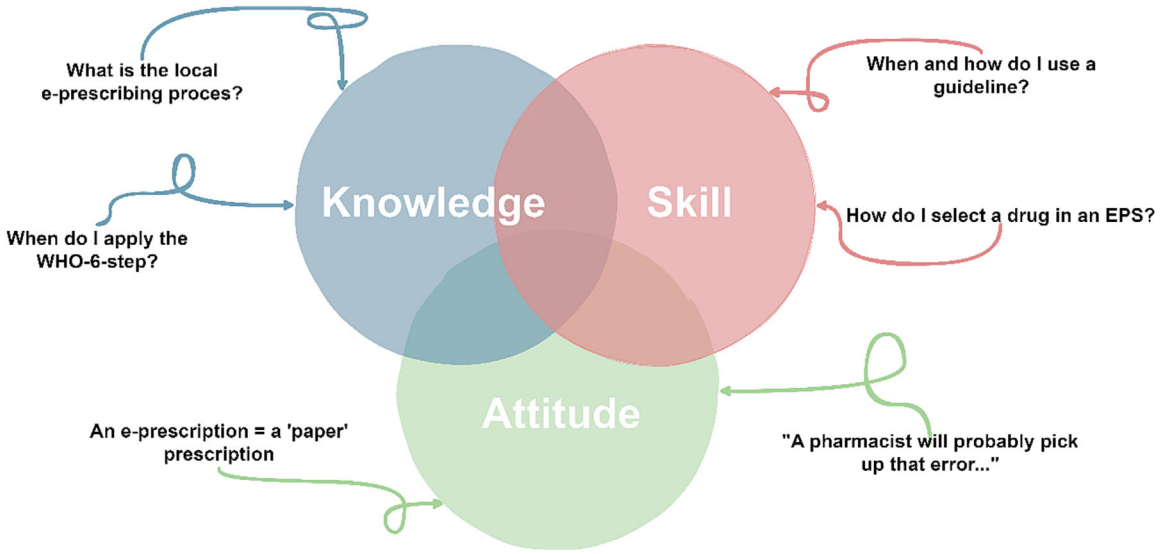

FIGURE 1 Prescribing competencies.

practice e-prescribing in a real-life-like setting, using the sandbox of the institution's EPS. In the final year, students perform a summative skill-based prescribing assessment in Pscribe, in a fashion similar to the formative assessment. Here, the students prescribe drugs for 4 junior-doctor level cases. In 1 of the cases, the students are instructed to use the WHO 6-step model to choose and prescribe the drug. In the remaining 3 cases, the drugs are predefined, placing emphasis on prescribing the correct form, dosage and dispensing quantity. Except for the 1-h e-prescribing practical, all education materials and assessments related to prescribing are located within the e-learning module Pscribe. The Medical Ethics Committee of the Erasmus MC determined that the Medical Research Involving Human Subjects Act (WMO) was not applicable to this study and approved the study (MEC-2022-0681). All participants provided written informed consent prior to the assessment. Upon registering in Pscribe, students consented to their data's use for research purposes. Thus, no additional consent was required for comparisons between participants and nonparticipants.

2.2 | Population and study procedure

In this prospective, randomized, controlled pilot intervention study, we included medical students in the first year of their master's phase from 1 November 2022 to 31 July 2023. During a mandatory class on medication safety, students were introduced to the study. At this stage, the students had already received some prescribing education and had completed the formative prescribing assessment 2 weeks earlier. Those willing to participate were invited to perform an additional prescribing assessment, either in an EPS (intervention group) or in Pscribe (control group), based on 1:1 randomization, respectively. This assessment took place during the week following the introduction and was conducted in a group setting in a designated classroom as the examination area. Randomization took place at the time of the study by order of arrival to the computer lab. Every other student was assigned to either the intervention group (assessment in the EPS) or the control group (assessment in Pscribe).

2.3 | The prescribing assessment

For the prescribing assessment used in this study, the participants were asked to prescribe a drug for 2 distinct patients. The 2 cases were identical for both the intervention and control groups. The first case involved a 7-year-old child diagnosed with allergic rhinitis, requiring a prescription of cetirizine. The second case involved a woman seeking to switch from an intrauterine device to an oral contraceptive, prompting the prescription of ethinyloestradiol/levonorgestrel. A team of 3 teachers carefully designed these cases based on their experience, aiming for a balance between the complexity and the potential for prescribing errors. As with the formative and summative assessments, students were allowed to use references but not do discuss. An invigilator was present throughout each assessment.

Considering that the students had not had their EPS practical at the time of intervention, they received a short class on e-prescribing prior to it. This class consisted of a 5-min presentation on the basics of using an EPS (e.g., navigating the EPS and prescribing a drug). Additionally, we asked the participants in the intervention group to record the starting and ending time of each assessment case, as this is automatically tracked for the control group in Pscribe.

After each assessment, the prescriptions were extracted from the EPS and Pscribe and checked for prescribing errors twice by a teacher (S.E.). The prescriptions were graded using a rubric (see Table S1), with a maximum achievable score of 9 points. The rubric was decided upon through a series of focus group sessions with pharmacotherapy

teachers, ultimately leading to consensus. The errors were subsequently categorized by type (see Table S2) and classified by severity (Table S3), in a fashion similar to our previous studies.[21,31] Additionally, we distinguished between prescribing errors that were exclusively made by a particular group and those that overlapped between the groups (*overlapping prescribing errors*). Within the first category, we further classified errors as either specific to a prescribing method or not.

A second teacher (L.K.) double-checked a 10% sample of the prescriptions. All uncertainties or discrepancies, stemming from the double check or otherwise, were discussed by S.E., L.K. and F.R. until consensus was achieved. The baseline characteristics for all participants were extracted from Pscribe, as each participant had an active account on the platform. All data were entered into a Castor database and all participants received personal feedback on their prescriptions.

2.4 | Prescribing platforms

To perform the assessment, the intervention group used the HiX sandbox (Chipsoft, Amsterdam, The Netherlands). The version of HiX used in our institution is a clinical electronic health record, integrated with an EPS. The sandbox EPS is a *copy* of the institution's EPS and contains both anonymized and test patients. In this environment, which is primarily used for testing updates, no action reaches actual patients. Within this copy of the EPS, the participants were able to prescribe as they would in actual practice.

The control group performed the prescribing assessment in Pscribe, an online e-learning platform that is currently used for the prescribing education and assessment. Here, participants type out a prescription in a template. We classify this as a traditional prescribing method because, although it is generated digitally, it still involves the manual transcribing of prescriptions, resembling the traditional act of writing. Furthermore, it lacks features associated with e-prescribing, such as EPS navigation, patient selection and structured data entry. Examples are provided in Figures S2–S4.

2.5 | Statistical analysis

As this was a pilot study, we did not perform a formal sample size calculation. We aimed to include a total of 180 participants, drawn from 3 cohorts of students. If this sample size was not reached, we would incorporate 1 more cohort. We analysed the data in 3 steps. Firstly, the baseline characteristics of the participants and the assessment metrics are described. Continuous variables are presented as means and standard deviation or as medians and interquartile ranges depending on the normality of a variable. Differences between 2 groups were examined using an independent sample *t*-test or Mann–Whitney *U* test for normally or non-normally distributed variables. Normality was assessed by the Shapiro–Wilk test. Secondly, the primary endpoint was the difference in prevalence of prescribing error types between the intervention and control groups, presented as numbers and percentages. When there were at least 5 observations per cell, between-group differences were compared using the Chi-square test. If not, the Fisher's exact test was used. Multiple-group comparison was done using the Fisher's exact test. Thirdly, the secondary endpoints were the prevalence of prescribing method-specific errors, differences in the prevalence of prescribing error subtypes and the difference in prevalence of prescribing error severities, which were presented and compared similar to the primary endpoint. A *P*-value <.05 was considered significant. No imputation was used in case of missing values. All the collected data were analysed using Python (Python Software Foundation. Python Language Reference, version 3.10.4). The data was visualized using the Plotly library (Plotly Technologies Inc., version 5.7.0, Montréal, Canada).

3 | RESULTS

Out of the 334 students that were asked to participate in this study from November 2022 to July 2023, 84 (25.1%) were included. As we did not reach the aimed sample size by the third cohort, we included 1 more. No statistically significant differences were found in the grades for the formative test between the participants and nonparticipants ($P = .14$; see Table S4). An overview of the inclusion and analysed prescriptions is shown in Figure 2. Sixty-two (73.8%) of the included participants were female and 46 (54.8%) participants had a passing grade for the formative assessment (see Table S5). No significant differences were found in sex or formative assessment grade between the intervention and control groups.

3.1 | Assessment metrics

An overview of assessment related results is shown in Table 1. No statistically significant differences were found between the intervention and control groups in mean time spent on the assessment, the median number of points achieved and the number of participants with at least 1 prescribing error. The intervention group, however, had significantly more participants with at least 1 prescribing error in both cases (95.2 *vs*. 59.5%). When excluding errors related to omission of the bodyweight of a child, which should be explicitly documented on a prescription and an error made by every participant in the intervention, no such difference is found.

3.2 | Prescribing error types

As shown in Figure 3, most prescribing errors were made in the category Inadequate information (e.g., wrong or missing usage instructions), with 100.0 and 88.1% ($P = .06$) of the participants making at least 1 prescribing error in this category for the intervention and control group, respectively. Significantly more participants in the intervention group made at least 1 prescribing error involving the

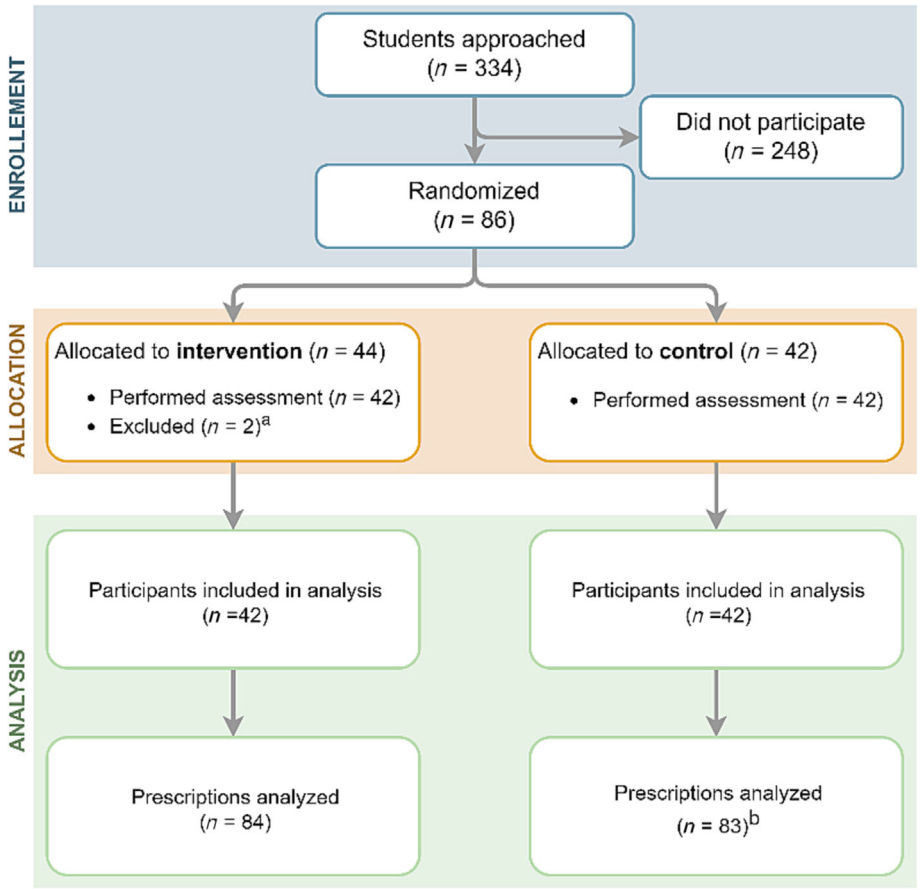

FIGURE 2 Included participants and analysed prescriptions.[a] Two participants were excluded due to a technical problem with extracting the prescriptions.[b] One participant did not make a prescription for the second case of the assessment.

TABLE 1 Assessment metrics and prescribing errors.

	Intervention ($n = 42$)	Control ($n = 42$)	*P*
Mean duration (min) per participant in:			
Both cases	10.3 ± 2.9	11.5 ± 3.2[a]	.10
Mean difference between Case 1 and Case 2 (min)[b]	2.6 ± 4.5[a]	2.9 ± 4.1[a]	.82
Median number of points[c] per participant in:			
Both cases	15.0 (13.3–16.0)	14.0 (11.0–17.0)	.87
Case 1	7.5 (6.3–8.0)	7.0 (5.0–9.0)[a]	.79
Case 2	8.0 (7.0–8.0)	8.0 (7.0–8.0)	.82
Number of participants with an error in:			
At least 1 case	42 (100.0)	39 (92.9)	.24
Both cases	40 (95.2)	25 (59.5)	**<.01**
Number of participants with an error (excluding missing weight errors) in:			
At least 1 case	41 (97.6)	37 (88.1)	.20
Both cases	22 (52.4)	22 (52.4)	>.99
Mean number of errors per participant in:			
Both cases	2.9 ± 0.7	2.9 ± 1.8	.95
Case 1	1.6 ± 0.6	2.0 ± 1.1	.07
Case 2	1.4 ± 0.5	1.6 ± 0.7	.07

Note: Values are expressed as a mean ± standard deviation, median (interquartile range) or *n* (%).

[a]1 missing value.

[b]The difference was calculated by subtracting the time spent on Case 1 by the time spent on Case 2.

[c]The participants could receive a maximum of 9 points per case.

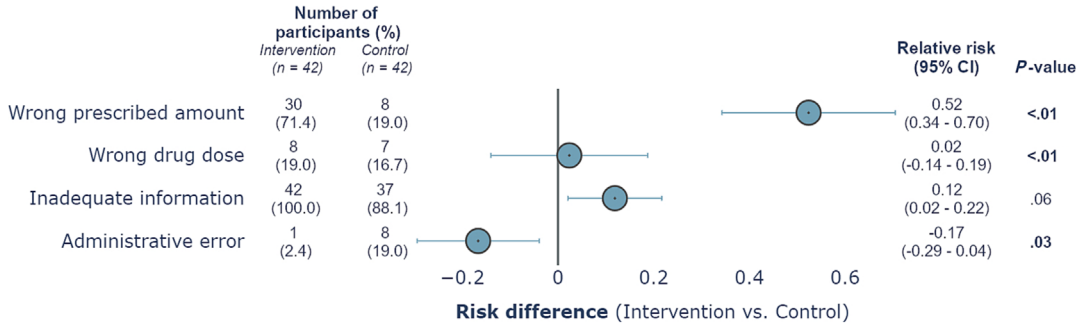

FIGURE 3 Forest plot of relative risk for prescribing errors between intervention and control.

prescribed amount (71.4 *vs.* 19.0%; $P < .01$) and less participants made at least 1 prescribing error involving administrative errors (2.4 *vs.* 19.0%; $P = .03$).

3.3 | Prescribing method-specific prescribing error types

In Table 2 we present all the prescribing errors made, stratified by subcategory. We identified 4 prescribing error subcategories made exclusively by the intervention group and 5 made exclusively by the control group. Among these errors, 2 were specific to the intervention group (EPS) and 3 in the control group (non-EPS). Overall, 4.8% of the participants made at least 1 EPS-specific prescribing error and 40.5% at least 1 non-EPS-specific prescribing error. The nonmethod-specific prescribing distinct errors pertained to errors that theoretically could have been made using either method.

3.4 | Overlapping prescribing error types

Among the overlapping prescribing errors (see Table 2), we found significant differences between the intervention and control group in errors related to the omission of the current bodyweight (100 *vs.* 57.1%, $P < .01$), errors related to a too high dispensing amount for the necessary treatment (21.4 *vs.* 2.4%, $P = .02$), errors related to a too high dispensing amount for newly started chronic drugs (23.8 *vs.* 4.8%, $P = .03$).

3.5 | Prescribing error severity

As shown in Table 3, significantly more participants in the intervention group made at least 1 B-class (100.0 *vs.* 57.1%; $P < .01$) and at least 1 D-class error (83.3 *vs.* 54.8%; $P = .01$) compared to the control group. Furthermore, when looking at the most severe prescribing error per participant, we find a significant difference in D-class errors as well.

Upon closer investigation, we found that, except for a single error in the control group, all B-class errors involved omitting the child's bodyweight from the prescription. Most D-class errors involved missing usage instructions for both the intervention (88.6%) and control (91.3%) groups. Specifically, the omission of any instructions pertaining when to start an oral contraceptive and additional contraceptive measures. Furthermore, except for 1 participant in each group, none of the D-class errors were prescribing method-specific.

A detailed overview of the individual prescribing error (sub)categories corresponding with the severities is show in Table S6.

4 | DISCUSSION

In our pilot study, we aimed to assess the differences in the frequency, type and severity of prescribing errors made by medical students when assessed in an EPS compared to a traditional prescribing method (e.g., typing out a prescription). We found that nearly all participants, both in the intervention and the control group, made 1 or more prescribing error (96.4%), with the majority of them making errors related to inadequate information in both the intervention (100.0%) and control (88.1%) groups, in line with the findings from earlier studies.[21]

Although no significant differences were found in the number of errors, we found that in the intervention group fewer participants made administrative errors (2.4 *vs.* 19.0%), but more participants made errors related to the prescribed amount (71.4 *vs.* 19.0%) when compared to the control group. The importance of integrating e-prescribing into the medical curriculum is apparent, as we identified EPS-specific prescribing errors. The required prescribing competencies for avoiding these errors are—as of now—not being taught sufficiently. For instance, the error involving the prescription of an insufficient amount due to an erroneous end-time highlights the need to teach that fields within an EPS are interconnected and can influence the final prescription. Entering data in a wrong field, such as specifying the dosage in the notes section, can lead to potentially harmful situations. Especially considering that—in the Dutch context—most EPSs also include a clinical decision support-system that relies on accurate data entry. Neglecting this can compromise patient safety, particularly when prescribers expect the system to intervene when necessary. In this study, participants in the intervention group would have received an alert when prescribing too high a dose.

TABLE 2 Prescribing errors.

Error category	Subcategory	Intervention ($n = 42$)	Control ($n = 42$)	*P*	Distinct?	Specific to
Administrative error	Value entered in wrong field (EPS)[a]	1 (2.4)	0 (0)	n/a[r]	Y	EPS
	Missing patient information (excl. bodyweight)[b]	0 (0)	8 (19)	n/a[r]	Y	Non-EPS
Inadequate information	No/incomplete dosage[c]	0 (0)	1 (2.4)	>.99	Y	-
	Wrong usage instructions[d]	0 (0)	2 (4.8)	.49	Y	-
	No concentration or dosage stated[e]	0 (0)	12 (28.6)	n/a[r]	Y	Non-EPS
	Wrong dose/concentration (combination)[f]	0 (0)	1 (2.4)	n/a[r]	Y	Non-EPS
	Confusing information[g]	3 (7.1)	10 (23.8)	.07	N	-
	Missing usage instructions[h]	37 (88.1)	31 (73.8)	.16	N	-
	No amount to supply stated[i]	1 (2.4)	1 (2.4)	>.99	N	-
	No weight of child[j]	42 (100)	24 (57.1)	**<.01**	N	-
Wrong drug dose	Dose too high[k]	1 (2.4)	0 (0)	>.99	Y	-
	Dose too low[l]	7 (16.7)	7 (16.7)	>.99	N	-
Wrong prescribed amount	Too little due to erroneous end datetime[m]	1 (2.4)	0 (0)	n/a[r]	Y	EPS
	Insufficient prescribed to finish treatment[n]	1 (2.4)	0 (0)	>.99	Y	-
	Insufficient prescribed which makes the prescription patient-unfriendly[o]	10 (23.8)	5 (11.9)	.25	N	-
	Too much prescribed for necessary treatment[p]	9 (21.4)	1 (2.4)	**.02**	N	-
	Too much prescribed for newly started chronic drugs[q]	10 (23.8)	2 (4.8)	**.03**	N	-

Abbreviation: EPS, electronic prescribing system.

[a]For example, dose entered in the notes-field as opposed to the dose-field.

[b]Omission of relevant patient information (e.g., name, date of birth or address).

[c]For example, cetirizine 1 mg/mL 2 times a day as opposed to cetirizine 1 mg/mL oral liquid 5 mg 2 times a day.

[d]For example, the instruction take with a glass of water in the case of a cetirizine oral liquid.

[e]For example, Cetirizine oral liquid as opposed to Cetirizine 1 mg/mL oral liquid.

[f]For example, ethinyloestradiol/levonorgestrel 10/150 microg. tablet as opposed to ethinyloestradiol/levonorgestrel 30/150 microg. tablet.

[g]For example, the presence of information related to another therapeutic indication or side-effects.

[h]For example, the absence of instructions pertaining to when to start taking an oral contraceptive and/or until when to take additional contraceptive measures.

[i]Omission of the amount to dispense (e.g., 200 mL or 63 tablets).

[j]Omission of the child's current weight, which should be explicitly stated in the prescription.

[k]For example, 10 mg 2 times a day as opposed to 5 mg 2 times a day.

[l]For example, 5 mg 2 times a day as opposed to 10 mg 2 times a day.

[m]For example, by entering a therapy end date that is too soon, the electronic prescribing system calculates the wrong amount to dispense.

[n]For example, prescribing an amount only sufficient for 1–2 days.

[o]For example, prescribing 63 tablets of a contraceptive as opposed to 90 tablets for a daily dosage of one tablet, when explicitly not prescribing a stopping week.

[p]For example, 90 tablets of an oral contraceptive, as opposed to 63 tablets, for 3 months when a stop week was prescribed.

[q]For example, prescribing 900 mL of cetirizine oral liquid where 200 mL would have sufficed.

[r]Not applicable to prescribing method-specific errors.

TABLE 3 Prescribing error severities.

	Number of participants per error class[a]			Number of participants by most severe error per participant[b]		
Severity class	Intervention ($n = 42$)	Control ($n = 42$)	*P*-value	Intervention ($n = 42$)	Control ($n = 42$)	*P*-value
B	42 (100.0)	24 (57.1)	**<.01**	1 (2.4)	2 (4.9)	>.99
C	31 (73.8)	30 (71.4)	>.99	6 (14.3)	13 (31.0)	0.12
D	35 (83.3)	23 (54.8)	**.01**	35 (83.3)	23 (54.8)	**.01**

Note: Values are presented as *n* (%). The percentages represent the proportion of the entire group. B: Error occurred but would not have reached the patient. C: Error would have reached the patient but would not have had the potential to cause harm. D: Error would have reached the patient and would have had required additional monitoring to confirm that it resulted in no harm and/or would have required intervention to preclude harm.

[a]The percentages exceed 100%, as some participants made multiple prescribing errors of various severities.

[b]The total percentage may not add up to 100% as not all participants made a prescribing error.

Interestingly, only a single student made this error in the intervention group, but none in the control group.

Furthermore, we found significant differences in the overlapping prescribing errors between the 2 groups, particularly in errors related to the prescribed amount and those related to inadequate information. Concerning errors related to the prescribed amounts, we found that errors related to overprescribing (e.g., 900 mL of cetirizine oral liquid instead of the required 200 mL) were significantly more common in the intervention group (21.4 *vs*. 2.4%). This results from omitting the specific quantity or duration, which—in our EPS—defaults to a 3-month supply. Errors related to underprescribing for the necessary treatment (only enough cetirizine oral liquid to last 2 days) exclusively occurred in the intervention group, although this was a single occurrence. We found the opposite for inadequate information errors, where there was less variety in the subcategories between the 2 groups. Nonetheless, we found a significant difference in the number of participants that omitted the bodyweight on a prescription for a child between the intervention (100%) and the control group (57.1%). It is remarkable that not 1 participant in the intervention group entered—or at least asked a question about—the bodyweight in the prescription. It is possible that due to the novelty of prescribing in an EPS, this aspect was simply forgotten. In the control group, errors related to confusing information were more common (23.8 *vs*. 7.1%), albeit not statistically significant. This difference may be attributed to the limitations of the EPS, which imposes constraints on the amount of information that can be entered into the notes section. This may hinder students from copying and pasting irrelevant information, potentially leading to confusion. This phenomenon is something we do not only observe in the control group, but also recognize from assessments performed by medical students as part of the current curriculum. Additionally, we found that participants in the intervention group (83.3%) made significantly more severe errors than those in the control group (54.8%). The fact that the vast majority of these errors were not prescribing-method specific further emphasizes the need for integration of e-prescribing into the medical curriculum.

Nonetheless, our study also revealed the existence of non-EPS-specific prescribing errors, such as omitting essential patient information or the drug concentration or strength, which does not occur in an EPS where drug details are part of the description of the selectable drugs. These findings underscore the importance of teaching medical students how to write traditional paper prescriptions, making them aware of the differences between the prescribing methods. Despite e-prescribing being the current practice, situations may arise where physicians must resort to traditional prescribing methods, such as during technical failures or emergencies.

In *A Competency Framework for all Prescribers*, developed by the Royal Pharmaceutical Society, prescribing is presented as a singular competency, supported by several statements.[15] Two of these statements refer to e-prescribing and the use of EPSs, namely, that a prescriber "electronically generates and/or writes legible, unambiguous and complete prescriptions which meet legal requirements" and "effectively uses the systems necessary to prescribe drugs". No other explicit references to e-prescribing related competencies were found. Nonetheless, to effectively incorporate e-prescribing competencies into our medical curricula, the distinct competencies need to be identified, properly defined and incorporated into prescribing frameworks. This requires further research and could be achieved extracting competencies from prescribing errors, as shown in Figure 4.

To our knowledge, there are currently no dedicated real-life-like e-prescribing environments available for medical students to hone their e-prescribing competencies. Utilizing the actual EPS of an institution is challenging, primarily due to patient safety concerns and the necessity for direct physician supervision. In practice, we see that students are allowed to prescribe in the institution's EPS during their clerkships, with the requirement for subsequent co-signing by a physician. However, not all systems have this functionality and the learning opportunity is limited to the clerkships, and, while our study utilized a sandboxed version of our institution's EPS, similar to what students experience during their e-prescribing practical, logistical challenges were evident. Prior to the intervention, the students had to be

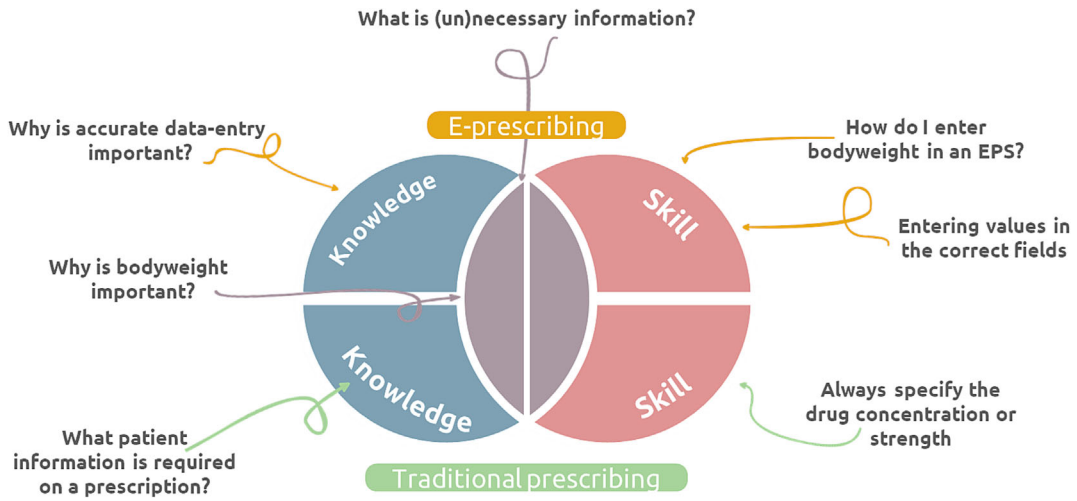

FIGURE 4 (Electronic-)prescribing competencies.

authorized individually in the EPS by the IT department. During the intervention, issues included participants not having access to the EPS, limited export options and frequent system refreshing. The latter, leading to the loss of the prescriptions of 2 participants. These administrative burdens hinder the educational experience for both students and teachers. Furthermore, the institution's EPS is tailored to the clinical setting, making it less suitable for teaching general (e-)prescribing. As such, there is a pressing need for an accessible real-life-like educational prescribing platform to ensure efficient and effective learning process.

Our study had several limitations, including its small sample size and the single-centre setting, which limit the generalizability of our findings and reduce the statistical power of the study. The low response rate (25%) may have introduced selection bias, as it is likely that the more motivated students participated in the study. Although there was no statistically significant difference in the distribution of the grades on the formative assessment between participants and nonparticipants, twice as many participants received a good grade. Moreover, we only included 46.7% of our intended inclusions. One contributing factor may have been the scheduling constraints, as the proposed timeslots for assessments may not have aligned with the students' availability. The limited number of assessment cases offered us valuable insights, while a larger variety of cases might offer a more comprehensive evaluation. For future research, it may be beneficial to offer an online assessment option with the freedom for participants to complete it at their convenience, which may increase participation rates. Regarding the checking, although all discrepancies were discussed until consensus was achieved, we did not calculate the interrater reliability. Additionally, we relied on the sandboxed version of our institution's EPS, which may not fully replicate the diversity of EPSs used in real clinical practice. Finally, it is important to acknowledge that EPSs and practices can vary significantly between countries, which should be considered when interpreting our results outside of the Dutch healthcare setting.

The results of our study emphasize the need for re-evaluating prescribing education within our medical curricula. It is essential to incorporate prescribing competencies tailored to both specific prescribing methods as well as those applicable. To achieve this, a follow-up to this pilot study is required, involving further research to identify these competencies across a larger participant population with a wider array of prescriptions. In parallel, the development of an accessible educational prescribing platform, is imperative. Meanwhile, educators should try to keep in mind the intended prescribing competencies when designing prescribing assessments.

5 | CONCLUSIONS

This study shows the importance of training e-prescribing competencies in medical curricula, in addition to traditional prescribing methods. It identifies prescribing-method-specific prescribing errors and emphasizes the need for further research to define e-prescribing competencies. Additionally, the need for an accessible real-life-like e-prescribing environment tailored to educators and students is essential for effective learning and incorporation of e-prescribing into medical curricula.

AUTHOR CONTRIBUTIONS

Samir El Abdouni, Laura S. Kalfsvel, Wim J.R. Rietdijk and Floor van Rosse designed the study. Data classification was done by Samir El Abdouni, Laura S. Kalfsvel and Floor van Rosse. Samir El Abdouni and Laura S. Kalfsvel processed the data. Samir El Abdouni performed the analysis and drafted the manuscript. All authors discussed the results and commented on the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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