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Evaluating medical students' ability to identify and report errors: finding gaps in patient safety education

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ABSTRACT

Background: Although there are frequent complaints of medical students' incompetence in reporting errors, few studies have examined their error-reporting abilities in the real world.

Objectives: Three sub-functions of self-regulation theory were used to evaluate medical students' ability to identify errors (self-monitoring), analyse root causes (self-judgment), and devise improvement plans (self-reactions). In addition, whether students reacted differently to their errors and those of others (three sub-functions) was also examined.

Methods: A total of 952 patient safety reports were reviewed retrospectively, submitted by third-year medical students between 2016 and 2018. Data were quantitatively and qualitatively analysed to investigate who committed the error, to identify the type of error and its root causes, and to find suggested improvement plans. Chi-square and Fisher's exact tests were used to compare students' responses to error origins.

Results: Students reported other errors more frequently than their own (67.6% vs. 32.4%). They reported common critical medical errors, including errors related to engaging with patients (34.5%), invasive procedures (20.2%), and infection (18.5%). The root causes identified were more precise than the improvement plans by the students (75.5% vs. 18.4%, respectively). The students' improvement plans were not practical, especially at the patient level (25.8%). When students committed errors, they considered human factors such as fatigue, scheduling, and training as the most common root cause, focussing on improvement plans at the individual level.

Conclusions: The results suggest that students were good at self-judgment, but not at self-monitoring and self-reactions. They reacted differently, based on who committed the error. To enhance self-regulated learning, Educators should encourage students to confront their errors, reflect on their self-reactions towards errors, develop well-being with time management, and think about the meaning of patient-centredness. Finally, active participation in clinical clerkship longitudinally may provide students with opportunities to learn from their errors.

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Introduction

Studies frequently present medical students' incompetence in reporting medical errors, which continues even after patient safety education [1,2]. Medical students showed low confidence, resistance, and fear of error reporting [1–3]. Additionally, they were more likely to report their colleagues' errors than their own [4]. When students themselves committed a medical error, they mentioned taking preventive action less frequently than when others caused the error [5]. Incident reporting provides individuals, teams, and organisations with the opportunity to learn from errors [6,7]. Thus, it has been suggested that medical students should learn error reporting and be encouraged to report errors in an intellectually and emotionally engaging manner [8,9]. Understanding medical students' ability to identify and report errors in detail will be helpful in improving error reporting.

Conceptual and theoretical framework

The three sub-functions of self-regulation in social cognitive theory can provide an excellent conceptual framework for teaching and assessing students' ability to report errors. The sub-functions are (1) self-monitoring of one's behaviour and its consequences; (2) self-judgment of one's behaviour in terms of personal standards, goals, or types of attribution; and (3) self-reactions to one's performance, such as goal setting, self-efficacy perceptions, metacognitive planning, and behavioural changes [10–12]. Preoccupied beliefs can influence people's selective

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attention and perception of their behaviour [11]. People judge their behaviour through reflective processes from multiple social sources [11]. Judgment motivates people to change their actions to pursue favourable outcomes [11]. These sub-functions reciprocally influence each other [12].

From the perspective of patient safety, students' ability to report errors can be explained through the sub-functions. Firstly, self-regulated learners monitor themselves, their teams, and the workplace, and identify common preventable medical errors. Secondly, they correctly judge the root causes of errors by utilising systems thinking [13,14]. Thirdly, they plan behaviour changes at the individual, team, organisational, and patient levels for further error prevention and quality improvement. In contrast, learners without self-regulation may not report errors because they do not notice any errors to report or do not know how to report them [7,15]. They may falsely judge the error causes with a hindsight bias. Furthermore, their self-reactions may lead them to neglect their errors, make judgments in their own favour, or prevent them from changing their behaviour [16–18].

Research gaps

Several studies have demonstrated the effectiveness of patient safety and error-reporting education for medical students [1,2,8,9,19,20]. These studies reported an improvement in students' knowledge and attitude in identifying and reporting errors after education [8,9,19,20]. However, most studies did not provide meaningful answers to whether the students recognised common errors, judged the root causes of systemic failure, and were motivated by the errors to change their behaviours for quality improvement. Furthermore, extant studies rarely offer clear answers about whether students recognise their errors or how they react to their errors differently. Most studies did not evaluate students' competence objectively and in detail, nor were they based on real student experiences. Instead, they dealt with subjective changes in students' self-confidence using self-rating questionnaires, vignettes, or self-reflective interviews. Some studies have investigated students' writing of experienced errors, but the results were not sufficient to reveal the whole picture [4,5,8,9,20].

Research aims and questions

By exploring students' errors in their actual clinical experiences during clerkship, we can understand their ability to recognise and report medical errors as self-regulated learners. This will allow us to evaluate students' strengths and weaknesses in improving error-reporting education. Observing and evaluating students' ability to report errors will also provide excellent opportunities to improve the medical education system. We think that self-regulated students will recognise errors, judge root causes, and plan for behavioural changes based on their own and others' errors. This study aims to determine the medical errors identified and reported by students and explore possible ways to improve medical students' error reporting abilities, which previous papers have not examined. The research questions were the following:

(1) Did the students frequently recognise and report common and important errors? This question is related to self-monitoring.
(2) Did the students judge the correct root causes using systems thinking? This question is related to self-judgment.
(3) Did students plan to change their behaviours for quality improvement? This question is related to self-reactions.
(4) Did the students identify and report their own errors differently from those committed by someone else? This question is related to the three sub-functions.

Methods

Participants

We retrospectively reviewed patient safety reports submitted by third-year students during clerkship between 2016 and 2018. We acquired the Institutional Review Board's permission to conduct this study (IRB No. INJE 2020–02-004).

The total number of reports was 1,045. In 2016, 112 students turned out 225 reports (average of two reports per student). In 2017 and 2018, a total of 111 and 98 students submitted 440 and 380 reports (average of four reports per student), respectively. We increased the number of reports submitted to facilitate the exploration of more errors among students. The final number of reports was 952.

Context

Our school has a 4-year undergraduate medical curriculum, and the clinical clerkship starts in the third year in five university-affiliated hospitals. The core clinical rotations consist of 12 weeks of internal medicine; 6 weeks each of surgery, paediatrics, obstetrics and gynaecology; 4 weeks of psychiatry; and 2 weeks of emergency medicine, which is the usual Korean clinical clerkship [21]. Students usually take two patients per week.

In 2012, our school integrated patient safety into the curriculum. At the beginning of the first year, students learn about the importance and concepts of patient safety, teamwork, and infection errors. During

the preclinical phase, students learn more knowledge and skills regarding patient safety in lectures, problem-based learning sessions, clinical skills laboratories, and doctoring classes. Third-year students take a more intensive patient safety course just before starting their clinical clerkship, where they learn common medical errors and root causes more precisely, and the significance of systems thinking, quality improvement, communication with the team and the patients and their family, and error reporting [19]. We used small-group discussions, reflective writing, formative feedback from peers and faculties, and portfolios to encourage students' reflection and error reporting [22,23].

Students also participated in patient safety discussion sessions during their third-year clinical placements. We emphasised the importance of reflecting on their medical errors and those of their peers and encouraged them to report their own errors. Additionally, we recommended a systematic approach at the individual, team, and patient levels for quality improvement. They were required to submit patient safety reports in their learning portfolios for every clinical placement. Clerkship directors and supervisors provided feedback to students during discussion sessions and online portfolio systems.

Data collection

We made a simple form because we wanted students to reflect without a pre-set framework (Supplementary material). The reports did not include any patient information, apart from age and sex. The reports have three questions of the Veterans Affairs Root Cause Analysis (VA RCA) system [24,25]; that is, 'What happened?' for identifying preventable errors, 'Why did it happen?' for analysing root causes, and 'How can it be prevented from happening again?' for behavioural changes to improve quality.

The patient safety course director asked the students to submit their best reports from their portfolios for student assessment and program evaluation. The students submitted medical and nonmedical errors committed during clerkship, from which only medical errors were selected for this study.

Evaluation

To answer the first research question, we analysed students' experience of errors. We quantitatively investigated the following: who caused the error, where the error occurred, and the type of error. We classified errors into five broad categories according to the common critical errors: (1) infection, (2) invasive procedures, (3) medication, (4) engaging with patients, and (5) others [23].

To answer the second research question, we assessed students' systems thinking in the root cause analysis. We investigated students' blame tendencies and identified the types of root causes reported by the students. We checked whether the root cause analysis was based on students' systems thinking. We divided the VA RCA system's root cause category [24] into the following six categories: (1) rules, (2) communication, (3) fatigue, scheduling, and training; (4) safeguards, environment, and equipment; (5) information technology; and (6) others.

To answer the third research question, we explored students' planning of behavioural change for quality improvement. We evaluated the suggested action plans for improvement at the individual, team, and patient levels.

To answer the fourth research question, we compared the differences in student responses according to error origin. We investigated how differently they recognised error types, blamed someone, analysed root causes, and made an improvement plan.

We assessed the quality of root cause analysis and improvement planning using a 4-point Likert-type scale (1: non-systematic, unorganised, scattered, few, irrelevant; 4: systematic, well-organised, presented more than three causes or plans, relevant, motivated, and specific). Before the assessment, we organised consensus workshops for scoring standardisation for all authors. Each author independently analysed the same 300 reports and discussed the similarities and differences among the analyses to reach a consensus on the evaluation criteria. We then divided the remaining reports into two sets. SL and JKP assessed root cause types and plan levels, and HR and MK assessed the qualities. We discussed uncertain and confusing reports until we reached a consensus.

Data analysis

We used descriptive statistics for the statistical analysis. Non-categorical comparisons were necessary to answer the fourth question. Furthermore, we used chi-square and Fisher's exact tests to evaluate the statistical significance of such incidents. The p-value significance was set at 0.05. The study used the RStudio software version 1.1.463 for Windows (RStudio, Inc., Boston, USA).

Results

Characteristics of medical errors reported by students

Among the 952 reports with medical errors, 67.6% (n = 644) were errors made by others and 32.4% (n = 308) were errors involving themselves, either the subject alone (n = 248, 26.1%) or committed

Table 1. Basic characteristics of medical errors reported by students.

	Categories	Frequency (%)
Subject making the medical error	Other(s)	644 (67.6%)
	Intern(s)/Resident(s)	171 (26.6%)
	Health professional(s)*	166 (25.8%)
	Attending staff	109 (16.9%)
	Nurse(s)/Paramedical(s)	99 (15.4%)
	Patient(s)/Family(ies)	84 (13.0%)
	Teammate(s)	33 (5.1%)
	Hospital worker(s)	14 (2.2%)
	Others	8 (1.2%)
	N/A	18 (2.8%)
	Myself	248 (26.1%)
	Myself and	60 (6.3%)
	Teammate(s)	26 (43.3%)
	Intern(s)/Resident(s)	23 (38.3%)
	Attending staff	15 (25.0%)
	Nurse(s)/Paramedical(s)	7 (11.7%)
	Health professional(s)*	6 (10.0%)
	Patient(s)/Family(ies)	3 (5.0%)
Place where the error occurred†	Ward	385 (40.4%)
	Out-patient clinic	144 (15.1%)
	Operating room	113 (11.9%)
	Emergency room	84 (8.8%)
	Intensive care unit	54 (5.7%)
	Delivery room	7 (0.7%)
	Laboratory/Procedure room	3 (0.3%)
	Others	79 (8.3%)
	N/A	91 (9.6%)

Abbreviations: N/A = not available.
Notes: *If the report documented that the error was made by some other health professionals but did not specify their working position in the hospital, we included them in this category.
†Several reports described more than one subject who committed the error or the place where the error occurred. Therefore, the total number of each category may exceed that of the reports, which is 952.

along with others (n = 60, 6.3%; Table 1). Several reports have described more than one subject who committed a medical error or where an error occurred. The general ward was the most common place (n = 385, 40.4%) where errors occurred, followed by outpatient clinics (n = 144, 15.1%) and operating rooms (n = 113, 11.9%).

Types of medical errors reported by students

The types of errors reported covered a broad range of spectra (Table 2). Errors related to engaging with patients (n = 328, 34.5%) were the most common, followed by those related to invasive procedures (n = 192, 20.2%) and infection (n = 176, 18.5%). Errors related to medication accounted for 7.8% (n = 74) of the total number of patients.

Students' judgment of root causes using systems thinking

The quality of the root cause analysis presented by the students was good (Table 3). Over half of the reports included more than three well-classified root causes (n = 496, 52.1%). Students blamed system failure (n = 740, 77.7%) much more than individuals (n = 148, 15.5%).

The most common root cause was 'rules' (n = 764, 80.3%). 'Fatigue, scheduling, and training' (n = 735, 77.2%) and 'communication' (n = 653, 68.6%) followed.

Students' improvement plans for behavioural changes

Unlike the root cause analysis, most proposed plans were unorganised and fragmented (n = 777, 81.6%), with questionable ability to bring substantial behavioural changes in actual medical practices (Table 4). Almost all reports contained plans at the individual and team levels (n = 875, 91.9% and n = 851, 89.4%, respectively). There were fewer suggestions for improvement at the patient level (n = 246, 25.8%).

Differences in students' responses according to whether they commit errors or not

The students recognised more errors in their own infection (n = 69, 22.4% vs. n = 107, 16.6%; $\chi^2 = 4.631$, df = 1, p = 0.031) and medication errors of others (n = 1, 0.3% vs. n = 73, 11.3%; Fisher's exact test, p < 0.001) (Table 2).

The quality of root cause analysis of the students was better in the case of their own errors (n = 253, 82.2% vs. n = 466, 72.4%; $\chi^2 = 10.787$, df = 1, p < 0.001) (Table 3). In the case of their own errors, students blamed less both individuals (n = 13, 4.2% vs. n = 135, 20.9%; $\chi^2 = 43.214$, df = 1, p < 0.001) and systems (n = 214, 69.5% vs. n = 526, 81.7%; $\chi^2 = 17.207$, df = 1, p < 0.001). They considered 'fatigue, scheduling, and training' to be the most common root cause for their own errors (n = 267, 86.7%). In contrast, in the case of others' errors, they considered 'rules' as the most common root cause (n = 524, 81.4%).

The quality of action plans was worse in the case of their own errors (n = 285, 92.6% vs. n = 492, 76.4%; $\chi^2 = 36.154$, df = 1, p < 0.001), making behavioural change plans more at the individual level (n = 298, 96.7% vs. 577, 89.6%; $\chi^2 = 14.356$, df = 1, p < 0.001) and less at the patient level (n = 58, 18.8% vs. 188, 29.2%; $\chi^2 = 11.673$, df = 1, p < 0.001) (Table 4).

Discussion

In this study, students frequently recognised common critical errors. They used systems thinking to pinpoint root causes accurately. However, they showed poor ability in improving planning for behavioural changes. These are the answers to the first, second, and third research questions. From the perspective of the three sub-functions of self-regulation theory [10–12], the

Table 2. Types of errors reported by students*.

Error types	Total (n = 952)	Myself involved (n = 308)	Others (n = 644)	p value†
Infection related errors*	176 (18.5%)	69 (22.4%)	107 (16.6%)	**p = 0.031**
Hand washing/sanitizing	101 (57.4%)	45 (65.2%)	56 (52.3%)	
Wearing protective equipment	60 (34.1%)	23 (33.3%)	37 (34.6%)	
Discarding biohazard waste	11 (6.3%)	1 (1.4%)	10 (9.3%)	
Others	20 (11.4%)	8 (11.6%)	12 (11.2%)	
Sterilisation of personal equipment	11 (55.0%)	6 (75.0%)	5 (41.7%)	
In-hospital infection	4 (20.0%)	0 (0%)	4 (33.3%)	
Contamination events at ward	3 (15.0%)	0 (0%)	3 (25.0%)	
Cleaning doctor's gown	2 (10.0%)	2 (25%)	0 (0%)	
Errors in invasive procedures*	192 (20.2%)	72 (23.3%)	120 (18.6%)	p = 0.088
Wrong patient, wrong site	60 (31.3%)	22 (30.6%)	38 (31.7%)	
Violation of aseptic procedures	58 (30.2%)	39 (54.2%)	19 (15.8%)	
Procedure-related complications	19 (9.9%)	2 (2.8%)	17 (14.2%)	
Others	56 (29.2%)	10 (13.9%)	46 (38.3%)	
Procedure failure	20 (35.7%)	4 (40.0%)	16 (34.8%)	
Errors during the procedure	10 (17.9%)	0 (0%)	10 (21.7%)	
Delayed operation	9 (16.1%)	1 (10.0%)	8 (17.4%)	
Injury to health workers	5 (8.9%)	0 (0%)	5 (10.9%)	
Wrong gauze count	4 (7.1%)	1 (10.0%)	3 (6.5%)	
Improper skills	3 (5.4%)	2 (20.0%)	1 (2.2%)	
Improper preparation	2 (3.6%)	0 (0%)	2 (4.4%)	
Failed anesthesia	2 (3.6%)	0 (0%)	2 (4.4%)	
Unsafe environment	2 (3.6%)	2 (20.0%)	0 (0%)	
Medication error*	74 (7.8%)	1 (0.3%)	73 (11.3%)	**p < 0.001¶**
In prescription	42 (56.8%)	1 (100%)	41(56.2%)	
In giving medication	27 (36.5%)	0 (0%)	27 (37.0%)	
In monitoring	5 (6.8%)	0 (0%)	5 (6.8%)	
Others	1 (1.4%)	0 (0%)	1 (1.4%)	
Errors in engaging with patients	328 (34.5%)	100 (32.5%)	228 (35.4%)	p = 0.372
Patient care and management‡	97 (29.6%)	19 (19.0%)	78 (34.2%)	
Informed consent	60 (18.3%)	24 (24.0%)	36 (15.8%)	
Spills of patient information	57 (17.4%)	26 (26.0%)	31 (13.6%)	
Treatment non-compliance	55 (16.8%)	4 (4.0%)	51 (22.4%)	
Miscommunication	27 (8.2%)	16 (16.0%)	11 (4.8%)	
Not protecting patient privacy	13 (3.9%)	6 (6.0%)	7 (3.1%)	
Others	19 (5.8%)	5 (5.0%)	14 (6.1%)	
Others	196 (20.6%)	68 (22.1%)	128 (19.9%)	p = 0.432
Delayed process	50 (25.5%)	12 (17.6%)	38 (29.7%)	
Errors in the treatment process	22 (11.2%)	7 (10.3%)	15 (11.7%)	
Errors in medical recording	21 (10.7%)	12 (17.6%)	9 (7.0%)	
Errors in teamwork	21 (10.7%)	8 (11.8%)	13 (10.2%)	
Error in diagnosis	13 (6.6%)	8 (11.8%)	5 (3.9%)	
Safety error in a hospital facility	12 (6.1%)	3 (4.4%)	9 (7.0%)	
Fall-related injury	11 (5.6%)	0 (0%)	11 (8.6%)	
Errors in team communication	9 (4.6%)	4 (5.9%)	5 (3.9%)	
Errors in patient isolation	7 (3.6%)	0 (0%)	7 (5.5%)	
Restrain injury	5 (2.6%)	2 (3.0%)	3 (2.3%)	
Providing wrong information to the patient	5 (2.6%)	0 (0%)	5 (3.9%)	
Unnecessary examinations	5 (2.6%)	0 (0%)	5 (3.9%)	
Transfusion error	1 (0.5%)	0 (0%)	1 (0.8%)	
Needlestick injury	1 (0.5%)	0 (0%)	1 (0.8%)	
Others	13 (6.6%)	6 (8.9%)	7 (5.5%)	

*Several reports were documenting two or more types of error. Therefore, the sum of sub-categories exceeded each category's total number of reports and error counts.
†Statistical analyses by Chi-square test.
‡This included every situation where patient complained, regardless of who contributed to their misunderstanding or how it started.
¶Statistical analysis by Fisher's exact test.

students were good at self-judgment but were not adept at self-monitoring and self-reactions.

The students also reacted differently depending on who made the errors. In the case of their own errors, the quality of students' root cause analysis was much better, and students focussed more on human factors as a root cause. In contrast, the quality of improvement planning in light of their own errors was poorer than when others made the errors, and students concentrated more on improvement plans at the individual level. These results are similar to those by Kiesewetter et al. [5], and they imply that routine patient safety education may not be sufficient for medical students to objectively observe their errors.

The students were prone to reporting others' errors, rather than their own. This result is consistent with the findings by Martinez and Lo [4]. We assume that cognitive and emotional self-reactions to errors may disturb self-monitoring. Students' prejudices may influence idealised doctor performance, and perfectionism may drive a high standard of practice. Errors, to them, mean that they are imperfect, which brings a sense of frustration and failure. Moreover, their emotions, such as fear and anxiety,

Table 3. Root cause analyses of reported errors by students.

Variables	Total (n = 952)	Myself involved (n = 308)	Others (n = 644)	p-value*
Quality of root causes presented				**p < 0.001**‡
Non-systematic, unorganised, irrelevant, less than 3 causes presented	208 (21.8%)	45 (14.6%)	163 (25.3%)	
Unorganised, but more than 3 causes presented	25 (2.7%)	10 (3.2%)	15 (2.3%)	
Systematic, classifiable causes, less than 3 causes presented	223 (23.4%)	89 (28.9%)	134 (20.8%)	
Systematic, well-classified, relevant, more than 3 causes presented	496 (52.1%)	164 (53.2%)	332 (51.6%)	
Blaming tendency				
Blaming the individual committing the error	148 (15.5%)	13 (4.2%)	135 (20.9%)	**p < 0.001**
Considering system failure	740 (77.7%)	214 (69.5%)	526 (81.7%)	**p < 0.001**
Types of root causes presented in reports†				
Rules	764 (80.3%)	240 (77.9%)	524 (81.4%)	p = 0.212
Fatigue, scheduling, and training	735 (77.2%)	267 (86.7%)	468 (72.7%)	**p < 0.001**
Communication	653 (68.6%)	159 (51.6%)	494 (76.7%)	**p < 0.001**
Safeguard, environment, and equipment	51 (5.4%)	10 (3.2%)	41 (6.4%)	**p = 0.046**
Information technology	42 (4.4%)	11 (3.6%)	31 (4.8%)	p = 0.334
Others	28 (2.9%)	12 (3.9%)	16 (2.5%)	p = 0.228

*Statistical analyses by Chi-square test.
†Classification of root causes was performed according to the VA National Center for Patient Safety RCA tools. Each report included more than one root cause. Therefore, the total count of root causes exceeded the total number of reports (n = 952).
‡In the statistical analysis, the quality of the suggestions was sorted into two categories: non-systematic unorganised and systematic, classified causes, and then compared using the Chi-square test.

Table 4. Students' improvement plans for behavioural changes.

Variables	Total (n = 952)	Myself involved (n = 308)	Others (n = 644)	p-value*
Quality of the suggestion				**p < 0.001**†
Non-systematic, unorganised, irrelevant, less than 3 suggestions presented	412 (43.3%)	124 (40.3%)	288 (44.7%)	
Unorganised, but more than 3 suggestions presented	365 (38.3%)	161 (52.3%)	204 (31.7%)	
Systematic, classifiable causes, less than 3 suggestions presented	31 (3.3%)	3 (0.9%)	28 (4.4%)	
Systematic, well-classified, relevant, specific, more than 3 suggestions presented, motivated	144 (15.1%)	20 (6.5%)	124 (19.3%)	
Categories of suggested plans				
Individual level	875 (91.9%)	298 (96.7%)	577 (89.6%)	**p < 0.001**
Team level	851 (89.4%)	274 (88.9%)	577 (89.6%)	p = 0.766
Patient level	246 (25.8%)	58 (18.8%)	188 (29.2%)	**p < 0.001**

*Statistical analyses by Chi-square test.
†Statistical analysis by Chi-square test. In the statistical analysis, the quality of the suggestions was sorted into two categories: non-systematic unorganised and systematic, classified suggestions, and then compared.

may decrease motivation to self-observation [10,11,22].

Students' self-judgment may also be affected by their self-reactions. In this study, the most common root cause of errors were human factors, such as fatigue, busy scheduling, or lack of training. We believe that the results of this study provide evidence that cognitive and emotional self-reactions to errors influence self-judgment. People naturally want to avoid being blamed by others when they make errors [15,16]. Furthermore, they want to be recognised as excellent in their work. Thus, students might be better at finding others' errors or blaming extrinsic factors, such as busy scheduling or lack of training as a defence mechanism. Alternatively, self-regulated students with high self-efficiency might be motivated to fill the gaps to feel confident.

Students' self-reactions may also be affected by their self-judgment. In our study, students concentrated on improvement planning at the individual level, but the planning quality was poor. The root causes that students considered can influence their desire for self-development. We believe that students' consideration of human factors as the leading root cause affects them to focus on individual-level improvement planning. However, suppose students judge errors as being caused by extrinsic factors. In that case, they may try to defend their errors by blaming medical schools, faculties, and learning environments, and deferring their self-regulated learning responsibility to the schools, leading students not to pay attention to improvement plans. Thus, the results may be evidence that students' self-judgment influences self-reactions.

Interestingly, students' improvement plans at the patient level were poorly organised, although they most frequently reported errors in engaging with patients. For the plans at the patient level, we expected that students would encourage patients and their families to actively participate in patient care. Students may consider patients as just a person who should be cared for, and not team members. Students may be influenced by doctors, organisations, and societal cultures in which patients are passive clients. Considering that patient-centredness is the core value of patient safety, students need to understand that the patient is part of the healthcare system and an active team member

[23]. Self-regulated students can learn from patients by monitoring them, understanding errors from patients' perspectives, and reacting to patients.

The low rate of reporting errors and insufficient improvement planning of students might reflect systemic dysfunction in our educational programs. Students might not have a chance to experience sufficient errors because they play a limited role in patient care. Furthermore, they might have limited understanding of the working process in hospitals due to fragmented clinical rotations. The ability to identify errors and plan for improvement requires longitudinal integrated hospital experience with active patient care responsibilities. Reforms in clinical clerkship to encourage students' active participation in patient care might provide them with more opportunities and insights to recognise their errors.

This study makes several suggestions to enhance students' self-regulated learning abilities in terms of error reporting. Firstly, reflection on their errors will help students increase their self-monitoring and self-reactions. Self-reflection about fixated ideas and emotions may allow students to face their errors [4,5,9,22]. It is desirable to encourage students to see errors as learning resources, not as evidence of incompetence. Secondly, developing students' well-being and time and task management skills will help them increase their self-efficiency perception. Studies have suggested mindfulness, writing practice, and mentoring with feedback as ways to develop these skills [4,5,22]. Third, improving the learning environment is a good strategy for promoting self-regulated learning. Both students and medical educators should try to innovate the learning environment for active participation in patient care longitudinally [26]. Finally, emphasising more patient-centredness will be helpful in developing a partnership with patients [23]. Self-reflection about their attitude towards the patient–doctor relationship and the reason for emerging patient safety concepts in a changing society may encourage students to engage more with patients and caregivers.

This study has several limitations. Firstly, we investigated only the reports of third-year students. We did not deal with fourth- or final-year students because our school only had a patient safety program from the first to the third year. It is still an obstacle for the patient safety education team to expand the program to the final year in our school. This requires team leadership. Secondly, we explored the results of only one Korean medical school. However, the results can be generalised because clinical rotations in many medical schools across different countries are similar to those in our school. Thirdly, we did not cross-check the authenticity and accuracy of the error reports. It was practically impossible to check whether a reported error occurred. However, the clerkship directors and staff assessed the portfolio reports, so we consider the reports to have already been cross-checked. Finally, although we tried to collect enough reports for the study, some of the analyses still had low sample sizes to infer meaningful conclusions. Despite these limitations, the results can help medical educators and health professionals improve patient safety education and enhance students' error reporting in schools in other countries.

Conclusion

The students in this study showed good ability to monitor common critical errors and judge root causes. However, they identified the errors of others more than they did their own. They considered human factors as the most common root cause, but showed limited competence in planning for improvements, especially at the patient level. They also reacted differently depending on who made the errors.

From the perspective of self-regulation, the students' abilities were good for self-judgment, but not good enough for self-monitoring and self-reactions. Cognitive and emotional self-reactions to errors may influence self-monitoring and self-judgment. Self-judgment may also affect self-reactions. To enhance students' error reporting abilities, we suggest educators should encourage students to confront their errors, reflect on their self-reactions towards errors, develop well-being and time management, consider the students' role in their learning environment, and think about the meaning of patient-centredness. Active participation in clinical clerkship will provide students with more opportunities to learn from errors.

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