

# Learning from mistakes – students' learning experiences from clinical adverse events.

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**Abstract:** Clinical training in the teaching practice is essential for developing patient-specific skills, yet the transition from preclinical to clinical training presents significant challenges for students. This study seeks to enhance clinical training quality by retrospectively examining adverse events reported by third-year pre-doctoral students from classes 202A, 202B, and 202C during their first ten months of clinical practice at the teaching practice. A total of 235 adverse events were reported across eight disciplines: Treatment planning (TP), Operative (OP), Periodontics (PER), Endodontics (EN), Oral Surgery (OS), Fixed Prosthodontics (FP), Removable Prosthodontics (RP), and Patient Management (PM). Case discussions followed, focusing on problem-solving and prevention. The distribution of events was as follows: TP (11.5%), OP (17.7%), PER (13.1%), EN (6.9%), OS (6.2%), FP (24.2%), RP (5.0%), and PM (15.4%), with FP, OP and PM experiencing the highest rates of adverse events. Across these disciplines, inadequate clinical skill proficiency was identified as a primary cause of adverse events. Other contributing issues included miscommunication, insufficient explanations to patients, a lack of administrative support, case complexity, and a deficit in diagnostic examinations and skills. The study highlights the prevalence of adverse event, suggesting that a better understanding of these incidences can improve student performance and patient outcomes, and reinforces the need to include such analyses in dental education.

**Keywords:** Learning from mistakes, Clinical teaching, Adverse event, Teaching practice, Dental education, Learning environment.

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## 1. Introduction

A humanistic and professional learning approach is critical in clinical education in dental schools. Dental educators are responsible for ensuring a learning experience in a productive and safe learning environment [1-3]. There is consensus in the dental education literature that student perceptions of the curriculum should be given serious consideration in all discussions and decisions relating to their education. [4-7]. One study indicated that students' learning environment perception deteriorates throughout the curriculum, especially within the preclinical training to clinical training transition [2]. Clinical training involves direct patient care, offering a unique and specific learning experience in contrast to preclinical training, which is practice-oriented and designed to prepare students for the realities of the clinical environment.

The Harvard School of Dental Medicine (HSDM) introduced an interdisciplinary course curriculum in 1990, which emphasized comprehensive treatment planning and

clinical care [8]. The goal of this curricular change was to assess the extent of comprehensive care delivered and to confirm that continuity of care was being maintained through the completion of comprehensive treatment plans [9-11]. In 2009, HSDM developed and implemented a case completion curriculum within the reformed predoctoral curriculum, which replaced the traditional model based on procedural numerical requirements [12]. The redesign of the clinical component aimed to facilitate a patient-based comprehensive care experience within the student teaching practice [13,14]. An analysis of five years of retrospective data, along with a survey of student perspectives, indicated that the case completion clinical curriculum – with its priority on comprehensive patient management – has enhanced patient-based care [15]. Further assessment revealed that the new curriculum not only encouraged students to deliver comprehensive care but also fostered a greater commitment to the completion of treatment plans. There have been fewer patient transfers between students and an improved transition of care upon graduation. Moreover, this clinical education model has been instrumental in teaching student’s patient management skills that are beneficial as they embark on their professional practice [16]. These studies offer further evidence supporting the value of a comprehensive care model in clinical education. Nevertheless, the transition from the pre-clinical phase to the clinical training phase still presents numerous challenges for students. Despite the systematic and structured support provided by dental schools for both students and faculty during this transitional phase, adverse events still occur. Students may experience nervousness and stress on their first day of performing clinical procedures. Additionally, patient management is a skill typically acquired through experience and is challenging to impart in a preclinical setting.

The definition of an adverse event varies. The National Health Service (NHS) defines a patient safety incident as ‘any unintended or unexpected incident which could have or did lead to harm for one or more patients receiving NHS-funded healthcare’, thereby including incidents that result in no harm and near misses [17]. In contrast, the Harvard Medical Practice Study’s methodology used in retrospective chart review studies in several countries considers adverse events to be injuries that result in prolonged hospitalization, disability, or death, which are caused by healthcare management including incidents with more severe consequences [18]. These large international reviews of patient charts estimate that between 4% and 17% of hospital admissions are associated with an adverse event and a significant proportion of these (one- to two-thirds) are preventable [8-28].

In dental clinical education, knowledge about adverse events is limited. These events could be better managed if students and supervising faculty understood their causes and potential solutions. In Advanced Dentistry, one of the seven multidisciplinary preclinical courses at HSDM, students discuss cases they have encountered. They identify and reflect on adverse events experienced during teaching practice. By discussing the event, its causes, and effective prevention methods, students can learn from each other’s experiences. Investigation adverse events sheds light on their incidence and highlights areas where risk can be mitigated, and prevention strategies can be implemented.

The aim of this study was to assess the adverse events that occurred at HSDM’s teaching practice during the first ten months of the students’ clinical training, by analyzing data from the Advanced Dentistry course that is held at the ten-month mark of their clinical education. This study aimed to analyze the frequency and characteristics of adverse events and propose preventive measures for both students and faculty to prevent their recurrence, thereby enhancing the quality of future preclinical education.

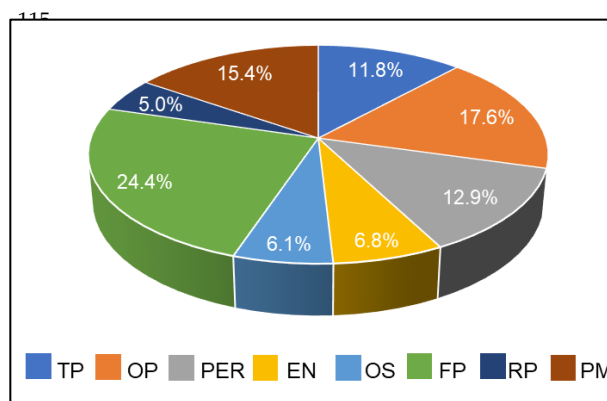
## 2. Materials and Methods

The Advanced Dentistry (AD) course, placed at the end of third-year dental curriculum at HSDM, requires to present a comprehensive review of three to four clinical adverse events they have experienced in the last 10 months since starting clinical procedures at the teaching practice. Each event presentation covers the adverse event that occurred, its resolution, strategies for prevention, and a literature review of their specific adverse event.

The incidents are also categorized into one of the following disciplines: Treatment planning (TP), Operative (OP), Periodontics (PER), Endodontics (EN), Oral Surgery (OS), Fixed Prosthodontics (FP), Removable Prosthodontics (RP), and Patient Management (PM). This retrospective study analyzed presentations from third year predoctoral students across three cohorts (classes of 202A, 202B, and 202C) at the Harvard School of Dental Medicine. All adverse events reported were examined in terms of the event frequency, discipline-specific characteristics and potential future preventive measures. This study was approved by the IRB of Harvard Faculty of Medicine (IRB22-1231).

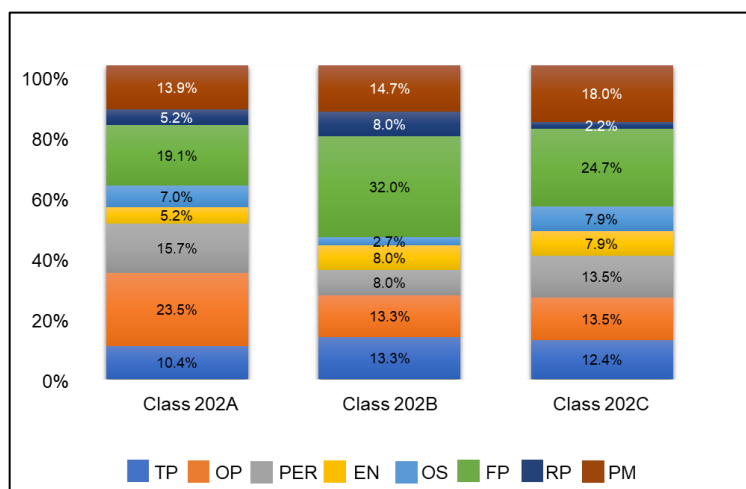
### 3. Results

In total, 279 adverse events were analyzed. Among the 279 events, 24.4% of events were in FP, 17.6% in OP, 15.4% in PM, 12.9% in PER, and 11.8% in TP. The disciplines of EN, OS, and RP accounted for less than 10% each (Figure 1). Looking into the frequency of adverse events across three classes (Figure 2), the distribution pattern within the disciplines was consistent, and no statistical difference was observed as determined by the chi-square test ( $p=0.2299$ ,  $\chi^2=17.512$ ).



**Figure 1. Incidence of Adverse Events in Dental Disciplines.**

Percentage of adverse events reported in each dental discipline by third year predoctoral students from 3 classes. The adverse events were divided as follows: 24.4% in Fixed Prosthodontics (FP), 17.6% in Operative (OP), 15.4% in Practice Management (PM), 12.9% in Periodontics (PER), 11.8% in Treatment Planning (TP), 6.8% in Endodontics (EN), 6.1% in Oral Surgery (OS), and 5.0% in Removable Prosthodontics (RP).



**Figure 2. Distribution of adverse events by discipline across all three class years at HSDM.**

The most frequently occurring adverse events across the three classes were in the disciplines of Fixed Prosthodontics (FP), Operative (OP), Practice Management (PM) and Treatment Planning (TP).

The causes of adverse events are detailed in Table 1 and illustrated in Figure 3. Table 1 describes the common areas of events that occur within each discipline and categorizes the various types of causes. Adverse events are caused by a variety of sources, including clinical errors, management mistakes, and administrative oversights, among others. Clinical proficiency was identified as the primary contributor across disciplines, with miscommunication, language barriers, inadequate patient explanations, and complex cases also contributing significantly.

**Table 1. Common areas of adverse events and categorized causes.**

| Discipline | Common Areas of Adverse Events                                                                                                               | Causes                                                                                                                                                                                                                                                                                                                                                                                     |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FP         | Provisional crown.<br>Tooth preparation.<br>Impression.<br>Damage to adjacent teeth/tissue.<br>Poor quality of crown.<br>Lab-related issues. | Poor clinical proficiency in fabricating provisional crown.<br>Poor clinical proficiency in tooth preparation.<br>Poor clinical proficiency in capturing bite registrations.<br>Poor clinical proficiency in material use/instrument control<br>Poor clinical proficiency in obtaining proper moisture control.<br>Inaccurate shade selection.<br>Miscommunication with dental laboratory. |
| OP         | Quality of fillings.<br>Post-operative pain.<br>Damage to other tissue.                                                                      | Poor clinical proficiency in composite restoration techniques.<br>Poor clinical proficiency in material use/instrument control.<br>Insufficient explanation to patients.                                                                                                                                                                                                                   |
| PM         | Cancellation of appointment.<br>Treatment costs.<br>Insurance coverage.                                                                      | Miscommunication (language barrier).<br>Poor patient communication.<br>Lack of administrative support.                                                                                                                                                                                                                                                                                     |
| PER        | Surgical procedure.<br>Treatment costs.<br>Damage to other tissue.                                                                           | Poor clinical proficiency in perio surgery.<br>Poor procedural preparation.<br>Lack of administrative support.<br>Case complexity.                                                                                                                                                                                                                                                         |
| TP         | Diagnosis.<br>Treatment plan comprehension.                                                                                                  | Deficient skills in diagnostic examinations.<br>Miscommunication (language barrier).<br>Case complexity                                                                                                                                                                                                                                                                                    |
| EN         | Obturation.<br>Diagnosis.<br>Post-operative pain.<br>Restorative work delays.                                                                | Poor clinical techniques.<br>Deficient skills in diagnostic examinations.<br>Miscommunication (language barrier).<br>Poor patient communication.                                                                                                                                                                                                                                           |
| OS         | Extraction.<br>Anesthesia.<br>Damage to adjacent tissue/teeth.                                                                               | Poor clinical proficiency in anesthesia techniques<br>Poor clinical proficiency in extraction techniques.<br>Poor clinical proficiency in surgical procedures.                                                                                                                                                                                                                             |
| RP         | Occlusion.<br>Post-operative pain.<br>Integrity of dentures.<br>Scheduling issues.                                                           | Poor clinical proficiency in capturing bite registrations.<br>Poor clinical proficiency in taking impressions.<br>Poor clinical proficiency in adjustment procedures.<br>Miscommunication (language barrier).                                                                                                                                                                              |

Figure 3 describes the frequency of causes for adverse events in each discipline. Poor clinical skill proficiencies were the major cause across all five clinical disciplines. In FP, the biggest clinical challenge involved managing provisional crowns, which accounted for 30.9% of adverse events, followed by tooth preparation (14.7%), bite registration (14.7%), tissue management (13.2%), shade matching (7.4%) and impression taking (5.9%), with lab-related miscommunications comprising 13.2%. In OP, clinical inadequacies in filling quality, particularly with resin composite restorations, were the leading cause. Adverse events in EN, OS, and RP primarily involved clinical complications with obturation, anesthesia, extraction, protection of adjacent teeth/tissue, denture bite registration, and prosthesis adjustment. Additionally, EN saw 26.3% of events arising from diagnostic

errors. Poor clinical skill proficiencies in PER accounted for 58.2% of issues, including periodontics' surgical techniques (16.7%) and procedure preparation (36.1%), while difficulties with patient communication accounted for 33%. In TP, the most common cause was diagnostic errors due to a lack of clinical and administrative information, such as up-to-date radiographs and insurance details. Interestingly, case complexity was indicated for PER and TP. PM was mostly affected by continuous cancellations, with miscommunication and language barriers identified as significant contributing factors (48.8%).

Looking into the frequency of causes across the three classes, a significant difference was observed in the disciplines of TP, PM, PER, EN, and RP ( $p < 0.01$ ). However, no significant difference was noted in OP, FP and OS (Figure 4).

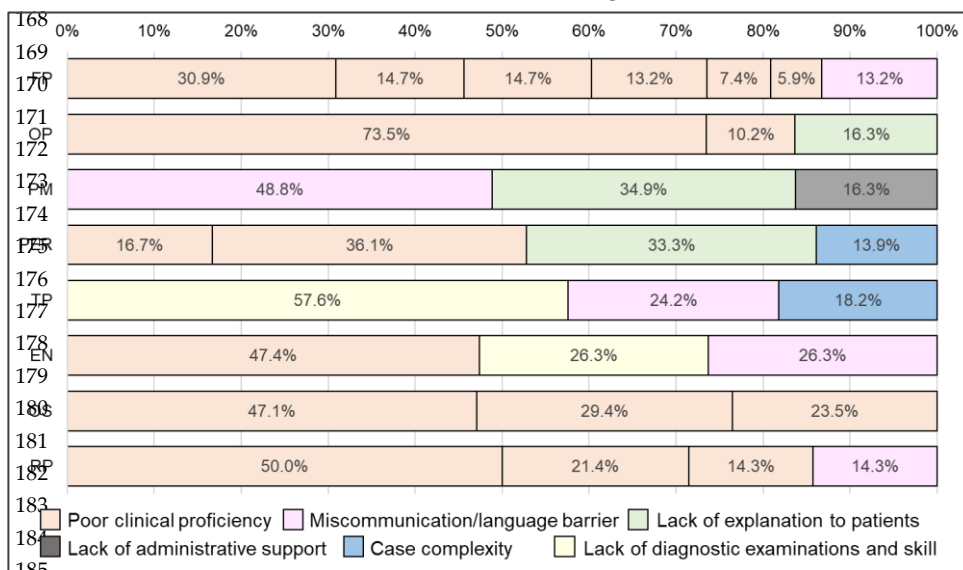


Figure 3. Frequency of Causes for Adverse Events by Dental Discipline.

The total frequency of poor clinical proficiency was calculated 86.8% in FP, 83.7% in OP, 52.8% in PER, 47.4% in EN, 100% in OS, and 85.7% in RP. Miscommunication was notable in 5 disciplines; TP, PM, FP, EN and RP.

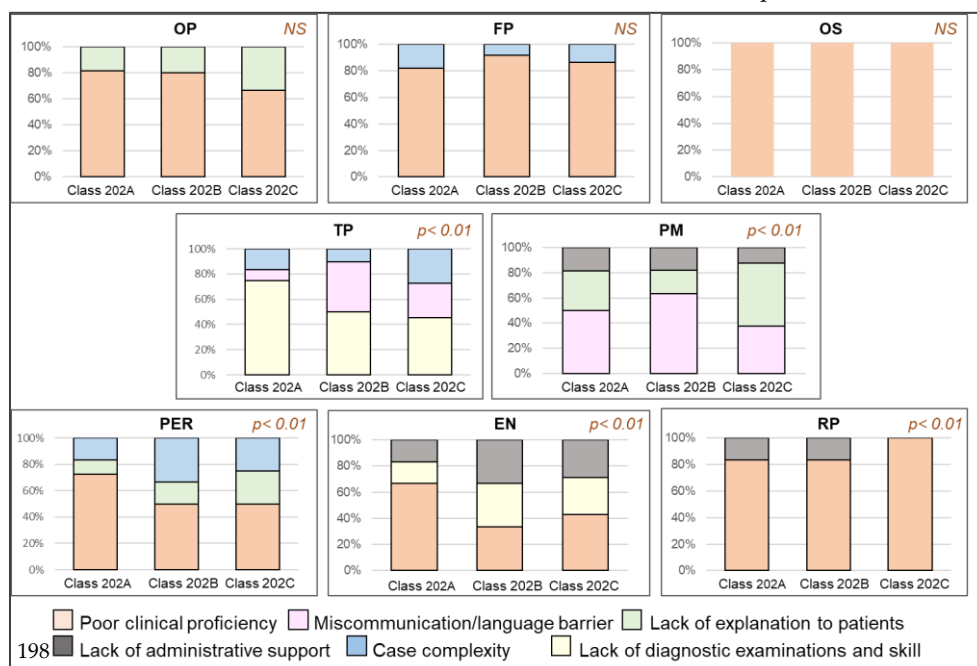


Figure 4. Cause Comparison of Adverse Events Between All Cohorts.

Each individual graph represents a particular discipline and illustrates the frequency of causes across all three classes. There was no significant difference observed in the clinical disciplines of OP, FP and OS.

#### 4. Discussion

##### *Aim and importance of learning from mistakes*

The study aims to analyze adverse event data to understand patterns and help develop preventive strategies that can aid both students and faculty in reducing recurrences and improving the quality of preclinical dental education.

Students in the AD course were asked to share three to four significant adverse events they experienced during their clinical training, with the only requirement being that each event fall within a recognized dentistry discipline. These events varied in terms of their severity and the impact on both patients and students. The nature of the mistakes shared ranged from minor, with negligible consequences, to major, with larger implications. Traditionally, research has suggested that students often learn more effectively from serious mistakes due to the strong emotional impact associated with the experience [29]. Indeed, the likelihood of repeating an error decreases when the consequences are substantial, as the experience tends to leave a lasting impression. The aim of integrating a 'learning from mistakes' session in the AD course is to collectively, as a class, comprehend the reasons behind which these adverse events occurred, and to ultimately reduce the incidence of such events occurring in the future within the predoctoral education.

##### *Analyzing the Frequency and Causes of Adverse Events Across Clinical Disciplines*

Complications in FP and OP, along with challenges in PM, were common across all classes. FP experienced the highest rate of adverse events (24.4%), followed by OP (17.6%). This pattern may reflect the higher demands for OP and FP procedures within the patient population at the HSDM teaching practice. In contrast, PER (12.9%), EN (6.8%), and OS (6.1%) reported fewer complications. This could be partly because the more complex cases in these disciplines are often assigned to residents and faculty, leaving pre-doctoral students with less challenging tasks. Additionally, while pain is more commonly experienced in invasive fields like OS and PER, it becomes notably more significant when it occurs in OP and EN procedures, where it is less expected.

The adverse events encountered within each discipline result from various factors. In OP, incidences are linked to students' inexperience with treating real teeth. The third year marks the first-time students work on real teeth, which contrast with the plastic models used in pre-clinical training. At HSDM, once third year students pass the operative course's preclinical summative, they can immediately begin procedures on patients. This transition presents new hurdles, such as managing patient behavior and expectations, achieving proper isolation, navigating time constraints, and satisfying faculty standards.

In Fixed Prosthodontics (FP), the most common complication was provisional crowns dislodging or breaking within a day or two of placement (30.9%). Students recognized these adverse events were frequently due to inadequate moisture control during cementation, improper tooth preparation including excessive taper, insufficient occlusal reduction, and inadequate height of the remaining clinical crown. Such problems reflect a need for more clinical practice and experience.

In Periodontics (PER) student inexperience, particularly with first-time clinical use of periodontal instruments (36.1%) in conjunction with inadequate procedural preparation, often led to adverse events. Other unanticipated challenges, such as damage to restorations (16.7%), which are not covered in pre-clinical training, further complicate real-world practice.

In Endodontics (EN), common complications included underfilling, overfilling, perforation, and case misdiagnosis. Incorrect filling often stemmed from poor gutta percha measurements. Lack of experience with radiograph interpretation and diagnostic tests often led to misdiagnoses, with miscommunication delaying restorations and, in severe instances, necessitating root canal retreatment.



Mistakes in Oral Surgery (OS) often stemmed from inexperience and insufficient clinical knowledge, leading to adverse events of ineffective anesthesia, extraction complications, and damage to adjacent teeth and tissues. The lack of pre-clinical OS practice meant students faced these procedures for the first time on real patients. While OS rotations take place during third and fourth years at HSDM, introducing clinical rotations earlier, in the second year, could be crucial for skill development.

In Removable Prosthodontics (RP), adverse events often arose from errors in taking bite registrations during the articulation processes. Accurate bite registrations are crucial yet one of the most challenging tasks in RP. Thus, identifying errors early is essential, as the success of all subsequent procedures depends on the precision of these initial measurements. Moreover, RP, as a field involves detailed lab work at every step. Meticulous attention to detail must be developed during early dental training to ensure high-quality outcomes throughout.

Patient Management (PM) and Treatment Planning (TP) are two major non-clinical areas prone to adverse events. PM issues often stem from poor provider-patient communication, scheduling conflicts, insufficient follow-ups, and unmet patient expectations. These errors underscore the challenge students face when transitioning from theoretical learning to practical, hands-on patient care. In recent years, the HSDM Teaching Practice has experienced an increase in non-English speaking patients, and while translation services via iPads are available, they frequently fall short due to audio problems and ineffective communication among provider, translator, and patient. The communication barriers can lead to misunderstandings, repeated cancellations, treatment postponement, and in some cases, teeth becoming non-restorable. Additionally, conversation about treatment costs are sensitive; varied insurance coverages necessitate increased administrative support for students to allow them to focus more on patient care.

In TP, errors often stem from difficulties in obtaining comprehensive diagnostic data, such as models, x-rays and consultations. Without precise diagnostics, creating an appropriate treatment plan is challenging. Additionally, insufficient patient information, such as chief complaint, goal and limitations can lead to misguided treatment plans. Miscommunications between students and patients due to unclear treatment planning principles or language barriers further complicate the process.

In general, performing procedures on patients for the first time is challenging for every dental provider. There are difficulties that arise in the clinical setting that cannot be trained for in pre-clinic. For example, accounting for patient emotions, which vary greatly in a dental setting, is impossible in a simulated environment. It is therefore unsurprising that issues with patient management rank as the third most common challenge in clinic. Increased interaction with patients helps students navigate these challenges.

### *The Importance of Analyzing Mistakes*

Understanding errors is crucial to the learning process and offers valuable lessons to students. Despite understanding this, there's often reluctance to discuss mistakes due to fear of judgement or repercussions. Dentistry is a field of lifelong learning, and embracing mistakes is a part of growth. For example, morbidity and mortality conferences in the medical field serves as a model. These conferences provide a secure space for physicians to discuss mistakes confidentially and constructively within a peer-protected environment [30]. Such open discussions are vital for self-reflection and encourage better future practices. In dental education, these discussions help students take responsibility, promote transparency, and maintain accountability, all of which are essential for learning. While there may be concerns about criticism or peer perception, openly addressing errors fosters a culture focused on learning and leads to deeper reflection and the development of more effective strategies for future practice.

Introducing the practice of acknowledging mistakes early in dental education is crucial, because it encourages students to adopt a habit of transparency with patients throughout their career. Dentists have an ethical responsibility to honor patient autonomy, necessitating transparency, particularly when errors affect a patient's health. Open disclosure, as taught in the Advanced Dentistry course, promotes a culture of transparency and deters concealment of mistakes from patients, a practice that could undermine trust in the dental profession. Therefore, it is imperative for dentists to be upfront with patients about any mistakes impacting patient health.

The transition from preclinical training to clinical practice is one of the most challenging times of a student's dental education. Students not only shoulder the responsibility of patient care but also juggle various other obligations. Amidst this high-stress environment, creating a supportive learning atmosphere can alleviate fear and encourage open discussions and reflections on mistakes. While some students excel under stress, others may benefit from calmer, "safer" spaces that are more conducive to sharing, such as the ones provided by group discussions in the AD course. In fact, studies using functional magnetic resonance imaging have found that the brain's reward-memory loop is more active during success, suggesting that achievements could have a stronger influence on learning than failures [31].

Ultimately, understanding the factors that drive both successes and failures is crucial. Examining the causes behind different outcomes enables students a deeper understanding. Educational programs should therefore incorporate discussions about both successes and failures into the curricula. It may also be advantageous to specifically discuss the factors contributing to successful procedures. That way, students are given the chance to understand the full spectrum of the clinical experience.

#### *Future study*

In the future, it's important to continue investigating whether a school is meeting its aims of transitioning pre-clinical students to clinical practice. Specifically, a longitudinal approach, such as conducting a five-year follow-up study to assess whether there has been a measurable improvement in the occurrence of adverse events would be helpful. However, it's clear that not all issues in dental education have been resolved, and ongoing research is needed to address these persistent challenges. By continuing to update current educational methods and provide safe environments for students to discuss their challenges and successes, dental education can work towards improving patient care and clinical training continuously.

## **5. Conclusions**

Our findings indicate that adverse events in the clinical setting are common. Understanding common adverse events prior to the clinical procedure would be helpful for students to perform better. Students should prepare as much as possible prior to practicing procedures in the clinical setting and be aware of common causes of adverse events. Educators should also be aware of the difficulties that unexperienced student clinicians face. Knowledge of common errors can help facilitate success in challenging and stressful clinical situations.

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## References

1. Haden NK, Andrieu SC, Chadwick DG, et al. The dental education environment. *J Dent Educ.* 2006;70(12):1265-1270. 368
2. Serrano CM, Lagerweij MD, de Boer IR, Bakker DR, Koopman P, Wesselink PR, Vervoorn JM. Students' learning environment perception and the transition to clinical training in dentistry. *Eur J Dent Educ.* 2021 Nov;25(4):829-836. doi: 10.1111/eje.12662. Epub 2021 Feb 2. PMID: 33474787; PMCID: PMC8597140. 369  
370  
371
3. Al-Ansari AA, El Tantawi MMA. Predicting academic performance of dental students using perception of educational environment. *J Dent Educ.* 2015;79(3):337-344. 372  
373
4. Subramanian J, Anderson V, Morgaine K, Thomson W. The importance of 'student voice' in dental education. *Eur J Dent Educ.* 2013;17(1):e136-e141. 374  
375
5. Henzi D, Davis E, Jasinevicius R, Hendricson W, Cintron L, Isaacs M. Appraisal of the dental school learning environment: the students' view. *J Dent Educ* 2005; 69: 1137-1147. 376  
377
6. Schonwetter DJ, Lavigne S, Mazurat R, Nazarko O. Students' perceptions of effective classroom and clinical teaching in dental and dental hygiene education. *J Dent Educ* 2006; 70: 624-635. 378  
379
7. Divaris K, Barlow PJ, Chendea SA, et al. The academic environment: the students' perspective. *Eur J Dent Educ* 2008; 12:120-130. 380  
381
8. Howell 382
9. Holmes DC, Boston DW, Budenz AW, Licari FW. Predoctoral clinical curriculum models at U.S. and Canadian dental schools. *J Dent Educ.* 2003;67(12):1302-1311. 383  
384
10. Holmes DC, Trombly RM, Garcia LT, Kluender RL, Keith CR. Student productivity in a comprehensive care program without numeric requirements. *J Dent Educ.* 2000;64(11):745-754. 385  
386
11. Evangelidis-Sakellson V. Student productivity under requirement and comprehensive care system. *J Dent Educ.* 1999;63(5):407-413. 387  
388
12. Park SE, Timothé P, Nalliah R, Karimbux NY, Howell TH. A case completion curriculum for clinical dental education: replacing numerical requirements with patient-based comprehensive care. *J Dent Educ.* 2011 Nov;75(11):1411-6. PMID: 22058389. 389  
390
13. Park SE, Susarla HK, Nalliah R, Timothé P, Howell TH. Karimbux NY, Does a Case Completion Curriculum Influence Dental Students' Clinical Productivity? *J Dent Educ* 2011;75(11):1411-6. 391  
392
14. Park SE, Timothé P, Nalliah R, Karimbux NY, Howell TH. A case completion curriculum for clinical dental education: replacing numerical requirements with patient-based comprehensive care. *J Dent Educ* 2012;76(5):602-8. 393  
394
15. Park SE, Howell TH. Implementation of a patient-centered approach to clinical dental education: a five-year reflection. *J Dent Educ.* 2015 May;79(5):523-9. PMID: 25941145. 395  
396
16. Park SE. Ten-year follow-up of patient-centered comprehensive care using case completion curriculum. *J Dent Educ.* 2021 Aug;85(8):1408-1414. doi: 10.1002/jdd.12607. Epub 2021 Apr 1. PMID: 33794004. 397  
398
17. NHS Patient Safety. 2011. <http://www.nrls.npsa.nhs.uk/report-a-patient-safety-incident/>. Last accessed 13 July 2014. 399
18. Brennan TA, Leape LL, Laird NM, Hebert L, Localio AR, Lawthers AG, et al. Incidence of adverse events and negligence in hospitalized patients: results of the Harvard Medical Practice Study I. *N Engl J Med* 1991; 324:370-6. 400  
401
19. Thomas EJ, Studdert DM, Burstin HR, Orav EJ, Zeena T, Williams EJ, et al. Incidence and types of adverse events and negligent care in Utah and Colorado. *Med Care* 2000; 38:261-71. 402  
403
20. Wilson RM, Runciman WB, Gibberd RW, Harrison BT, Newby L, Hamilton JD. The Quality in Australian Health Care Study. *Med J Aust* 1995; 163:458-71. 404  
405
21. Vincent C, Neale G, Woloshynowych M. Adverse events in British hospitals: preliminary retrospective record review. *Br Med J* 2001; 322:517-9. 406  
407
22. Davis P, Lay-Yee R, Briant R, Ali W, Scott A, Schug S. Adverse events in New Zealand public hospitals I: occurrence and impact. *N Z Med J* 2002; 115:U271. 408  
409
23. Baker GR, Norton PG, Flintoff V, Blais R, Brown A, Cox J, et al. The Canadian Adverse Events Study: the incidence of adverse events among hospital patients in Canada. *J Can Med Assoc* 2004; 170:1678-86. 410  
411
24. Miguel Hernandez University, Ministry of Health and Consumer Affairs. National Study on Hospitalisation-Related Adverse Events ENEAS 2005. In: Quality Agency Administration National Health System, ed. Madrid: Ministry of Health and Consumer Affairs, 2006. [http://www.who.int/patientsafety/information\\_centre/reports/ENEAS-EnglishVersion-SPAIN.pdf](http://www.who.int/patientsafety/information_centre/reports/ENEAS-EnglishVersion-SPAIN.pdf). 412  
413  
414
25. Soop M, Fryksmark U, Koster M, Haglund B. The incidence of adverse events in Swedish hospitals: a retrospective medical record review study. *Int J Qual Health Care* 2009;21:285-91. 415  
416
26. Zegers M, Bruijne MCd, Wagner C, Hoonhout LHF, Waaijman R, Smits M, et al. Adverse events and potentially preventable deaths in Dutch hospitals: results of a retrospective patient record review study. *Qual Saf Health Care* 2009;18:297-302. 417  
418
27. Sari AB-A, Sheldon TA, Cracknell A, Turnbull A, Dobson Y, Grant C, et al. Extent, nature and consequences of adverse events: results of a retrospective casenote review in a large NHS hospital. *Qual Saf Health Care* 2007; 16:434-9. 419  
420
28. Bates DW, O'Neil AC, Petersen LA, Lee TH, Brennan TA. Evaluation of screening criteria for adverse events in medical patients. *Med Care* 1995; 33:452-62. 421  
422

- 
29. Fischer MA, Mazor KM, Baril J, Alper E, DeMarco D, Pugnaire M. Learning from Mistakes. Factors that Influence How Students and Residents Learn from Medical Errors. *J Gen Intern Med* 2006; 21(5):419-23. 423  
424
  30. Kravet SJ, Howell E, Wright SM. Morbidity and Morality Conference, Grand Rounds, and the ACGME's Core Competencies. *J Gen Intern Med* 2006; 21(11):1192-1194. 425  
426
  31. Ripolles P, Marco-Pallares J, Alicart H, Tempelmann C, et al. Intrinsic monitoring of learning success facilitates memory encoding via the activation of the SN/VTA-Hippocampal loop. *eLife* 2016; 5:e17441 427  
428  
429  
430