

Article

Learning from Mistakes—Dental Students' Learning Experiences from Adverse Clinical 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 aimed to comprehend the challenges and issues faced by students at the onset of clinical training. It retrospectively investigated adverse events presented at the advanced dentistry course by third-year pre-doctoral students from classes 202A, 202B, and 202C during their initial ten months of clinical practice at the teaching institution. In this study, adverse events were defined as any undesirable experiences or incidents associated with a clinical treatment and administrative procedures. A total of 279 adverse events presented were categorized into eight disciplines: Treatment planning (TP), Operative (OP), Periodontics (PER), Endodontics (EN), Oral Surgery (OS), Fixed Prosthodontics (FP), Removable Prosthodontics (RP), and Patient Management (PM). 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. The distribution pattern within the disciplines was consistent, and no statistical difference was observed. Across these disciplines, a lack of clinical skill competency 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 frequency of causes varied across the three classes, but no significant differences was noted in OP, FP and OS, in which over 80% of causes were related to clinical skill competency. Adverse events in clinical settings are frequent. Knowing these beforehand can aid students' performance. Students should prepare thoroughly before clinical practice and understand common causes of errors. Educators should recognize the challenges inexperienced students encounter. Awareness of typical mistakes can enhance success in demanding clinical scenarios.

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]. 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 [14]. 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 [15]. 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 [16]. 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, and include incidents with more severe consequences [17]. 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 [8–27].

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 (AD), one of the seven multidisciplinary courses at HSDM, students discuss cases they have encountered. They identify and reflect on adverse events experienced during teaching practice. Adverse clinical events were defined as any undesirable experiences or incidents associated with administering a clinical treatment to a patient and interaction with patients. By discussing the event, its causes, and effective prevention methods, third-year students can learn from each other's experiences and improve upon them in their final year of dental school. Investigating adverse events sheds light on their incidence and highlights areas where risk can be mitigated, and prevention strategies can be implemented.

The objective of this study was to evaluate the adverse events that took place at HSDM's teaching practice during the initial ten months of the third-year students' clinical training. This was achieved by analyzing students' presentations during the Advanced Dentistry course, which occurs at the ten-month milestone of their clinical education. This study analyzed the frequency, characteristics of adverse events, and causes.

2. Materials and Methods

This study was approved by the IRB of Harvard Faculty of Medicine (IRB22-1231). The AD course, placed at the end of the third-year dental curriculum at HSDM, requires students to present a comprehensive review of three to four adverse clinical 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 presented at the AD course were examined in terms of the event frequency, discipline-specific characteristics, and potential future preventive measures.

Qualitative analyses were conducted to characterize adverse events within each discipline. The causes and characteristics of each event presented by students were reviewed and categorized into specific groups within the discipline by three researchers with more than 30 years of clinical experience.

Statistical Analysis was conducted using the chi-square test to compare the distribution of events by discipline and the causes of frequency across the three classes (0.01, SPSS ver. 24, IBM, Armonk, NY, USA).

3. Results

In total, 279 adverse events were analyzed: 89 events from class 202A, 75 from class 202B and 115 from class 202C. 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 ($p = 0.2299$, $\chi^2 = 17.512$). The events contents in FP, OP and PM were summarized in Figure 3. It was suggested that one adverse event could trigger a chain reaction of subsequent events, leading to a negative consequence spiral.

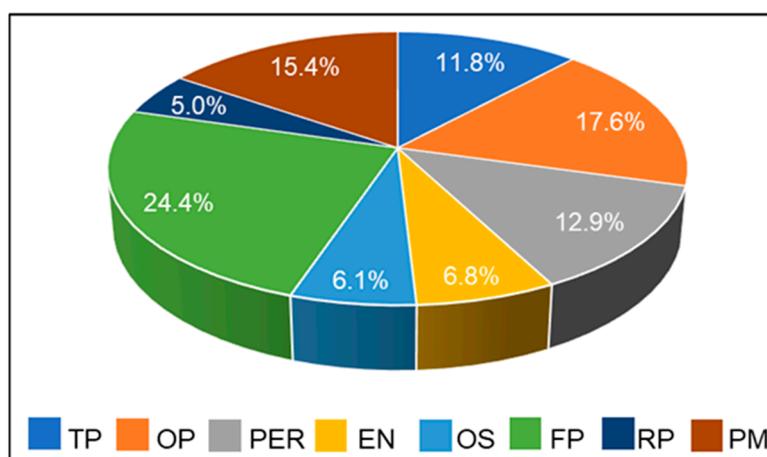


Figure 1. Incidence of adverse events in dental disciplines. Percentage of adverse events reported in each dental discipline by third year predoctoral students from the 202A, 202B, and 202C classes at HSDM. The adverse events were divided as follows: 24.4% in Fixed Prosthodontics (FP), 17.6% in Operative (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).

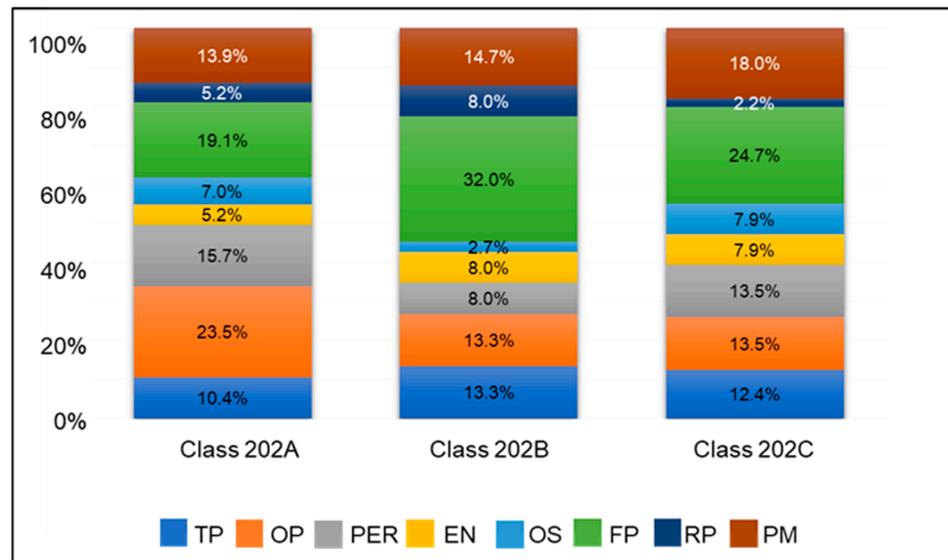


Figure 2. Distribution of adverse events by discipline across all three class years at HSDM. The most frequently occurring adverse events across the three classes were in the disciplines of Fixed Prosthodontics (FP), Operative (OP), Practice Management (PM) and Treatment Planning (TP).

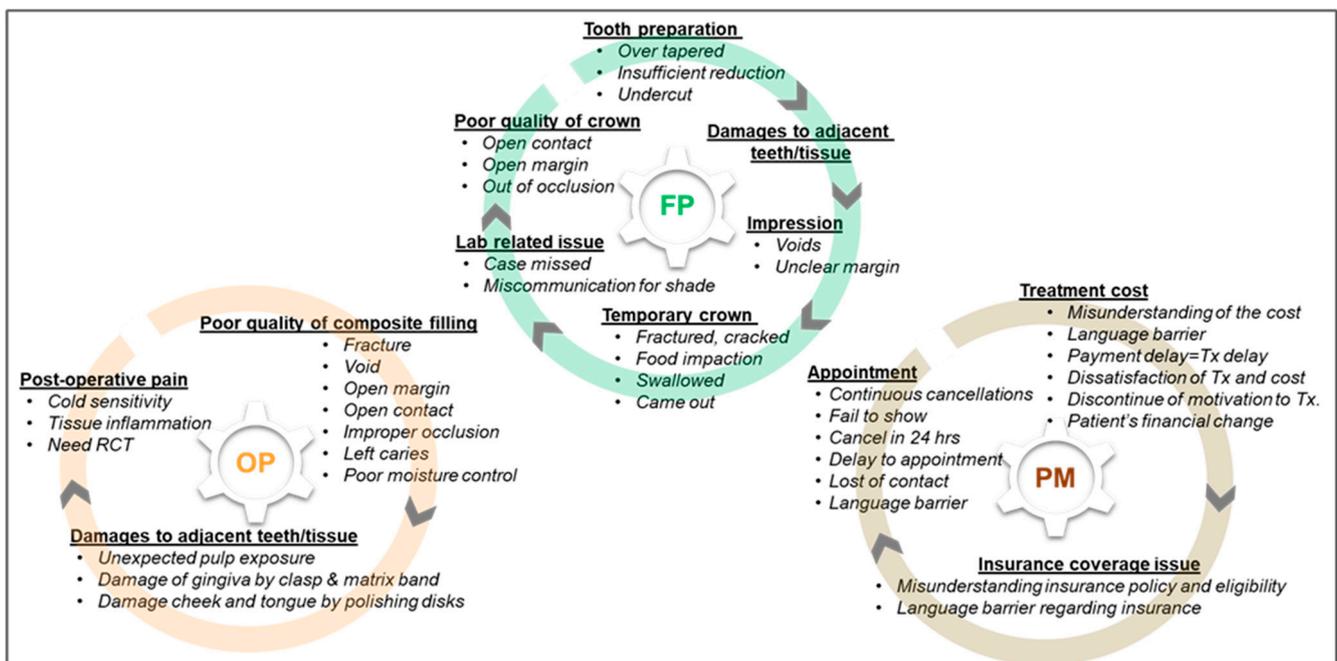


Figure 3. The events contents in FP, OP and PM. One event can lead to more events, causing a downward spiral.

The causes of adverse events are detailed in Table 1 and illustrated in Figure 4. 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. Lack of clinical competency 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	Temporary crown. Tooth preparation. Impression. Damage to adjacent teeth/tissue. Poor quality of crown. Lab-related issues.	Poor clinical competency in fabricating temporary crown. Poor clinical competency in tooth preparation. Poor clinical competency in capturing bite registrations. Poor clinical competency in material use/instrument control Poor clinical competency in obtaining proper moisture control. Inaccurate shade selection. Miscommunication with dental laboratory.
OP	Poor quality of fillings. Post-operative pain. Damage to other tissue.	Poor clinical competency in composite restoration techniques. Poor clinical competency in material use/instrument control. Insufficient explanation.
PM	Cancellation of appointment. Treatment costs. Insurance coverage.	Miscommunication (language barrier). Poor patient communication. Lack of administrative support.
PER	Surgical procedure. Treatment costs. Damage to other tissue.	Poor clinical techniques. Poor procedural preparation. Lack of administrative support. Case complexity.
TP	Diagnosis. Treatment plan comprehension.	Deficient skills in diagnostic examinations. Miscommunication (language barrier). Case complexity.
EN	Obturation. Diagnosis. Post-operative pain. Restorative work delays.	Poor clinical techniques. Deficient skills in diagnostic examinations. Miscommunication (language barrier). Poor patient communication.
OS	Extraction. Anesthesia. Damage to adjacent tissue/teeth.	Poor clinical competency in anesthesia techniques. Poor clinical competency in extraction techniques. Poor clinical competency in surgical procedures.
RP	Occlusion. Post-operative pain. Integrity of dentures. Scheduling issues.	Poor clinical competency in capturing bite registrations. Poor clinical competency in taking impressions. Poor clinical competency in adjustment procedures. Miscommunication (language barrier).

Figure 4 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 techniques, 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 clinical 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. PM was mostly affected by continuous cancellations, with miscommunication and language barriers identified as significant contributing factors (48.8%).

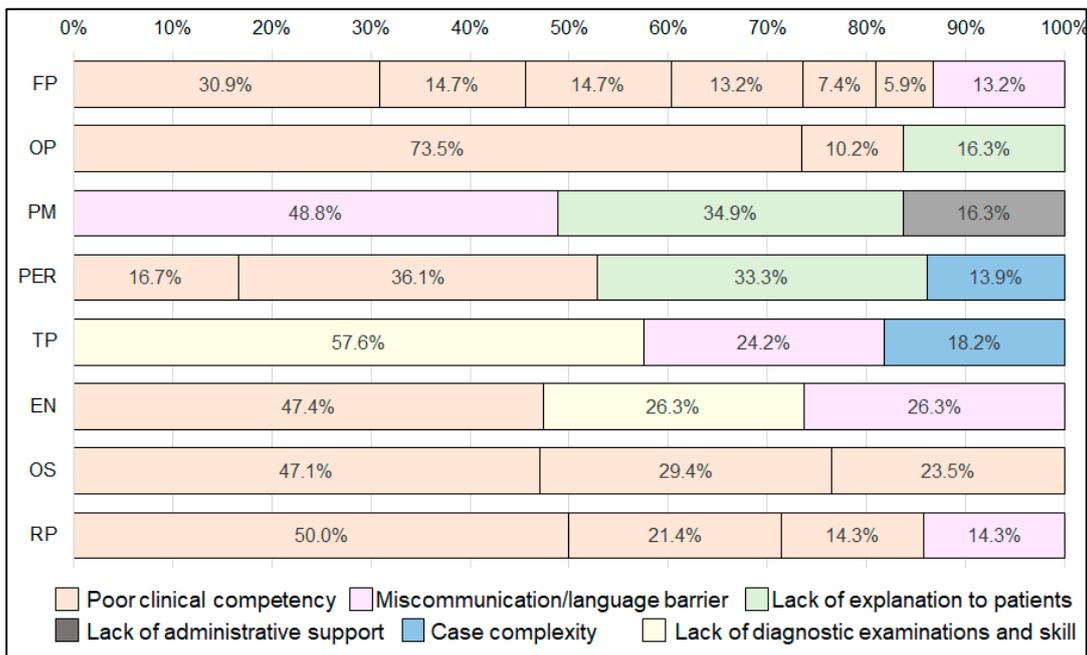


Figure 4. Frequency of causes for adverse events by dental discipline. The total frequency of lack of clinical skill was calculated 86.8% in FP, 83.7% in OP, 52.8% in PER, 47.4% in EN, 100% in OS, and 85.7% in RP. Miscommunication was notable in 5 disciplines; TP, PM, FP, EN ad RP.

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 5).

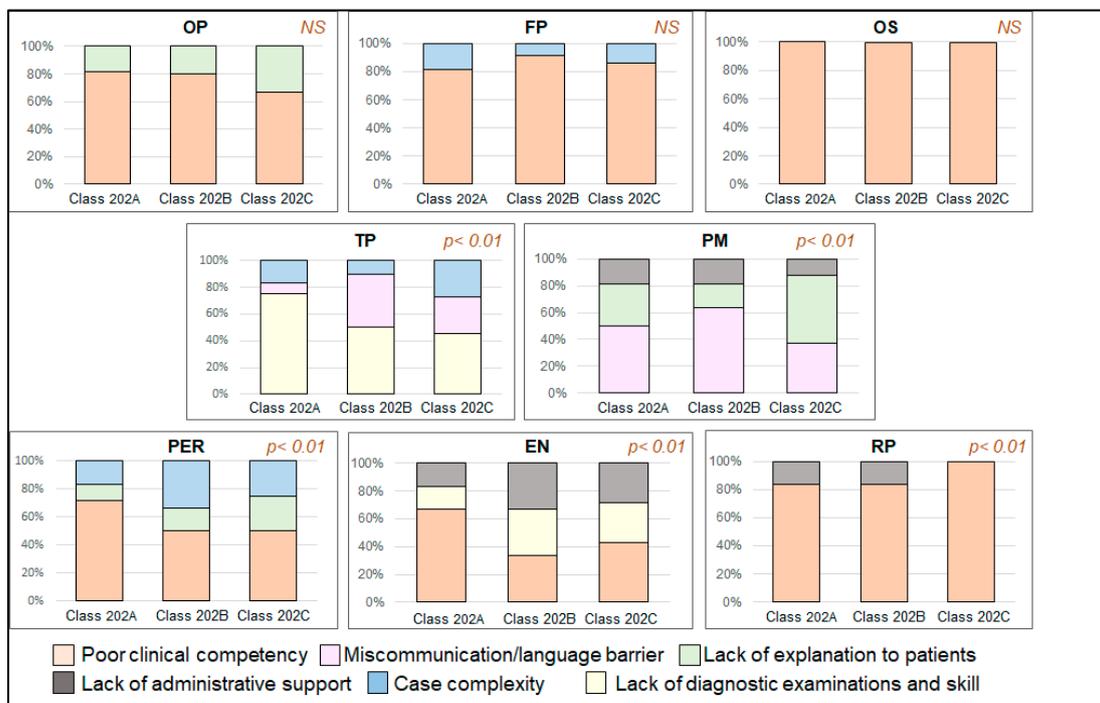


Figure 5. Cause comparison of adverse events between all cohorts. Each individual graph represents a particular discipline and illustrates the frequency of causes across all three classes. There was no significant difference observed in the clinical disciplines of OP, FP and OS.

4. Discussion

The study examines adverse events in clinical training to discern patterns and develop preventive strategies to reduce recurrences, improving the quality of preclinical dental education. Students in the AD course shared three to four significant adverse events experienced during their clinical training. The only requirement was that each event must fall within a recognized dentistry discipline. These events, ranging from minor to major, varied in severity and impact on both patients and students. Evidence suggests that students learn more from serious mistakes due to the strong emotional impact associated with the experience [28]. The purpose of including a 'learning from mistakes' component in the AD course is to collectively understand the reasons of these adverse occurrences and reduce future incidences in the predoctoral education.

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, which might be because complex cases in these disciplines are typically handled by residents and faculty, leaving simpler cases for pre-doctoral students. Moreover, while pain is typically anticipated in OS and PER procedures, its infrequent occurrence in OP and EN renders the experiences more notable when it does occur.

Adverse events within discipline result from a variety of factors, with inexperience being a common theme. At HSDM, third year students can immediately begin Operative (OP) procedures on patients once they pass the operative course's preclinical summative. This immediate shift from preclinical practice on plastic models to working on natural teeth during the third year introduces challenges such as managing patient behaviors, achieving proper isolation, and meeting faculty standards. Fixed Prosthodontics (FP) complications often involve provisional crowns dislodging or breaking shortly after placement (30.9%). Reported contributing factors include poor moisture control during cementation, incorrect tooth preparation such as excessive taper, insufficient occlusal reduction, and inadequate height of the remaining clinical crown. These problems reflect a need for more clinical practice and experience. Periodontics (PER) student faced challenges included procedural preparations and initial clinical use of periodontal instruments (36.1%). Additionally, unanticipated challenges like damage to restorations (16.7%), which are not covered in pre-clinical training, further complicate the transition to real-world practice. Endodontics (EN) complications frequently included underfilling, overfilling, perforation, and case misdiagnosis. Incorrect filling often resulted from poor gutta percha measurements. Incorrect radiograph interpretation and diagnostic tests led to misdiagnosis, with communication failures further delaying restorations and in severe instances, necessitating root canal re-treatment. Oral Surgery (OS) mistakes were due to lack of clinical knowledge, and resulted in adverse events of ineffective anesthesia, crown and/or root fractures during extractions, and damage to adjacent structures. The absence of pre-clinical OS practice means third year students perform these procedures for the first time with real patients. Thus, proposing earlier OS clinical rotations could be beneficial. In Removable Prosthodontics (RP), adverse events often occur during bite registrations in the articulation processes. Accurate bite registrations are one of the most challenging tasks in RP. Precision in these steps is crucial, as they set the foundation for the success of subsequent procedures. Thus, learning to mitigate these errors early on is essential. Furthermore, RP work demands meticulous lab work and this attention to detail must be emphasized during dental training.

Patient Management (PM) and Treatment Planning (TP) are two non-clinical areas with high incidences of adverse events. PM issues included poor provider-patient communication, scheduling issues, insufficient follow-ups, and unfulfilled patient expectations, highlighting the challenges students face when transition to hands-on patient care. This is compounded by iPad translation service issues at HSDM Teaching Practices, such as poor audio quality and ineffective communication between the provider, translator, and patient.

These issues ultimately contribute to repeated cancellations and potentially irreparable teeth. Additionally, already sensitive discussions about treatment costs are further complicated by various insurance coverages. Increased administration support for students in areas allows for students to focus more on patient care. In TP, errors often stem from challenges in acquiring comprehensive diagnostic data, such as models and X-rays. Without precise diagnostics, treatment planning is difficult. Furthermore, a poor understanding of a patient's chief complaint, goals and limitations can misguide treatment plans. Miscommunications between students and patients due to unclear treatment planning principles or language barriers further complicate the process.

In OP, FP, and OS, there was no significant difference observed across all three classes concerning the frequency of causes; approximately 75~80% of the causes were attributed to poor clinical competency for all classes. Attaining sufficient clinical skills is a challenging process, and continuous training is needed. Generally, first-time procedures on patients can be challenging for any provider due to the unforeseen challenges in the clinical environment that pre-clinical training cannot replicate. For instance, accounting for patient emotions, which vary greatly in a dental setting, is impossible in a simulated environment. Therefore, it is unsurprising that issues with patient management are the third most common challenge in clinic. Increased interaction with patients helps students navigate these challenges.

Acknowledging mistakes is essential in dentistry, yet discussions about mistakes are often avoided due to fear of judgement. Dentistry is a field of lifelong learning, and embracing mistakes is a part of growth. Medical morbidity and mortality conferences in the medical field serves as a model. These conferences are a secure space for physicians to discuss mistakes confidentially and constructively within a peer-protected environment [29]. Such open discussions promote personal responsibility and accountability, and serve as a model for dental education. While there may be concerns about criticism or peer perception, openly addressing errors fosters a culture focused on learning, leading to deeper self-reflection and the development of effective strategies for future practice.

Introducing the practice of acknowledging mistakes into dental education is key to instilling the habit of transparency within student providers. Open disclosure, as taught in the Advanced Dentistry course, emphasizes the importance of preserving patient trust through honest dialogue. Dentists have an ethical duty to inform patients, particularly when errors impact health; it is imperative that dentists hold themselves to the highest standards in patient care.

The transition from preclinical to clinical practice is one of the most stressful periods in dental education; students are responsible for balancing patient care alongside various other responsibilities. A supportive learning environment amidst these high stresses, as provided by group discussions in AD courses, helps alleviate stress and encourages openness about mistakes. Research with 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 [30]. Understanding the factors that drive both successes and failures is crucial, and analyzing the causes offers students deeper insights. Thus, dental curricula should encourage discussions of both successes and failures, with a focus on the factors that directly contribute to the successful outcomes, so students may develop a more holistic understanding of clinical care.

Some limitations of the study include adverse events reported that were beyond students' control, such as laboratory errors. However, we felt it was crucial to include these events, since laboratory work is an integral part of dental practice. Teaching dental students to write precise and detailed lab prescriptions is essential, and so is preparing them on how to handle situations where laboratories mistakes occur. Additionally, we would like to acknowledge the role of the COVID-19 pandemic on study findings. All three classes experienced different degree of disruptions due to school closures amid the COVID-19 pandemic. Notably, there was a discernible difference in completed cases between the classes, largely due to COVID-19-related shutdowns of dental clinics and social distancing in the clinical teaching practice. Despite these obstacles, the consistency in the pattern of

adverse events across all classes suggests that the quality of clinical education at HSDM was upheld throughout the pandemic.

In the future, it is 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 is 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 inexperienced student clinicians face. Knowledge of common errors can help facilitate success in challenging and stressful clinical situations.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author to maintain the privacy of the study cohort.

Conflicts of Interest: The authors declare no conflicts of interest.

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