

Original Article

## Determining the impact of stressors on students' clinical performance in endodontics



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### المخلص

**أهداف البحث:** تهدف الدراسة الحالية لتقييم تأثير الضغط النفسي على أداء طلبة طب الأسنان في العلاجات اللبية عن طريق تقييد الزمن المتاح لهم ووضعهم تحت ضغط اختبار الأداء.

**طرق البحث:** تحتوي عينة الدراسة على عينة عشوائية من 16 مشترك من طلبة طب الأسنان في السنة الرابعة الذين أتموا أنشطة المحاكاة المقررة في مناهجهم. شملت الدراسة تحضير أحد الأقفية السنية في رحتين سفليتين من أسنان المحاكاة البلاستيكية. تم التحضير في السن الأول تحت الظروف الاعتيادية وتم تحضير السن الثاني تحت ضغط الزمن والاختبار. اعتمد تقييم الأداء على دقة التحضير والزمن اللازم لإتمام التحضير. كما تم تقييم الضغط النفسي من خلال استبيانين معتمدين مسبقاً لقياس الضغط النفسي بالإضافة إلى قياس معدل ضربات القلب.

**النتائج:** لم تختلف دقة الأداء عند الطلبة بين الظروف الاعتيادية وظروف الضغط النفسي، بينما احتاج الطلبة الخاضعون للتجربة إلى وقت أقل (إحصائياً) تحت ظروف الضغط النفسي.

**الاستنتاجات:** تقترح نتائج الدراسة أن التعرض لضغوط نفسية عالية لم يكن مرتبطاً بتدهور الأداء أثناء تحضير الأقفية اللبية حيث أن الطلبة تمكنوا من التأقلم مع ظروف الضغط النفسي، الذي كان واضحاً من خلال التحسن الملحوظ في الزمن اللازم لإتمام التحضير والمحافظة على أدائهم تحت هذه الظروف. هناك حاجة لإجراء بحوث مستقبلية معنية بتحسين الأداء، وبشكل خاص تحت ظروف الضغط النفسي.

**الكلمات المفتاحية:** طب الأسنان؛ المعالجات اللبية للأسنان؛ المهارات الحركية الدقيقة؛ تقييم الضغط النفسي؛ القيود الزمنية

### Abstract

**Objectives:** This study aims to evaluate the impact of stress on the clinical performance of endodontics dental students.

**Method:** The study sample consists of 16 randomly selected fourth-year dental students who had completed pre-clinical activities stipulated in their curriculum. The distal canal of a plastic mandibular first molar is prepared on two separate occasions, first under normal conditions and then under stressful conditions. The preparation accuracy of the root canal and the time taken to complete the task area measured. Stress is assessed using subjective (State-Trait Anxiety Inventory and Perceived Stress Scale) and objective (heart rate) measures.

**Results:** While the accuracy of the root canal preparation did not differ significantly between the normal and stressful conditions ( $p > 0.05$ , paired t-test), the completion time for the root canal preparation decreased significantly under stressful conditions ( $p < 0.05$ , paired t-test).

**Conclusion:** The findings of this study suggest that there is no association between the high levels of stress and the performance breakdown of root canal hand instrumentation skills. Students develop an adaptive response to stress, enabling them to improve their completion times and maintain their performance under stressful conditions. Future research should focus on learning methods that can contribute toward better outcomes, especially in stressful environments.

**Keywords:** Stress; Root canal hand instrumentation; Clinical performance; Endodontics; Dental students

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## Introduction

Learning endodontic theory and practical skills can be challenging for dental students who must demonstrate continuous progress in a limited timeframe to meet adequate standards of patient care.<sup>1–3</sup>

Clinical endodontic teaching usually begins with a training phase that simulates part of the root canal procedures using extracted human teeth. Biomechanical preparation is an essential step to eliminate the sources of infection in the root canal.<sup>4</sup> The use of extracted human teeth, external and internal anatomy variability, and the type and condition of the treated tooth make root canal preparation a difficult and discouraging task.<sup>5</sup> Furthermore, the use of extracted teeth, especially molars, is classified as having moderate to high complexity and, thus, is deemed inappropriate for undergraduate preclinical teaching.<sup>6</sup> For these reasons it is recommended in dental curricula to learn endodontic procedures using simulated plastic models/teeth before using extracted human teeth.<sup>6,7</sup>

The use of simulated endodontic root canals allows for the standardisation of the root canal length, diameter, location, degree of canal curvature, and surface hardness.<sup>5</sup> This standardisation enables outcome reproducibility.<sup>8</sup> It has been found that simulated plastic root canal teeth can be useful for determining the root canal working lengths<sup>9</sup> and preparation techniques during the process of endodontic skill learning.<sup>10</sup> Simulated root canals (e.g. artificial dentine, resin blocks, and plastic teeth) have also been used to examine and compare the shaping ability of endodontic instruments, compare the different instrumentation techniques, and evaluate the potential procedural errors during root canal preparation.<sup>11</sup> However, the reliability of the simulated canals in resin teeth or blocks used to mimic the canals in human natural teeth is unclear. For example, the variation in physical properties between dentine and resin may be an issue. Moreover, the microhardness of the root canal dentine is higher than that of the clear resin endodontic blocks and artificial resin teeth.<sup>5,8</sup> Another difference is the size of debris generating from resin and dentine, which result in further blockages in the simulated resin root canals.<sup>12</sup> Despite these issues, simulated root canal models have been reported to be a suitable alternative to extracted human teeth in learning root canal endodontic procedures.<sup>10,13</sup>

Health care professionals must take responsibility for the best interests of their patients, be lifelong learners, and participate in multiple learning activities that require a lot of effort with constrained energy and time.<sup>14</sup> Thus, the medical and dental curricula are designed to equip students with the right knowledge and skills to overcome such challenges in their carrier. As such, it has been recognized that the

medical/dental curricula differ from other curricula in higher education because of its stressful nature that frequently has a negative impact on students' academic/clinical performance and physical and psychological general health.<sup>15</sup> This, in turn, increases pressure on students to develop their skills and meet the required competencies for clinical practice within the limited time available.<sup>14</sup> Consequently, continuous demanding conditions may result in burnout and stress, which can affect learning, clinical performance, and future life and carrier.<sup>15</sup>

The learning outcomes stipulated in the dental curricula must be achieved prior to graduation, and many are taught and assessed under stressful conditions.<sup>16,17</sup> It has been reported that the most common stressors encountered by practitioners include patient demands, fear of complaints, and nonclinical administrative tasks.<sup>17</sup> In addition to the stressors related to their clinical and academic performance, course workload and requirements, fear of failing or falling behind, and lack of time for study and relaxation,<sup>16</sup> patient demands are another source of stress for dental students. The stressors related to dental students' transfer from preclinical to clinical settings can result in the deterioration of performance.<sup>18</sup> These stressors are significant as they can compromise the performance of dental students<sup>16</sup> and can negatively impact their learning experiences and progress in their program.<sup>2</sup> Moreover, the limited relationship we find between surgical performance under simulation conditions and in theatre may be due to the stress associated with operating on live patients compared to completing a similar task that is merely simulated.<sup>19</sup> Thus, there is a need for further investigation of learning fine motor skills in dentistry under stressful conditions that result in robust performance in real-world stressful conditions.<sup>20–22</sup>

This study aims to investigate the impact of stress (i.e. the combined effect of time pressure and evaluation stressors) on the performance of dental students using subjective (psychological, i.e. self-report questionnaires) and objective (physiologic, i.e. heart rate [HR]) measures of stress.

## Materials and Methods

### *Participants*

The participants are fourth-year dental students at the University of Adelaide (n = 16) who successfully completed the conventional 15–20 h of preclinical endodontic activities. All participants signed a consent form to take part in the study.

### *Measurement of stress levels*

HR is used as a physiological indicator (objective measure), and self-reported questionnaires, e.g. the State-Trait Anxiety Inventory (STAI)<sup>23,24</sup> and Perceived Stress Scale (PSS),<sup>25–27</sup> are used as psychological and behavioural indicators (subjective measures). STAI consists of six statements relating to feeling calm, tense, upset, relaxed, content, and worried. Each of these statements required a

Likert scale response from 1 = 'not at all' to 4 = 'very much'.<sup>23</sup> The PSS is a 10-item scale that is widely used to measure stress perception. It measures the degree to which individuals may rate the situations in their life as being stressful. These items are designed to indicate how unpredictable, uncontrollable, and overloaded the participants find their lives.<sup>25</sup> The PSS is used to show that there are no differences in the overall stress perception between the experimental and comparative groups. A combination of objective and subjective measures of stress has been suggested as a requirement for constructing valid and reliable measures of stress.<sup>23</sup>

#### *Test 1: primary task condition*

Prior to this test, the students are asked to complete the root canal preparation under no-stress conditions. The completion time is calculated from the time of first instrument insertion to the point of self-reported completion of the task but with a predefined 12-min (min) timeframe. After completing the task, the participants complete the STAI, focusing on their responses to Test 1.

#### *Test 2: primary task and stressful condition*

In this test, Test 1 mentioned above is repeated but within a time limit and under pressured and stressful conditions. Specifically, these conditions involve time constraints and public-speaking stressors.<sup>21,24,28</sup> The time-constraint condition requires participants to complete the task in Test 1 a min faster than the best time they were told they had achieved in the previous tests.<sup>24</sup> Data from the previous study indicate that the times allocated to participants to complete the simulated root canal preparations range from 4 to 12 min (maximum time allocated). Time pressures are achieved using a countdown timer software (Versa Timer, version 1.02, Lux Aeterna Software, Sweden). Specifically, a timer is displayed on the computer screen in front of the participants and set to call out the remaining time (minutes and seconds [sec]) every 30 s. In the last 2 min, the timer calls out the remaining time every 15 s, finishing with an audio countdown of the last 10 s. In addition, a ticking sound (each sec, metronome) plays in the background from the start until the end of the test. The public-speaking stressor involves participants being told prior to the primary task that, after the test, they would have 3 min to prepare a speech describing their experiences during the tasks and 2 min to deliver the speech in front of a video camera.<sup>28</sup> They are informed that this presentation will be reviewed by an endodontic academic who teaches at another dental school and that they will use this presentation to develop materials that explain the aspects of endodontics to future students.

Participants are also asked to include in their presentations some information about why it is important to perform the task effectively for patients who might be afraid or experiencing discomfort. They are informed that the level of discomfort patients might experience will be evaluated from the video recordings of their tests and that the focus of the presentation is on the importance of completing the task effectively. Following the completion of the final test and

before they prepare their presentations, the participants are asked to complete the STAI and PSS with particularly focus on Test 2. After finishing the STAI and PSS, the participants are informed that there is no need to prepare a talk or record a video, and there will be no review by an endodontic academic. The participants are also instructed not to talk about the nature of the activities they performed in the tests with the other students.

#### *Assessment of performance*

##### *Accuracy of the root canal preparation and completion time*

The assessment of the accuracy of the root canal preparations and completion time are reported using the method described by El Kishawi et al.<sup>29</sup> This is achieved by checking the extent/fit of the last instrument used in the prepared canal in relation to the working length and its tightness/looseness. The accuracy of the root canal preparations in the respective two occasions is determined by measuring the difference in millimetres (mm) of the distance between the last instrument reached and the target distance (19.5 mm). The time taken to complete the canal preparations for each group is measured in minutes (min). Following this, the mean values and standard deviations are calculated.

##### *Statistical analysis*

The reliability of the measurements is assessed by repeating the outcome measures on 20% of the randomly selected teeth (eight teeth). Paired student t-tests are used to assess the differences in the accuracy of the prepared canals; determine the completion time between the two tests; and assess the differences in the STAI, PSS, and HR scores between the two tests. The validity of the STAI and PSS surveys is tested using the Cronbach Coefficient Alpha (standardized) ( $\alpha$ ) and through regression of survey variables against HR at each test (linear regression), the global p values were calculated. The STAI test-retest reliability is calculated using the Intra-class Correlation Coefficient (ICC) at two times.

The participants' HR data are transmitted at the end of each test to a computer via a bidirectional infrared interface using Polar Professional Training Software (Polar Pro-Trainer 5, V 5.41.002, Polar Electro Oy, Finland). The HR data are then corrected for all the participants using the Polar software.<sup>30</sup> The HR data are corrected to compensate for measurement errors that appear as sudden peaks in the HR beats.<sup>31</sup> Pearson product-moment correlations ( $r$ ) are calculated to test for associations between the three stress measures (i.e. STAI, PSS, and HR) and variations in the accuracy of preparation and completion time.<sup>23</sup> All the data analyses are conducted using SPSS (version 26.0; SPSS Inc, Chicago, IL), and the statistical significance for quantitative and categorical data is set at  $p < 0.05$ . The effect size (Cohen's  $d$ ) is calculated using the method described by Durlak (2009).<sup>32</sup>

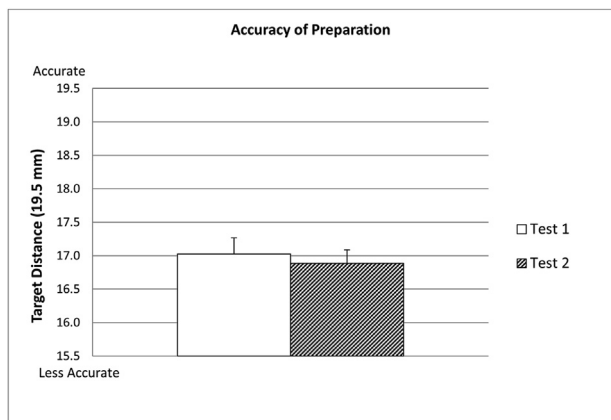
## **Results**

The sample comprises 16 participants (5 male and 11 female). Their ages range from 21 to 26 years with the mean age being  $22.9 \pm 1.5$  years. Intra- and inter-rater reliability

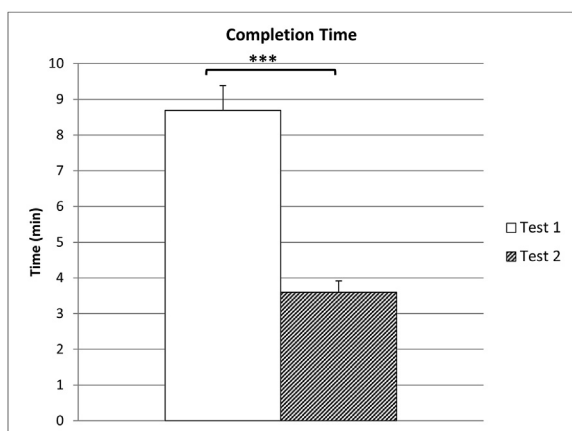
show no systematic bias ( $p > 0.05$ ) and a very high level of agreement ( $ICC > 0.8$ ). The mean length of the root canal prepared in Tests 1 and 2 ranges from 14.67 mm to 18.58 mm ( $M = 16.97$  mm,  $SD = 0.88$ ). A paired t-test shows no significant difference between the two tests with regard to the accuracy of the root canal preparation (Figure 1). The mean completion time for Tests 1 and 2 range from 1.42 to 12.30 min ( $M = 6.14$  min,  $SD = 2.03$ ). A paired t-test reveals a significant decrease in completion time at Test 2, ( $t(15) = 9.24$ ,  $p < 0.001$ ,  $d = 2.44$ ) (Figure 2).

*Stress levels*

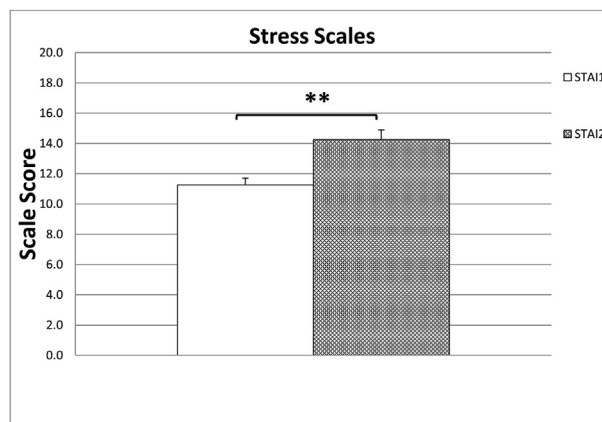
The mean STAI scores (out of 24 points) during the two tests range from 7 to 18 ( $M = 12.75$ ,  $SD = 2.17$ ) (Figure 3). The mean PSS scores (out of 40 points) range from 5 to 28 ( $M = 15.63$ ,  $SD = 5.06$ ) (Table 1). For the STAI survey, the value of Cronbach's  $\alpha$  (standardized) ( $\alpha$ ) is 0.851. This indicates good internal reliability.<sup>27</sup> With respect to the internal reliability, Cronbach's  $\alpha = 0.732$  and  $0.802$  for STAI 1 and 2, respectively. These indicate that the STAI



**Figure 1:** Mean distance (millimetres) for the last instrument reached compared to the target distance (19.5 mm) in Tests 1 and 2, error bars = +1 standard error.



**Figure 2:** Mean time (minutes) spent to complete the task during Tests 1 and 2, error bars = +1 standard error mean. \*\*\* significant difference between transfer tests ( $p < 0.001$ ).



**Figure 3:** Mean STAI survey scores (out of 24 points) for Tests 1 (STAI1) and 2 (STAI2). STAI = state trait anxiety inventory, error bars = +1 standard error. Significant difference between survey scores, \*\* = ( $p < 0.01$ ).

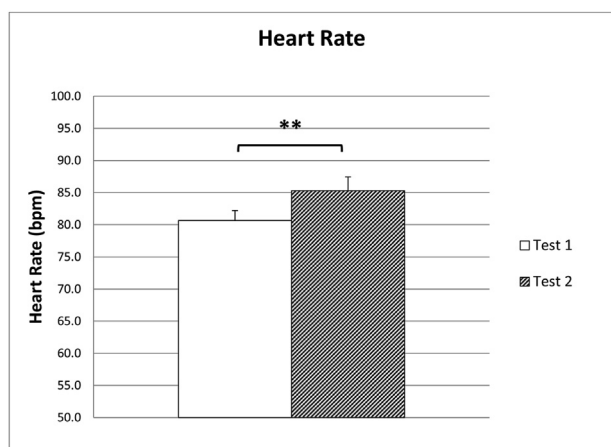
has good internal reliability.<sup>33</sup> These values are similar to those of previous studies using this survey.<sup>23</sup> A paired t-test shows a significant increase in STAI scores in Test 2, ( $t[15] = -4.35$ ,  $p = 0.001$ ,  $d = -1.4$ ) (Figure 3).

The mean HR during the two tests ranges from 67 to 102 ( $M = 83.27$  bpm,  $SD = 7.48$ ). A paired t-test reveals a

**Table 1: Percentages for the responses to the items in the Perceived Stress Scale.**

Questions	%N	%AN	%S	%FO	%VO
1) In the last month, how often have you been upset because of something that happened unexpectedly?	13	19	50	13	6
2) In the last month, how often have you felt that you were unable to control the important things in your life?	13	19	44	19	6
3) In the last month, how often have you felt nervous and 'stressed'?	0	13	44	38	6
4) In the last month, how often have you felt confident about your ability to handle your personal problems? (r)	25	56	19	0	0
5) In the last month, how often have you felt that things were going your way? (r)	6	56	25	13	0
6) In the last month, how often have you found that you could not cope with all the things that you had to do?	13	50	38	0	0
7) In the last month, how often have you been able to control the irritations in your life? (r)	19	44	31	6	0
8) In the last month, how often have you felt that you were on the top of things? (r)	6	31	50	13	0
9) In the last month, how often were you angered by things that were outside your control?	6	31	44	6	13
10) In the last month, how often did you feel that the difficulties were piling up so high that you could not overcome them?	31	31	31	6	0

%N = percentage of never response, %AN = percentage of almost never response, %S = percentage of sometimes response, %FO = percentage of fairly often response, %VO = percentage of very often response, (r) = reverse scored item.



**Figure 4:** Mean heart rate (bpm) during Tests 1 and 2, error bars = +1 standard error. Significant difference between heart rates, \*\* = ( $p < 0.01$ ).

significant increase in HR during Test 2 ( $t [15] = -4.38$ ,  $p < 0.001$ ,  $d = -0.64$ ) (Figure 4). There is no significant association between HR and STAI survey scores ( $r = 0.4$ ,  $p = 0.13$ ) or between HR and PSS scores ( $r = 0.1$ ,  $p = 0.67$ ). However, when PSS is regressed against STAI 1 (95% CI [0.09 to 0.28],  $p = 0.0002$ ),  $p = 0.0001$ ) and STAI 2 (95% CI [0.10 to 0.33],  $p = 0.0002$ ), significant associations are found. This indicates an increase in the STAI value when the PSS increases.

## Discussion

The participants in this study are asked to complete the two tests on two separate occasions. Test 1 involves a root canal preparation of the distal canal of a simulated mandibular first molar plastic tooth (i.e., primary task). While Test 2 involves the same task as in Test 1, the participants are required to carry out the task under pressured and stressful conditions (i.e., time constraints and the stress of having to speak publicly). In the pressured test, the performance related to the accuracy of the preparation is maintained, and no differences are evident. However, the completion time decreases significantly under stressful conditions.

The stress manipulation used in this study is effective. This is supported by the increase in HR (an objective measure) and STAI scores (subjective measures) for all participants, indicating an increase in their stress levels as they focus throughout the tests. However, the higher levels of stress during stressful conditions are not associated with decreased accuracy in their performance.

The retention of performance under the stressful condition used in this study may be explained by the cumulative clinical experience gained over the period preceding this study by the participating dental students, who are involved in patient dental care and exposed to different sources of stressors in the clinical environment.<sup>17</sup> Furthermore, the fourth-year dental students might have had multiple formative and summative assessments by this point in their program in which they were repeatedly placed under similar

pressure and stress conditions. Therefore, it is reassuring to discover that the students have developed an adaptive response to stress that enables them to maintain their performance under stressful conditions. Poolton, Wilson, Malhotra, Ngo, and Masters<sup>24</sup> evaluate the effect of different sources of stress on the performance of laparoscopic skills and find that high stress scores are not associated with deterioration in performance. This is important because the normal dental practices after graduation are not stress-free, and every patient is unique in terms of their dental and overall needs.

The decrease in the completion time of the task in Tests 2 compared to Test 1 might be related to learning or practice effects/familiarity with the task.<sup>34</sup> Another explanation is that the participants are asked to complete each task faster than the previous task, and, when they reach the second task, they are told to finish 1 min faster than the best time they achieved for the previous task. It is possible that the participants perceived the stress associated with working faster positively during this situation. The results show that participants develop adaptive physiological and cognitive responses to stress,<sup>35</sup> enabling them to maintain their performance and, thus, improve their completion times. This is supported by the results obtained from the PSS showing that 80% of participants score less than 20 of the possible 40 points (Table 1). This indicates that these participants do not perceive stress as something that affects their lives negatively.

Increased stress levels are linked with reduced life satisfaction, possibility of dropping out of the academic program, lower performance, and decreased commitment to the program.<sup>15</sup> Therefore, it is necessary for medical/dental students to adopt strategies that can help them cope with possible stress and burnout, boost their wellbeing, and overcome the challenges they face during their training.<sup>14</sup> These coping mechanisms may include improved interpersonal communication, motivating a positive interpretation and expression of emotions, effective counselling/mediation and support programs, and extracurricular social and physical activities.<sup>14</sup>

Future research should include two parallel groups of larger sizes and randomized into stress and no-stress groups to eliminate the confounding variables—for example, remembering the morphology of the root canals during the second occasion in the case of the self-control group as in the present study.

Further evaluation of the effect of different types of stress on the transfer of simulation skills to the clinical environment would also be desirable. Future research should focus on conducting experiments to investigate the effect of learning on skill retention in the long-term. Investigations on alternative fine-motor learning paradigms (e.g., dual-task learning, discovery learning, and using analogy) are also recommended. Testing students on the range of root canal preparation techniques, including simpler approaches (e.g., watch-winding and filing techniques), is recommended as these may enable students to learn some basic instrument-manipulation techniques before moving on to more complex techniques (e.g., balanced force technique). Furthermore, it is recommended that a comparison be drawn between the impact of stress while operating on simulated plastic teeth and that while operating on natural human

extracted teeth. Investigations on the effect of stress on the other fine-motor tasks in dentistry, including access cavity preparation, crown preparation, cavity preparation in restorative dentistry, and other surgical procedures that involve fine motor skills, are also necessary.

### Conclusions

Time-constraint pressure and students' evaluation of stress do not affect the accuracy of root canal preparation. Furthermore, the completion time of root canal preparation decreases significantly under stressful conditions. These results may suggest that dental students are able to develop an adaptive response to stress that enables them to improve their completion times and maintain their performance under stressful conditions. Future research should focus on learning methods that can contribute toward better outcomes, especially in stressful environments.

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### Conflict of interest

The authors have no conflict of interest to declare.

### Ethical approval

An ethical approval was granted by the University of Adelaide Ethical Approval Committee to conduct this study (ethical approval number: H-2012-117) in 2014.

### Authors' contribution

The authors' contributions to the manuscript are as follows: **ME**: Conceptualization, Methodology, Data Curation, Investigation, Funding Acquisition, and Writing - Review and Editing; **KK**: Validation, Methodology, Data Curation, Investigation, and Writing - Original Draft; **RO**: Validation and Writing - Review and Editing. All the authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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