



COVID-19 and Gender Effects on Dental Students' Preclinical Performance

Lubna Alkadi^{1,3,*} , Fathima Fazrina Farook^{2,3} , Maryam A. Alghilan^{1,3} , Abdulmohsen Alfadley^{1,3}  and Ahmed Jamleh⁴

¹Restorative and Prosthetic Dental Sciences Department, College of Dentistry, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia

²Preventive Dental Sciences Department, College of Dentistry, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia

³King Abdullah International Medical Research Centre, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia

⁴Department of Restorative Dentistry, College of Dental Medicine, University of Sharjah, Sharjah, United Arab Emirates

Abstract:

Introduction/Objective: Gender differences in academic performance exhibit global variations, with females often outperforming males at school levels, though university results are mixed. In dentistry, these trends are shaped by cognitive, affective, and psychomotor domains, alongside cultural and environmental factors. The COVID-19 pandemic's shift to online learning necessitates exploring the role of gender in dental academic achievements. This cross-sectional observational study examines the impact of gender differences on the academic performance of second-year dental students in preclinical restorative courses over five academic years before and during the pandemic.

Methods: Scores of 415 second-year dental students were analyzed and compared across four specific preclinical restorative courses: fixed prosthodontics, removable prosthodontics, operative dentistry, and endodontics, spanning from 2016-2017 to 2020-2021 academic years.

Results: The analysis revealed significant differences in the mean overall scores across all courses. Students achieved higher overall grades during the pandemic than before it, yet no clear association was found linking gender with the pandemic's effect on academic performance.

Conclusion: These insights reveal the complex dynamics of academic performance considering gender and the changing educational setting in the wake of the pandemic.

Keywords: Gender, Pandemic, COVID-19, E-learning, Dental education, Dental student, Performance.

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*Address correspondence to this author at the Restorative and Prosthetic Dental Sciences Department, College of Dentistry, King Saud bin Abdulaziz University for Health Sciences, Riyadh, Saudi Arabia and King Abdullah International Medical Research Center, Ministry of National Guard Health Affairs, Riyadh, Saudi Arabia; Mailing address: P.O. Box 22490, Riyadh 11426, KSA; Tel: +966 11 429 9999; Ext. 95723; Fax: +966 11 801111; Ext. 14010; E-mail: lubna.alkadi@gmail.com

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1. INTRODUCTION

The socially constructed distinctions between males and females, otherwise referred to as gender, has a profound impact on various spheres of life, inclusive of education [1]. A pertinent concern arising within this framework is the significant gender gap evident in academic performance, according to global studies conducted across various educational levels. It has been comprehensively documented that, spanning a broad spectrum of disciplines, females consistently surpass males in academic performance at school levels [2-5]. Nonetheless, at the university level, research results vary significantly. Some studies report a female advantage [6], others report a balanced gender performance [7], while a few studies imply a superior male performance [8].

Within the specific context of dentistry, academic performance is largely governed by a student's capacity to acquire taught skills across cognitive, affective, and psychomotor domains [9]. Gender-related attributes hold the potential to affect student performance across these learning domains, providing an explanation for the atypical trend observed in academic performance between male and female dental students [10].

To exemplify this concept, a study carried out during the second and third-year operative dentistry courses at Adelaide's dental program found that male students markedly surpassed the female students in cognitive tests. Yet, in a striking contrast, psychomotor tests demonstrated female students significantly outperforming their male counterparts. The results predicted the female students' cavity preparation performance to exceed that of male students by a factor of 4.6 [11].

Substantiating this, multiple international studies confirmed superior academic performance in female dental students. For instance, research conducted in Sri Lanka [12], Brazil [13], Australia [14], and Jordan [15, 16] found that female students consistently outperformed their male counterparts. However, contrastingly, studies from the United States suggested male students have scored higher in national board examinations, although no significant differences were observed in pass rates [17, 18].

However, such disparities are not solely attributed to the interaction between inherent gender traits and learning domains. Cultural, environmental, biological, and social factors, intricately interwoven, together with education expectations and values placed on individuals, collectively feed into the geographical differences observed [19]. Considering this influence, it remains uncertain whether gender impacts academic achievement in various dental courses in Saudi Arabia.

There is a substantial body of evidence indicating that the COVID-19 pandemic prompted a significant shift from in-person learning and physical attendance to online education. This shift resulted in enhanced e-learning adoption, positively influencing both students' learning behaviour and the acceptance of the programme, which merits further investigation. Therefore, this study aimed to

evaluate the influence of gender on dental students' performance by evaluating and comparing the final grades awarded in four preclinical restorative courses. Additionally, it explored the heterogeneity by investigating whether the COVID-19 pandemic affected the gender gap in educational performance.

2. METHOD

This retrospective cross-sectional observational study was conducted at the College of Dentistry, King Saud Bin Abdulaziz University for Health Sciences, Riyadh, Kingdom of Saudi Arabia. Ethical approval was obtained from the Institutional Review Board (IRB) of King Abdullah International Medical Research Centre (KAIMRC), with the project number RC20/078/R.

The study targeted second-year dental students encompassing the academic years from 2016-2017 to 2020-2021. Examination of the combined course completion grades from male and female students was conducted. The analysis covered four preclinical courses: Operative Dentistry II (RESO 413), Endodontics I (ENDD 411), Fixed Prosthodontics I (PROD 411), and Removable Prosthodontics I (PROD 412). The data were accessed between June 2022 and January 2023 to comprehensively analyse the course completion grades of male and female second-year dental students for the five academic years from 2016-2017 to 2020-2021.

Assessments spanning from both lecture material and practical laboratory sessions were incorporated into the analysis. Within these courses, the assessment method primarily involved written intra-semester and final examinations, continuous practical assessments, objective structured practical examinations (OSPE), and a final practical examination. The final numerical course grades (out of 100) were compiled from the total grades achieved in each of the aforementioned assessment components.

Obtaining the final course grades of the students was conducted through the Assessment Unit's (AU) e-register at the college, carried out by an authorized individual. As a procedure to ensure confidentiality, all personal identifiers, such as student names and numbers, were removed during this process. Access to student grades was executed without compromising their identities, providing robust assurance that the acquired data holds no linkage or traceability back to the individual students. The collated data were tabulated in Microsoft Excel.

Data entry and analysis were done with the NCSS version 2020. Independent t-test was used to assess the association between gender and the pre-clinical scores. A two-way ANOVA was used to assess the interaction between gender, the COVID-19 pandemic, and the scores in the preclinical courses. Statistical significance was assumed at 5%.

3. RESULTS

3.1. Characteristics of the Study Population

Out of the total 415 participants, a slight majority were males, constituting 226 (54.46%) of the sample, while 189

Table 1. Relationship between the mean and standard deviation (SD) of the scores (%) achieved by gender and academic year.

COVID-19 Pandemic	Academic Year	Sample Size (n)	Courses	Mean (SD) of Scores (%)		p-value
				Males	Females	
Before the Pandemic	2016-17	Males (n=26) Females (n=21)	RESD 413	74.4 (5.8)	82.9 (3.4)	<.001
			ENDD 411	76.0 (6.5)	82.7 (5.3)	<.001
			PROD 411	80.2 (6.9)	88.0 (3.8)	<.001
			PROD 412	73.7 (9.4)	82.0 (4.6)	<.001
	2017-18	Males (n=44) Females (n=33)	RESD 413	80.4 (4.9)	84.5 (3.8)	<.001
			ENDD 411	80.2 (4.9)	86.2 (4.5)	<.001
			PROD 411	77.2 (5.3)	84.1 (6.0)	<.001
			PROD 412	71.6 (7.0)	79.2 (6.3)	<.001
	2018-19	Males (n=42) Females (n=38)	RESD 413	74.9 (4.9)	79.5 (4.8)	<.001
			ENDD 411	83.7 (4.3)	83.4 (4.3)	.80
			PROD 411	81.0 (5.8)	78.3 (5.6)	.03
			PROD 412	83.4 (4.8)	84.5 (4.6)	.32
During the Pandemic	2019-20	Males (n=56) Females (n=48)	RESD 413	82.3 (11.9)	87.1 (3.6)	<.001
			ENDD 411	84.9 (12.5)	90.4 (2.5)	<.001
			PROD 411	87.3 (13.0)	92.3 (2.9)	<.05
			PROD 412	85.5 (12.9)	90.5 (3.1)	<.05
	2020-21	Males (n=57) Females (n=49)	RESD 413	74.5 (8.1)	84.3 (4.9)	<.001
			ENDD 411	81.7 (8.0)	85.8 (4.9)	<.001
			PROD 411	82.0 (8.9)	85.8 (6.6)	<.05
			PROD 412	79.4 (10.0)	84.4 (6.1)	<.001

(45.54%) were females. Approximately half of the students, 204 (49.16%), attended their courses prior to the onset of the COVID-19 pandemic, and the other half of students, 210 (50.84%), took their courses during the pandemic.

3.2. Performance Scores based on the Sample Characteristics

Table 1 presents an analysis of the achievement scores (%), expressed as mean and standard deviation (SD), and segmented by gender. Significant differences in the performance scores between genders were observed in the pre-clinical courses during the academic years of 2016-2017, 2017-2018, 2019-2020, and 2020-2021 ($p < 0.05$). However, in the 2018-2019 academic year, the variations in performance between genders did not reach the threshold of statistical significance, except for a single course, RESD 413.

Fig. (1) displays a box plot that provides a visual representation of statistical measures for different courses based on gender. The plot showcases the median, interquartile range, minimum and maximum values, and a line connecting the mean values across the genders for each course. This allows for a comparative analysis of these measures across genders within the context of various courses.

Table 2 presents the bivariate statistical analyses of students' grades across various courses, comparing results from both pre-pandemic and during-pandemic periods. The results revealed statistically significant differences in all pre-clinical courses with $p \leq 0.05$. During the pre-

pandemic period, students achieved the highest mean grade in ENDO 411 (Mean = 82.21, SD = 5.70). Conversely, amongst the pandemic, PROD 411 was the course with the highest attained mean grade (Mean = 86.66, SD = 8.67). An upward trend in students' performance was tracked across all courses during the pandemic, in comparison to grades acquired prior to the pandemic. The course PROD 411 witnessed the largest surge in average grades from before to during the pandemic, displaying a mean difference of 5.87. On the other hand, ENDO 411 exhibited the smallest increase, with a mean difference of 2.74.

A two-way ANOVA (Table 3) was performed to analyse the effect of gender and the COVID-19 period on the students' performance. The two-way ANOVA revealed that there was not a statistically significant association between the effects of gender and the COVID-19 period ($F(1, 411) = 0.003, p = 0.95$).

A simple main effects analysis indicated that gender had a statistically significant effect on the students' performance ($F(1, 411) = 55.92, p < 0.05$). The simple main effects analysis showed that COVID-19 did have a statistically significant effect on the students' performance ($F(1, 411) = 62.69, p < 0.05$).

Fig. (2) graphically demonstrates the interactional effect, showing gender as distinct lines and the timeframe of study (prior to and during the pandemic) along the horizontal axis. Examining this figure, it is evident that male students generally scored below the females during both time frames, both prior to and during the COVID-19 pandemic. This observation suggests a notable gender

implication on the students' academic performance in pre-clinical courses. Moreover, an upward trend is seen in scores from the period before compared to during the pandemic, indicating the influence of the COVID-19 pandemic on the overall academic scores of the students. However, the intersectional influence of both gender and

COVID-19 period on the students' performance does not carry statistically significant weight, as indicated by a set of parallel lines. Also, the disparity between male and female students' scores maintain consistent magnitude, unaffected by the changes in the period. This further reinforces the lack of statistical significance between the factors of gender and the COVID-19 period.¹¹

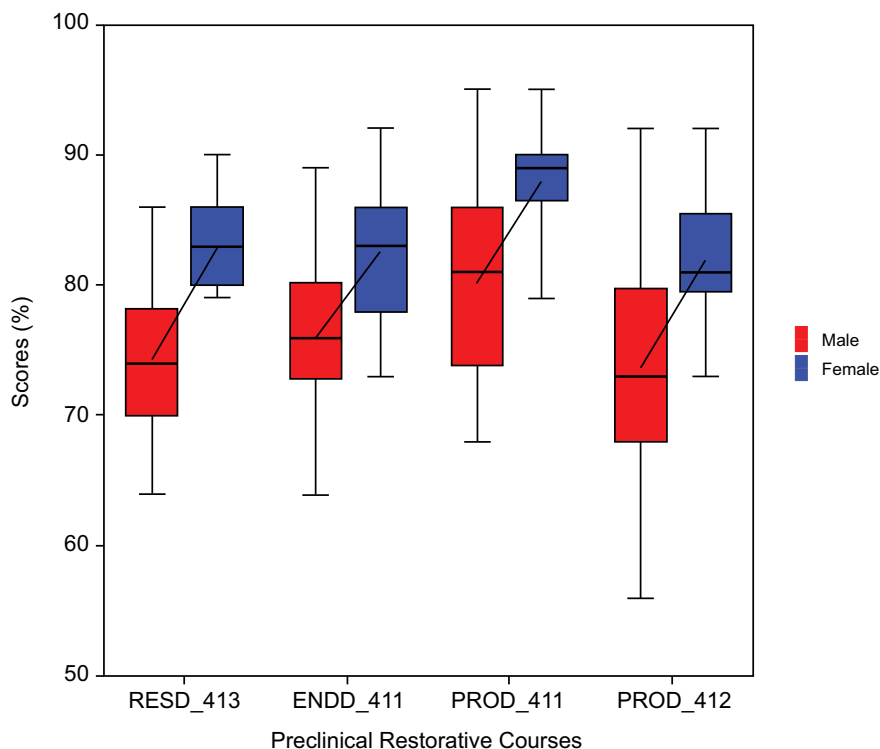


Fig. (1). Box plot showing the distribution of scores across genders.

Table 2. Sample statistics for the overall grades of the students for the preclinical courses before and during the pandemic year.

Courses	Mean (SD) Scores % (SD) by COVID-19 Pandemic Period			p-value
	Before COVID-19 (n=204)	During the COVID-19 (n=211)	Mean Difference	
RESD 413	79.24 (5.92)	84.10 (7.54)	4.86	<0.05
ENDD 411	82.21 (5.70)	84.95 (7.99)	2.74	<0.05
PROD 411	80.79 (6.53)	86.66 (8.67)	5.87	<0.05
PROD 412	79.01 (8.01)	84.23 (8.86)	5.22	<0.05

Table 3. Effect of gender and the COVID-19 pandemic on the scores of the preclinical courses: Two-way ANOVA.

Source of Variation	SS	Df	MS	F	Sig.
Gender	1967.032	1	1967.032	55.922	.000
COVID-19 period	2205.063	1	2205.063	62.689	.000
Gender * COVID-19 period	.115	1	.115	.003	.954
Error	14456.720	411	35.175	-	-
Corrected Total	18686.737	414	-	-	-

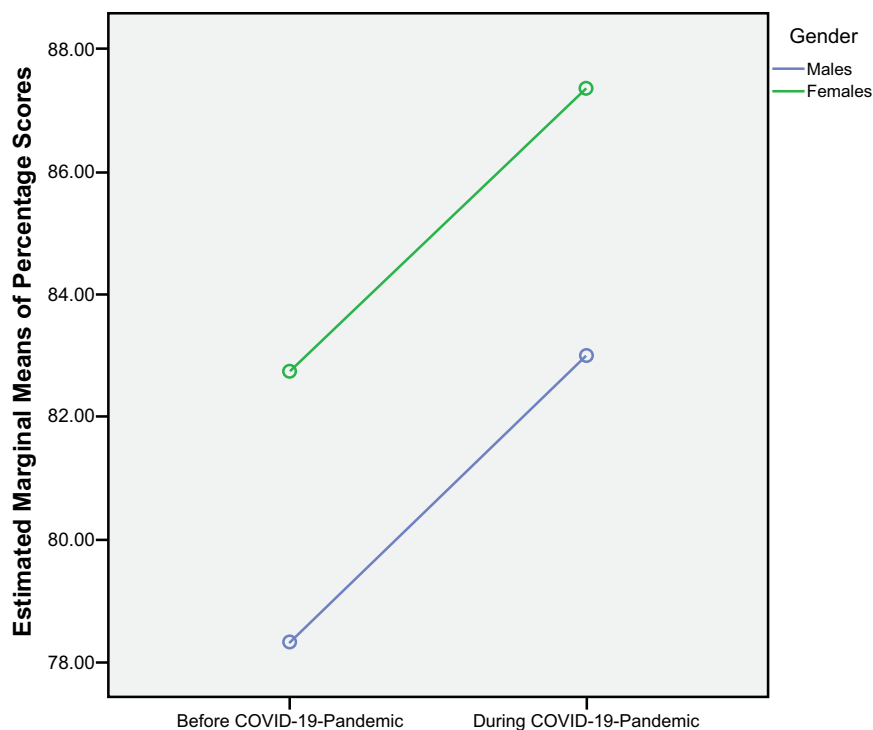


Fig. (2). Plot of the estimated marginal means of the scores of the preclinical courses between genders before and during the COVID-19 pandemic period.

4. DISCUSSION

The research findings suggest a correlation between gender and academic performance within a dental education context in Saudi Arabia, with female students achieving higher scores than their male counterparts. Furthermore, the findings highlight that student grades during the pandemic surpassed those recorded in the pre-pandemic years. Notably though, no significant interaction was observed between gender and the pandemic period in terms of influences on academic performance.

The results of the current study support the findings of multiple other studies conducted over the past decades showing a prevailing trend of superior academic achievement amongst females [20-22]. This pattern was confirmed by a meta-analysis of 369 studies which demonstrated a consistent female advantage, spanning all subject areas [23]. Potential explanations for such gender disparities have been suggested, including that of variations in brain organisation across genders. Gibb *et al.* (2008) proposed that these neurological differences might provide a compelling explanation behind the observed achievement gaps [24]. However, given the inconsistency of academic performance between genders - as evidenced in other studies [6-8], it is clear that gender-based categorization solely on the basis of brain differences is overly simplistic and unlikely to provide definitive answers. More gender-specific differences exist in other aspects related to dental students' learning experience, such as the level of perceived stress, self-confidence, and

preferences in learning styles [25-28]. The gender-related differences also found to be depicted on the level of emotional intelligence among the dental students [29]. Female dental students are more emotionally sensitive and expressive than the male counterparts [29], which adds another dimension to explain the differences in performance between genders.

Other factors such as academic aspiration and motivation can also influence achievement. Studies have found that students who are driven, inspired, and well-motivated tend to attain better results. It has been suggested that women often excel in these areas, displaying a heightened capacity to adapt and remain motivated compared to their male peers [30]. Additionally, a previous study established that female students demonstrated a greater internal locus of control compared to males in relation to their academic achievements, meaning they believed that their level of performance was a reflection of their own actions [3]. Furthermore, these women were more inclined to take responsibility for their academic failures. Meanwhile, males were found to utilize learning techniques to a lesser extent when compared to their female counterparts, which may also influence their academic outcomes [3].

Social support is a pivotal element in a student's success, as it significantly enhances academic persistence, a vital factor to achieving their aspirations. For instance, certain personality dimensions, such as aggressiveness, have been identified in literature as potential mediators

impacting the relationship between gender and academic performance [31].

Research into the gender gap in academic achievement encompasses a broad array of academic settings, ranging beyond merely school grades and performance. When this research is applied to a university context, the findings display considerable variability. Certain studies indicate a female advantage [6], others do not show discernible gender variations [7], while some show male advantages [8]. This diverse range of academic achievement outcomes in terms of gender across various disciplines and countries may derive from the influence of cultural, environmental, biological, and social elements. It could also be due to the anticipated levels of educational attainment, or the value ascribed to different subjects, which exhibit variance across different geographical settings.

The results of our study resonates with another body of research conducted in the same geographical region, suggesting a potential female advantage. In that study, eighth-graders Saudi female students demonstrated superior performance compared to their male counterparts in diverse subjects such as mathematics, science, among others [32].

Triggered by the COVID-19 pandemic, a surge in e-learning not only altered learning behaviours but also influenced acceptance of this mode of education. Therefore, evaluating if these unprecedented years impacted gender roles in academic achievement is worthwhile and could provide an intriguing perspective. The current research investigated the impact of the COVID-19 pandemic on academic performance, with a specific focus on gender differences. Notably, our findings suggested that females, on average, outperformed males academically during the pandemic, mirroring pre-pandemic trends. Existing literature suggests that students experienced significant stress due to the pandemic, a factor that might have catalysed their motivation to learn, study, and excel [33, 34]. Additionally, faculty members faced their own stress, driven by the pressure of delivering their courses effectively and accomplishing their stated objectives [33].

The pandemic led to the widespread adoption of digital learning tools such as Microsoft Teams, Blackboard, and Zoom, causing an exponential growth in e-learning's role within education. This evolution facilitated students' ability to engage with lectures, take examinations, and submit assignments in a digital environment [35]. The transformation also resulted in markedly improved faculty-student communication [35], potentially contributing to the observed grade increase during this period. Another possible explanation could be the adoption of more lenient assessment techniques during these challenging times. Furthermore, an intention to compensate for unforeseen and unintentionally exacerbated errors and difficulties may also have been a contributing factor to the observed inflation in grades.

The observed variation in grades between the

pandemic and pre-pandemic period's mirrors documented patterns of grade inflation during similar periods of crisis. In fact, the most notable rate of grade inflation ever documented at 9.21%, was identified in an investigation of higher education in Turkey [36]. Furthermore, our findings align well with those of a study conducted among third-year dental students in Saudi Arabia, where Binrayes *et al.* [37] reported elevated grades for these students across all courses during the pandemic, as compared to pre-pandemic results.

Considering the previous literature that has highlighted females' distinct challenges with computer literacy and mastery of Information and Communication Technologies (ICT) [38, 39], it was speculated that the shift to online learning, necessitated by the pandemic, might favour males. This assumption was based on the general perception that males have a higher perceived aptitude, comfort level, and engagement with computers [40]. However, research findings on this topic have proven mixed. While studies consistently report male students possessing greater self-confidence in their ICT skills, a trend observable from elementary school all the way to university levels [41-43]. A more recent meta-analysis of university students revealed that young women held stronger beliefs than their male counterparts about their competency in digital learning environments [44]. This shift might be explained by females' overall higher academic competence beliefs, which seems to override potential ICT-based stereotypes in this digital era [44]. The growing confidence among females in their ability to learn in digital settings could potentially explain their overall better academic performance during the COVID-19 pandemic.

The study's first limitation lies in its sample, which represents only one dental college in Saudi Arabia, thus limiting its generalizability. Students from one institution potentially exhibit distinct characteristics when compared to those from other institutions. Therefore, additional research is urged to validate these findings by incorporating a more diversified participant sample, which may encompass university students from different cultures, among other factors. The second limitation arises from the nature of the study's design. Employing a cross-sectional approach made it difficult to assess the relationship between the overall scores and the influencing factors. A third limitation concerns the study's analytical scope. Restricting the investigation to a limited selection of courses and batches that differ in student composition and instructional methodology, potentially constrains the comprehensiveness of the findings. Therefore, future research could consider exploring more courses and batches to overrule any outcome biases arising from these variances.

Research that examines student performance across various courses, as well as multicentre studies performed within the same nation to yield a holistic view, would be beneficial. Moreover, exploring the educational landscapes of other nations could provide meaningful comparative insights. An interesting avenue of inquiry, as suggested by

the current study, could investigate the underlying causes leading to female students outperforming male students in terms of grades. Understanding such gender-related achievement disparities could inform more gender-responsive approaches in education. These research findings are not only significant for educators, policymakers, school leaders, and the community within Saudi Arabia, but also have wider implications for Gulf countries. Given that these regions share similar educational architectures, cultural perspectives, and beliefs, and also observe comparable achievement gaps, the results can provide valuable inputs towards enhancing their educational strategies.

CONCLUSION

The research findings offer valuable insights into the multifaceted nature of academic achievement, particularly in relation to gender, within the dynamic educational landscape amid the pandemic. Understanding the complexities of how gender influences educational outcomes during such challenging times is crucial for developing inclusive and effective learning strategies. These insights can aid educators, policymakers, and institutions in addressing disparities and fostering a more equitable and nurturing learning environment for all students.

AUTHORS' CONTRIBUTION

Study concept or design: L.A., A.A.; Data analysis or interpretation: F.F.F.; Writing the paper: L.A., M.A.A., A.J.; Data collection: A.A., L.A.

LIST OF ABBREVIATIONS

ANOVA	= Analysis of Variance
AU	= Assessment Unit
COVID-19	= CoronaVirus Disease of 2019
ICT	= Information and Communication Technologies
KAIMRC	= King Abdullah International Medical Research Centre
OSPE	= Objective Structured Practical Examination
SD	= Standard Deviation

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Institutional Review Board (IRB) of King Abdullah International Medical Research Centre (KAIMRC), with the project number RC20/078/R.

HUMAN AND ANIMAL RIGHTS

All procedures performed in studies involving human participants were in accordance with the ethical standards of institutional and/or research committee and with the 1975 Declaration of Helsinki, as revised in 2013.

CONSENT FOR PUBLICATION

The IRB at KAIMRC has waived informed consent because our study uses data that is anonymous and de-

identified, preventing any linkage to individual participants.

STANDARDS OF REPORTING

STROBE and SAGER guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available from the corresponding author, [L.A.], on special request.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

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