Asian Journal of Research in Infectious Diseases

Volume 13, Issue 1, Page 32-42, 2023; Article no.AJRID.99033
ISSN: 2582-3221

The Impact of COVID on Microbiology Examination Result with its Further analysis based on Student's gender and Place of Residence

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Authors' contributions

This work was carried out in collaboration among all authors. Author LSS designed the study, choose the final literature for references and wrote the first draft of the manuscript. Authors ESA and YHD managed the analyses of the study. Author AAS conducted the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRID/2023/v13i1258

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/99033

Original Research Article

Received: 25/02/2023
Accepted: 28/04/2023
Published: 29/04/2023

ABSTRACT

Aims: To study the impact of COVID on Microbiology examination result, and analyze it further based on the gender and place of residence.
Methods: Simple analysis conducted cross-sectionally based on the comparison of the result of final Microbiology exam result based on the student's gender and place of residence. Data classified by the class of 2018 (Pre-COVID), 2019 (initial COVID) and 2020 (prolonged COVID).

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Results: There is a pattern of decreasing exam scores, both in theory and practicum, when compared to exam results before COVID (class of 2018), during the initial of the COVID pandemic (class of 2019) and 1 year after COVID became a pandemic but not yet fully controlled (class of 2020).
Conclusion: COVID caused direct impact to medical education, in our context to Microbiology examination result.

Keywords: Medical education; long distance learning; multiple choice question; student; infectious.

1. INTRODUCTION

Microbiology is an important subject on Medicine. It is the study of all micro-living organisms that are too small to be seen with unaided human eye that responsible for causing disease in human and or animal, with its application mainly in prevention, diagnosis and treatment [1]. It covers bacteria, archaea, viruses, prions and algae [2] (but in our faculty of Medicine, Protozoa and fungi, are part of Parasitology). These creatures collectively known as 'microbes' [2]. Teaching Microbiology to the medical students is important in order to prepare them to become a better doctor in the future; and how teaching modifications are made in an effort to ensure and maintain student's knowledge in the long term, even it is hoped that it will continue to exist and develop until they become doctors [3].

Actually, no single methods of education is ideal, especially in higher education and more specifically in the field of Medicine [4,5]. Recent best practice about effective clinical Microbiology education and learning requires a blend of 'hands-on' practical training and instructional remittance of pre-defined certain scientific knowledge (defined in the medical education curriculum), employing an instructional or interactive approaches that are considered 'appropriate and functional at its best' for the conveyance of Microbiology knowledge (basic and clinical) to enormous student numbers [6-8]. Microbiology practical laboratories are important learning milleu in which students acquire hands-on experience and grow their professional expertise [9,10]. Laboratory skills are taught in an innovative manner using mini cases and different lab sessions and are integrated with other basic sciences using combination of Problem Based Learning (PBL) and Team Based Learning (TBL) dealing with case based studies will help the students in their learnings [10,11]. The full range of first-hand encounter provided in this practicum session traditionally must be admitted cannot be changed through web based lectures and or library resources, even though a study conducted by Kapici et al. [12] revealed that combined both hands-on and virtual laboratories successively instead of in isolation actually produces preferable results for students' procurement of knowledge and inquiry skills. In other word, mixing virtual and hands-on laboratories may have complementary affordances to the benefit of the student. Laboratory practicum are a core component of the microbiology curriculum and central to the validation of the training experience [6-11].

However, COVID pandemic, which began to spread from Wuhan China at the end of 2019, then spread very quickly throughout the world, has shifted all the traditional beliefs and patron in every aspects of life, including medical education [13]. In Indonesia, on-site learning at all levels of education has been temporarily stopped by the government starting in March 2020. This forces education providers to take temporary measures, but this must be done as soon as possible, namely changing the education platform from onsite to online [13].

This severe and lethal infectious disease also forced medical faculty to adjust its traditional way of teaching into technology based teaching. Long distance learning, using well-known communication apps (*e.g.*, Zoom™ or MS Teams™), put into use in a hurry with continuous adjustments as the program went by trial and error. All things contemplated, including the need for new and brisk adjustments to the new situation, that collectively accepted as a major calamity to be overcome together. These adjustments have functioned as a beginning point for exceptional continuous innovations in the practice of medical education, including the advancement of an increased "evidence-based" perspective [14,15].

The aim of this simple study was to compare the results of our medical student exams in the Microbiology course before the pandemic (class of 2018), at the beginning of the pandemic (class of 2019) and a year after the pandemic was

rampant (class of 2020). Further comparison conducted by way of disaggregating student's test results based on their gender (male or female) and place of residence (own house or boarding house).

2. METHODOLOGY

We conduct a simple retrospective cross-sectional study using data of the result of Microbiology final exam, theory and practicum, from the class of 2018, 2019 and 2020. We are the oldest private faculty of Medicine in Indonesia, that already applied block based education (human body systems approach) to our undergraduate student. There are total 21 blocks in 7 semesters of our pre-clinical phase, and Microbiology studied in the 2nd semester in block 4. This means that class of 2018 studied Microbiology in early 2019 (before COVID), class of 2019 studied it in early 2020 (right when COVID pandemic hit, class based lectures had already run a third of the schedule, then the government stopped all education activities temporarily, forcing managers to change to online learning), and last but least class of 2020 studied in early 2021(COVID pandemic still exist, not fully managed yet; method of learning is still online based but the implementation is much better and well organized).

Observation being made by comparing the exam result (theory and practicum) based on gender and place of residence. The study conducted from June to September 2022 in a private faculty of medicine located in Jakarta-Indonesia. All data collected and further processed electronically and suitable statistical analysis applied in order to seek descriptive and analytic between variables.

3. RESULTS AND DISCUSSION

Actually, based on our data there are 449 active students from three class (2018,2019,2020). Number of data collected that eligible for further analysis were 432, consist of 115 male student (26.6%) and 317 (73.4%) female students. Those who were living in boarding houses as many as 205 (47.5%) and in own house as many as 227 (52.5%).

If divided further, member of class 2018 were 159 (36.8% of total) with 43 male student (19 lived in boarding house and 24 lived in their own house) and 116 female student (61 lived in boarding house and 55 lived in their own house). Class of 2019 were 138 in total number (31.9%) which consist of 39 male student (where 19 lived in boarding house and 20 lived in their own house) and 99 female student (can be sub dived into 58 lived in boarding houses and 41 lived in their own house) and class of 2020 were 135 (31.3 %) of total percentage with 33 male student (14 lived in boarding houses and 19 lived in their own house) and 102 female students (34 lived in boarding house and 68 lived in their own house). we can say, that roughly speaking, the ratio of male to female students ratio is of 0.36:1. While on the other hand, the number of student that lived in boarding house almost the same with those who lived in their own house.

In many countries today, there is an increase in the number of women practicing medicine [16]. This trend has been called the "feminization" of medicine and diverse teams of medical workforce (doctors) improve the group process and collective intelligence. Therefore, patient care and innovation can only benefit from a diverse medical workforce [17]. A study conducted by Kraljević et al. [18] found out a trend towards the feminization of medicine within the School of Medicine in Mostar, Bosnia and Herzegovina with a male: female ratio of 0.49:1. It will be interesting to study whether such demographic patterns also occur elsewhere in other faculty of medicine and whether it will give impact to these students, *e.g.*, future specialization trainings and perhaps also job opportunity.

We presented line graph regarding mean of Microbiology score (theory and practicum) from class of 2018, 2019 and 2020 in Fig. 1.

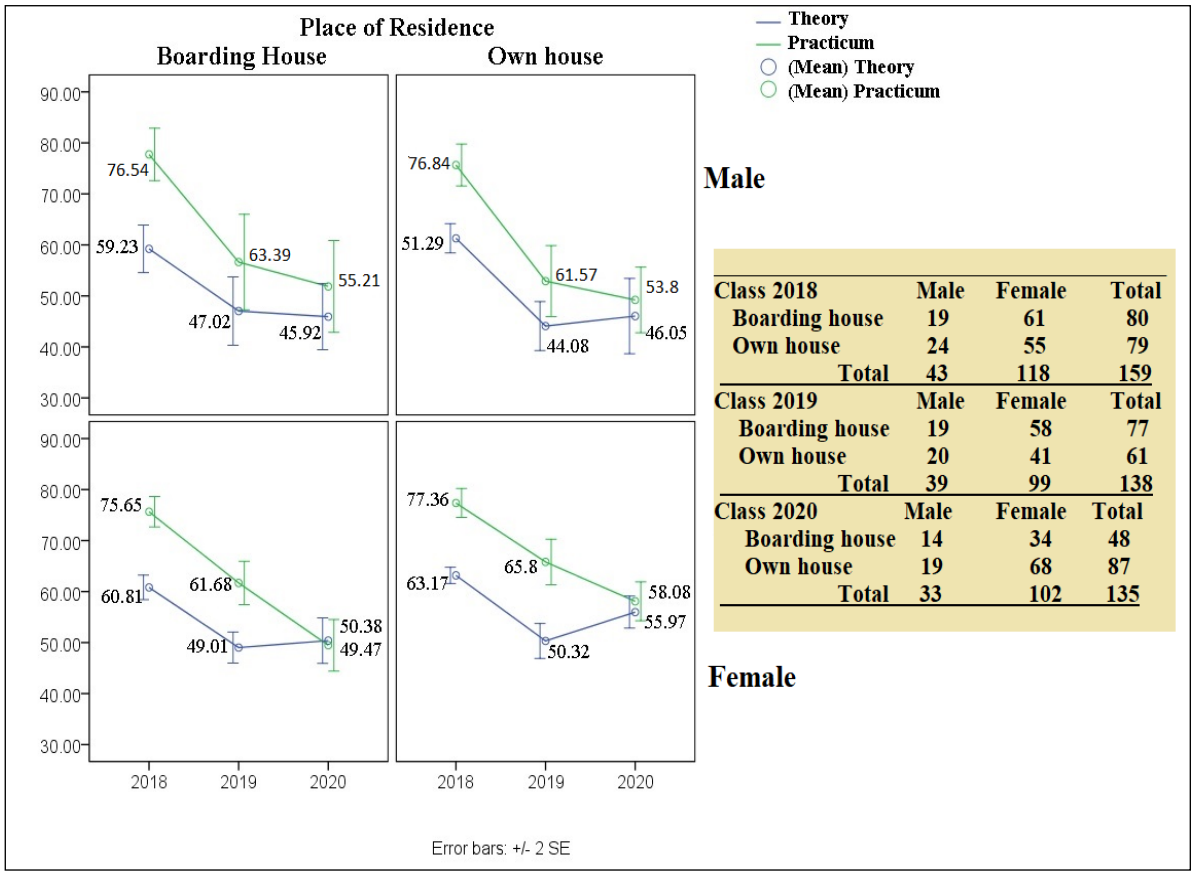
We can clearly see the decline of score, both in theory and practicum. Class of 2018, whose educational process was still normal and not yet affected by COVID, clearly showed they managed to obtain highest scores in both theory and practicum. Unfortunately, the class of 2019 and 2020, which had to struggle and undergo modified education model (*e.g.*, long distance learning), clearly showed significant lower test results; although when compared to the two (2019 and 2020), in class 2020 it appears that there has been an improvement, even though only in a few sub-groups, for example male and female students in class 2020 who live at their own houses obtain better mean score, as well as female students living in boarding houses. Unfortunately, due to the limitation of data available, it is difficult for us to analyze further;

e.g, what exactly was the problem with students living in boarding houses during COVID, especially those who failed their Microbiology exams.

COVID is clearly altering all aspects of human life globally, including medical education [19,20], This medical courses and trainings has been changed with COVID-19 disintegrating all the traditional routines in medical schools, primary health care [21], hospitals [22], areas where medical students practice family medicine [23] and community medicine [24] and so on. The rush of replacement of traditional in-person classes with long distance learning [25,26], online [15], or web based teaching [27] is a crystal clear prerequisite at this time. By accommodating those alternatives, unfortunately generates a loss of 'hands on' and also collaborative encounter between students and lecturers or instructors, or in other words, in a broader context, it causes the loss of the basic human touch [13], that has the inherent to be a serious drawback to educational purposes [28].

In Fig. 2, we presented linear regression between the result of Theory and Practicum exam score, with some modification to reveal how the achievement of student test scores was affected by COVID.

Statistically, linear regression method used to estimate or predict the relationship between two variables in quantitative research. Where this linear regression is able to make one additional assumption that correlates the independent and dependent variables through the most suitable line from the straight line data points.



Class 2018	Male	Female	Total
Boarding house	19	61	80
Own house	24	55	79
Total	43	118	159
Class 2019	**Male**	**Female**	**Total**
Boarding house	19	58	77
Own house	20	41	61
Total	39	99	138
Class 2020	**Male**	**Female**	**Total**
Boarding house	14	34	48
Own house	19	68	87
Total	33	102	135

Fig. 1. Line graph of mean of score that came from Microbiology examination result (theory and practicum), Number inside the box represented mean of score, while vertical line represented error bar (+/- 2 SE)

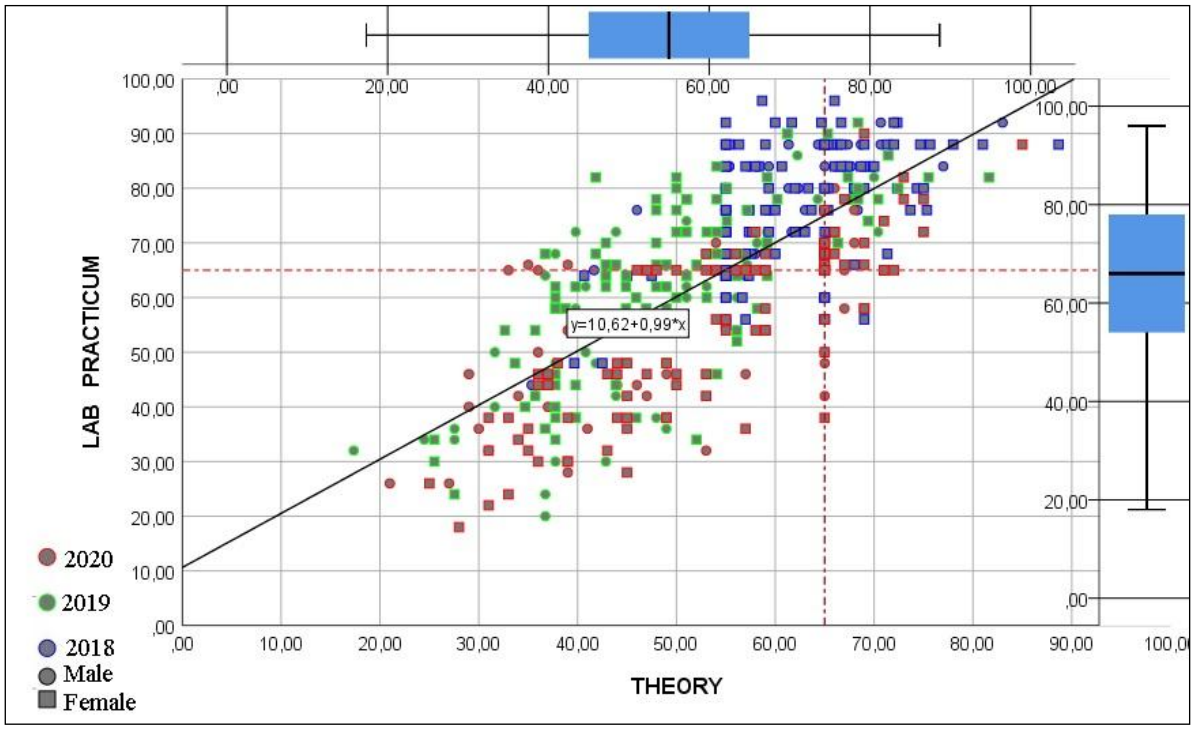


Fig. 2. Analysis of linear regression between score of theory against score of practicum. Red vertical line and red horizontal line are the minimum threshold value of passing (score 65). Vertical box plot (located in the outer right of the graph) represented the practicum score, while horizontal box plot (located in the outer upper part of the graph) represented the theory. Because of these imaginary red lines, we can have divided the graph in to four section, (1) the lower left quadrant, (2) lower right quadrant, (3) left upper quadrant, and (4) right upper quadrant. Blue dot represented the class of 2018, green class of 2019 and red class of 2020

Fig. 2 showed us the relationship between the score of theory and the score of practicum. By adding imaginary red line, vertically and horizontally, that represented the minimum threshold value of passing, which is 65, we can have divided the graphs into four quadrants, and the description as follows:

1. Any dots located in the lower left quadrants were representing failed students in both Theory and Practicum, and most of them were from the class of 2020, followed by 2019 and the least was 2018;
2. Those located in the right lower quadrant pass the Theory but not the Practicum exam, but they only small in number. Most of them that belong in this quadrant were from the class 2020 followed by only one student from class of 2018 but surprisingly there was no student from class 2019 that belong to this quadrant or at least located in the very edge of vertical red line,
3. Students that belong to left upper quadrant were those whose pass the Practicum exam but unfortunately failed in the theory; and most of them came from class of 2019 and followed by member of class of 2018 and the least in number were from class 2020 whose most located in the horizontal borderline.
4. The right upper quadrant contains those whose successfully passed both the Theory and Practicum exam. The majority came from member of class 2018 (blue dot), followed by class of 2020 (green dot) and the least in count were from class of 2019 (red dot).

Fig. 2 also showed us how Theory score can help to predict the Practicum score. The practicum score almost exclusively higher from the Theory with equation *y=10.62+0.99*x* where *x* was Theory score and *y* was Practicum score.

During the COVID-19 pandemic, medical education provider be in need of quick curricular innovations in order to keep its quality while on the other hand keeping its every stake holder

obeying the distancing guidelines and other regulation ruled out by the government [29]. Medical schools transformed existing pre-clerkship curricular structures to remote synchronous and asynchronous methods of teaching delivery [25,28], while at the same time struggling to maintain critical in-person clinical education through the augmentation of personal protective equipment, telehealth, and physical distancing [30]. While initial authentication suggested that remote teaching was effective and preserved student learning and engagement, a recent publication mention raising concern regarding reduced educational facilities due to regulation restrictions (*e.g*., turning non-COVID clinics into full services for COVID), lesser clinical exposures and diminished case volumes.[31] In the Philippines, Baticulon et al. [32] revealed about Barriers to online learning which were classified under several categories: (1) individual, (2) technological, (3) institutional, (4) domestic, and (5) community based barriers [32]. A scoping review of the Literature conducted by Connolly and Abdala [33] demonstrated that there are also constructive details related with remote or online or long distance learning, and these should be always bear in mind when organizing future teaching. Despite the chaos caused by the pandemic, there always have been beneficial lessons learned, and these should always be remembered. Globally, many specific medical courses have been reported to be affected by COVID, *e.g.,* obstetrics and gynecology [34], neurosurgery [35], orthopedics [36], ophthalmology [37], Anatomy [38], and of course there are many others publication that we have not had the chance to explore in detail via the internet. however, to the best of our knowledge, this is the first publication on the impact of COVID on Microbiology exam result for medical students. Although our research was modest, we were able to show differences in Microbiology academic performance by our student's gender and place of residence, both before and during COVID.

Academic performance is the combination of aggregate of learning (*e.g*., Theory) or acquisition of skills or knowledge (*e.g.,* Practicum) that is set for a particular course or age and can be assessed by sufficient and relevant tests/exams [39]. Exam scores are a critical measure of mastering material in medical school, even during a pandemic [40].

Unfortunately, due to follow the requirements of lockdown and its technical shift, from the traditional class based to virtual education, some medical institutions painstakingly able to organize web-based assessments in order to appraise the academic performance of their students in time; so that there are no longer delays in the educational process, including in the implementation of exams to assess learning outcomes; and this is not happening only locally but also nationally [41].

In order to ensure the success of students (who previously have been equipped with virtual education) in exams, then it's better that the institution have to make sure the embodiment long distance learning including its specific virtual constituents into their curriculum, forming a flexible hybrid design that connects the advantages of in-person and remote education [31]. Although this shift to web-based examinations was unavoidably, but all stakeholder (the institution, the governments and so on) must carefully considered other psychic/mental, philosophy of education, and technical characteristics to guarantee the accuracy and also efficiency as part of continuous quality assurance. The easiest way to address the new challenges is to administer traditional questions via a web-based platform [42].

In the context of Practicum, a study from the University of Technology and Applied Sciences (UTAS), Al-rustaq, Oman scrutinizes challenges and opportunities of online teaching and learning in the practicum during the time of COVID. The most notable discovery of the study was that previous web based or online teaching assisted students during practicum to augment them with sufficient confidence and provide them with the correct strategies and skills to utilize any online popular teaching platforms (e.g., Google Meet & Google Classroom) [43]. Also, the online teaching helped students to manage their pace, and use visual clues, affordable e-resources and teaching aids.

However, with all the goodness of distance learning, there are still problems, the most notably were internet connection and time management [13]. Even though knowledge domains can be easily evaluated via remote exams, non-traditional discipline-independent skills such Practicum are often overlooked. although the results of this study indicated that students scored better on the practicum exam than the theory exam. Material for theory exam usually are more numerous and complex than

practicum material. Even though theoretically online teaching is appropriate for providing knowledge, but the opportunity to develop practical skills may encourage students to understand more easily (compared when they learn about theory) and they were encouraged to use appropriate and relevant online techniques available in the internet [44]; this is what might cause the exam score of practicum is higher than theory. To our opinion, for students in boarding houses, ensuring an internet connection with adequate quota is actually a challenge for them; because to our knowledge there are rarely cheap boarding houses around campus that provide internet facilities. Most of those living in boarding houses are completely dependent on the internet on campus; so they often do assignments that require internet on campus late into the night. Such behavior can disrupt the ideal learning pattern that medical students should practice more regularly.

Our study showed us, that during COVID, initially our Microbiology exam result also affected, but a year later, it seems that there have been improvements in exam score along with improvements in learning process, lecture delivery, student assignment systems and the readiness of all stakeholders in responding to digital/electronic-based changes.

Based on gender, collectively female students have a higher mean score than male students, where for theory the mean score is 55.25 (SD 12.03) Vs 51.23 (SD 13.7) and for practicum scores 65.55 (SD 16.72) Vs. 61.62 (SD 18.69). Our results are consistent with the findings of a study from Saudi Arabia. This study using simple cross sectional design that scrutinized final theory examinations results of the students of undergraduate at College of Medicine, University of Dammam, Saudi Arabia, and the results revealed that female students showed overall better performance in all theory assessments [45]. The almost similar result also reported by McDonough et al in Dublin, Ireland [46], and also by Gorth et al. in Pennsylvania, US [47].

Female students tend to be more persistent, more focus regarding their studies and they work harder than male students do. Because of their responsibility, female students seem to be more attached to the academics while having fewer interests towards non academics activity and especially technical education. On contrary, male students were more related to the non-academics activity or in the technical aspects of education. Apart from that, sometime male students have contemplated their academics as dull and monotonous. Male students might think that the education or the academics could become interesting if the courses are made linked with the modern day technology.

A study was conducted the College of Medicine and Applied Medical Science at Taif University, to survey and measures study habits such as study time, study partners, source of study, breaks, study interruptions, difficulty concentrating, study activity, and delayed study. Comparisons were examined by high and low grade point average (GPA) and by gender [48]. Results indicated significant differences for time of study, study materials, study interruptions, study enjoyment between students of high and low GPAs. Gender differences were found for study time, study methods, study breaks, student activity, and delayed study time [49]. This showed us, that the academic achievement, including exam score, not only determined by one single factor, but by several internal and external factors that work together to produce the perpetrator's strong desire, in this context is to succeed in learning.

According to Bin Abdulrahman et al. [50] The top ten study habits of highly effective medical students are: (1) managing time effectively, (2) avoid interruptions (phone, family, friends) that disrupt routine daily work, (3) apply goal-setting to determine their most important activities, (4) having 3-4 hours of routine daily study hours, (5) study solitarily for knowledge retention of medical information, (6) using multiple sources to study and to learn, (7) invest in technology with high efficiency, (8) actively provide time to peer teaching, (9) study autonomously even no exam is coming, and they study lecture slides with notes and previous exam questions when preparing for upcoming exams; finally, (10) kept motivation for self-gratification and fulfillment of their own and also their family dreams.

A recent publication in the journal Nature Communications by team of researchers from Universitat de les Illes Balears and Erasmus University Rotterdam, has found that female students score better than male students on tests over two hours long, and they concluded that Females show more sustained performance during test-taking than males [51]. By taking all of these indirect factors more seriously, improvements can be made and students can catch up in Microbiology or other subjects.

Perhaps, it is mandatory that medical institution must start to consider applying a more reliable tools to evaluate, *e.g.*, the Microbiology for Health Sciences Concept Inventory (MHSCI). This inventory, as a validated assessment, is a valuable tool to evaluate student progress in health sciences microbiology courses [52].

4. LIMITATION

Limitation of this study of this study including our inability to explore more detail in the role of gender or place of residence in our student exam score. it would be very interesting to explore in more detail, the effect of personal biological or psychological properties that related to gender and or place of residence has an impact on academic performance, and whether those factors also affected during COVID.

5. CONCLUSION

Microbiology has also been affected by COVID, where it can be seen that our student exam results have decreased when compared to pre-COVID era and during COVID pandemic, both for male and female student or those who live in their own homes or boarding houses. A year later, our students exam scores began to improve along with refinements and adjustments to the long distance learning and the organization and usage of web-based educational system. Some future perspective should be prepare by the institution, in order to fill the gap if such a scenario happens; *e.g.,* the practice of second online learning.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

ACKNOWLEDGEMENTS

All authors would like to thank Dr. Forman Erwin Siagian from Dept. of Parasitology, Faculty of Medicine, Universitas Kristen Indonesia, Jakarta, Indonesia who provided assistance in manuscript preparation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/99033