

Medical students' understanding and interpreting abilities for Complete Blood Counts (CBC) in clinical practice

Tahir Jameel ¹, Mukhtiar Baig ², Mohammed Ibrahim Mohammed Albejad ³,
Taha Mohammed Abdullah Aljifri ³, Bander Abdualziz Taher Almaghrabi ³,
Raneem Yousef Qashqari ³

1. Department of Internal Medicine, Faculty of Medicine Rabigh. KAU Jeddah

2. Department of Clinical Biochemistry Faculty of Medicine Rabigh. KAU

3. Doctor, Faculty of Medicine Rabigh. KAU Jeddah

Corresponding author:

Tahir Jameel.

Department of Internal Medicine, Faculty of Medicine Rabigh.

KAU Jeddah

Kingdom of Saudi Arabia

Email: tjahmed@kau.edu.sa

Received: September 2022 Accepted: October 2022; Published: November 1, 2022.

Citation: Tahir Jameel et al. Medical students' understanding and interpreting abilities for Complete Blood Counts (CBC) in clinical practice. *World Family Medicine*. 2022; 20(11): 35-43. DOI: 10.5742/MEWFM.2022.95251363

Abstract

Introduction: The current study aimed to assess students' competency of the Faculty of Medicine, Makkah region Saudi Arabia in interpreting common laboratory investigations like Complete Blood Counts.

Methods: The current cross-sectional, quantitative and exploratory study was carried out at the Faculty of Medicine, Rabigh, King Abdulaziz University (KAU), Jeddah, from April 1 to April 20, 2022. An online questionnaire was circulated via various social media like Facebook, Twitter, and WhatsApp.

Results: A total of 1,010 respondents participated in the survey, representing an overall response rate of 70%. Among all the respondents, females were 677 (67%) while males were 333 (33%). There were 277 (27.4%), 479 (47.4%), and 254 (25.1%) students from the fourth, fifth, and sixth years, respectively. For most of the statements, more than 70% of students responded correctly, but particularly for three of the questions, students' correct responses were 561 (55.5%), 518 (51.3%), and 491 (48.6%), which were not up to the mark. A gender-wise comparison showed that the percentage of correct answers given by female students was significantly higher than that of male students for all statements ($p < 0.001$). For most of the indices, more than 70% of students responded correctly, while for four questions, students' correct responses were not up to

the mark. Comparison between students' gender revealed that, apart from two, the percentage of female students who correctly interpreted the indices was significantly higher than that of male students ($p < 0.001$). In the results of all participants' responses to the clinical scenario interpretation the female students performed significantly better in scenarios 1 and 2 ($p < 0.001$).

Conclusions: Overall, our study participants' comprehension of CBC values and interpretation of the case scenarios was adequate. On the other hand, female students demonstrated better conceptual understanding than male students. We recommend improving assessment systems to help students expand their interpretation skills.

Key words: Complete Blood Count, interpretation, medical students, Saudi Arabia

Introduction

Medicine is one of the most demanding professions since it involves dedication, passion, and concentration. Usually, medical education focuses little on understanding patients' different investigation results (1). Instructors primarily focus on the pathophysiology, sign symptoms, and treatment. However, different investigations are involved in understanding patients' problems such as blood, CSF, urine, and body tissues. Biochemistry, hematology, histopathology microbiology, and radio diagnostic units are involved. Students' mentalities toward learning are directly related to their level of subject-matter competence (1).

Blood Complete Counts (CBC) including differential WBCs, and reticulocyte counts are the time-tested laboratory studies in almost all the patients attending hospitals, either for outdoor or indoor facilities. CBC interpretation is key in diagnosing a number of commonly encountered clinical problems (2). CBC is beneficial in the differential diagnosis of anemia, hemoglobinopathy/Thalassemia, bleeding disorders, infections, metabolic disorders and in other clinical conditions (2). In their initial academic years, medical students are taught the utility of CBC in different clinical situations. In clinical years they get exposure to patients with various diseases and during bedside teaching, relevant investigations and their interpretation are discussed with the teachers (3).

This exposure to laboratory medicine during student life provides an educational background for future physicians, ensuring proper diagnosis and management of their patients. Pozdnyakova et al. pointed out recently that CBC findings were of immense value in the pandemic of COVID-19 (3). But one must be trained to acknowledge the developing drift in the parameters of CBC. In two studies conducted in different countries, May JE recently pointed out certain parameters of CBC, which clinicians mostly ignored during their consultations (2,4).

A couple of studies investigating the usefulness of CBC in general medical patients reporting in the emergency department, revealed significant value in early diagnosis of the patients (5,6,7). Its predictive value was greatly enhanced if the differential WBC count was taken in isolation in conditions requiring urgent management measures like neonatal sepsis and early detection of infections like occult focal bacterial infections (8, 9,10).

Wilson et al. stressed the need to train future physicians in laboratory medicine services to utilize the essential tool of routine investigations effectively (11). A recent study revealed that young physicians use laboratory facilities very effectively if they get sufficient exposure to interpretations of day-to-day laboratory facilities during their training time (11). The main purpose of this study was to assess the competency of medical students of the Faculty of Medicine Rabigh, KAU Jeddah along with other colleges of Makkah region Saudi Arabia, in the interpretation of common laboratory investigations like CBC. This study will provide information about students' understanding of this common

and mostly carried out laboratory test so that one knows the areas to be stressed in the future.

Material and Methods

The current cross-sectional, quantitative and exploratory study was carried out at the Faculty of Medicine, Rabigh, King Abdulaziz University (KAU), Jeddah from April 1 to April 20, 2022. Ethical approval was obtained from the Unit of Biomedical Ethics, KAU, Jeddah, SA. Our study participants were clinical students from different medical colleges in the Mecca Region. An online questionnaire was prepared with the help of the WHO myth-buster document and already published literature (12, 13). The questionnaire was converted to a Google form, and the link was sent to the students via various means like Facebook, Twitter, and WhatsApp.

Two senior faculty members validated the questionnaire for substance and intelligibility, and it was further updated based on their recommendations. A pilot study with 40 students was carried out to ensure the content validity. Cronbach's alpha was discovered to be 80.

The sample size was estimated using the Raosoft sample size calculator, with a population size of 2,500 medical students, a response rate of 50%, a confidence level of 95%, a margin of error of 5%, and statistical power of 80%. The calculated sample size was 334; it was inflated due to expected incomplete and missing questionnaires and non-responses and to increase the generalizability of the results. The data was coded and entered into the Statistical Package for Social Sciences (SPSS, IBM, USA) software version 22.0 for data entry and analysis. Both descriptive statistics and analytic statistics were examined. Categorical variables were compared by Chi-square test, and the scores were compared by Student t-test or ANOVA test. The level of statistical significance was set at $p < 0.05$.

Results

A total of 1,010 respondents participated in the survey, representing an overall response rate of 70%. Among all the respondents, females were 677 (67%) while males were 333 (33%). The mean age of students was 23.15 ± 1.3 years. There were 277 (27.4%), 479 (47.4%), and 254 (25.1%) students from the fourth, fifth, and sixth years, respectively. More than half of the students, 539 (53.4%), were from the Faculty of Medicine, King Abdulaziz University, Jeddah, while 471 (46.6%) were from other universities in Mecca region. Table 1 also shows other general characteristics.

Several statements were provided in the survey questionnaire, and the participants selected the correct option from the list of four. For most of the statements, more than 70% of students responded correctly, but particularly for three of the questions, students' correct responses were 561 (55.5%), 518 (51.3%), and 491 (48.6%), which were not up to the mark (Table 2). A gender-wise comparison

showed that the percentage of correct answers given by female students was significantly higher than that of male students for all statements ($p < 0.001$) (Table 2).

Several indices were interpreted, and participants chose the correct interpretation from four options. For most of the indices, more than 70% of students responded correctly, while for four questions, students' correct responses were not up to the mark. The correct response to a question about the normal range of MCH in an adult was 642 (63.6%). The correct answer for the question, normal range of RDW in an adult female, was 390 (38.6%), and the correct answers for questions, the value of RDW in Iron deficiency anemia and β Thalassemia, were 570 (54.4%) and 547 (54.2%), respectively (Table 3). Comparison between students' gender revealed that, apart from

two, the percentage of female students who correctly interpreted the indices was significantly higher than that of male students ($p < 0.001$) (Table 3). Additionally, for the normal range of reticulocytes, more males than females got the correct answer (0.0018) (Table 3).

The results of participants' responses to the clinical scenario's interpretation were 818 (81%), 807 (79.9%), and 590 (58.4%), respectively, for scenarios 1, 2, and 3. In the scenario related to pallor and moderate jaundice, the student's performance was not up to the mark 590 (58.4%). For the same question, there was no difference between male and female responses ($p=0.4671$). Female students performed significantly better in scenarios 1 and 2 ($p < 0.001$) (Table 4).

Table 1: Participants' general characteristics (N=1010)

Characteristics	Mean \pm SD	
Age	23.15 \pm 1.3	
Gender	Frequency	Percent
Female	677	67
Male	333	33
Place of study		
KAU	539	53.4
Others	471	46.6
Year of study		
Fourth year	277	27.4
Fifth year	479	47.4
Sixth year	254	25.1
GPA in last semester		
3-3.5	64	6.3
3.5-4	223	22.1
4-4.5	391	38.7
4.5-5	330	32.7
Less than 2	2	0.2
Failed in any previous module		
No	825	81.7
Yes	185	18.3

Table 2: All participants' correct responses to each statement and gender-wise comparison of correct answers (Total =1010, Female=677, Male=333)

Statements	Total correct responses n (%)	Female Responses n (%)	Male Responses n (%)	95% CI		p-value
				Low	High	
What does the White blood cell (WBC) count indicate?	799(79.1)	573(84.6)	226(67.9)	11.1%	22.4%	< 0.001
What does the WBC differential count indicate?	802(79.4)	582(86)	220(66.1)	14.2%	25.6%	< 0.001
What does the Red blood cell (RBC) count indicate?	799(79.1)	581(85.8)	218(65.5)	14.6%	26.1%	< 0.001
What does Hematocrit (Hct) indicate?	788(78)	564(83.3)	224(67.3)	10.3%	21.8%	< 0.001
What does Hemoglobin (Hb) indicate?	753(74.6)	547(80.8)	206(61.9)	12.9%	24.9%	< 0.001
What does Mean corpuscular volume (MCV) indicate?	813(80.5)	578(85.5)	235(70.6)	9.4%	20.5%	< 0.001
What does Mean corpuscular hemoglobin concentration (MCHC) indicate?	561 (55.5)	409(60.4)	152(45.6)	8.2%	21.1%	< 0.001
What does Red cell distribution width (RDW) indicate?	518 (51.3)	414(61.2)	104(31.2)	23.6%	35.9%	< 0.001
What does Platelet count indicate?	734(72.7)	543(80.2)	191(57.4)	16.7%	28.8%	< 0.001
What does Mean platelet volume (MPV) indicate?	491 (48.6)	398(58.8)	93(27.9)	24.6%	36.7%	< 0.001
What does the term reticulocyte indicate?	796(78.8)	569(84)	227(68.2)	10.2%	21.5%	< 0.001

Table 3: All participants, correct interpretation of indices and gender-wise comparison of the correct answer (Total =1010, Female=677, Male=333)

Statements	Total correct interpretation n (%)	Female Responses n (%)	Male Responses n (%)	95% CI		p-value
				Low	High	
WBC differential in a new born is.....x10 ⁹ /l	746(73.9)	550(81.2)	196(58.9)	6.2%	28.3%	< 0.001
WBC differential in an adult isx10 ⁹ /l	829(82.1)	580(85.7)	249(74.8)	5.6%	16.4%	< 0.001
WBC Differential in an in pyogenic infection isx10 ⁹ /l	832(82.4)	584(86.3)	248(74.5)	6.6%	17.2%	< 0.001
Morphological classification of anemia is dependent on:	834(82.6)	582(86)	252(75.7)	5.1%	15.7%	< 0.001
Average Hb in an adult male is..... g/dl	821(81.3)	578(85.4)	243(73)	7.1%	17.9%	< 0.001
Average Hb in a pregnant female is----- g/dl	750(74.3)	552(81.5)	198(59.5)	16%	28%	< 0.001
Normal range of MCV in an adult is femtoliters	752(74.4)	544(80.4)	208(62.5)	11.9%	23.9%	< 0.001
Normal range of MCH in an adult is picogram/cell	642 (63.6)	493(72.8)	149(44.7)	21.7%	34.2%	< 0.001
Normal range of MCHC in an adult is grams/dl	730(72.3)	548(80.9)	182(54.7)	20.1%	32.2%	< 0.001
Normal range of RDW in an adult male is%	733(72.6)	545(80.5)	188(56.4)	17.9%	30.1%	< 0.001
RDW range in an adult female is%	390 (38.6)	263(38.8)	127(38.1)	-5.7%	6.9%	P=0.8300
The value of RDW in Iron deficiency anemia is:	570(54.4)	446(65.9)	124(37.2)	22.2%	34.8%	< 0.001
The value of RDW in β Thalassemia is:	547(54.2)	435(64.3)	112(33.6)	24.3%	36.7%	< 0.001
The normal range of MPV in an adult is femtoliters	563(55.7)	439(64.8)	124(37.2)	21.1%	33.7%	< 0.001
The normal range of reticulocytes is?	565(55.9)	423(62.5)	141(72.4)	3.7%	15.7%	0.0018

Table 4: Responses of all participants to the interpretation of clinical scenario and gender-wise comparison of correct interpretation of clinical scenario (Total =1010, Female=677, Male=333)

Clinical Scenario	Total correct interpretation n(%)	Female Responses n(%)	Male Responses n(%)	95% CI		p-value
				Low	High	
A 32-year-old female presented for a routine checkup. Her CBC showed the following: Hb 9 g/dl, MCV 56 fl, RBC count $6.4 \times 10^{12}/l$, RDW 12.8%. Which one of the following is the possible explanation for this CBC report?	818(81)	577(85.2)	241(72.4)	7.4%	18.4%	< 0.001
A 66-year-old male was presented with pallor and mild jaundice. He complained of extreme tiredness. Blood CBC showed: Hgb 9.2g/dL, RBC $2.8 \times 10^{12}/l$, MCV 98 fl, WBC: $02 \times 10^9/l$, Platelet count $55 \times 10^9/l$. Reticulocyte counts 0.1 % (0.2-2%). Which one of the following is the possible explanation for his symptoms and blood counts?	807(79.9)	572(84.5)	235(70.6)	8.4%	19.5%	< 0.001
A 45-year-old male was presented with pallor and moderate jaundice. He complained of extreme tiredness and on examination, he had mild jaundice, and moderately enlarged spleen. Blood CBC showed: Hb 9.2g/dL, RBC $2.8 \times 10^{12}/l$, MCV 88 fl, WBC: $8 \times 10^9/l$, platelet count $355 \times 10^9/l$ and reticulocyte counts 5.8 %. Which one of the following is the possible explanation for his symptoms and blood counts?	590(58.4)	410(59.2)	189(56.8)	-4%	8.8%	0.4671

Discussion

CBC is the most advised test among outdoor and admitted patients. Quite deceptively, it is thought to be a simple test. It contains both simple quantitative results and the calculated complex results. One needs training to understand the message in the report (14,15). The present study concentrated on the students of clinical years, i.e., fourth, fifth, and sixth years. The response to a couple of the questions like MCH values and RDW interpretation was not up to the mark by our study cohort. Furthermore, the results showed that the senior medical students mainly concentrated on selected parameters of CBC, such as RBC count, Hemoglobin, MCV, total leukocyte count, platelets, differential WBC count, and reticulocyte count. Histograms and other parameters were at times ignored during the report interpretation. Similar trends were observed in a study concentrating on junior doctors (16). MCH (Mean Corpuscular Hemoglobin) and MCHC (Mean Corpuscular Hemoglobin Concentration), critical red cell indices, were mostly ignored by observers. MCH and MCHC values should be interpreted in conjunction with the MCV values. RDW (Red Cell Distribution Width), in conjunction with the MCH, is mainly among the neglected parameters of CBC (17). RDW values mostly reflect the distribution of RBC size, and it is considered a reliable indicator of anisocytosis, mostly used in the diagnosis of hypochromic microcytic and normochromic normocytic anemias. The RDW parameter helps to differentiate among the causes of anemia; a high RDW value indicates the possibility of Iron deficiency anemia, whereas normal RDW in the presence of low hemoglobin and low MCV suggests the presence of thalassemia state/disease (17).

A Brazilian study regarding knowledge of CBC interpretation by health professionals, especially concerning various clinical states, mentioned poor interpretations by many doctors despite having post-graduate qualifications. Most of these doctors were confident in being knowledgeable in CBC interpretations. It has been suggested that along with two other parameters in CBC, RDW is the most neglected finding among clinicians during the interpretation of CBC (18).

Our study revealed an interesting finding: female medical students responded to the survey with greater attention and with a thoughtful mind compared to their male counterparts. This fact has been noted in several previous studies carried out at KAU and other centers (19, 20, 21 & 22). In one study, it was pointed out that male students have many outdoor interests whereas female students being at home or in a hostel can spare more time for curricular activities (23). Statistical analysis revealed that in all the questions except in a couple of queries (26 out of 28), a strong statistical significance (<0.001) was observed in the responses of male and female students. It showed that the female students' conceptual understanding was better than males. The male students need to give more time to their studies.

We presented a few clinical scenarios with relevant hematological findings to access the applied clinical knowledge. The Overall response was encouraging

except in an odd scenario where the response was not up to the mark. Female students performed much better as compared to male students. It indicated that the female students' knowledge and interpretation skills are better than males. Therefore, it is suggested that male students should be more focused while interpreting the CBC reports. To improve their understanding and interpretation skills, they should discuss all their misconceptions with their teachers.

Rosenberg W stressed that evidence-based learning practice could improve the problem-solving capabilities among medical students (24). Burgess A et al. in a recent study emphasized that team-based learning and case-based learning modalities are strong instruments for polishing the problem-solving capabilities of medical students (25). It has been stressed that adopting layered analysis of self-explanation and structured reflection to support clinical reasoning helps medical students in clinical problem-solving.

A recent study reported that most medical students perceived case-based learning (CBL) as a tool that facilitates their transformation from fact, and memorizers into problem solvers, provides insight into real-life experiences, promotes deep learning, and keeps them engaged during the sessions (1). Therefore, CBL's importance in deeper learning is undeniable.

Students' continuous evaluation is essential to encourage their learning motives (26), hence, it has been proposed to link the assessments with CBL like activities so that students can focus more on conceptual knowledge. Such an approach will assist them in remembering the material for a more extended period and using it in real-life scenarios while interacting with patients (27, 28).

Khalid et al. have advocated that clinical exposure for medical students be included early in their MBBS programs to improve collaborative skills and self-directed learning (1).

A study reported that specific modes of training, such as CBL, and PBL, require medical students to search on the net and open their textbooks in order to obtain necessary knowledge (19).

CBC plays a crucial role in diagnosing several clinical conditions and patient management. The current practical knowledge among medical students regarding its interpretation needs attention. Medical students should be encouraged to interpret laboratory investigations concerning the clinical presentation of their patients (28, 29).

Limitations of the study: Our study was carried out in the immediate post COVID-19 era. We relied on the online questionnaire and couldn't arrange face-to-face sessions. There was a possibility that students may consult literature while answering the questions. But the authors were of the idea that we didn't ask our study cohort to reveal their identity so it would minimize the chances of taking help either online or through books.

Conclusion

Overall, our study participants' understanding regarding CBC values and their interpretation of the case scenarios was up to the mark. However, female students had better conceptual understanding compared to males. It is recommended that for further enhancing their skills of interpretation there should be an improvement in assessment tools.

References

- Khalid A, Ali Jaffar M, Khan T, Abbas Lail R, Ali S, Aktas G, Waris A, Javaid A, Ijaz N, Muhammad N. Hematological and biochemical parameters as diagnostic and prognostic markers in SARS-COV-2 infected patients of Pakistan: a retrospective comparative analysis. *Hematology*. 2021 Jan 1;26(1):529-42. doi:10.1080/16078454.2021.1950898.
- May JE, Marques MB, Reddy VV, Gangaraju R. Three neglected numbers in the CBC: the RDW, MPV, and NRBC count. *Cleve Clin J Med*. 2019 Mar 1;86(3):167-72. doi:10.3949/ccjm.86a.18072
- Pozdnyakova O, Connell NT, Battinelli EM, Connors JM, Fell G, Kim AS. Clinical significance of CBC and WBC morphology in the diagnosis and clinical course of COVID-19 infection. *American journal of clinical pathology*. 2021 Mar;155(3):364-75. doi: 10.1093/ajcp/aqaa231
- Birhaneselassie M, Birhanu A, Gebremedhin A, Tsegaye A. How useful are complete blood count and reticulocyte reports to clinicians in Addis Ababa hospitals, Ethiopia? *BMC Blood Disorders*. 2013 Dec;13(1):1-7. doi:10.1186/2052-1839-13-11
- Almeida BS, Alves BD, de Sousa Gehrke F, Adami F, Fonseca FL. Complete Blood Count Interpretation: A Survey of Health Professional in Brazil. *International Archives of Medicine*. 2017 Aug 3;10. DOI: <https://doi.org/10.3823/2499>
- Jazima Sulaiha S. Screening Tools for Early Prediction of Bacteremia in Febrile Children aged 3-36 Months (Doctoral dissertation, Madras Medical College, Chennai). DOI: 10.1111/j.1742-6723.2007.00981.x
- Nithya M. Study on Thrombocytosis as a Predictor of Serious Bacterial Infection in Young Infants (Doctoral dissertation, Madurai Medical College, Madurai).
- Cantey JB, Lee JH. Biomarkers for the diagnosis of neonatal sepsis. *Clinics in Perinatology*. 2021 Jun 1;48(2):215-27.
- Mohankumar MK, Paulose S. MEAN PLATELET VOLUME IN NEONATAL SEPSIS-A CASE CONTROL STUDY. *Journal of Evolution of Medical and Dental Sciences*. 2019 Jun 3;8(22):1808-13. DOI: 10.14260/jemds/2019/397
- Shoukry LR, Mohamed AN, Sharaf AE, Osman OB. Diagnostic markers for early detection of neonatal sepsis. *Journal of Scientific Research in Medical and Biological Sciences*. 2021 Aug 12;2(3):13-26. DOI: <https://doi.org/10.47631/jsrmb.v2i3.319>
- Wilson ML, Fleming KA, Kuti MA, Looi LM, Lago N, Ru K. Access to pathology and laboratory medicine services: a crucial gap. *The Lancet*. 2018 May 12;391(10133):1927-38. doi: 10.1016/S0140-6736(18)30458-6.
- Schumacher LD, Jäger L, Meier R, Rachamin Y, Senn O, Rosemann T, Markun S. Trends and between-physician variation in laboratory testing: A retrospective longitudinal study in general practice. *Journal of clinical medicine*. 2020 Jun;9(6):1787. doi: 10.3390/jcm9061787
- Zhong BL, Luo W, Li HM, Zhang QQ, Liu XG, Li WT, Li Y. Knowledge, attitudes, and practices towards COVID-19 among Chinese residents during the rapid rise period of the COVID-19 outbreak: a quick online cross-sectional survey. *International journal of biological sciences*. 2020;16(10):1745. doi: 10.7150/ijbs.45221
- Sandhaus LM, Meyer P. How useful are CBC and reticulocyte reports to clinicians?. *American journal of clinical pathology*. 2002 Nov 1;118(5):787-93. doi: 10.1186/2052-1839-13-11
- Sharma M. Applying feminist theory to medical education. *The Lancet*. 2019 Feb 9;393(10171):570-8. doi: 10.1016/S0140-6736(18)32595-9.
- Tefferi A, Hanson CA, Inwards DJ. How to interpret and pursue an abnormal complete blood cell count in adults. In *Mayo Clinic Proceedings* 2005 Jul 1 (Vol. 80, No. 7, pp. 923-936). Elsevier. doi: 10.4065/80.7.923.
- Hoffmann JJ, Urrechaga E. Role of RDW in mathematical formulas aiding the differential diagnosis of microcytic anemia. *Scandinavian Journal of Clinical and Laboratory Investigation*. 2020 Oct 1;80(6):464-9. doi:10.1080/00365513.2020.1774800.
- Almeida BS, Alves BD, de Sousa Gehrke F, Adami F, Fonseca FL. Complete Blood Count Interpretation: A Survey of Health Professional in Brazil. *International Archives of Medicine*. 2017 Aug 3;1. DOI: <https://doi.org/10.3823/2499>
- Nuzhat A, Salem RO, Hamdan NA, Ashour N. Gender differences in learning styles and academic performance of medical students in Saudi Arabia. *Medical teacher*. 2013 Apr 1;35(sup1):S78-82. doi: 10.3109/0142159X.2013.765545.
- Jameel T, Gazzaz ZJ, Baig M, Tashkandi JM, Alharenth NS, Butt NS, et al. Medical students' preferences towards learning resources and their study habits at King Abdulaziz University, Jeddah, Saudi Arabia. *BMC Res Notes* 2019; 12(1): 30. <https://doi.org/10.1186/s13104-019-4052-3>.
- Sayedalamina Z, Alshuaibi A, Almutairi O, Baghaffar M, Jameel T, Baig M. Utilization of smart phones related medical applications among medical students at King Abdulaziz University, Jeddah: a cross-sectional study. *Journal of infection and public health*. 2016 Nov 1;9(6):691-7. doi: 10.1016/j.jiph.2016.08.006.
- Jameel T, Baig M, Tariq S, Gazzaz ZJ, Butt NS, Althagafi NK, Hazazi EY, Alsayed RS. Psychosocial, cultural, and academic challenges to Saudi Arabian students in Australia. *PloS one*. 2022 Jan 31;17(1):e0262585. <https://doi.org/10.1371/journal.pone.0262585>

23. Jameel T, Baig M, Gazzaz ZJ, Tashkandi JM, Al Alhareth NS, Khan SA, Butt NS. Approaches towards professional studies and spare-time activities among preclinical and clinical year medical students. *Cureus*. 2019 Jun 14;11(6). doi: 10.7759/cureus.4905
24. Rosenberg W, Donald A. Evidence based medicine: an approach to clinical problem-solving. *BMJ*. 1995 Apr 29;310(6987):1122-6. doi: 10.1136/bmj.310.6987.1122.
25. Burgess A, Matar E, Roberts C, Haq I, Wynter L, Singer J, Kalman E, Bleasel J. Scaffolding medical student knowledge and skills: team-based learning (TBL) and case-based learning (CBL). *BMC Medical Education*. 2021 Dec;21(1):1-4. doi: 10.1186/s12909-021-02638-3.
26. Mehmood MS, Baig WS, Khan SA, Khan F, Awan SA, Babar A. Students perspective on online Medical education during lockdown as a result of COVID- 19 Pandemic. *Journal of University Medical & Dental College*. 2021 May 28;12(2):111-8. doi: 10.33314/jnhrc.v18i3.2851.
27. Chamberland M, Mamede S, Bergeron L, Varpio L. A layered analysis of self-explanation and structured reflection to support clinical reasoning in medical students. *Perspectives on medical education*. 2021 Jun;10(3):171-9. doi: 10.1007/s40037-020-00603-2
28. Chibnall JT, Blaskiewicz RJ, Detrick P. Are medical students agreeable? An exploration of personality in relation to clinical skills training. *Medical teacher*. 2009 Jan 1;31(7):e311-5. doi: 10.1080/01421590802638006.
29. Baig M. Assessment: a strategic tool for teaching and learning in medicine. *Journal of University Medical & Dental College*. 2020;11(1):v-i. DOI:<https://doi.org/10.37723/jumdc.v11i1.413>.