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Bridging the Digital Divide: Digital Health Literacy Among Undergraduate Medical Students

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Date Received:
03rd June, 2026
Date Revised:
06th July, 2026
Date Accepted:
23rd July, 2026

Abstract

Objective: The study aimed to assess digital health literacy levels and their association with sociodemographic factors among medical students.

Methodology: A Comparative cross-sectional study was conducted on MBBS students at Aziz Fatimah Medical & Dental College, Faisalabad, for six months. Online questionnaires disseminated on social media platforms were used to recruit 280 undergraduate MBBS students using (non-probability) serial sampling. Seven digital health literacy dimensions were assessed by the validated Van der Vaart Digital Health Literacy Instrument. Data were analyzed using SPSS version 25.0, with the application of descriptive statistics, correlation analysis, ANOVA with post-hoc tests, and multiple linear regression. Statistical significance was set at $p<0.05$.

Results: The overall mean digital health literacy score was 42.61 ± 14.02, classified as moderate. Basic operational skills were the strongest (55.80 ± 17.94) while privacy protection was the weakest dimension (30.74 ± 21.14). Internet usage >4 hours/day (71.1% of students) and multiple device access were the factors determining higher digital health literacy scores. Self-rated digital skills were found to be the most vital predictor ($\beta = 0.318$, $p < 0.001$) followed by the number of internet hours ($\beta = 0.162$, $p = 0.004$).

Conclusion: Medical students possessed a moderate level of digital health literacy with considerable weaknesses in the areas of privacy protection and information evaluation.

Keywords: digital health, health literacy, students, medical, privacy, internet use

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This article may be cited as:
Din MU, Habiba U, Nawaz H, Ali J, Khan AR, Ali MF: Bridging the digital divide: digital health literacy among undergraduate medical students. J Postgrad Med Inst. 2026;40(3):175-83. http://doi.org/10.54079/jpmi.40.3.3959

Introduction

Digital health literacy (DHL) has become a necessary competency for the future generation of doctors in the digital health sector which is changing very quickly. It includes searching for online health information, evaluating it, and applying it, and the new doctors-to-be should know all these skills.[1] The medical students' and practitioners' professional positions are very delicate in the health information and misinformation world, and the students' success in using the internet effectively and to their benefit always depends on the technology literacy competency they have.[2] Google Scholar is just one of the many digital tools they use as medics-in-training for seeking credible evidence. Basically, medical students constitute a specific group of online users; they are heavy users of digital material but will soon become very minor, two sources, one for patients and one for nursing. Studies suggest that even though health care students are "digital natives," they lack the ability to assess online health information critically and also to protect their digital privacy, as a result, they are not getting the most out of the digital world.[3] Nearly half of university students in a recent international survey admitted to not having the required skills to effectively manage complex health informational sites.[4] This difference in the ability of students of various disciplines to assess the quality of information on the internet is alarming especially when it comes to students of the medical profession. Misunderstandings could lead to wrong clinical decisions and patient negatively affecting the patient's health outcomes. Moreover, the socio-demographics "digital divide" keeps on limiting the access to health services as lower-income groups and women who live in rural areas are among the groups with the least access to digital healthcare services that might persist into the health profession.[5]

The adoption of digital health literacy in medical education is still not uniform across the globe, however, its value is increasingly acknowledged. Even though medical students often rely on digital resources for learning, they still do not get much organized training in judging the trustworthiness of digital health info or knowing about data privacy laws.[6] This knowledge gap is more severe in developing countries where the digital infrastructure and teaching resources are not very good. In Pakistan, for instance, recent studies indicate that the digital health literacy of medical students is hampered by poor internet access, the availability of different digital resources, and the prevailing cultural biases against technology use.[7] The sociodemographic determinants of DHL among medical students deserve special attention. Recent studies have shown different patterns regarding age, gender, and academic level as predictors of digital health competencies in diverse settings.[8] Some research indicates that female students and those in clinical years possess higher DHL while other studies report no significant differences, thus implying that the context and institutional factors may influence these relations.[9] Furthermore, the need to assess the extent of the relationship between self-perceived digital skills and actual DHL performance has arisen since precise self-assessment is vital for self-directed learning and acquiring competencies in the area of digital health during one's career.[10]

In light of these factors, the current study is aimed at assessing the digital health literacy of medical students at Aziz Fatima Medical and Dental College in Faisalabad, Pakistan, and the association with important sociodemographic characteristics. By utilizing the reliable Van der Vaart Digital Health Literacy Instrument, we assessed the aptitudes of the students in the seven areas to find out their strengths and weaknesses in the digital health domain. The methodology of comparative cross-sectional study made it possible to investigate the differences between the academic years and gender, whereas regression analysis showed the predominant factors affecting DHL performance. The intention behind the findings is to build an evidence base for curriculum design, indicating the areas needing intervention to ensure the future doctors are well-equipped to expertly navigate, critique, and make good use of digital health resources. Medical institutions will be addressing these educational requirements when they will be investing in students who are not only able to consume digital health information but also to act as ethical dispensers for the patients in the digital healthcare ecosystems, which will finally lead to improved health outcomes and decreased disparities during the digital era.

Methodology

After the ethics clearance was acquired (Reference: IEC/367-25), a comparative cross-sectional study was carried out on the undergraduate MBBS students at Aziz Fatimah Medical & Dental College, Faisalabad, for a duration of six months. The total number of undergraduate MBBS students was around 700. The sample size was calculated by using the mean estimation formula ($n = S^2Z^2/d^2$) with a standard deviation of 5.02, confidence level of 95% and margin of error of 0.44, which resulted in an initial estimate of 500 participants.11 Consequently, by taking finite population correction into consideration and estimating a 10% non-response rate, the final sample size was specified as 280 students. Using non-probability serial sampling, students were recruited through online questionnaires disseminated via social media channels. Until the desired sample size was reached, all eligible students who gave their consent during the data collecting period were included. All students were given an information sheet online before they participated in the study, which described the purpose of the study, that it was voluntary, that their answers would be kept confidential and that they could withdraw at any time without any consequence. All participants were asked to select an "I agree to participate" option at the beginning of

J Postgrad Med Inst 2026;40(3):175-83.
http://doi.org/10.54079/jpmi.40.3.3959

the online questionnaire, and only those who chose to participate were taken to the question items. The questionnaire was not submitted if a participant did not choose to participate.

To evaluate digital health literacy, the validated Van der Vaart Digital Health Literacy Instrument (DHLI) was used.12 The DHLI was utilized according to the usual academic procedure for approved tools, with accurate reference to the original creators, and was not altered from its published version. This 21-item tool evaluates 7 areas: operational skills, navigation skills, information searching, evaluating reliability, determining relevancy, adding content skills, and protecting privacy. The five subscales used a four-point difficulty scale (1=Very difficult, 4=Very easy), while the navigation and privacy subscales applied a four-point frequency scale (1=Never, 4=Always). Domain scores were converted from their original scale to a 0-100 standardized scale by the formula: [(mean of the sums of the item scores minus 3)/ (12-3)] × 100. The performance categories were: Very Undesirable (0-20), Undesirable (21-40), Moderate (41-60), Desirable (61-80), and Very Desirable (81-100). All participants were assured that their data would be handled confidentially and were given the opportunity to ask questions about the study before proceeding. The online questionnaire was created with all items having mandatory response fields, thereby making sure that for submitted questionnaires there were no missing data at all. Analysis of the data was done using SPSS version 25.0, with $p<0.05$ being considered statistically significant. The normality of data was tested with Kolmogorov-Smirnov tests and skewness/kurtosis indices. Sociodemographic characteristics were summarized by descriptive statistics. Comparison of groups was performed with independent t-tests (for gender) and one-way ANOVA followed by Tukey's post-hoc tests (for categorical variables). Spearman's correlation was used to assess relationships between age and DHL scores, whereas Pearson's correlation was employed for inter-subscale associations. Multiple linear regression accompanied by backward elimination was employed to detect the significant predictors, where multicollinearity was tested through Variance Inflation Factor (VIF < 10). To assess the robustness of our regression model, we carried out sensitivity analyses by exclusion of outliers (which were determined as DHL scores more than ±3 standard deviations) and repeating the regression. Cronbach's alpha was used to check the reliability of each subscale and the whole instrument.

Results

The sociodemographic characteristics and digital health literacy scores of the 280 medical students are shown in Table 1. The average DHL score for the entire student population was 42.61 ± 14.02. About 71% of the participants declared that their internet usage was more than 4 hours per day, and this group of students managed to get significantly higher DHL scores in comparison with the moderate users (2-4 hours). Internet usage was proved to be significantly related to DHL scores ($p<0.001$), and the students who use the internet for more than 4 hours daily were the ones that had the highest scores (44.76 ± 14.06). There were no significant differences on the basis of gender, age, year of study, or financial status. Among the participants, those who owned only smartphones were the largest group (37.1%) but on the contrary had the lowest DHL scores, whereas the users of multiple devices (4.6%) scored the highest.

Table 1: Sociodemographic Characteristics and Digital Health Literacy Scores Among Medical Students (n=280).

The performance on seven dimensions of digital health literacy is displayed in Table 2. The total DHL score was in the average range (42.61 ± 14.02). The best skill area was the basic operational skills (55.80 ± 17.94), while the least one was the privacy protection (30.74 ± 21.14), which was considered as 'undesirable.' Privacy protection is a critical area for educational intervention since 67.1% of students fell into the 'very undesirable' or 'undesirable' score range. All the dimensions have shown good to excellent reliability (Cronbach's α = 0.664-0.852) with overall scale presenting excellent reliability ($\alpha = 0.922$). A huge majority (81.1%) of students' scores were in the undesirable to moderate level, and only 15% reaching desirable levels, which highlights a significant gap in digital health literacy that needs to be filled.

The correlation matrix of Spearman between age and digital health literacy dimensions is given in Table 3. There was a weak but significant positive relationship between age and privacy protection ($r = .16$, $p = .007$), which accounted for only 2.6% of the variance ($r^2 = .026$). There were no significant correlations found between age and total DHL score ($r = .06$, $p = .292$) or other DHL dimensions. All DHL sub-scales were strongly positively correlated, and the weakest association was between information evaluation and overall DHL ($r = .86$, $p < .001$).

Post-hoc comparisons for the factors significantly correlated with digital health literacy scores are provided in Table 4. The daily internet usage for more than 4 hours was associated with a significant increase in DHL scores compared to the 2-4 hours group (mean difference = 8.49, $p < .001$). Those who used various devices scored better than those who used only smartphones in terms of DHL (mean difference = 12.56, $p = .025$). Self-rated digital skills created a distinct ranking pattern with 'excellent' self-raters being the highest scorers and having significantly higher scores than 'good', 'average', and 'poor' (all $p < .01$).

In Table 5, multiple linear regression analysis predicting digital health literacy scores is presented. This model could account for 15.8% of the variance in DHL scores

(Adjusted R^2 = .158, F (7,272) = 8.47, p < .001). Self-rated digital skills became the most significant predictor (β = .318, p < .001), closely followed by the daily internet usage of x hours (β = .162, p = .004). Moreover, it was found that raising self-rated digital skills by one point corresponds to an increase of 4.31 points in DHL score, whereas increasing internet usage by an hour would boost the score by 2.09 points. The factors of gender, age, financial status, and internet access type did not significantly contribute to the multivariate model. The regression model was found to satisfy all criteria: residuals were from a normal distribution (Shapiro-Wilk p > .05), the assumption of homoscedasticity was confirmed by the residual plots, and multicollinearity was not a problem (all VIF < 4). The students' self-rated digital skills were a powerful predictor of actual DHL scores (β = .318, p < .001), indicating that the students had very good metacognitive awareness concerning their digital capabilities.

Discussion

The present research shows that medical students in our university have a modest digital health literacy (DHL) level (42.61 ± 14.02), but their DHL level varies greatly depending on how they use the internet, what devices they have access to, and the competence they perceive themselves to have. The finding of a moderate overall

Table 1. Sociodemographic Characteristics and Digital Health Literacy Scores Among Medical Students (N=280)

Variable	Categories	n (%)	DHL Score (Mean ± SD)	Test Value	p-value
Gender	Male	143 (51.1)	42.12 ± 14.30	t = -0.59	0.558
	Female	137 (48.9)	43.11 ± 13.74		
Age Category	18-21 years	112 (40.0)	40.91 ± 13.05	F = 1.38	0.253
	22-25 years	155 (55.4)	43.79 ± 14.35		
	26-29 years	13 (4.6)	43.13 ± 17.44		
Year of Study	1st Year	58 (20.7)	43.29 ± 14.27	F = 0.13	0.970
	2nd Year	59 (21.1)	42.01 ± 14.68		
	3rd Year	58 (20.7)	41.56 ± 14.50		
	4th Year	68 (24.3)	41.32 ± 12.07		
	Internship	37 (13.2)	46.49 ± 15.08		
Financial Status	Good	162 (57.9)	43.69 ± 15.14	F = 1.95	0.144
	Fair	114 (40.7)	41.43 ± 12.31		
	Poor	4 (1.4)	32.44 ± 3.81		
Internet Hours/Day	<2 hours	27 (9.6)	39.42 ± 15.35	F = 9.07	<0.001
	2-4 hours	54 (19.3)	36.26 ± 10.78		
	>4 hours	199 (71.1)	44.76 ± 14.06		
Internet Access Type	Smartphone only	104 (37.1)	39.09 ± 11.37	F = 3.34	0.006
	Smartphone + Laptop	71 (25.4)	44.43 ± 13.64		
	Smartphone + Tablet	22 (7.9)	47.02 ± 15.20		
	Smartphone + PC	58 (20.7)	43.51 ± 16.72		
	Laptop only	12 (4.3)	39.98 ± 10.06		
	Multiple devices	13 (4.6)	51.65 ± 16.91		

J Postgrad Med Inst 2026;40(3):175-83.
http://doi.org/10.54079/jpmi.40.3.3959

Self-Rated Digital Skills	Very Poor	8 (2.9)	31.99 ± 4.52	F = 12.74	<0.001
	Poor	21 (7.5)	36.22 ± 5.79		
	Fair	37 (13.2)	33.20 ± 10.23		
	Good	108 (38.6)	42.20 ± 11.07		
	Excellent	106 (37.9)	48.37 ± 16.49		

Note: DHL = Digital Health Literacy; SD = Standard Deviation. p<0.05 indicates statistically significant differences. ^†Interpret with caution due to small sample size (n<5).

Table 2. Digital Health Literacy Subscale Performance and Reliability Among Medical Students (N=280)

DHL Dimension	Description	Mean ± SD	Performance Level*	Distribution n (%)	Cronbach's α
1. Basic Operational Skills	Using computers, browsers, and digital devices	55.80 ± 17.94	Moderate	Very Undesirable: 9 (3.2%) Undesirable: 39 (13.9%) Moderate: 125 (44.6%) Desirable: 84 (30.0%) Very Desirable: 23 (8.2%)	0.767
2. Navigation Skills	Finding way on websites, returning to pages	41.76 ± 17.32	Moderate	Very Undesirable: 31 (11.1%) Undesirable: 83 (29.6%) Moderate: 128 (45.7%) Desirable: 38 (13.6%) Very Desirable: 0 (0%)	0.759
3. Information Searching	Finding precise health information online	42.35 ± 18.70	Moderate	Very Undesirable: 40 (14.3%) Undesirable: 62 (22.1%) Moderate: 136 (48.6%) Desirable: 42 (15.0%) Very Desirable: 0 (0%)	0.767
4. Information Evaluation	Judging trustworthy health websites	42.38 ± 18.72	Moderate	Very Undesirable: 44 (15.7%) Undesirable: 56 (20.0%) Moderate: 139 (49.6%) Desirable: 41 (14.6%) Very Desirable: 0 (0%)	0.790
5. Information Application	Applying found information to health decisions	42.92 ± 18.48	Moderate	Very Undesirable: 34 (12.1%) Undesirable: 68 (24.3%) Moderate: 133 (47.5%) Desirable: 45 (16.1%) Very Desirable: 0 (0%)	0.664
6. Digital Communication	Formulating health questions, writing messages	42.29 ± 19.09	Moderate	Very Undesirable: 38 (13.6%) Undesirable: 68 (24.3%) Moderate: 130 (46.4%) Desirable: 44 (15.7%) Very Desirable: 0 (0%)	0.814
7. Privacy Protection	Managing personal health information online	30.74 ± 21.14	Undesirable	Very Undesirable: 93 (33.2%) Undesirable: 95 (33.9%) Moderate: 62 (22.1%) Desirable: 30 (10.7%) Very Desirable: 0 (0%)	0.852
Overall Digital Health Literacy	Composite of all dimensions	42.61 ± 14.02	Moderate	Very Undesirable: 11 (3.9%) Undesirable: 114 (40.7%) Moderate: 113 (40.4%) Desirable: 42 (15.0%) Very Desirable: 0 (0%)	0.922†

*Performance levels based on scores: Very Undesirable (0-20), Undesirable (21-40), Moderate (41-60), Desirable (61-80), Very Desirable (81-100). †Overall Cronbach's α calculated from total reliability.

Table 3. Spearman Correlation Matrix of Age and Digital Health Literacy Dimensions Among Medical Students (N=280)

Variable	1	2	3	4	5	6	7	8	9
1. Age	1								
2. Basic Operational Skills	.02	1							
3. Navigation Skills	.05	.46**	1						
4. Information Searching	.04	.48**	.54**	1					
5. Information Evaluation	.01	.49**	.56**	.79**	1				
6. Information Application	.05	.48**	.51**	.77**	.74**	1			
7. Digital Communication	.08	.47**	.61**	.60**	.59**	.57**	1		
8. Privacy Protection	.16**	.15*	.34**	.35**	.38**	.33**	.45**	1	
9. Overall DHL Score	.06	.63**	.74**	.85**	.86**	.83**	.80**	.55**	1

Note: *p<0.05, **p<0.01. Values represent Spearman's rho correlation coefficients.

Table 4. Significant Post-Hoc Comparisons of Digital Health Literacy Predictors

Comparison	Mean Difference	95% CI	p-value	Interpretation
Internet Hours				
> 4h vs. 2-4h	8.49	(3.57, 13.42)	<.001	> 4h group significantly higher
Internet Access				
Multiple devices vs. Smartphone-only	12.56	(0.96, 24.15)	0.025	Multiple devices advantage
Self-Rated Skills				
Excellent vs. Very Poor	16.38	(3.32, 29.43)	0.006	Large skill gap
Excellent vs. Poor	12.15	(3.64, 20.65)	0.001	Consistent advantage
Excellent vs. Fair	15.17	(8.37, 21.97)	<.001	Strong differentiation
Excellent vs. Good	6.18	(1.31, 11.04)	0.005	Even within higher skills
Good vs. Fair	8.99	(2.21, 15.77)	0.003	Good > Fair

DHL level in the present study is consistent with similar assessments in a study conducted in Jordan (55.80) and Pakistan (54.3), illustrating a widespread global trend in which digital natives have operational competence but lack good Health information management.[13,14] However, the present score is considerably lower than that of Darabi et al. (47.19) in a mixed-student Iranian population, which may be attributed to the character of medical education, characterized by scrutiny of online sources and hence, lower confidence scores, where the information is of high-stakes kind and difficult to verify.[15] The identification of privacy protection as the weakest dimension (30.74) very much reflects the international literature. Aydinlar et al. found that Turkish health students felt helpless regarding data protection laws.[16] Similarly, a recent global survey conducted in five European nations found that over 70% of healthcare students expressed anxiety regarding data security measures, making privacy concerns the biggest obstacle to their successful use of digital health resources.[17] The consistent cross-cultural vulnerability indicates a fundamental gap in digital citizenship education within professional healthcare curricula, not just a technical skills deficiency. The finding that operational skills were the strongest dimension (55.80) among the present study's students, mirroring results from Zahedan indicates that basic digital navigation is a generational strength, though it is not enough for making reliable health decisions.[18]

The strong positive correlation between internet use (more than 4 hours per day) and higher DHL stands in contrast with some studies that alert about the dan-

J Postgrad Med Inst 2026;40(3):175-83.
http://doi.org/10.54079/jpmi.40.3.3959

Table 5. Multiple Linear Regression Analysis Predicting Digital Health Literacy Scores Among Medical Students (N=280)

Predictor	B (Unstandardized)	SE	β (Standardized)	t	p-value	95% CI for B	VIF
Constant	15.84	15.12	-	1.05	.296	(-13.93, 45.60)	-
Gender	1.41	1.58	.051	0.90	.370	(-1.69, 4.52)	1.05
Age Category	1.91	2.64	.078	0.72	.470	(-3.29, 7.12)	3.80
Age (years)	-0.14	0.80	-.019	-0.17	.862	(-1.71, 1.43)	3.81
Financial Status	-1.12	1.37	-.046	-0.82	.412	(-3.81, 1.57)	1.05
Internet Hours/day	2.09	0.73	.162	2.87	.004	(0.66, 3.51)	1.06
Internet Access Type	0.82	0.54	.087	1.51	.131	(-0.25, 1.89)	1.10
Self-Rated Digital Skills	4.31	0.77	.318	5.64	<.001	(2.80, 5.81)	1.06

Model Summary: $R = .423$, $R^2 = .179$, Adjusted $R^2 = .158$, $F(7,272) = 8.47$, $p < .001$

Note: B = unstandardized coefficient; SE = standard error; β = standardized coefficient; CI = confidence interval; VIF = variance inflation factor. Significant predictors ($p<0.05$) in bold.

gers of digital overload but it is in favor of the "digital practice" hypothesis—more engagement equals more competence.[19] This also fits well with the study among Chinese internet users, where often usage was connected to higher eHealth literacy.[20] On the other hand, there was no difference in DHL among different academic years which is actually a conflict with Mousazadeh et al.'s observation of moderate e-health literacy in Iranian postgraduates.[21] This might imply that DHL is not naturally developed through regular medical teaching and that it is a skill that has to be taught specifically.

One of the most important findings of the present research is that self-rated digital skills were a strong predictor of actual DHL (β = .318), which adds nuance to the literature. In contrast to Šumak et al. who highlighted the importance of self-efficacy in the acceptance of technology, the present data specifically connect self-evaluation to measurable performance in a health context.[22] Such metacognitive awareness is indeed good news for educational interventions, as the students who accurately detect their weaknesses might be more inclined to attend the training. This supports the usefulness of student self-assessment as a screening tool and is consistent with recent research by Chang et al., which showed that self-perceived digital competence acts as a trustworthy stand-in for real eHealth literacy performance in medical education settings.[23] The fact that multiple-device users have an advantage over smartphone-only users confirms the "access diversity" model, similar to the result that device versatility enlarges information-seeking breadth.[24]

It is quite surprising that in multivariate model, demographic factors like gender, age, and financial status had no significant association with DHL, which contradicts previous studies that indicated female or higher socioeconomic status advantages.[15,25] This may be indicative of the uniformity created by the medical school admission criteria and the sharing of academic resources which, in turn, reduces digital divides that are often characteristic. The weak age-DHL link (only for privacy) is another point of divergence from research reporting stronger negative associations in general populations, possibly owing to the limited age range (18-29) which diminishes generational variance.

While discussing the results, it is necessary to address some limitations. First, the cross-sectional design does not allow causal inferences to be made about the relationships that were observed between the sociodemographic factors and the digital health literacy. Second, data were gathered from a single medical institution, and may not be generalizable to other medical institutions in other institutional or regional contexts. Third, it is important to consider the social desirability and self-report bias that could occur when self-administered questionnaires are sent via social media as students may have over- or under- estimated their digital skills and behaviours. Fourth, the non-probability serial sampling technique employed to recruit students online may have led to selection bias due to the less frequent participation of students who did not have internet access or have poor social media skills. Lastly, certain subgroups consisted of small numbers (e.g., n=4 for "poor" financial status), with some compari-

sons having reduced statistical power and thus should be interpreted with some caution.

Conclusion

The present research shows that medical students apply digital health literacy at a moderate level, with a noticeable lack of knowledge about privacy protection and information evaluation. They still possess good operational skills though. Internet usage time and self-assessed digital skills were found to be the most important factors predicting DHL performance. The results highlight a pressing need for the inclusion of specifically tailored digital health literacy training into the medical education curricula. Interventions of this nature need to focus mainly on the issues of online health information critical evaluation and data privacy.

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Authors' Contribution Statement

MUD contributed to the conception, design, acquisition, analysis, interpretation of data, critical review of the manuscript, and final approval of the version to be published. UH contributed to the acquisition, analysis, interpretation of data, and drafting of the manuscript. HN contributed to the acquisition, analysis, interpretation of data, and drafting of the manuscript. JA, ARK and MFA contributed to the acquisition, analysis, interpretation of data, and drafting of the manuscript.

Conflict of Interest

Authors declared no conflict of interest

Grant Support and Financial Disclosure

None

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.