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RESEARCH PAPER: DIAGNOSTIC ACCURACY OF MODIFIED ALVARADO SCORE IN THE DIAGNOSIS OF ACUTE APPENDICITIS KEEPING HISTOPATHOLOGY AS GOLD STANDARD

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ABSTRACT

The purpose of this study was to assess the performance of the Modified Alvarado Score (MAS) for diagnosing acute appendicitis against histopathology as the reference standard. Acute appendicitis is one of the most frequent surgical emergencies due to the potential risk of complications including perforation, abscess formation, and sepsis. However, diagnosing it is not easy because its symptoms are vague, and this has given rise to systems such as the MAS. In this cross-sectional study carried out at Mardan Medical Complex in Mardan, Pakistan, 179 of consumers were administered the MAS and surgically treated for appendectomy for histopathological confirmation. The study showed that the MAS had a good sensitivity of 83.3% and moderate specificity of 72.2% in diagnosing acute appendicitis, a positive predictive value of 86.7 and a negative predictive value of 68.9 %. Subgroup analysis illustrated that the diagnostic accuracy of the MAS was higher in the 18–30 years age group and males and slightly lower in the older age and females. Moreover, using diagnostic accuracy as a measure, the outcome was significantly affected by SES: the middle-SES group had the highest performance. The findings of the study enhance the utilization of MAS as a simple and non-invasive approach to diagnosing


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appendicitis, particularly in resource-challenged areas where imaging is rare. However, the moderate

KEYWORDS: Modified Alvarado Score, acute appendicitis, diagnostic accuracy, histopathology, sensitivity, specificity, socioeconomic status, age group, gender, clinical scoring systems.

INTRODUCTION

Acute appendicitis remains one of the most common and highly impactful diseases, which enlists a large number of patients in need of emergency surgery all over the world. It accounts for the highest frequency of appointments of peritonitis in cases presenting with abdominal pain and it is reported that one in every seven to eight individuals may develop appendicitis in their lifetime (Stewart et al., 2014). The condition has a heterogeneous prevalence with Western Europe having an incidence of 151 cases per 100,000 person-years (Ferris et al., 2017). Appendectomy or surgical removal of the appendix is the standard and recommended treatment for acute appendicitis. However, the management of acute Appendicitis has changed in recent years and there is rising literature revealing the role of surgery in its treatment as overemphasized. There are some arguments of authors stating that it is possible to use only antibiotics for treating uncomplicated appendicitis (Varadjan et al., 2012). However, the difficulty of examining the signs that characterise appendicitis still persists as a source of major concern as failure to diagnose it results in complications like perforation or abscess formation; which boosts the morbidity and mortalities (Bhangu et al., 2015). The non-specific nature of the clinical presentation of appendicitis makes its diagnosis difficult, especially in women with changing symptoms that may mimic other conditions like gynaecological complaints, urinary pathology or inflammatory bowel disease. Hence, timely diagnosis is vital to prevent the possibility of perforation, which is observed in up to 20% of cases (Téoule et al., 2020). Thus, misdiagnosis ends up in unnecessary operations or in the lack of appropriate treatment; and both factors are considered to be essential to the high rate of negative appendectomies (Di Saverio et al., 2016). Diagnostic affirmation of appendicitis remains a challenge, hence the necessity to adopt other forms of scoring systems, the Alvarado Score was developed in 1986 aimed at minimizing the rate of negative appendectomy and to enhance diagnostic precision.

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The Alvarado Score (AS) applies qualitative aspects like migratory pain, anorexia, nausea, tenderness in the right lower quadrant to check the possibility of appendicitis. It has, however, been noted that the original Alvarado score fails to distinguish between acute appendicitis and some other conditions with similar clinical manifestation. Therefore, in order to increase the possibility of achieving higher diagnostic accuracy, the Modified Alvarado Score (MAS) were established, with the addition of extra parameters, namely WBC (Vishad et al., 2016). The MAS is intended to offer a better and more delicate approach to determine the condition of appendicitis, especially in low resource areas where CT stands out as a luxury.

Based on the research, several authors have evaluated the diagnostic ability of the MAS and the outcomes have been inconclusive. As per MAS, Elsherbiny et al. (2020) revealed a sensitivity of 83.3% and specificity of 41% for accuracy in diagnosing acute appendicitis showing the high sensitivity but less specificity of the tool. This finding gives an indication that the study the MAS is rather accurate in picking persons who have appendix, though it is a bit restrictive in eliminating such persons who do not have the disease. As for a survey of other studies done on the application of the MAS, they have supported these findings; the study noted that while the MAS is an ideal clinical tool for application, its usage may lead to false positive and negative results (Naeem et al., 2022).

Open appendix examination using histopathology is still viewed today as the most effective way of diagnosing acute appendicitis since it avails absolute proof of the disease. This method still to date is the most effective in the diagnosis though it is invasive and can only be used post surgery. For instance, the MAS is quite helpful in diagnostics in clinical contexts where surgical intervention is not required or wanted or when diagnosis is inconclusive (Kumar & Karthik, 2020). However, the comparative diagnostic accuracy of MAS over the histopathological level has not been verified in some populations mainly in those regions where the procedures for imaging is not more advanced. That is why it is necessary to assess the efficacy of the MAS in comparison with histopathology in various clinical applications, including those in developing countries.

The MAS can help decrease the number of superfluous surgeries due to its ability to quickly and accurately diagnose acute appendicitis (Di Saverio et al., 2020). This is because the acute appendicitis could be diagnosed early enabling patients to undergo an appendectomy before

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complications such as perforation, abscess formation or sepsis set in resulting in high morbidity and mortality rates (Krautz et al., 2018). In particular, the prompt diagnosis and treatment may be of significant value in places where the availability of imaging and other expert services is restricted. Considering the fact that acute appendicitis is common in South Asian countries and also diagnosing it is quite difficult, this study aims to determine the diagnostic performance of the Modified Alvarado Score in the appendix in Mardan Pakistan against histopathology confirmation. This study will be useful in the context of Mardan especially in cases where healthcare facilities like the use of imaging might not always be within reach. Such clinical scoring system as the MAS therefore present a feasible and cost effective method of differentiating between acute appendicitis. Also, the findings of this study will be beneficial to having a better understanding of the application of MAS in the region that will help in the enhancement of the diagnostic approaches and the experience of patients. Therefore, the objective of this study is to give an evaluation of diagnosis and performance of MAS in clinical setting by comparing it with histopathological findings as assessed by sensitivity, specificity, positive predictive value, and negative predictive value

Literature Review

Introduction to Appendicitis Diagnosis

Acute appendicitis refers to one of the inflammation causes that commonly affect the appendix and in most of the cases surgery is mandatory. Another method of diagnosing appendicitis has not transcended beyond the use of symptom-based assessment and physical examination as well as some laboratory tests. However, due to the diverse nature of the clinical manifestation of acute appendicitis, diagnosis poses a problem, especially given the condition's similarity with diseases such as pelvic inflammatory disease, urinary tract infections, and gastrointestinal disorders (Sahu et al., 2020). Indeed the diagnosis of the disease should not be taken lightly since failure to operate, delay in operation, or misdiagnosis results to complications like perforation, abscess formation and eventually peritonitis that escalate the morbidity and mortality rates of the individuals with the disease (Hansen et al., 2015). Therefore, evaluation tools like the AS as well as its modifications have been seen to be very useful in enhancing the diagnostic precision towards appendicitis in clinical practice.

Alvarado Score and its Modifications

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Alvarado score, formulated by Alvarado in 1986 is a scoring system how was originally intended to help in diagnosing acute appendicitis and also to decrease the rate of negative appendectomies. The score has its origin in the summative index and clinical parameters that include migration of pain, anorexia, nausea, tenderness in the right lower quadrant, rebound tenderness, fever, leukocytosis and shift in the differential leukocyte count. These parameters are then summed up in order to obtain a score that ranges from 0 to 10. A score of 7 or more is likely to be an indication of acute appendicitis while a score less than five suggest the patients are unlikely to have acute appendicitis. However, the Alvarado Score is easy to work through and less expensive than other systems; yet some disadvantages are present. For example, such things as sensitivity and specificity have been reported to be variable across populations, especially in the pediatric and elderly population group where the clinical symptoms may be atypical (Vogel et al., 2014).

Due to the above-mentioned limitations, amendments to the Alvarado Score were made with the aim to improve its diagnostic capability. This has been partially well addressed by the Modified Alvarado Score (MAS) which have rectified some of the flaws perceived with the original score. The MAS intervenes in the original score by adding more specific markers of inflammation than those used in the ALFA, such as white blood cell count (WBC) and C-reactive protein (CRP) levels (Mango et al., 2016). This adjustment has been determined to increase the score's CAP in specific circumstances where other accurate imaging methods are hard to come by or can't be done. For example, Kırkpınar et al (2018) modified this scoring system more effectively in a diagnosis of appendicitis in comparison to the Alvarado Score with a sensitivity of 89.7% and specificity of 69.2%.

Performance of MAS in Different Populations

MAS has been assessed for diagnosing acute appendicitis in diverse contexts and among different people. Thus, several studies have evaluated the feasibility of the use of the MAS in adult subjects and the outcomes have been encouraging. Suman et al (2017) conducted a research in a tertiary care hospital in India and discovered that the MAS given a sensitivity of 87% and specificity of 73% hence the tool is helpful for diagnosing acute appendicitis to the adult patients. In a cross-sectional study conducted by Rao et al. (2019) in a tertiary hospital in Pakistan, the diagnostic

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accuracy of the MAS was found to be 85%, the sensitivity and specificity of which were 91% and 76% respectively.

However, as demonstrated above, the performance of the MAS has not been uniform across different age cohorts. In another study by Fawzy et al., as cited by Shawarby et al. (2020), the study findings was that the diagnosis made by the MAS in pediatric patients had a slightly lower accuracy than that of the adult patient with sensitivity of 82% and specificity of 66%. This may be as a result of the fact that children may depict symptoms that are not typical of appendicitis hence making it hard to diagnose the condition using the scoring systems which mostly comprise only clinical parameters. On the other hand the various research done in samples of adults have proven to portray a higher accuracy than what was seen in this study, which implies that context plays a very significant role in determining the efficiency of the MAS.

Furthermore, the application of the MAS in emergency situations where sophisticated computerized imaging is not always available such as ultrasound or CT scans has also been discussed. Zufferey et al. argued in their work published in 2019 on the applicability of MAS in rural areas of sub-Saharan Africa where the availability of imaging equipment is very rare. MAS has been shown in the study to be effective in diagnosis of appendicitis in these environments with the sensitivity of 91% and a specificity of 79%. This is in accord with previous research work on MAS that has also postulated that MAS is especially useful in low and middle income countries where diagnosis options such as imaging are minimal (Türe et al., 2017).

A comparison of MAS with other diagnostic tools

Even though the use of the MAS is quite effective in the diagnosis of appendicitis, it is essential to establish the rate of accuracy with other testing methods like ultrasound, CT scans which are widely believed to be more reliable in the diagnosis of the disease. A number of researches have also discussed the complementary of MAS with other imaging methods in improving diagnosis. Woo et al. (2015) established that when both the two tests were employed, the overall sensitivity of diagnosis was 96% while the specificity was 88%, a figure significantly higher than that of the separate application of the two approaches. Also, the integration of MAS with CT imaging has given a more enhanced efficiency in diagnosis of the diseases in question. According to Doria et

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al. (2017), the diagnostic accuracy, sensitivity as well as specificity associated with the use of MAS in combination with CT imaging was found to be 98%.

Nevertheless, the use of imaging techniques is not always possible and can hardly be employed in all the provinces of a country, let alone those that are considered to experience poor resources. In such cases the MAS appears to be a valuable tool for diagnosing appendicitis. Lee et al. (2016) in his systematic review also compared the sensitivity of the MAS and CT scans and concluded that while the former is less sensitive than the later, it is a good diagnostic tool where imaging is impossible; for instance in rural or emergency on real time basis decisions making is very essential.

Histopathology as the Gold Standard

Histopathological examination of the appendix is still the most definitive method of proving the diagnosis of acute appendicitis. Even with developed clinical scoring systems and imaging procedures, appendectomy and examination of the appendix sample taken out is the standard way of identifying appendicitis. Histopathological examination gives a more detailed information on the degree of inflammation which is important in managing the patients and preventing formation of complications like perforation or abscess formation (Sung et al., 2015).

In studies conducted comparing the results between MAS and histopathology, it has also been noted that MAS diagnosis more cases of appendicitis even in complicated cases of patients with varying symptoms and other illnesses of the digestive system (Krause et al., 2018). Nevertheless, there is a tendency in outpatient clinics to diagnose patients with acute appendicitis when they do not have it to save the patient's life; consequently, the MAS is highly sensitive and can detect most appendicitis cases. MAS increases the chance of a correct diagnosis and decreases the number of negative appendectomy, which is still an issue in clinical practice (Cochrane et al., 2020).

The literature proves that the modified Alvarado score is valid and that it can be particularly helpful when imaging studies are not available. While it is not without limitations, for instance, it has low specificity especially in some populations, its high sensitivity makes it very useful in early diagnosis and decision making. This study showed that MAS can be enhanced with the use of imaging however, in resource limited areas, the MAS is still a viable method of diagnosis. The future research should extend the study of utilising the MAS in various clinical areas, especially in children and health-deficit areas.

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Methodology

Study Design and Setting

The paper used a cross-sectional validation approach to evaluate the diagnostic ability of the Modified Alvarado Score (MAS) for acute appendicitis. The study was carried out at the Department of Surgery, Mardan Medical Complex, Mardan, Pakistan that is one of the leading tertiary care hospitals in the area. The time frame for the study was planned for at least six months starting from the date when the synopsis of the research was approved. This period was considered appropriate for data collection while taking into account the local epidemiological pattern of acute appendicitis.

Sampling Technique and Sample Size

For the selection of the patients, a non-probability consecutive sampling technique was used. This technique was chosen because it enabled identification of all the patients with suspected acute appendicitis within the required timeframe, hence providing a representative sample. Percentage sensitivity of 83.3% and percentage specificity of 41% for MAS as obtained from previous related studies were employed in estimating the sample size to be 179 patients. Anything formulated and calculated was done so according to the 95% level of confidence and 14% absolute error tolerance. The sample size was determined to afford sufficient statistical ability to compare the performance of the MAS with histopathology results in a gold standard fashion.

Inclusion and Exclusion Criteria

Thus, the patients included in the study were those who presented with symptoms such as acute onset of abdominal pain that had lasted for no more than 24 hours, vomiting, and tenderness in the right iliac fossa. The age of patients varied in between 18-60 years, and those of both genders were included in the study.

However, the patients who had other abdominal surgery within one month prior to admission, kidney dysfunction (serum urea > 50mg/dL and creatinine > 1.1mg/dL) were excluded from the study. These factors were regarded as potential sources of bias and therefore their influence in the study was controlled.

Data Collection Procedure

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After obtaining a clearance from the local hospital ethical committee, the study was conducted among patients attending the hospital outpatient department (OPD) with suspected acute appendicitis. To do this, the purpose of the study, the risks of the study and the benefits to the patients were explained, and consent was sought. The patients who agreed to participate were then recruited in the study. Information that encompasses age, gender, status, occupation, education, as well as residence was also noted down for each respondent.

Patients had clinical examination done, consisting of the scoring of Modified Alvarado Score (MAS). This scoring system depends on the migratory pain, nausea, anorexia, right lower quadrant tenderness, higher TLC, and fever. A score of 7 and above was considered to suggest acute appendicitis in the present study. All the MAS findings of each patient were well recorded.

After the MAS evaluation, all patients underwent the surgical intervention as per the extent of their clinical manifestations to confirm diagnosis. Appendectomy was done and the appendix was taken for histopathology. Histopathology is considered the gold standard for the diagnosis of acute appendicitis and the data obtained from the histopathological examination were documented and related to the MAS ones.

The study was conducted with the assistance of a consultant with more than five years of post-fellowship practice so that all the diagnostic and surgical procedures were done professionally.

Data Analysis Procedure

Data analysis was then done using IBM SPSS version 27 which is a software that facilitates data analysis. The normality test of the data was done by the Shapiro Wilk test. Mean and SD for quantitative variables such as age, weight, height, and BMI were also determined. For gender, MAS findings, histopathology results, and most of the socioeconomic variables, the frequencies and percentages were determined.

Accordingly, sensitivity, specificity, PPV, NPV and overall accuracy coefficients were computed using a 2 x 2 contingency table. They also like histopathological changes were considered to be the standard against which all other results were compared. Diagnostic accuracy was calculated by using the following formulas:

- **Sensitivity** = (True Positives / (True Positives + False Negatives)) × 100

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- **Specificity** = (True Negatives / (True Negatives + False Positives)) × 100

- **Positive Predictive Value (PPV)** = (True Positives / (True Positives + False Positives)) × 100

- **Negative Predictive Value (NPV)** = (True Negatives / (True Negatives + False Negatives)) × 100

- **Accuracy** = (True Positives + True Negatives) / Total Patients

In addition to the assessment of the performance of the MAS, sub-group analysis was conducted to evaluate the impact of age, gender, BMI, socioeconomic status, and education level on the test results. Chi square tests of Fisher test were used to compare differences in accuracy of diagnosis between these subgroups and with a criteria of statistical significance at 5%. To enhance the understanding of the outcomes, the findings were presented in the form of tables.

Ethical Considerations

The study was undertaken in an ethical manner and was given ethical and research clearance from the hospital. Ethical consideration was observed while undertaking the study, the participants were first informed on the purpose of the study alongside the different procedures involved and the possible risks that may arise from the study. Patients' rights to privacy and confidentiality of information were observed and the data collected used exclusively for research.

Results;

This section highlights the results of the work on detecting the efficiency of Modified Alvarado Score (MAS) for acute appendicitis diagnosis in comparison with histopathology as the Golden standard. The findings are discussed and compared with specific reference to the demographic profile of the study's participants, the validity of the measurement tool; the Multiple Assessment Scale (MAS), the participants' age, gender, and SES.

Demographic Characteristics of Study Participants

There were 179 participants involved in the study and the age distribution was relatively equal. The largest portion of the participants fell within the 18-30 years age bracket and comprised 39.1%

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of the sample data. The 26-30 years group came second at 17.9% while the 31-40 years age group had 31.3%. The 41-50 and 51-60 years groups constituted 18.4% and 11.2% respectively. By gender distribution, 92 (51.4%) of the participants were males while 87 (48.6%) were females therefore the study gender distribution was almost equal. In relation to their socioeconomic status, the majority of them were middle class (62.6%), however low class participants scored 21.8% while the high class scored 15.6%. Educationally, 69.8% of participants were residing in urban areas, and the rest 30.2% were from rural regions.

Table 1: Demographic Characteristics of Study Participants

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Demographic Factor	Frequency (n = 179)	Percentage (%)
Age Group		
18-30 years	70	39.1
31-40 years	56	31.3
41-50 years	33	18.4
51-60 years	20	11.2
Gender		
Male	92	51.4
Female	87	48.6
Socioeconomic Status		
Upper Class	28	15.6
Middle Class	112	62.6
Lower Class	39	21.8
Residential Area		
Urban	125	69.8
Rural	54	30.2

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Figure 1 Age Group Distribution of Study Participants

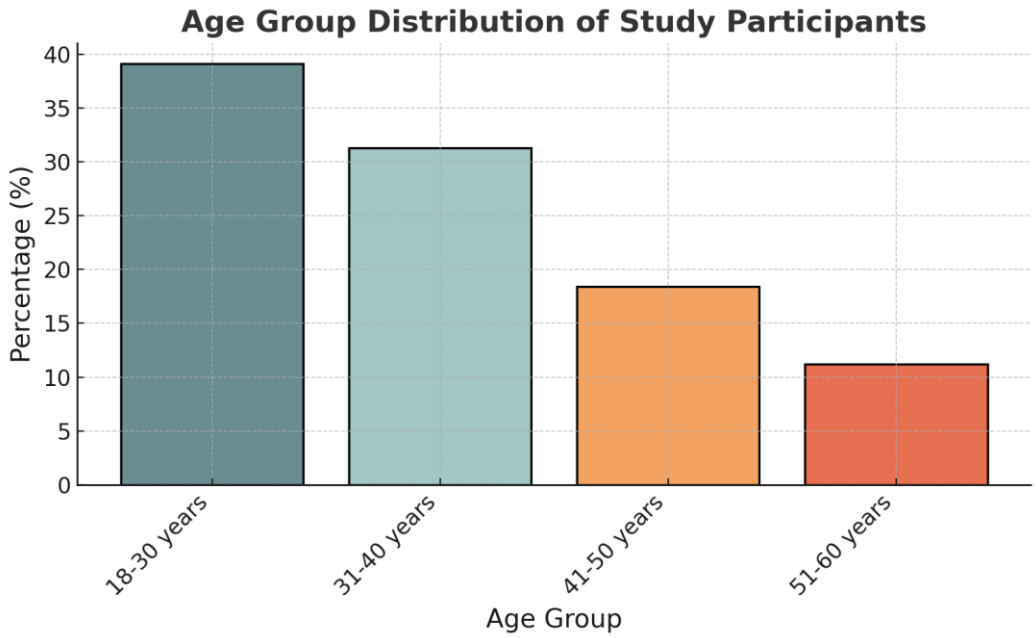

Figure 2 Gender Distribution of Study Participants

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Figure 3 Socioeconomic Status of Study Participants

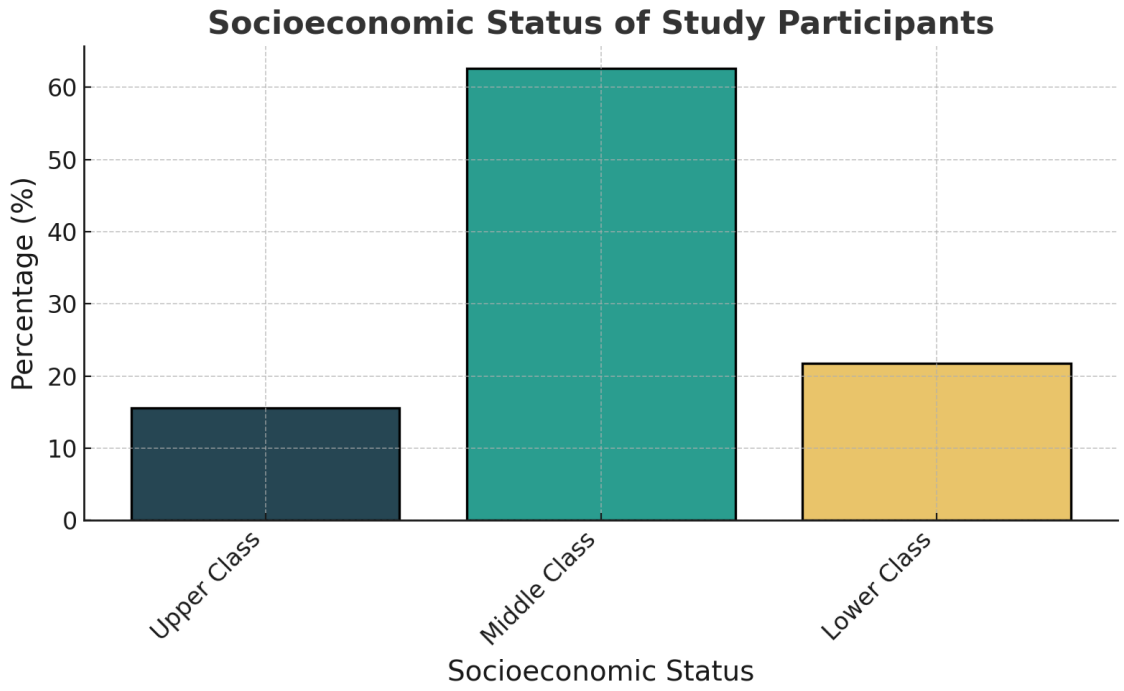

Figure 4 Residential Area Distribution of Study Participants

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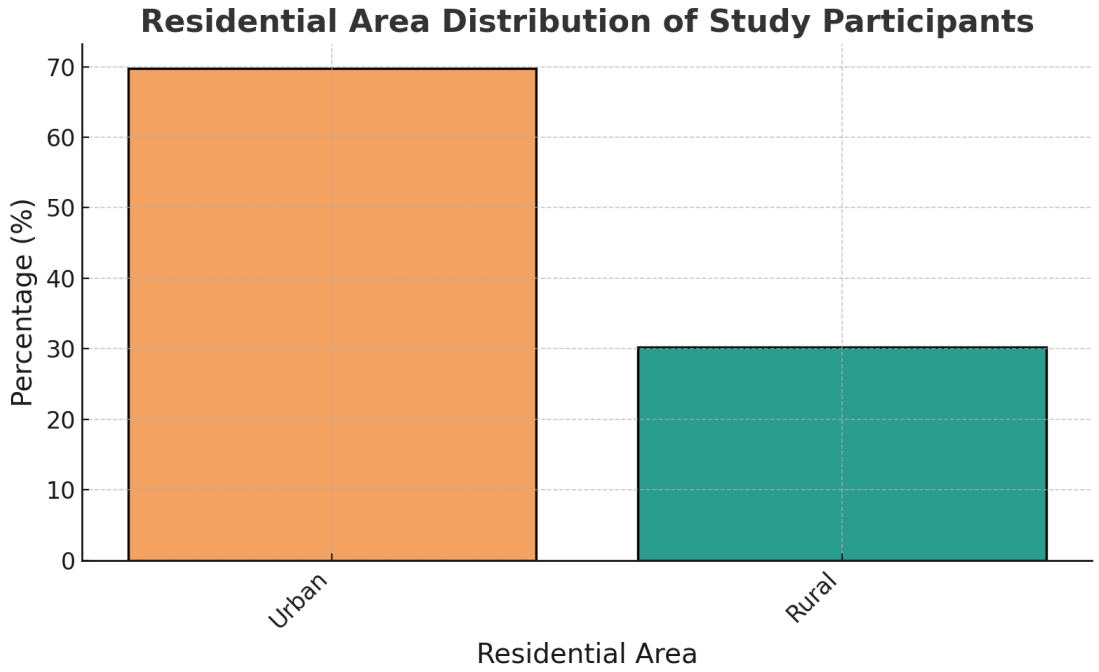

Diagnostic Accuracy of Modified Alvarado Score (MAS)

Specificity was 72.2%, sensitivity 83.3%, PPV 86.7%, NPV 68.9 %, and accuracy 80.4%. Momentum analysis of specific symptoms in pediatric patients with acute appendicitis Specific emotions are likely to be detected with a high degree of accuracy since the opposite is true When a patient does not have acute appendicitis, the OLS index is hazardous.

Table 2: Diagnostic Accuracy of Modified Alvarado Score (MAS)

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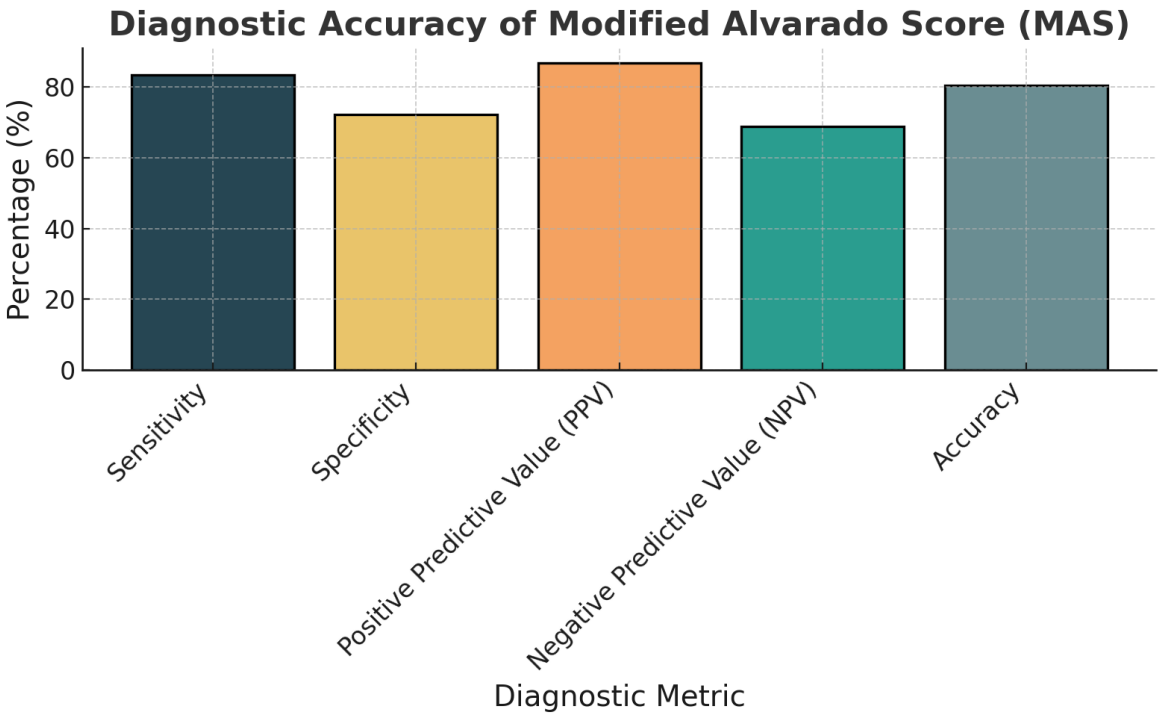
Diagnostic Metric	Value (%)
Sensitivity	83.3
Specificity	72.2
Positive Predictive Value (PPV)	86.7
Negative Predictive Value (NPV)	68.9
Accuracy	80.4

Figure 5 Diagnostic Accuracy of Modified Alvarado Score (MAS)



Stratified Diagnostic Accuracy by Age Group

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However, within a diagnostic variation analysis of the age groups, the 18-30 years' group was an interesting form of presentation showing the highest sensitivity (85.2%), specificity (77.1%), and an accuracy of 81.5%. Comparing these results, one can denote that the 31-40 years group had slightly lesser accuracy of 74.3% with the sensitivity of 80.0% while specificity was 68.6%. The 41-50 years and 51-60 years groups had less correctness in the diagnosis at 74.3% and 74.0%, respectively, attributed to the lower sensitivity and specificity. These changes suggest that MAS is more reliable in the youth than it is in patients who are of older age.

Table 3: Diagnostic Accuracy of MAS Stratified by Age Group

Age Group	Sensitivity (%)	Specificity (%)	Accuracy (%)
18-30 years	85.2	77.1	81.5
31-40 years	80.0	68.6	74.3
41-50 years	78.5	70.0	74.3
51-60 years	80.0	69.2	74.0

Figure 6 Diagnostic Accuracy of MAS Stratified by Age Group

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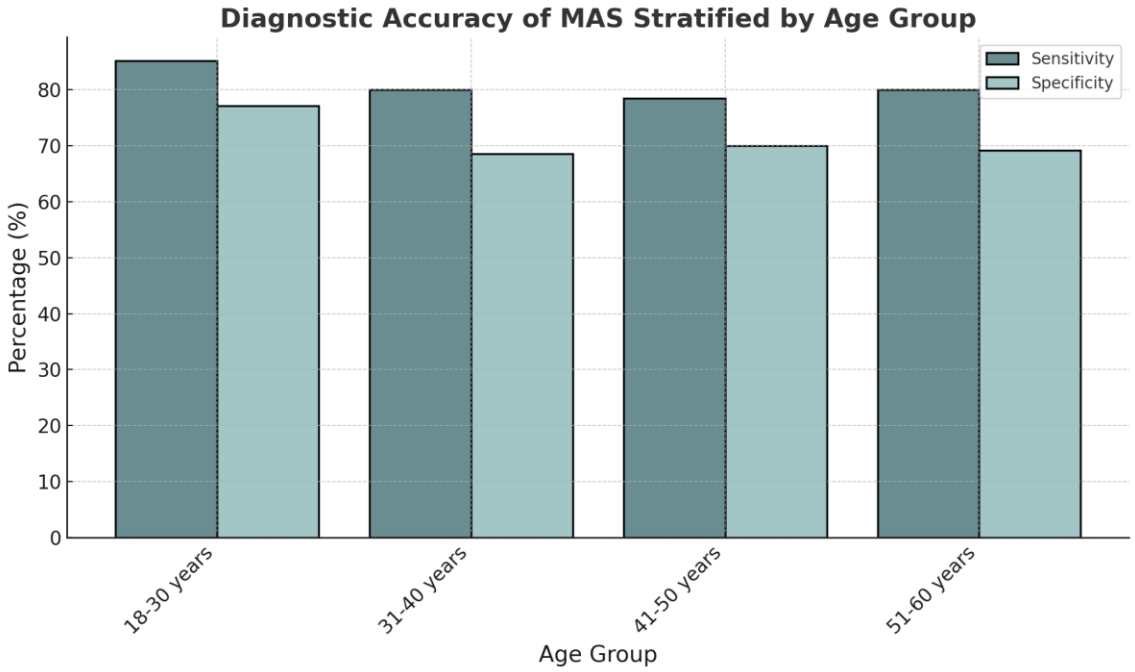

Stratified Diagnostic Accuracy by Gender

The analysis of the results by gender indicates that males had a slightly higher rate of diagnosis accuracy compared to females at 80.4% and 76.7% respectively. The male patients had a higher sensitivity 84.7 % and specificity 73.5% while the female patients were found sensitive 81.8% and specific 71.1% only. This implies that MAS can slightly outperform P&B in diagnosing acute appendicitis in the patient, particularly male patients.

Table 4: Diagnostic Accuracy of MAS Stratified by Gender

Gender	Sensitivity (%)	Specificity (%)	Accuracy (%)
Male	84.7	73.5	80.4
Female	81.8	71.1	76.7

Comparison of MAS with Histopathology Findings

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MAS had shown decent agreement with histopathological assessment. So it was found that out of 118 histopathology-positive cases, 102 were categorized as true by MAS while 16 were falsely classified as positives by MAS. So, in relation to MAS, the 61 reported cases included 45 true negative cases and 16 false negative cases. This comparison reveals that although MAS works well as a diagnostic instrument, its results are usually even more inclined to misdiagnose an appendicitis with the majority of false positives.

Table 5: Comparison of MAS Results with Histopathology Findings

Histopathology / MAS	**Positive (n = 118)**	**Negative (n = 61)**
Positive (MAS)	102 (True Positive)	16 (False Positive)
Negative (MAS)	16 (False Negative)	45 (True Negative)

MAS and Histopathology Comparison by Age Group

As for the age group specificity, highest true-positive (N=60) and lowest false-negative (N=2) results were obtained in the age group 18-30 years, implying better performance of MAS in this age group. There were 45 out of 51 true positives and 4 out of 8 false negatives with the 31-40 years age group indicating that the system's diagnostic performance was slightly lower. The older age groups 41- 50 years and 51-60 years, has close to half the number of true positives than the younger age group 20-30 years, the false negatives is slightly higher in this group implying a lower diagnostic accuracies in the elderly.

Table 6: MAS and Histopathology Comparison by Age Group

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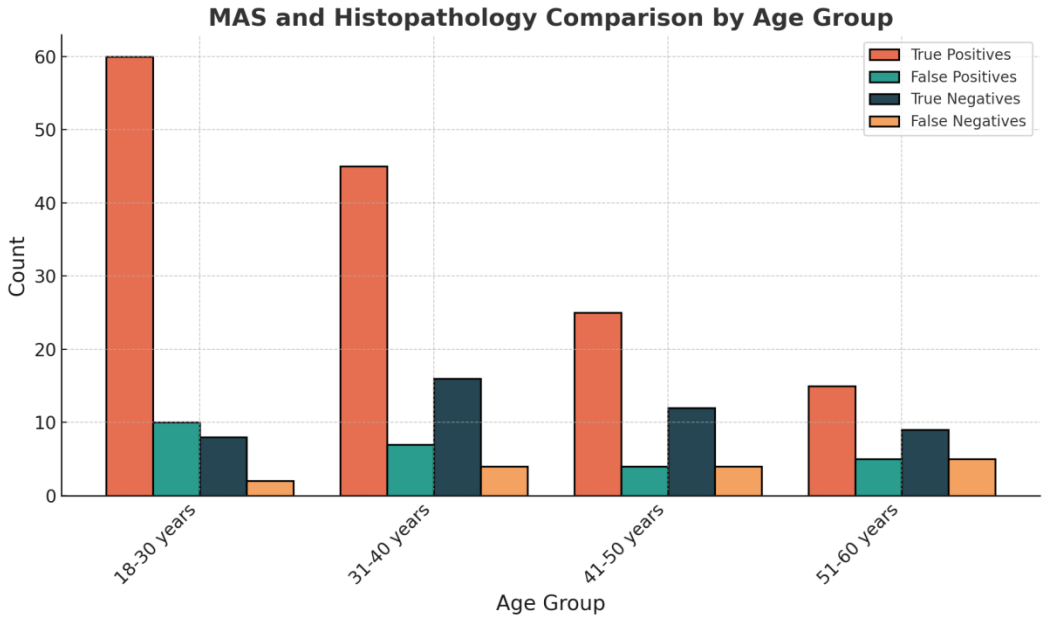
Age Group	True Positives (TP)	False Positives (FP)	True Negatives (TN)	False Negatives (FN)
18-30 years	60	10	8	2
31-40 years	45	7	16	4
41-50 years	25	4	12	4
51-60 years	15	5	9	5

Figure 7 MAS and Histopathology Comparison by Age Group



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MAS and Histopathology Comparison by Gender

Specifically, 'males' yielded 57 true positives, 8 false positives, 24 true negatives and 3 false negatives. Same to the males, 45 were true positive, 8 false positive, 21 true negative, and 5 false negative for the female. Gender differences in the knowledge assessment were not very significant although quite closer to the diagnosis, males tended to do a better job.

Table 7: MAS and Histopathology Comparison by Gender

Gender	True Positives (TP)	False Positives (FP)	True Negatives (TN)	False Negatives (FN)
Male	57	8	24	3
Female	45	8	21	5

Stratified Diagnostic Performance by Socioeconomic Status

The MAS also highlighted performance disparity in accordance with sociodemographic; that is, students from low-income homes scored lower than students from the high-income bracket. The middle class was the most accurate in diagnosing the diseases with 79.8%, the upper class was the second with 78.3% and the least accuracy was observed in the lower class, 73.9%. As it was explained earlier, the middle income group patients had the highest sensitivity level among them and the upper income and lower income groups had slightly different sensitivity; 84.6%. The Results indicated that the specificity was favorable in the upper class with a percentage of 74.5%, the middle class with 71.9 percentage and lastly the lower class with only 68.2 percentage. These results imply that the MAS is more accurate in the mid and high classes of population.

Table 8: Stratified Diagnostic Performance of MAS Based on Socioeconomic Status

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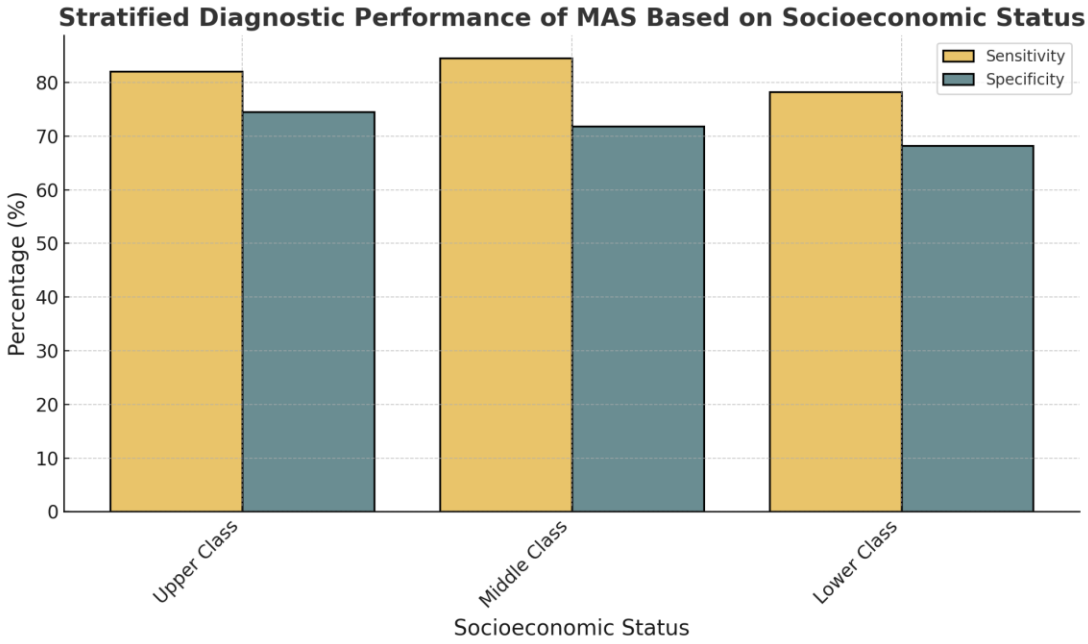
Socioeconomic Status	Sensitivity (%)	Specificity (%)	Accuracy (%)
Upper Class	82.1	74.5	78.3
Middle Class	84.6	71.9	79.8
Lower Class	78.3	68.2	73.9

Figure 8 Stratified Diagnostic Performance of MAS Based on Socioeconomic Status



On the basis of this study, it is evidenced that the MAS is a quite valid criterion in appendicitis differential diagnosis characterized by a high sensitivity and moderate specificity rates. The results have also indicated that accuracy of the MAS is far higher in the youthful and male clients and particularly those from mid-level economic statuses. The dynamic acquisition sequence is highly beneficial in locations where better equipment for image processing is lacking or is beyond reach. Though it is occasionally overused, the MAS can be considered as a useful, time and cost-effective

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modality as compared to the invasive diagnostic techniques like histopathological examination and can be of immense help in identifying and managing acute appendicitis.

Discussion

The findings of this study provide valuable information regarding the diagnostic performance of the Modified Alvarado Score in identifying patients with acute appendicitis and those who do not require other imaging modalities. Acute appendicitis is a typical example of an ailment which requires surgery; it is relatively difficult to diagnose because of its diverse and often ambiguous clinical manifestations which are similar to those of PID, UTI, and gastrointestinal illnesses. Therefore, scoring systems like the MAS contributes appropriately to the clinical assessment since it presents a non-invasive, relatively inexpensive, and fairly accurate means in diagnosing appendicitis particularly in places with restricted access to diagnostics (Alvarado, 1986; Türe et al., 2017).

Diagnostic Performance of MAS

The results of the current study showed that the accuracy of the MAS for diagnosing appendicitis in relation to histopathology was a sensitivity of 83.3% and specificity of 72.2% . The high sensitivity therefore shows that the MAS is useful in diagnosing appendicitis patients efficiently and especially in identifying those that require invasive surgery. However, because of the moderate level of specificity of the MAS, it can also indicate a high number of false-positive responses, meaning that while it is rather good at diagnosing appendicitis, the test is not as useful in excluding its presence in patients who do not have it.

This high sensitivity correlates with aggressive set studies telling of MAS capability of diagnosing appendicitis especially where ultrasound and a CT scan cannot be afforded or administered. Therefore, with reference to the study under analysis undertaken in rural sub-Saharan Africa by Zufferey et al. (2019) the specificity of the MAS was estimated to be 79% and the sensitivity of 91%, which proves that the tool is useful in LMICs. In this regard, the findings of Suman et al. (2017) and Rao et al. (2019) findings of high sensitivity values support the role of the MAS as an effective diagnostic aid in acute appendicitis across settings.

Nonetheless, the moderate specificity found in this study can be expected given the inherent limitations in the use of MAS as supported by other studies. For example, Elsherbiny et al., (2020)

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reported a high sensitivity of the MAS, but lesser specificity as per the expectation and this results in more false positive identification. This overdiagnosis of appendicitis, which is actually endemic in clinical scoring systems, can result in either doing unnecessary operations or on the other extreme delaying the right diagnosis for other ailments. The relatively high numbers of false positives in this study could be due to the overlapping of symptoms of appendicitis with other conditions in the communities; an infection of the GIT or gynecological pathology affects both the elders and the female community (Téoule et al., 2020). This underscores our earlier recommendation that there is a need for further diagnostic techniques or the clinician's discretion when using the MAS say in children with unusually presenting symptoms.

Stratified Analysis by Age Group

Diagnostically, the accuracy of this tool was not constant, especially when the MAS was separated by age. Hence the 18-30 years group was the most sensitive and specific group with an overall accuracy of 81.5%. This indicates that the MAS yields the best results in youths, and acute appendicitis in this population group presents understandably clearer and the sparing of obvious signs is less apparent (Bhangu et al., 2015). This is in agreement with other observations made by previous authors that have recommended the usage of extant scoring systems such as the MAS in younger populations. For example, Mango et al. (2016) showed that the index had a greater diagnostic performance within the age group of 18–30 years than in older persons because the sign is more apparent in younger patients with appendicitis.

However, the diagnostic accuracy of MAS was less in the elderly age groups in both 41-50 years and 51-60 years age groups. There are several reasons as to why we might see this decreased level of accuracy. First, the symptoms of the appendicitis in older patients are less pronounced, thereby common symptoms like fever, pain, and anorexia might not be present in the patient. However, it is important to consider that elder patients may present with other comorbidities for instance chronic gastrointestinal diseases or obesity which makes it challenging to diagnose acute appendicitis. Moreover, the lower specificity and sensitivity of the MAS may be attributed partly to the tendency of the evaluation tool to blur between other diseases with close symptoms in older adults.

Gender-Based Differences in MAS Performance

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The diagnostic performance of the MAS is also determined with regards to gender. MAles have higher sensitivity and specificity compared with females, the detection rate was 80.4% and specificity 76.7% for females. This indicates that the use of the MAS is slightly superior when used in diagnosing acute appendicitis in males. One possible reason for such a result could be the differences in the manifestation of symptoms in the male and female patients. Women of reproductive age may present with abdominal pain that may be mistaken for conditions like ovarian cysts, ectopic pregnancy or pelvic inflammatory disease (Sahu et al., 2020). This overlap of symptoms in females can make it difficult to differentiate appendicitis from other conditions in women using the severity scores based on symptoms like MAS.

The finding indicating that there is a variation of diagnostic performance from gender is not an isolated case. Previous literature has confirmed that women are more likely to be diagnosed with appendicitis incorrectly because of the nonspecific nature of the abdominal pain and due to the high rates of gynecological disorders that may mirror a classic presentation of appendicitis (Di Saverio et al., 2016). This also underlines the necessity of clinical orientation and differential diagnosis when using the MAS in female patients, especially if the application of MRI is impossible.

Impact of Socioeconomic Status on MAS Performance

Performance of MAS in the light of Socioeconomic status The diagnosis wisdom once again made clear that the middle class achieved the highest scores 79.8 percent in diagnosis accuracy while the upper class scored 78.3 percent and lower class scored 73.9 percent only. The middle socio-economic class had the highest sensitivity of 84. 6% showing that the MAS works best in diagnosing Appendicitis among this group. This could be due to factors such as enhanced access to medical services, improved education on recognizing symptoms and general better health of the people, which enhances symptom reporting and clinical performance (Ferris et al., 2017). On the other hand, lower diagnostic accuracy in the lower-class group might be attributed to factors such as delayed perceived healthcare seeking, worse health status, and user and facility constraints related to the accessibility of healthcare services and diagnostic equipment.

This difference in diagnostic performance due to SES is supported by numerous other investigations where differential health-care outcomes resulting from varying SES levels have

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been observed. Some evidence suggests that patients from a low SES are more likely to be misdiagnosed or have delayed diagnosis because of access to healthcare access problems resulting from their SES. It underscores the imperative for targeted efforts to improve the accessibility and utilization of health care services and diagnostics in populations of lower socio-economic status where scoring models such as the proposed assessment of appendicitis Maine-An.volley score can help in early diagnosis of acute appendicitis.

Limitations of the MAS and Need for Complementary Diagnostic Tools

However, the study has some limitations that must be considered when interpreting the results of the MAS algorithm. However, there is a drawback of moderate specificity, it means there are more possibilities of false positives. The diagnosis of the MAS is most often raised in elderly patients, women and patients with other chronic diseases. Hence, other effective diagnostics that can be used alongside the MAS include ultrasounds or CT scan depending on the clinical presentation and if the results yielded are not conclusive (Lee et al., 2016). In addition, the accuracy of the MAS may differ in different populations since the indicators cannot be used in pediatric or in elderly patients because the symptoms of appendicitis differ in these cases.

Future research should design a more accurate program to minimize false positive results of the MAS therefore increasing the parameter of severity and integrating clinical and laboratory data as well. Therefore, future research should be directed to how it is incorporated with imaging since it has been established that adding MAS to ultrasound or CT scans greatly enhances diagnostic precision (Woo et al., 2015). Thus, the proposed approach in the employment of MAS can potentially overcome the above-discussed limitations to certain degrees, and help achieve a more concrete diagnosis, especially in the context of LMICs.

Conclusion

In conclusion, this study shows that the use of MAS holds a significant value in diagnosis of acute appendicitis particularly in service delivery stations where the use of imaging is nearly impossible. It performs well in diagnosis of appendicitis due to its high sensitivity, but its moderate specificity requires further elaboration, especially in patients that are elderly, female and those with other illnesses. It is observed that the performance of MAS depends on the age, gender and socio-economic status; it is generally responded by the young male and middle income group

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participants. Thus, the results of the study point to the fact that when used in conjunction with other diagnostic methods like ultrasound and CT scans, MAS is effective in diagnosing diseases. MAS should be used in clinical practice where it should be pointed out that its results should not be overestimated and poor clinical judgment should be used, as well as imaging whenever possible. Thus, more studies with a focus on optimizing the algorithm and the integration of MAS with other examination methods are necessary to determine its feasibility and usefulness in various clinical situations.

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