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Complicated appendicitis and associated risk factors among children

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Abstract

Background Complicated appendicitis is one of significant pediatric surgical care challenges and its burden varied from 5 to 75%. However, there is limited study about prevalence of complicated appendicitis among children in Ethiopia. Therefore, this study aimed to assess the prevalence and associated factors of complicated appendicitis among children in Amhara region, Ethiopia.

Methodology A cross-sectional study design was employed. The data extraction tool was used to collect data from 423 sampled participants. Simple random sampling technique was used. The data was presented using table, and text forms. The data was also summarized by proportion and frequency depends on the data type. The logistic model was fitted. Any statistical test considered significant at *P*-value < 0.05.

Result A total of 406 study participants were included for analysis. The prevalence of complicated appendicitis was 32.02%, 95%CI(27.64%, 36.74%). Duration of symptom greater than 24 h, aOR = 1.64, 95% CI (1.01,2.66)), and white blood cell count greater than 12,000 cells/μl aOR = 2.08, 95% CI (1.15,3.77) were statistically significant predictors of complicated appendicitis in children.

Conclusion and recommendation The prevalence of complicated appendicitis was high as compared to the previous studies. Patient presentation after 24 h of symptom and white blood cell greater than 12000 cells/μl were significantly associated with complicated appendicitis. The surgical teams need to be aware that those children with greater white blood cell count and a chief compliant duration of greater than one day were present with complicated appendicitis.

Keywords Appendectomy, Children, Cross-sectional, Complicated appendicitis, Ethiopia

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Introduction

Despite advances in diagnostic methods, appendicitis is commonly delayed for diagnosis and management. The initial misdiagnosis rate for acute appendicitis ranges from 28 to 57% for older children and can reach 100% for those two years or younger [1, 2]. This results in delay in the discovery of an inflamed appendix [1, 3, 4]. The diagnostic or care seeking delay often leads to a higher incidence of complications, such as perforation with or without peritonitis, abscess formation, appendicular mass or gangrene formation necrosis [5]. Appendicitis with such complication called complicated appendicitis. Complicated appendicitis requires urgent surgical intervention and can lead to long-term complications if not managed effectively. It increased the likelihood of postoperative complications, prolonged length of hospital stay and service costs [6, 7].

In Ethiopian context, acute appendicitis accounts the major acute abdomen emergencies which reaches to (87.5%) [8]. Acute appendicitis might be presented as simple or complicated appendicitis. The burden of complicated appendicitis have varied study to study across the regions such as China (36.1%) [9], Malaysia (52%) [10], California (46%) [11] and Saudi Arabia (60.3%) [12]. Furthermore, among the complicated appendicitis; the rate of ruptured appendicitis is higher in children than in adults and varied from 5 to 75% depending on the study participants and can even reach 100% for those who are less than one year of age [2, 13]. Complicated appendicitis directly or indirectly related to the quality and accessibility of health care service. Regarding the health care challenges in health service delivery, not only Amhara region but also other regions of the country, Ethiopia faced several problems including geographical barriers (many rural areas lack healthcare facilities, making access difficult and others), transportation issues (poor infrastructure hinders movement to healthcare centers), a shortage of healthcare workers (there is a significant shortage of trained medical personnel, particularly in rural regions), issues with retaining health care workers (many health professionals migrate to urban areas or abroad for better opportunities), inadequate facilities (many health facilities are poorly equipped and lack essential supplies), quality of care (variability in the quality of services provided, especially in rural areas), out-of-pocket expenses (many people cannot afford healthcare services, causing delays in seeking treatment), and limited health insurance coverage (low penetration of health insurance exacerbates financial challenges) [14]. Educational status and age were also contribute for health seeking behavior for illness [15]. There is a possibility of appendicitis to be complicated as the children have not got early intervention [8].

Moreover, previous studies have suggested that age, sex, duration of symptom, vomiting, white blood cell (WBC) count, C-reactive protein, body temperature, and radiographic findings as possible predictors for complicated appendicitis [11, 16–18]. Socioeconomic status, and access to healthcare services are also believed to influence the incidence and severity of appendicitis [19]. In low-resource settings, barriers to timely medical care, including lack of awareness of appendicitis symptoms, inadequate health education, and limited access to surgical care center, may exacerbate the risk of complicated appendicitis [19, 20]. Elevated inflammatory markers such as erythrocyte sedimentation rate (ESR) from blood or even hyponatremia and hyperbilirubinemia have also been shown to assist in distinguishing between simple and perforated appendicitis [21].

The management of patients with complicated appendicitis differs greatly from that of acute appendicitis. It may determine the surgical approach even. It also leads to a longer hospital stay, likelihood of two or more surgical procedure and additional expenses [22, 23]. In addition,, lockdown during Covid-19 pandemic may also play its contribution for the occurrence of complicated appendicitis in developing countries like Ethiopia, where access to medical care is low [24].

Understanding the specific risk factors associated with complicated appendicitis in children in the country including Amhara region is crucial to design targeted prevention and management strategies. This research aimed to identify and analyze these risk factors, contributing to improved clinical practices and health outcomes for pediatrics patients. By addressing the knowledge gap in this area, the study seeks to inform healthcare providers and policymakers about the critical aspects of appendicitis diagnosis and management in children, ultimately enhances surgical outcomes and reducing complications in the region.

As far as our knowledge allowed, there is limited number of study on burden of complicated appendicitis in Ethiopia. Therefore this study aimed to assess the prevalence and associated factors of complicated appendicitis among children in Ethiopia.

General objective

To determine the prevalence of complicated appendicitis and associated factors among children underwent appendectomy in Amhara region, Ethiopia, 2024.

Specific objective

To estimate the prevalence of complicated appendicitis.

To determine the risk factors complicated appendicitis.

Methods

Study design and period

A cross-sectional study design was employed. A selected charts of the children with acute appendicitis who went appendectomy in a selected comprehensive and specialized hospitals in the region were reviewed. The actual data collection period was undertaken from January 5, 2024 to February 2, 2024.

Population

Source of population

All children aged 18 and below who underwent appendectomy from January, 2011 to December, 2024 in comprehensive and specialized hospitals of Amhara region were the source of population.

Study population

All children aged 18 and below who underwent appendectomy from January, 2011 to December, 2024 in the selected comprehensive and specialized hospitals of Amhara region were study population.

Eligibility criteria

All children and adolescents who underwent appendectomy from January, 2011 to December, 2024 were included in the study.

Variables

Dependent variables

Prevalence of complicated appendicitis.

Independent variables

The independent variables were included sex, age, fever, nausea/vomiting, abdominal pain, loss of appetite, hemoglobin, WBC, neutrophil, waiting, referral status, preoperative antibiotics, comorbidity, symptom duration, and residence.

Table 1 The prevalence of complicated appendicitis and its associated factors among children underwent appendectomy in comprehensive and specialized hospitals of Amhara region, Ethiopia, 2024

Assumption	Hyponatremia	Symptom duration
CI	95%	95%
Power	80%	80%
Ratio	1	1
OR	3.1	5.5
P1	63%	75%
P2	33%	36%
Sample size	116	58

Operational definitions

Complicated appendicitis: those children who had acute appendicitis with abscess formation, gangrenous appendix, appendicular mass or a perforated appendix with, or without peritonitis were considered as children with complicated appendicitis.

Sample size determination

The sample size was determined using epi info version 7.2 software. It is calculated by taking two-sided significant level of α 5%, power 80%, confidence level 95%, exposed to unexposed ratio 1:1 and respective proportion of complicated appendicitis among exposed groups and unexposed groups, denoted by p1 and p2, respectively. The variables, assumptions and respective required sample size calculation yield, are illustrated below, Table 1.

The sample size was also be determined by single population proportion formula with the estimated prevalence of complicated appendicitis in the previous study (50%) and precision 5% (0.05) using epi info version 7.2 software. The sample size using single population formula was $384 + \mathbf{38.4} \approx \mathbf{423}$. Therefore, the minimum required sample size became **423** study participants.

Sampling technique and sampling procedure

In Amhara region, there are 8 comprehensive specialized hospitals. Of these, two hospitals were selected randomly. Then, one list of the medical record numbers with hospital code (by authors) of children who underwent appendectomy during the study period was prepared. Finally, the required samples were selected using computer generated simple random sampling technique. Schematic diagram of sampling procedure was described below (Fig. 1).

Data collection tools and procedure

The data collection tool was prepared based on the literatures. Then, the data collected from patient charts. Charts were accessed based on their medical record number which were selected by simple random sampling by using computer-generated random numbers. One data clerk personnel for one day and two card room workers during the data collection period were recruited. The data were collected by 4 BSc nurses. The supervision was done by one health professional having BSc degree in nursing. Once the data is extracted from patient charts, the charts were coded to avoid duplication. During data collection, those charts which were incomplete for more than 40% of variables were replaced by other charts.

Data quality control

Pretest was employed on 42 charts. The necessary modification on questionnaire was made after pretest. Data quality was guaranteed by caring out a careful design

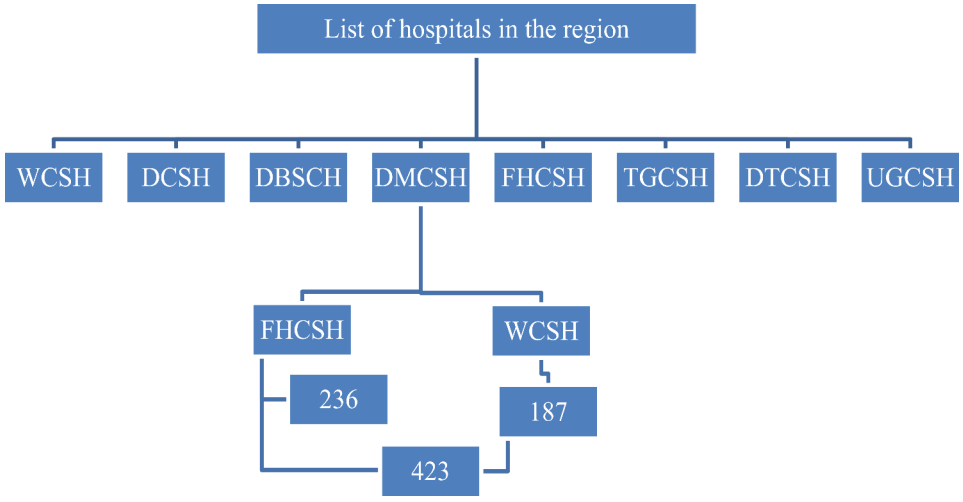

Fig. 1 Schematic presentation of sampling procedure to select study participants to determine prevalence and associated factors of complicated appendicitis among children in Ethiopia, 2024

of data extraction tool and appropriate adjustment. A proper recruitment, adequate training and close supervision of data collectors and supervisor were undergone. The data collectors and supervisors were trained before the actual data collection on the content of the tool, technique of data collection, and ethical considerations for two days. Principal investigator and supervisors were checked the data completeness and consistency on daily bases. Finally, double data entry was employed into the computer using Epi Data version 3.1 software.

Data processing and analysis

Data cleaned, coded and entered into Epi Data version 3.1 and exported to STATA version 14.0. The continuous variables distributions were checked for normality using the histogram normality graph. Since the data were not normally distributed, median and interquartile range was used as descriptive and summary statistics for continuous variables after checking the distribution of variables. Frequencies and proportions were used to describe the characteristics of categorical variables. The missing data detected via cross tabulation and was handled accordingly. The missing data was handled via multiple imputations for hemoglobin level, neutrophil level and preoperative antibiotics. Co linearity of variables was tested using Cramer's V correlation coefficient.

The logistic regression model was fitted after checking the required assumptions through Hosmer and lemeshow test. The bivariable analysis was done to identify associations between dependent and each independent variable. All variables were entered into the multivariable analysis. Adjusted odd ratio with 95% CI was used to assess the direction, strength of association and statistical significance. Any statistical test was considered significant at P-value < 0.05. Finally, the finding was presented in tables and text forms.

Result

The study included 406 patients who underwent appendectomy for analysis and the rest 17 patient records were discarded due to chart incompleteness. Of these, 96(23.64%) were age less than five years and 34.98% of them were female by sex (Table 2). The lowest and largest body temperature at their presentation was 35.1 ? and 39.8 ?, respectively. The lowest and largest duration of symptoms was 0.125 and 8 days, respectively. The median duration of symptom was 2 days.

Prevalence of complicated appendicitis

In this study, the prevalence of complicated appendicitis was 32.02%, 95%CI (27.64%, 36.74%). The prevalence of complicated appendicitis was higher in rural residents than urban residents (37% vs. 27.6%).

Determinants of complicated appendicitis

In both bivariable and multivariable logistic regression white blood cell count (WBC) and duration of symptom were significantly associated with complicated appendicitis. The odds of complicated appendicitis were 2 times more likely to occur in children who had WBC of greater than 12,000 cells/μl than their counter parts. Similarly, those children who visit the surgical centers after a day were 60% more likely to present with complicated appendicitis than those who present within days of symptom occurrence (Table 3).

Table 2 Characteristics of the study participants to determine complicated appendicitis among children underwent appendectomy in Amhara region comprehensive specialized hospitals, Ethiopia, 2024

		Outcome (*N* = 406)			
		Simple appendicitis		Complicated appendicitis	
		Frequency	%	Frequency	%
Fever	Yes	185	67.3%	90	32.7%
	No	91	69.5%	40	30.5%
Nausea/vomiting	Yes	229	70.0%	98	30.0%
	No	47	59.5%	32	40.5%
Abdominal pain	Yes	272	68.2%	127	31.8%
	No	4	57.1%	3	42.9%
Loss of appetite	Yes	167	71.7%	66	28.3%
	No	109	63.0%	64	37.0%
Age in years	< 5	64	66.7%	32	33.3%
	≥ 5	212	68.4%	98	31.6%
Anemia status	Anemic	10	55.6%	8	44.4%
	Not anemic	266	68.6%	122	31.4%
WBC cells/ μl	< 12,000	82	78.8%	22	21.2%
	≥ 12,000	194	64.2%	108	35.8%
Neutrophil in percent	< 76	68	74.7%	23	25.3%
	≥ 76	208	66.0%	107	34.0%
Waiting in hours	< 24	157	72.0%	61	28.0%
	≥ 24	119	63.3%	69	36.7%
Referral status	No	30	73.2%	11	26.8%
	Yes	246	67.4%	119	32.6%
Preoperative antibiotics	No	35	79.5%	9	20.5%
	Yes	241	66.6%	121	33.4%
Comorbidity	No	255	68.7%	116	31.3%
	Yes	21	60.0%	14	40.0%
Symptom duration in hours	< 24	103	73.6%	37	26.4%
	≥ 24	173	65.0%	93	35.0%
Sex	Male	180	68.2%	84	31.8%
	Female	96	67.6%	46	32.4%
Residence	Urban	155	72.4%	59	27.6%
	Rural	121	63.0%	71	37.0%

Table 3 Multivariable logistic regression analysis to determine risk factors of complicated appendicitis among children underwent appendectomy in Amhara region comprehensive specialized hospitals, Ethiopia, 2024

Variable	Categories	aOR
Residence	Urban	0.72(0.45,1.13)
	Rural	1
Sex	Male	0.897
	Female	1
Symptom duration in in hours	< 24	1
	≥ 24	1.64(1.01,2.66)**
Comorbidity	No	0.6(0.27,1.31)
	Yes	1
Taking preoperative antibiotics	No	1
	Yes	1.88(0.82,4.32)
Patient visit other health institution	No	1.31(0.58,2.93)
	Yes	1
Waiting after arrival to hospital in hours	< 24	0.73(0.46, 1.13)
	≥24	1
Neutrophil cells/μl	< 76	0.8(0.44, 1.45)
	≥ 76	1
WBC in cell/μl	< 12,000	1
	≥ 12,000	2.08(1.15,3.77)**
Anemia status	Anemic	1
	Not anemic	0.6(0.21, 1.71)
Age in years	< 5	1
	≥ 5	0.99(0.58, 1.71)
Fever	Yes	1.14(0.69,1.9)
	No	1
Nausea/vomiting	Yes	0.65(0.36,1.18)
	No	1
Abdominal pain	Yes	0.39(0.07,2.01)
	No	1
Loss of appetite	Yes	0.68(0.41, 1.13)
	No	1

Discussion

This study aimed to assess the prevalence of complicated appendicitis among children underwent appendectomy in Ethiopia. Complicated appendicitis was found to be 32.02% 95%CI (27.64%, 36.74%). The finding was consistent with other previous study reports by Öztaş T et al. (31.9%) [25], Koirala DP et al. (34.6%) [26] and Totapally A.(32%) [27]. The difference might be due to geographical barriers (many rural areas lack healthcare facilities, making access difficult and others), transportation issues (poor infrastructure hinders movement to healthcare centers), a shortage of healthcare workers (there is a significant shortage of trained medical personnel, particularly in rural regions), inadequate facilities (many health facilities are poorly equipped and lack essential supplies), quality of care (variability in the quality of services provided, especially in rural areas), out-of-pocket expenses (many people cannot afford healthcare services, causing delays in seeking treatment), and limited health insurance coverage (low penetration of health insurance exacerbates financial challenges) [14]. Educational status and age were also contribute for health seeking behavior for illness [15]. There is a possibility of appendicitis to be complicated as the children have not got early intervention [8]. Whereas, the finding was lower than other study carried out by Delgado-Miguel C (48.4%) [28] and Dagne H et al. (46%) [29]. Furthermore, the finding was higher than other studies conducted by Murthy PS et al.(27.27%) [30] and Singh M. et al. (21.5%) [2]. The epidemiological variability of complicated appendicitis might be due to surgical care accessibility, study design of the study, health seeking behavior of the community, initial visiting of the local health institution and similarity of symptoms with the locally prevalent health problems like intestinal

parasite infection. In addition, health care workers capacity in identifying the classical symptoms of acute appendicitis may also contributed for the epidemiological distribution. Absence of laboratory investigation and imaging diagnostics in developing countries were also the other contributor for the progress of acute appendicitis to complicated appendicitis.

Regarding to determinants of complicated appendicitis (CA), symptom duration and white blood cells count were significantly associated with CA.

The odds of CA among children underwent appendectomies who seek care after one day of acute symptoms of appendicitis was higher than those who seek care with in one day for symptoms of acute appendicitis. The finding supported the previous study carried out by Feng W. et al. [31]. They reported the link between the duration of the symptoms and the probability of complicated appendicitis. They concluded that the chance of complicated appendicitis is low in the first 36 h of the disease. In addition, this article finding also support other authors finding by Poudel R. et al. [32] and Bekiaridou K et al. [33]. We found a notable difference in the duration of symptoms between the simple appendicitis and complicated appendicitis, which is why concluded that one of the reasons for high rates of complicated appendicitis in this age group could be a delayed visit to the health institutions. Cappendijk V. et al. described that a 36-hour period from the onset of symptoms until surgery is considered a low-risk interval for appendicular perforation since the risk of rupture is minimal during the first 24 h, increases to 6% after 36 h, and stays constant at roughly 5% for each 12-hour period [1]. The difference might be due to the fact that acute appendicitis atypical presentation, poor communication (Children may have difficulty communicating), difficulty eliciting physical signs (It can be hard to find physical signs in irritable children), overlapping symptoms (Symptoms can overlap with other conditions such as intestinal parasite) and incorrect earlier diagnosis (An incorrect diagnosis during a previous visit can lead to a delayed diagnosis) [34]. The difference in experiencing complicated appendicitis between those who seek care within 24 h and after 24 or more might be due to the factors that influence timely healthcare access, such as socioeconomic factors, awareness, or barriers to healthcare (e.g., healthcare infrastructure or cultural beliefs). However, our study finding was contradicted with other previous study conducted by Bekiaridou K. et al. [35] in which the probability of acute complicated appendicitis was more likely in children with acute appendicitis presented with in 24 h of symptom occurrence. The discrepancy might be due to the variable categorization.

Moreover, those children who had a white blood cell count of 12000 cells/μl or more were more likely to experience complicated appendicitis than their counter parts. The finding supports the previous study carry out by Feng W. et al. [31], Poudel R. et al. [32], and Bekiaridou K et al.0.2) [33]. This study was conducted with some sort of limitation. Since the retrospective nature of the study, important laboratory investigations were missed such as platelet to lymphocyte ratio, c-reactive protein and hyponatremia (sodium level). In addition, since this study used cross-sectional by study design, the result could not show the real cause-effect relationship between complicated appendicitis and the identified factors. Even though there is no basic difference in service delivery, the selection of only two hospitals among eight within the region may have an impact on generalizing the findings. So, care full interpretation is required.

Conclusion

The magnitude of complicated appendicitis was high as compared to other previous studies. Duration of symptoms and white blood cell count were significantly associated with complicated appendicitis.

Recommendation

Since duration of symptom is a modifiable risk factor, clinicians, health care workers who are working in local health institution where no surgical care in not available need to prevent unnecessary referral delay. A prospective large sample size study which incorporate the missed variables such as platelet to lymphocyte ratio, c-reactive protein and hyponatremia(sodium level) is important.

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Author contributions

MA conceptualized the research idea. MA, DT, TAK, SFF, RNH, AK and BBA agreed to be held accountable for all elements of the work and took part at any points of the study's idea conception, methodology, data analysis, and interpretation. Based on this, they also contributed to the writing and revision of the paper. Finally, all authors gave their final review and approval.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Ethical clearance was obtained from Woldia University Institutional Review Board (Woldia University IRB) on November 11, 2023. The research directorate office wrote a supportive letter for each selected respective comprehensive specialized hospital. In turn, an internal permission letter obtained from chief executive officers of each hospital to the health service departments within the hospital. The name and the medical record number of the participants were not included in the tool. The retrieved information was used only for the study purpose. This study did not expose the study participants to unnecessary risk due to reviewing their medical records. Due to the

retrospective nature of the study, Woldia University Institutional Review Board waived the need of obtaining informed consent. Confidentiality was kept at all levels of the study. The data was also used only for this study purpose. The study was carried out according to the Declaration of Helsinki's relevant guidelines and regulations. Furthermore, since this study is not a clinical trial, clinical trial number is not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. Cappendijk VC, Hazebroek FW. The impact of diagnostic delay on the course of acute appendicitis. Arch Dis Child. 2000;83(1):64–6. https://doi.org/10.1136/adc.83.1.64.
2. Singh M, Kadian YS, Rattan KN, Jangra B. Complicated appendicitis: analysis of risk factors in children. Afr J Paediatr Surg. 2014;11(2):109–13. https://doi.org/10.4103/0189-6725.132796.
3. Sivit CJ, Siegel MJ, Applegate KE, Newman KD. When appendicitis is suspected in children. Radiographics. 2001;21(1):247–62. https://doi.org/10.1148/radiographics.21.1.g01ja17247.
4. Augustin T, Cagir B, VanderMeer TJ. Characteristics of perforated appendicitis: effect of delay is confounded by age and gender. J Gastrointest Surg. 2011;15(7):1223–31. https://doi.org/10.1007/s11605-011-1486-x.
5. Argaw MD, Abawollo HS, Tsegaye ZT, Beshir IA, Damte HD, Mengesha BT, et al. Experiences of midwives on Vscan limited obstetric ultrasound use: a qualitative exploratory study. BMC Pregnancy Childbirth. 2022;22(1):196. https://doi.org/10.1186/s12884-022-04523-3.
6. Rajah KH. Complicated appendicitis in children: current management. Review article. Eur J Med Health Res. 2024;2(2):127–32. https://doi.org/10.59324/ejmhr.2024.2(2).14.
7. Morrow SE, Newman KD, editors. Current management of appendicitis. Seminars in pediatric surgery. Elsevier. 2007. https://doi.org/10.1053/j.sempedsurg.2006.10.005.
8. Assefa Z, Gy A. Acute Appendicitis in Children admitted to Zewditu Memorial Hospital. Ethiop Med J. 2014;52(4):189–95. https://europepmc.org/article/med/26410992.
9. Manote M, Gebremedhin T. Determinants of postnatal care non-utilization among women in Demba Gofa rural district, southern Ethiopia: a community-based unmatched case-control study. BMC Pregnancy Childbirth. 2020;20(1):546. https://doi.org/10.1186/s12884-020-03244-9.
10. Ngim CF, Quek KF, Dhanoa A, Khoo JJ, Vellusamy M, Ng CS. Pediatric appendicitis in a developing country: what are the clinical predictors and outcome of perforation? J Trop Pediatr. 2014;60(6):409–14. https://doi.org/10.1093/tropej/fmu037.
11. Pham XD, Sullins VF, Kim DY, Range B, Kaji AH, de Virgilio CM, et al. Factors predictive of complicated appendicitis in children. J Surg Res. 2016;206(1):62–6. https://doi.org/10.1016/j.jss.2016.07.023.
12. Mallick MS. Appendicitis in pre-school children: a continuing clinical challenge. A retrospective study. Int J Surg. 2008;6(5):371–3. https://doi.org/10.1016/j.ijsu.2008.06.003.
13. Papandria D, Goldstein SD, Rhee D, Salazar JH, Arlikar J, Gorgy A, et al. Risk of perforation increases with delay in recognition and surgery for acute appendicitis. J Surg Res. 2013;184(2):723–9. https://doi.org/10.1016/j.jss.2012.12.008.
14. Fantahun M, Degu G. Health service utilization in Amhara region of Ethiopia. Ethiop J Health Dev. 2003;17(2):140–7. https://doi.org/10.4314/ejhd.v17i2.9855.
15. Moyehodie YA, Fenta SM, Mulugeta SS, Agegn SB, Yismaw E, Biresaw HB, et al. Factors Associated with Community Based Health Insurance Healthcare Service Utilization of Households in South Gondar Zone, Amhara, Ethiopia. A community-based cross-sectional study. Health Serv Insights. 2022;15:11786329221096065. https://doi.org/10.1177/11786329221096065.
16. Siddique K, Baruah P, Bhandari S, Mirza S, Harinath G. Diagnostic accuracy of white cell count and C-reactive protein for assessing the severity of paediatric appendicitis. JRSM Short Rep. 2011;2(7):59. https://doi.org/10.1258/shorts.2011.011025.
17. Gosain A, Williams RF, Blakely ML. Distinguishing acute from ruptured appendicitis preoperatively in the pediatric patient. Adv Surg. 2010;44(1):73–85. https://doi.org/10.1016/j.yasu.2010.05.021.
18. van den Bogaard VA, Euser SM, van der Ploeg T, de Korte N, Sanders DG, de Winter D, et al. Diagnosing perforated appendicitis in pediatric patients: a new model. J Pediatr Surg. 2016;51(3):444–8. https://doi.org/10.1016/j.jpedsurg.2015.10.054.
19. Takirambudde S, Ruffolo LI, Wakeman DS, Dale Bs Ba BS, Arca MJ, Wilson NA. Social Determinants of Health are Associated with postoperative outcomes in children with complicated appendicitis. J Surg Res. 2022;279:692–701. https://doi.org/10.1016/j.jss.2022.06.059.
20. Adu A, Birhanu Y. Acute appendicitis in Ethiopia: a systematic review and meta-analysis. Int J Afr Nurs Sci. 2021;15:100343. https://doi.org/10.1016/j.ijans.2021.100343.
21. Bröker ME, van Lieshout EM, van der Elst M, Stassen LP, Schepers T. Discriminating between simple and perforated appendicitis. J Surg Res. 2012;176(1):79–83. https://doi.org/10.1016/j.jss.2011.09.049.
22. Narsule CK, Kahle EJ, Kim DS, Anderson AC, Luks FI. Effect of delay in presentation on rate of perforation in children with appendicitis. Am J Emerg Med. 2011;29(8):890–3. https://doi.org/10.1016/j.ajem.2010.04.005.
23. Michelson KA, Reeves SD, Grubenhoff JA, Cruz AT, Chaudhari PP, Dart AH, et al. Clinical features and preventability of delayed diagnosis of Pediatric Appendicitis. JAMA Netw open. 2021;4(8):e2122248. https://doi.org/10.1001/jamanetworkopen.2021.22248.
24. Lucha TA, Engida TA, Mengistu AK. Assessing the potential determinants of national vitamin a supplementation among children aged 6–35 months in Ethiopia: further analysis of the 2019 Ethiopian Mini demographic and Health Survey. BMC Pediatr. 2022;22(1):439. https://doi.org/10.1186/s12887-022-03499-5.
25. Oztas T, Bilici S, Dursun A. Has the frequency of complicated appendicitis changed in children in the first year of the COVID-19 pandemic? Annals Pediatr Surg. 2023;19(1):3. https://doi.org/10.1186/s43159-022-00235-7.
26. Koirala DP, Gupta AK, Dahal GR, Shrestha BM, Shrestha S, Neupane S et al. Role of hyperbilirubinaemia as a predictor of complicated appendicitis in paediatric population. African Journal of Paediatric Surgery. 2022;19(2):61 – 4. https://doi.org/10.4103/ajps.AJPS_131_20.
27. Totapally A, Martinez P, Raszynski A, Alkhoury F, Totapally BR. Do racial/ethnic and economic factors affect the rate of complicated appendicitis in children? Surg Res Pract. 2020;2020(1):3268567. https://doi.org/10.1155/2020/3268567.
28. Delgado-Miguel C, Munoz-Serrano AJ, Miguel-Ferrero M, De Ceano-Vivas M, Calvo C, Martinez L. Complicated Acute Appendicitis during COVID-19 pandemic: the hidden epidemic in children. Eur J Pediatr Surg. 2022;32(3):268–73. https://doi.org/10.1055/s-0041-1723992.
29. Dagne H, Abebaw TA. Characteristics of patients presented with complicated appendicitis in Adama, Ethiopia: a cross-sectional study. Open Access Emerg Med. 2022;14:573–80. https://doi.org/10.2147/OAEM.S383550.
30. Murthy PS, Panda AP. Risk factors for complicated appendicitis among pediatric population. Indian J Child Health. 2018;5(9):600–3. https://doi.org/10.32677/IJCH.2018.v05.i09.013.
31. Feng W, Zhao X-F, Li M-M, Cui H-L. A clinical prediction model for complicated appendicitis in children younger than five years of age. BMC Pediatr. 2020;20:1–9. https://doi.org/10.1186/s12887-020-02286-4.
32. Poudel R, Bhandari TR. Risk factors for complications in acute appendicitis among paediatric population. 2017 https://pdfs.semanticscholar.org/2d6c/f2d0e6dbab6bfa0888bb49d1333e27a0b89e.pdf
33. Guy S, Wysocki P. Risk factors for intra-abdominal abscess post laparoscopic appendicectomy for gangrenous or perforated appendicitis: a retrospective cohort study. Int J Surg Open. 2018;10:47–54. https://doi.org/10.1016/j.ijso.2017.12.003.
34. Choi JY, Ryoo E, Jo JH, Hann T, Kim SM. Risk factors of delayed diagnosis of acute appendicitis in children: for early detection of acute appendicitis. Korean J Pediatr. 2016;59(9):368–73. https://doi.org/10.3345/kjp.2016.59.9.368.

35. Bekiaridou K, Kambouri K, Giatromanolaki A, Foutzitzi S, Kouroupi M, Aggelidou M, et al. Predicting Complicated appendicitis in children: pros and cons of a new score combining clinical signs, Laboratory values, and Ultrasound images (CLU score). Diagnostics (Basel). 2023;13(13):2275. https://doi.org/10.3390/diagnostics13132275.

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