



## OPEN Surgical site infection following appendectomy in children

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Surgical site infection (SSI) is one of the most common postoperative complications after appendectomy leading to recurrent surgery, prolonged hospital stay, and the use of antibiotics. The burden of surgical site infection varies from 1.2 to 20% across the previously conducted studies. However, there are limited studies available on this problem in Ethiopia. Therefore, this study aimed to assess prevalence of post-appendectomy surgical site infection among children in Amhara region, Ethiopia. A cross-sectional study was employed. The data extraction tool was used to collect data from 423 sampled participants. Simple random sampling technique was used. Data cleaned, coded and entered into Epi Data version 4.6 and exported to STATA version 14.0. The data was presented using table and text forms. The logistic regression model was fitted after checking the required assumptions through Hosmer and Lemeshow test to identify predictors of post-operative complications. The bivariable analysis was done to identify associations between dependent and each independent variable. Moreover, variables with  $P \leq 0.25$  levels in the bivariable analysis 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  $< 0.05$ . A total of 406 study participants were considered for analysis. The prevalence of surgical site infection was 9.11% (95%CI; 6.67%, 12.34%). Having fever (AOR = 2.788, 95%CI (1.10, 7.05)), being taking preoperative antibiotics (AOR = 7.3, 95%CI (2.5, 21)) and having drainage following appendectomy (AOR = 6.3, 95%CI (2.7, 14.7)) were statistically significant predictors of surgical site infection following appendectomy in children. The prevalence of surgical site infection was high as compared the national target. Taking preoperative antibiotics, having fever, and having drainage after operation were significantly associated with surgical site infection. Therefore, a prospective follow up study is important. Those children with appendicitis who presented with a clinical symptom of fever, leaving drainage after procedure and timing of preoperative antibiotics requires special attention of the surgical safety team.

**Keywords** Surgical site infection, Children, Appendectomy, Appendicitis

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### Introduction

Acute appendicitis (AA) is one of the most common and commonly missed surgical emergencies in children<sup>1</sup>. It is an inflammation of the appendix. Acute appendicitis occurs in developed countries at a rate of 5.7–50 patients per 100,000 populations annually<sup>2,3</sup>. The peak proportion was recorded between the ages of 10 and 30<sup>2,3</sup>. Geographical differences are also reported, with a lifetime risk for appendicitis in USA (9%), in Europe (8%), and in Africa (2%)<sup>4</sup>. Moreover, there is great variation in the presentation, severity of the disease, radiological workup, and surgical management of patients having appendicitis<sup>5</sup>. Abdominal pain is the most common symptom of appendicitis. Nausea, vomiting, fever, anorexia and/or derangements of some biochemical markers including leukocytosis, elevated C-reactive protein (CRP) and hyponatremia might be the other presentation of appendicitis. The etiology is varied and not always clear, and includes mucosal ulceration due to enteric infection, foreign bodies, ischemia, and luminal obstruction. The final common pathway of these factors is invasion of the wall of the appendix by intraluminal bacteria together with typical inflammatory changes<sup>4</sup>.

The diagnosis can be made clinically, laboratory markers and imaging. Because there are no typical signs or symptoms of appendicitis; diagnosis of appendicitis is difficult for pediatricians because clinical findings overlap

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with other disorders and the findings are difficult to interpret<sup>6,7</sup>. The correct diagnosis of appendicitis in patients with immunodeficiency and their management is also challenging for physicians like patient with leukemia<sup>8</sup>. Several risk scoring systems have also become commonly used tools to promote standardization of the approach to the child with abdominal pain and suspected appendicitis. Clinical scoring system includes Alvarado scoring system, appendicitis inflammatory response score, and pediatric appendicitis score have been developed to aid the diagnosis of acute appendicitis in children<sup>9,10</sup>. The clear aim of appendicitis risk scoring system is to make best use of diagnostic accuracy in acute appendicitis, and guide imaging evaluation and resource utilization. They all combine the predictive value of consistent symptoms, physical examination findings, and laboratory data yielding a numerical score. The systems most widely utilized are the Alvarado score and the Pediatric Appendicitis Score (PAS). The PAS combines elements of history (migration of pain, anorexia, nausea, vomiting) with physical examination findings (RLQ tenderness, rebound tenderness, fever) and laboratory data (white blood cell (WBC) > 10,000, polymorphonuclear neutrophils > 75%) to assign a risk score in the low, intermediate, or high-risk range for acute appendicitis.

Despite these diagnostic methods, appendicitis is the commonly missed or delayed in diagnosis. 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<sup>7,11</sup>. This results in delay in the discovery of an inflamed appendix<sup>7,12,13</sup>. Appendectomy is the definitive management of appendicitis. The surgeon can select the appropriate surgical strategy, ranging from antibiotics and delayed appendectomy to laparotomy, based on the grade of appendicitis (complex vs. uncomplicated)<sup>14</sup>. Laparoscopic and open appendectomies are the surgical technique undertaken during the appendectomy procedure. During the procedure appendix is resected unless the child has appendiceal carcinoid or neural endocrine tumor which requires hemicolectomy or right colectomy<sup>14,15</sup>. The diagnostic delay often leads to a higher incidence of complications, such as perforation, necrosis and intra-abdominal abscess formation<sup>16</sup>. Appendectomy may be ended with either smooth postoperative days or post-operative complications such as surgical site infections (SSIs), intra-abdominal abscess, and intestinal obstruction (adhesion or persistent ileus)<sup>17</sup>. Even Mustafa et al.<sup>18</sup> reported an evisceration through the drain site following successful appendectomy.

Surgical site infection (SSI) is one of the most common postoperative complications after appendectomy leading to recurrent surgery, prolonged hospital stay, and the use of antibiotics<sup>19,20</sup>. It has also been associated with an increased postoperative morbidity, which is a substantial additional healthcare cost, making this complication a concern for all surgical teams<sup>21</sup>.

Regarding to burden, the prevalence of surgical site infection varies from country to country, type of procedure and quality of peri-operative care (preoperative, intra operative and postoperative care). A study conducted in low and middle human development index countries reported that the prevalence of SSI was 17.9%<sup>22</sup>. Surgical site infection following appendectomy in Aboriginal and Torres Strait Islanders of Australia was 1.9%<sup>21</sup>. Other similar studies were reported in Saudi Arabia (7.2%), Spain 4.7%<sup>23</sup>, and Estonia (1.2%) SSI among children underwent appendectomy<sup>24</sup>. A systematic review study in Ethiopia reported that the prevalence of SSI was 12.3%<sup>25</sup> in general population which ranging from 3.5%<sup>26</sup> to 36%<sup>27</sup>. The prevalence of surgical site infection accounts 7.4%, 14.4%), and 20.0% in high, middle and low-income countries<sup>28</sup>. Another 3- month prospective study revealed a 6.6% of participants experience in surgical site infection<sup>29</sup>.

Numerous risk factors were associated with surgical site infection such as age<sup>30,31</sup>, being overweight or obese<sup>31,32</sup>, duration of the operation procedure<sup>23,29,30,33</sup>, neutrophil to lymphocyte ratio<sup>23</sup>, complicated appendicitis (perforation)<sup>33–36</sup>, degree of surgical contamination<sup>37</sup>, duration of surgery<sup>31,37</sup>, type of surgery<sup>37,38</sup>, number of diagnoses (comorbidity)<sup>31,37</sup>, the C-reactive protein value at admission<sup>38</sup>, purulent peritonitis<sup>38</sup>, placement of an abdominal drain<sup>38</sup>, administration of antibiotics<sup>38</sup>, total leucocyte count (TLC)<sup>31</sup>, duration of symptoms<sup>31</sup>, pediatric appendicitis score<sup>31</sup>, being on medications<sup>31</sup>, drain duration<sup>31</sup>, time to appendectomy (waiting time)<sup>39</sup>, and low albumin. Moreover, certain biochemicals including Butyrylcholinesterase (BChE) also have played their role to the occurrence of surgical site infection. A prospective single centered study in Germany reported that those patients with colorectal cancer who developed surgical site infection have lower Butyrylcholinesterase<sup>40</sup>. However, these factors all have in common a high inter-individual variability, as they greatly depend on the subjective assessment of the patient or the physician (radiologist or surgeon). In contrast, no objective parameters, such as inflammatory biomarkers easily detectable in laboratory tests, have been analyzed to date in order to quantify the risk of developing postoperative SSI. Therefore, it is essential to determine SSI predictive factors in order to prevent its occurrence. A positive association has been described between some factors and the development of SSI, such as time of symptoms onset<sup>7</sup>, ultrasound appendix diameter<sup>8</sup> or surgery time<sup>9</sup>, so that increasing any of these factors also increases the risk of SSI<sup>21</sup>.

Most surgical site infections can be prevented if appropriate strategies are implemented. These infections are typically caused when bacteria from the patient's endogenous flora are inoculated into the surgical site at the time of surgery. Development of an infection depends on various factors such as the health of the patient's immune system, presence of foreign material, degree of bacterial wound contamination, and use of antibiotic prophylaxis. Although numerous strategies are recommended by international organizations to decrease surgical site infection, only 6 general strategies are supported by randomized trials. Interventions that are associated with lower rates of infection include avoiding razors for hair removal (4.4% with razors vs. 2.5% with clippers); decolonization with intranasal antistaphylococcal agents and antistaphylococcal skin antiseptics for high-risk procedures (0.8% with decolonization vs. 2% without); use of chlorhexidine gluconate and alcohol-based skin preparation (4.0% with chlorhexidine gluconate plus alcohol vs. 6.5% with povidone iodine plus alcohol); maintaining normothermia with active warming such as warmed intravenous fluids, skin warming, and warm forced air to keep the body temperature warmer than 36 °C (4.7% with active warming vs. 13% without); perioperative glycemic control (9.4% with glucose < 150 mg/dL vs. 16% with glucose > 150 mg/dL); and use of negative pressure wound therapy (9.7% with vs. 15% without). Guidelines recommended appropriate dosing, timing, and choice of preoperative parenteral antimicrobial prophylaxis<sup>41</sup>. By tracking and evaluating SSIs, medical professionals can pinpoint areas

where surgical technique, postoperative care, and infection control procedures need to be improved. Extended hospital stays and additional medical treatments brought on by SSIs may raise the expense of healthcare. Both patients and healthcare systems can save money by lowering SSIs. Research on SSIs can help guide prophylactic antibiotic usage strategies, balancing the danger of antibiotic resistance with efficient infection prevention. Research can result in the creation of uniform policies and procedures for appendectomy operations.

As far as our knowledge allowed, there is limited study about surgical site infection among children who underwent appendectomy. Therefore, this study aimed to assess the prevalence and associated factors of post appendectomy surgical site infection among children in Amhara region, Ethiopia.

### Contextual vulnerability

Ethiopia is an African country found in the horn of Africa. Currently, it exercise a three tier health care system (specialized hospital, general hospital and primary health care unit). Ethiopia's healthcare system faces numerous challenges that can contribute to higher infection rates, particularly surgical site infections (SSIs). The country has made significant strides in improving healthcare access and outcomes, but various factors still impact the quality of surgical care such as limited Infrastructure (many healthcare facilities, especially in rural areas, lack adequate surgical infrastructure, including operating rooms, sterile supplies, and post-operative care units), insufficient Supplies (there is often a shortage of essential surgical materials, such as gloves, antiseptics, and antibiotics, which can increase infection risk), variable training levels (while there are trained professionals, the quality and consistency of surgical training can vary. Some personnel may not receive comprehensive training in infection prevention and control), continuous education (ongoing professional development opportunities for surgical staff are limited, impacting their ability to stay updated on best practices), poor implementation infection prevention protocols (many healthcare facilities may not have established or strictly enforced infection control protocols, leading to inconsistent practices), nutritional status (malnutrition is prevalent in Ethiopia, affecting patients' immune responses and increasing susceptibility to infections), comorbidities (high rates of infectious diseases (e.g., HIV, tuberculosis) and non-communicable diseases can complicate surgical outcomes and increase infection risk).

### Objective

#### *General objective*

To assess prevalence and associated factors of post appendectomy surgical site infection among children in Amhara region, Ethiopia, 2024.

#### *Specific objective*

To estimate the prevalence of surgical site infection.

To determine the risk factors of surgical site infection.

### 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 selected hospitals from December, 2017 to January, 2024 were reviewed retrospectively.

#### Population

##### *Source of population*

All children aged 18 and below who underwent appendectomy from January, 2017 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, 2017 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, 2017 to December, 2024 were included in the study.

#### Variables

##### *Dependent variables*

Prevalence of surgical site infection.

##### *Independent variables*

The independent variables were age, sex, residence, referral status, body temperature, vomiting, pain location at presentation, signs (rovsing sign, obturator sign, Dunphy sign, psoas sign), duration of symptoms, surgical techniques, OR duration, time to surgery (onset of symptom to hospital arrival, hospital arrival to operation commencement), hemoglobin, WBC, neutrophil.

#### Sample size determination

The sample size was determined by single population proportion formula with the estimated prevalence of surgical site infection in the previous study (50%), confidence level 95%. and precision 5% (0.05) using epi info version 7.2 software. The calculated sample size using single population formula was  $384 + 38.4 \approx 423$ . 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, 2 hospitals called Woldia comprehensive specialized hospital and felegehiwot comprehensive specialized hospital were randomly selected. 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. A total of 1200 appendectomy were performed during the study period. Of which 670 and 530 were at felege hiwot comprehensive specialized hospital and Woldia comprehensive specialized hospital, respectively. Of the study participants underwent appendectomy 236 and 187 at felege hiwot comprehensive specialized hospital and Woldia comprehensive specialized hospital, respectively were selected for the study using simple random sampling technique.

### Data collection tools and procedure

The data collection tool was prepared based on the literatures. Then, the data collected from patient charts in terms of socio-demographic variables, Clinical and laboratory related factors, treatment-related factors. Charts were accessed based on their medical record numbers 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.

### 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 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. The data collectors were informed about overview of the research objectives and significance, familiarization with data collection tools and methodologies, showcase how to use questionnaires, strategies for ensuring accuracy and reliability in data collection, how to identify and minimize biases during data collection, how documenting data collection processes and how to report issues or challenges encountered in the field to immediate supervisor, importance of informed consent and confidentiality and strategies for ensuring accuracy and reliability in data collection. Similarly, supervisors were familiarized about methods for evaluating the performance of data collectors, conflict resolution, compliant management, motivational techniques(encouragement), how to review data for accuracy and completeness, approaches to tackle challenges that arise during data collection, making informed decisions based on data quality assessments, establishing effective communication channels for providing feedback to data collectors, encouraging a culture of continuous improvement, about compiling and presenting data collection reports, ensuring proper documentation of all supervisory activities and ethical oversight. 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 4.6 software.

### Data processing and analysis

Data cleaned, coded and entered into Epi Data version 4.6 and exported to STATA version 14.0. Since the data were not normally distributed median and standard deviation/interquartile range were 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. 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. Moreover, variables with  $P \leq 0.25$  levels in the bivariable analysis 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 graphs, tables and text forms.

### Results

Of 423 study participants, 406 were included for analysis. Of the study participants, 34.98% were male. Moreover, 47.29% of the study participants were also rural residents (Table 1).

### Prevalence of surgical site infection and measurement parameter distribution

The median age, neutrophil count, white blood cell count, body temperature and length of hospital stay were 13.5 years, 80 cells/mm<sup>3</sup>, 13.2 cells/mm<sup>3</sup>, 37.6 °C, and 4 days, respectively. The prevalence of surgical site infection was 9.11% (95%CI; 6.67%, 12.34%). The prevalence of surgical site infection in rural residence was 12.5% where as it was 6.1% in urban residence once. Moreover, SSI accounted 20.2% in study participants who had drainage following appendectomy whereas the prevalence was lower in children who went appendectomy without drainage within them (4.5%).

### Risk factors of surgical site infection

In bi-variable analysis, hemoglobin level, residence, administration of preoperative antibiotics, having fever, and leaving drainage during surgical procedure were significantly associated with surgical site infection. However,

	Surgical site infection status					
	No		Yes		Total	
	Frequency	%	Frequency	%	Frequency	%
Sex						
Male	243	92.0%	21	8.0%	264	65.02%
Female	126	88.7%	16	11.3%	142	34.98%
Age in years						
<5	86	89.6%	10	10.4%	96	23.65%
≥5	283	91.3%	27	8.7%	310	76.35%
Residence						
Urban	201	93.9%	13	6.1%	214	52.71%
Rural	168	87.5%	24	12.5%	192	47.29%
Present with referral						
No	36	87.8%	5	12.2%	41	10.10%
Yes	333	91.2%	32	8.8%	365	89.90%
Fever						
No	173	95.1%	9	4.9%	182	44.83%
Yes	196	87.5%	28	12.5%	224	55.17%
Hemoglobin in mg/dl						
<11	13	72.2%	5	27.8%	18	4.43%
≥11	356	91.8%	32	8.2%	388	95.57%
WBC in cell/μl						
<10,000	94	90.4%	10	9.6%	104	25.62%
≥10,000	275	91.1%	27	8.9%	302	74.38%
Neutrophil cells/μl						
<75	84	92.3%	7	7.7%	91	22.41%
≥75	285	90.5%	30	9.5%	315	77.59%
Waiting after arrival to hospital in hours						
<24	195	89.4%	23	10.6%	218	53.69%
≥24	174	92.6%	14	7.4%	188	46.31%
Taking preoperative antibiotics						
No	32	72.7%	12	27.3%	44	10.84%
Yes	337	93.1%	25	6.9%	362	89.16%
Surgical technique						
Mc Burney point	332	91.7%	30	8.3%	362	89.16%
Laparotomy	37	84.1%	7	15.9%	44	10.84%
Having comorbidity						
No	338	91.1%	33	8.9%	371	91.38%
Yes	31	88.6%	4	11.4%	35	8.62%
Grade of appendicitis						
Simple	256	92.8%	20	7.2%	276	67.98%
Complicated	113	86.9%	17	13.1%	130	32.02%
Duration of symptoms in days in days						
<1	133	95.0%	7	5.0%	140	34.48%
≥1	236	88.7%	30	11.3%	266	65.52%
Drainage						
No	274	95.5%	13	4.5%	287	70.69%
Yes	95	79.8%	24	20.2%	119	29.31%
Intra operative duration in minute						
Continued						

	Surgical site infection status					
	No		Yes		Total	
	Frequency	%	Frequency	%	Frequency	%
< 45	217	93.1%	16	6.9%	233	57.39%
≥ 45	152	87.9%	21	12.1%	173	42.61%
Waiting after arrival to hospital in hours)						
< 12	288	91.7%	26	8.3%	314	77.34%
≥ 12	81	88.0%	11	12.0%	92	22.66%

**Table 1.** Characteristic of the study participants to determine prevalence of surgical site infection and associated risk factors among children underwent appendectomy in Amhara region comprehensive specialized hospitals, Ethiopia, 2024.

in multivariable analysis administration of preoperative antibiotics, having fever, and leaving drainage during surgical procedure were significantly associated with surgical site infection. The odds of surgical site infection among children underwent appendectomy with fever at presentation were 2.8 times more likely than those who had no fever at presentation (AOR = 2.788, 95%CI (1.10, 7.05)). Similarly, those children who didn't take preoperative antibiotic were 7 times more likely to experience surgical site infection than those who took preoperative antibiotics (AOR = 7.3, 95%CI (2.5, 21)). In addition, the odds of surgical site infection among children in whom drainage was left were 6.3 times higher than those who hadn't drainage during appendectomy (AOR = 6.3, 95%CI (2.7, 14.7)) (Table 2).

## Discussion

This study aimed to assess the prevalence of surgical site infection among children underwent appendectomy in Ethiopia. Surgical site infection was found to be 9.11% (6.67%, 12.34%).

The finding was consistent with previous studies in Saudi Arabia (7.2%)<sup>33</sup> and Japan (8.2%)<sup>42</sup>. Whereas, the finding was higher than other previous study shown in Spain 4.7%<sup>23</sup>, Estonia 1.2%<sup>24</sup>, USA 5.1%<sup>35</sup>, USA 0.99%<sup>30</sup> and Australia 1.9%<sup>21</sup>. The difference might be due to surgeons' preference (surgical techniques). Open surgery is most frequently exercised surgical technique in Ethiopia. Evidences showed that the rate of surgical site infection lower in laparoscopic appendectomy than open surgery<sup>33</sup>. The incision made in open surgery is more extended than laparoscopic surgery. Laparoscopic appendectomy has the advantages over open appendectomy procedures such as lower hospital stay, and earlier return to activities<sup>43</sup>. Evidence showed that the more extended incision in surgery tends to surgical site infection than lowest once<sup>42</sup>. The other differences might be due methodology, socio-demographic characteristics and health seeking behavior of care givers of the study participants. This study finding was also lower than a previous study in Mexico 18.7%<sup>44</sup>.

Moreover, a multivariable logistic regression analysis administration of preoperative antibiotics, having fever, and leaving drainage during surgical procedure were significantly associated with surgical site infection.

The odds of surgical site infection among children underwent appendectomy with fever at presentation was higher than those who had no fever at presentation. The finding supported the previous study carried out by Giesen et al.<sup>36</sup>. The difference might be due to the status of appendicitis (simple vs. complicated). On the other hand, those children who did not have fever or presented early might be scheduled for laparotomy procedure for exploration which took long duration for procedure and left extended surgical wound.

Similarly, those children who didn't take preoperative antibiotic were more likely to experience surgical site infection than those who took preoperative antibiotics. The finding supports the previous study carry out by Labricciosa et al.<sup>45</sup>, Frongia et al.<sup>38</sup>, Labricciosa et al.<sup>45</sup>, Khirallah et al.<sup>31</sup>, and Kasatpibal et al.<sup>46</sup>. The discrepancy in surgical site infection between the two groups might be due to the fact that those children who took preoperative antibiotics benefited from the antibiotics action. World health organization recommended antibiotic administration two hours before operation. In addition, in this study out of 337 participants who took preoperative antibiotic 25 individual (6.9%) developed surgical site infection. This can be explained by a break in infection prevention control protocol, antibiotics resistance, and other individual related factors. In Ethiopian context, metronidazole and ceftriaxone are the most frequently prescribed medications as preoperative prophylaxis. However, there are pathogens which are resistance for cephalosporin including ceftazidim like *Roseomonas* species like *Roseomonas gilardii*<sup>47</sup>. There is controversy about the occurrence of surgical site infection following surgery in patients in whom *Roseomonas* species detected<sup>8,47-50</sup>.

In addition, the odds of surgical site infection among children in whom drainage left were higher than those who hadn't drainage during appendectomy. The finding supports the previous study undertaken by Labricciosa et al.<sup>45</sup>, Murakami et al.<sup>42</sup>, Porrás-Hernández et al.<sup>44</sup>. The discrepancy in surgical site infection between the two groups might be due to the fact that drainage may increase the microbial accessibility for the surgical wound.

Although this study did not report as significantly associated with surgical site infection, previous studies reported that complicated appendicitis<sup>33,35,42,45</sup>, longer duration of surgical procedure<sup>29,30,33,44</sup>, high WBC count<sup>33,35</sup>, low albumin<sup>33</sup>, longer symptom duration<sup>51</sup>, delayed operation<sup>39</sup>, CRP > 50 mg/L, and open surgical procedures<sup>33,45</sup> were significantly associated with surgical site infection following appendectomy. In addition, according to the literature, level of Butyrylcholinesterase (BChE) has been proved a marker for the risk of developing SSI and septic complications in patients undergoing colorectal surgery<sup>40</sup>.

Variable	Categories	aOR	p-value	95% C I		Sig
Sex	Male	1				
	Female	1.265	0.614	0.508	3.148	
Age in years	< 5	1				
	≥ 5	1.369	0.54	0.501	3.74	
Residence	Urban	1				
	Rural	2.365	0.063	0.954	5.862	*
Present with referral	No	1.949	0.319	0.524	7.246	
	Yes	1				
Fever	No	1				
	Yes	2.788	0.03	1.103	7.046	**
Hemoglobin in mg/dl	< 11	4.313	0.085	0.816	22.801	*
	≥ 11	1				
WBC in cell/μl	< 10,000	1.21	0.712	0.441	3.321	
	≥ 10,000	1				
Neutrophil cells/μl	< 75	1	0.999	0.349	2.866	
	≥ 75	1				
Taking preoperative antibiotics	No	7.27	0	2.515	20.984	***
	Yes	1				
Surgical technique	Mc Burney point	1				
	Laparotomy	1.576	0.501	0.419	5.929	
Having comorbidity	No	1.36	0.644	0.369	5.006	
	Yes	1				
Grade of appendicitis	Simple	1				
	Complicated	1.722	0.213	0.732	4.05	
Duration of symptoms in days	< 1	1				
	≥ 1	2.153	0.119	0.821	5.643	
Drainage	No	1				
	Yes	6.301	0	2.695	14.733	***
Intra operative duration in minute	< 45	1				
	≥ 45	1.514	0.371	0.61	3.757	
Waiting after arrival to hospital in hours	< 12	1				
	≥ 12	1.774	0.206	0.73	4.313	

**Table 2.** Multivariable logistic regression analysis to identify risk factors of surgical site infection among children in Amhara region comprehensive specialized hospitals, Ethiopia, 2024.

## Conclusion

The prevalence of surgical site infection was high as compared the national target. Taking preoperative antibiotics, having fever, and having drainage after operation were significantly associated with surgical site infection.

## Recommendations

There are variable which are not measured due to the nature of study design such as CRP. Therefore, a prospective follow up study is important. Those children with appendicitis who presented with a clinical symptom of fever, leaving drainage after procedure and timing of preoperative antibiotics requires special attention of the surgical safety team. There are variables which are not covered by this study such as albumin level, CRP, and sodium level. A prospective study may be important to examine such variables. In addition, identification of the pathogen causing surgical site infection is also recommended to conclude whether the current preoperative prophylaxis effective or not.

## Implication of the study

### Health care providers

Hospitals may decide to examine and enhance their infection control procedures, including preoperative care, antibiotic prophylaxis, and sterilizing methods, in response to high prevalence rates of surgical site infection. In addition, knowledge of the prevalence of SSI may result in improvements to surgical methods or strategies, which could lower the risk of infection during appendectomies. Regarding to parents, better communication with parents and guardians regarding infection symptoms and the significance of postoperative care can result from heightened awareness of SSI risks. Knowing the prevalence of SSIs can also aid in determining the long-term effects on children's health, directing follow-up treatment, and keeping an eye out for any persistent

infection-related issues. The surgeons need to pay attention for preoperative antibiotics choice, preoperative timing in administration of the preoperative antibiotics and drainage placement requires.

#### *Administrative staffs/decision makers of health institution/*

The results can guide the requirements of creation of surgical team training curricula that highlight infection control best practices and pediatric patient-specific postoperative care. Moreover, resources might be allocated to certain hospitals or regions with higher SSI rates in order to lower infection rates through audits, training, or focused interventions.

#### *Policy change and development*

The policy makers may use the findings of this study. The study could have an impact on healthcare regulations pertaining to appendectomy operations, resulting in the creation of recommendations that particularly emphasize SSI prevention in children.

#### *Researchers*

This study finding may point to areas that require more study, like pediatric patient-specific risk factors, which could result in more thorough research on SSIs in children.

### Data availability

All relevant data is available within the paper. In addition, the corresponding author will provide anonymized data upon reasonable request from researchers who require more information.

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### References

1. Derbew, M. & Ahmed, E. The pattern of pediatric surgical conditions in Tikur Anbessa University Hospital, Addis Ababa, Ethiopia. *Ethiop. Med. J.* **44**(4), 331–338 (2006).
2. Ilves, I. et al. Seasonal variations of acute appendicitis and nonspecific abdominal pain in Finland. *World J. Gastroenterol.* **20**(14), 4037 (2014).
3. Viniol, A. et al. Studies of the symptom abdominal pain—a systematic review and meta-analysis. *Fam. Pract.* **31**(5), 517–529 (2014).
4. Bhangu, A., Søreide, K., Di Saverio, S., Assarsson, J. H. & Drake, F. T. Acute appendicitis: Modern understanding of pathogenesis, diagnosis, and management. *Lancet* **386**(10000), 1278–1287 (2015).
5. Gomes, C. A. et al. Management of appendicitis globally based on income of countries (MAGIC) study. *World J. Surg.* **42**(12), 3903–3910 (2018).
6. Kulik, D. M., Uleryk, E. M. & Maguire, J. L. Does this child have appendicitis? A systematic review of clinical prediction rules for children with acute abdominal pain. *J. Clin. Epidemiol.* **66**(1), 95–104 (2013).
7. Cappendijk, V. & Hazebroek, F. The impact of diagnostic delay on the course of acute appendicitis. *Arch. Dis. Child.* **83**(1), 64–66 (2000).
8. Mulita, F., Oikonomou, N., Provatidis, A., Alexopoulos, A. & Maroulis, I. *Roseomonas gilardii* in patient with leukemia and acute appendicitis: Case report and review. *Pan Afr. Med. J.* **36**, 283 (2020).
9. Pogorelić, Z. et al. Validity of appendicitis inflammatory response score in distinguishing perforated from non-perforated appendicitis in children. *Children* **8**(4), 309 (2021).
10. Pogorelic, Z., Rak, S., Mrklic, I. & Juric, I. Prospective validation of Alvarado score and Pediatric Appendicitis score for the diagnosis of acute appendicitis in children. *Pediatr. Emerg. Care* **31**(3), 164–168 (2015).
11. Singh, M., Kadian, Y. S., Rattan, K. N. & Jangra, B. Complicated appendicitis: Analysis of risk factors in children. *Afr. J. Pediatr. Surg.* **11**(2), 109 (2014).
12. Sivit, C. J., Siegel, M. J., Applegate, K. E. & Newman, K. D. When appendicitis is suspected in children. *Radiographics* **21**(1), 247–262 (2001).
13. Augustin, T., Cagir, B. & VanderMeer, T. J. Characteristics of perforated appendicitis: Effect of delay is confounded by age and gender. *J. Gastrointest. Surg.* **15**(7), 1223–1231 (2011).
14. Pogorelić, Z. et al. Incidence and management of appendiceal neuroendocrine tumors in pediatric population: A bicentric experience with 6285 appendectomies. *Children* **10**(12), 1899 (2023).
15. Mulita, F. et al. Appendiceal tumours as incidental findings in patients undergoing emergency appendectomy: A retrospective, single-center study and a brief overview of current practice standards. *Hellenic Surgery*.
16. Argaw, M. D. et al. Experiences of midwives on Vscan limited obstetric ultrasound use: A qualitative exploratory study. *BMC Pregnancy Childbirth.* **22**(1), 196 (2022).
17. He, J. H. et al. Advantages of gasless single-port transumbilical extracorporeal laparoscopic-assisted appendectomy in the treatment of uncomplicated acute appendicitis in children in China: A multi-institutional retrospective study. *Nagoya J. Med. Sci.* **84**(4), 848–856 (2022).
18. Mustafa, G. et al. Evisceration of appendix via drain site - a rare complication in a child. *Int. J. Surg. case Rep.* **106**, 108111 (2023).
19. Al-Qahtani, S. M. et al. Post-appendectomy surgical site infection rate after using an antimicrobial film incise drape: A prospective study. *Surg. Infect. (Larchmt)*. **16**(2), 155–158 (2015).
20. Arthur, T., Gartrell, R., Manoharan, B. & Parker, D. Emergency appendectomy in Australia: Findings from a multicentre, prospective study. *ANZ J. Surg.* **87**(9), 656–660 (2017).
21. Thong, D. W., Kim, J., Dobson, B., Cheung, H. & Arthur, T. Variation in anti-microbial prescription and complications post emergency appendectomy in Australia: Do we follow recommended guidelines? *ANZ J. Surg.* **90**(3), 251–256 (2020).
22. Foster, D., Kethman, W., Cai, L. Z., Weiser, T. G. & Forrester, J. D. Surgical site infections after appendectomy performed in low and middle human development-index countries: A systematic review. *Surg. Infect.* **19**(3), 237–244 (2018).
23. Delgado-Miguel, C. et al. Neutrophil-to-lymphocyte ratio as a predictor of surgical site infection in acute appendicitis. *Translational Pediatr.* **12**(4), 552–559 (2023).
24. Varik, K. et al. Incidence and risk factors of surgical wound infection in children: A prospective study. *Scand. J. Surg.* **99**(3), 162–166 (2010).
25. Forrester, J. A. et al. Development of a surgical infection surveillance program at a tertiary hospital in Ethiopia: Lessons learned from two surveillance strategies. *Surg. Infect.* **19**(1), 25–32 (2018).

26. Amare, B. et al. Postoperative surgical site bacterial infections and drug susceptibility patterns at Gondar University Teaching Hospital, Northwest Ethiopia. *J. Bacteriol. Parasitol.* **2**(8), 1000126 (2011).
27. Shiferaw, W. S., Aynalem, Y. A., Akalu, T. Y. & Petrucka, P. M. Surgical site infection and its associated factors in Ethiopia: A systematic review and meta-analysis. *BMC Surg.* **20**, 1–15 (2020).
28. Determining the worldwide epidemiology. Of surgical site infections after gastrointestinal resection surgery: Protocol for a multicentre, international, prospective cohort study (GlobalSurg 2). *BMJ Open.* **7**(7), e012150 (2017).
29. Uludag, Ö., Rieu, P., Niessen, M. & Voss, A. Incidence of surgical site infections in pediatric patients: A 3-month prospective study in an academic pediatric surgical unit. *Pediatr. Surg. Int.* **16**, 417–420 (2000).
30. Bucher, B. T. et al. Risk factors and outcomes of surgical site infection in children. *J. Am. Coll. Surg.* **212**(6), 1033–1038 (2011). e1.
31. Khirallah, M. G., Elsossuky, N. E. & Ghazaly, M. Predictive factors of post-laparoscopic appendectomy peritoneal collection in children and adolescents with complicated appendicitis. *Afr. J. Pediatr. Surg.* **18**(4), 190–194 (2021).
32. Delgado-Miguel, C. et al. Influence of overweight and obesity on acute appendicitis in children. A cohort study. *Cir. Pediatr.* **33**(1), 20–24 (2020).
33. Koumu, M. I. et al. Surgical site infection post-appendectomy in a tertiary hospital, Jeddah, Saudi Arabia. *Cureus* **13**(7) (2021).
34. Håkanson, C. A., Fredriksson, F. & Lilja, H. E. Adhesive small bowel obstruction after appendectomy in children - laparoscopic versus open approach. *J. Pediatr. Surg.* **55**(11), 2419–2424 (2020).
35. Boomer, L. A. et al. Does delay in appendectomy affect surgical site infection in children with appendicitis? *J. Pediatr. Surg.* **49**(6), 1026–1029 (2014).
36. Giesen, L. J., van den Boom, A. L., Van Rossem, C. C., Den Hoed, P. & Wijnhoven, B. P. Retrospective multicenter study on risk factors for surgical site infections after appendectomy for acute appendicitis. *Dig. Surg.* **34**(2), 103–107 (2017).
37. Casanova, J. F., Herruzo, R. & Diez, J. Risk factors for surgical site infection in children. *Infect. Control Hosp. Epidemiol.* **27**(7), 709–715 (2006).
38. Frongia, G., Mehrabi, A., Ziebell, L., Schenk, J.-P. & Günther, P. Predicting postoperative complications after pediatric perforated appendicitis. *J. Invest. Surg.* **29**(4), 185–194 (2016).
39. Teixeira, P. G. et al. Appendectomy timing: Waiting until the next morning increases the risk of surgical site infections. *Ann. Surg.* **256**(3), 538–543 (2012).
40. Verras, G. I. & Mulita, F. Butyrylcholinesterase levels correlate with surgical site infection risk and severity after colorectal surgery: A prospective single-center study. *Front. Surg.* **11**, 1379410 (2024).
41. Seidelman, J. L., Mantyh, C. R. & Anderson, D. J. Surgical site infection prevention: A review. *Jama* **329**(3), 244–252 (2023).
42. Murakami, T., Wada, T., Ishibe, A., Akiyama, H. & Endo, I. Abdominal drainage may be a risk factor for surgical site infection following appendectomy. *Asian J. Surg.* **42**(9), 897–898 (2019).
43. Mulita, F., Plachouri, K. M., Liolis, E., Kehagias, D. & Kehagias, I. Comparison of intra-abdominal abscess formation after laparoscopic and open appendectomy for complicated and uncomplicated appendicitis: A retrospective study. *Wideochirurgia i inne Techniki Maloinwazyjne = Videosurg. Miniinvasive Tech.* **16**(3), 560–565 (2021).
44. Porras-Hernández, J. D. et al. A prospective study of surgical site infections in a pediatric hospital in Mexico City. *Am. J. Infect. Control.* **31**(5), 302–308 (2003).
45. Labricciosa, F. M. et al. Epidemiology and risk factors for superficial surgical site infections after appendectomy for acute appendicitis: A secondary data analysis. *Surg. Infect.* **22**(2), 227–233 (2021).
46. Kasatpibal, N. et al. Risk of surgical site infection and efficacy of antibiotic prophylaxis: A cohort study of appendectomy patients in Thailand. *BMC Infect. Dis.* **6**, 1–7 (2006).
47. Shokar, N. K., Shokar, G. S., Islam, J. & Cass, A. R. Roseomonas gilardii infection: Case report and review. *J. Clin. Microbiol.* **40**(12), 4789–4791 (2002).
48. Rihs, J. D. et al. Roseomonas, a new genus associated with bacteremia and other human infections. *J. Clin. Microbiol.* **31**(12), 3275–3283 (1993).
49. Nahass, R. G., Wisneski, R., Herman, D. J., Hirsh, E. & Goldblatt, K. Vertebral osteomyelitis due to Roseomonas species: Case report and review of the evaluation of vertebral osteomyelitis. *Clin. Infect. Dis.* **21**(6), 1474–1476 (1995).
50. Lewis, L., Stock, F., Williams, D., Weir, S. & Gill, V. J. Infections with Roseomonas gilardii and review of characteristics used for biochemical identification and molecular typing. *Am. J. Clin. Pathol.* **108**(2), 210–216 (1997).
51. Boomer, L. A. et al. Delaying appendectomy does not lead to higher rates of surgical site infections: A multi-institutional analysis of children with Appendicitis. *Ann. Surg.* **264**(1), 164–168 (2016).

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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.

## Declarations

### Competing interests

The authors declare no competing interests.

## Ethics approval and consent to participate

Ethical clearance was obtained from Woldia University Institutional Review Board (Woldia University IRB) on November, 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.

### **Additional information**

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