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Pre-hospital management and patient-related factors affecting access to the surgical care of appendicitis – a survey study

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ABSTRACT

Background and aims: Long pre-hospital delay substantially increases the likelihood of perforated appendicitis. This study aimed to find patient-related factors affecting this delay.

Methods: A survey was conducted for patients with acute appendicitis after appendectomy. The participants were asked about their path to the surgical center and socioeconomic status. Variables affecting delays and the rate of complicated appendicitis were analyzed.

Results: The study included 510 patients; 157 (31%) had complicated appendicitis with a median prehospital delay of 42 h. In patients with uncomplicated appendicitis, the delay was 21 h, $p < .001$. Forty-six (29%) patients with complicated appendicitis were not referred to the hospital after the first doctor's visit. The multivariate analysis discovered factors associated with long pre-hospital delay: age 40–64 years (OR 1.63 (95% CI 1.06–2.52); compared to age 18–39), age more than 64 years (OR 2.84 (95% CI 1.18–6.80); compared to age 18–39), loss of appetite (OR 2.86 (95% CI 1.64–4.98)), fever (OR 1.66 (95% CI 1.08–2.57)), non-referral by helpline nurse (OR 2.02 (95% CI 1.15–3.53)) and non-referral at first doctors visit (OR 2.16 (95% CI 1.32–3.53)). Age 40–64 years (OR 2.41 (95% CI 1.50–3.88)), age more than 64 years (OR 8.79 (95% CI 2.19–35.36)), fever (OR 1.83 (95% CI 1.15–2.89)) and non-referral at first doctors visit (OR 1.90 (95% CI 1.14–3.14)) were also risk factors for complicated appendicitis.

Conclusions: Advanced age, fever and failure to suspect acute appendicitis in primary care are associated with prolonged pre-hospital delay and complicated appendicitis.

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Appendicitis; diagnosis; socioeconomic status; complicated appendicitis; pre-hospital delay; patient delay

Introduction

Complicated appendicitis is associated with worse outcomes than uncomplicated appendicitis, including higher costs, longer hospital stays and more post-operative complications [1]. Complicated appendicitis is more common in patients whose surgery is delayed. Past studies show that the pre-hospital delay is more consequential than the in-hospital delay [2] since a substantial proportion of perforations have most probably already occurred when patients are admitted to the hospital. Internationally, many publications state that minority race and ethnicity [3–5], older age [6–12], lower socioeconomic status [13] and inadequate insurance coverage [14–17] are associated with a higher incidence of complicated appendicitis. Li et al. [18] also discovered that delayed presentation of patients with acute appendicitis is associated with older age, living alone, a lack of knowledge of the disease, and low social support. These findings suggest that healthcare systems do not treat patients equally, and access to care varies between subgroups.

Different courses of appendicitis and its symptoms can affect the patient and the physician. Symptoms like profuse abdominal pain are prone to make patients head to medical care hastily, whereas other symptoms, such as vomiting, can confuse both the patient and the doctor.

In Finland, the healthcare system is based on public healthcare services to which everyone residing in Finland is entitled. The system is divided into primary health care and specialized medical care. In addition, there are private companies that mainly provide primary health care services, but also some specialized

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medical care. In Finland, patients with acute abdominal pain are first examined in primary care – public or private – and then invariably diagnosed and treated in public hospitals. All patients are informed to contact the medical helpline by telephone before arriving at the emergency clinics. The primary health care providers manage the helplines, and the nurses answering the calls are educated to advise all kinds of patients with different ailments. All services are available all the time. Consequently, the Finnish healthcare system can be considered reasonably equal for all emergency general surgical patients, such as patients with acute appendicitis.

To our knowledge, no prior studies have investigated the effect of the course of appendicitis or social, educational, professional or employment status on delay and rate of complicated appendicitis in Finland. Our goal in this study was to identify factors affecting delayed access to surgical care and, thus, find potential targets for quality improvement in patient management.

Materials and methods

Setting

This study of acute appendicitis was carried out as a survey at Meilahti Hospital in Helsinki. No pilot phase was carried out.

Patients

Acute appendicitis patients aged 16 or older who spoke either Finnish or Swedish were recruited at the hospital ward while still convalescing after having an appendectomy. Both doctors and nurses participated in the recruitment by asking patients to participate and fill out the questionnaire. Written informed consents were obtained from all the participants.

The questionnaire

A three-page printed questionnaire with 11 questions was offered in Finland's main official languages, Finnish and Swedish. In the questionnaire, patients were asked to fill in the timings of symptom onset and first primary care doctor's visits, the symptoms before seeing a doctor, if they had used a medical helpline, if they had used a private, occupational or public primary care provider, the examinations done in primary care, additional contacts to primary care before arrival to the surgical center, and usage of antibiotics during the 48 h before arriving to the surgical center. All the times were asked with an accuracy of 1 h. The questions were asked as closed-ended, but patients were provided additional space to construct their responses when needed. We also enquired about patients' educational, professional and employment statuses and living arrangements.

Data collection

The data regarding other demographics, laboratory parameters, vital signs, intraoperative and histopathological findings, and hospital admission timings and surgery start were collected from electronic patient records. The data on surgical site infections and post-operative complications classified by the Clavien-Dindo grade [19] were also collected. These data were combined with the data extracted from the questionnaire.

Data analysis

Delays were calculated. The patient, pre-hospital and total delays were defined as the time from the onset of symptoms to the first primary care doctor's visits, from symptom onset to arrival at the surgical center, and from symptom onset to surgery, respectively. Also, the delay from the first primary care doctor's visit to the arrival at the surgical center was calculated. Complicated appendicitis was defined as perforation with or without an abscess formation in surgery. The histopathological analysis showing transmural infiltration by neutrophils confirmed the diagnosis of acute appendicitis.

Research license

The institutional review board of Helsinki University Hospital approved this trial (ref. HUS/333/2019). It concluded that no ethical committee processing was needed since the study involved no interventions or changes to the standard management of acute appendicitis patients.

Statistical analysis

The delays in the univariate analysis were presented as medians with interquartile ranges and p values calculated using the Mann–Whitney U-test. When there were three or more categorical, independent subgroups, the Kruskal–Wallis test was first performed. If a statistical difference was found between the subgroups, the analysis continued with the Dunn–Bonferroni test to find the specific p values for subgroups. The odds ratios (ORs) for complicated appendicitis with 95% CI were

calculated. Multivariate analyses were performed using binary logistic regression analysis on long delay or complicated appendicitis. Statistical analysis was done using SPSS® Statistics version 28 (IBM, Armonk, NY).

Results

A total of 510 non-consecutive patients consented to participate in the study from 29 November 2017 to 31 January 2021. Twenty-three percent of all patients treated with appendectomy during this period were recruited. Fifty-four percent of participants were female, and 56% belonged to the youngest subgroup aged 18–39. The overall rate of complicated appendicitis was 31% among recruited patients. Three hundred and nine (61%) patients phoned a medical helpline before the first doctor's appointment. Four hundred and seventy-three patients (93%) were seen by a primary care doctor before arrival at the hospital: 385 (75%) once and 88 (17%) two or more times. Forty-six (33%) out of 141 patients who had complicated appendicitis at surgery and visited primary care doctors were not referred to the surgical center at their first doctor's visit. Among patients who did not visit the primary care, 70% were transported to the hospital by ambulance; the rest came to the hospital on their own ride. Private primary care was involved with the care of 41% of patients; there was no difference in the rate of complicated appendicitis in this group compared to other patients. The median patient delay was 20 (I.Q.R. 9–38 h), and the median time from the first primary care doctor's appointment to arriving at the surgical center was only two (1–5) hours. Demographics and clinical characteristics of patients with uncomplicated and complicated appendicitis are presented in Table 1.

Table 1. Demographics and clinical characteristics.

	Uncomplicated (n = 353)	Complicated (n = 157)	p Value
Age, years	33 (28–46)	46 (32–58)	**<.001**
Female*	189 (54)	87 (55)	.695
C-reactive protein, mg/l**	28 (9–61)	110 (53–188)	**<.001**
White blood cell count, $\times 10^9$/l**	13 (10–16)	14 (11–16)	.074
Body temperature, °C**	37.2 (36.7–37.6)	37.5 (37.0–38.3)	**<.001**
Patient delay, hours	17 (8–28)	32 (16–54)	**<.001**
Pre-hospital delay, hours	21 (12–34)	42 (25–69)	**<.001**
Total delay, hours	35 (25–50)	52 (35–85)	**<.001**
Abscess*	0 (0)	40 (25)	<.001
Open surgery*	4 (1)	8 (5)	**.006**
Length of stay, days	1 (1–1)	3(2–4)	**<.001**
Surgical site infection*	14 (4)	17 (11)	**.003**
Post-operative complications (Clavien-Dindo III–V)*	5 (1)	10 (6)	**.002**

The laboratory tests and body temperature at admission to the hospital. Values are median (I.Q.R.) unless indicated otherwise; values* in parentheses are percentages. p Values Mann–Whitney's test, except *Pearson's χ^2 test. **Values at hospital admission.
Significant findings with P-values less than 0.05 are bolded.

The study period included the start of the COVID-19 pandemic. No differences in patient or prehospital delays were noted between the periods before or after this.

Patient delay

In the univariate analysis of patient delay (Tables 2A and 2B), we found that older patients came to primary care for a doctor's visit substantially later than younger patients. Patients who did not feel pain or had fever or loss of appetite were more likely to see a doctor later. In contrast, nausea and vomiting made patients seek medical care earlier. Symptom onset at night led to earlier assessment by the primary care doctor, while weekends did not influence patient delay. Educational degree, professional status and employment status had little effect on patient delay, except for pensioners whose patient delay was substantially elevated.

The multivariate analysis (Table 3) confirmed that older patients had a higher risk for longer than median (20 h) patient delay. Also, fever, loss of appetite, and professional status of a working student were independent risk factors for the long patient delay. In contrast, nausea and the nightly onset of symptoms predict a speedier arrival to primary care.

Delay from first primary care doctor's visit to the surgical center

According to the univariate analysis (Supplementary Table 1), the risk of delayed referral to a surgical center by the primary care physician was high when patients presented with nausea, vomiting or felt no pain. Abdominal imaging and the start of antibiotic treatment were associated with longer delay in getting to the surgical center.

Pre-hospital delay

The univariate analysis (Tables 2A and 2B) showed that patient and pre-hospital delays shared many associating factors. Antibiotics were started in primary care or at a non-surgical department for 16 (3%) before sending patients to the surgical unit. The reason for antibiotics was the wrong diagnosis in each of these cases. The start of antibiotics was associated with long pre-hospital delays in univariate analysis.

In the multivariate analysis (Table 4), older age, fever and loss of appetite are shown to be independent risk factors for pre-hospital delay of 24 h or longer. If patients were not referred to a doctor from the

Table 2A. Univariate analysis of factors associated with patient, pre-hospital and total delay in appendicitis.

	n (%)	Patient delay/h (IQR)	*p*[a]	Pre-hospital delay/h (IQR)	*p*[a]	Total delay/h (IQR)
All patients	510 (100%)	20 (9–38)	N/A	25 (15–44)	N/A	39 (28–56)
Sex			0.464[b]		.563[b]	
Female	276 (54%)	20 (9–40)	N/A	26 (15–45)	N/A	40 (28–56)
Male	234 (46%)	20 (9–37)	N/A	25 (14–42)	N/A	39 (27–55)
Age			**<.001**[b]		**<.001**[b]	
Age 18–39 years	285 (56%)	17 (9–30)	Reference[c]	22 (13–38)	Reference[c]	36 (24–53)
Age 40–64 years	190 (37%)	23 (12–42)	**.007**[c]	27 (17–48)	**.010**[c]	42 (30–58)
Age over 64 years	35 (7%)	33 (20–48)	**.002**[c]	39 (24–62)	**.001**[c]	49 (34–75)
Living arrangement[f]						
Living alone	133 (26%)	20 (10–43)	.401	23 (14–45)	.597	37 (27–57)
Not living alone	376 (74%)	20 (9–37)	.401	26 (15–43)	.597	40 (28–55)
Educational status			.964[b]		.916[b]	
University degree	286 (56%)	20 (9–37)	N/A	25 (14–42)	N/A	39 (26–57)
Vocational upper secondary education	129 (25%)	21 (10–37)	N/A	26 (16–42)	N/A	40 (29–55)
General upper secondary education	55 (11%)	18 (9–37)	N/A	24 (14–47)	N/A	37 (28–55)
Basic education	40 (8%)	20 (7–44)	N/A	28 (17–48)	N/A	41 (29–63)
Professional status			.193[b]		.390[b]	
Worker	184 (36%)	19 (8–38)	N/A	26 (14–42)	N/A	40 (27–56)
Blue collar	59 (12%)	14 (9–31)	N/A	22 (12–34)	N/A	35 (28–50)
White collar	127 (25%)	21 (12–34)	N/A	26 (16–46)	N/A	39 (28–57)
Entrepreneur	57 (11%)	26 (13–41)	N/A	30 (17–47)	N/A	44 (31–57)
Student	47 (9%)	17 (8–35)	N/A	23 (13–47)	N/A	40 (24–56)
Student and working	33 (6%)	22 (16–40)	N/A	25 (19–46)	N/A	38 (31–66)
Other[d]	3 (1%)	10	N/A	19	N/A	40
Employment status			**<.001**[b]		**<.001**[b]	
Employed	358 (70%)	19 (9–34)	Reference[c]	25 (14–41)	Reference[c]	37 (27–87)
Unemployed	20 (4%)	11 (5–37)	1.000[c]	19 (11–56)	1.000[c]	32 (21–72)
Pensioner	46 (9%)	38 (21–53)	**<.001**[c]	42 (25–65)	**<.001**[c]	54 (40–85)
Other[e]	86 (17%)	20 (9–40)	1.000[c]	24 (16–47)	1.000[c]	40 (26–61)

N = 510. Values are presented as median (I.Q.R.). The values were left without the I.Q.R. when there were three or fewer patients in a group.
[a]Mann–Whitney's test.
[b]Kruskal–Wallis test.
[c]Dunn–Bonferroni's test. In the Dunn–Bonferroni test, 'Reference' indicates the reference group.
[d]One patient in the army, one patient was a pensioner and a student, and one patient did not answer.
[e]47 students, 33 students who also work, three on parental leave, two stay-at-home mothers, and one in the army.
[f]One patient did not give an answer on living arrangements.
Significant findings with P-values less than 0.05 are bolded.

medical helpline or to a surgical center from primary care, the pre-hospital delays tended to be extended.

Complicated appendicitis

The patient and pre-hospital delays were both associated with raised numbers of complicated appendicitis. With patient delay ≥20 h and pre-hospital delay ≥24 h, the Odds rates for complicated appendicitis were 3.69 (95% CI 2.45–5.54) and 4.72 (95% CI 3.07–7.26), respectively.

In the univariate analysis of complicated appendicitis (Supplementary Table 2), we discovered that patients in the youngest subgroup were least likely and patients in the oldest subgroup were most likely to present with complicated appendicitis in surgery. Patients who did not experience pain and had fever or vomiting as symptoms were prone to complicated appendicitis. If the first primary care physician failed to refer a patient to a surgical center, the patient had more chance of getting complicated appendicitis. Patients who reported their professional status as working students had less complicated appendicitis, while unemployed and pensioners had more complicated appendicitis.

In the multivariate analysis (Table 5), age, fever and unemployment stood out as independent risk factors for complicated appendicitis. Also, if patients were not referred to a surgical unit at the first primary care doctor's visit or did not visit the primary care, they had complicated appendicitis more often.

Discussion

The present study supports previous findings that older patients with appendicitis seek doctor's help later and have more complicated appendicitis compared to younger patients [7,9,10,12]. Since acute appendicitis is often considered to be a disease of children and young adults, the caretakers and physicians of senior citizens should be better educated to suspect it when evaluating abdominal pain. Although the most prolonged delays happen before seeing the primary care physician, elderly patients should be managed without

Table 2B. Univariate analysis of factors associated with patient, pre-hospital and total delay in appendicitis.

	n (%)	Patient delay/h (IQR)	*p*[a]	Pre-hospital delay/h (IQR)	*p*[a]	Total delay/h (IQR)
Symptoms						
Abdominal pain	504 (99%)	20 (9–37)	**.027**	25 (14–43)	**.030**	39 (28–55)
No abdominal pain	6 (1%)	65 (33–114)	**.027**	69 (35–201)	**.030**	75 (44–252)
Fever	152 (30%)	25 (13–46)	**<.001**	29 (19–49)	**.003**	42 (30–62)
Nausea	201 (39%)	15 (8–32)	**<.001**	23 (12–40)	**.015**	35 (24–53)
Vomiting	109 (21%)	14 (7–29)	**<.001**	21 (11–41)	.059	34 (23–51)
Loss of appetite	91 (18%)	24 (14–46)	**.002**	34 (22–57)	**<.001**	49 (32–70)
Tenderness to movement	95 (19%)	19 (12–29)	.817	26 (16–47)	.655	35 (29–57)
Diarrhea	48 (9%)	26 (9–58)	.186	40 (15–77)	**.009**	53 (31–91)
Symptom onset						
Between 10 pm and 6 am	129 (25%)	15 (9–33)	**.023**	19 (13–39)	.056	33 (26–52)
Between Friday 3 pm and Monday 6 am	209 (41%)	20 (11–38)	.571	26 (16–42)	.984	41 (28–54)
Telephone contact			.198[b]		.152[b]	
Referred to see a doctor	225 (44%)	20 (9–37)	N/A	24 (15–42)	N/A	37 (28–55)
Not referred to see a doctor	84 (16%)	23 (9–57)	N/A	29 (14–76)	N/A	42 (28–88)
No telephone contacts	201 (39%)	19 (9–34)	N/A	27 (14–43)	N/A	40 (27–56)
Examinations at the first doctor's appointment						
Abdominal imaging	34 (7%)	14 (6–28)	N/A	25 (14–41)	.588	36 (23–57)
Laboratory tests	395 (77%)	21 (10–38)	N/A	26 (16–46)	.145	40 (29–58)
Clinical examination only	77 (15%)	18 (9–39)	N/A	23 (14–41)	.127	37 (28–55)
Conclusion at the first doctor's appointment			.174[b]		**<.001**[b]	
Referred to a surgical center	361 (71%)	21 (11–37)	N/A	24 (14–40)	Reference[c]	37 (27–53)
Not referred to a surgical center	112 (22%)	14 (7–40)	N/A	35 (20–77)	**<.001**[c]	51 (34–87)
No doctor visits	37 (7%)	17 (7–37)	N/A	17 (7–37)	.131[c]	33 (21–48)
Antibiotic medication during 48 h before arrival at hospital	16 (3%)	16 (8–51)	.648	51 (26–146)	**.007**	72 (40–159)

N = 510. Values are presented as median (I.Q.R.). The values were left without the I.Q.R. when there were three or fewer patients in a group.
[a]Mann–Whitney's test.
[b]Kruskal–Wallis test.
[c]Dunn–Bonferroni's test. In the Dunn–Bonferroni test, 'Reference' indicates the reference group.
Significant findings with P-values less than 0.05 are bolded.

additional holdups and referred to surgical centers, bearing in mind that the representation of these patients is that of the more advanced disease.

The symptom profile of patients with acute appendicitis varies and affects the diagnosis and patient management. Most patients have abdominal pain; however, those who do not are at risk of being wrongly diagnosed and having complicated appendicitis. Painless patients arrive late to primary care with advanced appendicitis and often must wait even longer to be sent to the surgical unit. Lack of abdominal pain in the presence of other acute gastrointestinal signs and symptoms cannot rule out appendicitis. Similarly, fever was associated with longer patient delay and complicated appendicitis. Fever most likely does not delay patients from seeking help; instead, patients who arrive late to primary care are more likely to have already complicated appendicitis, causing the fever. Nauseous patients sought help earlier, but the primary care physicians probably confused the symptoms with non-surgical ailments since these patients' delay after primary care was elevated. Because appendicitis may present with atypical symptoms, patients with acute abdominal symptoms could benefit from a doctor's physical examination with simple laboratory tests (CRP, white blood cell count and polymorphonuclear cell count) [20]. Utilization of diagnostic scoring combined with selective imaging or active follow-up might also help identify patients with possible appendicitis. Repeated scoring with the Adult Appendicitis Score [21,22] can help diagnose patients with equivocal symptoms [23].

When symptoms started at nighttime, the patient and pre-hospital delays were shorter, but this did not significantly affect the outcome of these patients. The availability of medical care in Helsinki also seems adequate during the weekends since there was no peak in delays or advanced appendicitis in patients who became ill during weekends.

In Helsinki, patients are advised to contact the medical helpline by telephone before arriving at a medical facility. On the phone, a nurse evaluates the need and urgency of seeing a doctor based on the patient history and symptoms. Sixty-one percent of patients followed these instructions and made the call. Among them, 27% were not advised to see a doctor, and this was found to be an independent risk factor for the prolonged pre-hospital delay. On the contrary, not following the instructions was not affecting the delay. Therefore, it can be argued that using a medical helpline does not help and can even harm patients with possible appendicitis.

Table 3. Multivariate analysis of factors associated with long (20 h or longer) patient delay.

	OR (95% CI)	*p*
Female	1.06 (0.71–1.58)	.773
Age		
Age 18–39 years	Reference	Reference
Age 40–64 years	1.68 (1.10–2.58)	**.017**
Age over 64 years	4.07 (1.68–9.84)	**.002**
Symptoms		
No abdominal pain	4.44 (0.48–41.23)	.190
Fever	1.96 (1.27–3.02)	**.002**
Nausea	0.49 (0.28–0.83)	**.008**
Vomiting	0.76 (0.40–1.43)	.390
Loss of appetite	2.57 (1.50–4.42)	**<.001**
Tenderness to movement	0.62 (0.37–1.03)	.063
Diarrhea	1.34 (0.68–2.62)	.397
Symptom onset		
Between 10 pm and 6 am	0.49 (0.31–0.77)	**.002**
Between Friday 3 pm and Monday 6 am	1.24 (0.84–1.84)	.276
Telephone contact		
Referred to see a doctor	Reference	Reference
Not referred to see a doctor	1.68 (0.96–2.94)	.068
No telephone contacts	0.99 (0.65–1.50)	.955
Living alone	0.92 (0.59–1.42)	.700
Educational status		
University degree	Reference	Reference
Vocational upper secondary education	1.22 (0.74–2.00)	.434
General upper secondary education	0.79 (0.40–1.57)	.509
Basic education	1.08 (0.50–2.36)	.838
Professional status		
Worker	Reference	Reference
Blue collar	0.91 (0.47–1.75)	.769
White collar	1.10 (0.64–1.90)	.733
Entrepreneur	1.42 (0.72–2.80)	.306
Student	0.98 (0.47–2.06)	.965
Student and working	2.55 (1.08–6.04)	**.033**
Other	0.69 (0.05–9.15)	.780

OR: odds ratio; CI: confidence interval.
Significant findings with P-values less than 0.05 are bolded.

A substantial proportion of patients with appendicitis were not referred to the surgical center at the first doctor's appointment. This occurred in one-third of patients with complicated appendicitis who visited a doctor before going to the hospital, underlining the significant role of the first physician in assessing a patient in primary care. Not considering the possibility of appendicitis at that point increased the pre-hospital delay considerably, leading to more complicated appendicitis. Primary assessment sometimes led to the start of antibiotics, which was also associated with long pre-hospital delays. Patients who missed the primary care and arrived straight to the hospital by ambulance or their own ride, often had complicated appendicitis but not uncommonly long pre-hospital delay. They either had rapidly progressing appendicitis or did not recognize the earliest symptoms of appendicitis for some reason. Even though we noticed that abdominal imaging, namely ultrasound, at primary care slowed the process of getting to the hospital by a few hours, it should be considered a valid method to improve diagnostic accuracy [24].

Table 4. Multivariate analysis of factors associated with long (24 h or longer) pre-hospital delay.

	OR (95% CI)	*p*
Female	0.98 (0.66–1.46)	.923
Age		
Age 18–39 years	Reference	
Age 40–64 years	1.63 (1.06–2.52)	**.026**
Age over 64 years	2.84 (1.18–6.80)	**.019**
Symptoms		
No abdominal pain	3.71 (0.39–34.87)	.252
Fever	1.66 (1.08–2.57)	**.022**
Nausea	0.72 (0.42–1.22)	.217
Vomiting	0.63 (0.33–1.19)	.151
Loss of appetite	2.86 (1.64–4.98)	**<.001**
Tenderness to movement	0.80 (0.48–1.33)	.382
Diarrhea	1.98 (0.98–4.00)	.057
Symptom onset		
Between 10 pm and 6 am	0.50 (0.32–0.79)	**.003**
Between Friday 3 pm and Monday 6 am	1.24 (0.84–1.84)	.289
Telephone contact		
Referred to see a doctor	Reference	
Not referred to see a doctor	2.02 (1.15–3.53)	**.014**
No telephone contacts	1.42 (0.93–2.17)	.104
Conclusion at the first doctor's appointment		
Referred to a surgical center	Reference	
Not referred to a surgical center	2.16 (1.32–3.53)	**.002**
No doctor visits	0.78 (0.37–1.65)	.515
Living alone	0.68 (0.44–1.05)	.085
Educational status		
University degree	Reference	
Vocational upper secondary education	1.05 (0.64–1.73)	.854
General upper secondary education	0.99 (0.50–1.96)	.966
Basic education	1.13 (0.52–2.46)	.761
Professional status		
Worker	Reference	
Blue collar	0.66 (0.34–1.28)	.218
White collar	0.95 (0.55–1.65)	.862
Entrepreneur	1.66 (0.82–3.35)	.156
Student	0.97 (0.47–2.02)	.939
Student and working	1.22 (0.52–2.87)	.650
Other	0.44 (0.03–5.53)	.522

OR: odds ratio; CI: confidence interval.
The examinations at the first doctor's appointment, the use of antibiotics, and employment status were left out of the analysis to reduce the number of variables and to avoid overlap.
Significant findings with P-values less than 0.05 are bolded.

The living arrangements or educational, professional or employment statuses had little effect on delays or complicated appendicitis. Patients who reported being working students had long patient delays but very little complicated appendicitis. This can be presumed to be explained by most students being young. The long patient and pre-hospital delays observed with the pensioners were also associated with age. Unemployment was associated with a higher incidence of complicated appendicitis but not with long pre-hospital delay. This discrepancy could be partly explained by the higher prevalence of smoking [25–27], alcoholism [28,29] and depression [30] among the unemployed.

Table 5. Multivariate analysis of factors associated with complicated appendicitis.

	OR (95% CI)	*p*
Female	1.16 (0.75–1.81)	.506
Age		
Age 18–39 years	Reference	
Age 40–64 years	2.41 (1.50–3.88)	**<.001**
Age over 64 years	8.79 (2.19–35.36)	**.002**
Symptoms		
No abdominal pain	14.47 (0.94–222.00)	.055
Fever	1.83 (1.15–2.89)	**.010**
Nausea	0.76 (0.41–1.40)	.372
Vomiting	1.56 (0.76–3.17)	.223
Loss of appetite	1.39 (0.78–2.45)	.262
Tenderness to movement	0.85 (0.48–1.49)	.563
Diarrhea	0.96 (0.46–2.03)	.920
Symptom onset		
Between 10 pm and 6 am	1.09 (0.67–1.78)	.720
Between Friday 3 pm and Monday 6 am	0.73 (0.47–1.14)	.168
Telephone contact		
Referred to see a doctor	Reference	
Not referred to see a doctor	1.44 (0.79–2.65)	.235
No telephone contacts	1.41 (0.88–2.25)	.151
Conclusion at the first doctor's appointment		
Referred to a surgical center	Reference	
Not referred to a surgical center	1.90 (1.14–3.14)	**.013**
No doctor visits	2.30 (1.03–5.10)	**.041**
Antibiotic medication during 48 h before hospital	1.03 (0.28–3.75)	.963
Living alone	0.92 (0.56–1.50)	.723
Educational status		
University degree	Reference	
Vocational upper secondary education	1.05 (0.60–1.82)	.877
General upper secondary education	1.10 (0.50–2.45)	.813
Basic education	1.69 (0.72–3.96)	.224
Professional status		
Worker	Reference	
Blue collar	1.37 (0.67–2.83)	.390
White collar	1.52 (0.83–2.76)	.175
Entrepreneur	1.68 (0.83–3.43)	.152
Student	3.68 (0.26–51.52)	.334
Student and working	0.94 (0.05–16.26)	.966
Other	4.31 (0.22–83.52)	.334
Employment status		
Employed	Reference	
Unemployed	3.97 (1.36–11.59)	**.012**
Pensioner	0.77 (0.23–2.63)	.677
Other[a]	0.38 (0.03–4.76)	.455

OR: odds ratio; CI: confidence interval.
The examinations at the first doctor's appointment were left out of the analysis to reduce the number of variables and to avoid overlap.
[a]Forty-seven students, 33 students who also work, three on parental leave, two stay-at-home mothers and one in the army.
Significant findings with P-values less than 0.05 are bolded.

This study has weaknesses. Only 23% of patients who underwent appendectomy participated in the study. Patient selection was random, and the recruitment rate varied depending on current personnel resources and their workload, patients' language and cognitive skills, and length of stay at the hospital ward. Thus, we caught fewer patients speaking minority languages and more patients with complicated appendicitis recuperating longer in the hospital. The rate of complicated appendicitis was elevated among our participants compared to our regular rate (20.5% in 2023). The recruited patients were markedly younger than in a previous study conducted in our hospital [31]. Also, only retrospective and limited primary care data were available, making it difficult to study the reasons for non-referrals. The patients were asked to recall the previous days' events, so there may be some errors in this data, especially when some had had severe pain and fever at the time. These results describe the management of appendicitis patients in one particular healthcare system; therefore, all of the findings are not generalizable to other healthcare units. This study has strength in the number of participants. Also, the systematic collection of patients' symptoms and timing of symptom onset with the survey resulted in presumably better-quality data than a simple retrospective chart review.

Advanced age, fever and diagnostic challenges in primary care are associated with longer pre-hospital delays and complicated appendicitis. A large portion

of patients with complicated appendicitis suffer from shortages in our healthcare system. The advice provided at the telephone helpline could be improved by providing more education to the helpline personnel. These results also suggest that patients with acute abdominal symptoms should be sent to a doctor's appointment for clinical examination with a very low threshold. Because the diagnosis of appendicitis is still challenging, we would encourage the liberal use of laboratory tests and utilization of clinical scoring and active observation in patients with equivocal symptoms to avoid potentially hazardous delays in the diagnosis of appendicitis. The referral indications in primary care could be adjusted to reduce the risk of complicated appendicitis, especially among the elderly population.

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Author contributions

Conceptualization and methodology: KL, PM and AL; data collection: KL; validation: PM; formal analysis: KL and PM; writing – original draft preparation: KL; writing – review and editing: KL, PM and AL; visualization: KL.

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