Cite as: Romankiewicz E, Lewko J, Kosiorek D, Sierżantowicz R, Lewko K, Łukaszuk CR: Analysis of Lyme infections among children hospitalised in the Provincial Specialist Children's Hospital in Olsztyn in 2013–2018. Pediatr Med Rodz 2024; 20 (1): 106–117. DOI: 10.15557/PiMR.2024.0014

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Received: 13.08.2023
Accepted: 06.12.2023
Published: 11.07.2024

Analysis of Lyme infections among children hospitalised in the Provincial Specialist Children's Hospital in Olsztyn in 2013–2018

Analiza zakażeń boreliozą wśród dzieci hospitalizowanych w Wojewódzkim Specjalistycznym Szpitalu Dziecięcym w Olsztynie w latach 2013–2018

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https://doi.org/10.15557/PiMR.2024.0014

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Abstract

Introduction and objective: Lyme disease is the most common chronic, infectious, multisystem, multiform disease. The region of Warmia and Mazury, as well as Podlasie, and the region of Lower Silesia are endemic areas for Lyme disease in our country. The aim of the study was to analyse the prevalence of Lyme disease among children from the Warmian-Masurian Voivodeship hospitalised in the Provincial Specialist Children's Hospital in Olsztyn. **Materials and methods:** The study group consisted of 109 patients admitted to a hospital with Lyme disease diagnosis. The study used a retrospective method based on the analysis of the medical history of patients admitted to the hospital in the period from January 2013 to December 2018. **Results:** More than half of the cases (56.88%) were elective hospital admissions, while 43.12% were emergency admissions. The largest number of patients complained of headaches (68.81%). In about half of the patients (54.13%), the first symptoms of the disease appeared in less than 3 months. **Conclusions:** Among hospitalised patients diagnosed with Lyme disease, urban school age girls were significantly more likely to be affected. Most patients hospitalised due to Lyme disease denied a tick bite. The majority of patients hospitalised during the study period presented with non-specific symptoms of Lyme disease. The time between symptom onset and the diagnosis of Lyme disease was significantly shorter in children under 7 years of age. The time of hospitalisation of children under the age of 7 years was significantly shorter than in other age groups.

Keywords: children, Lyme disease, hospitalisation

Streszczenie

Wprowadzenie i cel: Borelioza jest najbardziej rozpowszechnioną wieloukładową, przewlekłą, wielopostaciową chorobą infekcyjną. Terenami endemicznymi dla zachorowania na boreliozę na terenie naszego kraju są regiony Warmii i Mazur, Podlasia oraz rejon Dolnego Śląska. Celem pracy była analiza częstości występowania boreliozy wśród dzieci pochodzących z województwa warmińsko-mazurskiego hospitalizowanych w Wojewódzkim Specjalistycznym Szpitalu Dziecięcym w Olsztynie. **Materiał i metody:** Grupę badaną stanowiło 109 hospitalizowanych dzieci, u których rozpoznano boreliozę. W pracy zastosowano metodę retrospektywną obejmującą analizę historii chorób pacjentów przyjętych do szpitala w okresie od stycznia 2013 do grudnia 2018 roku. **Wyniki:** Ponad połowa badanych (56,88%) była przyjęta do szpitala w trybie planowym, a pozostałe 43,12% zostało przyjęte w trybie nagłym. W badanej grupie najwięcej chorych skarżyło się na bóle głowy (68,81%). U około połowy pacjentów (54,13%) pierwsze objawy choroby pojawiły się w okresie krótszym niż 3 miesiące od ukłucia przez kleszcza. **Wnioski:** Wśród pacjentów hospitalizowanych z rozpoznaniem boreliozy znacznie częściej chorowały dziewczęta, które były w wieku szkolnym i pochodziły z terenów miejskich. Większość chorych hospitalizowanych z powodu boreliozy zaprzeczało ukłuciu przez kleszcza. Większość chorych hospitalizowanych w analizowanym okresie

zgłaszała się z nieswoistymi objawami boreliozy. Czas pomiędzy wystąpieniem objawów chorobowych a rozpoznaniem boreliozy był znacznie krótszy u dzieci <7. roku życia. Dodatkowo czas hospitalizacji dzieci <7. roku życia był również znacznie krótszy niż pozostałych grup wiekowych.

Słowa kluczowe: dzieci, borelioza, hospitalizacja

INTRODUCTION

Lyme disease (LD), also known as Lyme borreliosis, is the most widespread chronic, infectious, multisystem and multiform disease and the most common transmissible disease both in Poland and Europe[1–4]. The castor bean tick (*Ixodes ricinus*) is the main vector of pathogenic microorganisms, although the meadow tick (*Dermacentor reticulatus*) also plays an epidemiological role in eastern Poland[5–8]. The number of reported cases of LD is steadily growing each year. According to the National Institute of Hygiene, 12,773 cases of LD were reported in Poland in 2013, and up to 20,150 were reported in 2018[9–14]. Warmia and Mazury, as well as Podlasie and the Lower Silesia are endemic areas for LD in our country[15]. It is estimated that 30% of the tick population in some of the north-eastern regions of Poland are infected with LD pathogens[16,17]. A total of 103,132 clinically confirmed cases of LD were reported in Poland between 2013 and 2018; the highest incidence was reported for the Silesian Voivodeship, with 15,672 cases, and the lowest incidence was observed in the Świętokrzyskie Voivodeship, with 1,989 cases. In the same period, the Podlaskie Voivodeship had the highest incidence of LD estimated per 100,000 inhabitants, with an average of 112.9 cases, followed by the Warmian-Masurian Voivodeship with an average of 77.9 cases. Special attention should be paid to the marked increase in the incidence of LD in the Małopolskie Voivodeship between 2016 and 2018.

The clinical picture of *Borrelia burgdorferi* infection does not generally differ between children and adults, with the exception of acrodermatitis chronica atrophicans (ACA) and meningopolyradiculoneuritis, which are unlikely to be seen in children. In some cases, LD itself and other non-specific manifestations may have a slightly different picture in children than in adults, making correct diagnosis challenging, as the LD symptoms may often mimic those in other childhood diseases[18]. *Borrelia burgdorferi* infection is a progressive disease that may involve different stages with a varied course. The disease may also be asymptomatic, which is particularly dangerous due to multiple possible skeletal, cardiovascular and neurological complications[19,20]. Lyme arthritis, which is characterised by nagging, fluctuating pain in one or several joints, is the most common manifestation of *Borrelia burgdorferi* infection. Large joints of the limbs, most commonly the knees, are usually involved[21,22], and the pain may be accompanied by oedema and warming of the skin around the affected joint[23,24]. Cardiac LD is due to myocardial involvement by *Borrelia* spirochetes and manifests with atrioventricular block, right or left bundle branch block or other intraventricular conduction disturbances. Furthermore, it can cause dyspnoea, dizziness, retrosternal pain, palpitations, or be asymptomatic. The cardiac form is completely curable in 90% of cases[25]. Neurological LD, on the other hand, develops as a result of nervous system involvement, which may occur immediately after contracting *Borrelia burgdorferi* or even several years after a tick bite[26].

The aim of the present study was to assess the prevalence of LD among children from the Warmińsko-Mazurskie Voivodeship hospitalised in the Provincial Specialist Children's Hospital in Olsztyn.

MATERIALS AND METHODS

The study group included 109 children hospitalised in the Provincial Specialist Children's Hospital in Olsztyn who were diagnosed with LD (all cases diagnosed at that time). The study was conducted between 1 January 2013 and 31 December 2018. Approval was obtained from the Bioethics Committee of the Medical University of Bialystok (Resolution No. R-I-002/398/2108) and the Management of the Provincial Specialist Children's Hospital in Olsztyn (No. 2/2018).

This was a retrospective study involving the analysis of medical history of 109 patients. The study used a quantitative method with the use of a proprietary research tool, a survey questionnaire, which included sets of questions to collect patients' demographic, epidemiological and medical data. Demographic data included gender, age, place of residence and county of origin. Epidemiological data included a history of tick bite (yes/no), the place of tick attack, site of bite, number of confirmed LD cases by month, previous admission due to symptoms, care in specialist clinics and length of hospital stay. Medical history included pain score on admission, body temperature, blood pressure, heart rate, body mass index, symptoms on admission, initial diagnosis, time of symptom onset, skin lesions and complications.

Statistical analysis

Data were collected in Excel and statistical calculations were performed using the TIBCO STATISTICA 13.3PL package. Empirical data were statistically analysed using descriptive statistics such as chi-square test, Student's *t*-test and ANOVA. Quantitative data were described by *n* – number of cases, $\bar{x}$ – arithmetic mean, 95% confidence interval, *Me* – median, min. – minimum, max – maximum, Q_1 – lower

 DOI: 10.15557/PiMR.2024.0014

quartile, Q_3 – upper quartile and *SD* – standard deviation. Data were categorised and described by number of cases (*n*), and the percentage (%) of the group. The chi-square test (χ^2) was used to assess the homogeneity of variable distribution across groups. The Student's *t*-test (*t*) was used to assess the significance of differences for the mean in the two groups. The ANOVA analysis of variance (*F*) test was used to assess the significance of differences for the mean across several groups. Pearson's correlation was used to analyse the correlation between the number of admissions and incidence. The significance level was set at $p < 0.05$.

RESULTS

Characteristics of the study group

A group of 109 patients diagnosed with LD and hospitalised between 2013 and 2018 in the Provincial Specialist Children's Hospital in Olsztyn were included in the study. The study was based on the analysis of patients' medical records. There was a decrease in the number of children treated for LD over the years, from 26 cases in 2013 to 9 cases in 2018. The percentage distribution of treated patients by year is shown in Fig. 1.

The study enrolled 109 children aged 3–18 years. Boys and girls accounted for 29.36% and 70.64%, respectively.

Half of the subjects were 9–15 years old. The mean age was 11.7 ± 4 years with a median of 12 years (11.8 ± 3.9 years with a median of 13 years in boys, 11.6 ± 4.1 years with a median of 12 years in girls). Four age ranges were distinguished: early childhood (2–3 years), preschool age (4–6 years), school age (7–15 years) and adolescence (16–18 years). The majority of patients (63.30%) were in the age range 7–15 years. There were significantly fewer 16–18-year-olds (22.94%) and 4–6-year-olds (11.01%), and the fewest 2–3-year-olds (2.75%) (Tab. 1).

In a detailed analysis, the distribution of the number of patients in the individual age groups differed significantly over subsequent years ($\chi^2 = 32.88$, $p < 0.005$), with fewer youngest patients and significantly more school-aged patients (7–15 years) in 2016–2018.

In a detailed analysis, the distribution of the number of patients by gender also differed significantly over subsequent years ($\chi^2 = 13.09$, $p < 0.03$). The vast majority were girls, with more affected boys only in 2017 (Tab. 1).

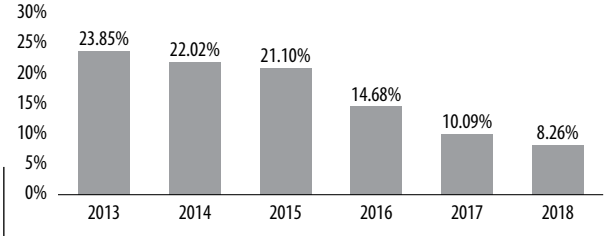

Fig. 1. Distribution of the number of medical records by years

The distribution of the place of residence in the study group was as follows: urban residents represented the majority (52.29%) of the study group, whereas rural residents accounted for 47.71%. The data are presented in Tab. 1.

In a detailed analysis, the distribution of the number of patients by the place of residence differed significantly over subsequent years ($\chi^2 = 12.44$, $p < 0.03$). In 2013 and 2017, significantly more patients were from rural areas, whereas there were significantly more urban patients in 2016 (Tab. 1).

Mode of hospital admission and patients' vital signs

There were both elective and emergency admissions (56.88% and 43.12%, respectively) (Tab. 1) in the study population.

In a detailed analysis, the distribution of the number of patients by the mode of hospital admission differed significantly over subsequent years ($\chi^2 = 24.01$, $p < 0.00006$). Significantly more emergency admissions were observed in 2014, while significantly more elective admissions were reported in 2015. Elective admissions accounted for the vast majority in 2017–2018.

More than three quarters of the study group (85.32%) were admitted to hospital with a referral and only 14.68% were admitted without a referral. In a detailed analysis, the distribution of the number of patients admitted with a referral was similar over subsequent years ($\chi^2 = 8.35$, $p < 0.13$) (Tab. 1).

On admission, patients underwent an initial examination for their vital signs. All children were transported to hospital by their parents or legal guardians. Normal and elevated body temperature was found on admission in 91.74% and 8.26%; normal and increased blood pressure was found in 87.16% and 12.4%; normal and elevated heart rate was recorded in 88.07% and 11.93% of patients, respectively. Lymph node findings were unremarkable in 94.5% of cases. Enlarged submandibular and cervical lymph nodes were found in 3.67% and 1.83% of patients, respectively. All children were conscious on admission.

During history collection on admission, about three-quarters of the patients (73.39%) reported that they had not previously been hospitalised, and 26.61% of the patients had already been hospitalised for reasons such as headaches (17.43%) or joint pain (9.17%), which could indicate non-specific infection with *Borrelia burgdorferi*. Additionally, about three quarters of patients (72.48%) had never attended a specialist clinic, while 27.52% of patients were already under the care of a neurological (19.27%), rheumatological (6.42%) or orthopaedic (2%) clinic due to symptoms similar to those presented on admission.

Symptoms on admission

In order to establish the diagnosis, medical history was taken from patients, including symptoms and complaints that were the reason for presenting to hospital. Most patients

DOI: 10.15557/PiMR.2024.0014

Sociodemographic data	2013		2014		2015		2016		2017		2018		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Age														
Early childhood – 2–3 years	1	3.85%	1	4.17%	0	0%	0	0%	0	0%	1	11.1%	3	2.75%
Preschool age – 4–6 years	3	11.54%	3	12.50%	4	17.39%	0	0%	0	0%	2	22.2%	12	11.01%
School age – 7–15 years	10	38.46%	15	62.50%	19	82.61%	12	75.00%	9	81.82%	4	44.4%	69	63.30%
Adolescence – 16–18 years	12	46.15%	5	20.83%	0	0%	4	25.00%	2	18.18%	2	22.2%	25	22.94%
Gender														
Male	8	30.77%	3	12.50%	7	30.43%	4	25.00%	8	72.73%	2	22.22%	32	29.36%
Female	18	69.23%	21	87.50%	16	69.57%	12	75.00%	3	27.27%	7	77.78%	77	70.64%
Place of residence														
Urban	10	38.46%	13	54.17%	11	47.83%	14	87.50%	4	36.36%	5	55,56%	57	52.29%
Rural	16	61.54%	11	45.83%	12	52.17%	2	12.50%	7	63.64%	4	44.44%	52	47.71%
Mode of admission														
Emergency	12	46.15%	19	79.17%	6	26.09%	8	50.00%	1	9.09%	1	11.11%	47	43.12%
Elective	14	53.85%	5	20.83%	17	73.91%	8	50.00%	10	90.91%	8	88,89%	62	56.88%
Admission with referral														
Yes	22	84.62%	18	75.00%	20	86.96%	13	81.25%	11	100%	9	100%	93	85.32%
No	4	15.38%	6	25.00%	3	13.04%	3	18.75%	0	0%	0	0%	16	14.68%

Tab. 1. Sociodemographic characteristics of patients

Symptoms on admission	*n*	%
Headaches	75	68.81%
Joint pain	22	20.18%
Pain in limbs	10	9.17%
Joint oedema	8	7.34%
Muscle pain	7	6.42%
Dizziness	32	29.36%
Fever	9	8.26%
Facial nerve palsy	9	8.26%

Tab. 2. Symptoms on admission

(68.81%) complained of headaches. Dizziness was experienced by 29.36% of patients, and about one in five patients (20.18%) reported joint pain. Limb pain was reported by 9.17%, fever by 8.26%, joint oedema by 7.34% and muscle pain by 6.42% of patients (Tab. 2).

During history taking, one, two and three symptoms were reported by 87.16%, 7.34%, and 5.5% of patients, respectively.

The patients usually reported various types of pain on admission. Perceived pain is measured in the Provincial Specialist Children's Hospital in Olsztyn using the FACES visual scale for children <3 years of age and the Numeric Rating Scale (NRS) for older patients. In the study group, pain on admission was rated on a 0–10 scale and was described using six severity categories. Most patients (35.78%) described their pain as moderate. Mild, severe, very severe, and unbearable pain was reported by 30.28%, 16.51%, 6.42%, and 2.75% of patients, respectively. No pain was reported by 8.26% of respondents. The data are presented in Tab. 3.

Pain severity ranged from 2 to 5 in half of the patients. The mean pain severity score was 3.6 ± 2.2 with a median of 4 (3.3 ± 1.8 with a median of 4 in boys, 3.7 ± 2.4 with a median of 4.2 in girls). A Student's *t*-test (*t*) used to assess the significance of differences for the mean in the male and female groups found no significant differences in pain severity on admission between these groups (Tab. 3).

In order to verify whether pain severity was related to age, it was analysed in two categories: 0–4 (no or mild-to-moderate pain) for 74.32% of patients and 5–10 (severe or unbearable pain) for 26.68% of patients. The mean age of the patients was calculated in each group. The significance of differences in the mean age of the patients in these groups was assessed using the Student's *t*-test. The analysis ($t = -2.05$, $p < 0.04$) showed that the mean age of subjects with pain 5–10 was higher than that of patients with pain 0–4 (Tab. 3).

It was also verified whether pain severity determined the mode of hospital admission. To this end, the distribution of patients with 0–4 and 5–10 pain was assessed in admission groups. The analyses revealed statistically significant differences in the distribution of the number of patients ($\chi^2 = 12.41$, $p < 0.0004$) (Tab. 3).

Patients with pain 0–4 were significantly more likely to be admitted electively, while those with pain 5–10 were admitted as an emergency.

Statistical significance was found in the group of patients with limb pain ($\chi^2 = 10.33$, $p < 0.005$). This group of patients was significantly more likely to present with a single symptom on admission.

Statistical significance was found in the group of patients presenting with muscle pain ($\chi^2 = 10.99$, $p < 0.004$). Patients in this group were significantly more likely to present with one symptom on admission (Tab. 4).

Skin lesions

In the study group, no skin lesions were found in 47.71%, one lesion was detected in 46.79%, and two or three lesions

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Pain on admission	***n***	**%**									
No pain 0	9	8.26%									
Mild 1–2	33	30.28%									
Moderate 3–4	39	35.78%									
Severe 5–6	18	16.51%									
Very severe 7–8	7	6.42%									
Unbearable 9–10	3	2.75%									
Total	109	100%									
Pain on admission by gender	***n***	$\bar{x}$	**−95%**	**+95%**	***Me***	**Min**	**Max**	**Q_1**	**Q_3**	**Range**	***SD***
Male	32	3.3	2.7	4.0	3	0	6	2	5	6	1.8
Female	77	3.7	3.1	4.2	4	0	10	2	4	10	2.4
Total	109	3.6	3.2	4.0	3	0	10	2	5	10	2.2
$t = 0.70, p < 0.48$											

Pain on admission by age	$\bar{x}$	***n***	***SD***	***t***	***p***
0–4	11.25	81	4.247	−2.05	0.04
5–10	13.04	28	2.975		
Total	11.71	109	4.024		

Mode of admission	**Emergency**		**Elective**		**Total**	
	n	**%**	***n***	**%**	***n***	**%**
0–4	27	57.45%	54	87.10%	81	74.31%
5–10	20	42.55%	8	12.90%	28	25.69%
Total	47	100%	62	100%	109	100%
$\chi^2 = 12.41, p < 0.0004$						

Tab. 3. Pain intensity by gender and mode of admission

were found in 2.75% of patients. It was verified whether the presence of skin lesions was related to the number of symptoms on admission. The analysis found a statistically significant relationship ($\chi^2 = 16.22$, $p < 0.01$) (Tab. 4).

Patients with no skin lesions were significantly more likely to present with a higher number of symptoms on admission. Children with skin lesions were significantly less likely to present with two or three symptoms on admission. The following skin lesions were observed in the study group: redness at the tick bite site (1%), lymphocytic nodule (5.5%) and erythema migrans (3.67%). Statistical significance was found in the group of patients with no skin lesions ($\chi^2 = 10.22$, $p < 0.006$). This group was significantly more likely to present with several symptoms on admission (Tab. 4).

The time between the diagnosis of Lyme disease and symptom onset and complications

The difficulty in correctly diagnosing LD in the absence of specific symptoms means that patients present to the doctor with non-specific symptoms and at different time points from their onset. More than half of the patients (54.13%) developed their first symptoms over less than 3 months (0–3 months). The first symptoms occurred over 4–6 months before the diagnosis in about one in four patients (23.85%), over 7–12 months in 14.68%, over 13–24 months in 3.67%, and 36 months before admission in 0.92% of patients.

In a further analysis, it was assessed whether age or gender determined the time of symptom onset. For this purpose, two categories of symptom onset were distinguished. For each group, the mean age of the patients was calculated and the Student's *t*-test was used to verify if the mean ages in the two groups were equal ($t = -2.28$, $p < 0.02$) (Tab. 5). The analysis found that the mean age of patients whose first symptoms appeared later than after 7 months was significantly higher (13.3 ± 3.9 years) than the mean age of those who developed their first symptoms before 7 months (11.2 ± 4 years). To confirm this, the chi-square test was used to check the distribution of the number of cases in the groups of symptom onset for age groups. The chi-square test showed that the distribution of cases in the groups of symptom onset differed significantly for age groups ($\chi^2 = -12.87$, $p < 0.004$) (Tab. 5).

The analysis demonstrated that there were significantly more younger patients in the groups with a more rapid symptom onset. There were no statistically significant differences in the time of symptom onset between boys and girls ($\chi^2 = 0.50$, $p < 0.47$).

To check whether there was a correlation between the month of developing LD and the time of symptom onset, patients were classified into three groups based on the time of symptom onset: 0–3 months, 4–6 months and >7 months. More than half of the patients (54.13%) developed symptoms at 0–3 months. About one in four patients (23.85% and 22.02%, respectively) developed symptoms at 4–6 or >7 months. The analysis showed that the distribution of

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Symptoms	Number of symptoms on admission								χ^2	*p*
	One		Two		Three		Total			
	n	%	*n*	%	*n*	%	*n*	%		
Headaches	65	59.63%	7	6.42%	3	2.75%	75	68.81%	2.45	0.29
Joint pain	17	15.60%	2	1.83%	3	2.75%	22	20.18%	3.06	0.21
Pain in limbs	5	4.59%	2	1.83%	3	2.75%	10	9.17%	10.33	0.005
Joint oedema	6	5.50%	0	0.00%	2	1.83%	8	7.34%	4.79	0.09
Muscle pain	3	2.75%	1	0.92%	3	2.75%	7	6.42%	10.99	0.004
Dizziness	28	25.69%	3	2.75%	1	0.92%	32	29.36%	1.54	0.46
Fever	6	5.50%	2	1.83%	1	0.92%	9	8.26%	2.96	0.22
Facial nerve palsy	8	7.34%	1	0.92%	0	0%	9	8.26%	1.2	0.54
Skin lesions										
Reddening at the bite site	11	3.67%	1	1.05%	0	0%	97	88.99%	1.44	0.48
Erythema migrans	3	5.50%	1	1.05%	0	0%	105	96.33%	0.62	0.44
Lymphocytoma	5	11.01%	1	1.05%	0	0%	103	94.50%	1.25	0.25
No	43	40.37%	1	1.05%	1	12.50%	44	40.37%	10.20	0.006
Number of skin lesions										
No lesions	40	42.11%	6	75.00%	6	100%	52	47.71%	$\chi^2 = 16.22$, $p < 0.01$	
One	50	52.63%	1	12.50%	0	0%	51	46.79%		
Two	3	3.16%	0	0%	0	0%	3	2.75%		
Three	2	2.11%	1	12.50%	0	0%	3	2.75%		
Total	95	100%	8	100%	6	100%	109	100%		

Tab. 4. Symptoms and skin lesions on admission

Symptom onset [months]	Age										
	n	$\bar{x}$	–95%	+95%	*Me*	Min	Max	Q_1	Q_3	Range	*SD*
0–6	85	11.2	10.4	12.1	12	3	18	9	14	15	4.0
>7	24	13.3	11.7	15.0	14	5	18	11	17	13	3.9
Total	109	11.7	10.9	12.5	12	3	18	9	15	15	4.0
$t = -2.28, p < 0.02$											

Symptom onset [months]	Early childhood – 2–3 years		Preschool age – 4–6 years		School age – 7–15 years		Adolescence – 16–18 years		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
0–6	3	100%	11	91.67%	58	84.06%	13	52.00%	59	54.13%
>7	0	0%	1	8.33%	11	15.94%	12	48.00%	50	45.87%
Total	3	100%	12	100%	69	100%	25	100%	109	100%
$\chi^2 = -12.87, p < 0.004$										

Tab. 5. Symptom onset depending on age

the time of symptom onset by month differed significantly ($\chi^2 = 39.99$, $p < 0.02$). A significantly higher number of patients had a time of symptom onset of 4–6 months between January and May, >7 months in August, 0–3 months in October and 4–6 months in November (Tab. 6).

The circumstances of infection

About 74.31% of patients did not recall a tick bite, and 26.69% of children claimed to have had a tick bite in the past.

Next, the relationship between the place of residence, age and gender of the children hospitalised in the Provincial Specialist Children's Hospital in Olsztyn and the confirmed or negated tick bite in medical history was assessed.

A detailed analysis with the chi-square test found no significant effect of the place of residence on confirmed or negated tick bite in medical history ($\chi^2 = 2.56$, $p < 0.10$) (Tab. 7).

A detailed analysis with the chi-square test revealed no significant effect of age on confirmed or negated tick bite in medical history ($\chi^2 = 3.13$, $p < 0.37$) (Tab. 7).

Also, a detailed analysis with the chi-square test showed no significant effect of gender on confirmed or negated tick bite in medical history ($\chi^2 = 1.19$, $p < 0.27$) (Tab. 7).

Circumstances of infection in the group of patients with confirmed tick bite

The cases of confirmed tick bite ($n = 28$), which were more common among girls (Tab. 8), were further analysed. Almost

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Month	0–3		4–6		7–12		Total	
	n	%	*n*	%	*n*	%	*n*	%
January	1	1.7%	4	15.4%	1	4.2%	6	5.50%
February	3	5.1%	0	0%	1	4.2%	4	3.67%
March	3	5.1%	3	11.5%	4	16.7%	10	9.17%
April	5	8.5%	5	19.2%	1	4.2%	11	10.09%
May	4	6.8%	4	15.4%	0	0%	8	7.34%
June	5	8.5%	0	0%	2	8.3%	7	6.42%
July	6	10.2%	0	0%	3	12.5%	9	8.26%
August	4	6.8%	4	15.4%	4	16.7%	12	11.01%
September	4	6.8%	0	0%	1	4.2%	5	4.59%
October	15	25.4%	2	7.7%	4	16.7%	21	19.27%
November	8	13.6%	4	15.4%	3	12.5%	15	13.76%
December	1	1.7%	0	0%	0	0%	1	0.92%
Total	59	100%	26	100%	24	100%	109	100%

Tab. 6. Distribution of the time of symptom onset by months in the study group of patients hospitalised in the Provincial Specialist Children's Hospital in Olsztyn

Data characteristics	Tick bite					
	Yes		No		Total	
	n	%	*n*	%	*n*	%
Place of residence						
Urban	11	39.29%	46	56.79%	57	52.29%
Rural	17	60.71%	35	43.21%	52	47.71%
Total	28	100%	81	100%	109	100%
$\chi^2 = 2.56, p < 0.10$						
Age						
Early childhood – 2–3 years	1	3.57%	2	2.47%	3	2.75%
Preschool age – 4–6 years	5	17.86%	7	8.64%	12	11.01%
School age – 7–15 years	14	50.00%	55	67.90%	69	63.30%
Adolescence – 16–18 years	8	28.57%	17	20.99%	25	22.94%
Total	28	100%	81	100%	109	100%
$\chi^2 = 3.13, p < 0.37$						
Gender						
Male	6	21.43%	26	32.10%	32	29.36%
Female	22	78.57%	55	67.90%	77	70.64%
Total	28	100%	81	100%	109	100%
$\chi^2 = 1.19, p < 0.27$						

Tab. 7. Tick bite in groups by the place of residence, age, and gender

half of patients (42.86%) were bitten on the head. A bite in the trunk area or lower limb was reported by 25% each, and 7.14% of children were bitten in the upper limb (Tab. 8).

Next, the extent to which the patients' gender and age impacted the site of tick bite was assessed. The analysis found no significant differences between boys and girls. The distribution of bite sites in the trunk, lower limb and unspecified bite site were similar in the groups of boys and girls ($p < 0.23$). No statistically significant differences were found when analysing the impact of age on the bite site. This means that the distribution of tick bite sites was similar across all age groups (Tab. 8).

Among the patients confirming a tick bite ($n = 28$), about half (53.57%), one in five (17.86%), and 10.71% of patients were attacked by a tick in the forest, a park, and on a meadow, respectively. One in five children confirming a tick bite could not identify the exact place of the attack (Tab. 9).

Next, it was verified whether there was a relationship between the place of residence, gender and age of admitted children and the place of tick attack. Statistically significant differences were found between the distribution of places of tick attack and the place of residence ($\chi^2 = 13.39$, $p < 0.003$). There were significant differences in places of tick attacks among the analysed groups. Rural patients were significantly more likely to be bitten by a tick on a meadow or in a forest, while urban children were more likely to be bitten by a tick in a park. There were no statistically significant differences between the distribution of places of tick attack and gender ($\chi^2 = 5.85$, $p < 0.11$). Places of tick attacks were similar for boys and girls (Tab. 9).

DOI: 10.15557/PiMR.2024.0014

Site of tick bite	Gender					
	Male		Female		Total	
	n	%	*n*	%	*n*	%
Head	1	16.67%	11	50.00%	12	42.86%
Upper limb	0	0%	2	9.09%	2	7.14%
Torso	3	50.00%	4	18.18%	7	25%
Lower limb	2	33.33%	5	22.73%	7	25%
Total	6	100%	22	100%	28	100%
$\chi^2 = 4.27, p < 0.23$						

Site of tick bite	Age							
	Early childhood – 2–3 years		Preschool age – 4–6 years		School age – 7–15 years		Adolescence – 16–18 years	
	n	%	*n*	%	*n*	%	*n*	%
Head	0	0%	2	40.00%	6	42.86%	4	50.00%
Upper limb	0	0%	1	20.00%	0	0%	1	12.50%
Torso	0	0%	1	20.00%	5	35.71%	1	12.50%
Lower limb	1	100%	1	20.00%	3	21.43%	2	25.00%
Total	1	100%	5	100%	14	100%	8	100%
$\chi^2 = 7.27, p < 0.60$								

Tab. 8. Site of tick bite and age and gender

There were no statistically significant differences between the distribution of places of tick attack and the age of patients ($\chi^2 = 14.89$, $p < 0.09$). Places of tick attacks were similar across different patient age groups (Tab. 9).

DISCUSSION

Lyme disease is the most common tick-borne disease in Poland. Ticks of the genus *Ixodes* infected with the *Borrelia* spirochete are increasingly common in both rural and urban areas. In the present study, we analysed medical records of children hospitalised in the Provincial Specialist Children's Hospital in Olsztyn, residing in the Warmian-Masurian Province. Warmia and Mazury is an endemic area for tick-borne diseases, with an average incidence of LD of 79.1 cases per 100,000 inhabitants in the general population. Although no statistical data are available on the incidence of LD among children in Poland, it can be assumed that it is at a similar level to that in our western neighbour. In Germany, the incidence of LD in the population of children under 15 years of age ranges from 5.9 to 8.6 cases per 100,000 population[27,28]. There was a steady increase in the incidence of LD between 2013 and 2018, with 736 cases in 2013 and 1,398 cases in 2016. The number of cases remained at a similar level between 2017 and 2018, with 1,302 and 1,306 cases in 2017 and 2018, respectively. An analogous decrease and stabilisation of LD cases was observed in the Netherlands[29].

Girls accounted for the vast majority of the study group (70.64%). This observation is in stark contrast to European studies, which indicate that LD is only slightly more prevalent in females[30,31], and at the same time contradicts the results of studies conducted in the United States, where LD was more prevalent in males by a few per cent, especially in the paediatric population[32]. In terms of gender, our findings differed from those obtained in a study conducted at the Medical University of Warsaw, where girls and boys accounted for 46.1% and 53.9%, respectively, of children diagnosed with LD based on the presence of erythema migrans[33].

Our patients were admitted to the Provincial Specialist Children's Hospital in Olsztyn electively or as an emergency. The mode of patient admission differed significantly over the study period ($\chi^2 = 24.01$, $p < 0.00006$). Significantly more emergency admissions were observed in 2014, while significantly more elective admissions were recorded in 2015. In 2017–2018, there were significantly more elective cases, which correlated with a decreasing number of hospital admissions each year and fewer children with LD-specific symptoms presenting to hospital. The majority of admitted patients (85.32%) presented with a referral, indicating that the disease had not previously been diagnosed and hospital stay was therefore required. About 72.48% of patients were under the care of specialist outpatient clinics due to presenting symptoms and 26.61% had previously been hospitalised in a lower referral unit.

On admission, patient's history collection, physical examination including lymph node assessment and basic investigations including body temperature, blood pressure and saturation were performed. Elevated body temperature was found in 5.5% of children, whereas it was normal in other children. Normal and elevated blood pressure was recorded in 87.16% and 12.84% of children, respectively. Oxygen saturation was normal in all subjects. Overweight or obesity was found in 17.43% of patients. These data differ from a 2013 study conducted at the Medical University of Bialystok, in which the majority of subjects were overweight, noting that these were adults[34]. On physical

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Data	The place of tick attack									
	Meadow		Forest		Park		Unspecified		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Place of residence										
Urban	0	0%	4	36.36%	5	45.45%	2	18.18%	11	100%
Rural	3	17.65%	11	64.71%	0	0%	3	17.65%	17	100%
Total	3	10.71%	15	53.57%	5	17.86%	5	17.86%	28	100%
$\chi^2 = 13.39, p < 0.003$										
Gender										
Male	2	33.33%	2	33.33%	0	0%	2	33.33%	6	100%
Female	1	4.55%	13	59.09%	4	18.18%	4	18.18%	22	100%
Total	3	10.71%	15	53.57%	4	14.29%	6	21.43%	28	100%
$\chi^2 = 5.85, p < 0.11$										
Age										
Early childhood – 2–3 years	0	0%	1	100%	0	0%	0	0%	1	100%
Preschool age – 4–6 years	1	20.0%	3	60.0%	1	20.0%	0	0.0%	5	100%
School age – 7–15 years	2	14.29%	4	28.57%	2	14.29%	6	42.86%	14	100%
Adolescence – 16–18 years	0	0%	7	87.5%	1	12.5%	0	0%	8	100%
Total	3	10.71%	15	53.57%	4	14.29%	6	21.43%	28	100%
$\chi^2 = 14.89, p < 0.09$										

Tab. 9. The place of tick attack by place of residence, age, and gender

examination, 94.5% of patients presented with no lymphadenopathy, only 3.67% had enlarged submandibular nodes and 1.83% had enlarged cervical nodes without evidence of inflammation in blood tests. Similar results were obtained by Żarkowski et al. (8.3% of patients had enlarged submandibular or cervical nodes)[35]. There was no borrelial lymphocytoma, which most often takes the form of a non-painful, well-demarcated red or bluish-red nodule, occurring in about 1% of affected children, in the study group[36].

Despite improvements in diagnostic techniques, the diagnosis of LD still poses a challenge. Patients with specific symptoms of LD, such as erythema migrans, are usually put on antibiotic treatment already by general practitioners. Only four patients (3.67%) in the study group presented with specific symptoms in the form of erythema migrans. The other children had non-specific symptoms such as pain (68.81%) and dizziness (29.36%), joint pain (20.18%), joint oedema (6.42%), limb pain (9.17%), skin lesions (11.93%), fever (8.26%) and facial nerve palsy (8.26%). These data are mostly in line with Żarkowski et al.[35] from the Poznan University of Medical Sciences, as well as with US studies[37]. Only the 20% increase in the number of children reporting headaches is noteworthy. The analyses showed that patients reporting limb pain were statistically significantly more likely to confirm one symptom during history taking on admission ($\chi^2 = 10.33$, $p < 0.005$); children who reported muscle pain as a symptom were also statistically significantly more likely to only have this one symptom ($\chi^2 = 10.99$, $p < 0.004$). If, on the other hand, patients presented with skin lesions on admission, they were statistically significantly more likely ($\chi^2 = 13.6$, $p < 0.001$) report other LD symptoms. In such cases, the diagnosis of LD requires a very detailed history, serological tests, as well as doctor's intuition and experience, as these symptoms also occur in other clinical entities.

The time between the onset of disease symptoms and treatment initiation is the key determinant of therapeutic efficacy. The shorter it is, the greater the chances of curing or minimising complications of the underlying disease.

This also applies to the course of LD. In the study group, symptom onset occurred less than 3 months after a bite in more than half (54.13%) of the children, between 4 and 6 months in one in four patients (23.85%), between 7 and 12 months in 14.68%, between 13 and 24 months in 3.67%, and >2 years before admission in only 0.92% of patients. It can be concluded based on statistical analysis that children <7 years of age were statistically significantly more likely ($\chi^2 = 12.87$, $p < 0.004$) to be hospitalised sooner as a result of reported symptoms, which contributed to a faster diagnosis of LD. Parents of younger children tend to respond to their children's reported symptoms more quickly, whereas the symptoms reported by older children are often misinterpreted by adults as reluctance to fulfil school duties, as highlighted in the collected history. This is due to child-parent communication difficulties, which tend to increase with age, as also indicated by White et al.[38].

During medical interview, most children (87.16%) confirmed the presence of only one symptom, 7.34% of patients reported two symptoms and only 5.5% reported three different symptoms. Pain, skin lesions and dizziness were the predominant symptoms, with fever and facial nerve palsy being less common. Pain of varying intensity was the most common symptom. The FACES scale was used for pain intensity measurement in children <3 years of age; the NRS numeric scale was used in other patients. Both tools measure pain intensity from 1 to 10. Only 8.26% of patients

DOI: 10.15557/PiMR.2024.0014

reported no pain on admission, with the remaining group (91.74%) complaining of pain of varying intensity. The pain score ranged between 2 and 5 in half of the patients. There were no significant statistical correlation between patient's gender and pain severity. Statistical analysis showed that the mean age of patients who rated their pain 0–4 was lower than that of patients rating their perceived pain as 5–10 ($t = 2.05$, $p < 0.4$). This was probably due to the fact that parents tend to respond to pain complaints reported by younger children much faster than in the case of older children. It may be assumed that parents of older children often underestimate symptoms they report, as they assume that these are deliberately simulated in order to avoid school or household duties. At the same time, adolescents often have difficulties in communicating with their parents and try to solve their problems without their involvement, which leads to further progression of the disease[39]. There were also statistically significant differences ($\chi^2 = 12.41$, $p < 0.0004$) between the perceived pain score and the mode of hospital admission. Patients with a pain score of 0–4 were more likely to be admitted on an elective basis, whereas children with a pain score of 5–10 were admitted as an emergency. This was probably due to the fact that parents did not underestimate pain of higher intensity and reported immediately to hospital emergency departments, as confirmed by Mazur et al.[40]. It appears rom the available literature that no studies have been conducted to date on the severity of pain during hospital admission in children with suspected LD.

In addition to pain, children hospitalised for LD reported various skin lesions. In the study group, they were observed in 11.93% of children, which is in contrast to studies by Andrzejewski and Woźniakowska-Gęsicka conducted in the 3rd Department of Paediatrics of the Polish Mother's Memorial Hospital – Research Institute in Łódź, where skin lesions were observed in 25% of children diagnosed with LD[41]. These lesions occurred in patients who presented to hospital within 3 months of symptom onset. Choroś et al. reported that 50–70% of infected individuals developed skin lesions between three days and one month after a tick bite[42]. Skin lesions such as redness at the bite site (11.1%), a lymphocytoma (5.5%) and erythema migrans (3.67%) were observed in patients. Erythema migrans, a specific symptom of LD, was observed in 3.67% of children, which differs from the results obtained in a Canadian study, where the percentage was 18%[25,43].

The analysis showed varying time elapsed between the onset of first symptoms and the month of hospital admission ($\chi^2 = 39.99$, $p < 0.02$). Between January and May, significantly more patients had a time of symptom onset of 4–6 months, >7 months in August, 0–3 months in October and 4–6 months in November.

A history of a tick bite was denied by 74.3% ($n = 81$), and confirmed by 25.69% ($n = 28$), which is largely in line with the results obtained by Flisiak and Szechiński[44], where one-third of patients could recall a tick contact. When assessing whether there was a relationship between the place of residence, gender and age and a confirmed tick bite, no significant statistical differences were found; it therefore can be concluded that the above factors have no impact on infection with *Borrelia burgdorferi*. However, a new phenomenon was observed in the study group. Namely, contrary to the prevailing view, urban (52.29%) rather than rural children (47.71%) were more likely to be bitten by a tick. This may be due to the greater activity of children during spring and summer, and the growing tick populations in urban areas. Ticks are brought to urban areas largely by migrating rodents, wild boar and small songbirds[45,46]. Progressing urbanisation related to the expansion of cities, which are getting closer to forest areas and various types of meadows and agricultural wastelands, promotes the spread of ticks.

The majority of patients confirming a tick bite ($n = 28$) came from rural areas (60.71%, $n = 17$), while 39.29% ($n = 11$) were urban residents. When analysing this subgroup, it was found that girls accounted for the vast majority (78.57%, $n = 22$). This is probably due to the fact that girls take more care of their personal hygiene, tend to look at their own bodies more often, and they report any suspicious symptoms, such as itchy skin, to their parents. Boys are less concerned with personal hygiene, and are more mobile, spending more time involved in activities that can result in all sorts of minor abrasions and scratches, making it more difficult to possibly detect a tick.

A forest (53.57%), followed by a park (14.29%) and a meadow (10.71%) were the most common sites of tick attacks. The site of tick attack could not be specified by 21.43% of the patients. Statistical analysis revealed significant differences between the distribution of the area where the tick bite occurred and the patient's place of residence ($\chi^2 = 11.8$, $p < 0.008$). Hospitalised children from rural areas were significantly more likely to have been bitten by a tick in a forest or on a meadow, while urban children were more likely to have been bitten in a park. As in the entire study population ($n = 109$), the age and gender did not significantly correlate with the site of tick attack. In patients confirming a tick bite, the head (42.86%), followed by the trunk and lower limb (25% each), as well as the upper limb (7.14%), was the most common location of bite, which is consistent with the available literature[3,47]. An analysis of the child's age and the site of a tick bite found that all children under 3 years of age were bitten on the lower limb.

CONCLUSIONS

School-age urban girls accounted for the majority of patients hospitalised with the diagnosis of LD. A tick bite was denied by 74.31% of children. Patients diagnosed with *Borrelia burgdorferi* infection were mainly admitted to hospital as emergencies. The severity of pain was correlated with the mode of hospital admission – children rating their pain >5 were more likely to be admitted as emergencies. The mean age of admitted patients with a pain level of 5–10 was higher compared to children who declared a pain level

 DOI: 10.15557/PiMR.2024.0014

of 0–4. Additionally, the patients' gender had no effect on the level of pain. The majority of patients (88.07%) hospitalised during the study period presented with non-specific LD symptoms. Children who complained of limb or muscle pain during hospital admission were significantly more likely to report one symptom, while multiple disease symptoms were significantly more common in children with skin lesions. The time between the onset of disease symptoms and the diagnosis of LD was significantly shorter in children <7 years of age. The time between symptom onset and diagnosis was up to 3 months in 54.13% of patients. The hospital stay of children <7 years of age was significantly shorter than for other age groups.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

Author contribution

Original concept of study: ER. Collection, recording and/or compilation of data: ER, DK. Analysis and interpretation of data: ER, JL, DK, CRŁ. Writing of manuscript: JL, RS. Critical review of manuscript: RS, KL, CRŁ. Final approval of manuscript: JL, RS, KL.

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