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Trends in Emergency Department Admissions Due to Renal Colic in the Pediatric Population: A Multicenter Study

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ABSTRACT

Background: Pediatric urolithiasis is relatively uncommon and is generally associated with predisposing anatomic or metabolic abnormalities. In the adult population, emergency department (ED) admissions have been associated with an increase in ambient temperature. The same association has not been evaluated in the pediatric population.

Objectives: To analyze trends in ED admissions due to renal colic in a pediatric population ($\leqslant$ 18 years old) and to assess the possible effect of climate on ED admissions.

Methods: We conducted a retrospective, multicenter cohort study, based on a computerized database of all ED visits due to renal colic in pediatric patients. The study cohort presented with urolithiasis on imaging during their ED admission. Exact climate data was acquired through the Israeli Meteorological Service (IMS).

Results: Between January 2010 and December 2020, 609 patients, ≤ 18 years, were admitted to EDs in five medical centers with renal colic: 318 males (52%), 291 females (48%). The median age was 17 years (IQR 9–16). ED visits oscillated through the years, peaking in 2012 and 2018. A 6% downward trend in ED admissions was noted between 2010 and 2020. The number of ED admissions in the different seasons was 179 in autumn (30%), 134 in winter (22%), 152 in spring (25%), and 144 in summer (23%) (P = 0.8). Logistic regression multivariable analysis associated with ED visits did not find any correlation between climate parameters and ED admissions due to renal colic in the pediatric population.

Conclusions: ED admissions oscillated during the period investigated and had a downward trend. Unlike in the adult population, rates of renal colic ED admissions in the pediatric population were not affected by seasonal changes or rise in maximum ambient temperature.

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KEY WORDS: climate, emergency department, nephrolithiasis, pediatric urolithiasis, renal colic

Pediatric urolithiasis is relatively uncommon and represent only 2% of all patients known to have urinary stones [1]. It has been reported that the incidence of pediatric stone disease has risen in the last two decades, with the greatest increase observed between the age of 12 and 17 years [2].

The etiology of adult kidney stones is multi-factorial, with observed geographic and seasonal differences affecting the rate of stone formation [3]. The etiology of pediatric urolithiasis is not as clear. Previous studies have reported that a high proportion of children with urolithiasis were found to have predisposing anatomic or metabolic abnormalities [4].

It has been reported that children with nephrolithiasis experience recurrence rates as high as 50% within 3 years [5]. Medairos and colleagues [6] performed a retrospective review of 200 children (< 17 years of age) with a diagnosis of nephrolithiasis. They reported that 41% had a subsequent stone event within 3 years, which they defined as either a subsequent surgical intervention, new stone on imaging, reported stone passage, or emergency department (ED) evaluation for renal colic. On multivariate analysis age > 12 years and personal history of urolithiasis were found to be associated with a subsequent stone event.

The etiology of adult urolithiasis has been associated with geographic and seasonal differences [7]. Multiple studies reported on the possible mechanisms in which climate factors influence the incidence of renal colic events [8]. Most have reported a link between an increase in ambient temperature and renal colic. Furthermore, it has been reported that both prevalence and incidence of urinary stones in the adult population has increased over the last three decades [9].

To the best of our knowledge, no study has investigated the recent trends in ED admissions related to pediatric renal colic and the possible effects of the climate on ED admissions. We hypothesized that, like in the adult population, pediatric renal colic events would both increase over time and be affected by a rise in ambient temperature.

PATIENTS AND METHODS

Following institutional review board approval from all participating medical centers, we performed a retrospective, multi-center study using hospital computerized databases to analyze all pediatric ED admissions due to renal colic. As this was a retrospective study, no patient consent form was necessary. The five included hospitals were geographically in the central and northern areas of Israel, spanning an area of approximately 2200 square kilometers. All hospitals were tertiary level hospitals with a designated pediatric ED.

The medical records of patients admitted to the ED were retrieved from the respective databases of each hospital, using International Classification of Disease (ICD) 10th version codes: calculus of kidney and calculus of kidney with calculus of ureter and renal colic (N20–N23). Included were patients ≤ 18 years old, who were admitted with renal colic and confirmed to have a urolithiasis after undergoing imaging.

Climate data was collected with the assistance from the Israeli Meteorological Service (IMS) [10]. The seasons were defined using meteorological definitions, according to the calendar months: spring (March 1–May 31), summer (June 1–August 31), fall (September 1–November 30), and winter (December 1-February 28 or 29). Relevant daily climate data that were collected included: daily maximum and minimum ambient temperature, daily maximum relative humidity and calculated heat index.

STATISTICAL ANALYSIS

Statistical analysis included descriptive analysis with mean and standard deviation and medians with range for continuous variables, proportions for discrete variables, and comparative tests (chi-square for discrete variables and *t*-tests for continuous variables). In addition, a multivariable logistic regression analysis was performed to determine possible associations with pediatric renal colic ED admissions. Variables in the multivariable model included season, heat index, relative humidity, maximal ambient temperature, and range of maximal and minimal daily ambient temperatures. Statistical analyses were performed using IBM Statistical Package for the Social Sciences statistics software, version 23 (SPSS, IBM Corp, Armonk, NY, USA). All statistical tests were two-tailed and a *P*-value < 0.05 was considered statistically significant.

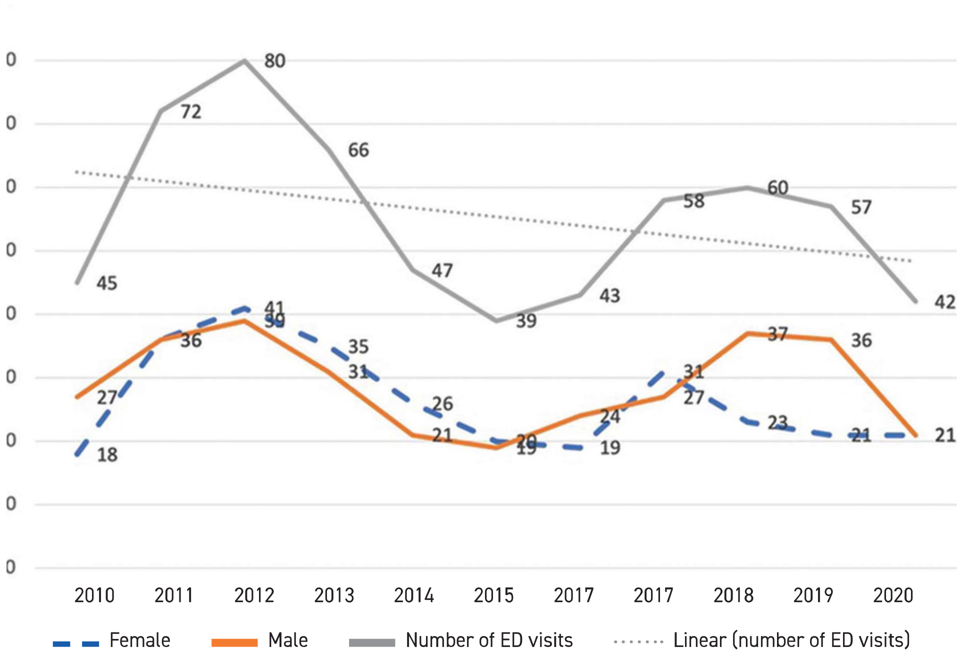
Table 1. Pediatric ED visits due to renal colic stratified by sex, 2010–2020

Variable	Total number of ED visits (n=609), n (%)	Male ED visits (n=318), n (%)	Female ED visits (n=291), n (%)	*P*-value
2010	45 (7)	27 (8)	18 (6)	0.3
2011	72 (12)	36 (11)	36 (13)	
2012	80 (13)	39 (12)	41 (14)	
2013	66 (12)	31 (10)	35 (12)	
2014	47 (8)	21 (7)	26 (9)	
2015	39 (6)	19 (6)	20 (7)	
2016	43 (7)	24 (8)	19 (6)	
2017	58 (9)	27 (8)	31 (11)	
2018	60 (10)	37 (12)	23 (8)	
2019	57 (9)	36 (11)	21 (7)	
2020	42 (7)	21 (7)	21 (7)	
Winter (December 1–February 28 or 29)	134 (22)	69 (21)	65 (22)	0.08
Spring (March 1–May 31)	152 (25)	70 (22)	82 (29)	
Summer (June 1–August 31)	144 (23)	77 (25)	67 (23)	
Autumn (September 1–November 30)	179 (30)	102 (32)	77 (26)	

ED = emergency department

Figure 1. Yearly pediatric ED admissions due to renal colic, 2010–2020

ED = emergency department



RESULTS

Between January 2010 and December 2020, 609 patients were admitted to the EDs in the five medical centers: 318 males (52%), 291 females (48%). The median age was 17 (IQR 9–16). The number of ED admissions per year and per season are shown in Table 1. ED admissions oscillated through the years, peaking in 2012 and 2018 [Figure 1]. Between the years 2010 and 2012, a 77% (35) percentage increase in admissions was noted, followed by a decline of 105% (41) in 2015. The second peak in admissions was recorded in 2018, with a 53% (21) percentage increase in admissions. The peak was followed by a 42% (18) percentage decline in the year 2020. A downward trend in ED admissions of 6% was noted between 2010 and 2020. The total of maximum monthly number of admissions in the years investigated was recorded during the months of October (66, 11%), followed by a sum of 60 admissions in both August and September (9.8% each), but this outcome was not found to be statistically significant ($P = 0.3$). The mean maximum ambient temperatures were 19.9, 25.5, 31.8, and 28.7 degrees Celsius during the winter, spring, summer, and autumn, respectively [Figure 2].

The number of ED admissions in the different seasons were 179 in autumn (30%), 134 in winter (22%), 152 in spring (25%), and 144 in the summer (23%) ($P = 0.8$). Last, logistic regression multivariable analysis assessing factors associated with ED visits did not show any correlation between climate parameters and ED admissions [Table 2].

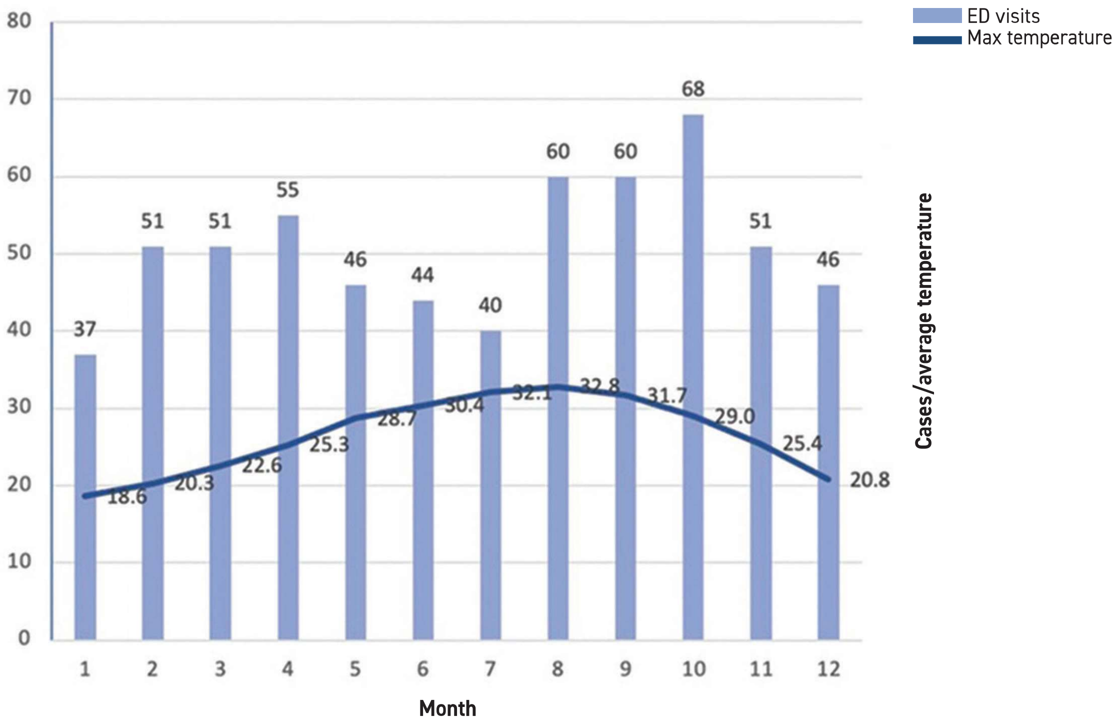
DISCUSSION

In this study we showed that the number of pediatric ED admissions due to renal colic oscillated during the years investigated. However, unlike the adult population, in which a rise in admissions was noted [11], we found a downward trend in pediatric admissions. Furthermore, we did not find any association between different climate parameters and renal colic pediatric ED admissions, in stark contrast to the adult renal colic population [12].

Urinary stone disease in the pediatric population is relatively rare, although recent data suggest an increased incidence of pediatric stones [11] and rising inpatient hospitalization rates [13].

Routh and co-authors [13] suggested possible explanations for the increased incidence of pediatric urolithiasis, including marketing, increased referral patterns,

Figure 2. Sum of yearly ED pediatric admissions due to renal colic and mean maximum monthly ambient temperature, 2010–2020
ED = emergency department
P = 0.3



increased pediatric urological staffing, and hospital capacity. Contrary to these findings, Yasui et al. [14] reported no significant changes in the incidence of pediatric urolithiasis in Japan between 1965 and 2005. In our study, we noted an oscillation in ED admissions due to renal colic, with a 6% percentage decrease in the years investigated. We hypothesized that the 42% decrease in ED admissions in the year 2020 is associated with the COVID-19 pandemic. The exact cause of these findings remains to be determined.

Adult nephrolithiasis has been reported to be more common in males [15]. This is not the case in the pediatric population. Pediatric urolithiasis has been reported with increased female predominance [13]. In our study we found an almost similar distribution between males and females in the pediatric population, with male ED admissions only slightly increased (52% vs. 48%).

The ages reported to be most affected by urolithiasis are 14–18 years old [11]. In their 12-year study, Sas and colleagues [11] reported that the lowest incidence of pediatric stones was ages 0–3 years old (0.6 per 100,000). The incidence increased to 34.9 per 100,000 in children aged 14–18 years.

Our study shows an age distribution within our cohort of pediatric ED visits spanning ages 1–18 years. The median age of our cohort was 17 years (range 1–18), indicating a notable representation of older adolescents within the study population. This observation differs from Dwyer et al. [2]. Those authors found that age-adjusted incidence rates were reported without explicit details on the age distribution. In contrast, our cohort, while inclusive of the pediatric age range, tended to skew toward older individuals. Moreover, the exclusive focus on patients younger than 17 years in the study by Medairos and colleagues [6], with a median age of 11.5 years, contrasts with our broader age inclusion. The median age of 14.8 years that Tasian et al. [5] found aligns more closely with the typical makeup of pediatric cohorts, thus providing a valuable benchmark for comparison.

Multiple studies have investigated the link between the climate, adult urolithiasis, and adult renal colic events. These studies reported an association between elevated ambient temperature and adult renal colic [16]. The exact mechanism leading to renal colic events in higher ambient temperatures remains unknown. It has been suggested that low urinary output due to sweating in higher ambi-

Table 2. Multivariable Logistic regression models assessing for possible associations with pediatric ED admissions due to renal colic

Variables	Odds ratio	95% confidence interval	*P*-value
Maximum temperature (Celsius)	1.004	0.975–1.034	0.790
Range of maximum and minimum daily ambient temperature (Celsius)	0.970	0.928–1.014	0.174
Relative humidity (%)	0.983	0.958–1.009	0.195
Heat index	1.014	0.994–1.035	0.162
Season			
Autumn (September 1–November 30), reference	NA	NA	NA
Spring (March 1–May 31)	0.837	0.637–1.100	0.202
Summer (June 1–August 31)	0.840	0.640–1.102	0.208
Winter (December 1–February 28 or 29)	0.754	0.520–1.092	0.135

ent temperatures may result in asymptomatic stones to migrate into the ureter, resulting in renal colic [16]. To the best of our knowledge, we are the first to investigate the effects of different climatic parameters on pediatric renal colic. We were surprised to find that, unlike the adult population, the climate did not seem to be associated with ED admissions in the pediatric population in the same manner. Furthermore, in a similar study conducted in Israel, Golomb and colleagues [12] reported on a link between high ambient temperature, lower heat index, and increased wind velocity as predictors for ED visits due to renal colic in the adult population. In this study we found no association between different climate parameters and renal colic events in patients ≤ 18 years of age. We surmised that this may be due to the different pathomechanisms resulting in urolithiasis in the pediatric and adult populations. In adults, stones have been mostly associated with dehydration, resulting in decreased urine volumes [17]. In the pediatric group, studies have reported on a link between metabolic abnormalities [4] and anatomic malformations [18] resulting in the majority of stones. It has been hypothesized that the increased incidence of pediatric stones may be related to childhood obesity, although clear data are lacking [19].

The key strength of our study is the large multicenter cohort and the novelty of our hypothesis. However, there are several limitations to our study, including its retrospective nature with the inherent selection bias, limited demographic data on the patients admitted to the ED with no data on either the type of imaging utilized or the imaging results, stone burden, blood work, metabolic workup, and pain levels. One notable limitation of our study pertains to the age distribution within our cohort. The inclusion criteria for our investigation were set at ages 1–18, resulting in a median age of 17 years for the 609 patients included. A substantial proportion of the cohort fell within the 17–18 age range. This demographic composition deviated from previous studies, where age ranges were more narrowly defined. This deviation may impact the generalizability of our findings, particularly when compared to studies focusing on younger age groups. Furthermore, the geographical area of the study was small compared to other countries. The small geographic area may not have provided enough regional variability across the five medical centers participating in the study. Moreover, the database was limited to ED data and thus only provided an estimate of the true incidence. Not all children with urolithiasis go to the ED; with some being treated at outpatient clinics and some not seeking care at all. Another limitation is that patients may have presented to the ED multiple times, with each presentation assigned as a unique visit. This reporting may have led to a false high number of presentations. In addition, Israel is a Mediterranean country with hot, humid weather with relatively little variability over the year. The data shown in this study may not be relevant to other parts of the world. Furthermore, given the possible influence of genetic factors in the formation of urolithiasis in the pediatric population, we believe a larger cohort of pediatric patients is required to effectively demonstrate the impact of climate on pediatric stone disease.

CONCLUSIONS

Pediatric ED admissions due to renal colic in Israel during a 10-year period remained relatively stable and did not increase. Furthermore, the rate of pediatric renal colic ED visits did not seem to be associated with seasonal changes or rise in maximum ambient temperature, perhaps resulting from the different etiology of stone disease in the pediatric population. This hypothesis needs to be further assessed in other parts of the world and in larger cohorts.

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Capsule

Independent and joint effects of air pollution and ambient temperature on all-cause mortality

Dimakopoulou and colleagues collected data from nine countries in Europe for air pollution (fine particulate matter [PM2.5], nitrogen dioxide [NO2], black carbon [BC], warm season ozone [O3]), land/built environment (normalized difference vegetation index [NDVI], distance to water, impervious surfaces), and ambient temperature (the mean and standard deviation of warm and cool season temperature). The authors observed over 3.1 million deaths out of approximately 204 million person-years. In administrative cohorts, increased exposure to PM2.5, NO2, and BC was significantly associated with all-cause mortality (pooled HRs 1.054, 1.033, and 1.032, respectively). They observed an adverse effect of increased impervious surface and mean season-specific temperature, and a protective effect of increased O3, NDVI, distance to water, and temperature variation on all-cause mortality. The effects of PM2.5 were higher in areas with lower (10th percentile) compared to higher (90th percentile) NDVI levels (pooled HRs 1.054 [95% confidence interval {95%CI} 1.030–1.079] vs. 1.038 [95%CI 0.964–1.118]). A similar pattern was observed for NO2. The CRI of air pollutants (PM2.5 or NO2) plus NDVI and mean warm season temperature resulted in a stronger effect compared to single-exposure HRs (PM2.5 pooled HR 1.061 [95%CI 1.021–1.102]; NO2 pooled HR 1.041 [95%CI 1.025–1.057]). Non-significant effects of similar patterns were observed in traditional cohorts.

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