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Original Article

Association between pluviometric index and the occurrence of acute appendicitis

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A B S T R A C T

Background: Epidemiological studies demonstrate, for unknown reasons, the prevalence of appendicitis in the summer and in young male adults, and there are controversies about its association with the rainy season. There are no studies in the State of Piauí about such association.

Objective: To establish an association between the occurrence of appendicitis and the pluviometric precipitation index.

Methodology: This is a cross-sectional study that was carried out using the database of the pathology service at a public emergency hospital in Piauí, and the pluviometric precipitation index in the State of Piauí from January 2009 to April 2014, with data from the National Institute of Meteorology. Descriptive statistics and association measures were applied using the Pearson correlation coefficient and the χ^2 test.

Results: We found a predominance of appendicitis cases in male subjects, from 11 to 20 years of age, with a predominance of the monthly mean of appendicitis cases in the second semester, which conforms to the dry season in the State of Piauí. Pearson's correlation coefficient was −0.260.

Conclusion: There is an association between the occurrence of appendicitis and the months of the year; however, this is a weak negative correlation between the monthly mean of cases of appendicitis and monthly pluviometric precipitation average in the State of Piauí.

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Associação entre índice de precipitação e a ocorrência de apendicite aguda

Palavras-chave:
Apendicite, associação
Precipitação atmosférica
Medidas de ocorrência de doenças
Análise estatística

R E S U M O

Contexto: Estudos epidemiológicos demonstram, por razões desconhecidas, o predomínio dos casos de apendicite no verão e em adultos jovens do sexo masculino, havendo controvérsias sobre sua associação com o período chuvoso. Não há estudos realizados no Piauí sobre esta associação.

Objetivo: Estabelecer uma associação entre a ocorrência de apendicite e o índice de precipitação pluviométrica.

Metodologia: Realizou-se um estudo transversal através do banco de dados do serviço de patologia de um hospital de emergência público do Piauí e do índice de precipitação no Piauí de janeiro de 2009 a abril de 2014 do Instituto Nacional de Meteorologia. Aplicou-se estatística descritiva e medidas de associação pelo coeficiente de correlação de Pearson e pelo teste qui-quadrado.

Resultados: Encontrou-se um predomínio dos casos de apendicite no sexo masculino, de 11 a 20 anos de idade, predomínio da média mensal de casos de apendicite no segundo semestre, coincidindo com o período de estiagem no Piauí. O coeficiente de correlação de Pearson foi de -0,260.

Conclusão: Existe uma associação da ocorrência de apendicite com os meses do ano, porém se trata de uma fraca correlação negativa entre a média mensal de casos de apendicite com a média da precipitação pluviométrica mensal estadual no Piauí.

Introduction

The cecal appendix is a blind-end, tubuliform structure located in the large intestine. Its size is variable; it is estimated that the appendix measures, on average, 5 cm. The cecal appendix is believed to have absorptive, bacterial proliferation (to establish the intestinal flora balance), and immunity (through the production of white blood cells) functions. Nevertheless, its real function in the human species remains elusive.[1]

Acute appendicitis is the most common surgical emergency in young adults, with a predominance of males. An incidence ratio of 1.4 men to 1 woman is estimated. In the United States, 11 out of 10,000 Americans will suffer from appendicitis throughout their lives. The etiology of appendicitis has not yet been fully elucidated. The most accepted theories are: viral, bacterial, fungal, and parasitic; but these theories are not exclusive and raise the need for pathophysiological and epidemiological clarifications.[2,3]

The morbidity and mortality of acute appendicitis are directly related to the time of evolution, and its most common complication is its perforation. It is estimated that, after 36 h of evolution, the risk of perforation is 16–36%, with an increase of 5% in every 12 h. In turn, mortality is a consequence of the time of evolution, that is, the presence of perforation. When there is no perforation, mortality in patients with appendicitis is 0.08%. Otherwise, this percentage increases to 0.51%.[3]

The average costs of an appendectomy worldwide are of the order of US$ 28,000. These costs do not take into account complications or an extended hospital stay. These values can reach more than US$ 180,000.[4]

In Brazil, since 2003, the Brazilian government, through the Ministry of Health, has instituted the National Emergency and Urgency Plan, with the aim of organizing and structuring the country's emergencies. With respect to appendicitis, an abdominal pain protocol was developed with the aim of facilitating an early diagnosis, in order to promote, as quickly as possible, the patient's referral and treatment. The goal is always the same: to reduce morbidity and mortality, in order to promote humanization in care and reduce public health spendings.[5]

Recently, several epidemiological studies have reported a historical reduction in the occurrence of appendicitis, prevalence in individuals aged 10–19 years, and a seasonal behavior in its incidence.[2]

In most countries, appendicitis occurs more often in the summer months; but this season assumes very different aspects, depending on the continent and on the country, especially with regard to the pluviometric index.[6] In Brazil, studies on this association were not recently published in Bireme; the last of these studies was published in 1992.[7] The present study aims to investigate the existence of an association between pluviometric index in the State of Piauí and the occurrence of confirmed cases of acute appendicitis seen at public hospitals in Teresina – PI.

Methodology

This is a cross-sectional study of appendicitis cases covering the period from January 2009 to April 2014 and performed at the Hospital de Urgência de Teresina Prof. Zenon Rocha (HUT), at the Pathology Service and by consultation of the electronic medical record of the patients, in order to obtain information on patient identification, his/her origin, and age at the time of diagnosis of appendicitis, and reports of the surgical specimen used by the Pathology Service for the diagnosis of appendicitis.

All cases whose origin was from another federative State or that did not have a defined origin, and also those cases whose histopathological reports had a different description of appendicitis (malignant or benign neoplasia) were excluded.

The Hospital de Urgência de Teresina Prof. Zenon Rocha (HUT) is the largest public emergency center in the State of Piauí and receives patients from all over its territory and from border cities in the State of Maranhão, thanks to the fact that among all the public hospitals of that Capital, this Center is provided with the greatest resources for laboratory and imaging exams and in terms of clinical body.

The pluviometric data for the State of Piauí from January 2009 to April 2014 were obtained by consulting the database of the National Meteorological Institute (INMET) website. Information was obtained on the monthly pluviometric precipitation average in millimeters (mm) in the State of Piauí for each of the months considered in this study. For each month of the year, a second mean of the monthly averages for each year included in the survey was generated.[8]

The data were collected and computed in a Microsoft Office Excel 2016® worksheet and transposed to a spreadsheet of the IBM SPSS (version 20) software; in this last program, descriptive statistics and inferential statistics were calculated. The cases of appendicitis were studied by age, monthly mean of cases of appendicitis, and monthly pluviometric precipitation average (in mm) in the State of Piauí for the interval studied. The frequency of cases was also calculated according to gender, age group, origin (Teresina, or Piauí's countryside), and month of the year. A p-value <0.05 was considered as statistically significant.

After calculating the measures of central tendency and dispersion, charts were elaborated for a preliminary analysis. In inferential statistics, in turn, we tested normality with the Kolmogorov–Smirnov test, at a critical level of 5%. Among the quantitative variables (monthly mean of cases of appendicitis, and mean of monthly pluviometric precipitation averages in the State of Piauí), we elaborated a scatter plot and calculated the Pearson's correlation coefficient. Among categorical or categorized variables, we evaluated the presence of an association between the variables with the application of the Pearson's chi-squared test, in accordance with Cochran's rules (the total sample should be greater than 25; at most, 20% of the expected values should be less than 5.0; and no expected value should be less than 1.0).[9,10]

We used the strength of the association through the Pearson's correlation to measure the degree of association between variables, that is, $|r| = 0$ means no correlation, up to 0.3 indicates a weak correlation, up to 0.6 suggests a regular correlation, up to 0.9 means a strong correlation, from 0.9 to 1 indicates a very strong correlation, and $|r| = 1$ implies a perfect correlation.[9]

The chi-squared test is classified as an association, adhesion or adjustment, and proportions or heterogeneity test. We reserved the first option in order to evaluate the existence of an association between two categorical variables, and the second option was used to determine if the categorical variables' data adjusted to an expected or theoretical distribution. The third option, which was not used in this study, serves to compare two or more populations in relation to a categorical variable. The Yates correction was reserved only for χ^2 tests with a degree of freedom (d.F.) = 1 in single input tables with two categories, or in 2 × 2 tables. The Yates correction consists of subtracting 0.5 from each absolute difference between observed and expected numbers, before calculating the difference squared.[9]

Table 1 – Age stratification by gender.

Age group	Gender		Gender index (M:F)	χ^2	p-Value	Total
	Female	Male				
0–10	137	258	1.88	37.06	<0.0001	395
11–20	226	404	1.78	50.29	<0.0001	630
21–30	170	337	1.98	55	<0.0001	507
31–40	108	218	1.28	37.11	<0.0001	326
41–50	62	131	2.11	24.66	<0.0001	193
51–60	53	107	2.01	18.22	<0.0001	160
61–70	37	75	2.02	12.89	0.0003	112
71–80	21	42	2	7	0.0082	63
>80	5	15	3	5	0.0253	20
Total	**819**	**1587**	**1.93**	**245.1**	**<0.0001**	**2406**

Source: Database of the Pathology Service, Hospital de Urgência de Teresina Prof. Zenon Rocha (HUT), 2016.

Note: Regarding gender, H = male; M = female. χ^2 refers to the Chi-squared test of Pearson.

This study did not confer bioethical or medical risks to the study subjects since patients were not directly approached. This study included only secondary data from information systems, being in line with the guidelines determined by the Treaty of Helsinki. The information is being kept under the full confidentiality of the authors; therefore, it may be made available to the editors of the journal at any time, upon express and official request.

The primary and secondary information inferred through this research is of interest to Public Health, considering that such information may serve as a tool for local administrators in the process of evidence-based decision making through local epidemiological observations.

Results

From January 2009 to April 2014, 3793 cases of acute appendicitis operated in the Hospital de Urgência de Teresina Prof. Zenon Rocha (HUT) were recorded, of these, 2426 cases did not meet the exclusion criteria of the study. Among these cases, there were 1599 men and 827 women, aged 0–92 years (mode = 12 years, median = 23.88 years, mean = 28.16 years, and standard deviation = 18.88 years), totaling 2406 cases with valid data.

Through an analysis of the distribution of cases, according to age groups, the cases were predominant in individuals aged 11–20 years. Likewise, in the stratification of the distribution of cases, according to gender, the same pattern of distribution was observed, but with a male gender predominance for all age groups, a finding with statistical significance (Table 1).

Table 2 – Acute appendicitis cases' counting, according to the month of diagnosis and the corresponding year.

Month of diagnosis	Diagnosis year						Total	Mean (cases/year)
	2009	2010	2011	2012	2013	2014		
January	3	28	30	33	59	42	195	39
February	1	34	49	35	53	30	202	40.4
March	5	52	24	43	59	62	245	49
April	0	45	25	24	63	39	196	39.2
May	0	37	34	39	60	–	170	42.5
June	4	37	28	21	55	–	145	36.25
July	11	29	40	0	44	–	124	31
August	40	46	52	61	70	–	269	67
September	37	44	25	45	46	–	197	49.25
October	42	44	38	65	39	–	228	57
November	49	53	28	60	51	–	241	60.25
December	30	66	30	47	41	–	214	53.5
Total	**222**	**515**	**403**	**473**	**640**	**173**	**2426**	

Source: Database of the Pathology Service, Hospital de Urgência de Teresina Prof. Zenon Rocha (HUT), 2016.

Table 3 – Monthly pluviometric precipitation average in the State of Piauí from January 2009 to April 2014.

Month	Year						Mean
	2009	2010	2011	2012	2013	2014	
January	4.89	3.71	5.59	3.01	5.18	3.27	4.27
February	6.88	3.21	7.99	5.45	2.68	7.07	5.54
March	8.11	6.39	8.39	5.33	5.28	5.4	6.48
April	11.37	5.85	6.84	2.27	5.51	5.98	6.30
May	7.8	1.67	3.88	0.82	2.07	–	3.24
June	4.89	1.39	0.71	0.87	0.65	–	1.70
July	0.73	0.2	0.78	0.126	0.67	–	0.50
August	0.157	0.02	0.217	0.008	0.18	–	0.11
September	0.05	0.043	0.03	0	0.19	–	0.06
October	2.53	2.2	2.53	0.041	0.497	–	1.55
November	0.834	1.7	1.99	1.84	1.934	–	1.65
December	3.37	4.8	0.98	1.85	3.79	–	2.95
Total	**4.30**	**2.59**	**3.32**	**1.80**	**2.38**	**5.43**	–

Source: National Institute of Meteorology (INMET), 2016.

1252 (51.6%) of the cases were from the interior of the State, and the other cases were from the Capital, with no statistically significant difference (χ^2: 2.508, 1 d.F. and p-value = 0.1133).

The cases of acute appendicitis were distributed according to months and years (Table 2). Except for the first six months of 2009, all other months have very similar absolute frequencies, and at first, it is not possible to perceive a pattern of distribution of cases over the months. However, with the use of a non-skewed estimator (the mean number of cases), it was possible to demonstrate a predominance of cases in the second half of the year, with a peak in August (Fig. 1).

By studying the monthly pluviometric index average over the period studied, we were able to observe a higher precipitation in the first semester, with a significant nadir in the second half of the year (Table 3). This finding allowed us to infer the existence of two well-defined seasons in the state of Piauí: the rainy season and the dry season (Fig. 2).

The distribution of the monthly means of cases of appendicitis and of the means of monthly pluviometric precipitation averages in the State of Piauí was normal, according to the Kolmogorov–Smirnov test (p-value = 0.20); thus, a Pearson's correlation was obtained.

After observing an inverse graphic association between the monthly mean of appendicitis cases *versus* months of the year, and between the mean of average annual pluviometric precipitation averages in the State of Piauí *versus* months of the year, we performed an analysis using the scatter plot and a calculation of the Pearson's correlation coefficient between the monthly means of appendicitis cases and the means of monthly pluviometric precipitation averages in the State of Piauí, resulting in a coefficient = −0.260 (weak negative correlation) and in a scatter plot without a well-defined trend (Fig. 3).

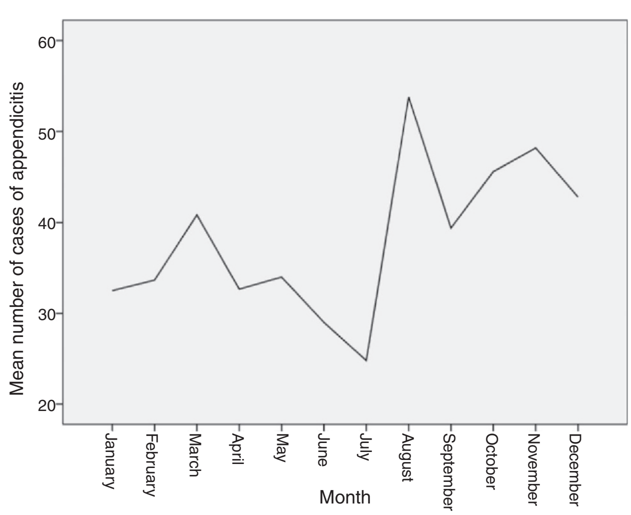

Fig. 1 – Mean number of cases of appendicitis during the months from January 2009 to April 2014.
***Source*: Database of the Pathology Service, Hospital de Urgência de Teresina Prof. Zenon Rocha (HUT), 2016.**

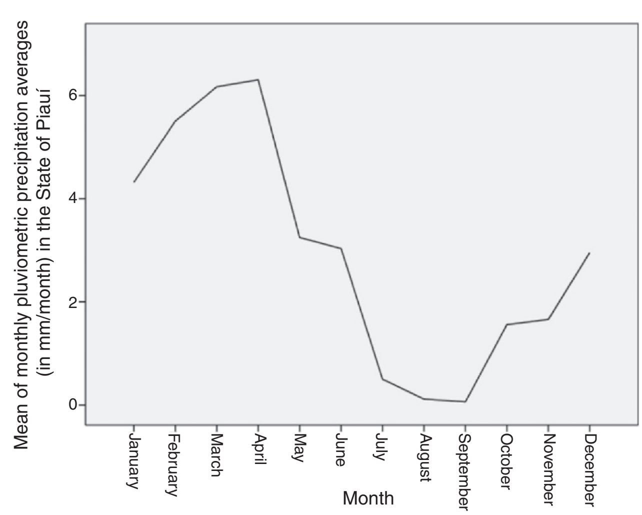

Fig. 2 – Means of monthly pluviometric precipitation averages (in millimeters) from January 2009 to May 2014 in the State of Piauí.
***Source*: National Institute of Meteorology (INMET), 2015.**

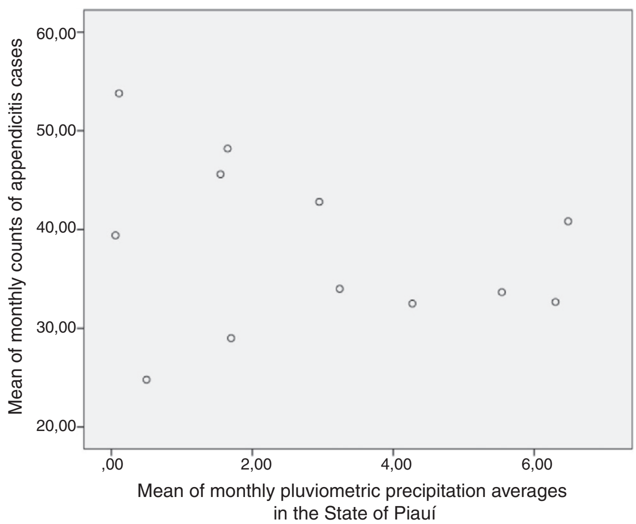

Fig. 3 – Means of monthly appendicitis cases by means of monthly pluviometric precipitation averages.
***Sources*: Secondary data obtained from the study of INMET data and from the Pathology Service, Hospital de Urgência de Teresina Prof. Zenon Rocha (HUT), 2015 and 2016.**

Discussion

The epidemiological study of appendicitis has been the focus of researchers throughout the 20th century. In the quest for causality, there are references to its association with viral diseases known to be seasonal, such as influenza. Time series obtained from 1970 to 1995 demonstrate a similar graphical behavior between influenza *versus* unperforated appendicitis and absence of a temporal relationship between appendicitis *versus* enteritis.[11]

In a national epidemiological review in Taiwan for a period of 10 years, the authors stratified the occurrence of appendicitis according to the year's seasons, taking into account the gender factor, with curves with similar tendencies for men and women, and different curves as to the frequency, that was higher for males in all months of the year. The peak incidence of appendicitis occurs in the months of May through July, with nadirs between August and February. Coincidentally, the authors demonstrated a positive correlation between the incidence of appendicitis and environmental temperature. On the other hand, it should be noted that the months of May to July show the highest rainfall records in Taiwan.[12,13]

The study by Rakesh et al. defines, in India, three seasons: summer, rainy season, and winter. There was a predominance of cases of appendicitis in the summer, and not in the rainy season, as would be expected by the preliminary association established between pluviometric precipitation and the occurrence of viral diseases. However, the study by Oguntola et al. showed that 68% of the cases of the disease occurred in the rainy season, which goes from April to September in Nigeria. Thus, it can be assumed that other factors – as yet unclarified – are associated.[14,15]

The findings of an association between the occurrence of appendicitis and months of the year led Jangra to propose a hypothesis, of a possible association also with the days of the week. The same author studied the seasonality of appendicitis in Northern Indian children throughout the months and days of the week, concluding that there were more cases of appendicitis between the months of July and October, and that, during the week, there was a peak frequency on Fridays.[16]

In the Federal District, Brazil, Vianna et al. observed a peak of incidence between February and July, a predominance of cases among individuals aged 11–20 years, and a slight predominance in males (51.9% *versus* 48.1%). The data from these investigators are in line with studies mentioned *a priori*, considering that the months of February to July include two seasons: summer (historically a rainy season) and autumn (historically a non-rainy season), in which very high temperatures and low air humidity, or long periods of precipitation and strong winds, can be registered.[7,17]

Therefore, there is an association between the occurrence of appendicitis and the months of the year, with differences among countries; in addition, its association with the pluviometric precipitation index is very controversial. There is no strong scientific evidence on the subject, but regionalized studies (cited above) that demonstrate well-established local patterns have been published.

Conclusion

With the study of the monthly averages for the interval from January 2009 to April 2014, it was possible to verify a predominance of cases of acute appendicitis in the second half of the year. It was also possible to verify the existence of two well-defined seasons, using the monthly pluviometric precipitation average in the State of Piauí: a rainy season in the first semester and a dry season in the second semester. Therefore, an annual dichotomy for both variables was perceived, which enabled us to correlate them with the Pearson coefficient. We found a weak negative correlation, that is, the higher the monthly pluviometric precipitation average, the lower the mean of monthly cases of appendicitis.

The existence of controversial studies in the literature does not allow us to affirm that the findings described above coincide with the findings of all cited authors. On the other hand, our study shows a local referential of the pattern of occurrence of appendicitis to the climatic conditions of the State of Piauí.

Conflicts of interest

The authors declare no conflicts of interest.

REFERENCES

1. Apêndice cecal. Wikipedia, a enciclopedia livre; 2016. Available from: https://pt.wikipedia.org/wiki/Apêndice_cecal [accessed 01.10.16].
2. Bernstein LS, Surick B, Leitman IM. Is acute appendicitis in the weather forecast? J Surg Res. 2013;185:23–5.

3. Bon TP, Frascari P, Moura MA, Martins MVDC. Comparative study between patients with acute appendicitis treated in primary care units and in emergency hospitals. Rev Col Bras Cir. 2014;41:341–4.
4. Daily news: an appendix removal can cost between $1.500 to $180,000 depending on where you take the surgery. New York City: The Associated Press; 2012. Daily News | Lyfestyle. Available from: http://www.nydailynews.com/life-style/health/study-hospitals-billings-shocks-researchers-appendix-removal-cost-1-500-180-000-depending-surgery-article-1.1066207 [accessed 02.10.16].
5. Brasil. Ministério da Saúde. Política nacional de atenção às urgências/Ministério da Saúde. Brasília: Ministério da Saúde; 2003.
6. Fares A. Summer appendicitis. Ann Med Health Sci Res. 2014;4:18–21.
7. Vianna A, Barichello A, Mendelssonh P, Watanabe L, Oliveira P, Diniz H, et al. Apendicite aguda: 20 anos depois. Rev Bras Coloproctol. 1992;12:77–82.
8. Brasil. Ministério da Agricultura. Pecuária e Abastecimento. Instituto Nacional de Meteorologia (INMET). Precipitação pluviométrica no Piauí de 2009 a 2014. Available from: http://www.inmet.gov.br/portal/ [accessed 01.10.16].
9. Callegari-Jacques SM. Bioestatística: Princípios e aplicações. Porto Alegre: Artmed; 2003. p. 255.
10. Higgins JJ. Introduction to modern nonparametric statistics. Belmont (CA): Books/cole, Cengage Learning; 2004. p. 366.
11. Alder AC. Association of viral infection and appendicitis. Arch Surg. 2010;145:63–71.
12. Wei P, Chen CS, Keller JJ, Lin HC. Monthly variation in acute appendicitis incidence: a 10-year nationwide population-based study. J Surg Res. 2012;178:670–6.
13. Stateopedia: Taiwan. Taiwan. Available from: http://www.stateopedia.ch/taiwan [accessed 01.10.16].
14. Rakesh R, Rashemina CD, Vijin V, Sunil HS, Aithala PS, Ramakrishna PJ. An evaluation of the seasonal variation in acute appendicitis. J Evol Med Dent Sci. 2014;3:257–60.
15. Oguntola AS, Adeoti ML, Oyemolade TA. Appendicitis: trends in incidence, age, sex, and seasonal variations in South-Western Nigeria. Ann Afr Med. 2010;9:213–7.
16. Jangra B, Jangra MS, Rattan KN, Kadian YS. Seasonal and day of week variations in acute appendicitis in north Indian children. J Indian Assoc Pediatr Surg. 2013;18:42–3.
17. Cavalcanti FR. O clima de Brasília: Estações do ano; 2012. Available from: http://doc.brazilia.jor.br/clima-de-Brasilia/estacoes-do-ano-em-Brasilia.shtml [accessed 02.10.16].