Ambient Temperature Is an Independent Risk Factor for Acute Tonsillitis Incidence

Jian Chen, MD, PhD1,*, Yibo Zhang, MD, PhD1,*, Xin Zhang, MS2, Yingfang Jiang, BS3, and Yibo Huang, MD, PhD1

Abstract

Objective: Acute tonsillitis is a common disease in otorhinolaryngology. Meteorological factors can affect the incidence of many infectious diseases. This study aims to analyze the correlation between acute tonsillitis and meteorological conditions.

Materials and Methods: We collected the meteorological data, including daily temperature, humidity, and fine particulate matter (PM$_{2.5}$) of Shanghai, China, from 2014 to 2015. The monthly number of acute tonsillitis cases in our hospital was also calculated and used as the outcome variable. The associations between them were evaluated, respectively.

Results: The average number of patients diagnosed with acute tonsillitis in our hospital per month was 68.67 ± 18.67 from 2014 to 2015. The average temperature, humidity, and PM$_{2.5}$ of Shanghai during the defined period was 16.84 °C ± 7.80 °C, 75.93% ± 5.45%, and 52.38 ± 14.23 μg/m$^3$, respectively. The temperature was significantly positively associated with the acute tonsillitis cases number both in Pearson correlation analysis ($R = 0.423, P = 0.039$) and in multivariate regression analysis (coefficient = 2.194, $P = 0.012$). However, no correlation between the acute tonsillitis cases number and relative humidity or PM$_{2.5}$ was found through a multivariate regression model ($P = 0.225$ and $P = 0.243$), respectively. Conclusion: The high temperature was associated with an increased incidence of acute tonsillitis.

Keywords

weather conditions, meteorological factors, temperature, acute tonsillitis

Introduction

Tonsils are parts of the lymphatic system and can be inflamed when the immune system is weak. Acute tonsillitis is a common disease in the department of otorhinolaryngology and occurs in patients at any age, especially in children of school age. Each year over 500 patients with acute tonsillitis are treated in our institution. These patients always present with a sore throat, fever, general malaise, and tonsil mucosa hyperemia, with or without tonsillar exudate. Peritonsillar abscess (PTA) is the most common complication of acute bacterial tonsillitis. Additionally, secondary parapharyngeal or retropharyngeal abscess may develop when the infection diffuses into the parapharyngeal or retropharyngeal space.¹ Severe complications of this disease include upper airway obstruction, septic thrombophlebitis, myocarditis, and acute nephritis.²

Meteorological conditions can affect the incidence of upper respiratory tract infections because they probably have a significant impact on the survival and spread of bacterial and viral pathogens in the environment.³⁴ Pathogens can survive longer outside the body under proper climate conditions, and susceptible persons are more likely to become infected then. Air pollution is also associated with the incidence of upper respiratory infections.⁵ The exposure of air pollution is suggested to decrease phagocytic ability toward pathogens, and thus evoking infections caused by these pathogens.⁶ Ambient particulate matter with an aerodynamic diameter of 2.5 mm or...

¹ ENT Institute and Department of Otorhinolaryngology, Eye & ENT Hospital, Fudan University, Shanghai, People’s Republic of China
² Shanghai Central Meteorological Observatory, Shanghai, People’s Republic of China
³ Nursing Department, Eye & ENT Hospital, Fudan University, Shanghai, People’s Republic of China
* These authors contributed equally to this work.

Received: August 16, 2020; revised: December 07, 2020; accepted: December 08, 2020

Corresponding Author:
Yibo Huang, ENT Institute and Department of Otorhinolaryngology, Eye & ENT Hospital, Fudan University, 83 Fenyang Road, Shanghai 200031, People’s Republic of China.
Email: adabohuang@126.com

Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (https://creativecommons.org/licenses/by-nc/4.0/) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (https://us.sagepub.com/en-us/nam/open-access-at-sage).
Materials and Methods

Meteorological data of 2014 to 2015 were collected from Shanghai Central Meteorological Observatory. The daily temperature, humidity, and PM$_{2.5}$ were collected and combined to provide a monthly average. The number of acute tonsillitis cases in our hospital per month was used as the outcome variable.

Patients receiving emergency care with a diagnosis of acute tonsillitis in the same tertiary hospital from January 2014 to December 2015 were included in the study. Patients with acute onset in other cities were excluded. The monthly number of acute tonsillitis cases was collected. Its correlation with the corresponding monthly meteorological factors was analyzed. All performed procedures in this study were in accordance with the World Medical Association Declaration of Helsinki. Informed consent was obtained from each participant included in the study. The study protocols were approved by the institutional ethics committee of our hospital (approved number: 2015038).

Results

We conducted a statistical analysis of 1648 patients who met the inclusion criteria, and the average number of patients diagnosed with acute tonsillitis per month and the average age of them were 68.67 ± 18.67 and 32.72 ± 14.55 years old, respectively. The characteristics of the acute tonsillitis patients are summarized in Table 1. There was a male prevalence with a sex-ratio of 1.25:1 and 18 to 40 years old is the peak age group. Children were also included in our study, but they preferred to visit other pediatric hospitals. The meteorological conditions from 2014 to 2015 are shown in Figure 1, as well as the monthly number of acute tonsillitis cases in the defined period. Acute tonsillitis cases in 2014 and 2015 reached a peak in May. The temperature ranged from 5.45 °C to 27.58 °C in the study period, and the average temperature was 16.84 °C ± 7.80 °C. Meanwhile, the average humidity and the PM$_{2.5}$ of Shanghai during the defined period were 75.93 ± 5.45% and 52.38 ± 14.23 µg/m$^3$, respectively.

Table 1. The Characteristics of Acute Tonsillitis Cases Involved in This Study.

| Characteristics | Case number (%) |
|-----------------|-----------------|
| Gender          |                 |
| Male            | 917 (55.6)      |
| Female          | 731 (44.4)      |
| Age, years old  |                 |
| ≤18             | 192 (11.7)      |
| 18-40           | 1107 (67.2)     |
| 40-60           | 260 (15.8)      |
| ≥60             | 89 (5.4)        |

Discussion/Conclusion

Acute tonsillitis is mainly caused by viruses, such as human adenoviruses, human Boca viruses, influenza, and parainfluenza viruses. Additionally, an overgrowth of bacterial taxa located in the oral and pharyngeal cavity is also responsible for this disease sometimes. The bacterial tonsillitis is recognized to be mostly caused by group A β-hemolytic streptococci, *Streptococcus, Staphylococcus, Bacteroides, Fusobacterium, Veillonella, Prevotella*, and *Haemophilus* are also reported to be associated with the incidence of this disease. However, there are numerous different bacteria and viruses detectable in the oral and pharyngeal cavity, and the interrelationship among them needs to be determined.
them is extremely complicated. Therefore, it is always difficult to distinguish the pathogenic germs from the present microflora. Therefore, we look for influencing factors of acute tonsillitis from a macro perspective.

Climate factors, especially temperature and humidity, have and will continue to affect the survival, reproduction rate, spread, and geographical distribution of both bacteria and viruses. Meanwhile, human behavior and the ecology of vectors are also closely correlated with the change of weather. As a result, it has been observed that many infectious diseases are associated with meteorological conditions, including respiratory infections, bacterial dysentery, malaria, hand–foot–mouth

Figure 1. The monthly number of acute tonsillitis patients visiting the same tertiary hospital and meteorological conditions by month in Shanghai. Acute tonsillitis cases and (A) temperature, (B) relative humidity, or (C) PM$_{2.5}$. 
disease, and cellulitis. Meteorological variables directly influence the survival and proliferation of infectious microorganisms, their vectors, and their animal reservoirs. Climate instability also affects human activities, and close contact may exacerbate the spreading of infectious diseases. As the major variate of weather, the temperature is a crucial factor to impact lots of infectious diseases. An increase of 1°C may cause bacterial dysentery, hand–foot–mouth disease, and malaria cases to increase by 3.6% to 14.8%, 1.8% to 5.9%, and 0.90%, respectively. Another study showed that every 1°C increase in ambient temperature may cause an increase of 3.47 per 100,000 cases of cellulitis. Meanwhile, the temperature was also able to influence the infections caused by a respiratory syncytial virus, human metapneumovirus, and Middle East respiratory syndrome coronavirus.

Humidity is another important climate factor. It was reported that the relative humidity is negatively correlated with respiratory syncytial virus detection but is positively associated with the incidence of hand–foot–mouth disease and Middle East respiratory syndrome. Environmental air pollution has been a global problem in recent years, which can increase the risk of cardiovascular diseases, pneumonia, and asthma. Davila discovered that PM$_{2.5}$ could trigger the incidence of respiratory diseases, including pneumonia and asthma, and PM$_{2.5}$ is significantly associated with the occurrence of childhood scarlet fever in another study. These climatic factors may affect the balance of microflora, thus prompting the occurrence of many infectious diseases. Therefore, temperature, humidity, and PM$_{2.5}$ were all enrolled in our study to observe the association between meteorological factors and acute tonsillitis.

The bacteria located beside the tonsils are critical for the occurrence of tonsillitis. Bacteria exist in the core region of tonsils differ a lot from the surface bacteriology and play a more critical role in the onset of tonsillitis. Dickinson et al proved that the oral microbial balance was broken during tonsillitis in comparison with healthy individuals. The Prevotella taxa were significantly enriched in the tonsillitis cohort, which can be potentially influenced by the climatic conditions. An appropriate temperature promotes the proliferation of viruses and bacteria which challenges the tonsil immune system and thus resulting in the increase of tonsillitis incidence. However, few studies sought for the relation between weather conditions and acute tonsillitis. Kim et al collected the climate data including temperature, humidity, spot atmospheric pressure, sulfur dioxide, nitrogen dioxide, ozone, carbon monoxide, and PM$_{10}$ to correlate the occurrence of PTA formation, the most common complication of acute tonsillitis. Finally, only nitrogen dioxide and PM$_{10}$ were positively associated with this complication in that study. However, a generally acknowledged theory recognized that PTA is not a direct complication of acute tonsillitis. The location of the majority of PTAs is at the superior tonsillar pole, and the tonsils are always not affected. The risk factors for them may not be consistent. In our study, PM$_{2.5}$ did not correlate with the incidence of acute tonsillitis, but the rise of temperature was able to induce the onset of acute tonsillitis. The infectious pathogen of tonsillitis may be mostly influenced by outdoor temperature but not by humidity nor PM$_{2.5}$. Only a few PTAs formed after acute infection, and the risk factors for PTA formation were nitrogen dioxide and PM$_{10}$ according to Kim’s study. This result reminds the susceptible population to take preventive measures when the temperature rises. For example, they should keep good oral hygiene during the warmer months.

Several confounders were not considered in this study. A large number of people would leave Shanghai during the Chinese Spring Festival; hence, the visiting number would decrease this month. Indoor activities are preferable for citizens during hot months, especially for the children during the summer holidays, and this may promote the spreading of infectious diseases. Therefore, temperature, humidity, and PM$_{2.5}$ were all enrolled in our study to observe the association between meteorological factors and acute tonsillitis.

![Figure 2](image)

**Figure 2.** Correlation between monthly hospital visits for acute tonsillitis and monthly ambient temperatures. Acute tonsillitis visits were positively correlated with temperature.

| Table 2. Multivariate Regression Analysis of Meteorological Factors Affecting the Monthly Number of Acute Tonsillitis Cases. |
|---------------------------------|------------------|------------------|------------------|-----|-----|----------|
| Unstandardized coefficients    | Standard error   | Standardized coefficients | $t$   | $P$  | VIF   |
| (Constant)                      | 80.142           | 71.031            | 1.128            | .273 |      |         |
| PM$_{2.5}$                      | 0.522            | 0.434             | 0.398            | 1.202 | .243 | 3.176   |
| Humidity                        | −0.998           | 0.797             | −0.291           | −1.252 | .225 | 1.572   |
| Temperature                     | 2.194            | 0.793             | 0.916            | 2.766 | .012 | 3.188   |
| $F$                             | 3.019            |                  |                  | .054 |      |         |
| $R^2$                           |                  |                  |                  | 0.312 |      |         |

Abbreviation: VIF, variance inflation factor.
contagious diseases. Other limitations of this study include the relatively short study period, the lack of detailed information about the tonsillitis cases, and the few meteorological factors involved in the research. The data only from a warm city are not enough to draw a firm conclusion.

In conclusion, we discovered that the incidence of acute tonsillitis was significantly and positively associated with the ambient temperature. Our findings are consistent with the theory that PTA does not directly occur because of acute tonsillitis. Meanwhile, these results may improve our understanding of acute tonsillitis etiology, and the association between climate change and microflora alteration during tonsillitis would be furtherly investigated in our future studies.

Authors’ Note
J.C. contributed to the design of the study and interpretation of data and drafting the article. Y.Z. contributed to acquisition of data and revising the article critically for important intellectual content. X.Z. contributed to acquisition of data. Y.H. contributed to the conception and design of the study and revising the article critically for important intellectual content. All authors contributed to final approval of the version to be submitted. J.C. and Y.Z. contributed equally to this work. This study was approved by the Ethics Committee of Eye, Ear, Nose, Throat Hospital of Fudan University.

Declaration of Conflicting Interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding
The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD
Jian Chen @ https://orcid.org/0000-0002-0578-9675

References
1. Klug TE. Incidence and microbiology of peritonsillar abscess: the influence of season, age, and gender. Eur J Clin Microbiol. 2014; 33(7):1163-1167.
2. Gahleitner C, Hofauer B, Stark T, Knopf A. Predisposing factors and management of complications in acute tonsillitis. Acta Otolaryngol. 2016;136(9):964-968.
3. du Prel JB, Puppe W, Gröndahl B, et al. Are meteorological parameters associated with acute respiratory tract infections? Clin Infect Dis. 2009;49(6):861-868.
4. Lin YK, Chang CK, Chang SC, Chen PS, Lin C, Wang YC. Temperature, nitrogen dioxide, circulating respiratory viruses and acute upper respiratory infections among children in Taiwan: a population-based study. Environ Res. 2013;120:109-118.
5. Hajat S, Anderson H, Atkinson R, Haines A. Effects of air pollution on general practitioner consultations for upper respiratory diseases in London. Occup Environ Med. 2002;59(5):294-299.
6. Zhou H, Kobzik L. Effect of concentrated ambient particles on macrophage phagocytosis and killing of Streptococcus pneumoniae. Am J Respir Cell Mol Biol. 2007;36(4):460-465.
7. Shahbaz M, Martikainen M, Rönkkö T, Komppula M, Jalava P, Roponen M. Urban air PM modifies differently immune defense responses against bacterial and viral infections in vitro. Environ Res. 2020;110244.
8. Kim SY, Kong IG, Min C, Choi HG. Association of air pollution with increased risk of peritonsillar abscess formation. JAMA Otolaryngol Head Neck Surg. 2019;145(6):530-535.
9. Freire G, Dos Santos J, Rolón P, Pinheiro G, Sampaio A. Peritonsillar abscess: epidemiology and relationship with climate variations. J Laryngol Otol. 2017;131(7):627-630.
10. Windfuhr JP, Toepfner N, Steffen G, Waldfahrer F, Berner R. Clinical practice guideline: tonsillitis I. diagnostics and nonsurgical management. Eur Arch Otorhinol. 2016;273(4):973-987.
11. Brook I, Yocum P, Friedman EM. Aerobic and anaerobic bacteria in tonsils of children with recurrent tonsillitis. Ann Otol Rhinol Laryngol. 1981;90(3 pt 1):261-263.
12. Esposito S, Blasi F, Bosis S, et al. Aetiology of acute pharyngitis: the role of atypical bacteria. J Med Microbiol. 2004;53:645-651.
13. Yi L, Xin X, Ge W, et al. The impact of climate variability on infectious disease transmission in China: current knowledge and further directions. Environ Res. 2019;173:255-261.
14. Hsu RJ, Chou CC, Liu JM, et al. The association of cellulitis incidence and meteorological factors in Taiwan. Epidemiol Infect. 2019;147:e138.
15. Zhang H, Wen S, Zheng J, Chen X, Lv F, Liu L. Meteorological factors affecting respiratory syncytial virus infection: a time-series analysis. Pediatr Pulm. 2020;55(3):713-718.
16. Coates S, Norton S. The effects of climate change on infectious diseases with cutaneous manifestations. Int J Womens Dermatol. 2020.
17. Darniøt M, Pitoiset C, Millière L, et al. Different meteorological parameters influence metapneumovirus and respiratory syncytial virus activity. J Clin Virol. 2018;104:77-82.
18. Altamimi A, Ahmed AE. Climate factors and incidence of Middle East respiratory syndrome coronavirus. J Infect Public Heal. 2020;13(5):704-708.
19. Coates SJ, Davis MDP, Andersen LK. Temperature and humidity affect the incidence of hand, foot, and mouth disease: a systematic review of the literature—a report from the International Society of Dermatology Climate Change Committee. Int J Dermatol. 2019;58(4):388-399.
20. Koutrakis P, Sax SN, Sarnat JA, et al. Analysis of PM10, PM2.5, and PM 2.5-10 concentrations in Santiago, Chile, from 1989 to 2001. J Air Waste Manage. 2005;55(3):342-351.
21. Gouveia N, Junger WL, Romieu I, et al. Effects of air pollution on infant and children respiratory mortality in four large Latin-American cities. Environ Pollut. 2018;232:385-391.
22. Cordova JE, Aguirre VT, Apestegui VV, et al. Association of PM concentration with health center outpatient visits for respiratory
diseases of children under 5 years old in Lima, Peru. *Environ Health Glob*. 2020;19(1):7.

23. Cheng W, Li H, Zhang X, et al. The association between ambient particulate matters, nitrogen dioxide, and childhood scarlet fever in Hangzhou, Eastern China, 2014-2018. *Chemosphere*. 2020;246:125826.

24. Dickinson A, Kankaanpaa H, Silen S, et al. Tonsillar surface swab bacterial culture results differ from those of the tonsillar core in recurrent tonsillitis. *Laryngoscope*. 2019;30(12):E791-E794. doi:10.1002/lary.28403

25. Yeoh YK, Chan MH, Chen Z, et al. The human oral cavity microbiota composition during acute tonsillitis: a cross-sectional survey. *BMC Oral Health*. 2019;19(1):275.

26. Di Muzio F, Barucco M, Guerriero F. Diagnosis and treatment of acute pharyngitis/tonsillitis: a preliminary observational study in general medicine. *Eur Rev Med Pharmacol Sci*. 2016;20(23):4950-4954.

27. Mazur E, Czerwińska E, Korona-Glowniak I, Grochowalska A, Kozioł-Montewka M. Epidemiology, clinical history and microbiology of peritonsillar abscess. *Eur J Clin Microbiol Infect Dis*. 2015;34(3):549-554.