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Epidemiological study of scarlet fever in Shenyang City, China

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RESEARCH

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ABSTRACT

Aims

To depict the Spatiotemporal epidemiological characteristics of the incidence of scarlet fever in Shenyang, China, in 2018 so as to provide the scientific basis for effective strategies of scarlet control and prevention.

Methods

Excel 2010 was used to demonstrate the temporal distribution at the month level and ArcGIS10.3 was used to demonstrate the spatial distribution at the district/county level. Moran's autocorrelation coefficient was used to examine the spatial autocorrelation and the Getis-Ord statistic was used to determine the hot-spot areas of scarlet fever.

Results

A total of 2,314 scarlet fever cases were reported in Shenyang in 2018 with an annual incidence of 31.24 per 100,000. The incidence among males was higher than that amongfemales (X^2=95.013, P≤0.001). A vast majority of the cases (96.89%) were among children aged 3 to 11 years. The highest incidence was 625.34/100,000 in children aged 5–9 years. There are two seasonal peaks occurred in June (Summer-peak) and in December (Winter-peak) in 2018. The incidence of scarlet fever in urban areas was significantly higher than that in rural areas(X^2=514.115, P≤0.001). The incidence of scarlet fever was randomly distributed in Shenyang. There are hot-spots areas located in seven districts.

Conclusion

Urban areas are the hot spots of scarlet fever and joint prevention and control measures between districts should be applied. Children in the kindergartens and the primary school students are the main population of scarlet fever and the time distribution of scarlet fever is highly consistent with their school and vacation time. It is suggested that measure for prevention and control of scarlet fever in kindergartens and primary schools is the key to control the epidemic of scarlet fever.

Key Words

Scarlet fever, spatiotemporal epidemiological characteristics, Shenyang

What this study adds:

1. What is known about this subject?

Scarlet fever caused by Group A Streptococcus (GAS) is mainly transmitted by direct contact with saliva and nasal fluids from infected persons.

2. What new information is offered in this study?

This study offers that the number of scarlet fever cases was the most highest among children aged 3–11 years and accounted for 96.89%. Children aged 3–11 are the children of kindergartens and primary schools in China.

3. What are the implications for research, policy, or practice?

Our study suggests that children in the kindergartens and the primary school students are at high risk for scarlet fever.

Background

Scarlet fever caused by Group A Streptococcus (GAS) is mainly transmitted by direct contact with saliva and nasal fluids from infected persons,[1] most commonly occurs in winter and spring and most commonly affects children.[2]

In 2011, an outbreak of scarlet fever hit Hong Kong (China) and over 600 cases were reported by the end of June 2011,[3] with two deaths. The same year in April to July, Shanghai witnessed an unprecedented outbreak of scarlet fever among children. In recent years, the number of scarlet fever has been increasing in china.[4] In 2017, a total of 74,369 cases of scarlet fever was reported, compared with 34,207 in 2013 and 54,247 in 2014 and 68249 in 2015 and 59282 in 2016 respectively.[5]

As a useful tool, geographic information system (GIS) has been widely applied in controlling infectious diseases.[6-8] However; few studies have focused on the spatiotemporal characteristics of scarlet fever. In Shenyang city, some researchers described the epidemiology of scarlet fever,[9-12] but none explored the spatiotemporal patterns.

In our study, we used Excel 2010 and ArcGIS 10.3 to depict the spatiotemporal characteristics of scarlet fever in Shenyang City followed the methods of Qi Zhang et al.[13] The objective of our study was to describe the temporal and spatial epidemic characteristics of scarlet fever in Shenyang and explore the risk factors affecting the epidemic of scarlet fever in order to provide scientific basis for the prevention and control measures of scarlet fever in Shenyang.

Method

Study area

Shenyang is the capital city of Liaoning province, located in latitude 41°11 ’–43°02 ’N and longitude 122°25 ’–123°48 ’E, measures 13000 Sqkm and consists of 13 districts/country named as follows: (1)Heping, (2)Shenhe, (3)Dadong, (4)Huanggu, (5)Tiexi, (6)Sujiatun, (7)Hunnan, (8)Shenbeix in, (9)Yuhong, (10)Liaozhong, (11)Kangping, (12)faku, (13)Xinmin. Among them Heping, Shenhe, Dadong, Huanggu, Tiexi, Sujiatun, Hunnan, Shenbeixin and Yuhong belong to urban areas. Liaozhong, Kangping, Faku and Xinmin belong to rural areas. The population in Shenyang City was 7,408,238 in 2018.

Data source

All reported cases (including the patient’s age, sex, occupation, and address) of scarlet fever in 2018 were extracted from The Nationwide Notifiable Infectious Diseases Reporting Information System (NIDRIS). Additionally, we retrieved population data from the Official Website of Shenyang Statistical Bureau. Maps of Shenyang were downloaded from Data Sharing Infrastructure of Earth System Science.

Case definition

The diagnosis of scarlet fever is based on the clinical criteria established by the Law of Communicable Diseases Prevention and Control of the People’s Republic China and Guidance offered by the Chinese Ministry of Health.[14] The clinical manifestations of scarlet fever (ICD A38.01) are acute onset of fever, pharyngitis with strawberry tongue, red rash with a sandpaper feel, and itching, as well as a throat swab culture and stain and a skin smear stain to confirm Streptococcus bacteria (Group A) infection.

Statistical analysis

SPSS 23.0 software was used for statistical analysis. Normal distribution measurements were expressed by $\overline{X} \pm S$, T-test was used for comparison between the two groups and Variance analysis was used for comparison among groups. Count data were expressed by rate; Chi-square test was used for comparison between groups. The test level is a=0.05.

Spatial autocorrelation analysis

The spatial autocorrelation (Global Moran’s I) statistic measure was used to evaluate whether the disease patterns are clustered, dispersed or randomly distributed in the area. In general, Moran’s I index values close to +1.0 indicate disease clustering, whereas Moran’s I index values close to -1.0 indicate dispersing, Moran’s I index values close to zero indicate that the disease is randomly distributed in the study area.[15] ArcGIS 10.3 was used to perform the analysis.

Hot spot analysis

The hotspot analysis (Getis-Ord, Gi*) statistic measure, was used to evaluate the intensity and stability of spatial clusters and it has the advantage of distinguishing high-high value clusters (hot spot) or low-low value clusters (cold spot). If the Z (Gi*) score is positive and significant, it shows that one district and its neighbouring regions have a relatively high frequency of scarlet fever incidents, which is a hot-spot. On the contrary, if the Z (Gi*) score is negative and significant, it shows that one district and its neighbouring regions have a relatively low frequency of scarlet fever incidents, which is a cold-spot. In general, districts with Z-scores >2.58 or Z-scores <-2.58 were considered to be significant at 99% confidence level (p< 0.01). Districts with Z-scores between 1.96–2.58 or Z-scores

between -1.96–-2.58 were considered to be significant at 95% confidence level (p<0.05). Districts with Z-scores between 1.65–1.96 or Z-scores between -1.65–-1.96 were considered to be significant at 90% confidence level (p<0.10).[16] ArcGIS 10.3 was used to perform the analysis.

Results

Demographic characteristics

A total of 2,422 scarlet fever cases were reported in 2018 and 108 of these cases were excluded because they did not reside in Shenyang. Finally, a total of 2,314 cases were included in the analysis. The annual incidence rate of scarlet fever was 31.24 per 100,000 populations. The incidence of male is significantly higher than that of female(X^2=95.013, P≤0.001). The incidence of children aged 5-9 years was significantly higher than that of other age groups(X^2=34947.179, P≤0.001) (Table 1).

Temporal pattern

The monthly distribution of scarlet fever cases had significant seasonality in Shenyang. The first large peak occurred in June (Summer-peak), followed by a small peak in December (Winter-peak). Children aged 3–11 accounted for 96.89% of all scarlet fever cases. The monthly distribution of cases aged 3–11 is consistent with the whole cases, and other cases are scattered (Figure 1).

Spatial pattern

The distribution of scarlet fever incidence varied at the district/county level in the Shenyang region in 2018 showed that Yuhong District had the highest incidence, Hunnan and Tiexi district had relatively high incidence, the incidences of Faku County was the lowest. The incidence of scarlet fever in urban areas was significantly higher than that in rural areas(X^2=514.115, P≤0.001) (Table 2 and Figure 2).

Spatial autocorrelation analysis and hot spot analysis

Table 3 describes the result of spatial autocorrelation (Global Moran's I) analysis and hotspot (Getis-Ord, Gi*) analysis in Shenyang. Spatial autocorrelation analysis showed that the incidence of scarlet fever was randomly distributed. The hotspot analysis demonstrates that hotspots (P≤0.05)are located in seven districts, namely Heping, Hunnan, Shenhe, Huanggu, Yuhong, Dadong and Sujiatun district (Table 3 and Figure 3).

Discussion

Over the past decade, an exceptional upside in the morbidity of scarlet fever has occurred in some Asian and European countries and areas, containing mainland China,[17] Vietnam,[18] Hong Kong,[19] South Korea,[20] Germany[21] and England[22] This worsening trend is becoming increasingly fierce, especially in China where the ongoing resurgence in disease morbidity has exerted a marked influence on Chinese population since 2011.[17,23] To tackle this, understanding the epidemic characteristics of this disease may play a significant role in the allocation of limited health resource and the formulation of prevention and control strategies.[24]

In this study, We found that the incidence of scarlet fever in Shenyang in 2018 is higher than that in Beijing[25] during 2005–2014 (14.25 per 100,1000) and Jiangsu[13] during 2005–2015 (1.87 per 100,1000), and is higher than the average annual incidence of the whole country[26] during 2003–2010 (1.58 per 100,1000) and during 2011–2016 (4.14 per 100,000). We also found that the incidence of scarlet fever in 2018 was the highest since the outbreak of scarlet fever in 2011 in Shenyang.[11-12]

According to our study, the incidence of scarlet fever was higher among males than among females, which is consistent with the findings of Gehendra Mahara,[25] Qi Zhang,[13] Shuangsheng Wu[27] and Gehendra Mahara.[28] The number of scarlet fever cases was the most highest among children aged 3–11 years g and accounted for 96.89%. The WHO and Public Health UK stated that a high-risk group of scarlet fever was among children 5–15 years old.[29-30] Our study suggests that children in the kindergartens and the primary school students are at high risk for scarlet fever.

Scarlet fever could occur throughout all the year, yet case notifications had a distinct seasonal distribution and showed double peak pattern in the year. There were fewer cases in February, and the number of cases increased sharply from March to June, the first peak occurred in June. The number of cases decreased from July to August and increased again between August and December, the second peak appeared in December, which is consistent with the findings of previous studies.[13,24-26] It can be seen that the month in which the number of scarlet fever cases increases is the time when the children in the kindergartens and the primary school students are in school. The month in which the number of scarlet fever cases decrease is the time when the children in the kindergartens and the primary school students are on vacation. Prompting us that scarlet fever has obvious aggregation in kindergartens and primary schools. Since there is no scarlet fever vaccine at present, it is very important to urge kindergartens and primary schools to implement the morning check system, epidemic reporting system and isolation measures. In addition, teachers and parents need to teach children to wash their

hands frequently and schools ought to improve environmental hygiene through disinfection of toys, banisters, and desks, etc.[31]

In our study, the disease mapping, spatial autocorrelation analysis and hotspot analysis were applied to depict the geographic distribution of scarlet fever incidence. The spatial distribution shows that scarlet fever cases are concentrated in urban areas with high population density, and the incidence of scarlet fever in urban areas is significantly higher than that in rural areas, which is consistent with the findings of Gehendra Mahara.[25] The autocorrelation analysis of Global Moran's I value demonstrated that the spatial distribution of scarlet fever were randomly distributed in Shenyang in 2018. However, hotspot analysis of Getis-Ord (Gi*) Z values revealed that the hotspot area with a high-high positive spatial association of scarlet fever incidence was located around the urban districts (Heping, Shenhe, Dadong, Huanggu, Sujiatun, Hunnan and Yuhong) and the cold-spot area with a low-low positive spatial association of scarlet fever incidence was not found, which is consistent with the findings of Gehendra Mahara.[25] Prompting us that scarlet fever is easily to form aggregation in urban areas with high population density and convenient transportation which increased the risk of scarlet fever exposure. These results remind us that prevention and control measures for scarlet fever should focus more on the hot-spot areas and joint prevention and control measures between districts should be applied.

Conclusion

The monthly distribution of scarlet fever cases is obviously seasonal in Shenyang. The time distribution of scarlet fever is highly consistent with their school and vacation time. Children aged 3–11 accounted for the vast majority of all scarlet fever cases. Prompting us that scarlet fever has obvious aggregation in kindergartens and primary schools and it is very important to focus on the prevention and control of scarlet fever in kindergartens and primary schools. The incidence of scarlet fever in urban areas with dense population and convenient transportation is significantly higher than that in rural areas. Urban areas are the hot spots of scarlet fever which reminding us that prevention and control measures for scarlet fever should focus more on the urban areas.

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PEER REVIEW

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CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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Table 1: Incidence of scarlet fever in different group in Shenyang in 2018

Group	Cases	Population	Incidence
Gender			
Male	1375	3651661	37.65
Female	939	3756577	25
X^2	95.013		
P	≤0.001		
Age group(Years)			
0-4	382	299215	127.67
05-Sep	1772	283368	625.34
Oct-14	130	253991	51.18
≥15	30	6571664	0.46
X^2	34947.18		
P	≤0.001		

Table 2: Incidence of scarlet fever in different districts/countries in Shenyang in 2018

Distrcts/countries	Cases	Population	Incidence
Urban areas			
Heping	227	698304	32.51
Shenhe	172	712589	24.14
Dadong	193	654329	29.5
Huanggu	296	833574	35.51
Tiexi	562	1047529	53.65
Sujiatun	130	424689	30.61
Hunnan	162	388078	41.74
Shenbeixin	99	326243	30.35
Yuhong	353	410975	85.89
Subtotal	2194	5496310	39.92
Rural areas			
Liaozhong	19	458961	4.14
Kangping	7	342918	2.04
Faku	11	439224	2.5
Xinmin	83	670825	12.37
Subtotal	120	1911928	6.28
X^2	514.115		
P	≤0.001		

Table 3: The results of the spatial autocorrelation and hotspot analysis of scarlet fever incidence in Shenyang in 2018

Autocorrelation Analysis			
Year	Moran *I*	*Z*-Score	*P*-Value
2018	0.099	1.741	0.082
Hot Spot Analysis			
Districts		Z-Score	P-Value
Kangping		-1.819	0.069
Faku		-1.819	0.069
Xinmin		1.298	0.194
Liaozhong		-0.048	0.962
Sujiatun		2.384	0.017
Dadong		2.533	0.011
Shenbeixin		1.742	0.081
Tiexi		1.851	0.064
Heping		2.533	0.011
Hunnan		2.533	0.011
Shenhe		2.533	0.011
Huanggu		2.533	0.011
Yuhong		2.283	0.022

Figure 1: Monthly cases of scarlet fever in Shenyang in 2018

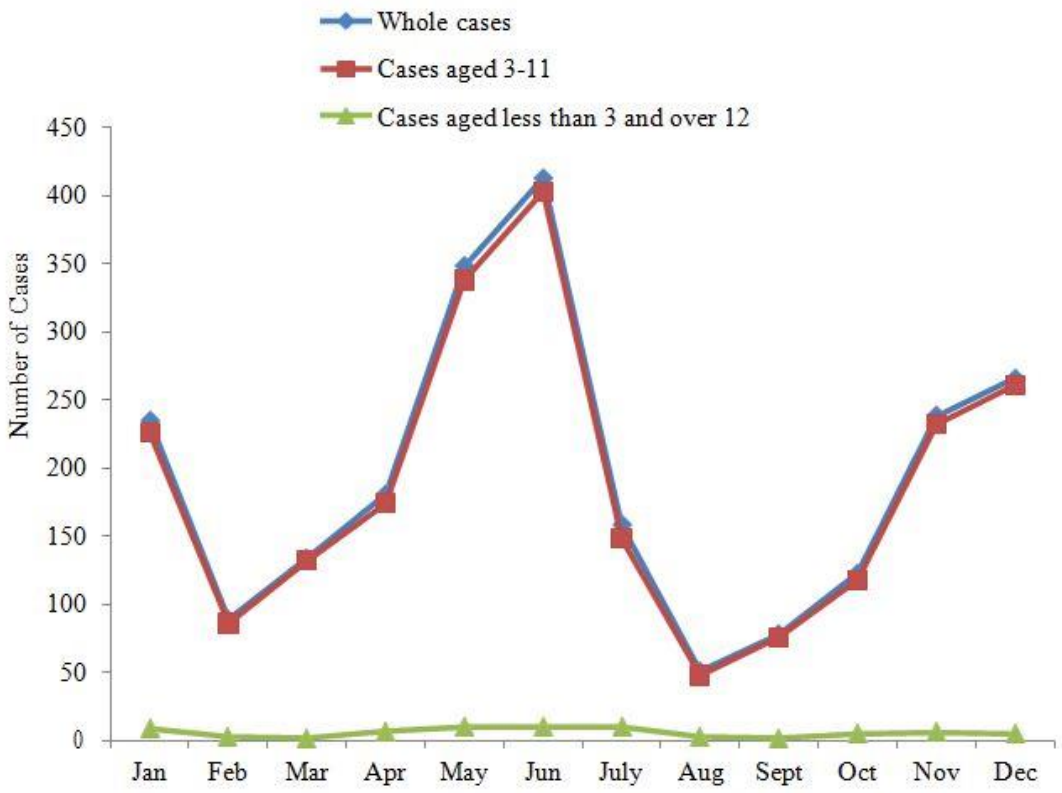

Figure 2: The spatial distribution of scarlet fever incidence in different districts/countries in Shenyang in 2018

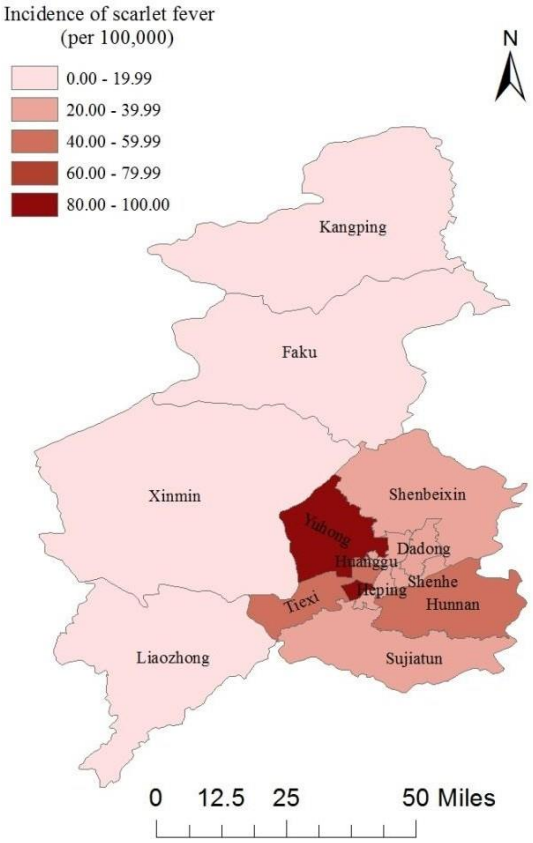

Figure 3: Hotspot clusters of scarlet fever incidence in Shenyang in 2018