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Risk factors for readmission of children hospitalized with acute asthma attacks in South China

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ABSTRACT

Objective: Asthma seriously endangers the health of children. Re-hospitalization for childhood asthma consumes a large amount of medical and health resources. The present study aimed to assess the rates and risk factors for hospital readmission of children with acute asthma attacks in south China.

Methods: We retrospectively enrolled 1702 acute asthma patients aged < 18 years from 1/1/2007 to 12/31/2015. Patients who were readmitted within one year after index hospital discharge were divided into a readmission group. Index hospitalization data were acquired from clinical records. Chi-square tests and multivariate logistic regression analyses were used to evaluate the risk factors.

Results: There were 90 (5.29%) readmitted patients from 1702 acute asthma patients. Considering the large sample differences between readmitted and single-admitted patients, 123 single-admitted patients (1.5-fold as many as the readmitted group) were randomly selected. Further univariate Chi-square tests and multivariate logistic regression analyses showed that the predictors of readmission included eczema history (odds ratio (OR) 3.122, $p=0.003$) and mycoplasma pneumoniae (MP) antibody immunoglobulin M (IgM) (OR 2.386, $p=0.037$).

Conclusions: Among the children admitted to a hospital in south China with acute asthma attacks, 5.29% were readmitted within the following year. Patients with history of eczema and positive MP antibody IgM had significantly increased the chances of one-year readmission, underlining the importance of targeted long-term postdischarge follow-up of these children.

Abbreviations: US: United States; ICU: Intensive Care Unit; EOS: Eosinophil; tIgE: Total Immunoglobulin E; sIgE: Specific Immunoglobulin E; MP: Mycoplasma pneumoniae; GINA: the Global Initiative for Asthma; IQR: Interquartile Range; OR: Odds Ratios; LOS: Length of Stay; CI: Confidence Intervals; RTI: Respiratory Tract Infection; SABA: Short Acting Bronchodilator; ICS: Inhaled Corticosteroid; IU: International Unit; ML: Milliliter; IgM: Immunoglobulin M.

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Introduction

Bronchial asthma is the most prevalent chronic respiratory disease in children. It has been listed by the World Health Organization as one of the major diseases for which prevention and control are urgently required in the 21st century. The prevalence of asthma is increasing in the past 20 years in China (1). The reported prevalence rates were 0.91% in 1990, 1.97% in 2000, and 3.02% in 2010 (2). Asthma causes many social problems. It seriously endangers the health of children, impacts their education and quality of life and leads to parental absence from work when children are hospitalized (3–6). Furthermore, it

increases the financial burden of the family. In a survey conducted in Beijing, China, the families of almost 40% of children with asthma had spent over 10 000 RMB (almost \$1,500) on asthma-related treatment (1,7). Re-hospitalization for childhood asthma is responsible for the consumption of a large amount of medical and health resources (8). Hospitalization costs account for a great proportion of asthma-associated medical expenses worldwide, and studies suggest that hospitalization accounts for nearly a third of the costs associated with childhood asthma in the US and the Netherlands (9,10). Hospitalization affects the quality of life of children and their parents, imposing a

financial burden and mental stress on the family. Some researchers believe that reducing asthma hospitalization by taking certain feasible measurements is a potential method of reducing the costs of medical care for children with asthma (11).

Studies have shown that the hospitalization rate of children with asthma is exhibiting a downward trend, while the prevalence of asthma is increasing, which may be due to the more standardized diagnosis and treatment of asthma. However, the rate of readmission for asthma is increasing (12). Asthma-related readmissions have been evaluated in many countries including France, the US, Australia, and Canada (12–19). In different studies, the readmission rates for childhood asthma in the year following discharge from the index admission range from 11.8% to 40.0%. Different risk factors for readmission have been reported in different countries and regions. Although these readmissions have been studied, few data from China are currently available. The present study was conducted to assess the rate and risk factors that increase the odds of one-year readmissions among children with acute asthma attacks in south China so that appropriate interventions can be instituted to decrease the number of readmissions.

Materials and methods

Study design and settings

This retrospective study was approved by the Institutional Review Board of our hospital. Medical records of all children aged < 18 years with a primary diagnosis of asthma exacerbation or a primary diagnosis of respiratory infection with asthma exacerbation as a secondary or tertiary diagnosis were collected. Asthmatic patients were identified using the billing database by asthma ICD 10 code (J45.901 & J45.903). Asthma exacerbation refers to a sudden onset of wheezing, cough, shortness of breath, chest tightness, etc., or the original symptoms are sharply aggravated. Children's meeting criteria for asthma exacerbation was determined by two respiratory physicians, who were blinded to each other. Index admission was defined as the first hospitalization for an acute asthma attack between 01 January 2007 and 31 December 2015. The readmission group was defined as patients who were readmitted within one year after discharge from their index admission, and it was simultaneously confirmed that patients admitted to the hospital between 1/1/2007 and 12/31/2007 did not have a history of hospitalization for acute asthma in the previous year. The single-admission group was defined as

patients with no readmissions during the study period. Our aim was to analyze the risk factors that led to one-year readmissions when compared to single-admission group. Cases with missing medical records were excluded from analysis. Considering the large sample differences between readmitted and single-admitted patients, cases of 1.5-fold as many as the readmission group were randomly selected from the single-admission group for final statistical analysis.

The following detailed information on the index hospitalizations was acquired by two members of the study group from clinical records: age at index admission, gender, place of residence, asthma characteristics, emergency room visit details, intensive care unit (ICU) visit details, intubations, asthma severity, pre-hospital medication (aerosol inhalation including budesonide, terbutaline sulfate, ipratropium bromide and salbutamol sulfate, as well as inhaled or oral, and intravenous corticosteroids), length of hospital stay, complications, birth weight, gestational age, natural birth or cesarean section, gravidity and parity history, history of comorbid conditions, history of allergic diseases (eczema, allergic rhinitis, and urticaria), history of food or drug allergy, parental allergic diseases, laboratory test results such as eosinophil (EOS) ratio, EOS count, total immunoglobulin E (tIgE), specific immunoglobulin E (sIgE), sputum culture, results of immunofluorescence detection tests for 7 types of respiratory viruses, mycoplasma pneumoniae (MP) antibodies, and lung function. Asthma severity was evaluated in accordance with the Global Initiative for Asthma (GINA) 2016 criteria (20). The two members of the study group who abstracted the clinical information from 1/1/2007 to 12/31/2015 index hospitalizations were blinded to whether that person had a subsequent readmission or not.

Statistical analysis

All analyses were performed using SPSS 21.0 (IBM SPSS Statistics V21.0). The normality of the distribution of datasets was determined via the Kolmogorov-Smirnov test, and arithmetic means, standard deviations, and 95% confidence intervals (CI) were calculated. For skewed data, medians and interquartile ranges (IQR) were calculated. Comparisons of group means were performed using the two-sided *t*-test. The χ^2 test was used to compare categorical variables, and Pearson's χ^2 , continuous correction, or Fisher's exact test were used depending on the conditions. The *p* values calculated were two-

sided, and $p < 0.05$ was considered statistically significant.

Based on the results of these univariate analyses, a multivariate logistic regression analysis was performed to calculate the odds ratios (OR) and 95% CIs of the independent variables. Factors with p values < 0.10 at the bivariate phase value were used for the selection of variables to be included in the logistic regression analyses. The Hosmer-Lemeshow statistic was used to check the fit of the reduced final model, and it was not significant, indicating an adequate fit.

Results

A total of 1702 children diagnosed with acute asthma attacks were hospitalized between 01 January 2007 and 31 December 2015, of which 69.27% were male and 30.73% were female. Of these, 36.90% were in the infancy or toddler stage, 50.65% were preschool aged, and 12.45% were school aged. Of the total 1702 acute asthmatic children, 60.40% were mild acute attacks, 32.73% were moderate acute attacks, and 6.87% were severe to extremely severe acute attacks. Hospitalizations peaked in Autumn (Table 1). Each patient was followed up for one year, 90 were readmitted to the hospital within the following one year after initial admission and 1612 had no readmissions. The one-year readmission rate was 5.29%.

Eight cases of readmission were excluded from analysis due to missing medical records. Thus, in the final analysis, 82 patients were included in the readmission group. In addition, considering the large sample differences between readmitted and single-admitted patients, 123 single-admitted patients (1.5-fold as

many as the readmitted group) were randomly selected to the single-admission group. In univariate analysis, asthmatic children aged < 2 years ($\chi^2 = 6.116$, $p = 0.013$), or children with a history of eczema ($\chi^2 = 11.089$, $p = 0.001$) were more likely to be readmitted within one year, and being a first-born child led to a lower likelihood of being readmitted ($\chi^2 = 4.946$, $p = 0.026$) (Table 2).

Positive MP antibody IgM was positively associated with one-year readmission, while use of systemic corticosteroids before the index hospitalization was negatively associated with 1-year readmission in the univariate analysis ($p < 0.10$). Other factors such as gender, place of residence, asthma characteristics, emergency room visit details, intensive care unit (ICU) visit details, intubations, asthma severity, length of hospital stay, complications, history of comorbid conditions, and others had no statistical significance (Table 2).

In binary logistic regression analysis, children with a history of eczema (OR 3.122 95% CI [1.508–6.953], $p = 0.003$) and positive MP antibody IgM (OR 2.386, 95% CI [1.053–5.406], $p = 0.037$) were predictors of one-year readmissions. Age of < 2 years increased the chance of one-year readmission, but it was not statistically significantly (OR 2.395, 95% CI [0.774–7.413], $p = 0.130$) (Table 3). Systemic corticosteroid use (OR 0.494 95% CI [0.233–1.045] $p = 0.065$) and being a first-born children (OR 0.605, 95% CI [0.283–1.295], $p = 0.196$) decreased the chance of one-year readmission, but this was not statistically significant.

Discussion

Our study was one of the few studies that focused on readmissions of children hospitalized with acute asthma attacks in south China and attempted to evaluate the factors associated with one-year readmission. Our study suggested that patients with a history of eczema and positive MP antibody IgM were risk factors of one-year readmission, underlining the importance of targeted long-term postdischarge follow-up of these children. Studies have shown that numerous measures can reduce the rate of readmission in children with asthma, such as improvements in family management planning, guided education of children and family members with regard to inhalation devices and the use of asthma control drugs, adjustment of asthma education strategies, home follow-up after discharge, and improvements to the child's bedroom environment (21–26). Understanding the factors that increase the risk of readmission of

Table 1. Demographic and clinical features of all patients from 1/1/2007 to 12/31/2015.

	<i>n</i> (%) ^a
Gender	
Male	1179 (69.27)
Female	523 (30.73)
Age range (years)	
0–2	628 (36.90)
3–6	862 (50.65)
7–18	212 (12.45)
Season of admission	
Spring	322 (18.92)
Summer	348 (20.45)
Autumn	660 (38.78)
Winter	372 (21.85)
Asthma severity	
Mild	1028 (60.40)
Moderate	557 (32.73)
Severe	117 (6.87)
Admissions for the same patient	
Single admission	1612 (94.71)
Multiply admissions	90 (5.29)

^a*n* for number of admissions, column % for Total column.

Table 2. Risk factors associated with 1-year readmission.

Characteristic	Total <i>n</i> (%) ^a	Single-admission <i>n</i> (%) ^a	Re-admission <i>n</i> (%) ^a	χ^2	<i>P</i>
Gender				<0.001	1.000
Male	140 (68.29)	84 (68.29)	56 (68.29)		
Female	65 (31.71)	39 (31.71)	26 (31.71)		
Place of residence				1.164	0.281
City	134 (65.37)	84 (68.29)	50 (60.98)		
Rural	71 (34.63)	39 (31.71)	32 (39.02)		
Age, years				6.116	0.013
<2	36 (17.56)	15 (12.20)	21 (25.61)		
≥2	169 (82.44)	108 (87.80)	61 (74.39)		
LOS > 6 days				2.190	0.139
Yes	75 (36.59)	40 (32.52)	35 (42.68)		
No	130 (63.41)	83 (67.48)	47 (57.32)		
Season					
Spring				0.163	0.687
Yes	30 (14.63)	17 (13.82)	13 (15.85)		
No	175 (85.37)	106 (86.18)	69 (84.15)		
Summer				0.217	0.642
Yes	33 (16.10)	21 (17.07)	12 (14.63)		
No	172 (83.90)	102 (82.93)	70 (85.37)		
Autumn				0.088	0.767
Yes	75 (36.59)	46 (37.40)	29 (35.37)		
No	130 (63.41)	77 (62.60)	53 (64.63)		
Winter				0.133	0.715
Yes	67 (32.68)	39 (31.71)	28 (34.15)		
No	138 (67.32)	84 (68.29)	54 (65.85)		
Summer and autumn				0.395	0.530
Yes	108 (52.68)	67 (54.47)	41 (50.00)		
No	97 (47.32)	56 (45.53)	41 (50.00)		
RTI				0.222	0.637
Yes	173 (84.39)	105 (85.37)	68 (82.93)		
No	32 (15.61)	18 (14.63)	14 (17.07)		
Lower RTI				0.299	0.585
Yes	159 (77.56)	97 (78.86)	62 (75.61)		
No	46 (22.44)	26 (21.14)	20 (24.39)		
Pneumonia				0.032	0.859
Yes	131 (63.90)	78 (63.41)	53 (64.63)		
No	74 (36.10)	45 (36.59)	29 (35.37)		
Serious complications				<0.001	1.000 ^c
Yes	2 (0.98)	1 (0.81)	1 (1.22)		
No	203 (99.02)	122 (99.19)	81 (98.78)		
Sinusitis				<0.001	1.000 ^c
Yes	5 (2.24)	3 (2.44)	2 (2.07)		
No	200 (97.56)	120 (97.56)	80 (97.56)		
Allergic rhinitis				<0.001	1.000
Yes	15 (7.32)	9 (7.32)	6 (7.32)		
No	90 (92.68)	114 (92.68)	76 (92.68)		
Moderate/severe attack				0.273	0.601
Yes	122 (59.51)	75 (60.98)	47 (57.32)		
No	83 (40.49)	48 (39.02)	35 (42.68)		
ICU admission				0.866	0.352 ^c
Yes	6 (2.93)	2 (1.63)	4 (4.88)		
No	199 (97.07)	121 (98.37)	78 (95.12)		
Main complain					
Wheezing				2.261	0.133
Yes	159 (77.56)	91 (73.98)	68 (82.93)		
No	46 (22.44)	32 (26.02)	14 (17.07)		
Fever				0.494	0.482
Yes	79 (38.54)	45 (36.59)	34 (41.46)		
No	126 (61.46)	78 (63.41)	48 (58.54)		
Shortness of breath				1.820	0.177
Yes	36 (17.56)	18 (14.63)	18 (21.95)		
No	169 (82.44)	105 (85.37)	64 (78.05)		
Aerosol inhalation				0.017	0.898
Yes	119 (58.05)	71 (57.72)	48 (58.54)		
No	80 (39.02)	47 (38.21)	33 (40.24)		
SABA				1.228	0.268
Yes	78 (38.05)	50 (40.65)	28 (34.15)		
No	121 (59.02)	68 (55.3)	53 (64.63)		
ICS				0.179	0.672
Yes	83 (40.49)	51 (41.46)	32 (39.02)		
No	118 (57.56)	69 (56.10)	49 (59.76)		

(Continued)

Table 2. Continued.

Characteristic	Total n (%) ^a	Single-admission n (%) ^a	Re-admission n (%) ^a	χ^2	P
Systemic corticosteroid				2.732	0.098
Yes	90 (43.90)	60 (48.78)	30 (36.59)		
No	114 (55.61)	63 (51.22)	51 (62.20)		
Difficulty breathing				2.094	0.148
Yes	85 (41.46)	46 (37.40)	39 (47.58)		
No	120 (58.54)	77 (62.60)	43 (52.44)		
Moist crackles in lung				0.589	0.443
Yes	76 (37.07)	43 (34.96)	33 (40.24)		
No	129 (62.93)	80 (65.04)	49 (59.76)		
Extensive wheezing				0.015	0.902
Yes	64 (31.22)	38 (30.89)	26 (31.71)		
No	141 (68.78)	85 (69.11)	56 (68.78)		
Eczema history				11.089	0.001
Yes	75 (36.59)	34 (27.64)	41 (50.00)		
No	129 (62.93)	89 (72.36)	40 (48.78)		
Allergy diseases history				1.680	0.195
Yes	32 (15.61)	16 (13.01)	16 (19.51)		
No	172 (83.90)	107 (86.99)	65 (79.27)		
Food or drug allergy				1.319	0.251
Yes	26 (12.68)	13 (10.57)	13 (15.85)		
No	178 (86.83)	110 (89.43)	68 (82.93)		
First born				4.946	0.026
Yes	102 (49.76)	69 (56.10)	33 (40.24)		
No	103 (50.24)	54 (43.90)	49 (59.76)		
First production				1.494	0.222
Yes	123 (60.00)	78 (63.41)	45 (54.88)		
No	82 (40.00)	45 (36.59)	37 (45.12)		
Cesarean section				1.799	0.180
Yes	81 (39.51)	44 (35.77)	37 (45.12)		
No	124 (60.49)	79 (64.23)	45 (54.88)		
Premature birth				1.294	0.255
Yes	17 (8.29)	8 (6.50)	9 (10.98)		
No	188 (91.71)	115 (93.50)	73 (89.02)		
Birth weight<2500g				1.199	0.274
Yes	15 (7.32)	7 (5.69)	8 (9.76)		
No	190 (92.68)	116 (94.31)	74 (90.24)		
Parental allergic diseases				2.347	0.126
Yes	65 (31.71)	34 (27.64)	31 (37.80)		
No	140 (68.29)	89 (72.36)	51 (62.20)		
EOS ratio > 4%				0.019	0.891
Yes	39 (19.02)	25 (20.33)	14 (17.07)		
No	151 (73.66)	95 (77.24)	56 (68.29)		
EOS count > $0.4 \times 10^9/L$				0.002	0.965
Yes	33 (16.10)	21 (0.81)	12 (14.63)		
No	155 (75.61)	98 (79.67)	57 (69.51)		
tIgE > 250IU/ML				0.086	0.769
Yes	89 (43.41)	56 (45.53)	33 (40.24)		
No	97 (47.32)	59 (47.97)	38 (46.34)		
sIgE positive				2.613	0.106
Yes	71 (34.63)	34 (27.64)	37 (45.12)		
No	34 (16.59)	22 (17.89)	12 (14.63)		
Virus positive				0.011	0.917
Yes	24 (11.71)	14 (11.38)	10 (12.20)		
No	148 (72.20)	88 (71.54)	60 (73.17)		
Bacterial positive				0.627	0.428
Yes	22 (10.73)	15 (12.20)	7 (8.53)		
No	165 (80.49)	98 (79.67)	67 (81.71)		
MP antibody IgM				3.677	0.055
Positive	37 (18.05)	19 (15.45)	18 (21.95)		
Negative	115 (56.10)	79 (64.23)	36 (43.90)		
Pulmonary function				1.111	0.292 ^c
Abnormal	5 (2.44)	1 (0.81)	4 (4.88)		
Normal	5 (2.44)	0 (0.00)	5 (6.10)		

RTI, Respiratory Tract Infection; SABA, Short Acting Bronchodilator; ICS, Inhaled Corticosteroid; IU, International Unit; ML, Milliliter; IgM, Immunoglobulin M.

^aN (%), Column % for Total column, Row % for Readmission columns.

^bp-values from Pearson χ^2 test.

^cp-values from Continuous correction χ^2 test.

Table 3. Odds ratios for risk factors in the single admission and readmission group.

Factors	Multivariate analysis		
	Odds ratio ^a	95% CI	<i>p</i> -value
Eczema history			0.003
No	1		
Yes	3.122	1.473–6.616	
First born			0.196
No	1		
Yes	0.605	0.283–1.295	
Age, year			0.130
≥2	1		
<2	2.395	0.774–7.413	
MP antibody IgM			0.037
Negative	1		
Positive	2.386	1.053–5.406	
Systemic corticosteroid			0.065
No	1		
Yes	0.494	0.233–1.045	

^aN (%), Column % for Total column, Row % for Readmission columns.

^bOdds ratios and *p* values from binary logistic regression, reference interval for continuous independent variables listed.

^cVariables that demonstrate protective effect.

asthmatic children will assist in the close monitoring of patients at risk, reduce the rate of readmission of children with asthma, reduce school absences and parental absences from work, improve the quality of life of children with asthma, and reduce treatment costs.

The definition of “readmission” varies in different studies. In the present study readmission was defined as that occurring within one year after the first admission, and the main diagnosis was required to involve acute asthma attack, in both initial hospitalizations and readmissions. The one-year readmission rate was 5.29% in the current study, which was lower than that reported in previous studies of the range in rates (12%–28%) (12–14,16–18). In France, a 1-year readmission rate of asthmatic children aged <15 years of 11.8% was reported (13). Variable readmission rates have been reported in the US. In a study conducted in Rhode Island in the US, the re-hospitalization rate of asthma patients aged <19 years was 15% from 2001 to 2005 (14). In another study involving a cohort analysis of 44 204 hospitalized children with asthma in 42 children’s hospitals in the US from July 2008 to June 2011, the 1-year readmission rate was 17.2% (16). In another study in which 12 842 representative asthmatic children from 21 databases in the US were analyzed, the rate of readmission within one year was 12% (17). In a study in Thailand the one-year readmission rate in asthmatic children was 26.3% (18). In an Australian study including data from a total of 53 156 cases, the rate of readmission of asthmatic children was 28% (12). The reasons for the re-hospitalization rate being lower in the present study than in studies conducted in other countries can be understood as relating to the following: ① the data in

the current study were derived from a single hospital, which may have resulted in the re-hospitalization rate being underestimated by way of children being re-hospitalized in other medical institutions after the first hospitalization; ② we pay great attention to asthma education for parents, emphasize the importance of inhaler availability after discharge, and provide post-discharge outpatient follow-up by appointment.

In the present study, asthmatic children with a history of eczema were significantly more likely to be readmitted to the hospital within one year after initial admission. Additionally, the binary logistic regression analysis suggests that asthmatic children with a history of eczema were associated with a three-fold increase in the chance of one-year asthma readmission (OR = 3.122; 95% CI [1.473–6.616], *p* = 0.003). Atopic dermatitis is one of the main factors in the Asthma Prediction Index. Allergic diseases develop gradually, and atopic dermatitis and food allergies are reportedly the primary manifestations within one year of age, then respiratory allergies such as rhinitis and/or asthma develop. It has previously been reported that an increased incidence of allergic diseases including allergic rhinitis and eczema is associated with an increased incidence of asthma (27). In a study on asthma genetics, the researchers reported that the filaggrin gene was associated with acute asthma attacks and increased risk of eczema. They suggested that skin barrier dysfunction is a novel mechanism driving early childhood asthma and that this mechanism is potentially modifiable (28). Unlike previous studies conducted in China, we used binary logistic regression analysis, and the data thus derived are more representative of the current situation than data derived from older studies.

Being a first-born child seemed to lead to a lower likelihood to be readmitted to the hospital in the univariate analysis, but it had no statistical significance when adjusted logistic regressions were run. Experts hold different opinions on the influence of birth order on asthma. Some hold that children with older brothers and sisters are less likely to develop asthma (29), whereas others suggest that siblings have no effect on the incidence of asthma (30). In the current study first-born children were less likely to be readmitted to the hospital within one year following discharge from their first hospitalization, a finding which was not reported in previous studies. Based on this result, we have considered whether it is possible to conduct a prospective study to explore the effects of birth order on the readmission of children with acute asthma attacks.

In the univariate analysis in the present study, the proportion of children aged < 2 years in the readmission group was significantly higher than that in the single-admission group, suggesting that age < 2 years may be a risk factor for readmission due to acute asthma attack. This result is concordant with a previous study conducted in southwestern China in which children aged ≥ 2 years were not as likely to be readmitted to the hospital for acute asthma attacks (31). However, the association was not statistically significant in the binary logistic regression analysis in the current study. It has been reported that the risk of a severe acute asthma attack is reduced by 0.015 for every one year of age, and that childhood asthma is gradually controlled from infancy to adolescence (32). In the majority of previous studies, the risk of readmission for asthma in children aged under 5 years (and especially those aged < 2 years) was several times higher than that of older children (33–35). It has been suggested that rates of readmission for asthma in children of young age may be overestimated because without further investigation it is initially difficult to distinguish asthma from other respiratory conditions such as respiratory infection, bronchial foreign body, or respiratory malformation (e.g. bronchoconstriction) when the main symptom is wheezing, particularly in children aged < 2 years. However, we think that for these very young asthmatic children, the low compliance caused by parents' lacking of adequate disease related knowledge may contribute to another potential source of easier readmission.

Another finding of our research was that positive MP antibody IgM was an independent risk factor for re-admission when adjusted logistic regressions were run. Positive MP antibody IgM was associated with a two-fold increase in the chance of early asthma readmission (OR = 2.386; 95% CI [1.053–5.406], $p = 0.037$), which has not been reported yet. MP infection is known to exacerbate asthma pathology as well as to cause the onset of asthma itself (36). In previous studies, it was reported that MP infection was frequently associated with exacerbations of asthma in children, and it could lead to decreased pulmonary function, difficulty in controlling asthma and more severe airway inflammation (37,38). Another study showed that asthma control and quality of life scores were lower in MP-positive patients with asthma (39). Based on these results, we supposed that MP infection increased the risk of readmission by worsening asthma control.

Systemic corticosteroid used before the index hospitalization seemed to lead to a lower likelihood of

readmission, but there was no statistical significance in the binary logistic regression analysis. We supposed that cases requiring the use of systemic corticosteroids before hospitalization successfully, attracted the physicians' and patients' attention, and then improved the control of asthma.

In the present study, patient history of eczema and positive MP antibody IgM was the main risk factors with regard to one-year readmission in children with acute asthma attacks, underlining the importance of targeted long-term postdischarge follow-up of these children although this differs substantially from some of the results of studies conducted in other countries. In some of these studies, the main clinical factors affecting readmission in children were emergency room visits, ICU visits, complex chronic comorbidities, asthma severity, the use of intravenous glucocorticoids, and lung function (40–43). This may be partly due to differing definitions of readmission. Furthermore, it was reported that children previously admitted to the ICU for asthma had shorter times to asthma-related readmission compared to children who did not require intensive care (44), indicating that we can explore risk factors of early readmission in the future. We postulate that differences in the management of asthmatic children in different countries may also be associated with differences in results across studies.

Many psychosocial risk factors associated with higher asthma readmission rates have been examined, including public insurance, perceptions of asthma, inhaled steroid treatment, family conflict, negative attitudes toward asthma treatment, financial influences, personal confidence, race and/or minority group identification, crowded housing conditions, living in a single parent household, and mother's level of education (41,45,46). Medical records had insufficient data on non-clinical features resulting in the inability for analyses and adjustment for psychosocial risk factors.

The current study had some limitations. First, it was unfortunate that important factors such as asthma medication compliance, asthma control levels, and family dynamics could not be analyzed in the study as this information was not noted clearly in the medical records. This may have been due to differences in the medical systems in different countries. Second, the data were all derived from a single hospital, and some patients may have been readmitted to other medical institutions after their first admission, resulting in an underestimation of the readmission rate. Notably however, the hospital is among one of the largest hospitals in south China and each year the hospital admits

more than 42 000 children between 2017 and 2018, which was approximately 10 folds than other hospitals in the same area. It is known as a professional children's hospital that specializes in the diagnosis and treatment of asthma. Therefore, it is routine for children in the area suffering from acute asthma attacks to be brought to that specific institution. In addition, the focus of the study was acute asthma attacks in children, who as such would be taken to the closest hospital due to the urgent onset of the condition. A prospective, multi-center study with a large sample size is required in the future.

Conclusions

Among the children admitted to a hospital in south China with acute asthma attacks, 5.29% were readmitted within the following year. Patients with a history of eczema and positive MP antibody IgM had significantly increased chances of one-year readmission, underlining the importance of targeted long-term post-discharge follow-up of these children. By taking some certain feasible measurements for these patients, readmissions can be decreased in order to improve the quality of life of children and their parents and lighten the financial burden and mental stress on the family.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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