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Correlations between clinical illness, respiratory virus infections and climate factors in a tropical paediatric population

T. P. LOH[1,2], F. Y. L. LAI[3], E. S. TAN[1], K. C. THOON[1], N. W. S. TEE[4], J. CUTTER[3] AND J. W. TANG[2]*

[1] *Department of Paediatric Medicine, Kandang Kerbau Women's and Children's Hospital, Singapore*
[2] *Department of Laboratory Medicine, National University Hospital, Singapore*
[3] *Communicable Diseases Division, Ministry of Health, Singapore*
[4] *Department of Laboratory Medicine and Pathology, Kandang Kerbau Women's and Children's Hospital, Singapore*

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SUMMARY

Weekly (August 2003–December 2008) numbers of five common paediatric diseases and the incidence of respiratory viruses were obtained from a children's hospital in Singapore and correlated with climate data using multivariate time-series techniques. Upper respiratory tract infections were positively correlated with the incidences of influenza A, B, respiratory syncytial virus (RSV) and parainfluenza viruses (types 1–3 combined). Lower respiratory tract infections were positively correlated with only the incidence of RSV. Both upper and lower respiratory tract infections were negatively correlated with relative humidity. Asthma admissions were negatively correlated with maximum temperature and positively correlated with the incidence of influenza B and increasing hours of sunshine. Although sporadic cases of adenovirus infection were identified, not enough cases were available for a more detailed analysis. Gastroenteritis and urinary tract infections, included as control diseases, were not correlated significantly with any climate parameters. These correlations are compatible with current understanding of respiratory virus survival under certain climate conditions and may assist the prediction of disease burdens and hospital resource planning in such tropical environments.

Key words: Infectious disease, infectious disease epidemiology, influenza (seasonal), paediatrics, public health.

INTRODUCTION

Although in temperate regions the incidence of some respiratory virus infections [e.g. influenza, respiratory syncytial virus (RSV), parainfluenza virus] appears to correlate well with seasonal weather conditions, in tropical countries this relationship has been much less well-defined with detectable respiratory virus activity all year round [1, 2]. In fact, it has been suggested that the relationships between certain meteorological factors (e.g. temperature and relative humidity) and the incidence of some respiratory viruses are the converse of those found in temperate regions [3, 4], which may be due to the majority of virus transmission occurring within indoor, air-conditioned (i.e. cooler, lower

* Author for correspondence: Dr J. W. Tang, Department of Laboratory Medicine, National University Hospital, 5 Lower Kent Ridge Road, Singapore 119074.
(Email: jwtang49@hotmail.com *or* julian_wt_tang@nuh.com.sg)

humidity) environments that favour airborne virus survival and transmission [5, 6].

Yet there is still a need to understand more clearly the relationship between respiratory illness, respiratory virus incidence and meteorological factors in tropical countries, as this may assist in hospital services planning for paediatric admissions. This has become particularly relevant with the recent emergence of the pandemic influenza A/H1N1/2009 virus, which is likely to become the predominant circulating influenza strain for the next several years [7, 8].

Singapore is an equatorial island, situated in the monsoon rain belt of South East Asia. Being in the tropics, the climate remains relatively stable all year round. Mean daily temperatures are 23·9–32·3 °C with a monthly rainfall of 107–329 mm. An annual wet season occurs from October to January when rainfall is above average followed by a relatively dry period from February to early March [9]. Although there has been one study relating meteorological conditions to respiratory virus incidence in Singapore [1], this used laboratory data only rather than data on clinical admissions for influenza-like illness.

Elsewhere, outside the tropics, there have been numerous studies examining the seasonality of influenza illness and its associated hospitalization burden and mortality [10, 11]. However, these studies did not specifically attempt any correlations with meteorological parameters. Other researchers have questioned the relevance of such climate variables as a significant underlying contributor to the seasonality of respiratory virus infections in more temperate regions, citing other potentially significant contributing factors such as host immune responses and viral virulence [12, 13].

There has been a call for more studies to be conducted in tropical areas [14, 15]. The present study was designed to explore the relationship between factors affecting the seasonality of five common presenting clinical conditions (i.e. asthma, upper and lower respiratory tract infections, urinary tract infections, acute gastroenteritis), the incidence of laboratory-confirmed respiratory viral infections and their correlation with various meteorological parameters in a tropical paediatric population.

MATERIALS AND METHODS

This is a retrospective study using previously collated data for the period 4 August 2003 to 28 December 2008. Approval from the Kadang Kerbau Women's and Children's Hospital institutional review board (reference no. RAU/2008/148) was given for this study.

Meteorological data

Daily meteorological parameters were obtained from the Meteorological Services Division, National Environment Agency of Singapore, for this period. The parameters included: maximum, average and minimum temperature, relative humidity, rainfall, amount of cloud and sunshine duration.

In addition, it has been suggested recently that absolute as opposed to relative humidity measurements may correlate more closely with influenza virus transmission and survival [16]. Vapour pressure (e) can be calculated from temperature and relative humidity using the following equations:

$$e = e_s(T) \times \frac{\mathrm{RH}}{100} \text{ and } e_s(T) = e_s(T_0) \times \exp\left(\frac{L}{R_v}\left(\frac{1}{T_0} - \frac{1}{T}\right)\right)$$

where $e_s(T_0)$ is saturation vapour pressure at reference temperature T_0 (6·11 mb), T_0 is the reference temperature (273·15 K), L is the latent heat of evaporation for water (2·27 MJ/kg), R_v is the gas constant for water vapour (461·5 J/kg.K), T is temperature in degrees Kelvin (K); and RH is relative humidity [16].

Hence, in this study, the relationship between absolute humidity and the various clinical conditions was also investigated by using vapour pressure as the measure of absolute humidity.

Clinical data

The Kadang Kerbau Children and Women's Hospital (KKH) is an 830-bed healthcare facility dedicated to the care of women and children in Singapore. The Children's Emergency department (CE) at KKH employs an electronic healthcare recording system where a patient's clinical diagnosis is coded according to the International Classification of Diseases – 9th Clinical Modification (ICD-9-CM) upon discharge.

The weekly total number of patients for this study period, together with their demographic characteristics, who were diagnosed as having upper respiratory tract infection (URTI, ICD-9-CM codes: 461-465), lower respiratory tract infection (LRTI, ICD-9-CM 033, 466, 483, 486, 770), asthma (ICD-9-CM 493), urinary tract infection (UTI, ICD-9-CM 590, 595, 599) or acute gastritis/gastroenteritis (ICD-9-CM 002, 005, 009, 535, 787) was extracted from the electronic patient database. Note that the

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ICD-9-CM codes used by the KKH CE is an abridged version which does not contain all the clinical codes. This is to allow rapid and streamlined encoding by the physicians based on the patients' presenting symptoms. As such, the grouping of clinical conditions in this study were selected from all available ICD-9-CM codes used by KKH CE and verified independently by three physicians. Cases of UTIs and acute gastritis/gastroenteritis were included as clinical admission controls, with the assumption that there was no expected association between these illnesses and respiratory virus infections or any particular meteorological parameter.

Laboratory data

The respiratory samples (usually nasopharyngeal aspirates) that were tested for respiratory viruses were mainly obtained from younger paediatric patients (aged 0–5 years, with no other demographic restriction), who presented with respiratory illnesses, most of whom were admitted to the wards. The routine respiratory virus panel that was applied to all respiratory samples included: influenza A (unsubtyped), influenza B, RSV, parainfluenza virus (types 1–3), and adenoviruses. These viruses were detected with a commercial slide-based assay, using virus-specific fluorescence-labelled monoclonal antibodies (D^3 Ultra™ DFA Respiratory Virus Screening & ID kit, Diagnostic Hybrids Inc., USA) and ultraviolet light microscopy. The weekly number of positives detected for each respiratory virus was routinely collated and archived. The data relevant to the period under study was extracted from this laboratory database for analysis.

Statistical analysis

We calculated the average time-series by week over the years between 4 August 2003 and 28 December 2008 and plotted these aggregated measures graphically to examine for the presence of seasonality. Multivariate time-series analysis was conducted to study the effect of meteorological factors on the paediatric admissions for asthma, URTIs, LRTIs, acute gastroenteritis and UTIs for this period.

First, an ARIMA (autoregressive integrated moving average) model was developed for each of these five weekly paediatric clinical conditions. ARIMA models predict the value of the target variable with a linear function of lag values (autoregressive part) plus an effect from random shock values (moving average part). The identification of the order of autoregressive and moving average followed the Box–Jenkins approach. The need for differencing was accessed by a visual inspection of the time-series plot as well as the autocorrelation plot of the time-series.

Second, meteorological parameters were inserted as explanatory variables into these ARIMA models. For URTIs, LRTIs and asthma, further models were explored to include the laboratory virological data (i.e. the positive respiratory virus immunofluorescence results) as explanatory variables. The selection of the explanatory variables was performed, based on a backward approach. Akaike's Information Criterion (AIC), which acts to penalize the number of parameters in the model, was used to guide the model selection, i.e. the lower the AIC, the better the model fit. The validity of the model was checked by examining the residuals with the modified portmanteau test. Statistical analyses were performed with SAS/ETS version 9.0 (SAS Inc., USA). A P value of $<0{\cdot}05$ was considered as statistically significant.

RESULTS

Meteorological data

During this study period, the average temperature in Singapore ranged between 25 °C and 30 °C throughout the year with the highest during April–May (average temperature 28 °C, average maximum temperature ~32 °C) and the coolest during December and January (average temperature 26 °C, average minimum temperature ~24 °C). Relative humidity tends to be highest (average 85–87%) in December and January, when the most rainfall occurs. Vapour pressure, a measure for absolute humidity, tends to be lowest in January and February reaching its highest in and around May. February tends to be the driest month of the year with the lowest rainfall and a relative humidity of about 80%. Sunshine duration is highest in January–February (average 6–8 h) and lowest towards the end of the year (average 4 h). The amount of cloud is lowest in January–February (average 85%) and highest towards the end of the year (average 89%).

Over the study period these meteorological parameters were found to conform to a longer historical trend from 1982 to 2008, without significant deviation, i.e. for each year the mean daily temperature was warmest during weeks 16–28 (April–June) while the wettest months occurred during weeks 44 to 4

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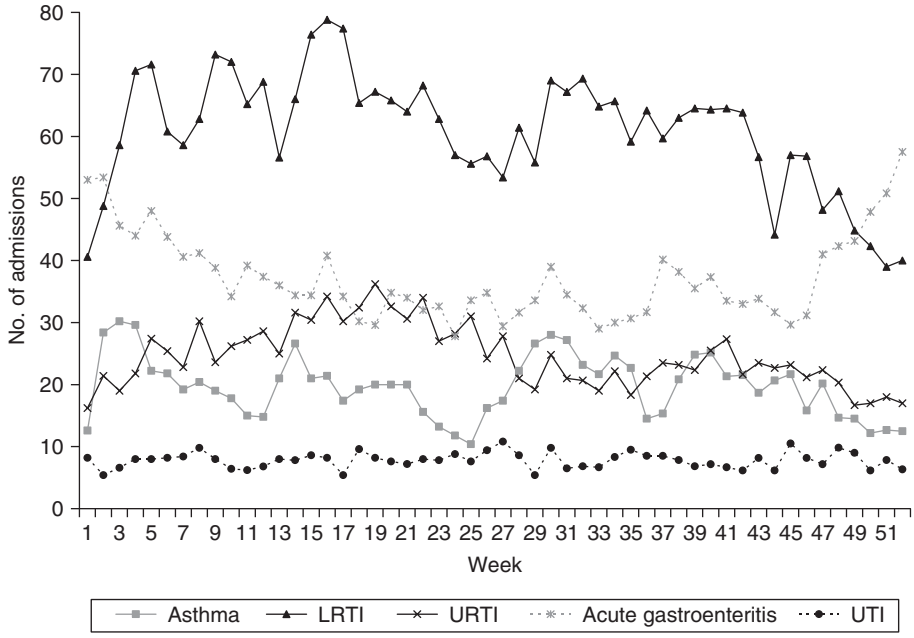

Fig. 1. Weekly average of various paediatric emergency admissions [asthma, lower respiratory tract infection (LRTI), upper respiratory tract infection (URTI), acute gastroenteritis and urinary tract infection (UTI)] in Singapore for the period August 2003 to December 2008.

(November to January of the following year) [9]. Hence this study period can be considered to be typical of Singapore with regard to climate parameters.

Clinical data

Clinical data from a total of 42 155 hospital admissions were included in this study. Of these, 58% were males and 42% were females. Almost three quarters of the patients were aged <5 years, 25% were aged between 5 and 14 years and <1% were aged >14 years. Chinese were the biggest ethnic group, accounting for slightly more than half of the study population, followed by Malays (30%) and Indians (11%), the remaining 5·8% were from other races. A plot of the weekly average of the paediatric emergency admissions over the study period is shown in Figure 1.

Admissions for URTIs and LRTIs tend to be highest in April (32–35 URTI, 76–78 LRTI admissions a week) and reach their lowest in December (18 URTI, 40 LRTI admissions a week). Admissions for LRTIs also show a second, smaller peak in August (70 admissions a week). Admissions for gastroenteritis tend to be high at the beginning of a year (52 admissions a week), then decline gradually to reach their lowest in August (30 admissions a week) then rise again towards the end of the year (50–58 admissions a week).

The number of paediatric admissions due to asthma appears to show two cycles a year with the peaks occurring in January and July (with about 30 admissions a week), followed by smaller peaks in April and October (25–26 admissions a week), reaching the lowest in June and December, respectively (10–12 admissions a week). These peaks appear to coincide with school re-opening months (January and July of each year) while the troughs fall within the school holiday periods of >4 weeks during June and December.

Admissions for acute gastritis/gastroenteritis are highest in December and January (>50 admissions a week) and then gradually decrease to their lowest in May and June (30–35 admissions a week). Admissions for UTIs do not seem to exhibit any obvious seasonality pattern with the admissions varying from 6 to 10 per week, throughout the year.

Laboratory data

A total of 44 026 respiratory samples were analysed by the laboratory during this period, with 7487 specimens being positive for at least one respiratory virus (overall positive rate of 17·0%).

From those laboratory-confirmed incidence data, RSV tends to peak in early June and late July with influenza A peaking in between. Influenza B activity tends to be relatively higher in the earlier months of

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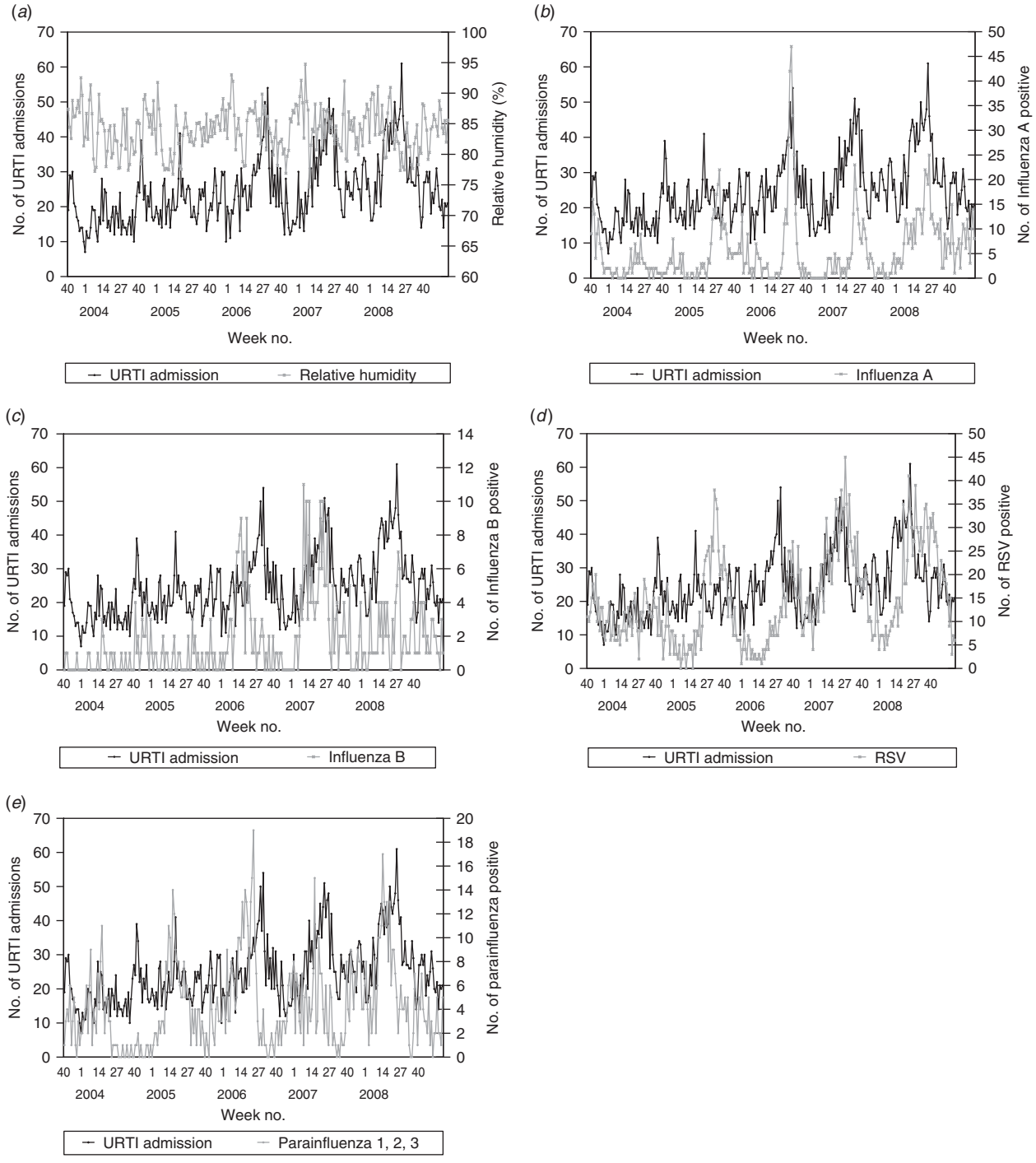

Fig. 2. (*a*) Weekly paediatric admissions for upper respiratory tract infection (URTI) against weekly average relative humidity and (*b*) weekly number of positives for influenza A, (*c*) influenza B, (*d*) respiratory syncytial virus (RSV) and (*e*) parainfluenza viruses (types 1–3).

the year with the activity declining towards the end of the year. A similar pattern is observed for the parainfluenza viruses (all types, 1–3 combined) (Fig. 2). No consistent seasonality pattern was observed for adenovirus (data not shown, but available on request).

A summary of the weekly statistics for the number of paediatric emergency admissions, meteorological parameters and laboratory virological data for Singapore during the study period is given in Table 1.

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Table 1. *Summary of weekly statistics for paediatric emergency admissions, meteorological parameters and laboratory virological data in Singapore during August 2003–December 2008*

Attribute	Mean	Lower quartile	Median	Upper quartile	Minimum	Maximum
Condition of admission						
Asthma	19·7	14	19	24	5	42
Upper respiratory tract infection	24·3	17	23	29	7	61
Lower respiratory tract infection	60·5	48	59	71	26	113
Acute gastroenteritis	37·2	27	34·5	46	7	84
Urinary tract infection	7·8	6	7	10	1	16
Meteorological parameter						
Average temperature (°C)	27·7	27·0	27·7	28·4	25·4	30·1
Minimum temperature (°C)	24·9	24·4	24·8	25·4	23·3	27·5
Maximum temperature (°C)	31·4	30·8	31·5	32·1	27·6	34·9
Relative humidity (%)	84·0	81·5	84·1	86·6	74·7	94·7
Vapour pressure (mb)	26·9	26·4	26·9	27·4	22·3	29·1
Amount of cloud (%)	87·3	86·5	87·6	88·7	65·0	94·7
Rainfall (mm)	6·7	1·4	4·5	8·7	0·0	58·1
Sunshine duration (h)	5·6	4·2	5·5	6·9	0·1	10·4
Laboratory parameter (no. of positives)						
Influenza A	5·3	1	3	8	0	47
Influenza B	1·7	0	1	2	0	11
Respiratory syncytial virus	14·4	7	12	20	0	45
Parainfluenza (types 1, 2, 3)	4·2	1	3	6	0	19
Adenovirus	0·9	0	0·5	1	0	8

Data analysis

The multivariate time-series models for paediatric admissions for asthma, URTIs, LRTIs, gastroenteritis and UTIs are summarized in Table 2. For URTI and LRTI admissions, the best models were found to be ARIMA(3,0,0) and ARIMA(2,0,0), respectively. Both URTI and LRTI admissions decreased with rising relative humidity. However, calculated vapour pressure did not show any significant correlation with URTIs and LRTIs ($P=0{\cdot}0663$ in the URTI model, $P=0{\cdot}2572$ in the LRTI model). With respect to laboratory-confirmed respiratory virus infections, URTI admissions were found to increase with the number influenza A ($\beta=0{\cdot}355$, $P<0{\cdot}0001$), influenza B ($\beta=0{\cdot}845$, $P<0{\cdot}0001$), RSV ($\beta=0{\cdot}208$, $P=0{\cdot}0012$) and parainfluenza viruses (types 1–3 combined, $\beta=0{\cdot}512$, $P=0{\cdot}0001$) positive test results. The model also indicates that for this dataset, there is an increase of 0·355 URTI admissions for each additional influenza A positive, i.e. on average, 1/3 laboratory-confirmed influenza A infection is admitted for URTI. Similarly, there are an extra 0·845, 0·208 and 0·512 URTI admissions for each additional influenza B, RSV and parainfluenza virus (types 1–3) positive infections, respectively (Fig. 2). So, for example, for RSV, this would mean that on average, 1/5 laboratory-confirmed RSV infection is admitted for URTI.

For LRTI admissions, the series was found to be positively correlated with the number of RSV positive tests ($\beta=0{\cdot}584$, $P<0{\cdot}0001$), i.e. on average, 3/5 laboratory-confirmed RSV infections are admitted for LRTI (Fig. 3).

Admissions for asthma were found to be a time-series process with moving average terms at lags 11 and autoregressive terms at lags 1, 26 and 52 with maximum temperature negatively correlated ($\beta=-1{\cdot}363$, $P=0{\cdot}0076$) and sunshine duration positively correlated ($\beta=0{\cdot}871$, $P=0{\cdot}0006$) with asthma admissions (Fig. 4). This suggests that on average there is a decrease of 2·7 asthma admissions per week for an increase of 2 °C maximum temperature. Conversely, there is an increase of 1·7 asthma admissions per week for an increase of 2 h sunshine duration. Asthma was also found to be positively correlated with the number of influenza B-positive samples ($\beta=0{\cdot}481$, $P=0{\cdot}0070$).

For all these admission conditions (asthma, URTIs, LRTIs), the addition of the meteorological parameters and laboratory results into the models

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Table 2. *Multivariate time-series models for paediatric admissions due to asthma, upper respiratory tract infection (URTI), lower respiratory tract infection (LRTI), gastroenteritis and urinary tract infection (UTI) (August 2003–December 2008)*

Parameter	Period of differencing	Lag	Model 1: Base model			Model 2: with meteorological parameters			Model 3: with meteorological and laboratory parameters		
			β	S.E.	*P* value	β	S.E.	*P* value	β	S.E.	*P* value
Asthma	0										
MA		11	−0·133	0·060	0·0272	−0·138	0·060	0·0220	−0·137	0·061	0·0241
AR		1	0·426	0·050	<0·0001	0·452	0·049	<0·0001	0·451	0·050	<0·0001
AR		26	0·211	0·054	<0·0001	0·216	0·054	<0·0001	0·207	0·054	0·0001
AR		52	0·208	0·057	0·0003	0·173	0·056	0·0022	0·166	0·057	0·0037
Max. temperature		0				−1·347	0·515	0·0089	−1·363	0·511	0·0076
Sunshine duration		0				0·883	0·258	0·0006	0·871	0·256	0·0006
Influenza B									0·481	0·179	0·0070
URTI											
AR	0	1	0·423	0·059	<0·0001	0·395	0·060	<0·0001	0·234	0·060	0·0001
AR		2	0·306	0·062	<0·0001	0·330	0·061	<0·0001	0·296	0·059	<0·0001
AR		3	0·104	0·059	0·0797	0·118	0·060	0·0478	0·187	0·060	0·0018
Relative humidity		0				−0·349	0·104	0·0008	−0·228	0·098	0·0200
Influenza A		0							0·355	0·083	<0·0001
Influenza B		0							0·845	0·211	<0·0001
RSV		0							0·208	0·064	0·0012
Parainfluenza		0							0·512	0·135	0·0001
LRTI											
AR	0	1	0·548	0·058	<0·0001	0·549	0·058	<0·0001	0·475	0·059	<0·0001
AR		2	0·202	0·059	0·0006	0·207	0·059	0·0004	0·206	0·059	0·0005
Relative humidity		0				−0·827	0·195	<0·0001	−0·760	0·192	<0·0001
RSV		0							0·584	0·124	<0·0001
Gastroenteritis	1										
MA		1	0·480	0·053	<0·0001						
AR		51	0·284	0·064	<0·0001						
UTI											
MA	0	1	0·800	0·089	<0·0001						
MA		26	0·109	0·040	0·0059						
AR		1	0·858	0·076	<0·0001						
AR		8	0·104	0·046	0·0231						
Asthma			Model 1 AIC = 1784·1			Model 2 AIC = 1777·0			Model 3 AIC = 1771·8		
URTI			Model 1 AIC = 1841·9			Model 2 AIC = 1832·9			Model 3 AIC = 1795·0		
LRTI			Model 1 AIC = 2185·6			Model 2 AIC = 2170·0			Model 3 AIC = 2152·3		
Gastroenteritis			Model 1 AIC = 1991·5								
UTI			Model 1 AIC = 1375·0								

MA, Moving average; AR, autoregressive; RSV, respiratory syncytial virus; AIC, Akaike's Information Criterion.

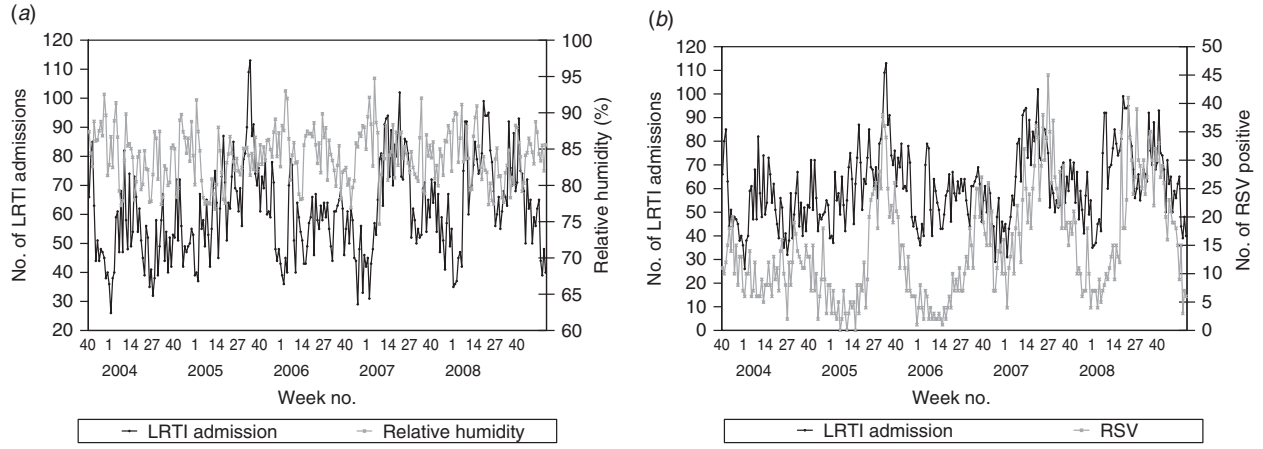

Fig. 3. (*a*) Weekly paediatric admissions for lower respiratory tract infection (LRTI) against weekly average relative humidity and (*b*) weekly number of positives for respiratory syncytial virus (RSV).

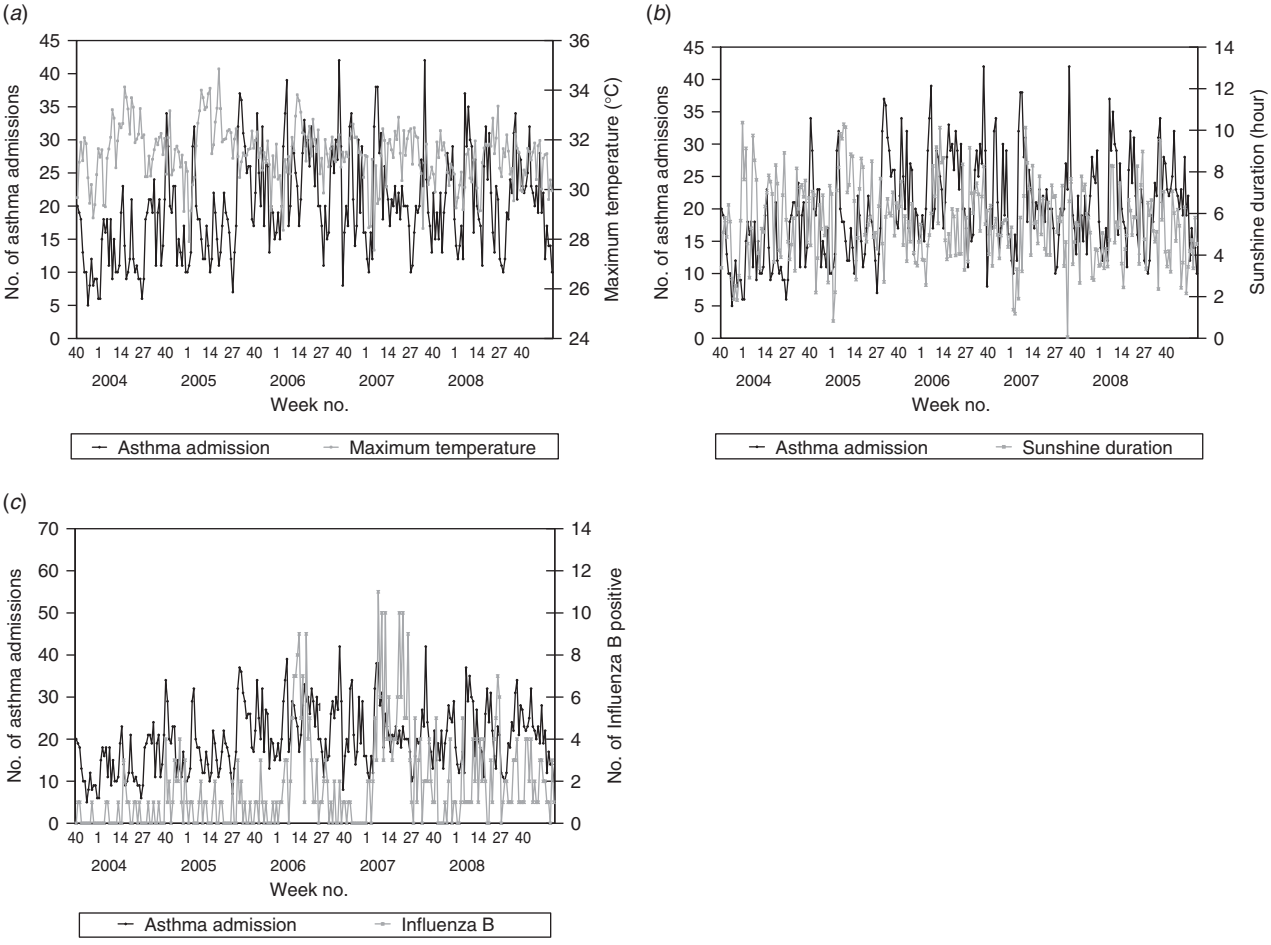

Fig. 4. Weekly paediatric admissions for asthma against (*a*) weekly average maximum temperature, (*b*) sunshine duration and (*c*) influenza B-positive samples.

resulted in a smaller AIC. The models with the meteorological variable(s) and laboratory results indicated a better fit than those without.

The admission series for gastroenteritis and UTIs were not found to correlate with any meteorological parameters. For all models, the modified portmanteau

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test showed that the autocorrelation of the residuals at each lag was not significant, indicating that error structure of the resultant models exhibited as white noise.

DISCUSSION

In temperate regions, there are clear seasonal variations in the occurrence of influenza activity, with a marked peak in the cold winter months. However, tropical regions have a much less well-defined seasonality with detectable background activity throughout the year. In particular, the relationship between three different, but potentially related groups of variables: hospital admissions for respiratory illness (asthma, LRTIs, URTIs), laboratory-confirmed respiratory virus infections, and meteorological parameters, in such a tropical climate has not yet been investigated. This study has examined these three different groups of variables in the tropical climate of Singapore, using multivariate time-series analyses.

As a statistical tool ARIMA models are useful in modelling the stochastic dependence structure of a time-series. Through the modelling of the stochastic dependence, ARIMA models have been shown to provide more accurate predictions than those obtained by the traditional regression methods [17, 18]. Time-series analyses have been increasingly used in seasonality studies of hospital admissions [19, 20], and epidemiological studies of respiratory tract infections [1, 4, 21–23]. Hence, this statistical approach, as used in the present study, is an acceptable method to analyse this data to determine any resulting correlations between the various clinical, laboratory or meteorological parameters.

Thus, in this study, using time-series analysis, CE admission of both URTIs and LRTIs were found to be negatively related to relative humidity. This finding is consistent with existing knowledge as higher relative humidities are known to decrease the survival of lipid-enveloped viruses, which include the four virus species above: influenza A (unsubtyped), influenza B, RSV, parainfluenza virus (types 1–3), although not adenoviruses [5, 6, 24–28].

Shaman & Kohn suggested that absolute humidity, as opposed to relative humidity, may better correlates with influenza virus survival and transmission [16]. In contrast, our study suggests that admissions for URTIs and LRTIs correlate better with relative humidity than absolute humidity. We have attempted to include vapour pressure, the surrogate measure of absolute humidity, instead of relative humidity in the LRTI and URTI models but neither model yielded a statistically significant correlation.

With respect to laboratory-confirmed data, URTI admissions were positively related to the incidences of influenza A and B, RSV, parainfluenza viruses (types 1–3, combined in this analysis), whereas LRTI admissions were only positively related to the incidence of RSV infections. Whereas all of these viruses can cause both URTIs and LRTIs, RSV tends to be the most common cause of bronchiolitis (a LRTI) in young children and this may have weighted the significance of this positive correlation with LRTIs towards RSV compared to the other respiratory viruses [29, 30].

Severe, early childhood infections with RSV (i.e. enough to warrant hospitalization) are thought to be linked to the subsequent development of childhood asthma, as well as its exacerbation [31]. In our study it was found that asthma admission was positively correlated to influenza B infection and that it decreased with maximum temperature and increased with duration of sunshine. These results may appear to be paradoxical because in more temperate climates it has been reported that asthma attacks tend to increase in the colder months which have fewer hours of sunshine [19, 20]. Despite the specific, significant correlation with influenza B (as opposed to the much more prevalent influenza A), many other non-viral and non-meteorological factors may influence asthma attacks, such as animal allergens (e.g. from rodents, cats, dogs, insects) [32], air pollution (which may account for summer asthma spikes) [19], and increased emotional stress (e.g. at the start of a new school year) [33]. Therefore, any correlation between those asthma admissions related to any specific respiratory virus infection may be easily hidden in the, possibly far greater number of admissions for asthma exacerbations triggered by these other non-viral factors. Moreover, the significant correlations with the meteorological parameters may actually reflect the influence of factors that vary with such climate factors, e.g. air pollution, timing of the new school year and the behaviour of animals.

Interestingly, neither acute gastroenteritis nor UTI-related admissions were found to be significantly correlated with the any of the meteorological parameters. However, previous studies of rotavirus infection (one of the commonest causes of infectious gastroenteritis in children) have demonstrated a

correlation with colder months in winter/early spring in more temperate countries [34]. This is less well-defined in more subtropical/tropical countries [35, 36], although some studies from such regions show some comparatively inconsistent relationships with climate parameters [37]. For noroviruses, which are a more common gastroenteritis pathogen in adults, again the peak incidence is usually in the winter months (hence the traditional name 'winter-vomiting disease') [38], although some recent studies have also shown a summer peak for this virus infection [39]. Given all of this, further studies of gastroenteritis infections with climate parameters are certainly warranted in this tropical paediatric population.

It is interesting that in this study of clinical respiratory illness, laboratory-confirmed respiratory virus incidence and climate data in a tropical setting, the correlations found can be explained with the current existing knowledge about airborne virus survival [5, 6, 24–28]. In contrast, a recent study from subtropical Hong Kong found contradictory correlations between their laboratory-confirmed respiratory virus incidence data and their meteorological parameters, i.e. an increasing incidence of lipid-enveloped respiratory viruses (like influenza) in the hotter more humid summer months, when airborne virus survival should be decreased. One possible explanation suggested for this was that in these hotter, humid months, indoor transmission in air-conditioned environments accounted for most of the transmission [4]. More studies may further improve the understanding of these complex relationships between clinical, laboratory and meteorological variables in such subtropical and tropical environments.

In summary, this study correlates three parallel sets of data in a tropical paediatric population: clinical illness, laboratory-confirmed respiratory virus incidence, and contemporary meteorological parameters. The correlations found were understandable with the current knowledge of these clinical diseases and virus biology, but additional investigations are required to confirm and augment these findings, especially with regard to the detection and correlation with the more prevalent common cold viruses (e.g. rhinoviruses and coronaviruses), which are not routinely tested for in most hospital diagnostic laboratories.

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DECLARATION OF INTEREST

None.

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