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An Australian national panel study of diurnal temperature range and children's respiratory health

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ABSTRACT

Background: It is still uncertain whether diurnal temperature range (DTR) affects children's respiratory function.

Objective: To examine the effects of DTR on lung function and respiratory symptoms for school children with asthma in Australia.

Methods: A panel of 270 children (ages 7–12 years) with asthma living in 6 Australian cities was recruited. They were asked to perform 3 successive forced expiratory maneuvers using a portable electronic peak flow meter twice daily for 4 weeks. The highest values for peak expiratory flow (PEF) were stored for each session. At the same time, they were asked to record their respiratory symptoms (eg, cough and/or phlegm and wheeze and/or chest tightness) every day in the morning (for nighttime symptoms) and evening (for daytime symptoms). Daily data on different metrics of ambient temperature and air pollution were obtained from fixed monitors nearby. Relative humidity data were downloaded from the Weather Underground website. Mixed models, adjusting for children's individual characteristics and air pollution, were used to examine the effects of DTR on PEF and respiratory symptoms.

Results: DTR had linear effects on PEF and respiratory symptoms. An increase in DTR induced a reduction in PEF and increased the occurrence of respiratory symptoms. In general, the effects lasted for 3 days (lag, 0–2 days). The effects occurred for both boys and girls.

Conclusion: Our findings provide evidence that DTR had significant effects on lung function and respiratory symptoms for children with asthma. These results indicate that it is important and necessary to protect children with asthma from the effect of unstable weather.

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Introduction

Recently, a number of studies have examined the association between ambient temperature and disease.^{1,2} However, less evidence is available on the effects of diurnal temperature range (DTR) on health. DTR, calculated as the difference between maximum and minimum temperatures within 1 day, is considered an important index of weather change (or weather variability) because it provides more information than the daily mean temperature alone.³

A small numbers of studies have reported that an increase in DTR adversely affects deaths and hospital admissions.^{4–6} However, no previous study has examined the effects of DTR on lung function and respiratory symptoms. Knowledge of this relationship would lead to greater understanding of the effects of short-term temperature changes on respiratory health.

Epidemiologic studies have focused on the health effects of ambient temperature on potentially sensitive population subgroups, such as children, to ensure protection of these susceptible population groups.^{7,8} Potential determinants of children's susceptibility include the continuing process of lung growth and development, immature host defenses, high rates of infection with respiratory pathogens, and activity patterns that increase exposure to ambient environment.⁹ The prevalence of asthma in Australia is one of the highest in the world, affecting 10% of Australians.¹⁰ It is the leading cause of burden of disease in children aged 0 to 14 years

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in Australia, accounting for 17.9% of the total burden in boys and 18.6% in girls.¹¹ However, few studies have examined the effects of temperature change on lung function and respiratory symptoms for children with asthma in Australia.

The aim of this article is to examine the short-term effects of DTR on lung function and respiratory symptoms in children with asthma. We used data from an Australia-wide panel study conducted in children. We examined the overall associations and the associations stratified by sex using mixed models, which allow for random effects for individuals. A better understanding of the adverse effects of DTR on lung function and respiratory symptoms among children with asthma will provide important information for developing public health plans and risk assessments in the ambient environment.

Methods

The Australian Child Health and Air Pollution Study is a cross-sectional study that examined both the cumulative and short-term effects of environmental factors (in particular, ambient air pollution, temperature, and relative humidity) on respiratory health in a representative sample of children aged 7 to 12 years living in urban areas of Australia. This study was conducted in 6 major Australian cities: Sydney, Melbourne, Brisbane, Adelaide, Perth, and Canberra. There were at least 2 air monitoring stations per city. All monitoring stations had a 5-year history of monitoring. The study period for each location is described in eTable 1. A panel of children with asthma or asthmalike symptoms was selected from the full Australian Child Health and Air Pollution Study population and formed the basis of the analyses.

Study Ethics

The study protocol was approved by the Departments of Education of the Universities of Queensland and Sydney in the Australian Capital Territory, New South Wales, Queensland, South Australia, Victoria and Western Australia. Ethics approval was also obtained from the Catholic Education Office of Victoria to perform the study at selected Victorian Catholic primary schools. All study participants and their parents or guardians gave written informed consent before participation in the study.

Study Participants

We sampled primary schools that were within 3 km of air monitoring stations. In those schools that met the eligibility criteria and agreed to participate, we distributed an information statement, consent form, and questionnaire to children in all or some classes in school years 3 to 5. This cross-sectional study was conducted during 2007–2008. The questionnaire was completed by a parent and asked questions about respiratory symptoms and illnesses and relevant environmental exposures. Children with physician-diagnosed asthma and symptoms of asthma within the preceding year and who were living within a 3-km radius of the corresponding air monitoring station were invited to take part in the panel study. The panel study was conducted in Melbourne, Brisbane, Adelaide, Perth, and Canberra during 2007 and in Sydney during 2008.

Lung Function Measurement and Respiratory Symptoms Diary

We provided each participant with an electronic peak flow meter (Mini Wright Digital; Clement Clarke, Essex, United Kingdom). They were taught how to use the electronic peak flow meter by trained investigators and asked to perform 3 successive forced expiratory maneuvers before taking any inhaled medication, twice daily for 4 weeks. The highest peak expiratory flow (PEF) from these 3 successive measurements were automatically stored in the device with a date and time stamp.

Children completed a diary for respiratory symptoms and medication use under their parents' instruction every morning (for nighttime symptoms) and evening (for daytime symptoms) for 4 weeks. Respiratory symptoms included cough and/or phlegm and wheeze and/or chest tightness. Symptoms during the night were recorded in the morning, whereas those that occurred during the daytime were recorded in the evening. At the same time, patients were asked to record the use of any bronchodilator (reliever) and preventer or controller medications.

Data on Meteorologic Factors and Air Pollution

Daily data on ambient temperature and air pollution during the study period were obtained from each selected air monitoring station. The measurements of interest for this study included daily mean, maximum, and minimum temperatures and mean ozone concentration during the previous 8 hours for each hour of the day (8-hour rolling mean ozone concentration). We calculated daytime DTR as the difference between the current day's maximum and minimum temperatures and nighttime DTR as the difference between the previous day's maximum temperature and the current day's minimum temperature.

Because data on relative humidity were not available at the monitoring stations, we collected daily mean relative humidity from the Weather Underground website (<http://www.wunderground.com/>) for each city. We assumed that there were small differences in the spatial distribution of relative humidity within cities. We compared the effect estimates and model fit for models with and without relative humidity.

Statistical Analyses

Generalized additive mixed models (GAMMs) were used to examine the effects of DTR on PEF and respiratory symptoms. We used a gaussian function for modeling PEF, which was normally distributed, and a logistic regression model for symptoms, which was binary. The GAMM allows flexible functional dependence of an outcome variable on covariates by using nonparametric and parametric regression.^{12,13} This mixed model is particularly useful in studies where repeated measurements are made on the same subjects (eg, panel study).

To examine whether the effects of DTR on lung function and respiratory symptoms were linear, a natural cubic spline with 3 df for DTR was used. Preliminary results revealed that the associations between DTR and children's lung function and respiratory symptoms were linear (Fig 1 and eFig 1) and that the linear model produced the lowest values for Akaike information criterion (AIC) and Bayesian information criterion (BIC) (eTables 2 and 3). Therefore, a linear function was used in the final analyses.

DTR was included in all models as the main fixed effect. Lung function is strongly related to height, is also related to sex and age, and may be related to weight. Respiratory symptoms also vary with sex and age. Therefore, we adjusted for these factors by including them as fixed effects in all the models. Participant identification number was included as a random effect; thus, it had the effect of also adjusting for season and location because each child was uniquely associated with one season and one location.

After establishing the basic model as described above, we introduced daily mean temperature, 8-hour rolling mean ozone concentration, relative humidity, and medication use into the regression model, step by step. By comparing the AIC and BIC values for all models, the model that gave the lowest AIC and BIC values was selected as the final model. We also used the final model to assess the effects of DTR on children's lung function and respiratory symptoms separately for boys and girls.

Because previous studies have reported that effects of ambient temperature appeared not only on the same day but also on subsequent days,^{2,14} we examine the lagged effects of DTR on children's

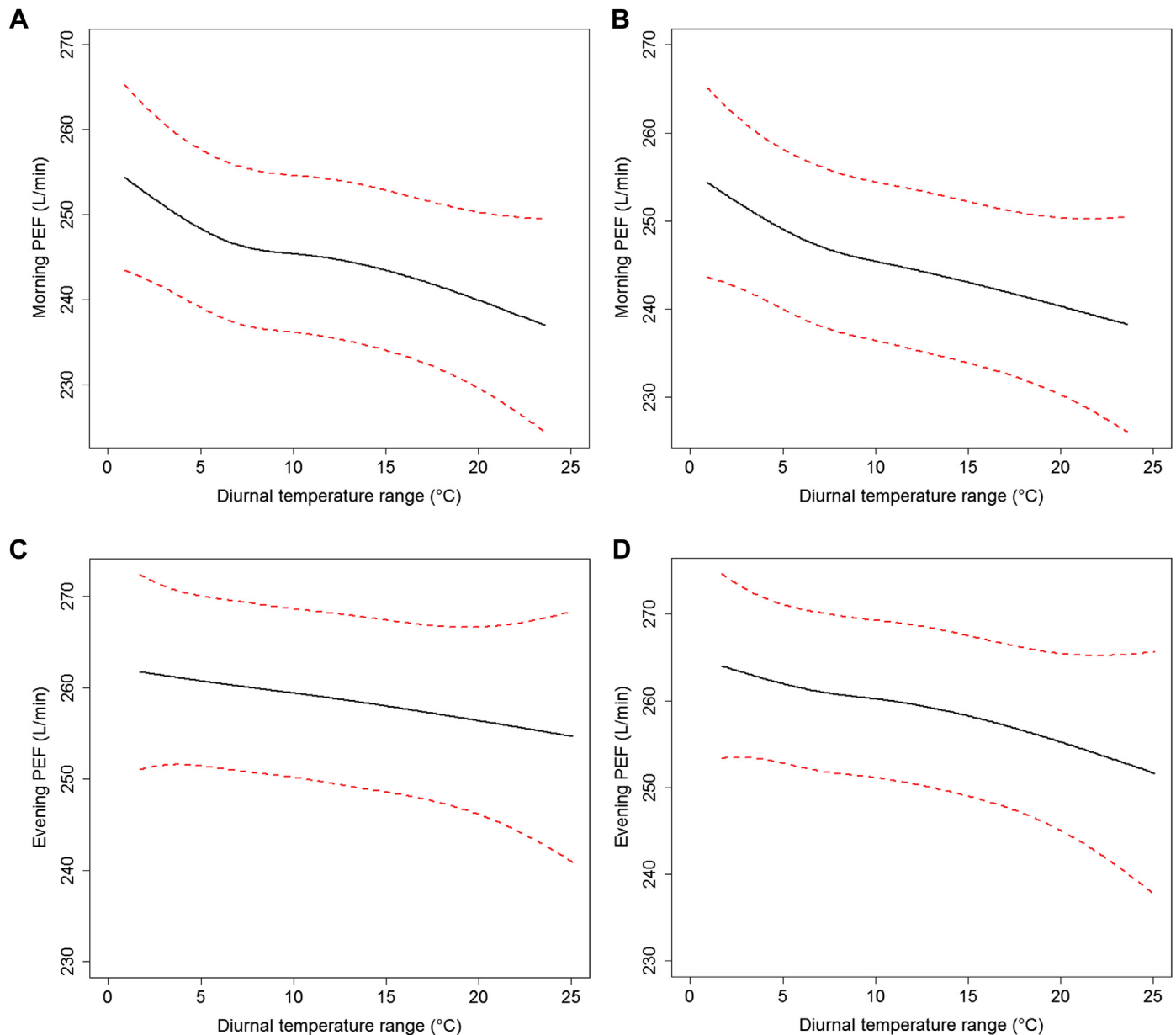


Figure 1. Association between diurnal temperature range and peak expiratory flow (morning and evening) on the current (lag 0) and previous (lag 1) day. A, Morning peak expiratory flow (PEF) exposed to lag 0 diurnal temperature range; B, morning PEF exposed to lag 1 diurnal temperature range; C, evening PEF exposed to lag 0 diurnal temperature range; and D, evening PEF exposed to lag 1 diurnal temperature range. A natural cubic spline within 3 *df* was used for diurnal temperature range, adjusted for sex, age, standing height, weight, 8-hour rolling mean ozone concentration, daily mean temperature, medication use, and subject-random effect.

lung function and respiratory symptoms up to 2 days. In all analyses, the first 3 days' recordings of lung function and respiratory symptoms were excluded to minimize any learning effects. R software¹⁵ was used to perform all statistical analyses. The "mgcv" package was used to conduct GAMMs for both mixed gaussian regression (for lung function) and mixed logistic regression (for respiratory symptoms).¹⁶ We present the results as estimated changes in lung function and odds ratios for respiratory symptoms, in each for a 5°C increase in DTR. All lung function changes and odds ratios are presented with 95% confidence intervals. $P < .05$ was declared as statistically significant.

Results

There were 270 study participants, 46% of whom were girls (Table 1). The children ranged in age from 7 to 12 years and had a mean (SD) standing height and weight of 140.9 (9.5) cm and 38.0 (10.6) kg, respectively. As expected, PEF rates were slightly higher

in the evening than in the morning. The observed daily mean temperature, nighttime DTR, and daytime DTR were 15.11°C, 9.50°C, and 9.49°C, respectively (Table 1). The mean values for 8-hour rolling mean ozone concentration and relative humidity were 25 ppb and 70%, respectively.

Table 2 lists the frequency of respiratory symptoms in panel members. All children reported that they experienced respiratory symptoms at least once during the 4-week period of the panel study. Most children recorded that they experienced respiratory symptoms less than 20% of the diary days.

Daily mean temperature, nighttime DTR, daytime DTR, and 8-hour rolling mean ozone concentration were positively and statistically significantly correlated with each other. They were negatively correlated with relative humidity. (eTable 4).

The introduction of daily mean temperature, 8-hour rolling mean ozone concentration, relative humidity, and medication use

Table 1
Descriptive statistics for daily exposure measurements and study participants

Index	Mean (SD)	Range
Weather and air pollution		
Mean temperature, °C	15.11 (4.66)	4.27–30.97
Maximum temperature, °C	19.95 (5.76)	9.50–39.90
Minimum temperature, °C	10.48 (4.35)	0.10–24.10
Nighttime diurnal temperature range, °C	9.50 (4.25)	0.90–23.70
Daytime diurnal temperature range, °C	9.49 (4.37)	1.70–25.10
8-Hour rolling mean ozone concentration, ppb	25.34 (8.63)	0.88–65.88
Relative humidity, %	70.55 (13.06)	32.00–94.13
All children (N = 270)		
Age, y	10.03 (1.20)	7.50–12.76
Standing height, cm	140.92 (9.47)	117.00–170.00
Weight, kg	38.02 (10.58)	21.00–84.00
Morning PEF, L/min	257.20 (64.53)	70.00–545.00
Evening PEF, L/min	265.90 (64.16)	65.00–605.00
Girls (n = 123)		
Age, y	10.11 (1.20)	7.50–12.31
Standing height, cm	141.64 (9.85)	117.0–170.0
Weight, kg	38.98 (10.93)	21.0–78.0
Morning PEF, L/min	261.79 (68.20)	70.0–515.0
Evening PEF, L/min	270.30 (65.23)	65.0–520.0
Boys (n = 147)		
Age, y	9.97 (1.18)	7.79–12.76
Standing height, cm	140.47 (9.02)	121.0–169.0
Weight, kg	37.34 (10.20)	22.0–84.0
Morning PEF, L/min	253.79 (61.13)	70.0–545.0
Evening PEF, L/min	262.65 (63.15)	70.0–605.0

Abbreviation: PEF, peak expiratory flow.

as covariates, either singly or together, did not result in any substantial change in the estimated effects of DTR on lung function and respiratory symptoms (eTables 5–8). This indicates that models and results are robust. In general, however, adjusting for 8-hour rolling mean ozone concentration, daily mean temperature, and medication use produced the lowest AIC and BIC values (eTables 9–16) and were therefore included in the final model. The final model adjusted for children's sex, age, standing height, weight, 8-hour rolling mean ozone concentration, daily mean temperature, and medication use.

DTR was negatively associated with morning and evening PEF and nighttime and daytime respiratory symptoms with a lag of 0 to 2 days (Fig 2 and eTables 5–8). In general, the nighttime DTR had greater effects on morning PEF than the effects of daytime DTR on evening PEF. The difference between nighttime and daytime respiratory symptoms was not significant.

Table 3 lists the effects of DTR on PEF in boys and girls. The effects of nighttime DTR on morning PEF were stronger in girls than in boys. Table 4 lists the associations between DTR and respiratory symptoms by sex. In general, the effects of DTR on daytime symptoms were greater for boys than girls. These differences in sex were not statistically significant using an interaction test (results not shown). The estimated effects of DTR on cough and/or phlegm and wheeze and/or chest tightness were similar (Table 4 and Fig 2).

Table 2
Frequency of respiratory symptoms by symptom type and time of day

Diary days, %	Nighttime, No. (%)		Daytime, No. (%)	
	Cough and/or phlegm	Wheeze and/or chest tightness	Cough and/or phlegm	Wheeze and/or chest tightness
<20	186 (68.89)	240 (88.89)	158 (58.52)	228 (84.44)
20–39	32 (11.85)	13 (4.81)	50 (18.52)	22 (8.15)
40–59	21 (7.78)	9 (3.33)	27 (10.00)	11 (4.07)
60–79	20 (7.41)	5 (1.85)	16 (5.93)	6 (2.22)
≥80	11 (4.07)	3 (1.11)	19 (7.04)	3 (1.11)

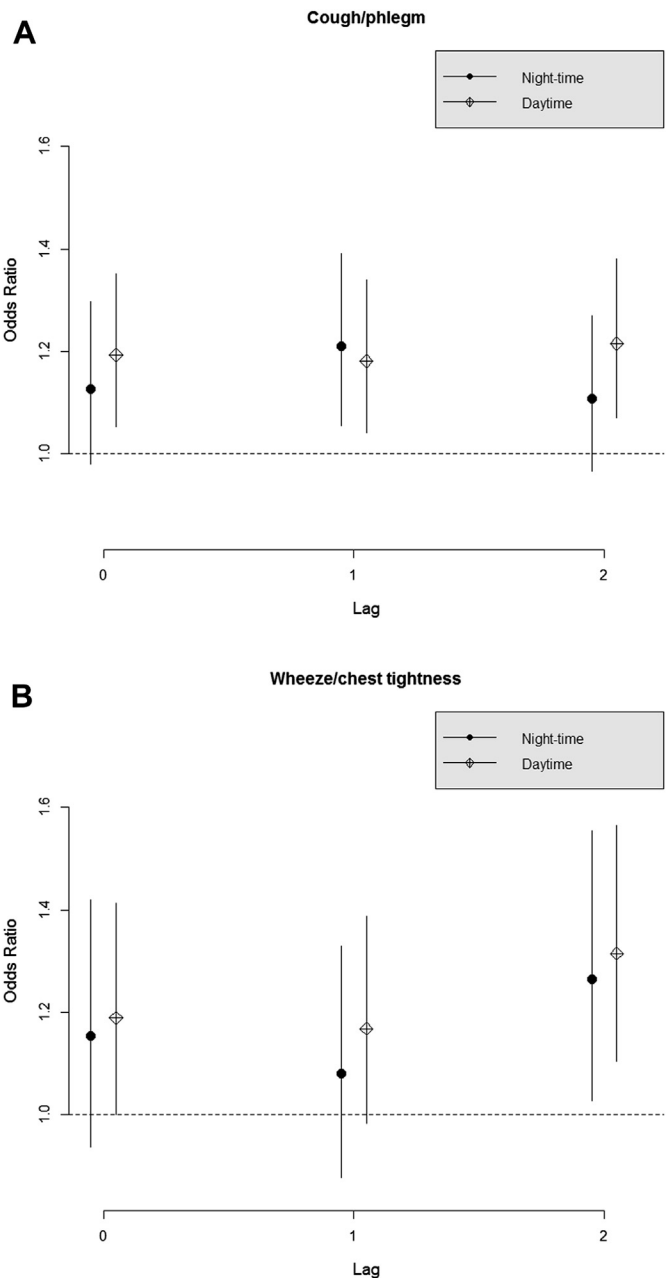


Figure 2. Relation between diurnal temperature range and respiratory symptoms by lag in days in children with asthma. Odds ratios (derived from a mixed logistic regression model) are for a 5°C increase in diurnal temperature range, adjusted for sex, age, standing height, weight, 8-hour rolling average O₃, daily average temperature, medication use and subject-random effect.

Discussion

It is well known that both cold and hot temperatures increase the risk of adverse health outcomes, in particular, deaths and hospitalizations. In this study, we assess the effects of another function of temperature, the daily amplitude or DTR, on lung function and respiratory symptoms in children with asthma. To the best of our knowledge, this is the first study to examine the short-term effects of intraday temperature amplitude on lung function and respiratory symptoms. The estimated effects of DTR on lung function and respiratory symptoms were generally insensitive to model selection, such as adjusting for air pollution, relative humidity, daily mean temperature, and medication use. We found that, in children with asthma, DTR was significantly inversely

Table 3

Effects of a 5°C increase in diurnal temperature range on PEF by time of day, sex, and lag in children with asthma

Lag	Coefficient ^a (95% CI)	
	Female	Male
Morning PEF		
0 Days	−4.54 (−6.76 to −2.32) ^b	−1.34 (−3.42 to 0.74)
1 Day	−4.32 (−6.41 to −2.22) ^b	−1.98 (−4.01 to 0.05)
2 Days	−3.18 (−5.28 to −1.08) ^b	−0.61 (−2.59 to 1.37)
Evening PEF		
0 Days	−2.29 (−4.37 to −0.21) ^c	0.00 (−2.23 to 2.23)
1 Day	−1.11 (−3.20 to 0.97)	−2.14 (−4.37 to 0.08)
2 Days	−1.71 (−3.82 to 0.40)	−1.08 (−3.31 to 1.15)

Abbreviations: CI, confidence interval; PEF, peak expiratory flow.

^aValues are coefficients from the mixed-effects model and represent the expected changes in PEF associated with every 5°C increase in diurnal temperature range, adjusted for sex, age, standing height, weight, 8-hour rolling mean ozone concentration, daily mean temperature, medication use, and subject-random effect.

^b*P* < .01.

^c*P* < .05.

related to lung function and directly related to risk of respiratory symptoms.

In some parts of the world daily minimum temperatures have increased at a faster rate than daily maximum temperatures during the era of climate change.¹⁷ This finding means that DTR is decreasing in those areas. However, the geographic pattern of DTR change over time is complex and may vary between regions. For example, in India, Russia, and parts of northern China, the DTR has increased as a result of a decrease in the minimum temperature. In addition, it is expected that daily maximum temperature will increase more than daily minimum temperature during summer, resulting in an increase in DTR in those regions.¹⁷ Meanwhile, the prevalence of asthma is increasing in some parts of the world, so it is now one of the most common chronic disorders among both children and adults in the world.¹⁸ Our findings on the effects of DTR on respiratory health outcomes in children with asthma might have increasingly important implications for planners and

Table 4

Association between diurnal temperature range and respiratory symptoms by sex and lag in children with asthma

Lag	OR ^a (95% CI)	
	Female	Male
Nighttime cough and/or phlegm		
0 Days	1.14 (0.92–1.41)	1.13 (0.94–1.37)
1 Day	1.11 (0.90–1.35)	1.32 (1.09–1.60) ^b
2 Days	1.05 (0.85–1.28)	1.18 (0.98–1.41)
Nighttime wheeze and/or chest tightness		
0 Day	1.10 (0.82–1.48)	1.19 (0.89–1.60)
1 Day	1.07 (0.80–1.43)	1.07 (0.80–1.44)
2 Days	1.35 (1.01–1.81) ^c	1.17 (0.87–1.56)
Daytime cough and/or phlegm		
0 Days	1.09 (0.90–1.32)	1.28 (1.09–1.51) ^b
1 Day	1.08 (0.89–1.31)	1.27 (1.08–1.50) ^b
2 Days	1.17 (0.96–1.42)	1.27 (1.07–1.50) ^b
Daytime wheeze and/or chest tightness		
0 Days	0.99 (0.76–1.30)	1.34 (1.07–1.68) ^c
1 Day	1.02 (0.78–1.33)	1.28 (1.02–1.60) ^c
2 Days	1.22 (0.92–1.60)	1.39 (1.11–1.73) ^b

Abbreviations: CI, confidence interval; OR, odds ratio.

^aORs (derived from a logistic mixed-effects regression model) are for a 5°C increase in diurnal temperature range, adjusted for sex, age, standing height, weight, 8-hour rolling mean ozone concentration, daily mean temperature, medication use, and subject-random effect.

^b*P* < .01.

^c*P* < .05.

policymakers seeking to promote safe environments for children with asthma.

Our results provide insights into a plausible biological mechanism for the previously reported observation that DTR is directly related to deaths and hospitalizations.^{4–6} Because lung function and respiratory symptoms are linked to risk of death and hospitalization attributable to cardiovascular^{19,20} and respiratory diseases^{21,22} and overall health status,²³ this may be the cause of the excess deaths and hospitalizations associated with increased DTR.

The effects of nighttime DTR on morning PEF were greater in girls than boys, but the effects of daytime DTR on daytime respiratory symptoms were greater in boys than girls. The reason might be that girls and boys have different patterns of physical activities. No consistent results have been reported in the literature regarding DTR risks by sex. Further detailed studies are needed to explore these sex differences.

We found that the estimated effects of DTR on lung function and respiratory symptoms lasted for several days. These findings are consistent with previous studies.^{4–6} The associations were often observed to be acute and short term, with the strongest effects recorded in the first 1 to 3 days after exposure. The lag (delayed) effect of DTR on health outcomes is relevant to planning preventive health interventions and risk management policies and to identify the total burden of DTR effects.

This study has several strengths. This is the first study, to our knowledge, to use a panel design to examine the short-term effects of DTR on lung function and respiratory symptoms in school children with asthma. This study used an Australian nationwide sample with a relatively large sample size (270 children). Nighttime and daytime respiratory symptoms were measured for approximately 4 weeks, which contributed to the reliability of this study, along with the examination of lag effects and assessment of the effects stratified by sex. To assess the independent effects of DTR on lung function and respiratory symptoms, we examined both a single-variable model, considering DTR alone, and multiple-variable models (including daily mean temperature, relative humidity, and air pollution). The effects of DTR remained statistically significant after adjusting for air pollution and other weather variables, suggesting our findings are robust. In addition, the panel study design eliminates confounding by time-invariant confounders.

This study has some limitations. The data were only from urban areas of Australia; therefore, we cannot generalize the results to children with asthma living in the rural areas. In addition, the data on ambient temperature and air pollution were monitored at fixed sites within a 3-km radius of the child's home and school. Relative humidity data were downloaded from the Weather Underground website because these data were not monitored at the fixed sites, which may lead to some exposure misclassification. However, these measurement errors are more likely to be nondifferential, and their influence on the results will be toward the null.²⁴ We did not assess or control for the effects of solar radiation on lung function or respiratory symptoms because the data on solar radiation were not available. We did not examine or adjust for the effects of indoor allergens and allergen sensitivity because the data were not available. Finally, we did not observe very low temperatures during the study. Similar studies in more severe low-temperature regions may clarify whether such extreme temperatures are also problematic for children with asthma.

Increased DTR is an independent risk factor for impaired lung function and respiratory symptoms among children with asthma in Australia. Although the magnitude of effects differed between boys and girls, children of both sexes were affected by DTR. The effects of DTR on lung function and respiratory symptoms were apparent on the same day and lasted for several days. The results suggest that an increase in exposure to large diurnal temperature variability is

likely to have an adverse effect on respiratory health, at least among children with asthma.

Acknowledgments

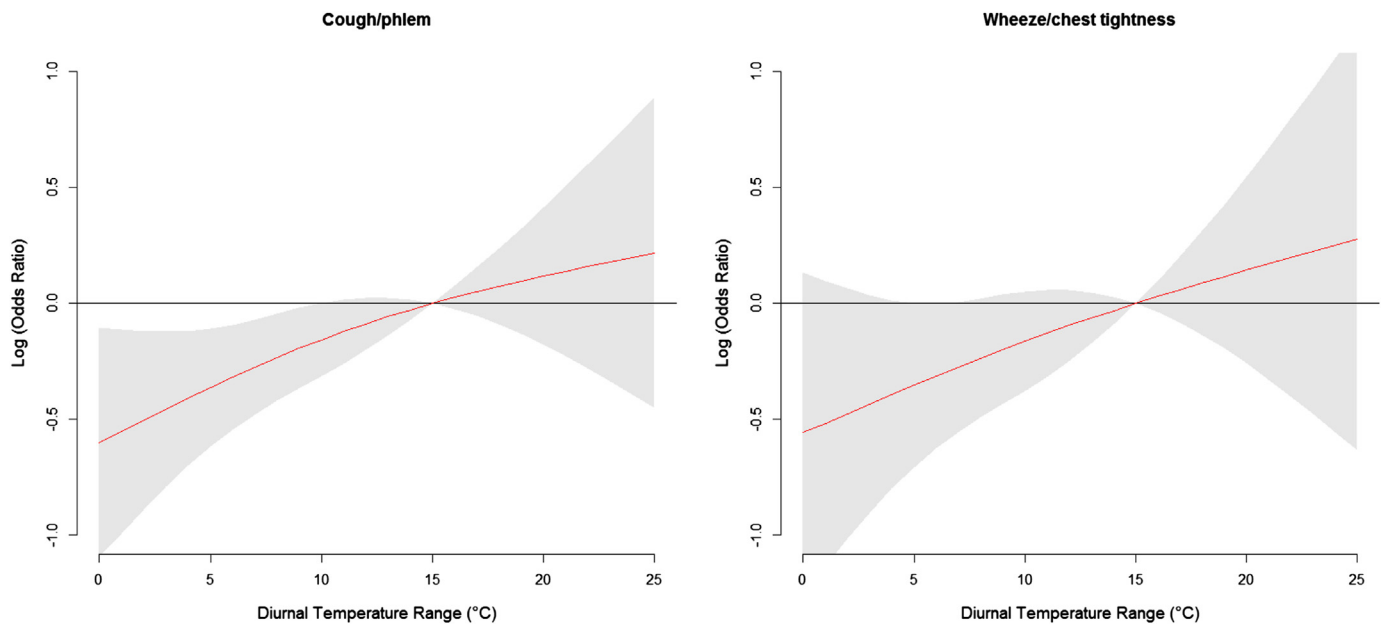
We gratefully acknowledge all the study participants, their parents and guardians, and the schools for their time and enthusiastic participation. We thank the generous contributions made to this project by the local Environmental Protection Authorities in Australian Capital Territory, New South Wales, Victoria, Queensland, South Australia and Western Australia. We are also very grateful to the staff of the Department of Epidemiology at Woolcock Institute of Medical Research for conducting the field work.

Supplementary Data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.anai.2014.01.007>.

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eFigure 1. Association between current day's diurnal temperature range and evening respiratory symptoms for children with asthma in Australia. Odds ratios were obtained with mixed logistic regression model, adjusted for sex, age, standing height, weight, 8-hour rolling mean ozone concentration, daily mean temperature, medication use, and subject-random effect.

eTable 1
Period for panel study in each city, Australia

City	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Canberra				2007								
Melbourne					2007							
Brisbane							2007					
Perth									2007			
Adelaide											2007	
Sydney			2008		2008							

eTable 2

Akaike information criterion values for mixed logistic regression model using different degrees of freedom for diurnal temperature range^a

Lag	Degrees of freedom					
	1	2	3	4	5	6
Nighttime cough and/or phlegm						
0 Days	3601.3	3601.1	3602.7	3603.8	3604.6	3606.0
1 Day	3610.4	3610.1	3610.6	3610.3	3610.1	3610.7
2 Days	3571.0	3568.3	3568.6	3568.1	3569.2	3566.7
Nighttime wheeze and/or chest tightness						
0 Days	1828.5	1828.4	1827.0	1826.7	1824.1	1824.2
1 Day	1816.1	1817.9	1819.6	1820.6	1814.7	1815.8
2 Days	1786.1	1787.8	1785.4	1787.3	1789.1	1790.6
Daytime cough and/or phlegm						
0 Days	4028.8	4030.6	4032.4	4034.0	4035.4	4037.5
1 Day	3988.1	3989.3	3991.3	3993.2	3994.7	3996.8
2 Days	3973.9	3974.8	3976.0	3972.7	3973.1	3975.1
Daytime wheeze and/or chest tightness						
0 Days	2308.1	2310.1	2308.0	2309.7	2311.4	2310.5
1 Day	2289.7	2291.6	2293.1	2294.5	2294.9	2296.4
2 Days	2263.2	2265.0	2266.4	2267.3	2268.7	2269.9

^aAll models adjusted for sex, age, standing height, weight, 8-hour rolling mean ozone concentration, daily mean temperature, medication use, and subject-random effect.

eTable 4

Spearman correlation between weather conditions and air pollution

Index	Mean temperature	Nighttime diurnal temperature range	Daytime diurnal temperature range	8-Hour rolling mean ozone concentration
Nighttime diurnal temperature range	0.32 ^a			
Daytime diurnal temperature range	0.28 ^a	0.80 ^a		
8-Hour rolling mean ozone concentration	0.39 ^a	0.15 ^a	0.14 ^a	
Relative humidity	−0.46 ^a	−0.47 ^a	−0.48 ^a	−0.38 ^a

^a $P < .01$.

eTable 3

Bayesian information criterion values for mixed logistic regression model using different degrees of freedom for diurnal temperature range^a

Lag	Degrees of freedom					
	1	2	3	4	5	6
Nighttime cough and/or phlegm						
0 Days	3666.0	3672.3	3680.4	3687.9	3695.2	3703.0
1 Day	3675.1	3681.2	3688.3	3694.4	3700.7	3707.7
2 Days	3635.6	3639.4	3646.2	3652.1	3659.7	3663.7
Nighttime wheeze and/or chest tightness						
0 Days	1893.2	1899.6	1904.6	1910.8	1914.7	1921.2
1 Day	1880.8	1889.1	1897.3	1904.7	1905.2	1912.8
2 Days	1850.7	1858.9	1863.0	1871.3	1879.6	1887.6
Daytime cough and/or phlegm						
0 Days	4094.2	4102.6	4110.9	4119.1	4127.0	4135.6
1 Day	4053.5	4061.2	4069.7	4078.1	4086.2	4094.9
2 Days	4039.2	4046.7	4054.4	4057.7	4064.7	4073.2
Daytime wheeze and/or chest tightness						
0 Days	2373.5	2382.0	2386.5	2394.7	2402.9	2408.6
1 Day	2355.0	2363.5	2371.5	2379.5	2386.4	2394.4
2 Days	2328.6	2336.9	2344.9	2352.3	2360.2	2367.9

^aAll models adjusted for sex, age, standing height, weight, 8-hour rolling mean ozone concentration, daily mean temperature, medication use, and subject-random effect.

eTable 5Mixed-model estimates of PEF With Every 5°C increase in diurnal temperature range among 270 children with asthma in Australia, models 1 Through 8^a

Lag	Coefficient ^b (95% CI)							
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Morning PEF								
0 Days	–2.45 (–3.74 to –1.16)	–2.56 (–4.00 to –1.13)	–2.00 (–3.45 to –0.56)	–2.32 (–3.65 to –0.99)	–2.80 (–4.14 to –1.46)	...	–2.33 (–3.80 to –0.86)	–2.95 (–4.43 to –1.47)
1 Day	–2.99 (–4.26 to –1.71)	–2.68 (–4.09 to –1.28)	–2.65 (–4.02 to –1.28)	–3.06 (–4.34 to –1.78)	–3.24 (–4.57 to –1.91)	–2.18 (–3.67 to –0.70)	–2.89 (–4.30 to –1.48)	–3.02 (–4.47 to –1.57)
2 Days	–2.34 (–3.62 to –1.07)	–1.88 (–3.27 to –0.49)	–1.96 (–3.31 to –0.61)	–2.29 (–3.57 to –1.01)	–2.31 (–3.64 to –0.98)	–2.09 (–3.65 to –0.53)	–1.84 (–3.23 to –0.45)	–1.87 (–3.31 to –0.43)
Evening PEF								
0 Days	–1.27 (–2.55 to 0.02)	–1.17 (–2.66 to 0.31)	–0.66 (–2.08 to 0.76)	–1.21 (–2.51 to 0.08)	–1.26 (–2.59 to 0.07)	–0.69 (–2.30 to 0.92)	–1.16 (–2.65 to 0.32)	–1.17 (–2.69 to 0.35)
1 Day	–1.66 (–2.94 to –0.38)	–1.61 (–3.06 to –0.15)	–1.18 (–2.55 to 0.20)	–1.53 (–2.84 to –0.22)	–1.60 (–2.92 to –0.28)	–0.60 (–2.14 to 0.95)	–1.52 (–3.00 to –0.03)	–1.67 (–3.16 to –0.18)
2 Days	–1.63 (–2.90 to –0.35)	–1.39 (–2.85 to 0.08)	–1.23 (–2.57 to 0.11)	–1.63 (–2.95 to –0.32)	–1.44 (–2.75 to –0.13)	–1.08 (–2.60 to 0.44)	–1.50 (–3.00 to 0.00)	–1.21 (–2.71 to 0.29)

Abbreviations: CI, confidence interval; PEF, peak expiratory flow.

^aModel 1: not control for 8-hour rolling mean ozone concentration, relative humidity, daily mean temperature, and medication use; model 2: control for 8-hour rolling mean ozone concentration; model 3: control for relative humidity; model 4: control for daily mean temperature; model 5: control for medication use; model 6: control for 8-hour rolling mean ozone concentration and relative humidity; model 7: control for 8-hour rolling mean ozone concentration and daily average temperature; and model 8: control for 8-hour rolling mean ozone concentration and medication use.^bCoefficients represent the expected changes in children's PEF associated with every 5°C increase in diurnal temperature range. All models adjusted for sex, age, standing height, weight, and subject-random effect.**eTable 6**Mixed-model estimates of PEF With Every 5°C increase in diurnal temperature range among 270 children with asthma in Australia, models 9 through 16^a

Lag	Coefficient ^b (95% CI)							
	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16
Morning PEF								
0 Days	–1.95 (–3.41 to –0.49)	–2.54 (–4.04 to –1.05)	–2.85 (–4.23 to –1.47)	–1.79 (–3.38 to –0.21)	–2.46 (–4.08 to –0.85)	–2.89 (–4.41 to –1.38)	–2.59 (–4.10 to –1.08)	–2.45 (–4.08 to –0.81)
1 Day	–2.87 (–4.27 to –1.48)	–3.02 (–4.45 to –1.60)	–3.28 (–4.62 to –1.95)	–2.50 (–4.01 to –0.99)	–2.61 (–4.14 to –1.07)	–3.16 (–4.61 to –1.70)	–3.14 (–4.59 to –1.70)	–2.80 (–4.36 to –1.25)
2 Day	–2.01 (–3.36 to –0.65)	–1.99 (–3.40 to –0.58)	–2.29 (–3.62 to –0.95)	–1.40 (–2.86 to 0.06)	–1.38 (–2.89 to 0.13)	–1.84 (–3.28 to –0.40)	–2.01 (–3.42 to –0.60)	–1.41 (–2.92 to 0.10)
Evening PEF								
0 Days	–0.67 (–2.09 to 0.75)	–0.60 (–2.06 to 0.86)	–1.21 (–2.55 to 0.12)	–0.70 (–2.31 to 0.92)	–0.62 (–2.27 to 1.03)	–1.16 (–2.68 to 0.37)	–0.60 (–2.07 to 0.87)	–0.62 (–2.27 to 1.04)
1 Day	–1.12 (–2.50 to 0.27)	–1.07 (–2.48 to 0.35)	–1.49 (–2.84 to –0.14)	–1.17 (–2.74 to 0.39)	–1.26 (–2.84 to 0.33)	–1.61 (–3.14 to –0.08)	–1.02 (–2.45 to 0.41)	–1.22 (–2.83 to 0.38)
2 Days	–1.31 (–2.67 to 0.05)	–0.99 (–2.37 to 0.39)	–1.48 (–2.83 to –0.13)	–1.24 (–2.78 to 0.31)	–0.86 (–2.41 to 0.70)	–1.36 (–2.89 to 0.18)	–1.10 (–2.51 to 0.30)	–1.04 (–2.62 to 0.55)

Abbreviations: CI, confidence interval; PEF, peak expiratory flow.

^aModel 9: control for relative humidity and daily mean temperature; model 10: control for relative humidity and medication use; model 11: control for daily mean temperature and medication use; model 12: control for 8-hour rolling mean ozone concentration, relative humidity, and daily mean temperature; model 13: control for 8-hour rolling mean ozone concentration, relative humidity, and medication use; model 14: control for 8-hour rolling mean ozone concentration, daily mean temperature, and medication use; model 15: control for relative humidity, daily mean temperature, and medication use; and model 16: control for 8-hour rolling mean ozone concentration, relative humidity, daily mean temperature, and medication use.^bCoefficients represent the expected changes in children's PEF associated with every 5°C increase in diurnal temperature range. All models adjusted for sex, age, standing height, weight, and subject-random effect.

eTable 7Odds ratios of diurnal temperature range on respiratory symptoms for children with asthma in Australia, models 1 through 8^a

Lag	Odds ratio ^b (95% CI)							
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Nighttime cough and/or phlegm								
0 Days	1.11 (0.99–1.24)	1.13 (0.99–1.29)	1.09 (0.96–1.24)	1.10 (0.98–1.24)	1.13 (1.00–1.27)	1.09 (0.95–1.26)	1.12 (0.99–1.28)	1.13 (0.99–1.30)
1 Day	1.21 (1.08–1.36)	1.19 (1.05–1.36)	1.22 (1.07–1.38)	1.21 (1.08–1.36)	1.24 (1.09–1.40)	1.17 (1.02–1.35)	1.20 (1.05–1.37)	1.20 (1.05–1.38)
2 Days	1.15 (1.03–1.29)	1.10 (0.97–1.25)	1.15 (1.01–1.30)	1.15 (1.03–1.30)	1.16 (1.02–1.31)	1.08 (0.94–1.23)	1.10 (0.97–1.26)	1.11 (0.97–1.27)
Nighttime wheeze and/or chest tightness								
0 Days	1.13 (0.96–1.34)	1.17 (0.97–1.42)	1.13 (0.94–1.37)	1.10 (0.93–1.31)	1.12 (0.94–1.34)	1.15 (0.93–1.42)	1.11 (0.91–1.35)	1.20 (0.98–1.47)
1 Day	1.08 (0.92–1.28)	1.06 (0.87–1.28)	1.08 (0.89–1.29)	1.10 (0.93–1.30)	1.05 (0.87–1.25)	1.02 (0.84–1.26)	1.10 (0.90–1.33)	1.05 (0.86–1.29)
2 Days	1.24 (1.04–1.47)	1.24 (1.02–1.50)	0.97 (0.81–1.16)	1.24 (1.04–1.47)	1.21 (1.00–1.45)	1.23 (1.00–1.50)	1.23 (1.01–1.49)	1.27 (1.03–1.55)
Daytime cough and/or phlegm								
0 Days	1.11 (1.00–1.23)	1.15 (1.03–1.30)	1.12 (1.00–1.26)	1.11 (1.00–1.24)	1.13 (1.01–1.26)	1.15 (1.01–1.30)	1.16 (1.03–1.31)	1.19 (1.05–1.35)
1 Day	1.11 (1.00–1.23)	1.13 (1.00–1.27)	1.11 (0.99–1.24)	1.12 (1.00–1.24)	1.11 (0.99–1.24)	1.11 (0.98–1.26)	1.14 (1.02–1.29)	1.16 (1.03–1.31)
2 Days	1.17 (1.06–1.30)	1.18 (1.05–1.32)	1.19 (1.06–1.32)	1.18 (1.06–1.32)	1.17 (1.05–1.31)	1.17 (1.04–1.32)	1.18 (1.05–1.34)	1.20 (1.06–1.36)
Daytime wheeze and/or chest tightness								
0 Days	1.13 (0.99–1.30)	1.15 (0.98–1.35)	1.07 (0.92–1.25)	1.13 (0.98–1.30)	1.15 (0.99–1.34)	1.07 (0.90–1.27)	1.15 (0.98–1.35)	1.19 (1.01–1.42)
1 Day	1.13 (0.99–1.30)	1.14 (0.97–1.33)	1.08 (0.93–1.25)	1.12 (0.97–1.28)	1.13 (0.97–1.31)	1.07 (0.90–1.26)	1.12 (0.96–1.31)	1.18 (0.99–1.39)
2 Days	1.29 (1.12–1.48)	1.29 (1.10–1.51)	1.26 (1.08–1.45)	1.26 (1.09–1.45)	1.27 (1.09–1.48)	1.24 (1.05–1.47)	1.26 (1.07–1.48)	1.34 (1.13–1.59)

Abbreviation: CI, confidence interval.

^aModel 1: not control for 8-hour rolling mean ozone concentration, relative humidity, daily mean temperature, and medication use; model 2: control for 8-hour rolling mean ozone concentration; model 3: control for relative humidity; model 4: control for daily mean temperature; model 5: control for medication use; model 6: control for 8-hour rolling mean ozone concentration and relative humidity; model 7: control for 8-hour rolling mean ozone concentration and daily average temperature; and model 8: control for 8-hour rolling mean ozone concentration and medication use.

^bCoefficients represent the expected changes in children's PEF associated with every 5°C increase in diurnal temperature range. All models adjusted for sex, age, standing height, weight, and subject-random effect.

eTable 8Odds ratios of diurnal temperature range on respiratory symptoms for children with asthma in Australia, models 9 through 16^a

Lag	Odds ratio ^b (95% CI)							
	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16
Nighttime cough and/or phlegm								
0 Days	1.09 (0.96–1.24)	1.09 (0.95–1.25)	1.12 (0.99–1.27)	1.09 (0.95–1.26)	1.07 (0.92–1.24)	1.13 (0.98–1.30)	1.09 (0.95–1.25)	1.07 (0.92–1.24)
1 Day	1.23 (1.08–1.40)	1.22 (1.07–1.40)	1.24 (1.10–1.41)	1.19 (1.03–1.37)	1.16 (1.01–1.35)	1.21 (1.05–1.39)	1.24 (1.08–1.42)	1.17 (1.01–1.36)
2 Days	1.15 (1.02–1.30)	1.13 (0.99–1.29)	1.16 (1.02–1.31)	1.08 (0.95–1.24)	1.06 (0.92–1.23)	1.11 (0.97–1.27)	1.14 (1.00–1.30)	1.07 (0.93–1.23)
Nighttime wheeze and/or chest tightness								
0 Days	1.12 (0.92–1.35)	1.12 (0.92–1.37)	1.12 (0.93–1.35)	1.11 (0.90–1.37)	1.15 (0.92–1.44)	1.15 (0.94–1.42)	1.07 (0.87–1.30)	1.12 (0.90–1.40)
1 Day	1.11 (0.92–1.35)	0.96 (0.79–1.18)	1.04 (0.87–1.25)	1.10 (0.89–1.35)	1.00 (0.80–1.24)	1.08 (0.88–1.33)	1.03 (0.84–1.26)	1.04 (0.83–1.30)
2 Days	1.27 (1.06–1.52)	1.18 (0.97–1.44)	1.20 (1.00–1.44)	1.24 (1.02–1.52)	1.23 (0.99–1.53)	1.26 (1.03–1.55)	1.20 (0.98–1.45)	1.25 (1.01–1.55)
Daytime cough and/or phlegm								
0 Days	1.13 (1.00–1.26)	1.13 (1.00–1.28)	1.13 (1.01–1.27)	1.15 (1.01–1.31)	1.17 (1.02–1.34)	1.19 (1.05–1.35)	1.13 (1.00–1.28)	1.17 (1.02–1.34)
1 Day	1.12 (1.00–1.25)	1.11 (0.98–1.25)	1.13 (1.01–1.27)	1.13 (0.99–1.27)	1.13 (0.99–1.29)	1.18 (1.04–1.34)	1.12 (0.99–1.26)	1.15 (1.01–1.31)
2 Days	1.19 (1.07–1.33)	1.17 (1.04–1.32)	1.19 (1.06–1.33)	1.17 (1.04–1.33)	1.19 (1.04–1.35)	1.22 (1.07–1.38)	1.19 (1.05–1.34)	1.19 (1.05–1.36)
Daytime wheeze and/or chest tightness								
0 Days	1.09 (0.93–1.27)	1.09 (0.92–1.28)	1.15 (0.99–1.34)	1.08 (0.91–1.29)	1.09 (0.90–1.31)	1.19 (1.00–1.41)	1.08 (0.92–1.28)	1.09 (0.90–1.32)
1 Day	1.08 (0.93–1.25)	1.07 (0.91–1.26)	1.13 (0.97–1.31)	1.06 (0.90–1.26)	1.08 (0.90–1.30)	1.17 (0.98–1.39)	1.07 (0.91–1.26)	1.09 (0.91–1.30)
2 Days	1.24 (1.07–1.44)	1.23 (1.05–1.44)	1.26 (1.08–1.47)	1.22 (1.03–1.44)	1.27 (1.07–1.52)	1.31 (1.10–1.56)	1.22 (1.04–1.44)	1.26 (1.05–1.50)

Abbreviation: CI, confidence interval.

^aModel 9: control for relative humidity and daily mean temperature; model 10: control for relative humidity and medication use; model 11: control for daily mean temperature and medication use; model 12: control for 8-hour rolling mean ozone concentration, relative humidity, and daily mean temperature; model 13: control for 8-hour rolling mean ozone concentration, relative humidity, and medication use; model 14: control for 8-hour rolling mean ozone concentration, daily mean temperature, and medication use; model 15: control for relative humidity, daily mean temperature, and medication use; and model 16: control for 8-hour rolling mean ozone concentration, relative humidity, daily mean temperature, and medication use.

^bCoefficients represent the expected changes in children's PEF associated with every 5°C increase in diurnal temperature range. All models adjusted for sex, age, standing height, weight, and subject-random effect.

eTable 9Akaike information criterion values for mixed models of PEF with diurnal temperature range increase among 270 children with asthma in Australia, models 1 through 9^a

Lag	Akaike information criterion value							
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Morning PEF								
0 Days	59592.6	49456.1	59583.7	59594.0	54657.0	49445.4	49456.2	45600.9
1 Day	59765.7	49542.4	59756.8	59763.4	54794.6	49531.1	49537.4	45660.2
2 Days	59869.9	49546.3	59859.7	59479.8	54905.9	49523.5	49253.6	45679.8
Evening PEF								
0 Days	60876.8	50897.2	60874.8	60809.4	58266.1	50896.9	50830.4	48975.9
1 Day	61086.6	51001.4	61085.1	60596.9	58449.9	50883.5	50617.9	49063.4
2 Days	61217.1	51038.1	61215.7	60573.4	58596.7	51037.8	50595.2	49126.4
Total	362408.9	301481.6	362375.8	360816.9	339670.2	301318.3	300290.8	284106.6

Abbreviation: PEF, peak expiratory flow.

^aModel 1: not control for 8-hour rolling mean ozone concentration, relative humidity, daily mean temperature, and medication use; model 2: control for 8-hour rolling mean ozone concentration; model 3: control for relative humidity; model 4: control for daily mean temperature; model 5: control for medication use; model 6: control for 8-hour rolling mean ozone concentration and relative humidity; model 7: control for 8-hour rolling mean ozone concentration and daily average temperature; and model 8: control for 8-hour rolling mean ozone concentration and medication use.

eTable 10Akaike information criterion values for mixed models of PEF with diurnal temperature range increase among 270 children with asthma in Australia, models 9 through 16^a

Lag	Akaike information criterion value							
	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16
Morning PEF								
0 Days	59585.4	54649.4	54658.9	49446.0	45591.7	45597.8	54651.1	45593.7
1 Day	59755.8	54786.7	54795.3	49528.3	45650.3	45654.2	54787.9	45650.5
2 Days	59471.0	54896.7	54534.7	49242.6	45667.9	45393.3	54526.0	45387.5
Evening PEF								
0 Days	60808.2	58263.6	58200.0	50830.4	48975.1	48905.1	58198.0	48909.4
1 Day	60595.9	58447.7	57972.9	50618.0	49063.0	48676.7	57971.1	48681.4
2 Days	60572.4	58594.5	57975.0	50595.3	49125.6	48680.5	57973.2	48684.9
Total	360788.7	339638.6	338136.8	300260.5	284073.7	282907.7	338107.4	282907.4

Abbreviation: PEF, peak expiratory flow.

^aModel 9: control for relative humidity and daily mean temperature; model 10: control for relative humidity and medication use; model 11: control for daily mean temperature and medication use; model 12: control for 8-hour rolling mean ozone concentration, relative humidity, and daily mean temperature; model 13: control for 8-hour rolling mean ozone concentration, relative humidity, and medication use; model 14: control for 8-hour rolling mean ozone concentration, daily mean temperature, and medication use; model 15: control for relative humidity, daily mean temperature, and medication use; and model 16: control for 8-hour rolling mean ozone concentration, relative humidity, daily mean temperature, and medication use.

eTable 11Bayesian information criterion values for mixed models of PEF with diurnal temperature range increase among 270 children with asthma in Australia, models 1 through 8^a

Lag	Bayesian information criterion value							
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Morning PEF								
0 Days	59646.2	49514.7	59643.9	59654.2	54716.5	49510.5	49521.2	45665.2
1 Day	59819.3	49601.0	59817.1	59823.7	54854.1	49596.2	49602.5	45724.5
2 Days	59923.5	49604.9	59920.0	59540.1	54965.4	49588.6	49318.6	45744.1
Evening PEF								
0 Days	60930.5	50956.0	60935.2	60869.7	58326.1	50962.2	50895.7	49040.8
1 Day	61140.3	51060.2	61145.5	60657.3	58509.9	50948.7	50683.1	49128.2
2 Days	61270.9	51096.8	61276.1	60633.7	58656.7	51103.1	50660.4	49191.3
Total	362730.6	301833.5	362737.8	361178.6	340028.6	301709.3	300681.6	284494.1

Abbreviation: PEF, peak expiratory flow.

^aModel 1: not control for 8-hour rolling mean ozone concentration, relative humidity, daily mean temperature, and medication use; model 2: control for 8-hour rolling mean ozone concentration; model 3: control for relative humidity; model 4: control for daily mean temperature; model 5: control for medication use; model 6: control for 8-hour rolling mean ozone concentration and relative humidity; model 7: control for 8-hour rolling mean ozone concentration and daily average temperature; and model 8: control for 8-hour rolling mean ozone concentration and medication use.

eTable 12Bayesian information criterion values for mixed models of PEF with diurnal temperature range increase among 270 children with asthma in Australia, models 9 through 16^a

Lag	Bayesian information criterion value							
	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16
Morning PEF								
0 Day	59652.4	54715.4	54725.0	49517.6	45662.5	45673.6	54723.8	45670.9
1 Day	59822.8	54852.8	54861.4	49599.9	45721.0	45730.0	54860.6	45727.6
2 Days	59537.9	54962.8	54600.7	49314.1	45738.6	45469.0	54598.6	45464.5
Evening PEF								
0 Days	60875.2	58330.2	58266.6	50902.1	49046.4	48981.4	58271.3	48987.2
1 Day	60662.9	58514.4	58039.5	50689.7	49134.4	48753.0	58044.4	48759.2
2 Days	60639.4	58661.2	58041.6	50667.0	49196.9	48756.8	58046.5	48762.7
Total	361190.6	340036.8	338534.8	300690.4	284499.9	283363.7	338545.2	283372.1

Abbreviation: PEF, peak expiratory flow.

^aModel 9: control for relative humidity and daily mean temperature; model 10: control for relative humidity and medication use; model 11: control for daily mean temperature and medication use; model 12: control for 8-hour rolling mean ozone concentration, relative humidity, and daily mean temperature; model 13: control for 8-hour rolling mean ozone concentration, relative humidity, and medication use; model 14: control for 8-hour rolling mean ozone concentration, daily mean temperature, and medication use; model 15: control for relative humidity, daily mean temperature, and medication use; and model 16: control for 8-hour rolling mean ozone concentration, relative humidity, daily mean temperature, and medication use.

eTable 13

Akaike information criterion values for different mixed models of diurnal temperature range on respiratory symptoms for children with asthma in Australia, models 1 through 8^a

Lag	Akaike information criterion value							
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Nighttime cough and/or phlegm								
0 Days	4851.7	3992.1	4853.4	4853.5	4332.3	3992.8	3993.9	3599.4
1 Day	4857.0	4000.3	4858.9	4858.4	4339.0	4001.8	4001.6	3608.9
2 Days	4856.3	3998.3	4858.1	4815.4	4342.2	3998.7	3958.9	3609.8
Nighttime wheeze and/or chest tightness								
0 Days	2560.2	2046.3	2562.2	2560.2	2262.6	2048.2	2040.5	1830.3
1 Day	2548.9	2035.7	2550.8	2548.3	2249.3	2037.0	2028.6	1818.7
2 Days	2548.1	2035.8	2568.9	2519.2	2245.4	2037.7	2000.2	1815.2
Daytime cough and/or phlegm								
0 Days	5288.2	4421.3	5290.0	5280.0	4820.5	4423.3	4413.1	4033.0
1 Day	5289.7	4421.0	5291.6	5238.5	4823.1	4422.6	4372.7	4032.9
2 Days	5275.1	4405.2	5276.6	5224.3	4806.4	4407.1	4360.9	4015.3
Daytime wheeze and/or chest tightness								
0 Days	3235.5	2614.6	3234.7	3231.9	2855.2	2612.1	2610.8	2309.7
1 Day	3229.7	2607.6	3228.5	3214.2	2848.8	2604.3	2593.6	2301.0
2 Days	3206.6	2584.3	3207.6	3187.6	2827.3	2583.6	2569.1	2276.8
Total	47746.9	39162.6	47781.4	47531.5	42752.1	39169.2	38943.9	35251.1

Abbreviation: PEF, peak expiratory flow.

^aModel 1: not control for 8-hour rolling mean ozone concentration, relative humidity, daily mean temperature, and medication use; model 2: control for 8-hour rolling mean ozone concentration; model 3: control for relative humidity; model 4: control for daily mean temperature; model 5: control for medication use; model 6: control for 8-hour rolling mean ozone concentration and relative humidity; model 7: control for 8-hour rolling mean ozone concentration and daily average temperature; and model 8: control for 8-hour rolling mean ozone concentration and medication use.

eTable 14

Akaike information criterion values for different mixed models of diurnal temperature range on respiratory symptoms for children with asthma in Australia, models 9 through 16^a

Lag	Akaike information criterion value							
	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16
Nighttime cough and/or phlegm								
0 Days	4855.3	4333.0	4334.2	3994.7	3598.1	3601.3	4335.0	3600.0
1 Day	4860.0	4340.8	4340.5	4003.3	3609.3	3610.4	4342.4	3611.1
2 Days	4817.3	4343.0	4302.1	3959.9	3608.2	3571.0	4303.3	3570.2
Nighttime wheeze and/or chest tightness								
0 Days	2562.0	2266.6	2261.9	2042.5	1831.4	1828.5	2269.7	1830.1
1 Day	2550.2	4321.5	2251.4	2030.6	1818.4	1816.1	2250.9	1817.1
2 Days	2520.4	2249.6	2232.5	2002.0	1816.4	1786.1	2224.0	1787.9
Daytime cough and/or phlegm								
0 Days	5281.8	4822.5	4816.0	4415.0	4034.6	4028.8	4818.0	4030.2
1 Day	5240.5	4825.1	4775.2	4374.1	4033.7	3988.1	4777.0	3988.5
2 Days	5226.1	4808.4	4758.9	4362.6	4016.6	3973.9	4760.9	3974.9
Daytime wheeze and/or chest tightness								
0 Days	3232.5	2854.1	2854.3	2609.8	2305.3	2308.1	2853.7	2304.7
1 Day	3214.2	2847.3	2835.7	2591.5	2296.0	2289.7	2834.4	2285.3
2 Days	3189.0	2827.9	2809.4	2568.6	2274.9	2263.2	2809.8	2260.9
Total	47549.3	44839.7	42572.1	38954.7	35242.9	35065.1	42579.1	35061.1

^aModel 9: control for relative humidity and daily mean temperature; model 10: control for relative humidity and medication use; model 11: control for daily mean temperature and medication use; model 12: control for 8-hour rolling mean ozone concentration, relative humidity, and daily mean temperature; model 13: control for 8-hour rolling mean ozone concentration, relative humidity, and medication use; model 14: control for 8-hour rolling mean ozone concentration, daily mean temperature, and medication use; model 15: control for relative humidity, daily mean temperature, and medication use; and model 16: control for 8-hour rolling mean ozone concentration, relative humidity, daily mean temperature, and medication use.

eTable 15

Bayesian information criterion values for different mixed models of diurnal temperature range on respiratory symptoms for children with asthma in Australia, models 1 through 8^a

Lag	Bayesian information criterion value							
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Nighttime cough and/or phlegm								
0 Days	4898.8	4044.6	4907.3	4907.4	4385.5	4051.8	4052.8	3657.6
1 Day	4904.2	4052.7	4912.8	4912.3	4392.2	4060.7	4060.5	3667.1
2 Days	4903.4	4050.8	4912.0	4869.2	4395.4	4057.7	4017.9	3668.0
Nighttime wheeze and/or chest tightness								
0 Days	2607.3	2098.8	2616.0	2614.0	2315.7	2107.1	2099.4	1888.6
1 Day	2596.1	2088.1	2604.7	2602.2	2302.5	2096.0	2087.5	1877.0
2 Days	2595.2	2088.2	2622.8	2573.0	2298.6	2096.7	2059.2	1873.4
Daytime cough and/or phlegm								
0 Days	5335.4	4473.9	5343.9	5334.0	4874.2	4482.4	4472.2	4091.9
1 Day	5336.9	4473.5	5345.6	5292.4	4876.9	4481.7	4431.8	4091.8
2 Days	5322.3	4457.8	5330.6	5278.2	4860.2	4466.2	4420.0	4074.2
Daytime wheeze and/or chest tightness								
0 Days	3282.7	2667.1	3288.6	3285.8	2908.9	2671.2	2669.9	2368.6
1 Day	3276.9	2660.1	3282.5	3268.1	2902.5	2663.4	2652.7	2359.9
2 Days	3253.8	2636.9	3261.6	3241.6	2881.0	2642.7	2628.1	2335.7
Total	48313.2	39792.4	48428.5	48178.2	43393.6	39877.6	39652.0	35953.9

^aModel 1: not control for 8-hour rolling mean ozone concentration, relative humidity, daily mean temperature, and medication use; model 2: control for 8-hour rolling mean ozone concentration; model 3: control for relative humidity; model 4: control for daily mean temperature; model 5: control for medication use; model 6: control for 8-hour rolling mean ozone concentration and relative humidity; model 7: control for 8-hour rolling mean ozone concentration and daily average temperature; and model 8: control for 8-hour rolling mean ozone concentration and medication use.

eTable 16

Bayesian information criterion values for different mixed models of diurnal temperature range on respiratory symptoms for children with asthma in Australia, models 9 through 16^a

Lag	Bayesian information criterion value							
	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16
Nighttime cough and/or phlegm								
0 Days	4915.9	4392.8	4394.0	4060.2	3662.7	3666.0	4401.4	3671.2
1 Day	4920.6	4400.6	4400.3	4068.8	3674.0	3675.1	4408.8	3682.3
2 Days	4877.9	4402.9	4361.8	4025.3	3672.9	3635.6	4369.7	3641.3
Nighttime wheeze and/or chest tightness								
0 Days	2622.7	2326.4	2321.7	2108.0	1896.0	1893.2	2336.2	1901.3
1 Day	2610.8	4381.4	2311.2	2096.1	1883.1	1880.8	2317.4	1888.3
2 Days	2581.0	2309.4	2292.3	2067.5	1881.1	1850.7	2290.4	1859.0
Daytime cough and/or phlegm								
0 Days	5342.5	4882.9	4876.4	4480.7	4100.0	4094.2	4885.1	4102.1
1 Day	5301.1	4885.6	4835.5	4439.7	4099.2	4053.5	4844.1	4060.4
2 Days	5286.7	4868.8	4819.3	4428.2	4082.1	4039.2	4828.0	4046.8
Daytime wheeze and/or chest tightness								
0 Days	3293.2	2914.6	2914.7	2675.5	2370.7	2373.5	2920.9	2376.7
1 Day	3274.8	2907.7	2896.0	2657.1	2361.4	2355.0	2901.5	2357.2
2 Days	3249.6	2888.4	2869.8	2634.2	2340.3	2328.6	2876.9	2332.8
Total	48276.9	45561.3	43293.3	39741.3	36023.7	35845.5	43380.3	35919.5

^aModel 9: control for relative humidity and daily mean temperature; model 10: control for relative humidity and medication use; model 11: control for daily mean temperature and medication use; model 12: control for 8-hour rolling mean ozone concentration, relative humidity, and daily mean temperature; model 13: control for 8-hour rolling mean ozone concentration, relative humidity, and medication use; model 14: control for 8-hour rolling mean ozone concentration, daily mean temperature, and medication use; model 15: control for relative humidity, daily mean temperature, and medication use; and model 16: control for 8-hour rolling mean ozone concentration, relative humidity, daily mean temperature, and medication use.