

CORRELATION OF ASIAN DUST STORM EVENTS WITH DAILY CLINIC VISITS FOR ALLERGIC RHINITIS IN TAIPEI, TAIWAN

Chih-Ching Chang¹, I-Ming Lee², Shang-Shyue Tsai³, Chun-Yuh Yang¹

¹Institute of Public Health, Kaohsiung Medical University, Kaohsiung

²Department of Health Care Administration, Diwan College of Management, Tainan

³Department of Health Care Administration, I-Shou University, Kaohsiung County, Taiwan

In spring, windblown dust storms originating in the deserts of Mongolia and China head toward Taipei city. These occurrences are known as Asian dust storm (ADS) events. The objective of this study was to assess the possible associations of ADS on the daily clinical visits for allergic rhinitis of residents in Taipei, Taiwan, during the period 1997–2001. Forty-nine dust storms were identified and classified as index days. Daily clinical visits for allergic rhinitis on the index days were compared with clinical visits on the comparison (non-ADS) days. Two non-ADS days for each index day, 7 d before the index day and 7 d after the index day, were selected. The effects of dust storms on clinic visits for allergic rhinitis were prominent 2 d after the event (19%). However, the association was not statistically significant. There may not have been enough power to detect associations resulting from the inadequate sample size of allergic rhinitis visits on ADS days. Further study is needed to clarify this association.

In spring, windblown dust storms originating from the arid deserts of Mongolia and China make their way to populated cities in East Asia, including Taipei, Taiwan (Chan, 2002). The movement of an Asian dust storm (ADS) in late April 1998 was detected by GOES9 satellite imagery and followed by a community of scientists in both Asia and North America. The storm resulted in enhanced PM₁₀ levels that were higher than those ambient concentrations found normally (Husar et al., 2001).

Course particles (between 2.5 and 10 µm in diameter) originate primarily from geologic sources (soil and other crustal materials). The occurrence of high levels of coarse particles is usually associated with high wind speeds that may tend to mask the detection of fine particles and other combustion-related pollutants (Schwartz et al., 1999). A few studies examined associations between daily mortality and episodes of high levels of coarse particles (Schwartz et al., 1999; Ostro et al., 1999; Kwon et al., 2002; Chen et al., 2004). Schwartz et al.

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Address correspondence to Chun-Yuh Yang, PhD, MPH, Institute of Public Health, Kaohsiung Medical University, 100 Shih-Chuan 1st RD, Kaohsiung, Taiwan, 80708. E-mail: chunyuh@kmu.edu.tw

(1999) found no evidence that mortality was elevated on dust storm days in Spokane, WA. Ostro et al. (1999) showed an association between elevated PM_{10} levels and daily mortality in the Coachella Valley, a desert resort and retirement area east of Los Angeles, CA, where coarse particles of geological origin typically comprise approximately 50–60% of PM_{10} and might exceed 90% concentrations during wind events. Two studies undertaken in Asia reported that Asian dust events might be associated with increased risk of death due to cardiovascular and respiratory complications (Kwon et al., 2002; Chen et al., 2004).

Studies showed that intercontinental dust storms contain viable microbes that are transmitted (Taylor, 2002). Griffin et al. (2001, 2003) were able to isolate over 200 viable bacteria and fungi when an African dust storm affected St. John island in the U.S. Virgin Islands with a two- to eight fold increase in the number of airborne microbes. They suggested that the microbes survived during the long voyage as a result of dust cloud shielding, preventing hazardous ultraviolet (UV) exposure. Studies on bioaerosols obtained from ADS were conducted. Yeo and Kim (2002) identified four major fungal genera in the suspended particulate matter samples taken in west Korea during ADS periods in 2000. Increasing ambient concentrations during ADS episodes were reported for some major fungi, including basidiospore, *Penicillium/Aspergillus*, and nigrospora in southern Taiwan (Tainan city) (Wu et al., 2004). The rising numbers of fungal spores were associated with increasing ambient levels of PM_{10} . Such an observation was considered indirect evidence of the potential contribution of regional atmospheric fungal spores to ADS (Wu et al., 2004).

Pollens are the most important reported cause of seasonal allergic rhinitis (Pederson & Rung Weeke, 1984; Solomon, 1984; Frank et al., 1999). However, the role of ambient fungal spores has received little attention. The effect of fungal spores on morbidity from allergic rhinitis is mostly unknown. A recent study by Cakmak et al. (2002) suggested that allergic rhinitis might be induced by fungal spores present in the air. To our knowledge, no previous studies examined the relationship between daily clinic visits for allergic rhinitis with episodes of ADS events. Wu et al. (2004) reported an enhancement of PM_{10} levels contained elevated fungal spore concentrations (Wu et al., 2004). Previous studies demonstrated adverse effects of ADS on daily hospital admissions for stroke (Yang et al., 2005) and cardiovascular disease (Chen & Yang, 2005) in Taipei. The objective of this study was to assess the possible effects of ADS on clinic visits for allergic rhinitis in Taipei during the period 1997–2001.

MATERIALS AND METHODS

Individual-based reimbursement claims randomly selected from the National Health Insurance Database, which was collected by the Bureau of National Health Insurance and compiled by the National Health Research Institute (NHRI) in Taiwan, were used. The National Health Insurance (NHI) Program, which provides compulsory universal health insurance, was implemented

in Taiwan in March 1995 and covers most of the population (the coverage rate was 96.16% in 2000) (BNHI, 2001). Computerized records of daily clinic visits are available for each contracted medical institution. All medical institutions must submit standard claim documents for medical expenses on a computerized form, which includes the date of visits, identification number, gender, birthday, and the cause of each visit according to the International Classification of Diseases, 9th revision (ICD-9). Because the complete files from the original database were too large to be managed and analyzed, the NHRI released a sampled database for research use, in which a proportional systematic sampling was used to receive 1 in every 500 records from the original data files. In this study, data on clinic visits in which the principal diagnosis was allergic rhinitis (ICD-9 code 477) from the medical insurance file for the period 1997–2001 were abstracted.

Taipei, the capital city of Taiwan, is situated in a basin in the north of Taiwan, and has a population of approximately 2.6 million. No industrial sources of air pollution are present in Taipei city. Vehicular traffic is the only source of ambient air pollution. Mt. Tatan and Mt. Chihsing, both over 1000 m high, form a backdrop to the northeast of the city and now constitute Yangmingshan National Park. ADS events encountered in Taiwan were associated with the northeastern winds of the winter monsoon, and therefore the air quality monitoring stations along the north and northeast coasts of Taiwan showed the largest impacts of dust-storm events (EPA/Taiwan, 2001). Yangmingshan station is a background monitoring site. Elevation in PM_{10} levels at Yangmingshan station (826 m altitude), which has low background concentrations of this PM_{10} due to its relatively clean mountain environment, makes the enhancement easier to identify. A rise in PM_{10} levels may be used to predict major ADS events in Taipei. In this study, an ADS event was defined as occurring when the level of hourly PM_{10} concentration observed in Yangmingshan station exceeded the air quality standard ($125 \mu\text{g}/\text{m}^3$) and lasted for at least 3 h for each day of the study period. In total, 49 dust storm episodes (index days) were identified between 1997 and 2001 in Taipei city (Chan, 2002) (Table 1).

In addition to the Yangmingshan station, six air quality monitoring stations were established in Taipei city by the Taiwanese Environmental Protection

TABLE 1. Dust-Storm Days in Taipei, 1997–2001

Year	Date
1997	2 January, 28 April.
1998	18–19 April.
1999	7 January, 27 January, 3 February, 12 February, 19 February, 6–9 April.
2000	3 January, 5 January, 24–25 March, 28–31 March, 12 April, 22 April, 27–28 April, 1 May, 14 May.
2001	13–15 January, 1 February, 16–17 February, 21–25 February, 2–7 March, 12–13 April, 2–4 May.

Administration (EPA), a central governmental agency. The monitoring stations were fully automated and provided daily readings, including SO₂ (by ultraviolet fluorescence), PM₁₀ (by beta-ray absorption), NO₂ (by ultraviolet fluorescence), carbon monoxide (CO) (by nondispersive infrared photometry), and ozone (O₃) (by ultraviolet photometry). The pollutant values from all six stations were then averaged to provide single estimates of the daily concentrations for each pollutant and used to indicate the exposure of people living in Taipei. Daily information on mean temperature and mean humidity was provided by the Central Weather Bureau's Taipei Observatory.

In the primary analysis, allergic rhinitis visits on the index days (day of ADS) were compared with visits on the comparison days (day with no ADS). Comparison days were the same week days as the corresponding index days and when dust storms did not occur on that day. Two comparison days were selected for each index day, 7 d before the index day and 7 d after the index days. If dust storms occurred on a comparison day, the day that was 14 d preceding/following the index day was selected. The adverse effects of dust storms, if any, might be delayed over a period of several days. To test this hypothesis, the adverse effects were examined on the same day and 1, 2, and 3 d after the storm events. Counts of daily clinic visits for allergic rhinitis were modeled using Poisson regression. The rate ratio for dust-storm days versus non-dust-storm days was estimated in a Poisson regression model, controlling for temperature, humidity, PM₁₀, and O₃. All analyses were performed using the SAS software package; *p* values less than or equal to .05 (two-sided) were considered statistically significant.

RESULTS

Table 2 shows the average values for air pollutant levels and meteorologic measurements in Taipei for the index (ADS) and comparison (non-ADS) days. The PM₁₀ levels for the index days were significantly higher than in non-ADS days. The levels of several other pollutants (CO, NO₂, SO₂) were very similar.

TABLE 2. Pollutant Levels and Environmental Factors in Taipei, 1997–2001

Parameter	Index days (<i>n</i> = 49)	Comparison days (<i>n</i> = 98)
PM ₁₀ (μg/m ³)	110.37 ± 37.86 ^a	61.73 ± 30.22
SO ₂ (ppb)	4.60 ± 2.30	4.27 ± 2.20
NO ₂ (ppb)	36.17 ± 9.93	36.40 ± 9.86
CO (ppm)	1.34 ± 0.39	1.35 ± 0.39
O ₃ (ppb)	28.36 ± 8.16 ^a	22.78 ± 8.72
Temperature (°C)	19.52 ± 4.01	19.78 ± 3.49
Humidity (%)	68.20 ± 10.43 ^a	76.99 ± 10.56

Note. Data are given as mean ± SD for index (ADS) and comparison (non-ADS) days Data are for a 24-h period.

^aSignificantly different from non-ADS days.

TABLE 3. Comparison of Clinic Visits for Allergic Rhinitis Between ADS and Non-ADS Days

	The same day	1-d Lag ^a	2-d Lag ^b	3-d Lag ^c
Index days (<i>n</i> = 49)	4.29 ± 2.48	3.82 ± 2.75	3.55 ± 2.89	3.43 ± 2.78
Comparison days (<i>n</i> = 98)	3.97 ± 2.39	3.33 ± 2.19	2.85 ± 2.03	3.10 ± 2.25
Relative risk (95% CI)	1.09 (0.89–9.43)	1.11 (0.92–9.68)	1.19 (0.98–11.39)	1.08 (0.89–9.17)

Note. Data are given as mean ± SD of number of visits.

^aAt 1 d following the dust-storm days.

^bAt 2 d following the dust-storm days.

^cAt 3 d following the dust-storm days.

However, the O₃ levels were markedly elevated during ADS days. The correlation coefficient between O₃ and PM₁₀ was 0.22. Relative humidity was significantly lower during the dust storm days.

Table 3 shows the mean daily number of clinic visits for allergic rhinitis occurring on ADS and non-ADS days as well as for various lags periods up to a maximum lag of 3 d. The number of clinic visits for allergic rhinitis was quantitatively higher during ADS and all lag days following ADS. The associations between dust storms and clinic visits for allergic rhinitis were highest 2 d after the event, but this was not statistically significant. Sensitivity analysis was performed in order to confirm the robustness of our findings. The model results were examined after consecutively deleting 1, 5, and 10% of the days with the lowest concentrations of PM₁₀. There was little change in the estimated risk of clinic visits for allergic rhinitis on dust-storm days (data not shown).

DISCUSSION

The PM₁₀ associated with ADS events is comprised of coarse crustal particles rather than combustion related particles. A 19% increase in the risk of clinic visits for allergic rhinitis during the ADS events (2 d following the ADS days) was found, although this change was not statistically significant.

The average concentrations of other combustion-related pollutants (SO₂, NO₂, CO) during the events did not differ markedly from those on non-ADS days. As expected, the ADS led to enhanced PM₁₀ and ozone levels in Taipei city. The correlation coefficient between O₃ and PM₁₀ was low (0.22); thus, colinearity was not a problem in our Poisson regression models. Furthermore, no previous associations were reported between O₃ and allergic rhinitis. It may therefore be conceivable that the study findings is due mainly to PM₁₀. A previous study found an association between fungal spores and daily emergency department visits for allergic rhinitis (Cakmak et al., 2002). Further, in a study conducted in southern Taiwan (Tainan city) there were increasing ambient concentrations of fungal spores during ADS episodes. The numbers of fungal spores are associated with elevated ambient levels of PM₁₀ (Wu et al., 2004). This observation is considered indirect evidence of the contribution of regional

atmospheric fungal spores to ADS (Wu et al., 2004). In this study no attempt was made to measure the concentrations of fungal spores. However, it was assumed that residents in Taipei city, on average, experience higher levels of fungal spores on ADS days. To our knowledge, this is the first study to examine the relationship between clinic visits for allergic rhinitis and ADS events. A biologically plausible explanation is that the increase in clinic visits for allergic rhinitis during ADS events is caused by a rise in ambient fungal spores, which is consistent with a previous study (Cakmak et al., 2002). Our analysis also indicates that cause precedes effect (the association was still prominent 2 d after the event).

Studies of air pollution and daily mortality or morbidity traditionally must control for secular, seasonal, and weekly trends. Symmetrical comparison days 1 wk (or 2 wk) before and after the event were chosen. This method controls for confounding by long-term time trends and seasonal patterns and, by definition, controls for day of the week (Bateson & Schwartz, 1999). This investigation implements a study design that controls for many confounders by design rather than through statistical modelling. Furthermore, meteorologic factors known to affect clinic visits, particularly temperature, did not differ between the index and comparison days. Therefore the observed relationships cannot be attributed to confounding by any of the already mentioned factors.

Several of the ADS events lasted for 3–5 d. It is thus possible that there is a harvesting effect whereby those who are susceptible to the outcomes under study tend to visit a clinic a certain number of days after the “initial” exposure. Subsequently this is followed by a corresponding drop in clinic visits. This decrease in number of clinic visits also occurs on non-ADS days and might account, in part, for the nonsignificance of the results reported here.

In summary, ADS events may increase the risk of daily clinic visits for allergic rhinitis in Taipei, although the association in this study was not statistically significant. There may not have been enough power to detect an association resulting from the inadequate sample size of allergic rhinitis visits on ADS events days. However, it seems worthwhile to pay more attention to the ADS events and health in the future.

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