 Biomed Environ Sci, 2013; 26(12): 994-997

Letter to the Editor

Dengue Fever Epidemiological Status and Relationship with Meteorological Variables in Guangzhou, Southern China, 2007-2012*

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Ecological methodology plus negative binomial regression were used to identify dengue fever (DF) epidemiological status and its relationship with meteorological variables. From 2007 to 2012, annual incidence rate of DF in Guangzhou was 0.33, 0.11, 0.15, 0.64, 0.45, and 1.34 (per 100 000) respectively, showing an increasing trend. Each 1 °C rise of temperature corresponded to an increase of 10.23% (95% CI 7.68% to 12.83%) in the monthly number of DF cases, whereas 1 hPa rise of atmospheric pressure corresponded to a decrease in the number of cases by 5.14% (95% CI: 7.10%-3.14%). Likewise, each one meter per second rise in wind velocity led to an increase by 43.80% or 107.53%, and one percent rise of relative humidity led to an increase by 2.04% or 2.19%.

Dengue Fever (DF) is an acute febrile disease caused by arboviruses (arthropod-borne viruses) of the *Flaviviridae* family, it is primarily transmitted by *Aedes* mosquitoes, particularly A. *aegypti*. As the largest trading city in southern China, Guangzhou has been a representative city suffering annual dengue virus transmission, more than 50% of the dengue cases in mainland China were reported here[1], and public health authorities are concerned about its high prevalence. Currently, effective chemoprophylaxis or vaccination approaches for dealing with DF are still not available. Programs to prevent this disease concentrate on monitoring and predicting dengue incidence. In recent decades, weather variables have been widely studied for their potential as early warning tools to fend off climate-sensitive infectious diseases[2], such as hand-food-mouth disease, malaria, Legionnaires' disease and diarrheal disease. Previous studies have shown that temperature, relative humidity et al. had significant correlation with DF. However, due to the difference in geographical and climate characteristics, meteorological variables influence DF incidence in different areas in different ways. In this paper, we use ecological methodology to conduct an analysis on epidemiological characteristics of dengue in Guangzhou for the period of 2007-2012, and compared those with the weather factors, in effort to assess the relationship between meteorological variables and DF, and assist public health prevention and control measures.

During study period, a total of 376 DF confirmed cases were reported in Guangzhou, annual incidence rate from 2007 to 2012 was 0.33, 0.11, 0.15, 0.64, 0.45, and 1.34 (per 100 000) respectively, showing an increasing trend. Similar to the study from Thailand, et al.[3], most of DF confirmed cases in Guangzhou were adults and the greatest number of cases was in age group 20-44 years, which accounted for 43.62% (164/376) of total cases. Monthly changes in the number of cases indicated the majority of DF cases were detected in autumn, a peak in the number of cases occurred during September to November, 78.99% (297/376) of all cases were reported during this period, this is consistent with the findings from some other Asia regions[4]. However, our results implied that more attention should be given to housewife/househusband and retirees, which have become the noticeable DF infection group in Guangzhou. In the recent six years, over 40% (152/376) of all cases were identified as housewife/househusband or retirees. One of possible explanations for this might be that DF infections associated with home or leisure activities[5] (Figure 1).

A negative binomial regression was used to identify the relationship between meteorological variables and DF. A preliminary analysis was conducted through Pearson's correlation coefficient ('r') matrix within meteorological variables. This indicated that the model constructed using contemporaneously both temperature and atmospheric pressure suffered from collinearity problems, because the two variables showed strong negative correlation (r=-0.86, $P<0.01$) (Table 1). Thus, we carried out two separate negative binomial regression models: the first included average temperatures but no atmospheric pressure, while the second considered atmospheric pressure but no temperature data. Both models included additionally relative humidity, wind velocity, and "year" as independent variables. To quantify the effects of meteorological variables, we computed the influences ($e^{\beta}-1$), which virtually correspond to the relative risks (RR). As shown in Table 2, temperature

doi: 10.3967/ bes2013.036
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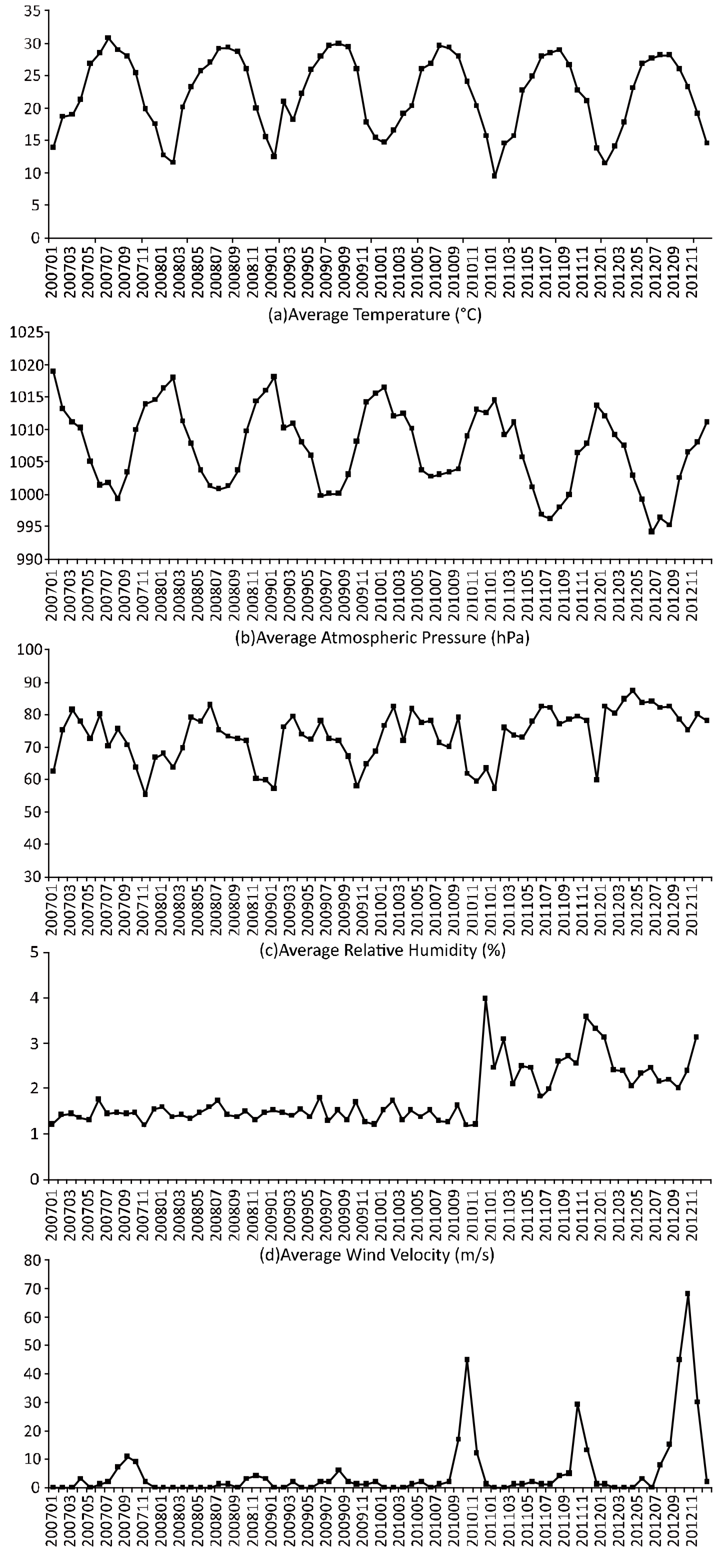

Figure 1. Monthly disturbance of a) Average temperature; b) Average atmospheric pressure; c) Average relative humidity; d) Average wind velocity; e) Df confirmed cases in Guangzhou, southern China, 2007-2012.

was found positively associated with dengue incidence, each 1 °C rise of temperature corresponded to an increase of 10.23% (95% CI 7.68% to 12.83%) in the monthly number of DF cases. This finding is in general agreement with other studies[6] which indicated that temperature was considered to be a precipitating factor for dengue transmission. It has been reported that temperature affects the potential spread of the dengue virus through each stage in the life cycle of the mosquito[7], higher temperatures might assist larvae of *Aedes* mosquitoes survival in winter, and also affects the extrinsic incubation period (EIP), the period between when the mosquito imbibes virus-laden blood and actually becomes infectious. The EIP is becoming shorter at high temperatures, which causes the mosquito to be more likely to survive long enough to transmit the virus.

Humidity was found positively associated with the dengue incidence of the same month, each one percent rise of relative humidity led to an increase by 2.04% or 2.19% of monthly reported cases. Similar observation was also reported in India[8]. Relative humidity is a crucial factor for the newly laid eggs as well the adult mosquitoes throughout the life cycle. Higher moisture facilitates better survival and emergence of larvae, whereas lower humidity is probably a limiting factor for dengue transmission as the eggs are subjected to desiccation[9].

In contrast to the findings from Barbados where wind velocity at a lag of 3 weeks had a negative effect on dengue transmission, the result of current study showed that the wind velocity contributed to dengue transmission in Guangzhou, each one meter per second rise in wind velocity may lead to an increase by 43.80% or 107.53% in the monthly number of cases. This difference may be explained by Kennedy's theory[10] which showed when wind velocity is over 1.5 m/s, it could reduce mosquito activity and dengue transmission. However, when the wind velocity is moderate (≤1.5 m/s), it may eventually increase dengue incidence. We found in Guangzhou, the average wind velocity is 1.82 m/s during study period, more than 60% (44 mos./72 mos.) of months monthly average wind velocity was less than 1.5 m/s, belonging to the gently-moderate level. Recently, Heukelbach et al. reported that the outbreak of DF in Brazil spread parallel to the prevailing direction of the wind[11]. This suggested that in some regions, high wind velocity was associated with higher occurrence of dengue fever.

Table 1. Pearson's Correlation Coefficient ('r') Matrix of Meteorological Variables in Guangzhou, Southern China, 2007-2012

Items	Average Temperature	Relative Humidity	Atmospheric Pressure	Wind Velocity
Average temperature	1.00	-	-	-
Relative humidity	0.31 (*P*=0.01)	1.00	-	-
Atmospheric pressure	-0.86 (*P*=0.00)	-0.58 (*P*=0.00)	1.00	-
Wind velocity	-0.30 (*P*=0.01)	0.19 (*P*=0.10)	-0.08 (*P*=0.52)	1.00

Table 2. Negative Binomial Regression Model of Meteorological Factors Associated with Risk of DF Inciedence

Items	β	Std. Error	*P*	$(e^{\beta}-1)$=RR (%)	95% Confidence Interval for RR (%)	
					Lower Bound	Upper Bound
(A)						
(Intercept)	-1799.682	129.5631	0.00	-	-	-
Relative humidity	0.02	0.01	0.01	2.04	0.40	3.64
Atmospheric pressure	-0.05	0.01	0.00	-5.14	-7.10	-3.14
Wind velocity	0.36	0.08	0.00	43.80	23.89	66.92
Year	0.91	0.06	0.00	149.29	126.56	170.08
(B)						
(Intercept)	-1821.228	126.4066	0.00	-	-	-
Relative humidity	0.02	0.01	0.00	2.19	0.74	3.61
Average temperature	0.10	0.01	0.00	10.23	7.68	12.83
Wind velocity	0.73	0.09	0.00	107.53	72.41	149.81
Year	0.92	0.06	0.00	150.93	128.41	172.81

Note. *Negative binomial regression model for monthly DF incidence without average temperature (A) and without atmospheric pressure (B). RR, relative risk.

To the best of our knowledge, the relationship between atmospheric pressure and dengue fever has not been reported in subtropical area. The present report is first to investigate the effect of atmospheric pressure on DF incidence in southern China. We found that atmospheric pressure was inversely associated with the dengue incidence of the same month, each 1 hPa rise of atmospheric pressure corresponded to a decrease in the number of cases by 5.14% (95% CI -7.10% to -3.14%). This result is consistent with the study from Brazil[12]. A possible explanation for this might be that low atmospheric pressure may suppress the flight activity of *Aedes*[13].

Some limitations must be acknowledged for this study: the incubation period of 2-15 d for every DF case cannot be determined exactly. We chose to use monthly aggregated data of DF case reported and monthly average meteorological data, the direction of these approximations, however, are likely to be random, suggesting that our risk estimates are reliable. Moreover, owing to this investigation being an ecological study, we cannot exclude that we could not identify and consider some potential confounding variables, although we emphasizes the impact of climate, other factors such as population growth, disorderly urban development, and inappropriate public waste disposal etc., need to be addressed in further studies.

Taken together, despite these limitations, we reported present-day epidemiological status of DF in Guangzhou. We also found weather factors had significant influence on occurrence and transmission of DF. A rise of temperature, relative humidity and wind velocity may increase the risk of DF infection, whereas an increase in atmospheric pressure may reduce the risk of DF infection. Our finding provides preliminary but fundamental information that may be useful for better understanding epidemic trends of DF and developing of a simple, precise, and low cost functional early warning system.

ACKNOWLEDGEMENTS

All enrollees who participated in the study are appreciated. We wish to give special thanks to the public unit coordinators and nurses in hospitals in Guangzhou.

*This work was supported by the Research Fund from Health Bureau of Guangzhou (201102A212006), Science and Technology Bureau of Guangzhou (2012Y2-00020) and Medical Sciences Program of Guangdong (A2011507).

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Received: May 1, 2013;

Accepted: July 8, 2013

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