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Original Research

Influence of meteorological factors and air pollution on the outbreak of severe acute respiratory syndrome

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Summary *Objectives:* To understand the association between the outbreak of severe acute respiratory syndrome (SARS) and meteorological factors and air pollution.
Study design: An ecological study was conducted.
Methods: Three hundred and fifty primary probable SARS cases diagnosed in mainland China between 1 January and 31 May 2003, and their 6727 close contacts during the period of their clinical symptoms before admission, were included in this study. Of the 6727 close contacts, 135 (2.0%) later developed clinical symptoms and were diagnosed as probable SARS cases. The daily meteorological data and daily air pollution data during the same SARS outbreak period in mainland China were used in the data analysis. Logistic regression analyses were conducted to explore the association between the secondary attack rate of SARS and meteorological factors and air pollution.
Results: In univariate analyses, daily average temperature (DAT), daily average air pressure (DAAP), and daily average relative humidity (DARH) were inversely associated with secondary attack rate ($P<0.001$); a significant positive association was found for daily hours of sunshine (DHS) ($P<0.001$). In multivariate analyses, factors associated with secondary attack rate were DAAP (odds ratio (OR) = 0.53,

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95% confidence interval (CI): 0.42, 0.66), DARH (OR = 0.73, 95% CI: 0.53, 1.00), and daily average wind velocity (DAWV; OR = 0.81, 95% CI: 0.68, 0.96). Adjustment for the onset time of a primary case led to little change in the results. In addition, in Hebei Province, a major affected area in China, only DAWV (OR = 0.38, 95% CI: 0.20, 0.72) was a significant predictor of secondary attack rate with adjustment for the onset time of primary case. In Inner Mongolia, another major affected area in China, DAWV (OR = 0.50, 95% CI: 0.26, 0.94) and DHS (OR = 0.27, 95% CI: 0.09, 0.81) were significant predictors of secondary attack rate with adjustment for the onset time of primary case.

Conclusions: Our results suggest that the SARS outbreak was significantly associated with DAWV, and that DAAP, DARH and DHS may also have influenced the SARS outbreak to some extent. However, because of ecological fallacy and uncontrolled confounding effects that may have biased the results, the association between the SARS outbreak and these meteorological factors and air pollution deserve further investigation.

Introduction

More than two years after the severe acute respiratory syndrome (SARS) outbreak of 2003, the devastating impact of the spring 2003 emergence is still fresh in the minds of the public health authorities. As most established respiratory pathogens of human beings such as human coronavirus 229E and OC43 recur in wintertime,[1,2] it is an important public health issue whether SARS, which is a respiratory infectious disease caused by SARS-associated coronavirus (SARS-CoV), will follow the pattern of other respiratory viruses and reappear sometime. Furthermore, reports of four confirmed SARS cases in China's Guangdong Province in the winter of 2003–2004 prompted widespread speculation that SARS was making a seasonal resurgence.[1,3]

The potential sources of SARS resurgence include the natural animal reservoir, laboratory spillage, and an undetected low level of human infection.[4] Since some SARS cases shed detectable SARS-CoV RNA in their stools for at least nine weeks following recovery,[5] and the source or sources of the 2004 SARS viruses have not been definitively established,[1] recurrence of SARS from persistently shedding human or animal reservoirs is biologically plausible. If SARS behaves like newly emergent zoonotic diseases such as ebola or pandemic strains of influenza, it may be difficult to predict when, or if, it will re-emerge.[1] Therefore, an enhanced understanding of the determinants of the SARS outbreak, which will help public health officials to make better public health decisions to control a future outbreak, still assumes great importance.

Although there has been striking progress in the science of SARS, our understanding of the impact of weather or climate on a SARS outbreak remains fragmentary. In 2003, the SARS outbreaks in Vietnam and Guangzhou were brought under control earlier than in Hong Kong. The argument that Vietnam and Guangzhou controlled the outbreaks by better medical facilities and hygienic standards is unconvincing.[6] Anecdotal reports suggest that changes in temperature may have been a contributing factor. The wider use of heaters in Toronto and air conditioning in Hong Kong and Singapore, usually to keep the room temperature within 18–22 °C, may have contributed to the long-lasting outbreak in these developed cities.[6] There have been some studies reporting an association between the SARS outbreak and meteorological factors and air pollution.[3,7–12] However, these studies have largely been inconclusive. In fact, they use public data on SARS morbidity to obtain the daily reported number of probable SARS cases instead of the true daily onset number. Apparently, the results they obtained from the public data were doubtful due to time-delays and chaos in case reporting. In addition, as the designs in these studies focused on the relationship between the absolute daily number of SARS cases and meteorological factors, the results were greatly biased by the size of population in the affected areas. Therefore, no acceptable results up to now have been obtained concerning the association between