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Red warning for air pollution in China: Exploring residents' perceptions of the first two red warnings in Beijing

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ABSTRACT

Air pollution early warnings have been issued in China to mitigate the effects of high pollution days. Public perceptions and views about early warning signals can affect individual behaviors and play a major role in the public's response to air pollution risks. This study examined public attitudes and responses to the first two red warnings for air pollution in Beijing in 2015. An online survey was sent out, and 664 respondents (response rate = 90%) provided their perspectives on the red warnings. Descriptive statistics, sign tests and binary logit models were used to analyze the data. More than half of the respondents reported that their life and work were affected by the red warning in December 2015. In contrast to their perceptions about the second red warning period, the public thought that the first red warning should have been issued earlier and that the number of consecutive days of warnings should have been reduced. The respondents also recommended that instead of reducing the number of red warnings, the red warning emergency measures should be adjusted. Specifically, the public preferred the installation of air purifiers in schools rather than closing schools and strengthening road flushing and dust pollution controls over restrictions on driving. Data analyses were conducted to examine the affected groups and different groups' perceptions of the necessity of implementing emergency measures. The results indicated that men and more educated respondents were more likely to be affected by driving limitations, and men were less supportive of these limitations. The age and education of respondents were significantly negatively associated with the opinion that schools should be closed, whereas wealthier respondents were more supportive of school closings. The finding of a negative attitude among the public toward the first two red warnings may be used to help local governments modify protective measures and pollution mitigation initiatives to increase acceptance.

1. Introduction

China has experienced rapid economic development and urbanization over the past three decades that has been accompanied by increasing air pollution, especially in polluted mega-city areas. Beijing, the capital city of China, is located on the northwestern edge of the North China Plain; it had a population of 21.705 million and a vehicle fleet of 5.619 million in 2015 (Beijing Municipal Bureau of Statistics, 2016). Coal dominates the energy structure of Beijing, and sharp increases in the use of motor vehicles as well as thousands of active construction sites have resulted in high pollutant emissions (Sun et al., 2006; Tang et al., 2009; Han et al., 2013; Wang et al., 2014); as a result, fine particles are becoming the most severe air pollutants in Beijing (Guo et al., 2010; Hu et al., 2009; Ji et al., 2016; Schleicher et al., 2015; Hu and Pan, 2011). There were 50 pollution days in 1980 (Zhao et al., 2012), whereas there were only 50 days of fairly good air quality in 2015, accounting for only 13.8% of the days in a year (Ministry of Environmental Protection of the People''s Republic of China MEP, 2014). Studies have been carried out in Beijing to examine the effect of air pollution on emergency hospital visits for hypertension (Guo et al., 2010) and cardiovascular diseases (Guo et al., 2009) as well as outpatient visits for allergic rhinitis (Zhang et al., 2011), cardiovascular mortality (Breitner et al., 2011), respiratory mortality (Yang et al., 2015; Afroz et al., 2003) and endothelial dysfunction (Wu et al., 2016). Zhang et al. (2007) estimated that the total economic cost of particulate matter (PM) accounted for 6.55% of the gross domestic product (GDP) of Beijing annually. Air pollution is unlikely to be eliminated in the foreseeable future; therefore, personal-level mitigation interventions are needed for the optimal protection of human health. Air pollution early warnings are applied as a risk mitigation measure against air

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pollution hazards. Air pollution warnings can warn the public to take protective measures and reduce health and economic losses caused by air pollution. However, the health effects of air pollution are delayed, while the social impacts of contingency plans during air pollution warnings are immediate. Therefore, public perceptions and attitudes regarding air pollution early warnings are critical for the effective implementation and acceptance of mitigation issues, as they can affect individual behaviors and play a major role in the public response to air pollution risks.

A red warning is the highest level of four air pollution warning signals in the 2015 *Beijing city air pollution emergency plan*, and it is issued when the air quality index (AQI) is forecasted to exceed 200 for more than 3 days. A red warning issuance is accompanied by a series of contingency plans to alleviate pollution and to protect public health. Protective measures include reducing time outside; wearing a smog mask; closing kindergarten, primary, and middle schools; allowing for flexible work schedules; and informing the public of health protection measures. Pollution mitigation initiatives include increasing the use of public transportation, restricting driving, increasing road flushing and dust pollution control, closing factories, and controlling outdoor barbecues (Beijing Municipal Environment Protection Bureau (BJEPB), 2015a). These emergency control measures ultimately decreased the pollutant emission intensity per day by approximately 36% and the concentration of PM with mean aerodynamic diameters of less than 2.5 μm ($PM_{2.5}$) by 11–21% during these heavy pollution events (Xue et al., 2016). However, these mitigating measures may disrupt residents' lives and work.

The first two red warnings were issued on 7 December and 19 December 2015 in Beijing. Heavy-pollution events 1 and 4 (Fig. 1) occurred before and after the two red warnings, respectively, and did not prompt a corresponding red warning despite reaching the air pollution threshold for issuance.

To understand how red warnings for air pollution in Beijing could be more effective, it is crucial to determine residents' attitudes regarding the need to issue a red warning for these two heavy-pollution events in 2015, as well as public attitudes regarding the rationality of the first two red warning issuances and their corresponding emergency measures.

The objective of this study was to investigate the social repercussions of issuing a red warning in Beijing when the air pollution reaches the AQI threshold. We aimed to answer the following questions: 1) Should an air pollution red warning be issued in Beijing when conditions reach the standard for a red warning? 2) What are the attitudes and responses of residents toward the first two red warnings issuances? 3) What are the most serious social effects of a red warning issuance? 4) What are the relationships between socio-demographic indicators and perceptions of red warning measures? 5) Which response measures that accompany red warnings should the government undertake?

2. Methods

2.1. Survey

A web-based survey approach (Gosling et al., 2004) was used to administer a questionnaire regarding public opinions of the first two red warnings in Beijing in 2015. The online survey was distributed on December 26, 2015. In China, the most popular and accessible social networks are Wechat, Weibo and Tencent, and we used them to distribute the survey link to people who live in Beijing; we also asked the social network users to share the survey link within their social networks. Participants who identified themselves as residents of Beijing were confirmed according to their use of IP addresses within Beijing. This online survey approach is efficient, although it requires respondents to have a Wechat, Weibo or Tencent account. Participants were not paid for their participation in the study.

This study focused primarily on several key areas, namely, socio-demographic characteristics (e.g., gender, age, educational level, monthly income, occupation, and residence), attitudes toward red warning issuance for air pollution and its emergency measures, and society-level expected responsive actions.

2.2. Analysis

IBM SPSS Statistics 23.0 was used for statistical analysis. The sign test was used for paired nominal data to examine public feedback toward the first two red warnings. The significance level was set at $p < 0.05$. Binary logit models were used to assess the associations between demographic factors and perceptions of life effects and compulsory measures to red warnings. Significance was set at the 1%, 5%, and 10% levels.

3. Results

3.1. Study participants

Table 1 shows the general socio-demographic characteristics of the respondents. Among the 739 total questionnaires, 664 were completed and used in the analysis (response rate = 90%). The spatial distribution of the respondents is shown in Fig. 2. The average age of the sample participants was approximately 35 years. The respondents were more educated than the general population of Beijing, a phenomenon also found in other studies (Geelen and Souren, 2013; Ban et al., 2017; Huang et al., 2013, 2017) that might be due to several reasons: highly educated persons are active on social networks, and less-educated people who are active on social networks are more likely to have difficulty understanding survey questions, causing them to return incomplete questionnaires. Most respondents (84.9%) lived in an urban area. The two most common occupations were informal business and casual labor.

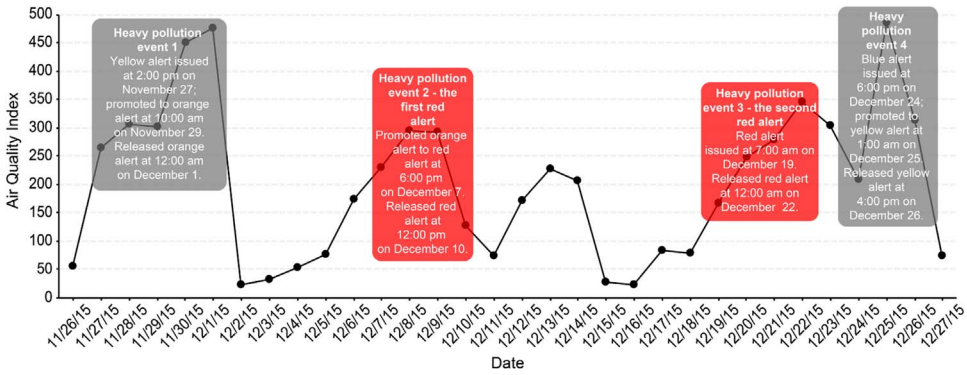

Fig. 1. Four heavy-pollution events in Beijing in 2015.