Impact of Ambient Air Pollution on Public Health under Various Traffic Policies in Shanghai, China[1]

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Objective To investigate the potential impact of ambient air pollution on public health under various traffic policies in Shanghai. **Methods** The exposure level of Shanghai residents to air pollution under various planned traffic scenarios was estimated, and the public health impact was assessed using concentration-response functions derived from available epidemiological studies. **Results** Our results showed that ambient air pollution in relation to traffic scenarios had a significant impact on the future health status of Shanghai residents. Compared with the base case scenario, implementation of various traffic scenarios could prevent 759-1574, 1885-2420, and 2277-2650 PM_{10}-related avoidable deaths (mean-value) in 2010, 2015, and 2020, respectively. It could also decrease the incidence of several relevant diseases. **Conclusion** Our findings emphasize the need to consider air pollution-related health effects as an important impact of traffic policy in Shanghai.

Key words: Air pollution; Traffic; Public health impact

INTRODUCTION

Road traffic is an important source of outdoor air pollution worldwide, contributing to fine particulate matter, carbon monoxide, and oxides of nitrogen. Recent epidemiological and animal studies suggest that exposure to traffic air pollution is associated with cardio-respiratory mortality and morbidity[1-3]. Several impact assessment studies of traffic air pollution have been initiated and completed by local, national and international organizations and institutions[4], highlighting the impact of traffic air pollution on public health. For example, the World Health Organization (WHO) estimated that 6% of deaths per year in Austria, France, and Switzerland are due to air pollution, and half of these deaths are linked to traffic fumes. The cost of treating diseases associated with traffic pollution across the three countries amounts 1.7% of their gross domestic product, exceeding the costs arising from traffic accidents[4].

Shanghai is a rapid-developing city and the cause of air pollution has changed from the conventional coal combustion to the mixed coal combustion/motor vehicle emission due to the rapid increase of motor vehicles within the city. Clearly, traffic policies in Shanghai will have a significant effect on the future local air pollution and health of Shanghai residents. The present study, was to evaluate impact of ambient air pollution on public health under various traffic scenarios in Shanghai.

MATERIALS AND METHODS

Scenarios of Traffic Policies and Air Pollutant Concentrations

Scenarios related to this study included base-case (BC), implementation of strict emission standard for new vehicles (scenario 1 below), and comprehensive vehicle pollution control (scenario 2 below). Details of the scenarios are described below:

● Under BC scenario, vehicle CO, VOC, NOx, and PM emissions in the whole city will increase to 1.563 million tons, 117 000 tons, 111 900 tons, and

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15 900 tons by 2020, approximately by 2.7, 1.4, 1.3, and 1.3 times higher than those in 2004, respectively.

● Under scenario 1, bus and taxi sectors take the lead in implementing GB III emission standard in 2006, GB III standard will be implemented for all new vehicles in 2007, GB IV standard will be implemented in advance in 2009. By 2020, the vehicle CO, VOC, NOx, and PM emissions in the whole city will be 742 000 tons, 82 800 tons, 54 700 tons and 8 500 tons, which will be reduced by 53%, 29%, 51%, and 46% as compared with those under BC scenario.

● Scenario 2: By integrated implementation of strict emission standard for new vehicles, reinforcement of I/M program and acceleration of old vehicle elimination, vehicle CO, VOC, NOx, and PM emissions in the whole city will become 574 000 tons, 70 600 tons, 50 500 tons, and 7 100 tons by 2020, which will be reduced by 23%, 15%, 8%, and 17% as compared with those under strict standard implementation scenario. The vehicle CO and VOC emissions in the whole city can be kept at the level of 2004, and NOx and PM emissions can be reduced by half as compared with the level of 2004.

This project uses ADMS-Urban model to link emission scenarios and pollutant concentrations. This model is the most complex one among the atmospheric dispersion model systems developed by Cambridge Environmental Research Consultants Ltd. (CERC, Ltd.), including point source, line source, area source, volume source and grid source models, embedded with chemical conversion and physical dispersion mobility modules. It can simulate synchronously the influence of the primary pollutant, secondary sulfate aerosol and ozone pollution resulting from the emission from industrial, civil and road transportation pollution sources in the urban area. One advantage of ADMS-Urban is that it can be used jointly with a geographical information system (GIS). It also features concepts based on Monin Obukhov length and boundary layer height, which make the boundary layer structure be defined with the directly measurable physical parameters. Therefore, it can express the dispersion process changing with the height more exactly, and simulate pollutant concentration distribution more accurately and reliably.

Human Exposure Level to Air Pollution

The year of 2004 was selected as the base period in this analysis. Air quality changes in 2010, 2015, and 2020 were estimated under the following scenarios: BC, implementation of strict emission standard for new vehicles, and comprehensive vehicle pollution control.

In this assessment, Shanghai was divided into four kilometers by four kilometers grid cells, and the changes in population exposure level and incidence of adverse health effects in each cell were estimated. Total health outcomes associated with air pollution in Shanghai were equal to the sum of grid-cell-specific changes of health outcomes.

Traffic-related air pollution consists of a mix of different pollutants (e.g. NO_2, PM_{10}, total suspended particles, fine particle, CO). In the present analysis, PM_{10} was selected as an indicator of air pollution to estimate the relevant health effects, since PM_{10} has the strongest epidemiological evidence among all air pollutants to support its association with adverse health effects. Our choice of indicator pollutant is also in line with other similar assessments of traffic-related air pollution[4].

All people living in Shanghai (excluding Chongmin County) were considered the exposed population in this analysis. An estimate of the number of Shanghai residents in each 4 km × 4 km grid cell was then made based on the population data collected from the Shanghai Bureau of Statistics. By combining the PM_{10} level and population size in each cell, we estimated the population exposure level to air pollution under various scenarios of traffic policy in Shanghai.

Estimation of Health Effects

Since most epidemiological studies linking air pollution and health endpoints are based on a relative risk model in the form of Poisson regression (Fig. 1), the cases at a given concentration C, could be given by:

$$E = \exp(\beta\times(C-C_0))\times E_0 \qquad (1)$$ [5]

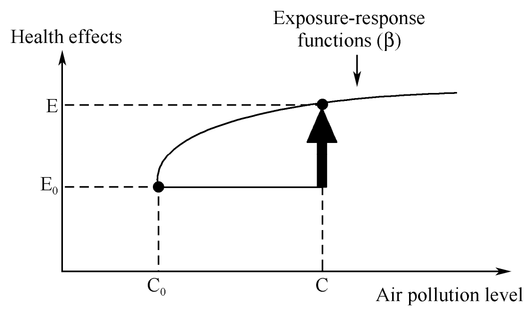

FIG. 1. Model to derive the number of cases under different scenarios[5].

where C and C_0 are the air pollutant concentration under one specific scenario and baseline scenario, respectively, and E and E_0 are the corresponding health effect cases under concentration of C and C_0. The health effect (benefit/damage) under